The Bureau of Reclamation: History Essays from the Centennial Symposium Volumes I and II

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COMMISSIONER'S INTRODUCTION

While I was regional director of the Lower Colorado Region in Boulder City, it was a great pleasure to be the executive sponsor of Reclamation's Centennial activities. This is one of the last of these activities to reach fruition. Commissioner John W. Keys III and I opened the history symposium the day after the Water for the West Foundation sponsored a spectacular birthday party for Reclamation at Hoover Dam.

The Bureau of Reclamation has a grand tradition of which I have been part since 1975 when I started work in the regional office in Sacramento. Reclamation's history closely parallels that of the development of the twentieth century American West. Reclamation was established in 1902 by President Theodore Roosevelt to "make the desert bloom." Reclamation projects have been the seed for many of the modern American West's large agricultural and metropolitan centers. I have watched completion of the Central Arizona Project and seen its effect on growth in Valley of the Sun communities.

Today, Reclamation provides one out of five Western farmers with water for 10 million irrigated acres. These farmlands produce sixty percent of the nation's vegetables and twenty-five percent of its fruits and nuts. We are the largest electric utility in the seventeen western states (operating 58 hydropower plants) and the nation's largest wholesale water supplier, administering 348 reservoirs with a total storage capacity of 245 million acre-feet. Nearly 30 million people all over the West depend on Reclamation projects for their municipal, industrial, and domestic water supplies.

Throughout its history, Reclamation has been an innovator in the engineering and science of dam design and construction, hydroelectric power production and delivery, water delivery, conservation, and multipurpose uses of water. Reclamation's masonry dams represent a distinguished lineage and include many landmarks of the West: East Park, Pathfinder, Buffalo Bill, Arrowrock, Owyhee, Hoover, Grand Coulee, Shasta, Friant, and Morrow Point are only the highlights of the list. Reclamation's embankment dams follow an equally distinguished lineage and include Belle Fourche, Anderson Ranch, and San Luis.

Reclamation's history is a rich tapestry filled with the politics, colorful personalities, and the unique character of the West. It is marked by engineering accomplishments and economic growth woven into the tapestry of western water development and delivery. These essays prepared for Reclamation's history symposium in 2002 add new dimensions to the story of Reclamation.

Robert W. Johnson
Commissioner
Bureau of Reclamation

SENIOR HISTORIAN'S INTRODUCTION

On June18-19, 2002, the Bureau of Reclamation and Department of History at the University of Nevada, Las Vegas, hosted a symposium on the history of Reclamation. The symposium was held in conjunction with the Bureau's centennial anniversary birthday party at Hoover Dam the afternoon and evening of June 17, and Dr. Andrew Kirk and Ms. Mary Wammack made the local arrangements at UNLV.

Reclamation's commissioner and executive staff from about 1992 forward supported centennial activities planned by the committee I chaired for Reclamation, including publication of these papers. Various issues have prevented preparation of this publication until several years after the symposium was held. In particular, commissioners Dennis Underwood, Daniel Beard, Eluid Martinez, John W. Keys III, and Bob Johnson and other executive staff such as Margaret Sibley, Elizabeth Harrison, and Roseann Gonzales have been very supportive of the history program and this publication. The support of my supervisors, Richard Rizzi and Ronald (Rusty) W. Schuster, was also very important to the success of these activities.

The proposed papers for the history symposium were vetted through a peer review group consisting of James Corbridge of the University of Colorado School of Law, Patricia N. Limerick of the University of Colorado, Toni Rae Linenberger of Reclamation, Donald J. Pisani of the University of Oklahoma, William D. Rowley of the University of Nevada-Reno, Wm. Joe Simonds of Reclamation, and me. In addition, Larry Walkoviak reviewed proposals for papers from an internal Reclamation perspective and provided comments on the proposals.

It was always the intent of the planning to embrace a broad range of ideologies, attitudes, and interpretations of Reclamation's history, and neither I nor the Bureau of Reclamation nor the members of the peer review committee necessarily agree with, or in any way endorse, the authors' selection of data or their interpretation of that data.

I consulted two noted, veteran, western history editors, Dr. Maxine Benson and Dr. Judith Austin, about how to approach this collection of papers. As a result, it has been my choice as editor to avoid trying to homogenize each symposium paper to uniform format, writing, and endnote styles. Instead, each author's work is permitted to show differences of professional training, endnote style, and writing style. Generally we have tried to use dictionary guidance for spelling and for a few stylistic issues have gratefully used the guidance of *The Chicago Manual of Style's* fifteenth edition. Among a few other items of which the reader might wish to be aware are the following standards we have tried to follow:

- quotations, notwithstanding our few efforts at standardization, were not altered, except that quotations of three or more lines were separated from text and double-indented with quotation marks removed;
- quotations were not checked for accuracy by the editor;
- no U.S. Postal Service or other abbreviations for states were used outside quotations; no abbreviations for months were used outside quotations;
- we used abbreviations for footnote and bibliography entries only when they are standard to the publication cited;
- we used the convention of "U.S." with no space between the letters while placing a space between letters for the initials of names, e.g., R. F. Walter;
- and, except in the more technically-oriented papers, where we have adhered to the conventions of the authors, we normally spelled out numbers under 100 and used numerals for 100 and over.

Because of the lapse of time between the symposium and this publication, some of the authors have placed their papers in other locations. When those other publications vary significantly from the original manuscript, we have also published the symposium original. All author-reported publications incorporating significant portions of the original symposium paper are listed in the "Bibliography of Papers Published in Other Locations." The remaining papers are presented in this publication, and we appreciate the authors' continuing assistance to us. These papers represent a tremendous amount of labor in terms of research and writing, and we are pleased that the history program is now able, through the support of Commissioner Robert W. Johnson, to provide this information to those interested in Reclamation's history.

To bring some order to the presentation of these essays, I felt it necessary to group them according to topic, but that proved more difficult than I had originally thought. In the end, the groupings became an engineering/technical section, a general Reclamation history section, and a section devoted to essays limited largely to a single Reclamation project.

Two technical notes are in order. In neither of these instances have we tried to correct authors' text to conform to these technical notes.

- First, there is a widespread belief among historians and the water community that the Colorado River Basin is divided at "Lee's Ferry" into the Upper Colorado River Basin and the Lower Colorado River Basin. This is an assumption that has gained currency over the years both because the Lee's Ferry site, at the mouth of the Paria River, is of historical significance as an early settlement on the Colorado River at the upriver edge of the Grand

Canyon and because there is a confusing similarity of terminology. The Colorado River Compact states that the division between the basins is at “Lee Ferry” and specifies in its definitions section that “The term ‘Lee Ferry’ means a point in the main stream of the Colorado River one mile below the mouth of the Paria River.” Therefore, “Lee Ferry” and “Lee’s Ferry” are slightly different locations—the Compact definition assures that the Paria River is a tributary wholly within the Upper Colorado River Basin.

- Second, some authors have referred to Reclamation as an “agency.” This is a common misconception held both within and outside the federal government. The term “agency” refers to cabinet level agencies, e.g., the Department of the Interior or the Department of Agriculture, and some independent agencies. The term “bureau” refers to subdivisions within agencies—such as the Bureau of Reclamation, the Bureau of Indian Affairs, and the National Park Service, all bureaus within an agency—the Department of the Interior.

Finally, layout and design of our publication was carried out in Reclamation’s Technical Services Center, by Charles Brown with assistance from Bonnie Gehringer. The assistance provided from that office is particularly important to the successful and timely completion of this publication.

Brit Allan Storey, Ph.D.
Senior Historian
Bureau of Reclamation

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and Water Resources Institute of the American Society of Civil Engineers and EWRI National History and Heritage Committee. Edited by Jerry R. Rogers and Augustine J. Fredrich (ASCE: Reston, Virginia, 2003), pp. 87-98. This ASCE book contains an abridged version, but the entire original paper is included in this publication under the title "Concrete Dam Evolution: The Bureau of Reclamation's Contributions." Reclamation publishes this version of the paper after conversations with the editorial staff of ASCE regarding copyright issues.

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Concrete Dam Evolution: The Bureau of Reclamation's Contributions to 2002

By:
Gregg A. Scott
Larry K. Nuss
and John LaBoon

I. Introduction

Over the last 100 years the Bureau of Reclamation (Reclamation) has made significant engineering contributions to the advancement and evolution of concrete dam analysis, design, and construction. The beginning of Reclamation's long history of world renowned concrete dam construction began shortly after the turn of the century with landmark masonry dams. Arch, gravity, and buttress dam design evolved through the 1920s. In the 1930s with the design and construction of Hoover Dam, significant strides were made in design, analysis, and construction. Advances were also made in concrete materials, temperature control, and construction techniques. Concrete technology improved to solve the problems of alkali-aggregate reaction and freeze-thaw damage following Hoover Dam. In addition to Hoover Dam, some of the largest concrete dams in the world were constructed by Reclamation during the 1930s, 1940s, and 1950s. Following the failure of Malpasset Dam (France) in the late 1950s, it became fully recognized that foundation conditions were critical to the stability of concrete dams. Reclamation made significant contributions in the areas of rock mechanics and dam foundation design in the 1960s and later. In the 1970s attention was paid to the earthquake response of concrete dams, and Reclamation was among the first to apply the finite element method to these types of analyses. A new method of concrete dam construction, termed roller-compacted concrete (RCC), was developed in the 1980s using earthmoving and paving technology to transport and place concrete materials, resulting in shorter construction times and decreased cost. Reclamation advanced RCC materials design and placement methods. Continued evaluations for dam safety, operations, and maintenance have been in the forefront of recent Reclamation activities. As the behavior and risks posed by these dams are better understood, modifications have been made for several concrete dams to improve their safety and service life. Part of the evolution of concrete dam analysis, design and construction, has been associated with waterways; specifically spillways and outlet works. These features are key components to safely pass water through concrete dams. Although these features are also critical for embankment dams, advances often came during concrete dam design due to the high heads associated with many of these structures.

Table 1.1. Large Masonry and Concrete Storage Dams Designed and Built by the Bureau of Reclamation or Currently in the Bureau of Reclamation Inventory.

Dam	Year Completed*	Type	Structural Height (feet)**	State
Pathfinder	1909	Thick Arch	214	Wyoming
Buffalo Bill	1910, 1990	Thick Arch	325	Wyoming
East Park	1910	Gravity Arch	139	California
Jackson Lake	1911	Composite Gravity/ Embankment	66	Wyoming
Theodore Roosevelt	1911, 1996	Thick Arch	280 raised to 356	Arizona
Arrowrock	1916	Gravity Arch	350	Idaho
Elephant Butte	1916	Gravity	301	New Mexico
Clear Creek	1918, 1993	Thick Arch	84	Washington
Warm Springs	1919	Thin Arch	106	Oregon
Black Canyon Diversion	1924	Gravity	183	Idaho
Gerber	1925	Thin Arch	88	Oregon
Mormon Flat	1926	Thin Arch	224	Arizona
Horse Mesa	1927	Thin Arch	305	Arizona
Stony Gorge	1928	Slab and Buttress	139	California
Gibson	1929	Medium-thick Arch	199	Montana
Stewart Mountain	1930	Thin Arch	207	Arizona
Deadwood	1931	Medium-thick Arch	165	Idaho
Owyhee	1932	Thick Arch	417	Oregon
Thief Valley	1932	Slab and Buttress	73	Oregon
Hoover	1936	Thick Arch	726	Nevada/Arizona
Parker	1938	Medium-thick Arch	320	Arizona

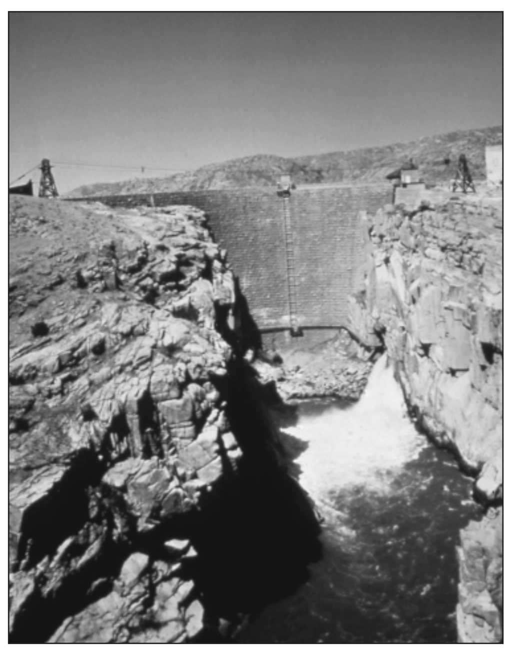
Dam	Year Completed*	Type	Structural Height (feet)**	State
Bartlett	1939	Multiple Arch	309	Arizona
Seminoe	1939	Medium-thick Arch	295	Wyoming
Friant	1942	Gravity	319	California
Grand Coulee	1942, 1974	Gravity	550	Washington
Marshall Ford	1942	Gravity	278	Texas
Altus	1945	Curved Gravity	110	Oklahoma
Shasta	1945	Curved Gravity	602	California
Angostura	1949	Composite: Gravity/ Embankment	193	South Dakota
Olympus	1949	Composite: Gravity/ Embankment	70	Colorado
Keswick	1950	Gravity	157	California
Kortes	1951	Gravity	244	Wyoming
Hungry Horse	1953	Thick Arch	564	Montana
Canyon Ferry	1954	Gravity	225	Montana
Folsom	1956	Composite: Gravity/ Embankment	340	California
Monticello	1957	Medium-thick Arch	304	California
Anchor	1960	Thin Arch	208	Wyoming
Flaming Gorge	1964	Medium-thick Arch	502	Utah
Glen Canyon	1964	Thick Arch	710	Arizona
East Canyon	1966	Double-curvature Arch	260	Utah
Yellowtail	1966	Medium-thick Arch	525	Montana
Swift	1967	Double-curvature Arch	205	Montana
Morrow Point	1968	Double-curvature Arch	468	Colorado
Wild Horse	1969	Double-curvature Arch	110	Nevada

Dam	Year Completed*	Type	Structural Height (feet)**	State
Mountain Park	1975	Double- curvature Arch	133	Oklahoma
Pueblo	1975	Composite: Massive-head Buttress/ Embankment	250	Colorado
Crystal	1976	Double-curvature Arch	323	Colorado
Nambé Falls	1976	Composite: Double-curvature Arch/ Embankment	150	New Mexico
American Falls	1978	Composite: Gravity/ Embankment	104	Idaho
Upper Stillwater	1987	RCC Gravity	292	Utah
Brantley	1989	Composite: Gravity/ Embankment	144	New Mexico

* For cases where the height or shape was significantly altered, the modification date is also given
** Structural height is generally the difference between the dam crest and lowest point of the excavation

II. Masonry Dams and the Early Years

Shortly after the beginning of the twentieth century, just after the establishment of the U.S. Reclamation Service, explorations were underway for large storage dams. In September 1903 George Y. Wisner, consulting engineer for the Reclamation Service, addressed a conference of Reclamation Service Engineers in Ogden, Utah. He indicated Reclamation would be required to build masonry dams of great height in order to store the water required to reclaim arid lands. This could be accomplished in narrow canyons where the arch action of the dam could be taken into account, provided the plans were based upon accurate data and correct determination of the stresses to which the dams would be subjected. In 1904, Wisner began what was to be a leading role in the design of Pathfinder Dam on the North Platte River in central Wyoming, collaborating with Edgar T. Wheeler, consulting engineer, on the analysis. It was recognized that masonry dams are far from rigid, and that temperature was an important load. The modulus

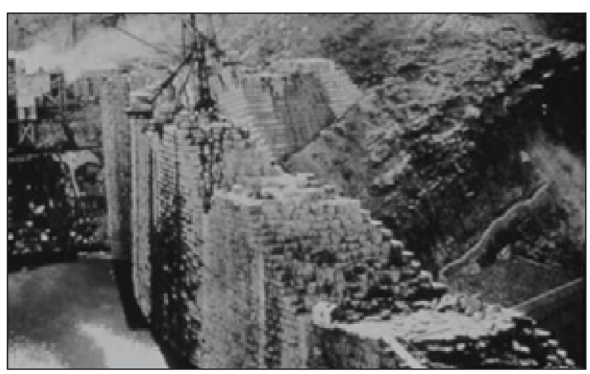


1.1. Pathfinder Dam, Wyoming.

and coefficient of thermal expansion were estimated for a composite of rock and concrete. The dam was designed as a combination of an arch and a vertical cantilever fixed at the base. The load, both temperature and reservoir, was distributed between the arch and cantilever so as to produce equal deflections. The stresses resulting from the deflections were then calculated. This was the early beginnings of what was to later become the Trial Load Method of analysis. The designed cross-section, constructed on a radius of 150 feet, was determined to give sufficient thickness to safely resist the forces that would act upon it. Above elevation 5830, reinforcement was considered necessary to reduce thermal cracking.

The dam was constructed in a narrow granite canyon. A large tunnel was constructed to divert the flow of the river, and later was used for the outlet works. Foundation excavation and dam construction were facilitated by an overhead cableway and guy derricks with steam driven hoist engines. The overhead cableway was key to constructing in the deep narrow canyon. Cableways are still an important component of modern construction for such conditions. Steam engines powered the concrete and mortar batch plant as well as the aggregate crushing and sorting plant. The side walls of the canyon were excavated to produce surfaces normal to the face of the dam. The first masonry was laid in August 1906, and the dam was completed in 1909. It was recognized that an impervious dam could be built at the same cost as a leaky dam, the main difference being more rigid inspection and an understanding at the start that first-class work only would be allowed. Any rock to be built against and any material to be placed in the dam was thoroughly washed and cleaned. A course of masonry was built on the upstream and downstream faces, and granite stone from the spillway excavation, varying in size from one to five cubic yards, was set in a heavy bed of mortar between the faces. The stones were lifted, reset, and vibrated with bars as necessary to get them completely in contact with the mortar. The vertical joints were filled with concrete consisting of cement, sand, and coarse aggregate. The concrete was fairly wet and would flow into most of the joints, where it would be worked by shovels

1.2. Original Theodore Roosevelt Dam, Arizona.



1.3. Masonry Construction at Theodore Roosevelt Dam, Arizona and leveled. Spalls or small stones were placed in the wider joints. The stone was placed from abutment to abutment. Stone of differing heights resulted in beds of mortar at varying elevations throughout the structure. Due to the high cost of cement, which was furnished by the Government, attempts were made to optimize the use of concrete and mortar. This required skilled masonry workers. Flat deformed steel bars were placed in the mortar joints near the face of the dam above elevation 5830. The finished dam has a structural height of 214 feet, and impounds about 1 million acre feet of water. The dam has performed extremely well for nearly a century, and for all practical purposes should have an indefinite life.

Similar masonry construction was in progress about the same time for Theodore Roosevelt Dam on the Salt River, in south-central Arizona. The design of the dam was somewhat more conservative than Pathfinder Dam, having a more conventional gravity dam section. This probably reflects the fact that it was designed under the direction of different engineers, F. Teighman and Louis C. Hill, and that the design for Theodore Roosevelt Dam probably predates that for Pathfinder Dam, even though Pathfinder Dam was completed first. Construction at Theodore Roosevelt Dam began in 1903. It appears that a simpler design methodology was employed. The dam was designed two-dimensionally such that the resultant force from maximum anticipated static loading fell within the middle third of the structure, and then the dam was arched to provide an extra margin of stability. It was recognized that temperature could affect the upper portions of the dam, and records indicate that some reinforcing steel was used in this area. Despite this, the thinner upper portion of the dam cracked vertically at regular intervals, in effect forming contraction joints. Leakage through these cracks was minimal. The dam was built in a narrow canyon formed by Precambrian siltstone, sandstone, and dolomite. Dolomite blocks formed the masonry for the dam. The construction practices were nearly identical to those at Pathfinder Dam, and a sound and water-tight dam, with a structural height of 280 feet and a storage volume of about 1.4 million acre feet, resulted. One of the main differences from Pathfinder Dam involved the early use of hydroelectric power at Theodore Roosevelt Dam. A 19-mile long power canal was constructed from a diversion dam upstream of the site. The canal fed a 7-foot diameter penstock tunnel leading to a temporary hydroelectric unit installed in a cave behind the permanent powerhouse. This provided construction power. Six 25-cycle units were installed in the original powerhouse with a combined capacity of 11,000 horsepower. President Theodore Roosevelt, in whose honor the dam was named, attended the dedication ceremonies held on March 18, 1911. Completed in 1996, modifications to the dam included raising the crest 76 feet to mitigate dam safety concerns, provide additional conservation storage (i.e., raise the top of active conservation from 2136 to 2151 feet), and enlarge flood storage. The original masonry dam was found to be in excellent condition, and was incorporated nearly entirely into the modified structure (discussed later in this paper).

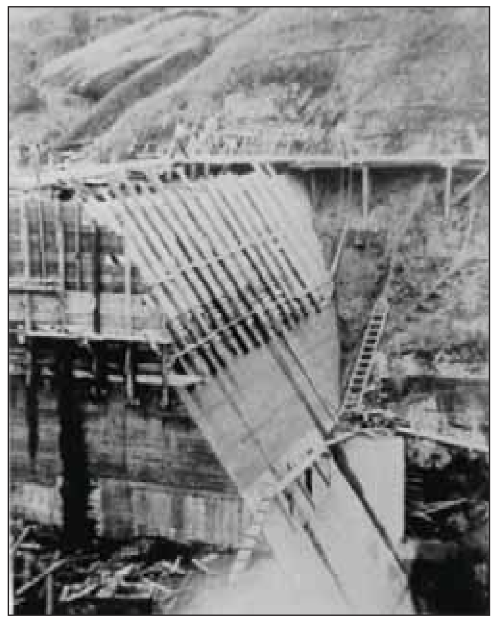
At approximately the same time, in northwest Wyoming, plans were underway to construct the then highest dam in the world across the Shoshone River. Initially called Shoshone Dam, it was originally designed as a straight gravity masonry dam in 1904, but in 1905, because of the narrow granite canyon across which it was to be constructed, the arch design proposed by George Y. Wisner was also adopted for what was to later be called Buffalo Bill Dam. The cross-section of the dam is nearly identical to Pathfinder Dam. It is of interest to note that independent arch theory design, where the thickness of the dam at any given elevation is a function of water depth and radius of curvature, was also being developed during this time period. In fact, a discussion by John S. Eastwood, describing how the thickness of Shoshone Dam could be substantially reduced by using this theory, appears in an early edition of *Engineering News*. The construction of the dam differed from that used at Pathfinder and Roosevelt Dams, beginning the transition from masonry construction to concrete construction. Wooden forms were built at the upstream and downstream faces for concrete placement. Concrete was mixed and deposited in 8-inch layers. Granite plum rocks, forming approximately 25 percent of the concrete volume, were placed in the concrete, and were shaken or rammed into final position. This solidified the mass to a remarkable degree, and additional tamping was scarcely required. However, spading and tamping was performed to work the concrete into all the cavities of the rock and ensure consolidation against the forms. The plum stones usually projected about half of their thickness above the surface of the new concrete. This presented a rough surface for bonding with the next layer. When a layer of concrete had set for more than 24 hours, the surface was thoroughly cleaned and a thin coat of mortar was placed prior to the next layer of concrete. The concrete was placed from abutment to abutment without contraction joints. Due to the contractor's desire to complete the work, winter placements occurred under a steam-heated tent. Upon completion in 1910, the dam was 325 feet high, and capable of storing over 400,000 acre feet of water. The dam was raised 25 feet in 1989.

1.4. Buffalo Bill Dam (includes 1990 raised dam and replacement spillway), Wyoming

1.5. Construction at Buffalo Bill Dam, Wyoming. Note wooden forms at downstream face and plum stones protruding from previous lift.

The first use of vertical radial contraction joints for a Reclamation concrete dam occurred at East Park Dam in north-central California. The radial joints were spaced at 20 feet, and a key, six inches deep by three feet long, was constructed in the contraction joints about six feet from the upstream face. Although there is no indication that waterstops were installed in the joints, a system of four-inch diameter tile drains was constructed downstream of the keys to convey water from the joints to the outlet tunnel. This dam also was constructed entirely of concrete. The original design called for sandstone blocks to be imbedded in the concrete to make up 20 to 30 percent of the mass. However, the sandstone was of poorer quality than first believed, and the sandstone blocks were omitted from the construction. The aggregate was processed and screened into three sizes (1/4, 1, and 3 inch). A little over one barrel (4 sacks) of cement was used for each cubic yard of cement. The concrete was placed quite wet, and water cured for 10 days. The dam was designed as a curved gravity structure, similar to Theodore Roosevelt Dam. It was constructed in a narrow gorge of massive conglomerate. Although the dam was completed in 1910, construction began in 1908, after construction of Theodore Roosevelt, Pathfinder, and Buffalo Bill Dams had begun. Despite the work of Wisner, a more conservative approach was taken. The 140-foot high dam impounds a reservoir of about 50,000 acre feet.

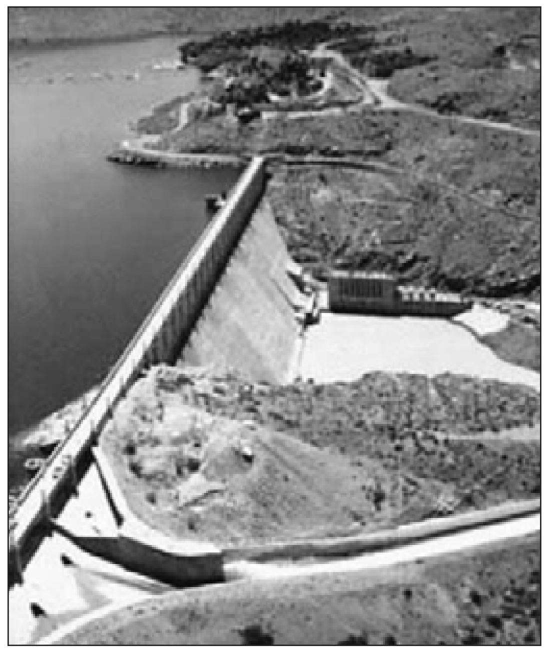
1.6. East Park Dam, California.



1.7. Construction at East Park Dam, California. Note the vertical formed contraction joint and concrete forms.

The reign of Shoshone Dam as the world's highest dam was short lived. In 1916, Arrowrock Dam was completed to a height of 350 feet. Once again, the cross section of this dam was similar to a gravity dam, but the dam was constructed as an arch. The construction of Arrowrock Dam also made use of vertical radial contraction joints. Radial joints were formed in the upper portion of the dam by building alternate sections at different times. The joints were spaced at various intervals dependent on the elevation and thickness of the dam. Three vertical wells were formed in each joint which were later filled with concrete during cold weather, after the dam had undergone contraction. A Z-strip annealed-copper water stop was installed in each joint 5 feet from the upstream face of the dam, and immediately downstream from this strip a triangular drain was formed in the joint. These drains collect water which gets past the waterstop and transports it to inspection or operating galleries. A unique material called "sand cement" was used for the construction of this dam, and for Elephant Butte Dam, a 300-foot-high straight gravity dam near Truth or Consequences, New Mexico, completed the same year. This consisted of standard Portland cement to which was added a little less than an equal amount of pulverized sand, reground to such fineness that 90 percent would pass a No. 200 sieve. Although this saved on the quantity of cement used, the concrete did not attain as much strength, and as a result, the durability suffered. This was not significant for the relatively mild climate at Elephant Butte Dam, but at Arrowrock Dam, spray from downstream releases resulted in severe freeze-thaw damage to the concrete. This necessitated construction of a new overlay on the face of the dam in 1936. The use of sand-cement in the construction of concrete dams was discontinued after these projects. The concepts of foundation grouting and drainage appear at Arrowrock and Elephant Butte Dams, and galleries were constructed in both of these dams. Shallow grout and drainage curtains (25 to 30 feet deep) were constructed by drill holes in the granitic near the upstream face of Arrowrock dam. The foundation drainage holes, spaced at about 10-foot centers, exit in an inspection gallery 27.5 feet from the upstream face. Vertical formed drains were also constructed within the concrete, spaced at 15 feet and located 12 feet from the upstream face of the dam. These drains also exit in the inspection gallery. Similar construction occurred at Elephant Butte

1.8. Arrowrock Dam, Idaho.



1.9. Elephant Butte Dam, New Mexico.

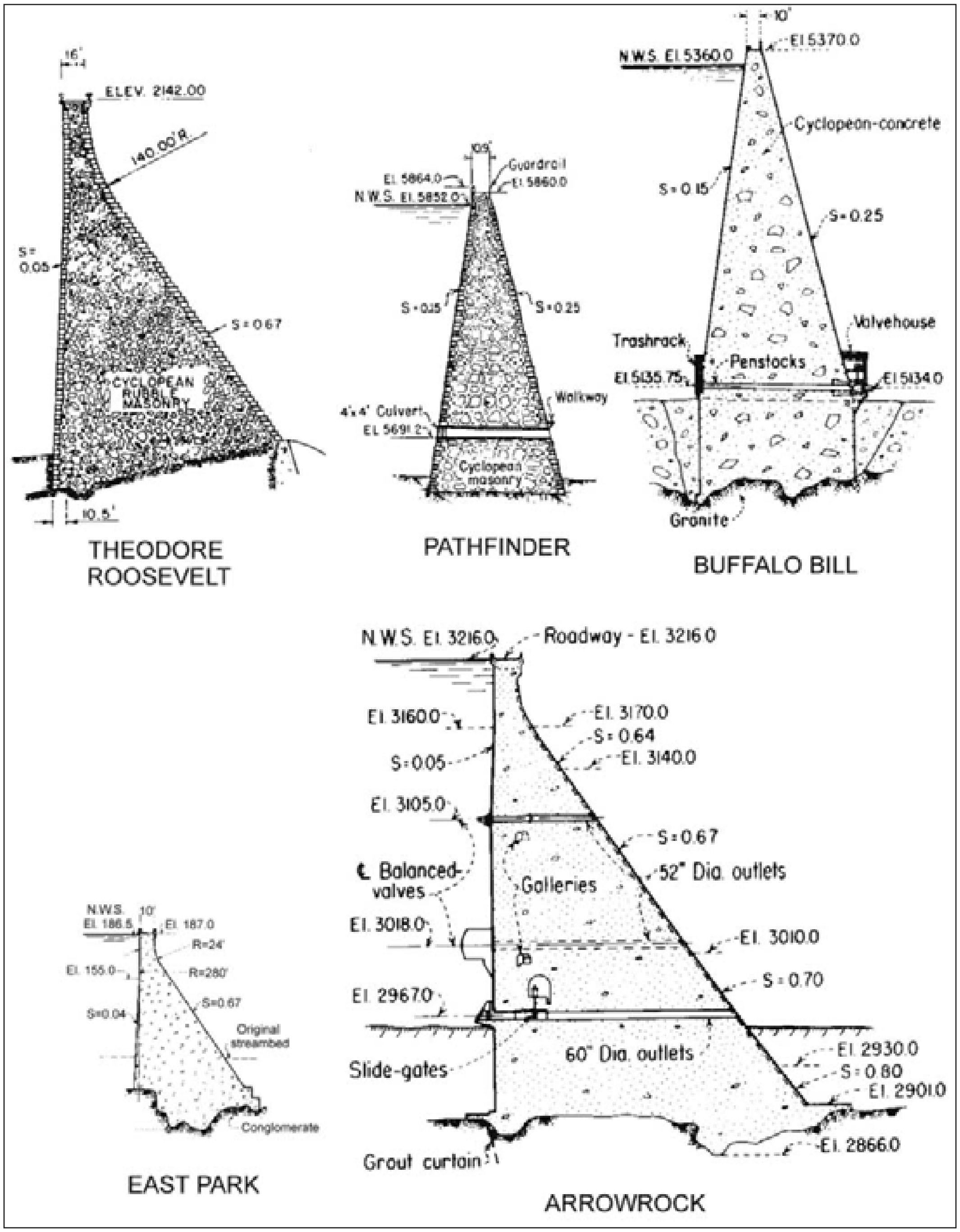
Dam.

In 1918 Duff A. Abrams first published results of research that investigated the effect of water-cement ratio and grading of aggregates on concrete quality. This was a major breakthrough in developing the science of concrete technology. Obviously, Reclamation concrete dams constructed up to that point did not have the benefit of his research, and the concrete quality and durability was largely a function of fortuitous circumstances and the experience of the on-site staff. With the exception of Arrowrock Dam, which required fairly minor modifications for freeze-thaw damage due to nondurable concrete, the early concrete dams of the Bureau of Reclamation have held up remarkably well.

III. The Amazing Arch and Developments of the 1920s

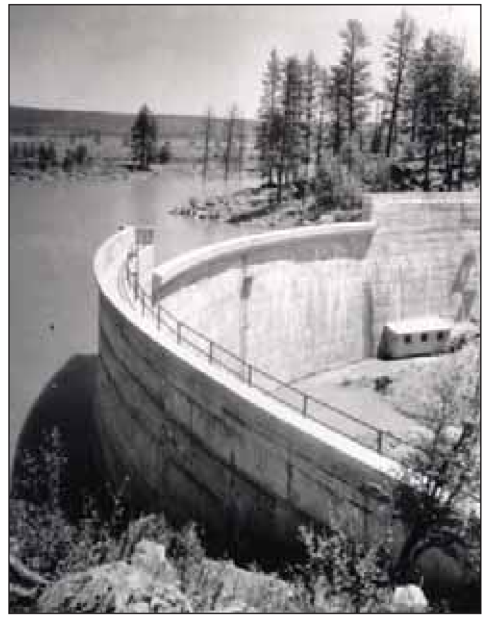
During the 1920s, materials were relatively expensive, and there was a desire to optimize dam design to reduce the required concrete. Independent arch theory became the order of the day, as thinner dams resulted from this method of design. Hence, many thin concrete arch dams were designed and constructed during this era. In addition, buttress dams became popular for wider canyons, since they minimize the required materials in favor of a more labor-intensive construction. The Bureau of Reclamation inventory contains only one gravity dam (Black Canyon Diversion) from this era. Most of the arch dams from this era in the Reclamation inventory were designed and constructed by water user groups. Titles were later transferred to Reclamation for various reasons. One of the exceptions is Gerber Dam. Gerber Dam was completed in 1925 on Miller Creek, a tributary of the Lost River in southern Oregon. The dam is a variable radius arch with a structural height of 85 feet and a reservoir volume of 94,000 acre feet. The Design Engineer was J. L. Savage and the General Construction Superintendent was F. T. Crowe, two individuals who would play prominently into later Reclamation projects. The foundation for the dam is basalt with weak clayey interflow zones. As was the practice up until this time, the main concern for foundation conditions related to the strength and hardness of the rock, and the water-tightness of the foundation. To assess the water-tightness of the foundation, tests were conducted in drill holes. Pipes were grouted and sealed into eight drill holes. Water was applied to all eight holes simultaneously under pressure from an elevated water tank. The leakage was determined to be small. Still, after excavating a keyway trench for the foundation to a depth greater than anticipated, a grout curtain was installed to a depth of 15 feet in holes spaced about 5 feet apart throughout the length of the foundation. The holes were grouted after the concrete above the grout hole reached a thickness of 6 feet by applying a steam pressure of 100 lb/in^2. No foundation drainage was included in the design or construction.

Concrete was placed in the dam by use of a trestle with rail buggies, a stiff leg derrick, and a high line. Most of the concrete was placed by cars with a ¾ yd^3 capacity, run on the trestle from the mixer and dumped into chutes and pipes leading to the forms. Five to six sacks of cement were used for each



1.10. Comparison of Maximum Sections of Early Reclamation Arch Dams.

cubic yard of concrete. Plum rocks, not exceeding 20 percent of the volume, were placed in the concrete at locations away from the forms, to reduce the needed concrete volume and provide small keys between lifts. Cold weather placements required heating the sand and mixing water, as well as heating the concrete placements under canvas enclosures. The rock foundation and concrete surfaces were thoroughly cleaned with wire brushes and water jets prior to concrete placement. All surfaces were sprinkled with water and dry cement just prior to placements. The concrete was placed in 4-foot lifts between keyed contraction joints at 50-foot centers, with no plum rocks in the bottom of the lift. The concrete was spaded against the forms to reduce "bug holes." Two closure slots, four feet wide were left near the ends of the center overflow section. Concrete was placed in these slots at low temperature conditions, once the dam had cooled. Extensive field testing was performed on samples taken during construction. This included sieve tests of the sand and aggregate used for the concrete, tensile tests on briquettes composed of the sand and cement used in the concrete, compression tests on 6- by 12-inch cylinders of concrete taken from the forms confirming the 1600 lb/in^2 required 28-day strength, colorimetric tests to determine the cleanness of the sand, and slump tests for concrete wetness. The slump was limited to 3 inches for most of the work to allow the concrete to flow through the chutes, but a slump of 6 to 8 inches was allowed in thinner reinforced walls. This represents early use of extensive standardized testing to control the work quality. Gerber Dam also represents the first installation of instrumentation in a Reclamation concrete dam. Seventeen electric resistance thermometers were placed in horizontal layers at three elevations in the crown cantilever (vertical plane of the line of arc centers). Berry Strain Gages, consisting of eight posts set in a circle about a center post, were installed in nine locations on the downstream face of the dam. Two post stations were installed on the crest of the dam across contraction joints on each side of the dam. A dial gage instrument was used to take the readings, which were adjusted by also reading a reference invar bar. Four



1.11. Gerber Dam, Oregon.

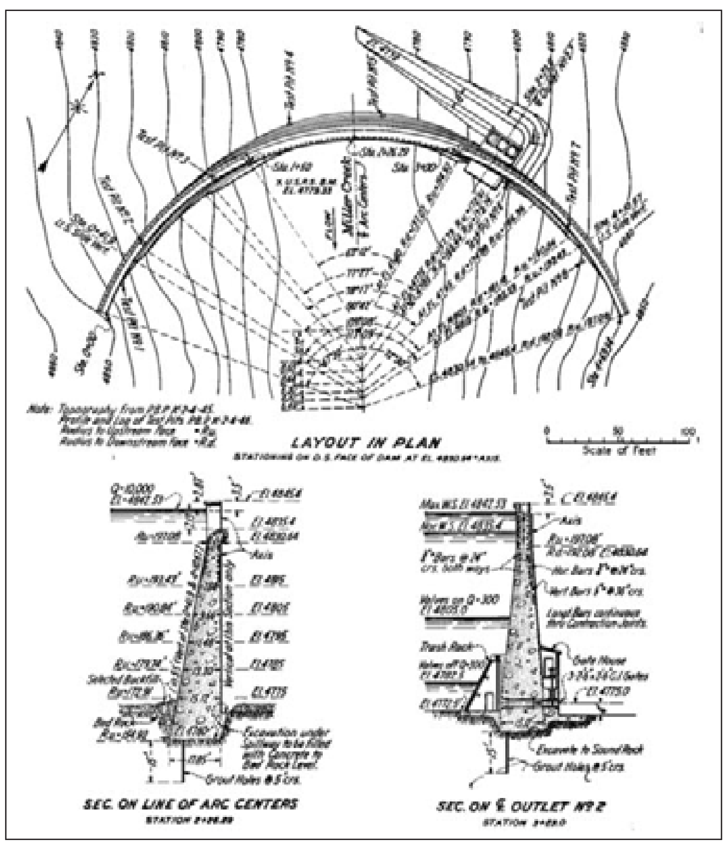
1.12. Stony Gorge Dam, California.

1.13. Construction of Gerber Dam. Note closure slot near left side of photo.

survey targets were set in the downstream face of the dam at the line of centers for measurements relative to reference targets on the abutments. Later tests for concrete modulus, coefficient of thermal expansion, and other properties were planned. The intent of the instrumentation was to verify the arch dam design and analysis techniques. Documentation describing this evaluation could not be located.

The first buttress dam constructed by the Bureau of Reclamation was completed in 1928. Stony Gorge Dam is an Ambursen type slab and buttress dam built downstream of East Park Dam. It has a structural height of about 140 feet, and a reservoir capacity of 50,000 acre feet. The dam is made of individual simply supported elements; buttresses, upstream face slabs, and struts bracing between buttresses in the downstream areas. The sloping upstream slabs span between and transfer the reservoir loading to the buttresses; the buttresses carry the upstream-downstream loading and transfer it to the foundation; and the struts provide lateral stiffness to the buttresses and keep them from deforming excessively in the cross-canyon direction. The reinforced concrete members were designed using codes available at the time. Additional horizontal reinforcing was added to the buttresses following the early appearance of vertical cracks in some of the taller

1.14. Photo taken during construction of Stony Gorge Dam, California from downstream side. Note struts between buttresses and sloping slabs on left side of photo.



1.15. Gerber Dam Plan and Sections

buttresses. A recent check indicates the design is generally acceptable for normal static loading conditions, even considering modern American Concrete Institute (ACI) code. The concrete mixing plant discharged into bottom-dump buckets of 1½ cubic yard capacity which were successively transported by hoist, highline cableway, and small cars on light tracks supported by the buttress forms to chutes conveying the concrete from the buckets to its final position.

The method of using chutes to convey the concrete was common practice during this era. This required a wet concrete mix for enough workability to allow the concrete to flow along the chutes. Unfortunately, this also resulted in somewhat weaker and less durable concrete than could be attained with a drier mix. In addition, it often resulted in latence rising to the lift surfaces. If this was not removed and thoroughly cleaned, bonding between successive lifts was compromised. However, many dams from this time period have performed well and are still in service. Although concrete technology had advanced, the effects of alkali-aggregate reaction and freeze-thaw deterioration were not well understood. Most of the arch dams constructed during this era in cold climates suffer from freeze-thaw deterioration, such as Gerber Dam. If built with reactive aggregate, the resulting cracking typically accentuates the freeze-thaw damage. Dams subject to alkali-aggregate reaction in mild climates, such as Stewart Mountain Dam, tend to exhibit cracking but continue to perform well.

IV. Prelude to Hoover Dam

Owyhee and Gibson Dams were built before Hoover Dam and included experimental sections for collecting temperature data and grouting in preparation for the construction at Hoover. These were also the first Bureau of Reclamation concrete dams to use tunnel spillways. Some of the final developments for the Trial Load Method were also performed during the design of these structures.

1.16. Owyhee Dam, Oregon.

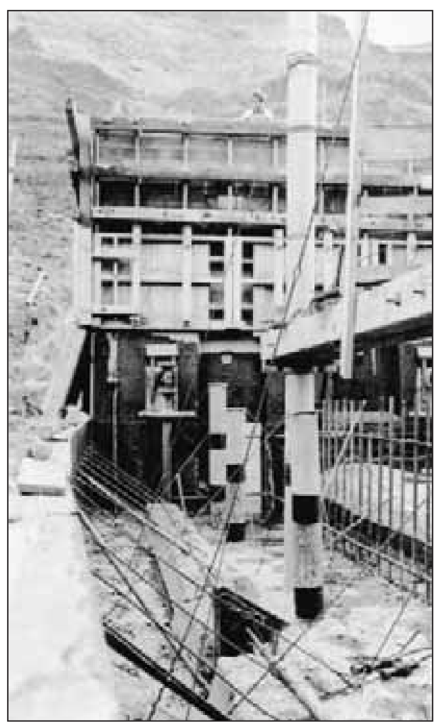
Owyhee Dam is located on the Owyhee River in eastern Oregon. It is a concrete, thick arch structure with structural and hydraulic heights of 417 and 325 feet, respectively. The crest is 833 feet long and 30 feet wide at elevation 2675. The maximum base width is 265 feet. The dam was completed in 1932. The dam forms a reservoir (Lake Owyhee) with storage of 1,183,300 acre feet at elevation 2675. Owyhee Dam was the world's highest dam at the time of completion. John L. Savage, Chief Designing Engineer, wrote:

From an engineering standpoint the Owyhee Dam, to be constructed on the Owyhee Project in eastern Oregon, is the most outstanding dam undertaken to date by the Bureau of Reclamation.… this dam is likely to stand as the highest dam in the world until the great Boulder Canyon Dam [Hoover Dam] is constructed.

The Owyhee River valley was visited early in the nineteenth century by Hawaiian trappers who are credited with having named the river “Hawaii.” Later, this name was handed down phonetically by scouts, Indians, and early settlers as “Ow-Y-Hee”, and ultimately the name was given this spelling. The dam site is also referred to as the “Hole-in-the-Ground” site. Intermittent site explorations began in 1903, a feasibility report was issued in 1925, and the project was recommended by the Secretary of the Interior on October 9, 1926. The General Construction Company of Seattle, Washington, was the low bidder at $3,198,779 and was awarded the contract on July 7, 1928. The government field organization reached its peak in 1931 with 107 employees under the charge of F. A. Banks (later to become Construction Engineer for Grand Coulee Dam). In June 1931 the contractor was placing from 40,000 to 50,000 cubic yards of concrete per month. The contractor’s workforce reached 274 people. Construction was completed five months ahead of schedule in 1932. The first water was delivered to the irrigation lands in 1935.

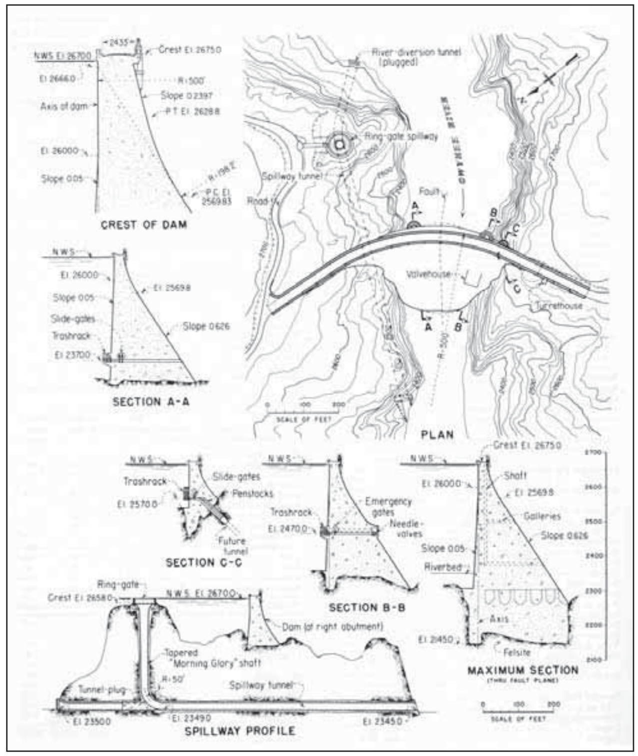
The materials and construction were similar to structures that had come before. The complete details will not be repeated here, but a few items of note are provided. Cobble rock was added to the mix. The cobble rock was sound, clean gravel or broken rock of such size as passed through a screen having 8-inch square or 9-inch round openings and was retained on a screen having 2¾-inch square or 3-inch round openings.

Porous concrete tile drains were placed in the dam near its upstream face. The joints in the tile were not cemented. The concrete tile had an internal diameter of not less than 5 inches, and wall thickness of not less than 1 3/16 inches. The tile was made of 1 part Portland cement and 4 parts total aggregate, the aggregates being so proportioned as to give a degree of porosity such that an 18-inch length of tile when set on end on a water-tight base shall discharge water poured into it at the rate of not less than 3 gallons per minute. Construction today would form these drains using a removable five- to six-inch- diameter tapered steel pipe.



1.17. Owyhee Dam, Oregon. Tile formed drains, strain meter for Hoover test, and gallery reinforcement.

The main advancements made during the design and construction of Owyhee Dam involved temperature control. Owyhee Dam was the largest dam at the time in which radial contraction joints were to be pressure grouted. Radial vertical contraction joints were placed at 50-foot intervals with 9-inch deep by 3-feet wide shear keys at 3-foot centers along each joint. The vertical contraction joints were grouted from March 30 to May 8, 1934, which is two years after construction of the dam. Internal temperature measurements, concrete cracking, grout operations, grout takes, grout pressures, and contraction joint opening measurements were reported in 1934. The grouting system installed in Owyhee was similar to that previously used in Gibson and Deadwood Dams except for a few minor improvements. A system of pipes were installed along the vertical contraction joints to cool the mass concrete to 50°F and grout the joints. Grout zones were 100-feet high and isolated with 20-gage soft copper sheets. The radial contraction joints in the dam were pressure grouted with cement grout forced through the pipe grouting systems. The grout was forced in to ensure a pressure of at least 100 pounds per square inch at the highest point in the system being grouted. Vertical keys were built in the joints. The entire face of each vertical joint in the dam, except the grouting units and copper expansion strips, were painted with one thin coat of water-gas tar paint and allowed to dry before the adjacent concrete was placed against it. The tar paint served as a bond breaker between the blocks of concrete. Copper grout stops were



1.18. Owyhee Dam Plan and Sections.

1.19. Owyhee Dam, Oregon. Grout pipes and shear keys on vertical contraction joint.

laid horizontally at vertical intervals of about 100 feet. The top of the grout zone was at elevation 2400, 2500, 2600, and top of dam. Construction today would limit the grout zone to approximate 60 vertical feet. The headers on the upstream face below elevation 2500 were not available for grouting because the reservoir elevation at the time of grouting varied between 2520 to 2527. Owing to the fact that there were quite a few cracks in the concrete in the dam, all cement used was screened through a 200 mesh sieve with the intention that this fine cement would seal most of the cracks. However, considerable cracking in the concrete on the downstream face of the dam occurred, primarily due to alkali-aggregate reaction.

Placing the mass concrete of the dam was begun in the fall of 1930 and completed in the summer of 1932. In the cooler months of the year, concrete was placed at around 52° to 70°F and heated up to around 98° to 116°F. In the warmer months of the year, concrete was placed at around 65° to 82°F and heated up to around 112° to 119°F. At the time of grouting, the internal concrete temperatures varied from 42° to 62°F. Grouting pressures inside the joint were around 100 lb/in^2. The allowable placing temperatures were much higher than allowed by modern standards and probably contributed to surface cracking. Electric resistance thermometers were placed in the concrete immediately on pouring. Dissipation of setting heat was accelerated by circulating water through the grout system except in the middle of winter. An experimental cooling system was located in panel 8 at elevation 2486. Tests in Panel 8 measured the effectiveness of cooling coils to dissipate heat in a thick concrete section. Additionally, the upper 82 feet of panels 3 and 4 (blocks 3 and 4, between contraction joints at stations 2+00 and 3+00) at Owyhee Dam were used as a test section to test cooling coils placed on the top of lift lines and their ability to open contraction joints for grouting. In this location of the dam, a system of cooling coils 1-inch diameter were placed 4-feet 7.5-inches apart near the bottom of each 4-foot lift. The section was highly instrumented to obtain temperature and strain measurements. The test section was placed from March 3, 1932, to May 28, 1932, at a fairly uniform rate with about three and one-half days between pours. Reservoir water was circulated in the test section cooling coils for only one month between May 13, 1932, and June 20, 1932. This period of time permitted cooling until the rising river water temperatures and lowering concrete temperatures permitted no further heat extraction from the concrete. Measurement of concrete temperature before cooling shows interior concrete around 117°F and the surface temperatures around 75°F, producing a thermal gradient

1.20. Owyhee Dam, Oregon. Spillway "Burp" (unstable flow condition, sometimes referred to as "blow-back").

of 42°F. This amount of gradient is very high and probably contributed to the surface cracking. The contours after the cooling coils were turned off show interior concrete and surface concrete about the same temperature at 70°F. The thermal gradient is very small which would minimize if not eliminate any surface cracking.

A series of model tests of the Owyhee morning-glory spillway were made from 1930 to 1931. No formal reports were prepared at the time of these studies. In 1944, the hydraulic studies for the spillway tunnels at Owyhee Dam and Gibson Dam were documented. In 1928, when designs for Owyhee Dam were underway, there were few installations of vertical shaft or glory-hole spillways and there was little information available that would assist in the design. The ring gate had no precedent whatsoever. A 1:48 scale model, which included the topography surrounding the spillway, the spillway and ring-gate control, and the discharge tunnel below the spillway was built to aid in the design. The design included forty-eight 1/16-inch holes equally spaced around the circumference of the lower crest which served as air vents to aerate the crest when the gate was raised. Prototype behavior indicates for heads of from 1 foot to 2 feet over the gate, the water falls in a solid sheet toward the center of the shaft, apparently entraining air faster than it can be released at the outlet end of the tunnel. This entrainment causes the pressure to increase until it is sufficient to regurgitate or “break back” through the sheet of overflowing water; then air emerges with sufficient force to carry spray 50 feet or 60 feet above the level of the gate. This phenomenon occurs sometimes as often as once every fifteen seconds and sometimes only once in five minutes, depending on the tailwater elevation. For heads less than 1 foot over the crest, entrained air can apparently move back up the spillway shaft unhampered. For heads greater that 2 feet, the air pressure is not sufficient to break back and the air is forced through the outlet end of the tunnel, causing spray to be thrown high into the canyon. This action is directly related to the tailwater as a rather large tailwater depth causes a jump to form in the tunnel for most discharges. With a 1000 second-foot discharge, the flow into the stilling basin was undisturbed, but as the flow increased an unexpected disturbance occurred that was not detected in the model. The stream of water from the spillway tunnel created waves on the surface of the stilling pool. These waves traveled across the canyon, reflected, and returned. As they struck the oncoming high-velocity stream from the tunnel an incident occurred which for lack of a better term, is called an explosion. With this particular flow (3000 second-feet) the spray from the explosion was thrown two-thirds the distance up the adjacent cliff. Larger discharges threw spray to the top of the cliff. Evidently the air drawn into the spillway entrance was ejected as a strong wind. When the reflected waves reach the tunnel portal, they are great enough to seal the exit for a short time and the air is quickly compressed to the extent that an explosion results from the release of the air.

During construction, a circular concrete-lined 22.6-foot diameter tunnel 1005 feet long was used for diversion. The tunnel was plugged with concrete upstream from the vertical morning glory shaft. Downstream of the vertical shaft it is used as the permanent spillway outlet. The diversion tunnel was constructed in rhyolite tuff requiring no timbering. First a 9- by 9-foot pioneer tunnel was driven followed by the full size tunnel. The rock in the tunnel was hard, self-supporting, full of incipient cracks, with an occasional mud seam. Immediately before placing concrete, the foundation surface was cleaned of mud and debris using a combination of air and water under pressure. The invert was placed by hand and screeded to shape. The crown and side walls were placed in 20-foot sections using wooden forms built in place. A 1-yard Ransome concrete gun shot the concrete through a 6-inch pipe and rubber hose into a V notched in the crown of the previous placement. The concrete then flowed along training boards into place. The concrete was worked into place by hammering on the forms with air hammers and by workers equipped with hip boots working and spading the concrete behind the forms. Grout pipes were placed into crevices and holes drilled into the foundation rock at frequent intervals. A 5-sack-per-yard mix was used in the tunnel lining between the inlet and the spillway shaft. A 6-sack-per-yard mix was used from the shaft to the outlet portal. The tunnel was equipped with a grouting system, and the lining-rock interface was grouted in 1934 using a 1.0 water to cement ratio in the invert and side walls. Sand was added to the mix in the roof grouting.

The spillway was featured in the 1956 *Transactions of the American Society of Civil Engineers* (ASCE). Excerpts from this article are as follows:

> The Owyhee Dam spillway in Oregon, completed in 1932 by the USBR, was a daring design at the time. The capacity is 30,000 cu ft per sec, the maximum head on the crest for this discharge is 12 ft, and the water is dropped 320 ft through a vertical shaft. A flood occurred in 1936 in which 300,000 acre-ft of water were passed in 3 months. The maximum discharge recorded was 15,000 cu ft per sec, or one-half capacity. Subsequent to this flow, smaller discharges have passed through the spillway frequently. A flow of 6,600 cu ft per sec was recorded in 1951. The greatest flood occurred in 1952, when the spillway operated for more than a month. The maximum discharge through the spillway was 20,000 cu ft per sec, or 67 % of capacity. Inspections of the spillway have been conducted frequently since the spillway first operated in 1936; the latest inspection was made after the 1952 flood. The spillway shaft appeared to be in excellent condition.

The form board marks still appeared on the concrete surface. The visible part of the invert of the vertical bend showed only slight surface wear, the maximum probably not exceeding 1/4 inch in depth.

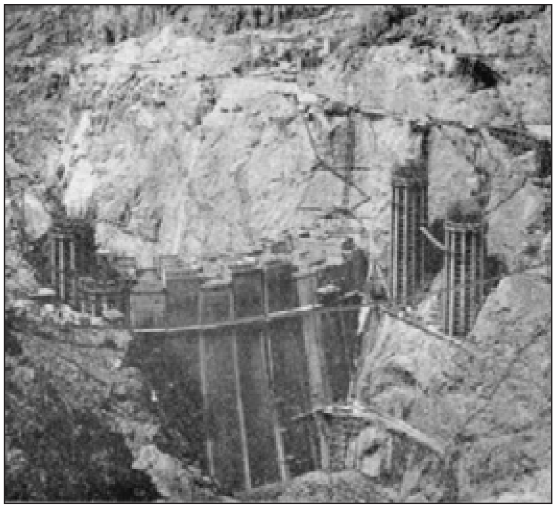
V. Hoover Dam—Quantum Leaps Forward

Hoover Dam is a 726-foot-high, concrete, thick-arch dam located on the border between Arizona and Nevada about thirty-six miles from Las Vegas, Nevada. The dam was completed in 1935, has a crest length of 1244 feet, a crest thickness of 45 feet, and a maximum base width of 660 feet. It is the highest concrete dam in the United States, the eighteenth highest dam in the world, and forms the largest manmade reservoir in the United States. The designs for Hoover Dam evolved over several years of careful study, representing the combined efforts of many engineers of Reclamation and various consulting boards. Preliminary designs were prepared from time to time over a period of ten years, so the successive designs reflected some of the developments in design techniques during the 1920 to 1930 decade. In 1920, the first design for a high dam in Boulder Canyon was prepared. At that time the highest dam in existence was Arrowrock Dam in Idaho. Hoover Dam was to be more than double the height of Arrowrock Dam. As such, it was evident from the start that many new problems in design and construction would require solution before the dam could be built.

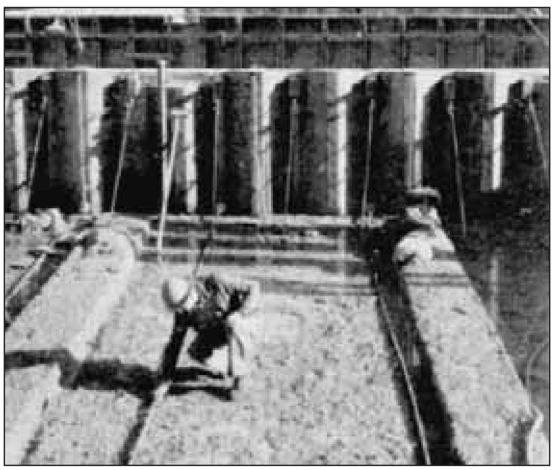
1.21. American Flag displayed during the 1996 Summer Olympics, Hoover Dam, Arizona-Nevada.

As a result of intensive research, improvements were made in practically every feature in the dam, spillway, and appurtenances. To bring the materials to the site, railroad lines of forty-eight miles length and thirty-five miles length were constructed, and paved roads from Las Vegas were built. A 150-ton cableway across the canyon was built. Electrical power had to be supplied to the dam site, Government operations, and the newly founded Boulder City. The town of Boulder City had to be planned and built for all the workers at the site. Aggregate, sand, cement, and mixing plants had to be built for the massive amounts of concrete. The concrete was artificially cooled by circulating water through cooling pipes placed at the top of each 5-foot high concrete lift. This required a massive cooling tower 143 feet long, 16 feet wide, and 43 feet high. A steel fabrication manufacturing plant was built to construct the massive penstocks and steel works. Drill crews on elaborate truck-mounted

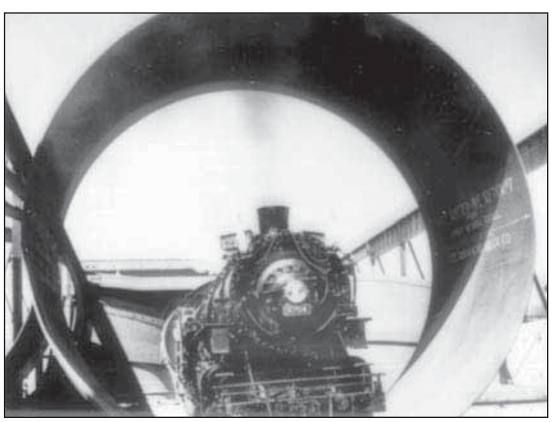
1.22. Hoover Dam, Arizona-Nevada. 50- by 50-foot concrete block placements



1.23. Upstream face of Hoover Dam, Arizona-Nevada.



1.24. Hoover Dam, Arizona-Nevada: Horizontal lift line and vertical contraction joint.



1.25. Hoover Dam, Arizona-Nevada. Relative size of penstocks

carriages excavated the 56-foot-diameter diversion and spillway tunnels. These tunnels were lined with 3 feet of concrete. The site had to be excavated to sound rock for the foundation of the dam. In the river channel, silt, gravel, and boulders had to be removed to a depth of 120 feet. The foundation was then grouted for the purpose of providing an impervious zone under the dam. The initial grouting involved drilling 6,700 feet of holes and injecting 7,500 sacks of cement. The main cut-off grouting was not started until the dam was at 100 feet high. This operation took 54,000 feet of holes and more than 60,000 sacks of cement (1 sack = 1 cubic foot). The dam was built in a series of 50-foot by 50-foot by 5-foot high blocks. An 8-foot slot was left open down the middle of the dam for the extensive system of cooling pipes. The vertical and horizontal surfaces have formed shear keys. A combination of water stops and grout stops were embedded in the concrete. After each 50-foot vertical section of dam had been cooled, grout was injected into the radial and circumferential joints. The 3.25 million cubic yards of concrete were placed from June 1933 to May 1935 in approximately 23.5 months. Systems of drains were installed in the dam and in the foundation. The foundation drains were 3.5 inches in diameter and extended 100 feet into the foundation at the base and graduated to 30 feet depth at elevation 1200. The internal drains in the concrete were 8-inch porous concrete pipes placed vertically at 10-foot intervals in a line parallel to the dam axis.

Hydraulic and structural models played an important part in the design of Hoover Dam to verify existing theories as well as advance the current state-of-the-art for applications of greater magnitude than those previously developed. The hydraulic models provided direct empirical data while the structural models furnished checks on analytical methods using the Trial Load Method. There were two complete models of Hoover. The first model, 1:240 scale, was made of a mixture of plaster and diatomaceous earth. The second model, 1:180 scale, was made of a rubber-litharge compound. In addition, detailed models were made of the crown cantilever and a thick arch at elevation 900 using model tests and slab analogy tests. Therefore, three independent solutions of the same problems were obtained.

1.26. Scale model of Hoover Dam, Arizona-Nevada.

Determining stress distributions in an arch dam requires a 3-dimensional analysis which was very difficult in the 1930s. The Trial Load Method of analysis was developed to represent the 3-dimensional arch structure with a grid of 2-dimensional arch and cantilever elements. The analysis would adjust the load into the elements and bring the elements into geometric agreement. As such, accurate solutions of the arch and cantilever elements had to be known.

V.A. *Boulder Canyon Project Final Reports: Part V—Technical Investigations: Bulletin 2—Slab Analogy Experiments,* Denver 1938.

Professor Harald M. Westergaard, at the University of Illinois in 1931, proposed the use of slab analogy in experimental investigations of stresses in Hoover Dam by means of measurements on rubber slabs. Slab analogy experiments were made to deflect slab models of the crown cantilever and an arch at elevation 900 to obtain stress functions usable in the Trial Load analyses. Stresses in the slab are proportional to twists and curvature in the slab. In other words, any system of curvatures and twists possible in a slab due to deformation of the boundaries is analogous to a distribution of stress in a plane solid of the same shape distorted by loads applied at the edges. Therefore, to solve a plane stress problem by slab analogy methods, it is sufficient to apply along the boundary of a slab, similar in shape to the original, curvatures proportional at every point of the boundary to the loading on the original. The two structures, being analogous at the boundaries, are thereby analogous throughout; and the direct stress or shear at any point in the solid may be determined from curvatures and twists at the corresponding point in the slab. So proper curvature measurements were made at the desired location and translated into stresses.

V.B. *Boulder Canyon Project Final Reports: Part V—Technical Investigations: Bulletin 3—Model Tests of Boulder Dam,* Denver 1939.

Before the Hoover model tests, there were model tests on Gibson Dam in cooperation with the University of Colorado, the Engineering Foundation Arch Dam Committee, and Reclamation. Concrete was mixed with the same aggregate as in the dam, and mercury was used for the water load. Results showed the Trial Load Method gives accurate results for an arch dam, and measurements on the model checked closely with measurements on the downstream face of the dam. It was evident however that a different material would need to be used in the Hoover model to permit measurable deflections. As a result, a mixture of plaster and diatomaceous earth (Celite) was developed and used for the first model. During testing of the plaster/diatomaceous earth model, the Aluminum Corporation of America developed a rubber-litharge compound which was used in the second model of Hoover Dam. It had a lower modulus and same unit weight as concrete. Water could be used for reservoir load instead of mercury permitting measurements on the upstream face. The model tests showed stress concentrations at the top of Hoover Dam where there was a rapid change in lengths of the arches. As a result, fillets were added to increase the thickness of the dam near the abutments.

V.C. *Boulder Canyon Project Final Reports: Part V—Technical Investigations: Bulletin 4—Stress Studies for Boulder Dam,* Denver 1939.

Stress studies for Hoover Dam included several special analyses that had not been previously made including: analysis of tangential shear, twist, Poisson's ratio effects, radial shear in the arch elements, horizontal shear in the cantilever elements, foundation deformation, thermal induced stresses from artificial cooling and exposed surfaces, nonlinear stress distributions in arch and cantilever elements, spreading of canyon walls and settling of the reservoir bottom from reservoir load, grouting and stage construction sequencing, and earthquake loading. Maximum stresses and nonlinear stress variations in typical arch and cantilever elements were checked by slab analogy experiments and by tests on slab models. The method of analyzing nonlinear stress effects was based on the analogy between partial differential equations for an Airy's surface and for a homogeneous slab loaded at the edges. Solutions were obtained both by mathematical analyses and by experiments on rubber slabs deflected by twists and moments applied at the edges. Adjustments were made for cantilever elements varying radially in thickness from downstream to upstream. Supervisors during the stress studies were R. S. Lieurance for the Trial Load studies, F. D. Kirn for the nonlinear cantilever studies, and R. E. Glover for the nonlinear arch studies and special studies.

V.D. *Boulder Canyon Project Final Reports: Part V—Technical Investigations: Bulletin 6—Model Test of Arch and Cantilever Elements,* Denver 1940.

It was desirable to obtain comparisons between cross-sectional models and the three-dimensional model of the entire dam. The cross-sectional models were performed at the University of Colorado in Boulder.

Cantilever model—the cantilever model was 3-inches thick and at 1:240 scale was the same scale as the three dimensional model of the dam. The depth, upstream, and downstream dimensions of the foundation were equal to the height of the cantilever.

Arch model—the purpose of the arch model was to obtain experimental measurements of strains and deflections in a thick arch element. Thin arches had been investigated in detail, but thick arches had not been thoroughly studied. A horizontal section at elevation 900 was selected for the study. Prior to these experiments, this thick arch had been investigated analytically and experimentally by slab analogy. The arch model was built at 1:120 scale.

V.E. *Boulder Canyon Project Final Reports: Part VII—Cement and Concrete Investigations: Bulletin 1—Thermal Properties of Concrete,* Denver, 1940.

One of the major problems at Hoover was the prevention and removal of heat in the concrete due to the heat of hydration. The problem was compounded by the rapid construction and extraordinary size of the dam—locking in temperatures that would take more than 100 years to dissipate. A series of radial and circumferential contraction joints were installed to control shrinkage of the concrete. For the dam to act as a monolithic structure, the joints must not open. However, the joints would open as the dam contracted from cooling of the concrete. Under this scenario, grouting the joints would have to be done over generations. Various methods were considered to remove the excess heat. This included low-heat cement and artificial cooling. Low-heat Portland cement was developed to reduce the heat of hydration by one-third and the temperature rise by about one-fourth. Investigations were performed to determine the effects

1.27. Concrete cylinder test for Hoover Dam, Arizona-Nevada of physical and chemical composition of the Portland cement on strength, temperature rise, and other properties. The design of the artificial cooling plan was based on the measured properties and mathematical theory of heat conduction. Knowledge base at the time did not provide accurate and applicable values for these properties, so investigations had to be performed. Considerable preliminary testing was necessary to develop apparatus and procedures for accurate thermal tests. Thermal property tests on concrete were also made for Gibson and Owyhee Dams. A method was developed for predicting thermal properties of concrete from these tests. Computed internal temperatures showed close agreement with measured test sections at Hoover and Owyhee Dams, where concrete was cooled by circulating water through metal pipes in the dam. Laboratory tests showed the effect on concrete temperatures of various rock types, water content, cement types, mix proportions, and age. The investigations were made at the Welton Street laboratory of Reclamation under the direction of H. S. Meissner, Arthur Ruetgers, and Robert F. Blanks.

V.F. *Boulder Canyon Project Final Reports: Part VII—Cement and Concrete Investigations: Bulletin 4—Mass Concrete Investigations,* Denver, 1940.

The selection of the most suitable mass-concrete mix for Hoover Dam and the exact determination of its properties and qualities was one of the most important design problems affecting the economies of the design. The effects of aggregate size, test cylinder size, curing, and relative humidity on the strength, elasticity, permeability of the concrete; and on the bond strength of the horizontal lift surfaces were studied. Rocks as large as two people could lift, plums, were used in the past in some dams. Reclamation felt more satisfactory results could be obtained with a maximum size aggregate able to fit in a mixer. A 9-inch maximum size was arbitrarily chosen to match available sources in the area. Little information existed on material properties using aggregate of this size; therefore, a comprehensive investigation program was initiated. Procedures for this type of concrete mix at the time would screen off any aggregate larger than 1.5-inch and test 6-inch diameter by 12-inch high concrete cylinders. No complete investigation had been performed to study the effect of the screening process.

Information existed concerning the effect of various curing conditions on concrete properties, but no direct comparison could be made between strengths of concrete cured in the interior of a large dam and the conditions in a laboratory. Only permeability tests on concrete under low water pressures had been performed. Because of the height of Hoover Dam, concrete permeability tests for high water pressures were performed. Most of these tests were performed in the old Custom House laboratory under the supervision of E. N. Vidal. Concrete dams are built in lifts. Subsequent concrete placements must be sufficiently bonded. Bond tests were conducted at the University of California Material Laboratory, Berkeley, California.

V.G. *Boulder Canyon Project Final Reports: Part VII—Cement and Concrete Investigations: Bulletin 2—Investigations of Portland Cement,* Denver, 1940.

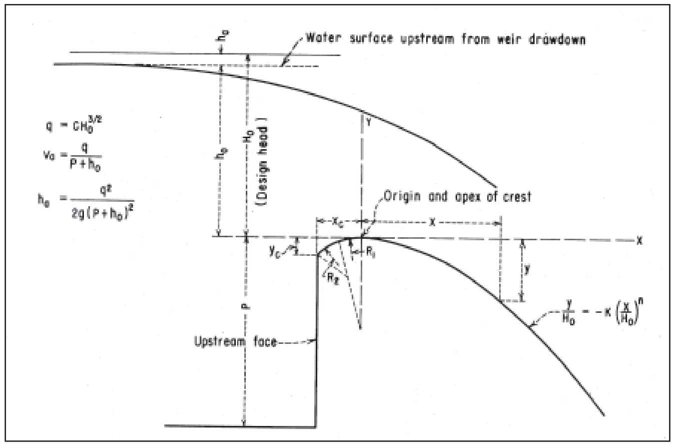
Although Portland cement had been used as a building material for more than a century, the unsuitability of the standard product for a structure as massive as Hoover Dam had become generally recognized at the time design work was begun. The main concerns were the heat generated during the hydration process and the shrinkage. The ideal cement for all purposes would be one which would permit the concrete to have no volume change subsequent to setting. Other desirable properties of mass concrete, which are dependent on the cement, are slower and better sustained hardening and adjustment to early stresses. In constructing the dam, contraction joints were provided at regular intervals in both the radial and circumferential directions. The structure was built in columnar blocks, approximately 50 feet square. The joints in between the blocks would allow for contraction of the concrete when it cooled.

At the time Hoover was designed, little work had been done on the investigation of cements for mass concrete. C. P. Williams during construction of the Rodriguez Dam in Mexico first recognized the value of low-heat cement in reducing temperatures and reducing cracking. Late in 1930 Burton Lowther, a Denver consulting engineer, recognized the desirability of a low-heat cement and performed investigations for Reclamation at the Pierce Testing Laboratories in Denver. At the laboratories of the Bureau of Standards, Washington, D. C., preliminary tests were made of forty-nine commercial cements, selected from various parts of the United States. The work begun in Washington was continued and greatly expanded in the Engineering Materials Laboratory of the University of California at Berkeley. Some specimens cast and tested were concrete, but the majority were mortar or neat cement. Concurrent with and supplementing the investigations at Berkeley were the investigations made in the laboratories of the Bureau of Reclamation in Denver. Unlike the Berkeley test, most of the tests in Denver were made on concrete specimens rather than mortar specimens.

In summary, it is safe to say that the sheer size of the Hoover Dam project, and the associated need to overcome many shortcomings in the design, analysis, and construction of concrete dams up until that time, led to significant advancements in the state-of-the-art, ultimately to become the state-of-practice. This project, perhaps more than any other, came to represent the Bureau of Reclamation's world renowned expertise.

VI. Hydraulics for High Concrete Dams

Without question, a major breakthrough in the understanding of high-head, high-velocity spillway designs resulted from the Boulder Canyon Project and construction of Hoover Dam. Between 1928 (authorization of the Project) and 1948 (completion of Project documentation), extensive research formed the "benchmark" for present-day spillway designs and analyses. The unprecedented size of the spillways (each with design capacity of 200,000 ft^3/s and a maximum average velocity approaching 175 ft/s) for Hoover Dam was the motivation to initiate a comprehensive research program. Of particular note, was the research and development of methods to design the "ogee" spillway crest, which is still used for spillway designs around the world. Prior to this research, methods of estimating the "under-nappe" of a jet of water moving over a sharp crested-weir were based on approximate observations made by M. Bazin in the late 1800s and typically used a vertical upstream face on the spillway crest. The shape of the under-nappe defines a minimum shape or profile for the spillway flow surface. Unless the flow surface matches or is flatter than the under-nappe, sub-atmospheric pressure can occur, possibly leading to reduced stabilizing tailwater backpressure, increased cavitation potential, or vibrations. The Boulder Canyon Project hydraulic research expanded on Bazin's methods and developed design tools, which can still be found in Reclamation's *Engineering Monograph* (EM) *No. 9* by J. N. Bradley and in *Design of Small Dams*. The design tools provide considerable flexibility and methods to: (a) determine the spillway ogee shape required to best fit the under-nappe of the overfalling stream for any practical condition of design; (b) derive the nappe shape due to varying approach velocities; (c) determine the coefficient of discharge for overfall dams (or spillways) with vertical, sloping, overhanging and offset upstream faces; (d) determine effects on coefficient of discharge due to different crest shapes with and without control gates, including the effects of adjacent terrain, piers, and position of gates; and (e) determine the effects on the coefficient of discharge due to downstream submergence.



1.28. Modern Ogee Spillway crest configuration.

1.29. Basin X (tunnel flip bucket), spillway discharging approximately 27,000 ft^3/s - Glen Canyon Dam, Arizona.

A second major breakthrough in hydraulic design for high dams occurred in 1958 with the first printing of Reclamation's *Engineering Monograph (EM)*

No. 25, Hydraulic Design of Stilling Basins and Energy Dissipators by Alvin J. Peterka. This publication summarized twenty-three years of research and design experience, and provided a practical design tool for sizing stilling basins. Since that initial printing this EM has been updated and was last reprinted in 1984. Until the development of this EM, attempts to generalize data from hydraulic model studies and resulting designs led to inconsistent results. To resolve this, a research program was undertaken, starting with observing all phases of the "hydraulic jump." With an understanding of this phenomenon, it was possible to develop practical and common aspects of energy dissipation designs. This EM documents that effort, and provides general design rules and procedures for ten stilling basin or energy dissipator types, which in some cases eliminates the need for hydraulic model studies. It should be noted that hydraulic model studies still play an important role in the design process. They are used to optimize the structure's size, account for non-symmetrical approach and exit conditions, and to evaluate unusual flow conditions in or through the structure. Three types of stilling basins and energy dissipators have been primarily used for spillways associated with high concrete dams. These include:

1. Basin V (sloping aprons)—This basin relies on a hydraulic jump to dissipate energy. The downstream basin slopes gently downstream. Designs that used Basin V stilling basins included Shasta, Canyon Ferry, Olympus, Friant, and Keswick Dams.

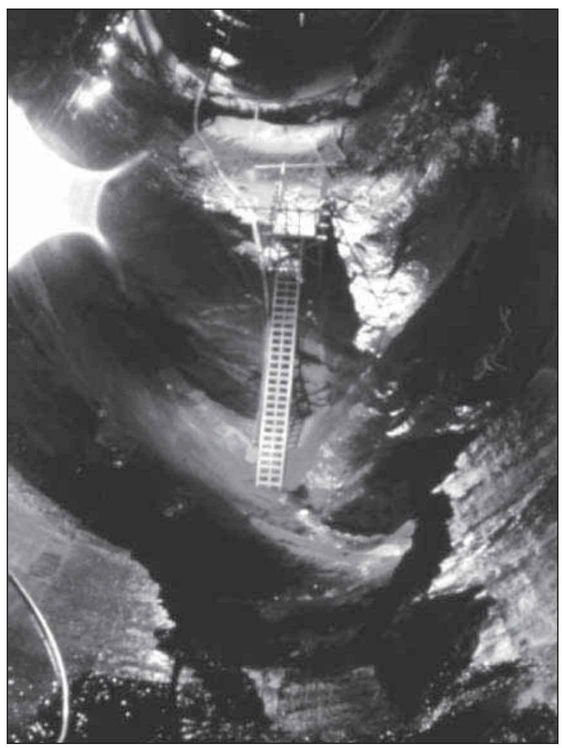
2. Basin VII (slotted and solid buckets)—As with Basin V, this basin also relies on a hydraulic jump to dissipate energy. However, the downstream basin is curved up with a lip at the downstream end. Designs relying on Basin VII stilling basins included Grand Coulee Dam, (solid bucket); and Angostura Dam (slotted bucket).

3. Basin X (tunnel flip buckets)—Unlike the basin V and VII, a hydraulic jump is not initiated. This is an energy dissipater that projects the exiting jet into the air, spreading and aerating the jet before it impinges into the tailwater. Basin X energy dissipators were used for Glen Canyon, Hungry Horse, Yellowtail, and Flaming Gorge Dams.

A third major advancement in evaluating hydraulics for high concrete dams involved the understanding of cavitation. Although Reclamation had investigated cavitation damage and implemented repairs since 1941, the understanding and methodology to adequately mitigate cavitation damage was not developed until after significant cavitation damage occurred at Glen Canyon and Hoover Dam tunnel spillways as a result of flooding in 1983. Prior to this, standard practice was to specify very stringent concrete finishes for flow surfaces associated with discharge velocities greater than 75ft/s. The concrete finishes for these flow surfaces were very difficult to achieve in the field. A more effective method had actually been employed in 1961 and 1969 with the installation of aerators to address the cavitation damage which occurred at Grand

Coulee Dam outlet works tubes, and the Yellowtail Dam spillway, respectively. The installation of the aerator for Yellowtail Dam spillway is thought to be the first of its kind, and after which, it was noted that aerators were being installed worldwide. It is interesting to note that research had already illustrated the effectiveness of extremely small quantities of air entrained in flowing water in significantly reducing the tendency for cavitation damage. However, it was not until the mid- to late-1980s that sufficient research, design, and experience had been gained to change Reclamation's approach to mitigating cavitation potential. Cavitation was found to be the result of formation and collapse of vapor cavities at abrupt changes in geometry of the flow surface. Resulting from an eight year effort, Henry T. Falvey's *Engineering Monograph (EM) No. 42, Cavitation in Chutes and Spillways* was published in 1990, providing common-sense guidance on how to identify and mitigate cavitation potential. Two important developments include: (1) generalized guidelines and tools were developed to assess the potential degree of cavitation, and to develop preliminary aeration designs, and (2) concrete finishes (surface textures) were decoupled from concrete tolerances (surface offsets and irregularities), recommended surface tolerances were revised to be more achievable in the field, and these tolerances were linked to cavitation indices. These indices are a function of the fluid velocity and pressure, and empirically give an indication of the potential for cavitation.

Today, as standard practice in the technical evaluations of existing and new spillways, the cavitation potential is evaluated by first evaluating the cavitation index (σ) profiles at different discharges. Based on cavitation index profiles, the required surface tolerances are determined as a function of the minimum value of cavitation index. If the cavitation index is less than 0.2, cavitation would be expected, and the effects of changing the spillway geometry on the cavitation index should be evaluated. If low values of the cavitation indices cannot be raised by changing the geometry, a concept change or an aeration device should be considered. Using these procedures, aerators have been installed in the spillway tunnels for Glen Canyon, Flaming Gorge, Hoover, and Yellowtail Dams.



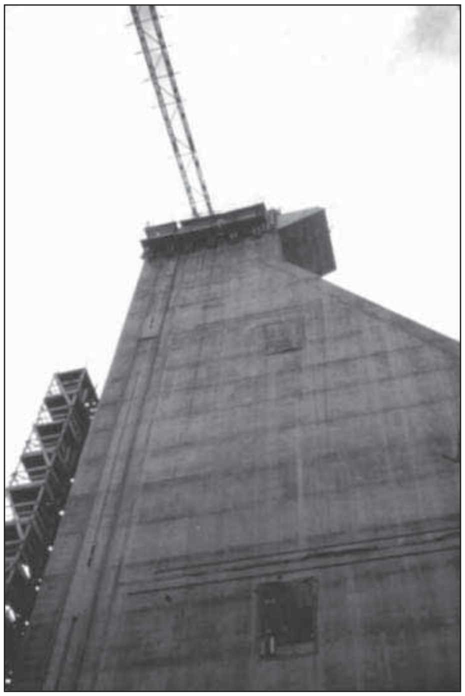
1.30. 1983 cavitation damage in the Left Spillway Tunnel. The "big hole" extends approximately 27 feet below the tunnel invert, Glen Canyon Dam, Arizona.

VII. World War II Era—Large Gravity Dams

In the 1930s the United States was hungry for electric power, and this became even more important to power war production factories following entry into World War II in 1941. The technology developed during the design and construction of Hoover Dam was available to construct large concrete dams and associated hydroelectric power plants. In order to tap the energy reserves of large and wide rivers, it became necessary to construct gravity dams. Two of the largest of these, Grand Coulee and Shasta Dams, were constructed by the Bureau of Reclamation in the late 1930s and 1940s. These dams became engineering landmarks, and have been studied and emulated by other countries around the world. During this time, John "Jack" L. Savage served as Chief Design Engineer. His office in Denver then was the foremost engineering office in the world for water resource heavy construction projects. Savage gained world-wide renown for his work with the Bureau of Reclamation, and received may honors and awards. He was reputed to be modest to an extreme, and was of such character as to readily receive the loyalty of his capable organization.

1.31. Grand Coulee Dam, Forebay Dam, and Third Powerplant, Washington.

The original design of Grand Coulee Dam called for a low dam to be built to elevation 1116 with the left power plant included. It would accommodate a future dam raise and expansion of the power plants, but originally would not provide irrigation water. The specifications were issued, the contract awarded, and the Notice to Proceed issued on September 25, 1934, for the low dam concept. Shortly after the construction activities began, renewed pressure came from the local agricultural constituents for the high dam. They caught the ear of President Franklin D. Roosevelt during his August 4, 1934, visit to the site. A reevaluation of the economics and technical issues associated with raising the dam indicated substantial benefits in going directly to a high dam. By June 5, 1935, a major change order was issued, increasing the excavation and changing the shape and details of the dam to allow immediate construction of a high dam to elevation 1311 through a second contract. The dam would be a gravity structure nearly a mile long and 550 feet high, with a downstream slope of 0.8:1, and a central spillway section controlled by drum gates capable of releasing 1,000,000 ft^3/s. Water would be pumped from the Columbia River to a reservoir in the Grand Coulee, a basin eroded by the river during the Ice Age when ice blocked the main course of the river. In January 1942, about a month after the Japanese attacked Pearl Harbor, a contingent of the U.S. Army took up quarters in Mason City and performed guard duty at the dam due to concerns about a possible enemy thrust


1.32. Construction of Grand Coulee Forebay Dam, Washington. (Note unkeyed contraction joint.)

into the area. All efforts were concentrated on getting the power online to supply energy to aluminum plants and shipyards.

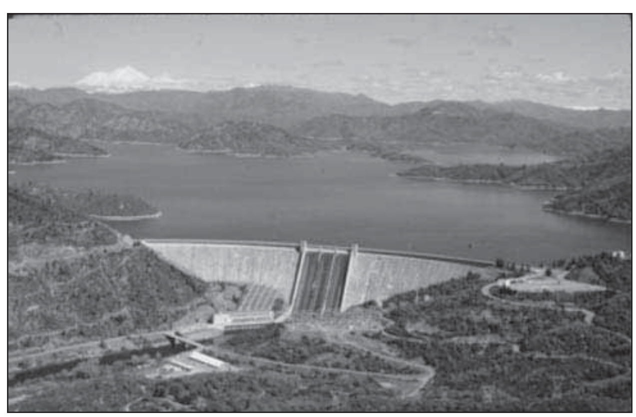
Diversion of such a large river posed many problems, but a series of cofferdams, and diverting flows over the low blocks in the dam allowed the construction to proceed. Landslides in the fine-grained deposits from the Ice Age mantling the river banks were also problematic. Stabilization included flattening slopes, installing drainage, and temporarily freezing the soil. The dam was founded on hard granite scoured by the pre-ice age river. As had become standard practice, foundation grouting and drainage were constructed. Three-dimensional Trial Load twist analyses, fully developed during the design of Hoover Dam, were performed for the high gravity dam design. Due to stress concentrations in the portion of the dam adjacent to the sharply rising abutments and concerns for potential cracking, vertical “twist slots” were designed for the abutment sections to give the structure some flexibility to adjust to loads. Five twist slots were constructed, two on the left side and three on the right side. The slots were initially filled with sand. After the reservoir had filled to elevation 1150, the sand was removed and the slots filled with concrete.

Low heat cement was used for the project. It had a slower set time delaying stripping of the forms, but lower heat of hydration than conventional cement was a great bonus in cooling the concrete and keeping cracking to a minimum. The concrete was made of aggregate, cement, and water. No admixtures, other than limited quantities of calcium chloride to accelerate the set, had become acceptable at that time. Two mixing plants were constructed, one on each side of the canyon, and at the peak of production 20,684 yd^3 of concrete were placed in 24 hours on May 29, 1939. The rock and concrete surfaces were thoroughly cleaned for placement of concrete using wire brushes, sand blasting, and water jets. The concrete was placed in 5-foot lifts and about 50-foot square maximum size blocks. At least 72 hours were required between successive lift placements. Cooling coils were placed on the lift surface, and drain forms installed. Then a ½-inch-thick layer of mortar was placed on the surface to provide a good bond. Concrete with a 2-inch slump or less was delivered in four-yard buckets using small trains running on a trestle and cranes. The concrete was placed in one foot layers and thoroughly consolidated with electric and pneumatic vibrators. The exposed surfaces were kept wet for fourteen days. River water was pumped through the cooling coils to cool the concrete. An evaporative cooling tower was eventually installed to enhance the concrete cooling. The concrete was cooled to about 45 degrees Fahrenheit, and then the transverse keyed contraction joints, spaced at 50 feet, were grouted. Reclamation's 4,000,000 lb. testing machine was installed in the Denver laboratory at the U.S. Customs House during the period of dam construction to permit testing the strength of large aggregate concrete, using cylinders up to 36 inches in diameter.

The Forebay Dam and Third Power Plant were completed in 1974, and they greatly increased the power generating capacity of the project. Two concrete mixes were used for construction of the Forebay Dam; a richer mix for exterior surfaces and a somewhat leaner mix for the interior mass concrete. Fly ash and air entrainment were used in all concrete. The fully automatic batching plant had provisions for handling five aggregate sizes ranging to 6-inch maximum, and a refrigeration plant for chilling water and making ice to cool the mix to the required 40 to 50°F placement temperature. All concrete was membrane cured. Vertical contraction joints normal to the axis were spaced at alternating distances of 50 and 70 feet, the large spacing required to accommodate the 40-foot-diameter penstocks. Artificial cooling was performed in the lower portions of the blocks. The contraction joints contain water stops, but only the lower portions were grouted, presumably to stabilize the sections of the dam that contain the penstocks. However, the more important consideration is that the contraction joints keyed. This allows each block to adjust to movements individually, but also reduces load transfer between adjacent monoliths in the case of local instability.

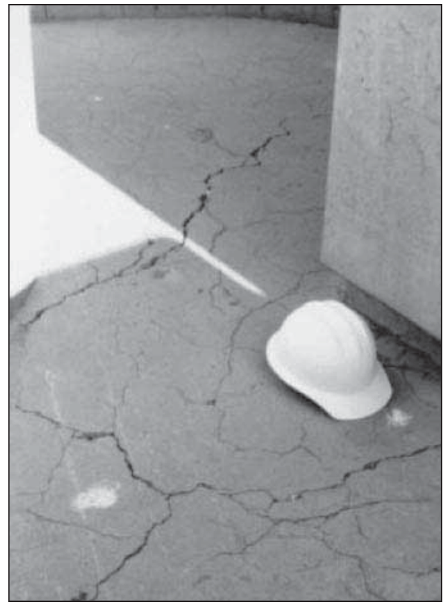
1.33. Construction of Grand Coulee Dam, Washington. (Note Keyed contraction joint.)

Construction of Shasta Dam in northern California overlapped with construction of the original Grand Coulee Dam. At the time, Shasta Dam was second only to Grand Coulee in volume, and second only to Hoover in height. The dam is on the Sacramento River in northern California, and is the cornerstone of the Central Valley Project.



1.34. Shasta Dam, California.

Although curved in plan to match the site conditions, the dam was designed as a gravity dam, with a downstream slope of 0.8:1. By this time efficient placement and cooling of large volumes of concrete could be readily achieved, due largely to the development that occurred during the design and construction of Hoover Dam. Construction methods were nearly identical to those at Grand Coulee Dam. As an interesting note, two generators lay idle at Shasta Dam in the early days of World War II, with no prospect for immediate use. They were shipped and installed at Grand Coulee Dam, providing power during the critical war years, and then returned to Shasta following the war.



1.35. Cracking at Friant Dam due to Alkali-Aggregate Reaction, Friant Dam, California.

It should be noted that during this period of time the effects of alkali-aggregate reaction (AAR) came to the forefront. A chemical reaction between the alkali in the cement and certain types of aggregates causes expansion of the concrete usually leading to cracking, and in cold climates the damage can be exacerbated by freeze-thaw mechanisms as water enters the cracks. Extensive cracking and deterioration at Parker Dam in Arizona, and American Falls Dam in Idaho led the Bureau of Reclamation to conduct studies into the phenomena beginning about 1941. Petrographic examination of aggregates became the primary means of identifying potentially reactive aggregates in about 1941. The limitation of alkalis in the cement to less than 0.6 percent as a means to control AAR was first published in the Fourth Edition of the *Concrete Manual* by the Bureau of Reclamation in October 1942. Investigations into the effects of pozzolans to reduce alkali- aggregate reaction were begun in the early 1940s. Using 20 percent Class F or N pozzolans as a replacement for cement became standard practice for the Bureau of Reclamation in about 1970. This not only reduces the cost of the cementitious material, but also provides additional protection.

1.36. Freeze-thaw damage on downstream face of Deadwood Dam, Idaho. (Note that damage is near contraction joint due to leakage.)

By this time, deterioration of some concretes in cold climates had been noted, and was described in general terms as durability. The problem was freeze-thaw damage, whereby water present in the saturated cement expands upon freezing, exerting pressures that far exceed the tensile capacity of the paste, causing cracking and ultimately failure of the concrete after repeated cycles. It was found that high strength concrete made with good quality aggregates and low water to cement ratios generally had better durability. However, experience accumulated during the 1920s and 1930s suggested that other factors also contributed to whether a concrete was susceptible to freeze-thaw damage. The Bureau of Reclamation began testing concrete for freeze-thaw durability in about 1937 with the development of accelerated freezing-thawing test apparatus. The first studies of standard concrete mixes of the time indicated that failure usually occurred after about 150 to 200 cycles. Formal studies of the effects of an air-entraining admixture performed in 1942 reported an increase in the number of cycles to 400 to 450. However, the Fourth Edition of Reclamation's *Concrete Manual* provided no reference to air entrained concrete. Due to World War II, this information was not published until 1949 in the Fifth Edition of the *Concrete Manual*. Air-entrained concrete as a means to increase concrete durability has been standard practice since.

VIII. The Post-War Boom—Developments Continue

Following World War II, the country entered into a boom period. The demand for power was high, and the developments that occurred with the building of large concrete dams and associated power plants such as Hoover and Grand Coulee were put to use in quickly building several more monumental concrete dams and power plants, such as Glen Canyon (a 710-foot high thick arch dam on the Colorado River), Yellowtail (a 525-foot high arch dam on the Bighorn River in Montana), and Flaming Gorge Dam (a 502-foot high arch dam on the Green River in Utah). The first of these large post-war concrete dams was Hungry Horse.

1.37. Hungry Horse Dam, Montana.

Hungry Horse Dam, constructed in 1948-1953, is a concrete arch structure that has a structural height of 564 feet and a crest length of 2,115 feet at crest elevation 3565.0. The dam is located on the South Fork of the Flathead River in northwestern Montana, south of the southern border of Glacier National Park. The dam impounds a reservoir containing 3,467,000 acre feet of storage at elevation 3560.0. The reservoir provides the benefits of power generation, flood control, irrigation, river regulation for fisheries, and recreation.

Hungry Horse Dam was designed and analyzed by Trial Load Methods. (Though not used for Hungry Horse, physical model studies were still in use, and were performed later for Glen Canyon and Morrow Point Dams.) The analyses include the stage construction of varying reservoir elevations and grout zones. Concrete was cooled by embedded cooling pipes to 38°F. Original designs called for the vertical radial contraction joints to be 50 feet apart, but based on temperature studies, an 80-foot spacing was used. One cross canyon contraction joint was used across blocks 10 to 23 at alternating distances of 134 feet and 186 feet from the axis. The vertical contraction joints have shear keys. Formed drains were constructed at each contraction joint and at 10 feet on centers across the dam. Collected drainage flows by gravity into a sump consisting of two pumps each discharging 500 gallons per minute.

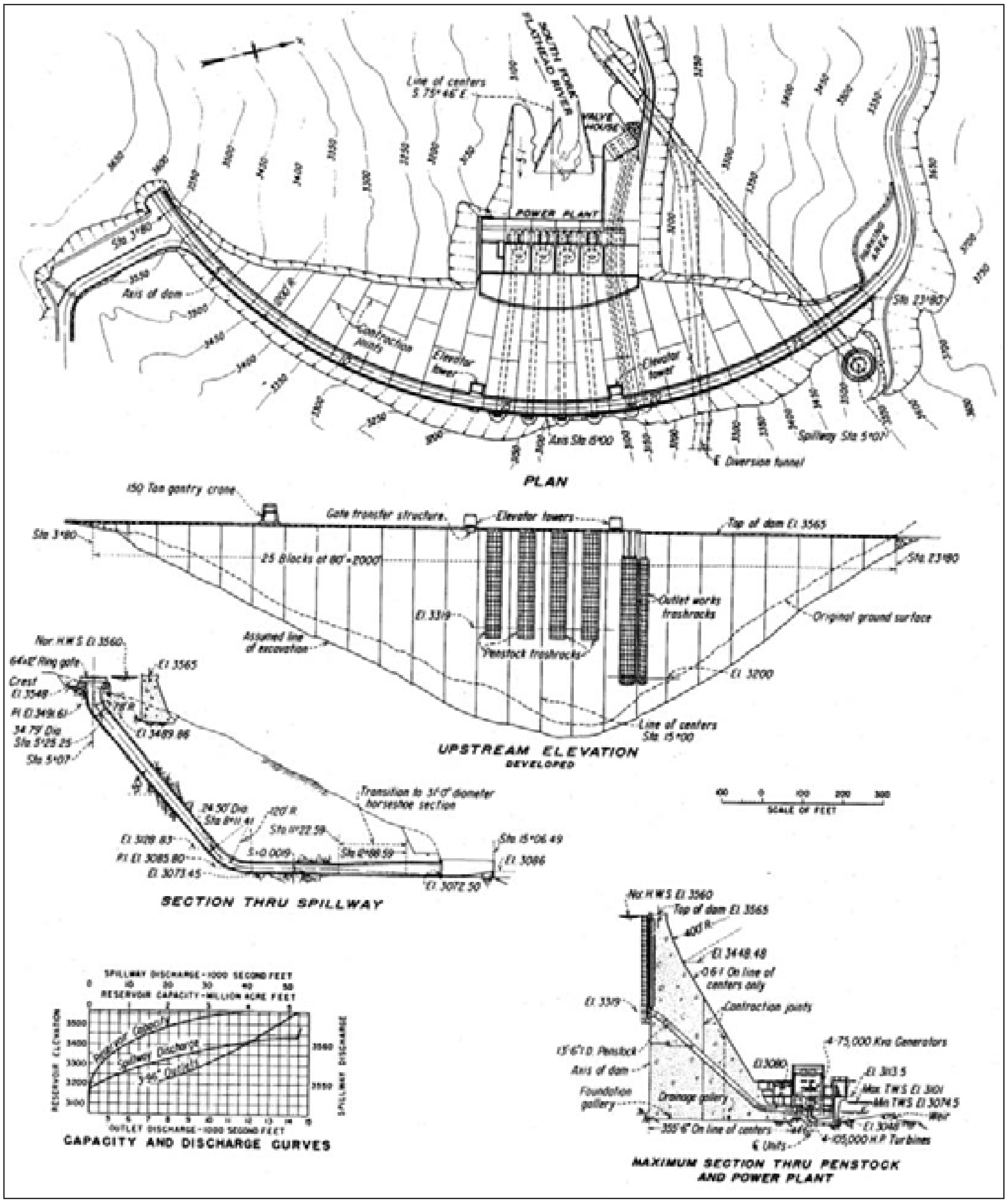
The dam consists of 27 blocks numbered from 2 on the left abutment to 28 on the right abutment. Lifts were 5 feet in height. There were different concrete mixes for the interior and exterior (5 foot minimum to 9 foot average exterior concrete thickness on the faces and crest roadway) of the dam consisting of cement, fly ash, and 6-inch maximum sized aggregate. Flyash used as pozzolan helped reduce the heat of hydration while providing long term strength gain.

Another major development of the post-war era was the use of air-entraining admixtures to increase the durability of concrete to freeze-thaw damage. Problems with air entrainment persisted throughout construction of Hungry Horse Dam, but were perfected at later structures. Early stripping of forms was a major cause of surface damage.

Extensive instrumentation systems had become standard by this time. The dam has seven lines of uplift measurements at the dam to foundation contact, three plumb lines, and flow measurements from drain holes in the right abutment. Deflections are measured with three plumb lines located in blocks 8, 17 (crown), and 24. The dam has permanently shifted upstream about 0.3 inches since 1962. The dam moves a total less than 0.4 inches season to season.

The dam was constructed close to current day standards with vertical contraction joints, formed drains at 10-foot centers in the concrete, foundation drains at 10-foot centers in the foundation, foundation grouting, artificial cooling of the mass to 38°F and contraction joint grouting, cleaning of the lift lines and dam to foundation contact for bond, and concrete strengths (tested during construction) averaging over 4000 lb/in^2. There is radial cracking on the crest in blocks 4 and 24 progressing 30 feet down on the downstream face and into the roadway gallery. Radial cracking on the crest is probably thermal induced cracking because the contraction joints are 80 feet apart and not the typical 50 feet.

The spillway at Hungry Horse Dam is a concrete-lined tunnel with a morning-glory intake on the right abutment designed for a maximum discharge capacity of 53,000 ft^3/s for a reservoir elevation at the crest of the dam (elevation 3565.0). The normal high water surface is 5 feet lower than this maximum with the ring gate in the raised position. The spillway was designed using two laboratory models and approximately 200 tests. Subatmospheric pressures were reduced to very low levels by shaping the crest profile, developing an efficient venting system, increasing the lower bend radius from 55 to 120 feet, and providing a guide vane for the upper bend together with a pier on the spillway crest. The only difference in the actual spillway was the elimination of the vane and pier because of difficulty in construction. The venting system vents the



1.38. Plans and Sections of Hungry Horse Dam and spillway, Montana.

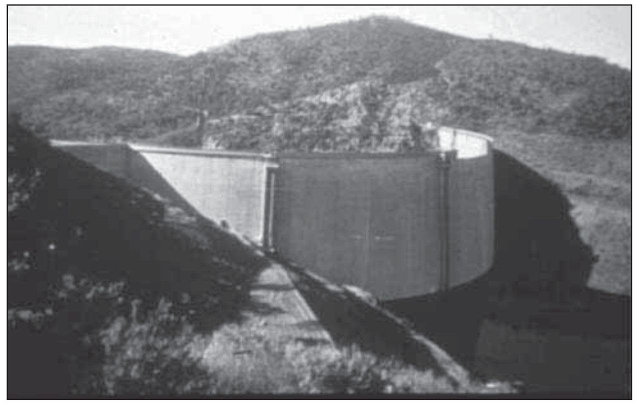
undernappe from the crest structure with nine 8-inch pipes at 30 degree centers around the crest and vents the crown of the spillway tunnel in the upper bend at elevation 3514.0 with an additional inlet. Air is supplied by a 6-foot square air inlet tunnel in the right abutment. With 53,000 ft^3/sec discharge, velocities of the water at the outlet portal are computed to be between 132 and 146 ft/sec. The spillway crest is controlled by a 64-foot diameter buoyant ring gate having a maximum lift of 12 feet from elevation 3548.0 to 3560.0. A deicing system using compressed air bubblers prevents ice forming on the gate. Spillway discharge varies from free-flow discharge at low heads to orifice-flow discharge at higher heads.

Several precautions were taken during construction of the spillway to assure accurate alignment and smooth concrete surfaces. Even construction joints were eliminated in the vertical curve and deflector sections to avoid offsets at the joints. A 50 degree inclined shaft was chosen over a vertical shaft for economic reasons and ease of excavation, to cross bedding planes at right angles and confine overbreaks to the upper right-hand quadrant of the shaft because of one of the joint systems. After placement of the tunnel lining, the surrounding rock was thoroughly grouted using pressures varying between 125 lb/in^2 and 150 lb/in^2. Irregularities in the lining were eliminated by grinding, sandblasting, hand-stoning with a fine-grit Carborundum™ stone, and then final grinding after 7 days of cure. The vertical bend and deflector sections were placed without construction joints and cooled with river water pumped through cooling coils. Rather extensive repairs of the concrete surfaces in the spillway tunnel were required because of retractions and bulges in the wood forms. Concrete was placed in above-freezing temperatures and curing was by hand sprinkling.

The foundation at Hungry Horse Dam is the Siyeh limestone formation with beds ranging in thickness from a few inches to several feet. The average strike of these beds is N38W and an average dip of 30NE which is upstream and into the right abutment. Several faults were present in the foundation which required excavation and backfill concrete treatment. Foundation grouting and drainage were typical for the time. However, an unusual foundation treatment was used for the first time. A clay seam along bedding was discovered in blocks 11, 12, and 13. It was decided to wash out the clay with water and air at less than 30 lb/in2 pressure and backfill with grout rather than to remove the 7,100 cy of rock above the seam. At some point, pressures of 250 lb/in2 were used. The seam was excavated above fault 3. The treatment was verified to be effective by extracting core and inspections down calyx sized holes.

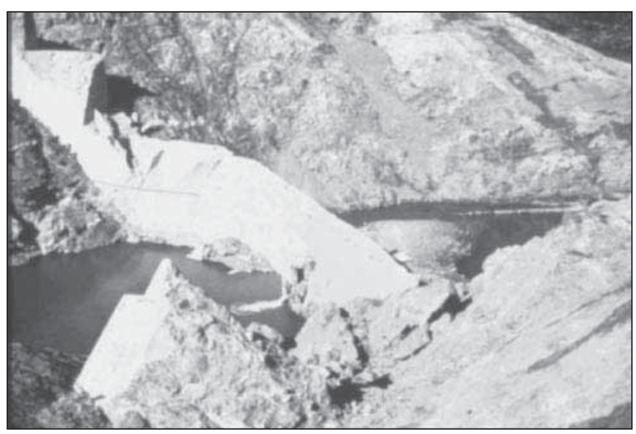
IX. The Failure of Malpasset Dam—Rock Mechanics and Foundation Design Develops

Although several concrete dams failed due to foundation deficiencies during the early years of concrete dam construction in the United States, it wasn't until the failure of Malpasset Dam in 1954 that the profession recognized a need for more rigorous foundation investigations and analytical design methods. Malpasset dam was a 216-foot high thin arch dam completed on the Reyran River upstream of Frejus in the Cannes District of France. The reservoir had a capacity of 41,700 acre feet. Although the foundation contact was blanket grouted with 16-foot deep holes, a grout curtain was considered unnecessary due to the low permeability of the rock. No drainage had been provided in the dam or foundation, and no instrumentation, other than surface measurement points, was installed. The foundation consisted of metamorphic schists. Heavy rainfall occurred during the fall of 1954 shortly after completion of the dam, and by mid-November the reservoir was within 17 feet of the normal maximum level. At that time operators discovered a trickle of clear water about 60 feet downstream of the dam on the right abutment. Cracks had been seen in the concrete apron at the toe of the dam, but no one knew when they first appeared. Another intense rainstorm began on November 28, and by December 2, the reservoir was full and the outlet was opened. At 8:45 p.m., the caretaker left the dam without observing anything unusual. At 9:10 p.m. the dam failed suddenly, causing total destruction along a 7-mile course to the Mediterranean Sea.



1.39. Malpasset Dam, Cannes District, France.

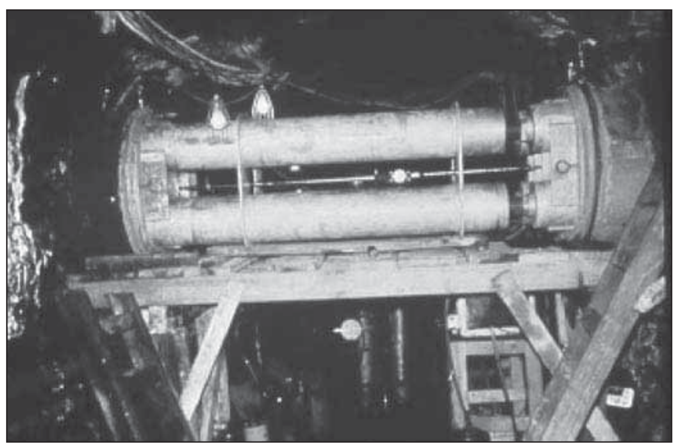
Analysis of the displacements of the dam remains showed that the left side of the dam and underlying foundation lifted and rotated as a monolithic unit about a vertical axis located where the crest met the right abutment. Conventional structural analyses using a wide range of material properties showed concrete stresses were well within strength parameters, and did not explain the failure. Arch buckling analyses also indicated an ample margin of safety. The failure left an upstream dipping fault zone and downstream dipping foliation plane exposed on the left abutment, intersecting below where the dam once stood. The measured movements and post-failure evidence pointed to abutment sliding on the fault as the cause of failure. Dr. Pierre Londe developed three-dimensional



1.40. Malpasset Dam failure, Cannes District, France.

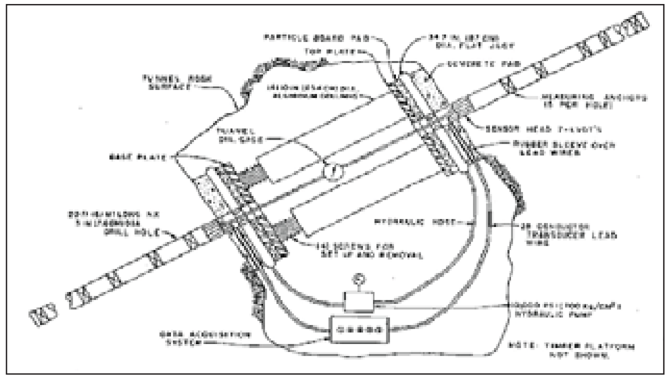
limit equilibrium analysis techniques to evaluate the stability of a dihedral wedge formed by the fault, the shear, and a third joint release plane. The stability of the wedge was evaluated under loads consisting of dead weight, water uplift forces on each plane, and the thrust from the dam. Instability was explained by this analysis when large uplift forces were assumed to develop on the foliation shear.

Thus, the science of rock mechanics was applied to concrete dam foundations. Shortly after this, in the late 1950s and early 1960s during the design of Yellowtail, Glen Canyon, and Morrow Point Dams, the Bureau of Reclamation began further developing rock mechanics methods in application to concrete dam foundation design and analysis. Large scale in-situ tests were developed for determining rock mass deformability properties. Exploratory drilling and geophysical testing were performed to evaluate foundation conditions, and careful attention was paid to major discontinuities within the rock. However, it was not until the designs for Auburn Dam were underway in the late 1960s that the foundation exploration, analysis, and design were coherently integrated. Under the direction of Louis R. Frei, James S. Legas, and J. Lawrence Von Thun, world class foundation investigations, testing, evaluation, design, and treatment occured at the Auburn Damsite. Although Auburn Dam was never completed, this work was an enormous contribution to the profession, and formed the basis for future evaluations within the Bureau of Reclamation.



1.41. Photo of Uniaxial Jacking Test performed at the Auburn Damsite, California, to measure deformation properties of foundation rock mass.

The Auburn Damsite consists of complex metamorphic geology. The basic rock type is a dense amphibolite, but numerous faults and talc zones cut the rock, and metasediments occurred within the foundation. Careful diamond core drilling using split inner tube core barrels, trenching, and excavation of exploratory tunnels and drifts was performed to define the geologic conditions. The results of this exploration were portrayed on geologic plan, section, and structural contour maps to provide a complete three-dimensional picture of the foundation. Weathering profiles and fracture density characterization were used to define the foundation excavation to suitable rock. It was recognized that the rock deformation properties were key in determining how load was distributed to the foundation from the dam, and that jointing and discontinuities within the rock had a pronounced effect on these deformation properties. In-situ deformation testing was performed in the exploratory tunnels and drifts. Despite the large size of the tests, it was recognized that they still represented a small point in the foundation rock. Methods were therefore developed to extrapolate these results to the rest of the foundation. From this, the deformation properties of the foundation were defined for input to finite element and Trial Load structural analyses of the concrete arch dam.



1.42. Schematic of Uniaxial Jacking Test performed at the Auburn Damsite, California, to measure deformation properties of foundation rock mass.

Seepage analyses were performed to evaluate potential foundation uplift pressures. Exit gradients at fault and talc zones near the toe of the dam were analyzed, and testing was developed to determine critical exit gradients where piping of these zones would initiate. Potential modes of instability were identified by evaluating discontinuities (faults, shears, joints, foliation planes, talc zones) within the foundation. "Failure mode assessment" as it is sometimes called, was developed fully in the rock mechanics arena, and has been a valuable contribution to other areas of engineering. Foundation blocks formed by discontinuities that intersected beneath the dam, with the intersection or one of the planes daylighting downstream, were analyzed using limit equilibrium techniques. The shear strength of the critical potential sliding planes was evaluated by laboratory and in situ testing of samples from the appropriate faults, talc zones, and joints. Arch thrust from gravity, reservoir, and temperature loads; dead load of the foundation blocks; uplift on the planes that formed the blocks; and earthquake loading were all considered in the evaluations. Finally, foundation treatment, in the form of excavation of the weak zones and replacement with mass concrete, was designed based on the results of all the studies. In some cases the treatment was controlled by the need to develop a smooth deformation pattern or transfer of load across discontinuities. In others, the treatment was controlled by the extra shear strength needed for stability, or by the need to reduce exit gradients.

Although improvements to the analysis methods have been made over the years including better methods for evaluating seismic stability, the basic evaluation process remains essentially the same as that developed at the Auburn Damsite. Many concrete dam foundations have been evaluated using these procedures. Detailed foundation rock mechanics analyses are now an important aspect of the standard practice for evaluating concrete dams.

X. The Double-Curvature Arch—A New Standard for Efficiency

Beginning in about the early 1960s a new concept for shaping arch dams found its way to the Bureau of Reclamation. This shape, termed "double-curvature" provided for more efficient distribution of loads within the structure and to the abutments. A double-curvature arch is curved in plan view and section view. This results in more of a "bowl" shape to the structure. The undercutting at the heel of the dam that results from this shape, and the inward curvature on the downstream face, eliminate areas where tensions typically develop in arch dams.

The first double-curvature dam constructed by the Bureau of Reclamation is Morrow Point Dam. The dam has a structural height of 468 feet and a crest length of 724 feet. The dam is a variable-center arch structure with an axis radius of 375 feet. The crest of the dam at elevation 7165 carries a 12-foot-wide roadway. Storage in the Morrow Point Reservoir is 117,190 acre feet at the top of active conservation.

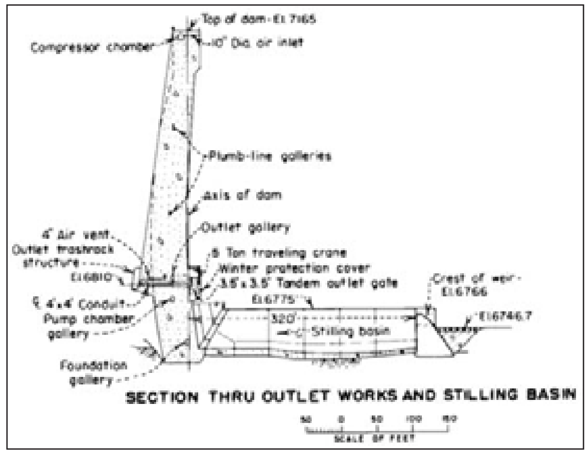
1.43. Morrow Point Dam, Gunnison River, Colorado.

In addition to being Reclamation's first double-curvature arch dam, the project also boasts Reclamation's first (and only) underground power plant. The power plant chamber is tunneled into the canyon wall in the left abutment about 400 feet below the ground surface. Two 13.5-foot-diameter steel penstocks carry flow to the power plant, which contains two 86,667-kilowatt generators driven by two 83,000-horsepower turbines.

Because Morrow Point Dam was the first double-curvature thin arch dam built by Reclamation, the geologic exploration program was one of the most extensive programs ever carried out. The geologic data was developed through a comprehensive investigation which included detailed geologic mapping, diamond core drilling, excavation of five exploratory tunnels, examination of drill holes by television, and seismic surveys. Geologic studies were also coordinated with horizontal and vertical in-situ jacking tests and with Whittemore and borehole strain gage measurements. However, failure mode assessment and foundation stability analyses were not part of the original foundation studies.

Morrow Point Dam is located in a narrow section of the Black Canyon of the Gunnison River with very steep canyon walls and many overhangs. The rock encountered at the damsite consists of alternating lenticular and irregular beds of biotite schist, mica schist, micaceous quartzite, and quartzite, all of which were intruded by granite pegmatite ranging from small veinlets to massive intrusions. The quality of rock type varies considerably, the hardest being the granite pegmatite and the quartzite with variations of hardness down to the weaker biotite schist.

The damsite is located on the axis of a synclinal fold which plunges gently to the south (or into the left canyon wall) at about 5 degrees. The fold is expressed by the attitude of foliation or bedding which dips toward the axis from both upstream and downstream. The rock contains stress relief jointing which generally parallels the canyon walls and dips steeply toward the river, probably resulting from unloading through the removal of overlying rock by river erosion. Another indication of stress relief is an apparent halo of fractured rock which extends to a depth of about 80 feet beneath the valley floor.



1.44. Section thru outlet works and stilling basin, Morrow Point Dam, Colorado.

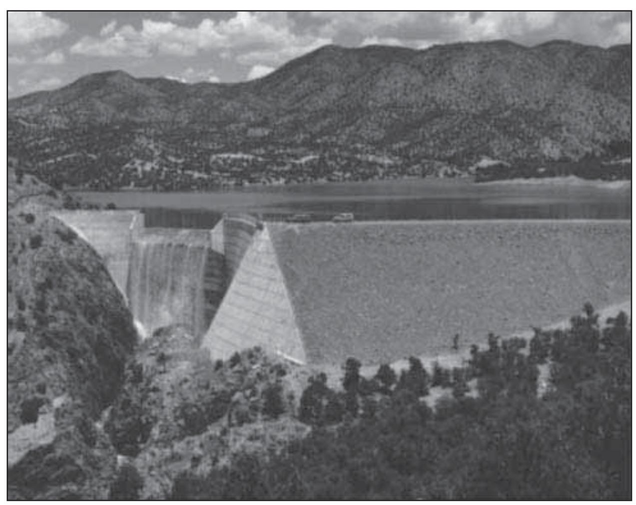
The analyses were very thorough since the design and layout requirements went beyond the state-of-the-art of that time. The dam was mathematically modeled and analyzed using the Trial Load Method of Analysis when subjected to static load and was further analyzed using the computerized adaptation of the Trial Load Method (ADSAS—Arch Dam Stress Analysis System) to refine the design and layout for nine different loading conditions, including seismic loads, construction loads, various temperature and grouting conditions, and the as-excavated foundation layout. In addition, the dam was analyzed by the use of physical models as a check to the mathematical modeling process. One model of the dam and foundation was prepared by Reclamation and the other was made by the *Laboratorio Nacional de Enenharia Civil* of Portugal. All the analyses indicated the dam could safely withstand any of the loading conditions applied.

The contract for construction of Morrow Point Dam and Powerplant was awarded to a joint venture of the Al Johnson Construction Company and Morrison-Knudsen Company on May 14, 1963, with construction completed on May 24, 1968. In general, the dam and power plant were constructed in accordance with the designs and specifications with only a few complications arising requiring changes in the planned construction.

Open stress relief jointing, especially in the left abutment, caused several small rockslides in the excavation for the access road and the upper left keyway. To keep the excavated surfaces stable and at grade, the contractor had to use controlled blasting techniques and the installation of many rockbolts. Asphaltic grouting was later performed to control seepage along relief joints. This adverse jointing and the presence of shears within the excavation for the underground power plant caused movement of large blocks of rock within the power plant walls. This prompted the contractor to install additional access/drainage tunnels and extensive systems of rockbolts, post-tensioned cables, and flat-jacks to support the rock mass and prevent further movement.

At the beginning of concrete placements in 1966, two longitudinal cracks were found in the top of blocks 9 and 11 at elevation 6777.5. Both cracks were in the center of the block, extended completely across the block, and had a maximum width of 0.03 inches. A mat of No. 11 reinforcement bars was placed over these cracks and concrete placements continued with no additional problems identified in this area.

In May of 1966 the center formed drain in block 10 was found to be plugged at elevation 6815 and had filled with sand and debris to about elevation 6897. The contractor requested permission to use high pressure water to loosen and remove the plug. Reclamation granted permission as long as the pressure in the formed drain did not exceed 100 lb/in^2. On May 5, 1967, the contractor applied the water pressure to the hole, but used pressures of almost 300 lb/in^2 and cracked the concrete in block 10 shortly after placements in this block reached elevation 7100. The crack formed in block 10 extended completely across the block and extended a short distance into block 9. The repair work included the following: all concrete was removed upstream of the crack, 24 rockbolts were installed within the dam below the crack to prevent downward propagation, 56 No. 11 dowel bars were installed to anchor the replacement concrete to the undamaged concrete, concrete was replaced using an epoxy bonding agent, and a mat of No. 11 bars was placed over the repair area to prevent any upward propagation of the crack. No problems have been identified at this area since the repairs were completed.



1.45. Nambé Falls Dam, New Mexico.

Several other double-curvature arch dams were successfully designed and constructed by the Bureau of Reclamation in the late 1960's and 1970's. One that bears mention is Nambé Falls Dam, a 150 foot high dam on Rio Nambé in New Mexico. The arch is part of a composite structure with a massive concrete thrust block on the left abutment that ties into an embankment dam. The dam is quite thin, and temperature loadings were difficult to design for. Therefore, a series of flat jacks were installed in the crown cantilever, and the flat jacks were pressurized to prestress the dam into a state of compression that could handle all loading conditions adequately. Another item of interest is the development of elliptical arches by the use of “three-centered” geometry. The elliptical arches are approximated by a central section with a smaller radius, flanked by abutment sections with larger radii. This allows double-curvature arch dams to be designed for wider canyons. Although none of these were built by Reclamation, the method was developed and several designs were completed.

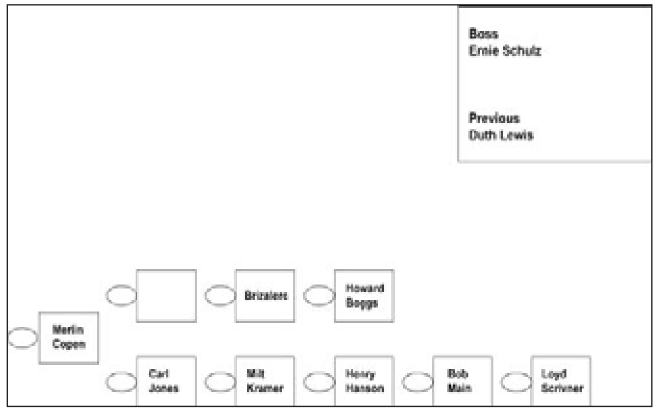
XI. Structural Analysis Developments

A. Development and Computerization of the Trial Load Method

The Trial Load Method of stress analysis assumes that the load applied to an arch dam would be divided between horizontal (arch) and vertical (cantilever) elements in such a way as to produce equal movements in all directions at points of intersection of these horizontal and vertical elements. Each arch and cantilever element is assumed to move independently of all others, but at the conclusion of the analysis, geometrical continuity exists at the intersections. Only a few representative arch and cantilever elements (5 to 10 each) need be analyzed. The basic concept is that the internal loads equal the external loads at any intersection point. The internal loads are divided between the arch and cantilever elements until the deflections match. Thus the name, Trial Load Method of analysis. Then tangential and twist loads are applied in equal and opposite directions, one on the arch and one on the cantilever. This way the arch and cantilever deflections are brought into tangential and rotational agreement without changing the external load on the structure. These internal loads set up the three-dimensional interaction between two-dimensional arch and cantilever elements. To facilitate the process of dividing the internal loads between arches and cantilevers, certain patterns of loads called unit loads were developed. In applying the unit loads, it was advantageous to compute the movements of arches and cantilevers from unit loads before attempting to divide the external load between the arches and cantilevers. The total load resisted by the arches and cantilevers are determined by the Trial Load adjustments. With these loads, stresses are then computed.

There are basically three levels of Trial Load analysis depending on the desired accuracy and time duration for computations. 1) The crown cantilever analysis consisted of adjusting deflections of arch elements and the crown cantilever (the maximum vertical section in the center of the dam). The results were crude and neglected the effects of tangential shear and twist, but the computation time was relatively short and with judgement was an effective tool for preliminary designs. 2) The radial deflection analysis added two more cantilevers so radial deflection agreement was obtained at the crown and quarter points of the dam. The distribution of load along the arch was more accurate but the tangential shear and twist were still neglected, so the accuracy was only slightly better. The time for a radial deflection analysis was only slightly longer than the crown adjustment. 3) The complete Trial Load analysis produced agreement of all three linear and all three angular displacements by properly dividing the radial, tangential, and twist loads between the arches and cantilevers.

The accuracy was only limited by the number of arches and cantilevers used, the exactness of the basic assumptions (stress distribution), and the magnitude of error permitted in the slope (angular) and deflection adjustments. The results from a complete analysis were confirmed by the Hoover Dam model studies. The major limitation was the time required to perform an analysis.



1.46. Seating arrangement in the Analysis Section.

In the 1960's before the application of computers to structural analysis, computations for the Trial Load analysis were done by a group of six to eight engineers operating mechanical "adding" machines and filling in values on large tables. One analysis would take a pair of engineers from six to eight weeks depending on the skill of the designer. As such, not many load combinations were analyzed. New rotation engineers performed these tedious computations. They would work in pairs so one could check the other's computations as they were performed. The seating arrangement in the Section was like a Viking ship with the row master behind the rowers. They worked with an experienced design engineer. It would take about 5 years to transition from a human calculator to a beginning designer. Arch dam designers would layout a preliminary shape for an arch dam. The loading conditions to analyze were decided upon and younger engineers would start the Trial Load computations. When the computations were complete, the results were returned to the designer and displacements were plotted. Adjustments to the loads between the cantilever and arches were determined, and the process repeated. Some designers, such as Howard Boggs, Milt Kramer, and Carl Jones, had a tremendous feel for how an arch dam reacted to loads and were very skillful in making adjustments. This took many years to develop. Howard Boggs wrote *Engineering Monograph No. 36* explaining the beginning steps to lay out an arch dam. However, this produced only a beginning shape. The real skill then came in trying to adjust the shape and produce the most optimum design. Layouts were done on a topography map with a large beam compass, french curve, and graph paper. Mechanical calculators ran eight hours a day, five days a week, for weeks. There were replacement calculators on hand and Eddie Carlson was a full-time repair person from the Marchant company. The mechanical machines had 100 keys (10 rows of 10 keys) and the decimal point was set with a key.

With the application of computers to civil engineering problems in the 1960s, some engineers saw the potential of having the computer do the tedious manual calculations while other engineers viewed the computer as a threat to their jobs. Merlin Copen wrote:

> The major limitation to the use of the complete trial-load analysis is the time required to perform such studies, and the high degree of technical training necessary to efficiently conduct such an analysis. The time element has been effectively reduced by use of the electronic computer, and will be further diminished as the analysis is completely programmed. The number of highly-trained engineers required will also be greatly reduced.

In 1957, Loyd Scrivner was the first engineer to write a computer program to compute geometric values. Reclamation initially rented time on an IBM 650 located in downtown Denver and eventually obtained one for themselves. Scrivner's initial programs were not written to be reused for other dams but had hard coded values inserted so a new program had to be written for each dam. Bob Main started with Reclamation in the summer of 1958 in the newly created Data Processing Section. Darrell Webber, who later became the Assistant Commissioner of the Engineering and Research Center, was a rotation engineer in that unit at the time. Because Bob could program on the IBM 650, he was hired into the analysis section. Bob wrote the general purpose geometry program for the lines of centers, introduced the idea of inputting values so the same program could be used for other dams, and introduced the concept of subroutines.

Loyd Scrivner wrote:

> In 1957, the Analysis Unit of the Concrete Dams Section (USBR) began the development of a series of electronic computer programs to reduce the time and cost required to complete a trial-load study. Programs have been developed utilizing the IBM 650 digital electronic data processing machine (system)…
>
> Most of the programming was done using a modified form of an interpretive routine (Bell Interpretive Language) which was developed to handle floating decimal arithmetic including the computation of the elementary transcendental functions. The electronic computer, to date, has been used primarily for the computation of forces and deflections in arch elements due to unit arch loads. This approach has been followed because of the following:
>
> 1. About 70 percent of the man-hours, and therefore the cost of performing a trial-load study, is expended making these computations.
> 2. These computations are repetitive in nature, which is a factor favoring advantageous use of electronic computers.
>
> Although we are not committed to any particular solution for the deflection adjustments, serious consideration will be given to an iteration process as opposed to a procedure based on the solution of a large group of simultaneous equations.

Merlin Copen wrote:

> The initial layout for an arch dam is based largely on the experience and judgement of the designer.… As soon as a layout for a particular site has been completed, it is checked by means of a crown cantilever analysis to obtain an estimate of the stresses in the proposed dam. Currently the deflections of the arches and cantilevers produced by unit loads are computed by electronic digital computer. The time required, in a normal situation, to determine stresses with a crown adjustment, is approximately three days for two men. Several layouts may be necessary before a satisfactory stress condition is obtained. Then a radial deflection adjustment is made. This provides a more complete stress picture and might indicate the possibility of necessary or desirable changes. The radial deflection analysis requires approximately two days more than the crown cantilever analysis, or a total of approximately five days for two men.
>
> In practice, after a design has been analyzed and found to be acceptable with a radial deflection analysis, the effects of tangential shear and twist are estimated, based on the experience of the designer.… Now the final test of the efficiency of the dam is made. While the detailed design work proceeds, a complete trial-load analysis is made of the structure. This will require approximately 100 to 150 man-days, depending on the size and complexity of the dam and the accuracy required from the analysis. It is anticipated that in the near future, further application of electronic computer processes will result in considerable reduction in the layout, such changes are made and incorporated in the detailed design procedures.

There was plenty of arch dam work in the 1960s. Merlin Copen, George Wallace, and George Rouse went on a 10-week tour to Europe to see how they designed arch dams. As stated in their report:

> In recent years European engineers have made many important contributions to the design and construction of concrete dams. Through experimentation and studies European engineers have devised new techniques and have extended or improved existing practices.… The team traveled in six countries and visited 15 organizations.… Forty-three dams in various stages of completion were inspected together with 25 power stations. Thirteen laboratories were visited as well as six manufacturing plants and more than 100 engineers were interviewed.

It was this trip that led to the development of double-curvature design methods at Reclamation. Yellowtail and Flaming Gorge were being designed and Morrow Point was on the horizon. Additional design staff probably would have been hired for this work. Additional design groups would probably have been created and promotion to heads of these groups would have been made. However, as Merlin Copen predicted, the large staffs were not required for this workload because of the advent of the efficient computer methods. Interviews for this paper revealed there may have been bitter feelings about lost advancements and lost promotion potential because of the computer. However, the computer did reduce the tedious part of structural analysis for arch dams. Some engineers that left the analysis section because of the tedious, boring, and repetitive computation work actually came back to the unit because of the joy and prestige of designing and working with arch dams.

There were disagreements on the best way to determine the response and design of arch dams. In 1960, Merlin Copen wrote:

> Since the end of World War II, interest in the design and construction of dams has received considerable impetus. This interest has resulted in novel approaches to problems of design. Currently the methods used appear to fall in one or more categories: (1) analysis of small scale models; (2) thin cylinder theory; (3) relaxation methods; (4) shell theory; and (5) trial-load analysis. Each of these has advantages and disadvantages. The choice of methods generally resolves into accuracy and reliability desired as opposed to time, finances, and experience available for design procedures.
>
> After exhaustive study of the various possibilities, the United States Bureau of Reclamation, Dept. of Interior (USBR) adopted the Trial Load Method of analysis for designing and analyzing arch dams. Whereas there have been notable advances in the use of other methods, the USBR has still found the use of trial-load to be completely satisfactory and unexcelled in this field. Recent developments in the use of electronic digital computers, and the effective application of simplified analyses have made this method even more effective.

The steps to develop a computerized Trial Load Method were to first program the geometry, then the arch computations, next the cantilevers, and then combine this into a crown adjustment (several arches and one cantilever). The computer being used could only handle forty-two equations. The final step was a complete analysis. This was a very challenging task with limited computer capabilities. After the IBM 650, Reclamation obtained time on a Honeywell machine in Minneapolis. Cards would be sent in on Friday and results would be back on Wednesday. Reclamation obtained their own Honeywell 800. The programming language was Automath, Honeywell's version of Fortran. Harry Beck, Assistant Division Chief of the Data Processing Group, taught the new rotation engineers this version of Fortran. The dams section hired Dale Morsette as a GS-12 because he had a Masters Degree. This caused some bad feelings in the Section because most individuals were GS-11's and the requirement to be a GS-12 was the ability to do a complete analysis unassisted. Dale worked on the initial phases of computerizing a complete analysis from 1963 to 1967. This was a very frustrating task for Dale. In 1967 H. Walter Anderson realized the Honeywell did not have the capability needed for arch dam analyses, so he arranged time on a Control Data Corporation (CDC) 1601 at the Environmental Science Services Administration (ESSA), currently the National Bureau of

Standards, in Boulder, Colorado. Reclamation had a daily shuttle that would take cards up to Boulder at 3:00 and return the next day at 10:00. Reclamation started moving into Building 67 on April 13. Dale left in early 1967, so Glenn Tarbox was assigned the programming task since he knew how to do a complete analysis. Bob Main, a computer programmer, started assisting in June of 1967, and a working version was accomplished in September 1967. The programming was divided into 4 phases: 1) data reorganization, 2) equations, 3) solution, and 4) stresses.

These computer programming efforts and advancements for the Trial Load Method evolved into what is called today the Arch Dam Stress Analysis System (ADSAS). ADSAS was a computerized version of a flexibility method of analysis referred to as "trial load." However, equations were developed and written to compute deflections at any location along the cantilevers and arches. The equations for deflections could be solved directly without using trial-loads. This essentially is a precursor to the finite element method. The computers still did not have enough storage space to hold all the matrices at one time. So ADSAS used an iteration method to solve the simultaneous equations. The solution technique used in ADSAS is unique and innovative and based on approaches developed for the hand calculations.

ADSAS really advanced the state-of-the-art in arch dam analysis, sped up the design process, and helped justify the engineering mainframe computers. ADSAS changed the way the concrete dam group operated because more load combination and geometrical shapes could be investigated in minutes rather than weeks. Output from ADSAS was still in paper form and was about one inch thick. Designers would quickly thumb through the large volume of paper output, propose changes to the dam geometry, and have the younger engineers run ADSAS and bring back the paper output.

Despite the advances that came with ADSAS, it was still not appropriate for dynamic analysis. In addition, the ADSAS program and users manual were developed for internal use, there was machine-dependent computer code specifically for a Cyber 70-74/28, and the program was in excess of 39,000 cards long with over 240 subroutines. This caused problems for others to convert the program to their computers and use the program.

B. Linear Structural Analysis

In 1974 the Structural Analysis Program (SAPIV) was written by Klaus Bathe and Ed Wilson at the University of California at Berkeley. Glenn Tarbox and Karl Dreher were instrumental in getting SAPIV operational on the CDC mainframe computer at Reclamation, debugging the program, and developing the finite element capability for arch dams. Many sensitivity runs were made comparing the Trial Load Method (ADSAS) with the finite element method (SAPIV) during the design of Auburn Dam. Full dynamic time-history, linear elastic, three dimensional, modal superposition analyses were performed. Auburn Dam was the first "test" case. Since that time, almost every arch dam in Reclamation's inventory has been analyzed using SAPIV for earthquake loading. SAPIV also has the ability to handle static loading including reservoir, temperature, and stage construction, making it a powerful tool for dam analysis. Many engineers in the analysis group wrote pre- and post-processing programs to work with SAPIV, which sped-up and advanced the finite element analysis of arch dams.

Evaluating the results of dynamic finite element analyses required advances in estimating concrete strengths for comparison to the calculated stresses. It was postulated that concrete would be stronger in both tension and compression under the rapid loading associated with earthquake events. Rapid loading laboratory tests were developed which confirmed this is the case. An increase in tensile strength of approximately 50 percent can be expected under dynamic loading.

Reclamation funded the University of California at Berkeley to develop a computer finite element program specifically for arch dams: the Arch Dam Analysis Program (ADAP). The development was supposed to occur over three years, but funding got tight after the first year. As such, only a partial program was developed. Dr. John R. Mays, from the University of Colorado at Denver was hired part-time to debug the program and get it operational. Over the years, the University of California at Berkeley, continued to develop ADAP. The Enhanced Arch Dam Analysis Program (EADAP) contained hydrodynamic interaction and ADAP-88 was a nonlinear version that implemented contraction joints in the form of contact surfaces. This program has not been used much at Reclamation, but has found some use on the outside.

The University of California at Berkeley also developed a series of computer programs specifically for arch dams: Earthquake Analysis of Concrete Dams (EACD). The current version implements hydrodynamic interaction with incompressible or compressible fluid elements and dam to foundation interaction incorporating the damping effects of the foundation. Engineers in Reclamation have developed pre- and post-processing programs to aid in the use of this program. It has been used for the earthquake analysis of several Reclamation concrete dams.

In 1978 Reclamation obtained the first general purpose nonlinear finite element program from Klaus Bathe from the Massachusetts Institute of Technology (MIT): Automatic Dynamic Incremental Nonlinear Analysis (ADINA). The program mainly implemented the material nonlinearity of concrete. Dr. John R. Mays developed a nonlinear joint element within ADINA. Howard Boggs and Dr. Mays were some of the first engineers to analyze an arch dam with nonlinear contraction joints. ADINA was used sparingly for specialty problems at Reclamation until 1996 when Reclamation made the transition to

ABAQUS. In 1984, the structural analysis group purchased a Hewlett-Packard UNIX workstation for pre- and post-processing finite element data using PATRAN. The finite element analyses were still run on the Cyber mainframe computer.

In August 1993 the mainframe Cyber computer was being decommissioned and the structural analysis group made the transition to a larger Hewlett-Packard UNIX workstation (HP-755). In 1997 a HP J2240 was obtained that had 2 CPUs, 2 Gigabytes of internal memory and 90 Gigabytes of hard disk storage. This was more powerful than the early computers at Reclamation just 35 years previous. Structures modeled with 38,000 nodes, 100,000 degrees-of-freedom, contraction joint contact surfaces, and nonlinear concrete material properties are now being analyzed for earthquake loads.

C. Nonlinear Structural Analysis

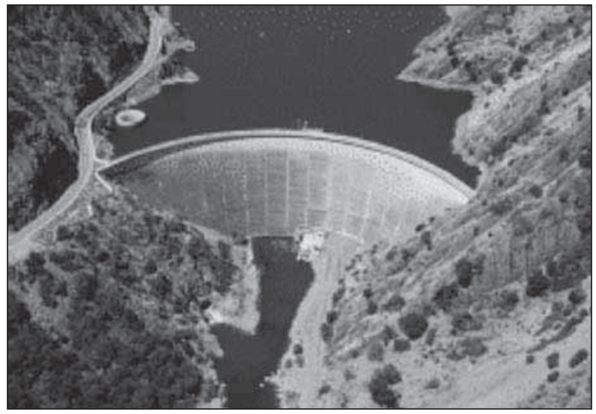
Linear finite element analysis has long been accepted as a way to analyze structures. There are limitations, however, when performing a linear analysis. Stresses calculated in a linear analysis can exceed the allowable strengths of materials. In these cases the actual behavior of the structure after the material strengths were exceeded could be significantly different than that predicted by the linear analysis. Also, response of geometric nonlinearities (contraction joints or compression only members) cannot be modeled using linear analysis. In the past, attempts have been made to model these conditions by modifying the modulus of elasticity in a particular direction and by using a combination of members to simulate the expected behavior of a connection with limited success. Analysis tools have now progressed to the point where good nonlinear capabilities are available. Nonlinear analysis is the next step in addressing these limitations.

Engineers at Reclamation are very familiar with linear finite element analysis. In the past several years, work has been done using non-linear capabilities as well. Two nonlinear analysis methods have been used using ABAQUS finite element code. The first method employs the standard stiffness formulation (F=Kx). The second method solves an explicit formulation with Newton's Second Law, F=Ma. Each method has advantages and disadvantages. The following examples illustrate the use of nonlinear analysis for dynamic and static loading conditions.

C.1. Nonlinear Structural Analysis of Monticello Dam

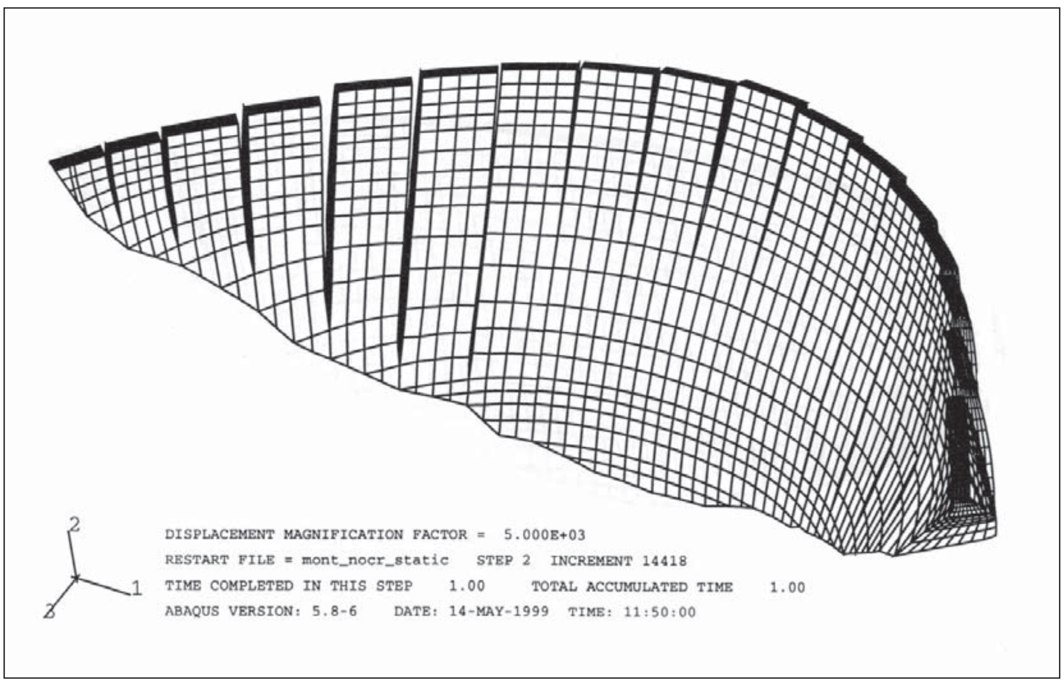
Monticello Dam is a 304-foot-high constant-center concrete arch dam, with fillets at the abutments, located on the Putah Creek, thirty miles west of Sacramento, California. The dam was constructed from 1953 to 1957, has a crest length of 1,023 feet, a crest thickness of 12 feet, and a maximum base thickness of 100 feet. The earthquake response of the structure, incorporating the vertical contraction joints and weak horizontal lift lines, was analyzed non-linearly using the ABAQUS/Explicit computer code.

In this analysis, eight elements through the thickness were chosen to better model the contact surface interactions. The 8-noded linear brick element and the 6-noded linear wedge element were chosen for the 3-D model. The 8-noded element is a reduced integration element. The foundation rock was modeled to a distance of two times the dam height to properly model earthquake energy around the dam itself. It was modeled with the same type of elements that were used to model the dam. For this analysis Rayleigh damping values of α = 3.0 and β = 0.0 were used. This is comparable to the 5 percent of critical viscous damping used traditionally in dam analysis.



1.47. Monticello Dam, California.

As expected, the tensile arch stresses are less with the model that



1.48. Finite element model of Monticello Dam, California. (Foundation mesh not shown.)

incorporates the contraction joints in comparison to a linear elastic analysis. Cantilever compression stresses increase in the center portion of the dam on the downstream face, and tensile cantilever stresses decrease slightly in the bottom center of the dam on the upstream side. The existence of tensile cantilever stresses on the upstream face with the contraction joint model indicates that the cantilevers are taking load. This is because when the winter temperature load is applied, the cantilevers contract and create openings in the joints. The hydrostatic loads tend to close these openings, but can not fully because of resistance offered from the cantilevers in bending (initially no cracking of concrete or horizontal weak lift lines was incorporated in this model to relieve the stress). Thus, a large tensile cantilever stress continues to exist on the upstream side toward the bottom center of the dam. Gravity load was applied first. Although gravity was applied to the entire structure at once, the contact surfaces used to model the vertical contraction joints prevented the structure "hanging" from the abutments as would be the case if gravity was applied without contact surfaces. The gravity load caused the cantilevers to displace upstream, thereby, allowing the weight of each cantilever to act independently. Next the reservoir load was applied. This caused the cantilevers to move downstream and the contraction joints to close. The temperature load was applied as temperature differentials at all the nodes in the dam. Hydrodynamic interaction was incorporated by adding mass to the upstream nodes of the finite element model based on an incompressible fluid element formulation.

Three earthquake records were applied to the contraction joint model. Crest displacements, crest velocities, contraction joint opening and closing, and arch and cantilever stress histories were obtained for each record. Crest displacements at the centerline of the dam reach peak values of about 7 inches. Permanent offsets at joints were less than 1 inch. Maximum crest velocities at the centerline of the dam are on the order of 40 in/sec in the cross canyon direction, 14 in/sec in the vertical direction and 100 in/sec in the upstream/downstream direction. Contraction joints at the centerline of the dam open to a maximum value of about 0.4 inches. Tensile arch stresses reduced significantly in comparison to linear elastic analyses

Large tensile cantilever stresses continue to exist in the dam during static and dynamic loadings with the contraction joint model. These stresses will be relieved by horizontal crack formation in the dam. Since the lift lines of the cantilevers are weak in comparison to the parent concrete (based on laboratory test of drill core), these cracks will occur at the lift line locations. There are two ways to model these lift lines. The first method is to set the cracking stress to a low value in the nonlinear concrete material property statement. This would allow the concrete to crack and relieve any cantilever stress that would exceed the cracking stress value specified. However, it isn't possible to specify that the lift lines are weaker than the parent material within the concrete cracking model. The second method, which was ultimately used, is to insert a series of horizontal contact surfaces, spaced so as to model the effect of the weak lift lines. This approach further lends itself to a kinematic study; i.e., a series of blocks stacked on top of each other held in place by the arch action of the dam. The analyses indicated the dam would be stable even with cracked lift lines. Although 6-inch-deep shear keys exist at each contraction joint of the dam, these keys were not included in the finite element model because of the need to keep the contact surfaces simple in order to obtain a stable solution. The effects of neglecting the keys, and better methods for modeling contraction joints, are the subject of ongoing research.

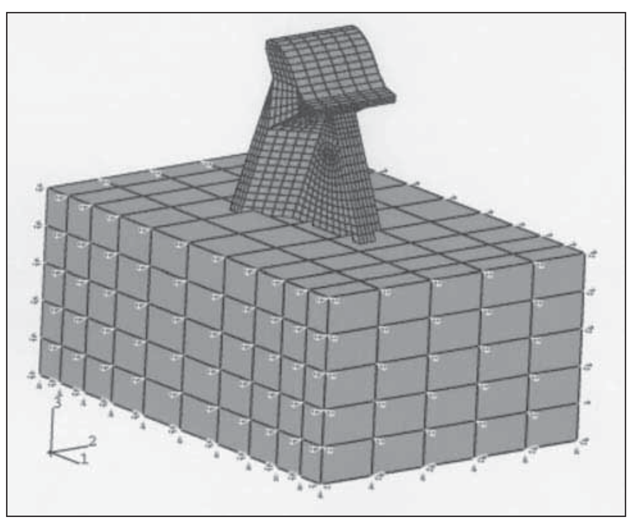
C.2. Nonlinear Structural Analysis of Pueblo Dam

Pueblo Dam is located near Pueblo, Colorado. Pueblo Dam is a composite concrete and earthfill structure approximately 10,230 feet in length. The concrete portion consists of a massive head buttress dam including a 550-foot overflow spillway section located near the central part of the concrete dam. The dam was designed and constructed by Reclamation, and completed in 1975.

1.49. Pueblo Dam, Colorado.

The purpose of this nonlinear study was to reevaluate the sliding stability at potentially disbonded lift lines and the vertical stress level at the dam heel using a three dimensional finite element model incorporating horizontal contact surfaces. Previous linear-elastic finite element analyses completed at Reclamation resulted in acceptable factors of safety against sliding (with some cohesion) but they also indicated that tensions would develop at the dam heel under some static load cases. Since the linear elastic analyses completed previously used a continuous mesh, the potential nonlinear characteristics existing along the dam-foundation contact surface were not captured; therefore, it was necessary to complete a nonlinear finite element analysis incorporating a horizontal contact surface in order to capture the effects of stress redistribution upon opening of the contact at the dam heel, representing crack propagation along the contact if weak lift lines are actually present.

A single overflow buttress of Pueblo Dam was modeled using ABAQUS / STANDARD. The model used three-dimensional 8-noded fully integrated brick elements throughout the dam and foundation. The foundation



1.50. Finite element model of an overflow buttress at Pueblo Dam, Colorado.

was modeled as a large rectangular block of solid sandstone, approximately 350 feet long, 250 feet wide and 150 feet in depth. The upper surface of the foundation block, at elevation 4755 feet, was used to define the lower half of the non-linear contact surface in these analyses. The dam model was positioned in the center of the foundation block with the bottom surface of the dam model forming the upper half of the non-linear contact surface. The edges of the foundation were fixed, but there were no translation or rotation boundary conditions applied at nodes in the dam model. Although a tension limit could be input, once cracked the only force preventing rigid body motion of the dam was the frictional force developed on the contact surface; therefore, additional iterations were required to obtain convergence of the first increment of the gravity loading to establish normal forces on the contact surface.

The ABAQUS / STANDARD finite element program uses time varying load application for all of the static loads. The gravity load was applied gradually from zero to one second of analysis time, followed by application of the reservoir and uplift pressure loads. The uplift pressures were also automatically recalculated at each analysis time increment as both a function of the current reservoir depth and the crack (open contact surface) length. The non-linear analyses indicated that the dam was stable for these static loading conditions. The tensile stresses which developed at the dam heel in the previous linear analysis were relieved upon opening of the contact surface when zero tensile strength was assumed on the contact surface, but a significant portion of the dam remained in compression, and was capable of carrying the load.

XII. Roller-Compacted Concrete—Rapid Construction for Gravity Dams

Despite advances in automated mixing, handling, and placement of mass concrete, the procedures were still somewhat labor intensive and time consuming in comparison to earthfill production rates. In the late 1970's and early 1980's some relatively small projects were completed using the concept of roller-compacted concrete (RCC). The concept involved placement of a lean and dry concrete mix by spreading it in thin layers with a bulldozer, and compacting it with vibratory drum rollers. The lean mix reduced the heat generated, and rapid production rates could be achieved, as the placement was mechanized and there was no need to wait for curing before placing the next lift. The Bureau of Reclamation began testing a high paste (cement plus flyash) RCC concept in 1980. This resulted in a strong and stiff material with similar properties to conventional concrete. Thus, the design of gravity dams using this type of material could be based on conventional gravity dam design methods.

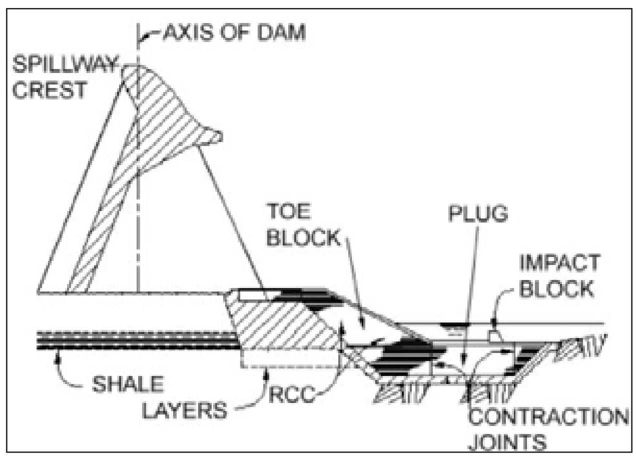
In 1985 RCC placements began at Upper Stillwater Dam, the Bureau of Reclamation's first RCC dam and at that time the world's largest. The straight gravity dam is about 280 feet high, and nearly 2700 feet long, and contains more than 1,600,000 yd^3 of concrete (most of which is RCC). Although the downstream slope is 0.6:1, the point of intersection of the downstream and upstream slopes is above the dam crest, which results in an equivalent downstream slope of about 0.7:1 for the height of Upper Stillwater Dam when compared to other typical gravity dams. The upper part of the downstream slope was steepened to allow sufficient crest width for the construction equipment. This increases the mass and stiffness of the dam when compared to traditional gravity sections.

1.51. Upper Stillwater Dam, Utah.

1.52. Compacting RCC at Stillwater Dam, Utah.

Typical excavation and treatment of the quartzitic sandstone and argillite foundation rock were performed. Crushed aggregate and sand were manufactured for the RCC. A richer RCC mix was used near the upstream face. The RCC contained between 135 and 160 pounds of cement per cubic yard, and between 290 and 350 pounds of flyash per cubic yard. Temperature control was achieved by placing the RCC below 50°F and by replacing cement with flyash to limit the heat rise. The RCC was tied to the abutments and to the foundation by use of conventional concrete. At the base of the dam, conventional concrete was first placed to form a level surface to start RCC placements. At the abutments, conventional concrete was placed between the RCC and the rock. Laser-guided slip-form machines were used to place concrete elements forming the upstream and downstream faces of the dam. This proved to be a fairly rapid means of forming the dam, and eliminated the relatively time consuming and labor intensive process of erecting and stripping conventional forms. RCC was delivered to the dam from the batch plant using a conveyor belt. There it was loaded into trucks, transported to the placement, and spread with a small bulldozer using a laser controlled blade. A vibratory drum roller then compacted the material into a dense mass. In 1986, over 715,000 yd^3 of RCC was placed in less than five months. The peak shift placed over 5400 yd^3. Joint cleanup was required, depending on the age of the concrete, and joints greater than 72 hours old were required to be sandblasted or waterblasted. Very good bond was achieved. In fact, it was difficult to find the lift lines in the core taken from the dam.

The major drawback to the design and construction of Upper Stillwater Dam was the exclusion of contraction joints or other means to control the cracking and subsequent leakage through the dam. Thermal and structural analyses had indicated that cracking would be limited to the face of the dam, and would not extend through the dam thickness. However, this proved to be incorrect, and regularly spaced vertical cracks propagated through the dam normal to the axis. Leakage from some of these cracks became significant, and the grouting and drainage gallery constructed about 20 feet from the upstream face of the dam received large inflows. The leakage at two of the cracks was exacerbated by small sliding movements on an argillite layer within the foundation that stopped when the passive rock mass downstream of the dam was mobilized. This tended to open the cracks on either end of where the movement occurred. All open cracks were grouted twice. The upper portions of the cracks were grouted with hydrophillic polyurethane grout, and the lower portions were grouted with cement grout. This proved to be effective for several years. However, seasonal movements of the cracks due to variations in reservoir level and temperature eventually reopened the cracks, resulting in renewed leakage. Plans are being developed to seal the cracks with an upstream membrane or a secant wall drilled across the cracks upstream of the gallery.



1.53. Section through Buttress 8 or 9 at Pueblo Dam, Colorado. Showing RCC stabilization measures.

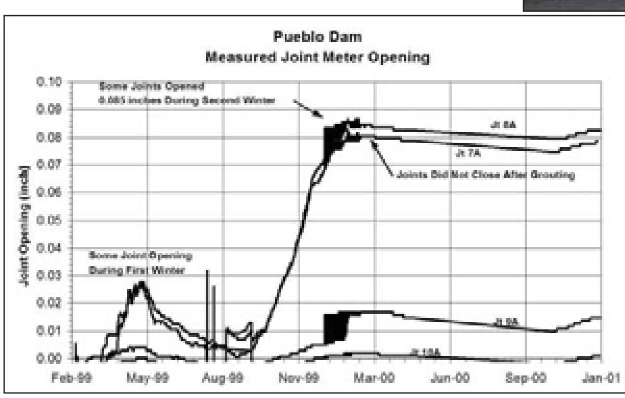
The contraction joint issue in RCC dams is critical. For gravity dams it is adequate to control the cracking by forming joints or placing crack inducers to control the crack locations. Water stop features can then be designed to reduce flow through the cracks. If RCC is to be used for arch dams, it will be necessary to develop a way to grout the joints to lock in arch action at the desired temperature. The Bureau of Reclamation developed such a system for the foundation modifications at Pueblo Dam in the late 1990s.

By way of background on this project, nearly horizontal shale layers beneath the massive head buttresses of the dam daylighted in the spillway stilling basin excavated at the toe of the dam, downstream of some of the buttresses. Due to the large population downstream of this dam, potential sliding of the structure on these shale layers posed a high risk, and was a dam safety concern. A RCC plug and toeblock, anchored with double-corrosion-protected high strength rock bolts, were constructed in the stilling basin to block the daylighting planes and buttress the foundation. State-of-the-art distinct element analyses, and probabilistic stability analyses were performed to ensure the RCC geometry would be effective in stabilizing the dam. The RCC material was somewhat different than that used at Upper Stillwater Dam. Rounded river aggregates up to 1½ inch maximum size were used. Approximately 120 pounds of cement and 180 pounds of flyash were used per cubic yard of RCC. Surface cleanup and bonding mortar were used on all lift surfaces of the toe block and on lift surfaces more than twelve hours old in the plug (below elevation 4728). Although the design strengths were met, a somewhat porous zone developed a few inches below the lift surface, particularly for lifts that were a day old when the next layer of RCC was placed. It was thought that the rounded aggregate made the RCC more susceptible to damage from construction traffic on lifts that were in a fragile condition just after setting of the RCC. Windy conditions at the site may have also prematurely dried the surface of the RCC lifts during and shortly following placement.

1.54. RCC placement, spreading, and compaction operations in the spillway pool, Pueblo Dam, Colorado.

Contraction joints were formed in the RCC by vibrating steel plates into the freshly compacted lifts. The joints trending in the cross-canyon direction needed to be grouted to ensure that load could be transferred across the joints with minimal displacement. The plate locations were carefully surveyed prior to installation so that the joints could be intercepted by vertical grout holes. Six-inch-diameter holes were drilled at 10-foot spacing in the upstream-downstream direction and 5-foot spacing in the cross-canyon direction. Steel plates were not placed in the drill

1.55. Installing joint inducing plates in RCC at Pueblo Dam, Colorado.



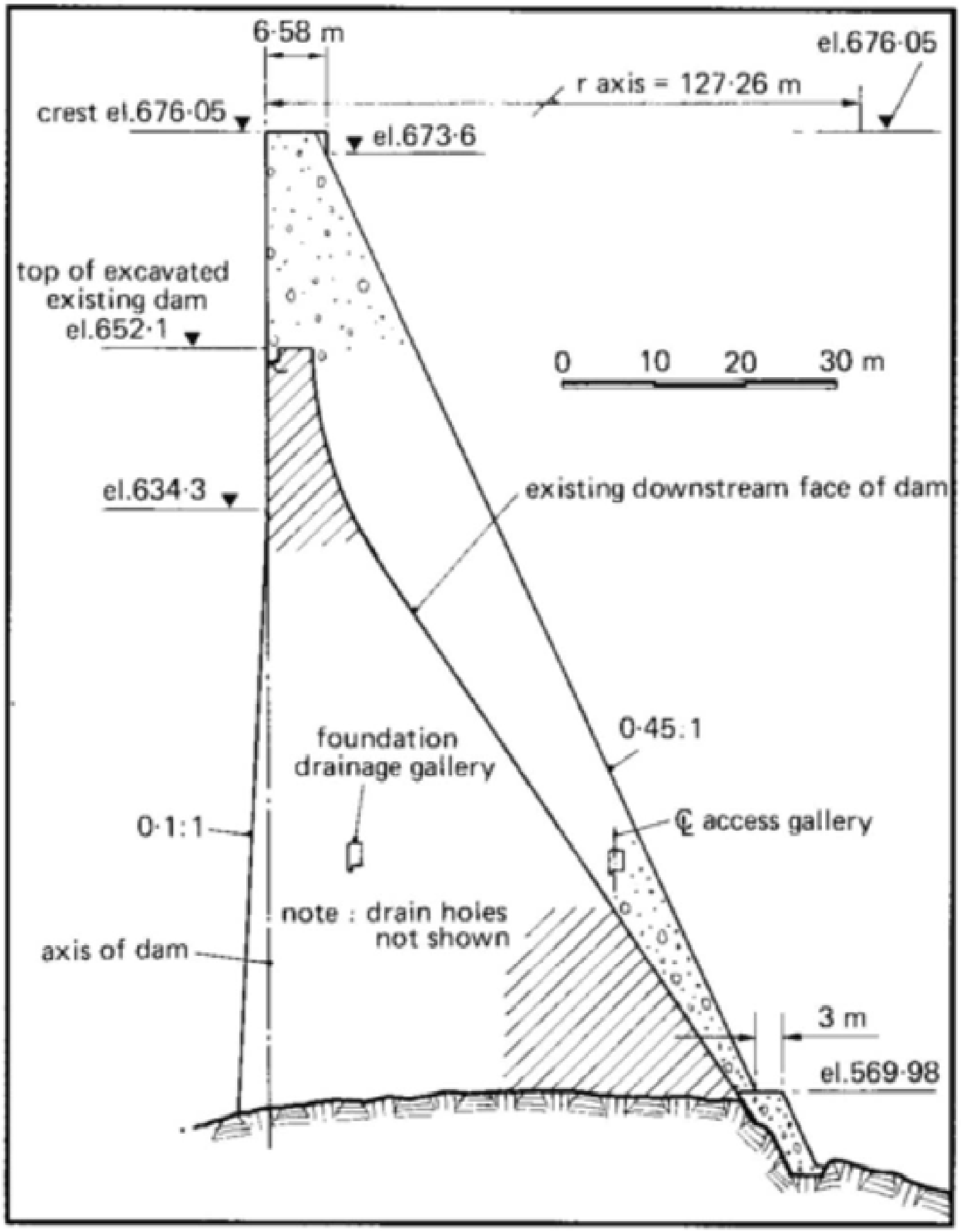
1.56. Opening of transverse contraction joint in RCC at Pueblo Dam, Colorado. Grouting of joints occurred in February 2000.

hole locations. Some holes were filled with polyurethane grout to isolate grout zones. Tubing was designed and installed in the holes to provide grout supply and return lines, and venting to remove air and water from the system. Grouting was performed the second winter following RCC placement when joint meters indicated sufficient joint opening for grouting. The grouting was successful, and the joints did not close the following summer, indicating good filling of the joints.

XIII. Transition to Dam Safety—Applying Technology to Reduce Risk

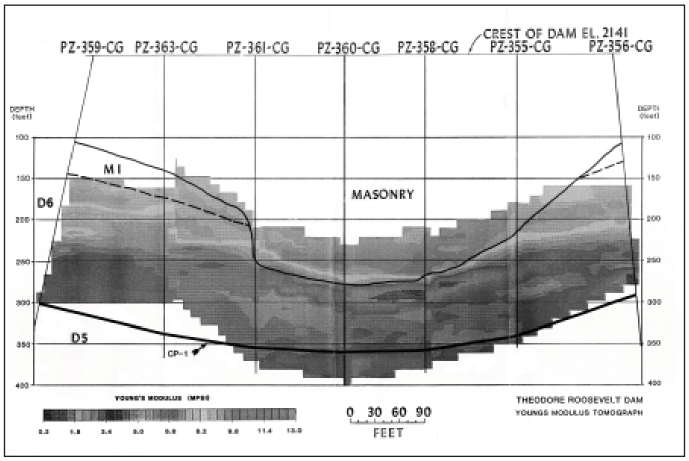
The Bureau of Reclamation has been actively involved with a formal safety of dams program since April 1977 when an Executive Order was issued initiating the Federal guidelines for dam safety. The aim of Reclamation's dam safety program is to ensure that the agency's dams do not pose an unacceptable risk to the downstream public. To that end, Reclamation has pioneered the use of risk analysis in assessing dam safety. Once it is determined that structural modifications are needed to reduce risk, Reclamation has used the design and construction technology developed over the past century to fix existing dams. For concrete dams, this means application of detailed analyses, design procedures, and modern concrete technology. Two cases, Theodore Roosevelt and Pueblo Dam modifications, illustrate this point. The case of Pueblo Dam was discussed in the previous section on roller-compacted concrete (RCC). Additional details of the Theodore Roosevelt Dam modifications are provided here.

Potential deficiencies with regard to the potential to pass large floods, potential instability during large earthquakes, inadequate release capacity, and the need for more water storage resulted in major modifications to Theodore Roosevelt Dam between 1988 and 1995. Part of those modifications resulted in raising the arch dam 77 feet. It was necessary to determine whether the dam and foundation could withstand this increase in head. Combinations of joints and bedding planes (dipping upstream at about 20 to 25 degrees) in the Precambrian sedimentary foundation rock formed potentially unstable blocks. Initial stability analyses indicated that the foundation would not meet the desired factors of safety under the increased loading. Therefore, foundation drainage was installed from adits excavated in the rock and a gallery excavated through the existing masonry. Piezometers were installed to measure foundation water pressures before and after construction of the drainage, and pressure contour maps were developed for determining uplift forces in the foundation analysis. The drainage was very effective, reducing pressure heads by about 43 to 68 feet. In situ uniaxial jacking tests were performed in the drainage adits, and correlated with seismic tomography testing to estimate the deformation properties of the foundation rock mass and concrete masonry of the existing dam. These properties were included in finite element structural analyses to study the behavior of the dam and more closely determine loads acting on the foundation. Final foundation analyses indicated that the raised dam with the drainage in place met the desired safety factors, and was more stable than the existing dam without drainage.



1.57. Schematic of raising Theodore Roosevelt Dam, Arizona.

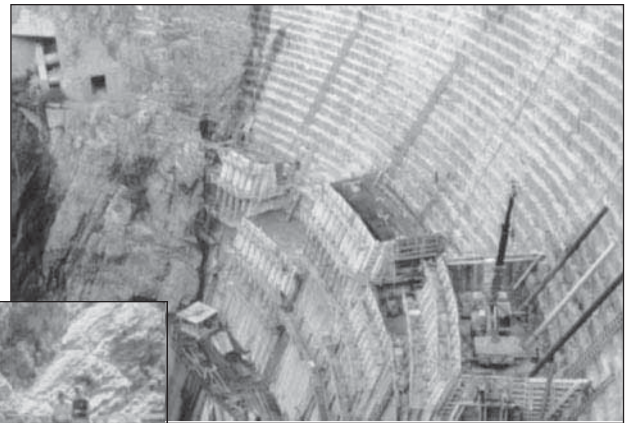
Constructing an overlay of conventional concrete on the existing dolomite masonry dam posed some additional challenges. A concrete test panel was constructed on the downstream face of the dam to determine the likely bond strength between the new concrete overlay and the masonry. Core samples were extracted and the interface was tested in tension and direct shear. This information was used in extensive computer modeling to verify the design and shape of the overlay. The dam was analyzed for static and dynamic loading using finite element methods. The existing masonry was modeled in three horizontal stages to simulate the layered construction. The mass concrete overlay was modeled as it was constructed, in blocks separated by (keyed) contraction joints. Recommended block dimensions, lift heights, concrete placement temperatures, and cooling requirements were based on temperature control studies. These studies took into account the thermal properties of the concrete mix design, and the expected temperature rise within the mass concrete during construction. The concrete was cooled using cooling coils embedded in the 10-foot lifts, and the contraction joints in the overlay were grouted to provide arch action and improve the stress distribution within the structure. The numerical modeling simulated this construction sequence. Final analysis of the composite structure indicated improved stress conditions within the existing masonry portion of the dam, and results meeting Bureau of Reclamation stability and stress criteria. Seismic response analyses indicated the structure should perform well under large seismic loadings. Construction of the overlay followed typical mass concrete placement techniques, developed and refined since the construction of Hoover Dam. A high line was used to transport concrete to the placement in buckets. The concrete was placed in layers and vibrated into place. Something not done before included placement of geo-composite strip drains between the existing masonry and the new concrete to provide drainage at the interface.



1.58. Results of seismic tomography testing at Theodore Roosevelt Dam, Arizona.

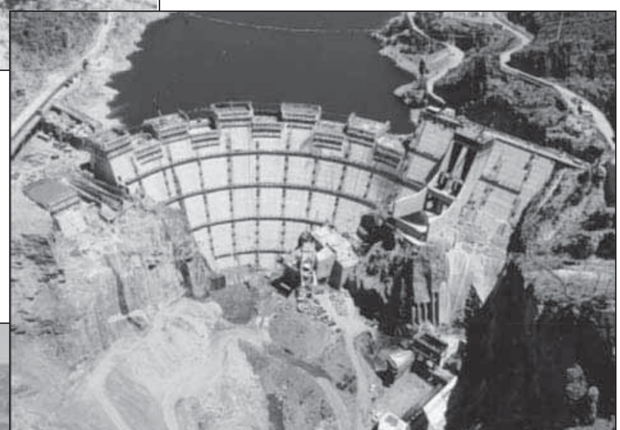
Other modifications to the dam included construction of a lake tap and tunnel system to provide a new outlet works and power penstock. New mass concrete thrust blocks were constructed on each abutment to fill the gap formed by the original spillway cuts. New spillways were constructed through each thrust block. Hydraulic model studies were used in the hydraulic design of the spillways. Spillway flows enter a diverging chute and flip structure before plunging to an excavated basin in the river channel below. The spillway alignments cause the discharge jets to impinge at or above tailwater level, while both spillways are operating under higher reservoir heads.

The following illustrations show concrete placement during modifications to Theodore Roosevelt Dam. Note placement and vibration of concrete in layers , placement in blocks against the masonary, and new thrust block and spillway.

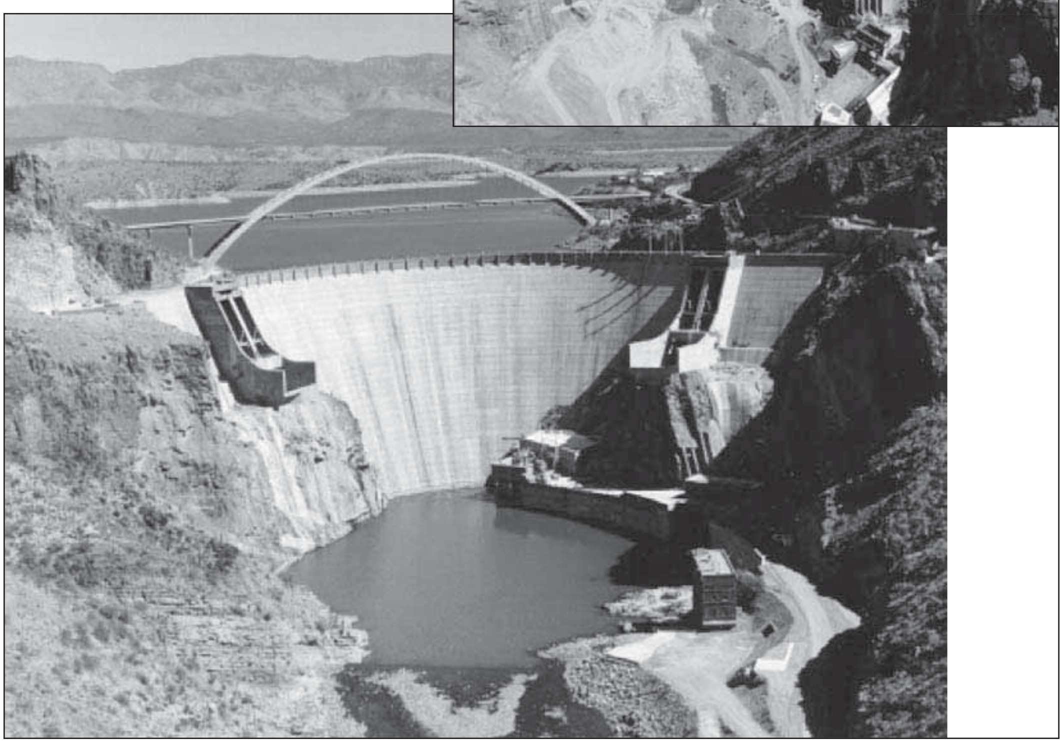


1.59. Concrete placement during modifications to Theodore Roosevelt Dam, Arizona.

1.60. Placement and vibration of concrete in layers during modifications to Theodore Roosevelt Dam, Arizona.



1.61. Showing the new thrust block and spillway at Theodore Roosevelt Dam, Arizona.



1.62. Modified Theodore Roosevelt Dam, Arizona, completed and rededicated in 1996.

XIV. Conclusions

We hope you have enjoyed this tour of the evolution of concrete dam design, analysis, and construction within the Bureau of Reclamation over the past century. There is no question that the early pioneers in this effort were extremely talented and set the stage for some of the great feats of human engineering that were to follow. Monumental projects like Hoover and Grand Coulee Dams are still "wonders" today. During the heyday of dam construction in the United States, the Bureau of Reclamation developed a reputation as a world leader in concrete dam technology. The construction of dams in the United States is winding down now after a century of extensive development. The last new concrete dam constructed by the Bureau of Reclamation was completed over a decade ago (1989). The legacy and expertise in concrete technology and dam construction at the Bureau of Reclamation remains a valuable national resource, and has been recently used to efficiently fix dams where safety concerns exist. So what do the next 100 years hold? As long as dam safety projects remain to be done, the expertise will be maintained and developments will slowly occur. However, without large projects, it is likely that the leadership in this area will gradually shift to developing countries in the future. The Bureau of Reclamation can be proud of the giant springboard they have provided from which these efforts can be launched.

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100 Years of Embankment Dam Design and Construction in the U.S. Bureau of Reclamation

by:
Richard Lyman Wiltshire

Introduction

The design and construction of earthfill and rockfill embankment dams in the western United States and throughout the world have evolved dramatically during the past 100 years. The U.S. Bureau of Reclamation (Reclamation) played a significant role in that evolution of embankment dam engineering, construction, and dam safety. There are now more than 240 water-storage embankment dams in the western United States that were designed and constructed by Reclamation during the twentieth century, which was the most intensive period of dam building the world has ever seen. The list of embankment dams built by Reclamation includes many of the most innovative, largest, and highest dams of their eras. The list of civil engineers and other professionals who have helped to design and build Reclamation's embankment dams is lengthy and highly regarded.

Reclamation is currently organized into five Regions, across the seventeen western states, and the Washington and Denver Offices. The five Regions, which have performed almost all of the dam construction work, are: 1) Pacific Northwest, 2) Mid-Pacific, 3) Lower Colorado, 4) Upper Colorado, and 5) Great Plains. The Denver Office includes the Technical Service Center, the current name of the engineering organization that has performed most of the embankment dam engineering and design work.

This paper summarizes Reclamation's embankment dam design and construction history. The last 100 years have seen the design and construction of embankment dams develop from the relatively simple homogeneous or two-zone earthfill embankments designed in 1904 or 1905 into the extremely complex, highly analyzed, well-instrumented zoned earthfill and/or rockfill structures that are the embankment dams of the new millennium. This embankment dam engineering evolution has also involved the growth of several related disciplines, including engineering geology, seismology, hydrology, hydraulic engineering, instrumentation engineering, mechanical engineering, and electrical engineering. A central component of the evolution of the engineering of embankment dams has been the birth and maturation of geotechnical engineering as a civil engineering specialty. The use of computers and computer programs for the analysis and design of embankment dams became standard practice within a fairly short time after they were developed by geotechnical engineers. Another component of this evolution has been the development of larger, faster, more powerful, and more efficient earthwork construction equipment. The paper also discusses the design and construction organizations within Reclamation and how they have changed during the last 100 years. Reclamation's publication of its well-known engineering books, such as the *Earth Manual*[1] and the *Design of Small Dams,*[2] is noted. Lastly, the successes and failures that occurred during the last 100 years of Reclamation's embankment dam design and construction history are discussed, and the lessons learned from those experiences are summarized.

In telling the story of the evolution of Reclamation's embankment dam engineering, the paper separates the 100-year history into five periods, which are partly based on noteworthy events such as World Wars I and II and the failure of Teton Dam in 1976. Period I runs from 1902 to 1918; Period II extends from 1919 to 1933; Period III covers 1934 to 1944; Period IV includes 1945 through 1975; and Period V runs from 1976 to the Present (2002). This paper examines the embankment dam design and construction changes that occurred during each period. Representative and remarkable/notable embankment dams from each of the five periods are discussed. A few problems, some significant, occurred during the construction and/or subsequent operation of Reclamation's embankment dams and they are also discussed. And the effects of certain developments, such as the Proctor compaction (moisture density) test procedure and the failure of Teton Dam, are discussed in the paper.

Reclamation's Design and Construction Organizations

In 1902, the new U.S. Reclamation Service (Service) was organized within and was drawn from the U.S. Geological Survey's (USGS) Division of Hydrography, Hydrographic Branch, that had studied western water resources for the previous 20+ years. Frederick H. Newell, Chief of USGS's Division of Hydrography, was selected to head the new Service under USGS Director Charles D. Walcott and was titled Chief Engineer, and Arthur Powell Davis was Newell's chief assistant.[3] Based on the studies previously conducted by USGS, which had included studies of streams, watersheds, irrigable lands, and potential dam and reservoir sites throughout the West, six projects were approved for design and construction by the Secretary of the Interior in 1903. Out of 79 projects investigated, a total of 25 projects had been examined and authorized for construction by the Secretary within the first five years, and 15 of those had been started by private companies or by a group of cooperating farmers who requested the Service's help.

Period I (1902-1918)—Reclamation's Design and Construction Organizations

At the beginning of Period I, each of the 16 western states (17 states after Texas was added in 1906) had at least one district under the direction of a "District Engineer," who was responsible for all Reclamation activities, including surveys, investigations, designs, and construction. For each authorized project, a qualified (civil) engineer was selected as the "Resident Engineer" and he was responsible for conducting site investigations and developing preliminary design plans on the embankment dam judged appropriate for the site. On a larger project, the Resident Engineer might have the help of an Assistant Engineer. Supervisory Service engineers, who functioned as liaison representatives of the Chief Engineer on certain projects, and consulting engineers with special skills, reviewed the preliminary plans and made project recommendations to the Secretary of the Interior. Upon the Secretary's approval, the Service was authorized to develop final plans and specifications. The early embankment dams were constructed either by contract with private contractors or by "force account" using Government forces. Both types of construction were managed/supervised by Service engineers and inspectors. Most of the dam sites were fairly remote, so construction included transportation of all necessary equipment and materials to the dam site, as well as construction of the camps and facilities required to house the construction workers.

In 1903, a permanent western headquarters office was established in Denver, Colorado, to house the engineers and assistants of the Hydrographic Branch who would facilitate the location and construction of dams, in order to avoid overcrowding in the Washington, D. C., office. The Reclamation Service became independent from the USGS in 1907, with Chief Engineer Newell becoming the Service's first Director and Davis becoming Chief Engineer. Newell reorganized the 17 states into six divisions to enhance the Service's administration of its large workload: the Central, Idaho, Northern, Pacific, Southern, and Washington Divisions. The Division boundary lines were determined by the ease of railroad travel and communication, with drainage boundaries also being considered. Each of the six Divisions was headed by a Division Engineer. Reclamation's early Project, District, and Division Engineers included such notables as: Ira W. McConnell, Raymond F. Walter, Frank E. Weymouth, Joseph B. Lippincott, Hiram N. Savage, David C. Henny, Ernest G. Hopson, Louis C. Hill, and Charles H. Swigart. Note that engineers Weymouth, Lippincott, and Hill were all elevated to Honorary Member status in the American Society of Civil Engineers (ASCE).

In 1913 the Service's hierarchy was reorganized, creating a five-member Reclamation Commission, which included: the Director of the Service, Chief Engineer, Chief Counsel, Comptroller, and Supervisor of Irrigation. In December 1914 the Chief of Construction was added as a member of the Reclamation Commission. Davis became Director of the Service in December1914 after Secretary of the Interior Franklin K. Lane removed Newell as Director and named him "Consulting Engineer." Newell finally resigned from the Service in May 1915 and became Chairman of the Civil Engineering Department at the University of Illinois. Also in May 1915, the Commission's membership was reduced to three, consolidating the Director and Chief Engineer positions with Davis as Director and Chief Engineer and retaining the Comptroller and Chief Counsel positions (which also appears to have removed the Supervisor of Irrigation and the Chief of Construction as members of the Commission). That same year, the direction of field operations was centralized at the Denver Office under the Chief of Construction. With the establishment of the Chief Engineer's Office in Denver, Reclamation's engineering design and construction management functions were centralized in the Denver Office. In 1918 the Secretary of the Interior followed Arthur P. Davis' recommendations and the top level structure of the Service was again reorganized, making the Comptroller and the Chief Counsel subordinate to the Director and Chief Engineer.

Period II (1919-1933)—Reclamation's Design and Construction Organizations

In May 1920 Director and Chief Engineer Davis changed his title to Director and appointed the Chief of Construction in Denver, Frank E. Weymouth, to the Chief Engineer position. Arthur Powell Davis served as President of ASCE in 1920. On June 18, 1923, the Service became the Bureau of Reclamation headed by the Commissioner of Reclamation; Davis resigned from Reclamation the following day. David W. Davis was named Reclamation's Commissioner on July 1, 1923, quickly followed by Elwood Mead after Davis left office on April 2, 1924. Dr. Mead served as Commissioner from 1924 until his death on January 26, 1936. Reclamation's design and construction organizations remained much the same for the next 20 years. During the 1920s and 1930s, the status of the Chief Engineer grew as Reclamation's authority was consolidated in the office of the Chief Engineer headquartered in Denver. Reclamation's various laboratories first got started in 1930 with the hydraulic model testing performed in the laboratory of the Colorado Agricultural Experiment Station in Fort Collins, Colorado. The Concrete Laboratory and the Earth Materials Laboratory were also begun in the early 1930s in the U.S. Customs House in Denver.

Period III (1934-1944)—Reclamation's Design and Construction Organizations

In 1942 and 1943, Secretary of the Interior Harold Ickes reorganized Reclamation in accordance with a plan designed to: 1) decentralize the authority for work execution along regional lines, 2) limit the authority of the Chief Engineer and his staff to project design and construction, and 3) establish a "functional type" of organization with the Commissioner's authority going straight to the Regional Directors. The reorganization provided for:

> Four major branches in the Denver Office: Design and Construction under the Chief Engineer, Project Investigations, Operation and Maintenance, and Fiscal and Administrative Management. The Chief Engineer remained Reclamation's ultimate authority in the technical execution of construction projects, even though responsibility over construction in the field was now divided between the Regional Directors and the Chief Engineer.

Six Regional Offices, later expanded to seven, concentrated on planning and development activities, and supervised the operation and maintenance of completed project facilities. The seven Regional Offices were located at Boise, Idaho; Sacramento, California; Boulder City, Nevada; Salt Lake City, Utah; Amarillo, Texas; Denver, Colorado; and Billings, Montana. The Regional Directors reported directly to the Commissioner's Office.

Period IV (1945-1975)—Reclamation's Design and Construction Organizations

In 1945 the Commissioner won support for his position that "the responsibility for the technical aspects of design and construction work should remain in the Chief Engineer, and therefore, authority for this work should also be vested in the Chief Engineer." This created problems for the Construction Engineers because they had two bosses: the Regional Director and the Chief Engineer. Reclamation's Denver Office included some 2,000 employees by 1948 that were scattered around the Denver metropolitan area. Reclamation's new Denver headquarters was established in 1950 as the Engineering and Research Center at the Denver Federal Center in Lakewood, located 10 miles west of downtown Denver. In 1953, during the Eisenhower Administration, the Chief Engineer's authority was upgraded and the title was changed to Assistant Commissioner and Chief Engineer. This title continued to be changed, becoming Director, Office of Design and Construction in 1963, Director, Office of Design and Construction/Chief Engineer in 1970, and Director, Office of Design and Construction in 1972.

Period V (1976-2002)—Reclamation's Design and Construction Organizations

Reclamation's Teton Dam failed on June 5, 1976, killing 11 people and causing about $400 million in property damage. This failure had a profound effect on the Bureau of Reclamation. Two official panels of technical experts reviewed the probable causes of the dam's failure and released reports in December 1976, April 1977, and January 1980. Significant recommendations by these two panels involved several areas of concern. These included: the need to establish independent dam design and construction review boards, greater documentation of design decisions, closer project supervision and oversight by design personnel, and more intensive construction and post-construction monitoring of the structures. A team was named by then Commissioner R. Keith Higginson in 1977 to review Reclamation's dam design and construction procedures, which resulted in a November 1977 reorganization that reaffirmed many of the 1943 reorganization's objectives to more clearly define the respective functions of the Denver and Washington Offices and to streamline the lines of authority and accountability. Reclamation's staff for technical review and support was established and added to the Denver Office. Since the failure of Teton Dam, and with the decrease in the authorization of new projects, the majority of the embankment dam design and construction work has involved dam safety evaluations and modifications of existing dams and appurtenant structures.

The title Director, Office of Design and Construction was changed to Assistant Commissioner for Engineering and Research in 1978. In 1979, the Bureau of Reclamation's name was briefly changed to the Water and Power Resources Service, which lasted until 1981 when the name was changed back to the Bureau of Reclamation. The Lower Missouri Region was absorbed into the Upper Missouri/Great Plains Region in 1985. The Southwest Region was abolished in 1988, splitting its area between the Upper Colorado Region and the Great Plains Region. Reclamation now has five regions: Pacific Northwest in Boise, Mid-Pacific in Sacramento, Lower Colorado in Boulder City, Upper Colorado in Salt Lake City, and Great Plains in Billings. In 1994, the Denver Office was reorganized, and the title Assistant Commissioner for Engineering and Research was changed to Director, Technical Service Center (TSC) under the Director of the Reclamation Service Center, with the latter position recently abolished. The 1994 reorganization increased the relative authority and power of the Regions and their local project and area offices, and reduced that of the TSC engineering organization.

The majority of the embankment dam design work, now mostly dam safety modifications determined necessary on existing dams, is still performed by the civil/geotechnical engineers in the TSC. The majority of the embankment dam modification construction work is done by civil engineers in the Regions and their Project and Area Offices. There are still Construction Engineers in the TSC who perform the construction management work and/or function as liaisons and provide oversight on the construction work managed by the Regions and the Project and Area Offices.

Modern Embankment Dam Design and Construction

As different cradles of civilization evolved all over the world, irrigation works and dams were basic components of their development. The earliest known design and construction of an embankment dam occurred around 2900 B.C. with the construction of Sadd el-Kafara Dam in Egypt. The early history of dams in the world includes many other countries as well, such as India, China, and Iraq. In North America, the Hohokam Indians built diversion works and canals along the Salt and Gila Rivers in southern Arizona as early as about 300 B.C. And in the Four-Corners area (Colorado, Utah, Arizona, and New Mexico), the Anasazi and Pueblo Indians constructed mud-wattle dams across streams that diverted infrequent runoff into ditches and storage reservoirs throughout the area in order to support their agricultural civilization, according to a recent study by Wright Water Engineers, Inc. of Denver, Colorado. According to *Dams and Public Safety*[4] by Robert B. Jansen (Reclamation's Director, Office of Design and Construction and Assistant Commissioner for Engineering and Research, 1977-1979), the first dam built in North America by European-Americans was built in 1623 on the Piscataqua River to operate a sawmill at South Windham, Maine. The first embankment dam was called Mill Pond Dam and was built in 1677 at Newington, Connecticut. In the far West, in early

California, Old Mission Dam was built on the San Diego River about 1813 by the Jesuits to provide water for the mission. It was composed of mortared rubble masonry and was about 5 feet high.

Starting about 1850, gold miners in California built rock-filled log-crib dams faced with wood planking that ranged up to about 125 feet in height to store water for hydraulic mining, but there were numerous failures. It should be noted that many of the early dams constructed in California during the latter half of the nineteenth century supplied water for mining purposes. One of the earliest notable non-mining dams in the West was San Andreas Dam, constructed on San Mateo Creek near San Francisco, California, in 1870 to supply water for the city. This dam is notable because it was unknowingly built across the San Andreas fault zone. This earthfill dam was about 105 feet in height and was built using the nineteenth century puddled-core technique, where the upstream and downstream shells consisted of rolled clay and the narrow core was made by manually tamping wet clay. The dam's upstream slope was 3.5:1 (horizontal:vertical, H:V) and the downstream slope was 3:1. The embankment included a cutoff trench excavated down through the alluvium and colluvium (30 to 40 feet thick) that was backfilled with a clay puddle core about 20 feet wide that was extended upward to form the central portion of the dam. The dam was subsequently raised about 12 feet in 1875 and another 6 feet in 1928. The great San Francisco earthquake of 1906 caused a horizontal strike-slip offset of about 6 to 8 feet in the left abutment, but the dam embankment was not damaged.

Across San Francisco Bay, the highest embankment dam built in the United States during the nineteenth century was Chabot (Lower San Leandro) Dam, which was constructed in 1875 above San Leandro (near Oakland) on San Leandro Creek with a height of 115 feet above the streambed. Its reservoir stored residential water for the East Bay communities. It was constructed as a central-core earthfill dam, with the earthfill dumped from wagons, sprinkled, and compacted by the wagon wheels and by a herd of horses moved back and forth across the fill. The dam's cross-section included a central foundation (cutoff) trench excavated down through foundation soils to 30 feet below the streambed. In the bottom of the cutoff trench, three parallel concrete cutoff walls were constructed 3 feet thick and 5 feet high, with about half the height (2½ feet) anchored into the foundation and half protruding up into the fill. The core zone was about 90 feet wide/thick at its bottom in the foundation trench. The embankment's upstream slope was 3:1 and the downstream slope was 2.5:1. A buttressing zone of earth and rock material was sluiced onto the downstream slope, giving the embankment a total volume of about 543,000 yd^3. In 1890, the dam was enlarged by sluicing earthfill onto the downstream slope. Subsequent raising and buttressing of the dam embankment has increased the height to 154 feet. A good source of information on the evolution of dam design and construction, including embankment dams, is *Development of Dam Engineering in the United States,*[5] which includes information on six of Reclamation's embankment dams. Such was the state-of-the-art in embankment dam design and construction at Reclamation's birth.

The design of modern earthfill and rockfill embankment dams is far more complex today than was the case just 100 years ago. There are now many college courses, books, collections of professional papers, professional groups, computer programs, etc., related to the design of modern embankment dams. Most of the major unknowns and uncertainties involved with the design of embankment dams 100 years ago have been removed by the evolution of engineering experience, research, knowledge, and education. Reclamation has played a central role in that engineering evolution through its pioneering embankment designs, analyses, and soil behavior work on developing new laboratory tests and procedures for soils; development and publication of geotechnical and embankment dam engineering manuals and books; and contributions to the articles, transactions, and proceedings of engineering periodicals and professional civil engineering organizations. Some of Reclamation's learning and knowledge has come at a high price, as was the case with the 1976 failure of Teton Dam in Idaho.

In addition to the books and professional papers that now exist on modern embankment dam design and construction, several professional organizations regularly deal with and publish state-of-the-art papers on the design and construction of embankment dams and related topics. These organizations include: ASCE, the recently renamed United States Society on Dams (USSD, formerly the United States Committee on Large Dams, USCOLD), its worldwide parent organization, the International Commission on Large Dams (ICOLD), the International Society on Soil Mechanics and Geotechnical Engineering, and The Institution of Civil Engineers (in Great Britain).

To the lay-person, embankment dams may look like huge "piles of dirt" thrown across a valley or canyon, and it can be hard to imagine how truly complex and amazing they actually are. Most people can perceive how complex a large concrete dam, like Hoover Dam, must be with a height of 726 feet. The highest embankment dam in the world is currently Rogun Dam on the Vakhsh River in Tajikistan at a height of about 1,066 feet, and California's Oroville Dam the highest in the United States at about 770 feet. The largest embankment dam volume in the world is Tarbella Dam on the Indus River in Pakistan with a volume of about 159,000,000 yd^3, and Montana's Fort Peck Dam is the largest in the United States with a volume of about 126,000,000 yd^3. Many of these huge embankment dams are almost as amazing in their own way as Hoover Dam.

There are many more embankment dams (currently about 72 percent) than there are concrete dams (currently about 28 percent) in the United States, out of the total of about 77,000 dams, meeting minimum dam height and reservoir volume criteria. Among several reasons, one key aspect of why embankment dams are so popular is that in general, a properly designed embankment dam can be constructed at almost any damsite, as opposed to the more stringent site limitations associated with concrete dams. A limited "picture" of the various elements that are included in the design (and construction) of a modern embankment dam is presented below. A more complete understanding can be obtained by reading publications such as Reclamation's *Design Standards No. 13—Embankment Dams*[6] and the previously mentioned *Design of Small Dams*.

Once the need for a new dam and reservoir and a variety of other factors such as funding availability and environmental impacts have been resolved, several potential damsites are studied and investigated in sufficient detail that a conceptual design report can be developed, which includes recommendations as to the preferred damsite and the appropriate type of embankment dam and related features. Once the damsite, the type of embankment dam, and related features have been selected, more detailed studies, investigations, and analyses are conducted in order to have the information necessary to start the final design work, which concludes with the preparation of written specifications and drawings that are used as the basis for constructing the new embankment dam. The various studies, investigations, and analyses included in these design phases, which often overlap, generally include:

1) a hydrologic study of the upstream drainage basin;
2) a geologic study of the damsite and the reservoir basin, including a seismotectonic study of the area;
3) a field investigation of the foundation at the damsite and of the locally available earthfill and rockfill materials and concrete aggregates;
4) a laboratory program including testing and analysis of the soil, rockfill, and bedrock materials obtained from the damsite and the borrow area(s);
5) a conceptual design study, intended to develop and present various alternatives and their costs, and to recommend the preferred alternatives for the embankment dam, spillway, and outlet works features;
6) a final design based on the selected-alternative features, including the necessary construction specifications and drawings;
7) during construction, embankment design details often change to accommodate the changed conditions encountered; and
8) during "First Filling" of the reservoir and for the first few years thereafter, the performance/behavior of the foundation and/or the dam embankment may indicate the need for changes or modifications to the original design.

It should be noted that even a brief a description of how to design an embankment dam is beyond the scope of this paper. The hydrologic study of the drainage basin above the damsite develops information on the probable flood hydrology that is used to design the dam embankment and the appurtenant spillway and outlet works features. If the dam and its appurtenant features can't accommodate the flood flows resulting from the various potential storm events, the reservoir can overtop the dam embankment and cause it to fail. The geologic study develops the necessary information on the geology of the damsite and the surrounding area, which often affects the type of dam selected for design and construction. Unless the damsite's geology is properly understood, the response of the foundation to the loads imposed by a dam and reservoir may cause malfunction, leading to serious maintenance or in some cases failure of the dam. This is especially true in the event of an unexpected earthquake shaking a dam that is not designed to withstand the severity of the loading imposed on the structure. The dam, spillway, and/or outlet works can all fail because of a moderate to severe earthquake event. The field investigation and laboratory testing of the dam foundation and the embankment borrow materials accumulate and develop engineering design data on the foundation soils, bedrock, and borrow soil and rockfill materials. These field and laboratory design data are critical and must be properly collected and evaluated if dam failure is to be avoided. These design data form the basic information used in the various analyses conducted during the design of an embankment dam, including standard concerns about seepage, internal erosion/piping, settlement, static stability, seismic stability, etc. Design information on sources of sand and aggregate materials for concrete is also developed.

After the design data have been properly developed, and the various design analyses have been completed, the dam embankment's alignment, cross-section, freeboard, foundation treatment(s), material zoning, filters, drainage, camber, upstream and downstream slope protection, and instrumentation (for monitoring performance) are then determined. Computers have greatly enhanced the designer's ability to perform extremely complex analyses, as well as to create 3-dimensional models portraying the dam's configuration to ensure that all of the dam embankment's components join together properly. The written specifications and drawings that describe the details for construction of the dam are then developed. The spillway and the outlet works are similarly designed, and must be compatible with the embankment dam's design. Because of the potential public danger created by any dam and reservoir, dam design work (including that performed by Reclamation) undergoes a very high level of review, including review by boards of outside consultant experts, where appropriate, to ensure that our designs achieve the high quality required.

A well-known saying related to embankment dam design is that the design work is not complete until the dam's construction has been finished. And, this "construction period" should also include the first few years of a dam's performance under full reservoir loading. If the "First Filling" of a large reservoir takes 10 to 20 years to complete, then the "construction period" during which design changes and modification of the dam may be necessary could last well over 15 to 25 years. The design uncertainty during the dam's construction involves the fact that the geologic studies, the field investigation data, and the laboratory testing data actually involve a relatively limited exposure and assessment of the dam's entire foundation and all of the earthfill materials used to construct the embankment. When the final foundation surface is completely exposed, there can easily be overburden soils and bedrock that were not encountered by any of the subsurface investigations conducted, depending on the damsite geology. And, when the borrow materials are brought to the damsite for construction of the dam embankment, some of the material may not be quite what was sampled and tested in the laboratory. The dam construction process may also be affected by the construction contractor's plans for constructing the embankment. The contractor might propose a different approach than was anticipated by the designer, such as the use of different construction equipment and the use of soil amendments to improve one of the earthfill material's characteristics (such as decreasing its permeability). Design changes during construction are most often subject to the same review process as the initial design.

The dam engineering work required in the development of the design data, the performance of analyses, the preparation of the final design, and the construction of a modern embankment dam and its appurtenant features generally involves a large number of related disciplines, including engineering geology, seismology, hydrology, civil engineering, geotechnical engineering, instrumentation engineering, structural engineering, hydraulic engineering, mechanical engineering, electrical engineering, and construction engineering. Several of the above disciplines are included as sub-disciplines or specialties within the civil engineering profession: geotechnical, structural, hydraulic, instrumentation, and construction engineering. As you can see from the "brief" description provided above, the planning, design, and construction of a modern embankment dam is a complicated process that requires the civil engineers and other professionals performing the work to have high levels of expertise and years of experience. The entire dam design and construction process can take years (sometimes tens of years) to complete.

Improvements in the size, speed, and efficiency of construction equipment during the last 100 years have played a major role in the evolution of embankment dam construction. The construction of a modern embankment dam and its appurtenant structures involves a large variety of construction equipment. A brief list of the common types of larger construction equipment typically used in constructing an embankment dam includes: backhoe, dragline, crane, articulated concrete pumper, pneumatic drill, front-end-loader, belly-dump truck, tandem end-dump truck, all-terrain haul truck, belt conveyors, water truck, bulldozer, motor grader, self-elevating scraper, excavators of all types, tamping-foot compactor (static and vibratory), sheepsfoot roller, and smooth-drum roller (static and vibratory). Construction on a large dam or at a difficult damsite may effectively utilize more efficient or unusual equipment, such as a belt conveyor system or a short railroad for hauling the borrow material to the damsite.

Reclamation's History of Embankment Dam Design and Construction

The history of Reclamation's century of embankment dam design and construction is separated into the five periods already used in describing Reclamation's design and construction organizations. More than 240 reservoir-storage embankment dam structures have been designed and constructed by Reclamation during the past century. Some of the information presented in the following period sections on Reclamation's embankment dam design and construction history through 1958 is taken from *Development of Earth Dam Design in the Bureau of Reclamation*[7] by F. C. Walker, then Head of the Earth Dams Section, Dams Branch, Division of Design. The location map and map index of Reclamation's embankment (earth-fill) dams are shown in 2.1 and 2.2.

2.1. Location map of Reclamation's earthfill dams.

LOCATION INDEX
OF
BUREAU OF RECLAMATION EARTH-FILL DAMS

NAME OF DAM	LOCATION NO.	MAX. SECTION ON SHEET NO.	NAME OF DAM	LOCATION NO.	MAX. SECTION ON SHEET NO.	NAME OF DAM	LOCATION NO.	MAX. SECTION ON SHEET NO.
AGATE	168	17	HELENA VALLEY	126	10	RYE PATCH	37	3
AGENCY VALLEY	31	3	HERON	173	16	SALMON LAKE	21	2
ALAMOGORDO	39	3	HORSETOOTH	73	6	SANFORD	153	13
ALCOVA	34	3	HOWARD PRAIRIE	123	10	SAN JACINTO RES.	64	5
ALTUS	55	4	HUNTINGTON NORTH	172	16	SAN JUSTO DIKE	219	22
AMERICAN FALLS	25	2	HYRUM	32	3	SAN JUSTO	209	22
ANDERSON RANCH	57	4	ISLAND PARK	43	3	SAN LUIS	160	14
ANGOSTURA	85	5	JACKSON GULCH	80	6	SATANKA DIKE	87	7
ANITA	40	3	JACKSON LAKE DAM MODIFICATION	211	23	SCOFIELD	62	5
ARBUCKLE	169	16	JACKSON LAKE DIKE	12	1	SCOGGINS	191	19
AVALON	1	1	JAMESTOWN	104	8	SENATOR WASH	184	16
BATU	MALAYSIA	23	JOES VALLEY	174	15	SHADEHILL	88	7
BELLE FOURCHE	2	1	JORDANELLE	212	23	SHADOW MOUNTAIN	63	5
BIG SANDY	98	8	KACHESE	10	1	SHEEP CREEK	140	12
BLUE MESA	147	13	KEECHELUS	16	2	SHERBURNE LAKE	19	2
BOCA	45	4	KEENE CREEK	127	10	SHERMAN	141	12
BONNY	84	7	KEYHOLE	99	8	SILVER JACK	186	17
BOTTLE HOLLOW	167	16	KIRWIN	105	8	SLY PARK	116	9
BOX BUTTE	56	5	LAHONTAN	13	1	SODA LAKE DIKE	95	7
BOYSEN	78	6	LAKE ALICE	14	1	SOLDIER CANYON	76	6
BRANTLEY	210	22	LAURO	101	8	SOLDIER CREEK	165	18
BUCKHORN	214	23	LEMON	150	13	SPRING CANYON	77	6
BULL LAKE	41	3	LEWISTON	151	13	STATELINE	200	21
BULLY CREEK	148	12	LITTLE PANOCHE	177	16	SPRING CREEK DEBRIS	156	14
BUMPING LAKE	7	1	LITTLE WOOD RIVER	133	11	STAMPEDE	187	18
CABALLO	42	3	LION LAKE DIKES	81	6	STARVATION	186	18
CACHUMA	93	7	LONG LAKE	74	6	STEINAKER	142	12
CALAMUS	204	21	LOS BANOS	175	16	STRAWBERRY	15	1
CARPINTERIA RES.	103	8	LOST CREEK	176	15	STUBBLE FIELD	112	9
CARTER LAKE	94	7	LOVEWELL	119	9	SUGAR LOAF	185	17
CASCADE	66	5	LOWER TWO MEDICINE	178	17	SUGAR PINE	202	21
CASITAS	121	9	MANN CREEK	179	16	TAYLOR PARK	38	3
CAUSEY	157	14	MARSHALL FORD DIKE	48	4	TETON	190	19
CAWKER CITY DIKE	163	15	MARTINEZ	68	5	TIETON	24	2
CEDAR BLUFF	85	7	MARYS LAKE DIKES	65	5	TOA VACA	PUERTO RICO	18
CHENEY	149	13	MASON	180	17	TRENTON	92	7
CHOKE CANYON	201	21	McGEE CREEK	207	22	TRINITY	128	10
CLARK CANYON	154	14	McGEE CREEK DIKE	208	22	TWIN BUTTES	145	12
CLE ELUM	30	3	McKAY	23	2	TWIN LAKES	196	20
CLEAR LAKE	8	1	McMILLAN	6	1	TWITCHELL (VAQUERO)	125	10
COLD SPRINGS	5	1	McPHEE	206	22	UNITY	44	3
CONCONULLY	9	1	MEDICINE CREEK	82	6	VALLECITO	52	4
CONTRA LOMA	170	17	MEEKS CABIN	181	17	VEGA	129	10
CRANE PRAIRIE	53	4	MERRITT	152	13	WANSHIP	120	9
CRAWFORD	143	12	MIDVIEW	35	3	WASCO	136	11
CRESCENT LAKE	117	9	MINITARE	18	2	WEBSTER	109	8
CURRANT CREEK	192	19	MINIDOKA	4	1	WHISKEYTOWN	146	12
CUTTER	171	18	MOON LAKE	36	3	WICKUP	54	4
DAM NO. 2	110	8	MT. ELBERT FOREBAY	194	20	WILLARD	188	15
DAM NO. 13	111	8	NAMBE FALLS	193	19	WILLOW CREEK-MONTANA	56	4
DAVIS	59	5	NAVAJO	134	11	WILLOW CREEK-COLORADO	96	7
DAVIS CREEK	215	24	NELSON DIKES	22	2	WINTERING	198	20
DEAVER	20	2	NEWTON	61	5			
DEER CREEK	49	4	NEW WADDELL	213	23			
DEER FLAT	3	1	NORTH	89	7			
DEERFIELD	60	5	NORTON	159	14			
DIAMOND CREEK DIKE	216	24	OCHOCO	90	7			
DICKINSON	86	7	OLYMPUS	83	6			
DIXON CANYON	70	6	O'NEILL FOREBAY	161	14			
DOWNS DIKE	164	15	ORTEGA RES.	106	8			
DRY FALLS (SO. COULEE)	71	6	O'SULLIVAN	75	6			
ECHO	28	3	PACTOLA	107	8			
EKLUTNA	ALASKA	16	PALMETTO BEND	195	20			
ELEPHANT BUTTE DIKE	17	2	PALISADES	113	9			
EMIGRANT	130	11	PALO VERDE	124	10			
ENDERS	72	6	PAONIA	137	11			
FLATIRON	97	7	PATHFINDER DIKE	11	1			
FONTENELLE	155	14	PICACHO NORTH	114	9			
FORT COBB	131	11	PICACHO SOUTH	115	9			
FOSS	132	11	PILOT BUTTE	27	2			
FRESNO	46	4	PINEVIEW	33	3			
FRUITGROWERS	50	4	PISHKUN DIKES	29	3			
FUNKS	197	20	PLATORO	91	7			
GLEN ANNE	100	8	PRINEVILLE	135	11			
GLENDO	118	9	PROSSER CREEK	138	11			
GLEN ELDER	162	15	PUEBLO	189	19			
GRANBY	67	5	RATTLESNAKE	102	8			
GRASSY LAKE	47	4	RED FLEET	199	20			
GRAY REEF	139	12	RED WILLOW	144	12			
GREAT CUT DIKE	205	22	RIDGES BASIN	217	24			
GREEN MOUNTAIN	51	4	RIDGEWAY	203	21			
GUERNSEY	26	3	RIFLE GAP	182	18			
HAYSTACK	122	9	RUEDI	183	18			
HEART BUTTE	79	6						

THIS DRAWING AND INDEX SUPERCEDES DRAWING No. 103 - D - 825

LOCATION INDEX
AND MAP

2.2. Location index of Reclamation's earthfill dams.

Period I (1902-1918)—Reclamation's History of Embankment Dam Design and Construction

As already mentioned, at Reclamation's emergence in 1902, the USGS's Division of Hydrography, Hydrographic Branch had been studying water resources in the West for about 20 years, developing data on potential reservoir and dam sites. The USGS had published reports such as *Reservoirs for Irrigation*,[8] authored by James D. Schuyler in 1897. When the U.S. Reclamation Service was established and given its mission of developing western water resources, Frederick H. Newell and his nucleus of engineers were transferred from the USGS's Hydrographic Branch to the Service and they quickly started work on the design of the six projects that had been approved for design and construction by the Secretary of the Interior in 1903. Work on the additional dams and projects approved for design and construction during the next few years commenced as quickly as was possible.

What was the state-of-the-art in embankment dam design and construction in 1903? Only a few books had been published in the United States that covered the design and construction of dams, including embankment dams. The first such book was *The Design and Construction of Masonry Dams*[9] written by Edward Wegmann (Member, ASCE) in 1888, followed in 1899 by his *The Design and Construction of Dams, Including Masonry, Earth, Rockfill, Timber and Steel Structures*[10]. The third important book on dams, *Reservoirs for Irrigation, Water-Power, and Domestic Water Supply*,[11] was written by James Dix Schuyler (Member, ASCE) in 1901, with a second edition in 1909,[12] which included information on the Service's Minidoka, Belle Fourche, and Cold Springs Dams. The 1909 book included chapters on: rock-fill dams, hydraulic-fill dams, masonry dams, earthen dams, steel dams, reinforced concrete dams, natural reservoirs, and miscellaneous dams, and included a total of 381 photos, figures, and illustrations.

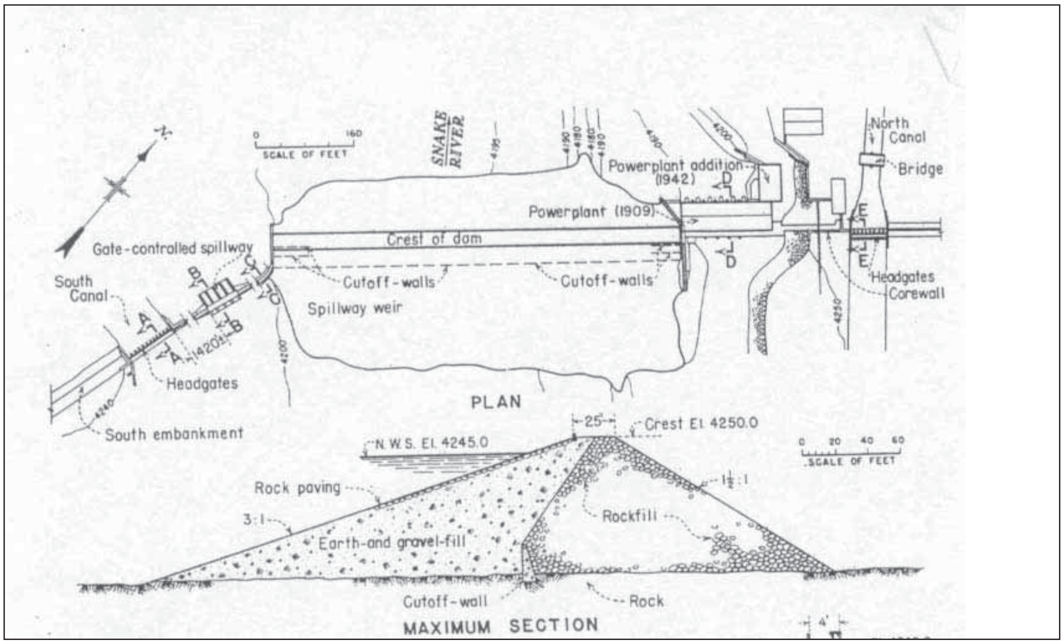
The publications of several engineering, mining, and construction organizations were the primary source of information on which embankment dam designs worked or failed, and why. These publications included: *Engineering News and Engineering Record* (both subsequently merged to form *Engineering News-Record*), *Mining and Scientific Press, Engineering and Mining Journal, Transactions of the American Institute of Mining Engineers*, and ASCE. Service engineers such as Hiram N. Savage had already written articles on dams,[13] published before the Service was created. Within a relatively short period, more books were written about dams, an increasingly important subject in the arid West. Articles about the new Service and its dams first appeared in *Engineering News* in 1903 and then in other publications like *Engineering Record, Engineering and Construction, Irrigation Age,* and *Pacific Builder and Engineer* shortly thereafter. Papers on the Service's dams began to appear in the *Proceedings* of ASCE in 1907 and of the American Society for Testing Materials in 1908 (dealing with cement and concrete work).

The Service's Chief Engineer and his initial staff of 15 (civil) engineers and related disciplines reportedly had lots of previous practical experience. Although the Denver Office was established in 1903 for the engineers and assistants from USGS, a Resident Engineer at each irrigation project was assigned to supervise the development of all phases of the project, which included investigations, design, and construction. The project plans were reviewed by a "project board" consisting of the Resident, District, and Supervising Engineers. If warranted, one of Reclamation's technical experts or a consultant would assist on a complex or difficult project. The actual records from this early period are fairly limited. Once the reservoir storage site was examined and appeared acceptable, it was used only if the observable geological conditions were "unquestionably adequate in light of past experience." Where explorations were made, they were directed at locating a competent foundation, with little consideration given to the material overlying the good foundation. Streamflow records were either short or nonexistent. Except for critical items such as gates, cement, and reinforcing steel for concrete, materials for constructing the dam, including sand and gravel for concrete, had to be locally available due to transportation difficulties.

Reclamation's first approved project was the Truckee-Carson Project, later called the Newlands Project that was located in California and Nevada. Reclamation's first constructed dam was part of that project. Truckee River Diversion Dam located on the Truckee River in Nevada, now called Derby Diversion Dam, was constructed as a combination gated concrete structure and earthfill wing embankment dam. Construction of the diversion dam and canal works began under Specifications No. 1 in 1903 and was completed in June 1905. The dam was 1,331 feet long, had a structural height of 31 feet and a hydraulic height of 15 feet, contained about 37,000 yd^3 of earthfill, and had a 3:1 upstream slope and a 1.5:1 downstream slope. The Project Engineer responsible for design and construction was Leon H. Taylor. Reclamation's first completed embankment dam, whose primary purpose was to impound a water-storage reservoir, was Minidoka Dam located on the Snake River in Idaho (see 2.3). Its construction began in 1904 and was completed in 1906 (see 2.4). It was a zoned earthfill and rockfill embankment 80 feet high that contained 257,000 yd^3 of earth and gravel fill and rockfill materials, had a crest length of 664 feet, and impounded 210,000 acre-feet of water. Minidoka Dam was designed by John H. Quinton (Member, ASCE) and was constructed under the supervision of Construction Engineer F. C. Horn.

Rolled (compacted) earthfill was generally preferred by Reclamation for embankment dam construction because of the difficulty in handling rockfill material, but hydraulic or semi-hydraulic fill construction was used in several instances. Foundation treatment varied substantially. Some of the dam foundations were excavated to bedrock, some had cutoff trenches excavated to bedrock, and some had multiple trenches. Some cutoff trenches included a concrete cutoff wall constructed into the foundation bedrock that extended up into the cutoff trench backfill. Some trenches were for drainage and some provided additional cutoffs. Two dams had pile cutoffs: one made of wood and one made of steel sheet piling; neither of them was considered very effective. Almost all of these embankment dams had one to three feet of riprap on the upstream slope.

Most of the embankment dams constructed by Reclamation during Period I were relatively small structures (by today's standards) that still took quite some time to build with the methods available at the time (Belle Fourche Dam took over 5 years). The designs for these dams, which depended on the nature of the locally available earthfill materials (and still do today), were based on a relatively limited knowledge of geotechnical engineering and the other disciplines mentioned earlier. The design standards of that time were limited: 1) an adequate foundation to support the dam, 2) an impervious core or upstream facing, and 3) a spillway capable of passing flood flows without damage to the embankment. Data on the hydrology of the drainage basins were very limited. The geology of the damsites may have been studied and documented, but its effect on the dams to be designed and constructed was probably poorly understood. The field investigation performed at the damsite and on the earthfill borrow areas was generally limited to test pits and borings of shallow depth.



2.3. Minidoka Dam plan and section.

2.4. Minidoka Dam construction.

Any laboratory testing of the anticipated earthfill materials was extremely limited by today's standards since most of the tests now performed on earthfill and rockfill materials were developed during and after the 1920s. Grain size analysis was probably performed on the soils, but only of the sand, gravel, and cobble size materials, and information on the amount of clay and silt materials was not possible until later. Darcy's Law about the rate of water-flow through a soil (its permeability) was promulgated in 1856, and it dictates how and where different types of earth materials (clay, silt, sand, gravel, cobbles, and rockfill) can be used in an embankment dam, which is still very relevant today. Early scientists, physicists, and engineers like Charles A. Coulomb (1773), Alexandre Collin (1846), and W. J. M. Rankine (1857) developed theories about earth pressure on retaining walls and tests of the shear strength of soil materials, but there were no standardized shear-strength tests performed on soil materials or analysis of slope stability as are an integral part of embankment dam design today. The Atterberg limits tests, still used today to help characterize clayey materials, were developed by A. Atterberg of Germany in 1911. In 1916 K. E. Pettersson and S. Hultin developed a slope stability analysis method to analyze the failure of a quay wall in Goteborg, Sweden, but it does not appear to have been introduced to engineers in the United States until several years later. And settlement/ consolidation behavior of soil materials was not tested, although settlement benchmarks were first installed along the edges of the embankment crest at Belle Fourche Dam in 1911. Thus, the ability to develop the necessary data and to analyze an earthfill structure like an embankment dam during Period I was very limited by today's standards.

The various types of construction equipment that existed during Period I played a large role in defining the size and height limitations placed on these early embankment dams. Excavation of foundation overburden soils (alluvium and colluvium) or borrow materials was performed by pick and shovel, horse-drawn (Fresno) scraper, dragline, and/or steam shovel. The borrow soil materials were excavated by hydraulic monitor or dredge for use in hydraulic-fill embankment dams, and by dragline and/or steam shovel for the other types of embankment dams. For relatively short distances, transportation of borrow materials to the damsite was accomplished by hydraulic pipelines or flumes in the case of hydraulic-fill dams and by horse-drawn wagons and/or scrapers for the other types of embankment dams. For longer distances, borrow materials were transported by railroads using trains of side-dump cars pulled by small "dinkey" steam locomotives. After the earthfill material was brought to the embankment and dumped, it was spread out in relatively thin (i.e., 6-inch-thick) layers using horse-drawn drags and/or graders. Water may or may not have been added to the layers of uncompacted earthfill before compaction. Each layer of earthfill was then compacted by team and wagon travel, steel-drum rollers, concrete (cylinder) rollers, and/or steam-powered engines ("traction engines" were used at Belle Fourche Dam). The use of the sheepsfoot roller for earthfill compaction was reportedly developed around 1905, but they were not used on Reclamation's dams for a while yet. Rockfill material was either placed without compaction or was sluiced with hydraulic monitors. Period I construction by Reclamation was accomplished either by government forces or by contract with a construction company.

During this early period of embankment dam design and construction, the height of dam and the foundation geology had little effect on the design of the embankment dam section. However, the type of earthfill materials available for embankment construction had a noticeable influence. Hence, depending on the nature of the earthfill materials available in the borrow area(s), the dam embankment section was either: 1) an upstream impervious zone supported by a downstream rockfill zone, 2) an upstream impervious zone supported by a downstream gravel zone, or 3) a modified homogeneous section, which included design features that modified the homogeneous performance.

Upstream Impervious Zone Supported by Downstream Rockfill Zone

Period I embankment dams utilizing this type of cross-section included: Avalon, Clear Lake, Minidoka, and McMillan Dams, and Elephant Butte Dike. Avalon and McMillan Dams, both on the Pecos River near Carlsbad, New Mexico, were actually the second or third reconstructions of earlier private dams that had failed by overtopping that breached both dams during floods. Neither dam included a transition/filter zone between the earthfill and rockfill zones, which was added to later dams of this type. Avalon Dam also had a part sheet-pile, part concrete core/cutoff wall the full height of the dam. The upstream slope of these dams was typically 3:1 that was often steepened to 2:1 above the full reservoir level, and the downstream slope was typically 1.5:1. The relatively high cost of using rockfill material with the equipment then available was the reason that few of this type of embankment dam were constructed by Reclamation. The failure of several non-Reclamation dams of this type during this period probably contributed to the decision to stop building this type of dam.

Upstream Impervious Zone Supported by Downstream Gravel Zone

Period I embankment dams utilizing this type of cross-section included: Cold Springs, Lahontan, Keechelus, and Minitare Dams, and Pathfinder Dike. The upstream slope of these dams was typically 3:1 and the downstream slope was typically 2:1, except for Minitare Dam. Minitare Dam had a 2.5:1 upstream slope to the full reservoir level, a 2:1 slope above that level, and a 2.5:1 downstream slope. Pathfinder Dike also had a concrete cutoff wall that extended above the reservoir level. The earthfill zone became thicker during the period, probably because gravel material was more difficult to use with the construction equipment then available, and because of the greater relative abundance of earthfill material. Although the mechanics of internal erosion (piping) of earthfill materials was not yet understood, dam designers did understand the nature of the problems potentially caused by seepage from the reservoir, as indicated by their efforts to control that seepage with defensive measures like cutoff trenches and walls. The designers also made the embankment's upstream impervious earthfill zones thicker than twice the hydraulic water-pressure head from the reservoir. Cold Springs Dam, constructed between 1907 and 1908, had a total of four zones in which the gravel content increased from 50 percent in the upstream zone to 67 percent, then 80 percent, and finally 100 percent in the downstream zone.

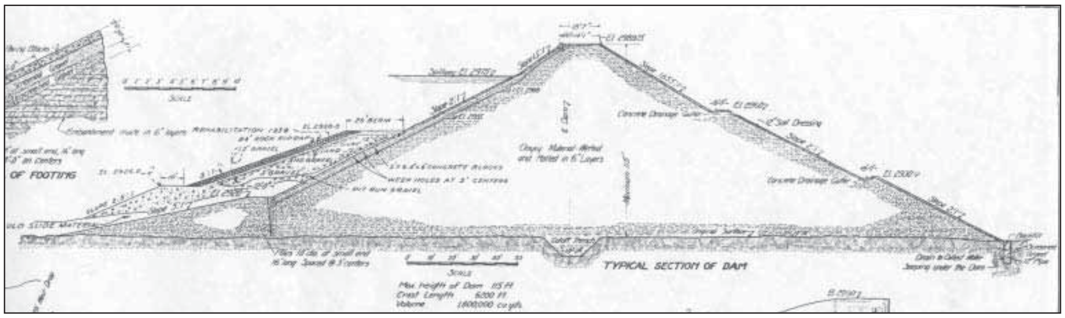
Modified Homogeneous Section

The remaining Period I embankment dams were of the "modified" homogeneous cross-section type, and they included: Belle Fourche, Deer Flat, Strawberry, and Sherburne Lake Dams. Except for Belle Fourche Dam, the other dams had 3:1 upstream slopes and 2:1 downstream slopes. Sherburne Lake Dam includes a vertical screened-gravel drain near the center of the embankment section, with this type of design detail being many years ahead of its time. Belle Fourche Dam had a "bold" (less conservative) embankment cross-section, probably due to its large size. The lower upstream slope is 5:1 to a berm, 2:1 above the berm to the full reservoir pool level, and 1.5:1 above that; and the upper downstream slope is 1.655:1 to a berm and drain gutter, and 2:1 below that level. At the time it was built, Belle Fourche Dam was reportedly the largest rolled earthfill dam constructed in the world; it is discussed in greater detail below. Strawberry Dam also had a reinforced concrete core wall that extended above the reservoir level.

Belle Fourche Dam

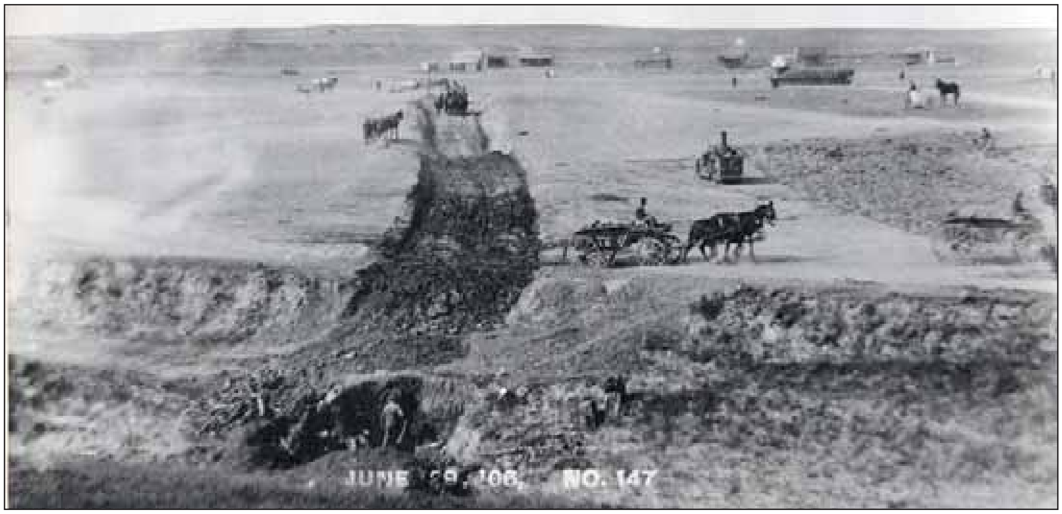
Belle Fourche Dam (locally called Orman Dam) is located on Owl Creek about 10 miles northeast of Belle Fourche, South Dakota, and was the most notable embankment dam constructed by Reclamation during Period I. The dam was constructed 115 feet high above its streambed with a crest length of 6,262 feet, an earthfill volume of 1,783,000 yd^3, impounded a 192,000 acre-foot off-stream reservoir and a water-surface area of about 8,000 acres, and was fed by a 6-mile-long canal that conveyed a maximum of 1,600 ft^3/s of water diverted by a diversion dam on the Belle Fourche River. Information on the embankment's as-built slopes is given above. The original upper slopes shown on the 1905 Belle Fourche Dam design drawings were 1:1 instead of 1.5:1 upstream and 1.75:1 instead of 1.655:1 downstream. The decision was made during construction to flatten the upper upstream slope and flatten the upper downstream slope, moving the crest downstream (see 2.5).

The greater steepness of the upstream slope, compared to the other embankments designed and built by the Service during Period I was an important difference. Construction under contract No. 73 awarded to Orman & Crook of Pueblo, Colorado, began in November 1905, but work was suspended in early 1908 when Orman & Crook went into bankruptcy. Construction resumed in April 1908 under a new contract with the National Surety Company of New York, which was the "bondsman" for Orman & Crook. The National Surety Company subcontracted with several private companies to perform the construction and the dam was completed on June 30, 1911. The total cost, including engineering, construction, cement, and general expenses, was about $1,299,000. An article on Belle Fourche Dam by Project Engineer Raymond F. Walter was published in *Engineering Record* in March 1906.[14] A second article on the dam by Resident Engineer O. T. (Oliver) Reedy (Associate Member, ASCE) was published in *Engineering Record* in April 1910,[15] describing the early plans for the project and the construction to date (early 1910) on the dam and appurtenant structures. Some of the more unique or informative details related to Belle Fourche Dam's design and construction are discussed below.



2.5. Belle Fourche Dam section.

In April 1904 a board consisting of Arthur P. Davis, John H. Quinton (consulting engineer from Los Angeles), and Charles H. Fitch (Supervising Engineer) examined the Belle Fourche Project and ordered detailed surveys of the irrigable areas, potential damsites, and canal alignments. Three dam sites were located and the final damsite was selected in May 1905. The dam foundation had been "thoroughly prospected" by both open test wells and by earth auger borings located every 200 feet along the dam's alignment. The embankment was founded on a "heavy compact clay," locally known as "gumbo," which overlies a soft slatey shale located 20 to 40 feet below the surface. There were occasional pockets of gravel encountered in the overburden layer. The dam embankment was constructed using the locally available clay obtained from borrow pits located upstream and at both ends of the dam. An expert "Engineer of Soils," Thomas H. Means came and tested the proposed earthfill material. Small scale experiments determined that this material needed an additional 7 percent water, by weight, for compaction to achieve the maximum density of the earthfill. Belle Fourche Dam was designed under the direction of Project Engineer Raymond F. Walter, with the resulting plans approved by a board of engineers consisting of John H. Quinton, C. E. Wells, Charles H. Fitch, and Raymond F. Walter, resulting in a July 5, 1905, letter in which they approved the plans and specifications, recommending "that the drawings be reduced to standard size and the specifications printed in Washington and that the work be advertised as soon as possible." The 1905-era Specifications No. 56 contained a total of 37 pages and 12 drawings used to show the dam embankment, appurtenant structures, and canals. The specifications sections included topics such as: Engineer, Changes, Sanitation, Use of liquor, Embankment construction, and Measurements. During construction, several design details related to the dam's upper slopes and the appurtenant structures had to be revised. Resident Engineers Patch and Reedy were in daily to weekly contact with Project Engineer Walter during the entire period of dam construction. Visitors (mostly engineers) from as far away as South Africa and Sweden visited the dam during construction.[16]

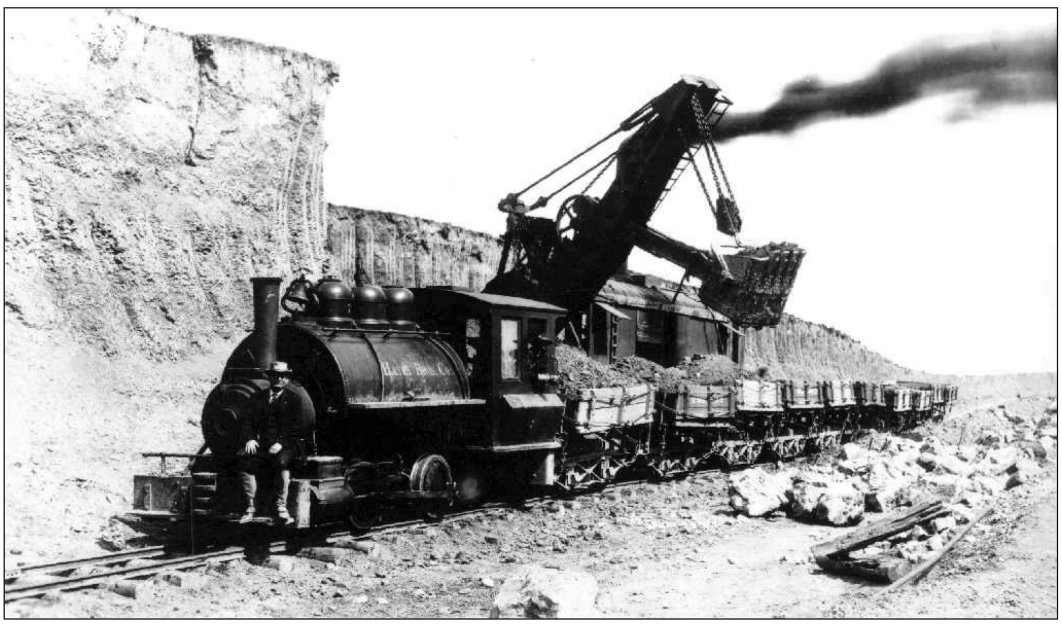


2.6. Belle Fourche Dam: Cutoff trench construction.

In August 1910 engineers from the U.S. Army Corps of Engineers (Corps) visited the dam for a few hours and subsequently informed Reclamation that they considered the dam's slopes, particularly the downstream slope to be excessively steep. Reclamation's engineers, including Project Engineer Walter and Chief Engineer A. P. Davis, developed the response to the Corps and provided a list of some 20 recently constructed embankment dams built with slopes steeper than at Belle Fourche Dam. They knew that the location (height) of the phreatic surface in the dam embankment would affect the slope stability of the embankment, so they decided to install some 2-inch-diameter vertical pipes to function as observation wells for monitoring the "plane of saturation." More details on these pipe observation wells are provided below.

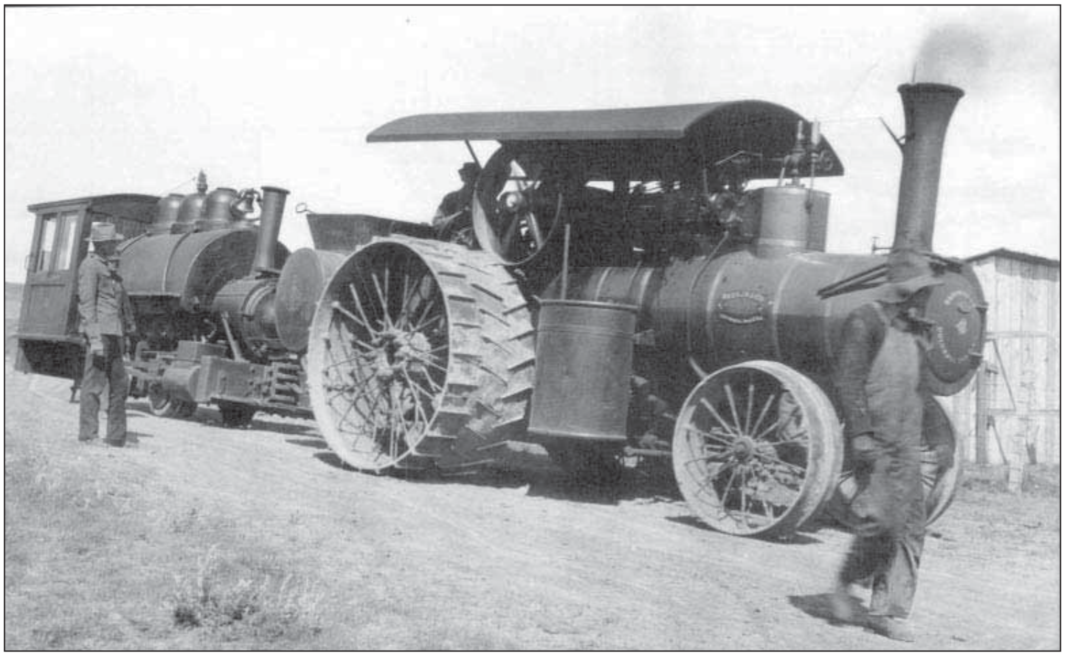
The cutoff trench was excavated by horse-drawn "wheel scrapers" and a locomotive crane, using a ½-yd^3 clamshell bucket, after which the trench was backfilled with compacted "select material" (see 2.6). The earthfill material in the borrow area(s) was excavated by 70-ton and 75-ton steam shovels with a 2½-yd^3 bucket/dipper and was dumped into the 4-yd^3 Western side-dump cars (see 2.7). The trains of 10 to 13 side-dump cars (a total of about 60 side-dump cars were used) were pulled by 18-ton Dinkey locomotives that hauled the trains about ¾-mile to the embankment, up a maximum grade of about 4 percent onto the embankment surface. The 36-inch gage train tracks and wooden ties were moved every third layer as the embankment rose in height. Three-horse-team 1¼-yd^3 dump wagons, filled by Western graders pulled by traction engines, were also used to haul earthfill from some of the upstream borrow pits.

Four-horse-team Fresno scrapers were used to move the dumped earthfill a maximum distance of 50 feet away from the tracks, and ordinary four-horse-team road graders ran over the material deposited by the scrapers to spread and level the layer (see 2.8). The layer of earthfill was thoroughly wetted, if necessary, using a 2-inch hose to apply water pumped up from wells or small reservoirs. If the earthfill was compacted immediately after being placed on the fill, little if any water needed to be applied. The specifications required that the earthfill material be placed and rolled in 6-inch layers using steam rollers weighing not less than "200 pounds per linear inch of roller rim." According to O. T. Reedy's article, one of the rollers used was a 12-ton roller with a 4-foot rolling base. According to the Belle Fourche Project History,[17] an "8-ton asphalt dirt roller with smooth wheels" was also used, but it often became stuck on the slick surface of the embankment. However, most of the compaction was accomplished by four 32-horsepower 18-ton and 21-ton traction (steam) engines, with the rear wheels having been widened to create a 6-foot-wide "rolling base." The traction engines accomplished the compaction more quickly due to their greater power (see 2. 9).



2.7. Belle Fourche Dam: Steam shovel, dinkey locomotive, and side-dump cars in borrow pit.

2.8. Belle Fourche Dam: Embankment fill construction.



2.9. Belle Fourche Dam: Traction engine hauling "dinkey" locomotive to damsite.

A somewhat unique feature of the construction of Belle Fourche Dam was a gap through the embankment in the vicinity of station 42+00 (note that the distance between stations 0+00 and 1+00 equals 100 feet) that was left open to pass Owl Creek flows through the damsite from the start of construction until it was quickly closed in 1909. The "Owl Creek Gap" (Gap) had side slopes a little steeper than 1.5:1. Flooding on Owl Creek occurred several times during construction, with a maximum flow of about 5,500 ft^3/s moving through the Gap. Earthfill cofferdams were constructed at the upstream and downstream ends of the Gap. Three cutoff trenches were excavated across the Gap that were backfilled with select earthfill material. A drainage system consisting of 4-inch tile pipes enclosed in screened gravel was constructed in the Gap's bottom downstream of the lower cutoff trench to collect and convey any foundation seepage to discharge into Owl Creek downstream of the dam. The Gap was closed using earthfill hauled to the dam by wagon and by train, which involved dumping the earthfill off a Howe truss bridge, and spreading and compacting the earthfill layers as rapidly as possible. The Howe truss bridge consisted of one 100-foot center span and two 60-foot side spans built across the Gap. The Gap fill was joined to the two existing embankments by excavating the slopes of the Gap until firm material was reached. Due to the confined area, the bottom layers of earthfill were compacted by hand tampers that could exert a pressure of 1 lb/in^2, by a wooden tamper weighing about 200 pounds operated by the locomotive crane, by the small 12-ton roller, and then by the wheels of a traction engine.

Another unique feature of the dam's design was the upstream slope protection. The nearest rock quarry was located 32 miles away and the sandstone's quality was considered poor, together causing its use to be rejected. The selected upstream slope protection consisted of 8-inch-thick concrete blocks/

slabs that measured 5 feet by 6½ feet, and weighed about 3,000 pounds each. A concrete footing wall was constructed at the bottom of the 2:1 slope and the bottom course of blocks rested against this wall. Along the center portion of the embankment, the concrete footing wall was buttressed by 10-inch-diameter 16-foot-long timber piles driven into the earthfill on 3-foot centers. The concrete blocks were placed on a 24-inch-thick bed of gravel using stiff-leg 3-ton-capacity traveling derricks with 25-foot masts and 50-foot booms operated by 20-horsepower hoisting engines. The blocks were moved into place with the derrick and were then levered and hammered into place. 2.10 shows the nearly-completed dam embankment from the right abutment.

2.10. Belle Fourche Dam: Embankment from right abutment.

The upstream slope protection at Belle Fourche Dam suffered some degree of damage by wave action almost every year due to the common, sustained high winds in the area and the 8-mile fetch (length) along the Owl Creek arm of the reservoir. A 4-foot-thick layer of grouted riprap was suggested in 1943 by Chief Design Engineer John L. (Jack) Savage (Honorary Member, ASCE), but World War II caused the work to be deferred. A 4-foot-thick layer of dumped rock riprap was constructed in 1976-1977, but the wave-erosion/beaching problem still persists in some areas on the upstream slope.

The downstream slope was finished by placing a 12-inch-thick layer of rich loam-soil dressing, which was then “seeded with a mixture of grasses recommended by the Department of Agriculture.” Concrete gutters were also placed on berms located 30 feet apart vertically, with down-slope gutters every 1,000 feet, to collect and remove runoff during heavy rainstorms.

The dam included two canal outlet works, each one well above the old Owl Creek channel, and a waste weir (spillway) at the left (north) end of the embankment. Downstream of the weir structure, the spillway channel was earth lined below which it was concrete lined. Ensign-type balanced valves were installed on the canal outlet works in 1910 and 1911. Two 58-inch valves were installed at the upstream end of the North Canal outlet works conduit and one 58-inch valve was installed at the upstream end of the South Canal outlet works conduit.

During the summer of 1910, after the reservoir had reached a maximum elevation of about 2930 feet, seepage began to surface downstream of the dam where the ground is at about elevation 2910. Borings were driven to investigate the cause and source of the seepage, which indicated a strata of disintegrated shale and gravel about 10 feet below the surface. The engineers had known about this layer of gravel, but thought it was 30 to 40 feet below the ground surface. Supervising Engineer David C. Henny of Portland, Oregon, had been brought in as a "consulting engineer" during much of the work on the dam, and he was again consulted on the seepage problem. A drainage system was advised, designed, and constructed along the downstream toe of the embankment in November and December 1910. This drainage system consisted of a trench excavated about 3 feet wide and up to 17 feet deep between stations 26+00 and 41+00 (1,500 feet), with 14-inch-diameter "telephone pole auger" wells drilled in the bottom of the trench that were backfilled with coarse screened gravel, covered by fine screened gravel and then pit-run gravel. A 12-inch-diameter vitrified clay tile pipe was placed with open joints and surrounded by coarse screened gravel (1-inch to 2-inch) and by fine screened gravel (¼-inch to 1-inch) surrounding the coarse gravel in the bottom of the trench, which was then covered with unscreened gravel and regular backfill. Manholes were constructed at several locations along the toe drain—using 2-foot-diameter vitrified clay pipe. The outflow from the drainage system reached a maximum of 45 to 50+ gal/min, which varied with the reservoir water surface elevation. The flow from this drainage system has been monitored ever since, and constitutes the longest continuous monitoring performed on one of Reclamation's embankment dams.

In late 1911, a series of 2-inch-diameter open-end pipe (observation) "wells" were installed in the embankment in the vicinity of stations 37+00 and 38+00 to determine the "plane of saturation" (phreatic surface) and to obtain data on its movements with reservoir fluctuations. A wash-boring apparatus was used to drill the holes into which the pipes were installed; 34 wells were constructed, ranging in depth from 10 to 90 feet. These were the first "instruments" installed in a Reclamation embankment dam for the purpose of monitoring the porewater pressures in the dam and/or foundation. A few of these observation wells are still monitored, making them the longest continuously monitored instruments of that type. Their rate of response to reservoir fluctuation is very slow (about a 2-year lag time) due to the relatively large diameter of the 2-inch pipes and the very low flow rate (permeability) of the seepage percolating through the gumbo-clay embankment. Also in 1911, a set of iron benchmarks was installed every 300 feet along the embankment crest to monitor its settlement, also the first of that type of instrumentation installed on a Reclamation dam. Belle Fourche Dam was quickly turned into the most instrumented embankment dam built by Reclamation between 1902 and 1911.

The 90-year-long performance of Belle Fourche Dam has been quite an interesting story. The concrete paving blocks protecting the upstream slope have suffered storm damage fairly frequently, which is why that type of slope protection was not used after the construction of Minitare Dam in 1915. In 1928, after 17 years of acceptable embankment performance, parallel cracks several hundred feet long occurred on the embankment crest between stations 27+00 and 31+00, and they occurred close to the upstream slope. This led to an investigation and exploration shafts; the cracks were up to 3 inches wide and up to 12 feet deep. The resulting judgement was that drying out of the embankment was the cause. Other cracks had also been reported in the vicinity of station 39+00 to 46+00. Then on August 2, 1931, after a fairly rapid drought-caused reservoir drawdown of 27 feet in 60 days, part of the upstream slope failed, resulting in a slump about 610 feet long between stations 40+50 and 46+60. The slide mass averaged a thickness of 9 to 10 feet and extended from about elevation 2962 down to the base of the 2:1 slope at elevation 2920. Several factors contributed to this slide, but the steepness of the upstream slope, the (low) shear strength of the as-constructed "gumbo" clay embankment material, the low permeability of the "gumbo" clay material, and the rapid reservoir drawdown were the primary factors that caused the failure.

The slope failure was quickly examined by Reclamation's engineers, including Chief Design Engineer Savage on August 12th. Plans for reconstruction of the upstream slope were agreed upon. On August 24th, a ¾-yd^3 dragline began building an access ramp into the slide and began to remove the concrete blocks. A total of 20,320 yd^3 of the slumped embankment material and gravel bedding was excavated by a larger dragline with a 50-foot boom and a 1¾-yd^3 bucket, making sure to dig at least 1 to 2 feet below the "lowest slip plane," and placing the material in stockpiles to one side for reuse. The embankment was then rebuilt by several pieces of equipment. The larger dragline picked up a half-bucket of gravel, then filled the bucket with stockpiled embankment material, and dumped the material into the excavation where it was hauled and spread in 6-inch layers by Caterpillar tractors pulling Fresno scrapers. These layers were then compacted by rollers pulled by the Caterpillar tractors. The initial attempts to use concrete rollers for compaction encountered difficulty when the roughness of the roller prevented it from being properly cleaned. An "iron mule" loaded with one yard of gravel was tried, but it was too slow. They then tried an old printing press roller, for which they had to make a pulling device, and filled the roller with concrete. This smooth roller allowed the use of cleaning scrapers and it worked well pulled by a "Fifteen" (horsepower) Caterpillar tractor. A total of eight Caterpillar tractors were used, ranging in size from fifteen to forty horsepower. The most effective "dirt mover" was a "Thirty" Caterpillar tractor pulling a 1½-yd^3 Fresno scraper. Up to three working shifts were used due to the approach of winter. Once the embankment was rebuilt, the gravel bedding was rebuilt and the concrete paving blocks were placed back on the upstream slope.

After the completion of this reconstruction, Reclamation proceeded during the remainder of the 1930s to drill, sample, install piezometers (for monitoring water pressure) in the dam embankment and foundation, and then conduct a laboratory investigation of the Belle Fourche Dam embankment material in one of the most comprehensive laboratory investigations conducted up to that time. That work was followed by a (then) state-of-the-art analysis of the upstream slope stability. Finally, in 1939, a 25-foot-wide earthfill berm was constructed to improve the stability by buttressing the upstream slope. The berm sloped at 3:1 and included a 3-foot-thick layer of well-graded ¼-inch to 3-inch gravel that was placed against the existing dam embankment to provide drainage. The berm included earthfill material similar to the original embankment material, but it was enclosed in gravel for drainage. The earthfill material was placed in 6-inch lifts and was compacted by 12 passes of a tamping roller. The tamping rollers were to be configured such that they had one ball foot or knob for each square foot, a knob end area between 5 and 7 in^2, produced a knob pressure of not less than 300 lb/in^2, and were equipped with roller cleaners. The berm was surfaced with 24 inches of riprap placed on 12-inches of gravel bedding. Weep holes were also drilled on 5-foot centers through the concrete paving slabs for drainage purposes. The embankment section shown in 2.5 includes this upstream berm. The concrete paving slabs on the upstream slope continued to be damaged by wave action, and in 1976-1977, the upper portion of the upstream slope was rebuilt to provide 4 feet of riprap slope protection on a 2.33:1 slope from the top of the 1939 berm (elevation 2950) to the embankment crest (elevation 2990). Longitudinal cracks have continued to appear on the dam crest into the 1990s, and the rate of reservoir drawdown continues to be carefully controlled in order to prevent further drawdown-induced slope instability.

Belle Fourche Dam is a truly amazing and unique early embankment dam in Reclamation's history. ASCE designated Belle Fourche Dam a National Historic Civil Engineering Landmark in 1988, and (somewhat surprisingly) it is Reclamation's <u>only</u> embankment dam so honored. Many of the design details and construction procedures developed and utilized at Belle Fourche Dam starting 97 years ago are still used by Reclamation engineers today, especially some of the innovative design and construction concepts.

Period II (1919-1933)—Reclamation's History of Embankment Dam Design and Construction

Reclamation engineers had helped advance the state-of-the-art in embankment dam design and construction during Period I. Reclamation's reputation grew as the numbers of its successful projects increased throughout the West. Reclamation received more and more publicity in the articles and papers published in western newspapers, magazines, and professional journals to which Reclamation's engineers contributed their experience, innovations, and new design ideas.

Reclamation's engineering design groups had been centralized and were better organized in the Denver Office, and they produced designs for new projects and dams at a high rate. Respected civil engineers like J. L. Savage, who had started his career with Reclamation on the Minidoka Project in 1903, had joined the new Denver Office staff as a Design Engineer in 1916 and was subsequently promoted to Chief Design Engineer in February 1928. The Chief Engineers during Period II were Arthur P. Davis (also serving as Director of the Service until 1923), Frank E. Weymouth, and Raymond F. Walter.

The embankment dams designed and constructed during Period II were larger and the designs were more varied. Consultants were used extensively during Period II, although the list of dams constructed during this period is fairly small. Most of them were built with homogeneous sections, had little foundation treatment of note, and generally had 3:1 upstream and 2:1 downstream slopes. Early in this period, the 40-foot-high Salmon Lake Dam was constructed between 1919 and 1923 on Salmon Creek as part of the Okanogan Project in Washington state. It was Reclamation's first embankment dam that utilized a central impervious (sandy loam) core and a flattened downstream toe or "tail" with 5:1 and 10:1 slopes. It was also the first dam to be constructed on a "questionable" foundation (sand and clay of unknown depth). The base of the impervious core was widened, and in the bottom of the 8-foot-wide cutoff trench located 25 feet upstream of the dam crest, Wakefield sheet piling 38 feet long was driven into the foundation with part of the sheet piles extending up into the core. Note that these embankment design changes were included on a relatively small dam.

Several other notable embankment dams were designed and constructed during Period II. These included: Sherburne Lake, Tieton, McKay, Guernsey, American Falls, Echo, and Cle Elum Dams. Most of the embankment dams constructed during Period II were compacted earthfill structures, with some semi-hydraulic fill dams built too, such as Tieton Dam. Most of them were built on rock foundations that required the excavation of the overburden soils. Some of these dams included reinforced concrete core walls the full height of the reservoir, such as at Tieton and American Falls Dams. Sherburne Lake Dam, completed in 1921, included a vertical zone of screened gravel located beneath the downstream edge of the crest intended to prevent saturation of the downstream embankment material. This was one of the earliest uses of a "chimney drain" inside an embankment dam to control the phreatic surface and porewater pressures.

Tieton Dam, completed in 1925 with a maximum height of 185 feet above the streambed, was the highest embankment dam built by Reclamation during Period II. It was the first Reclamation dam designed on the basis of a stability analysis, and the soil's shear strength characteristics were assumed on the basis of the material's angle of repose. A concrete core wall 10 feet thick was excavated down a maximum of 134 feet through river-channel deposits and 10 feet into bedrock. This foundation wall was constructed by mining out vertical shafts driven to bedrock and horizontal side drifts, forming a wall within the foundation. The core wall foundation was also pressure grouted using five holes each 22 feet deep in one of the first such applications (the maximum grout take was only one sack per foot). Grout is generally a mixture of cement and water, and possibly sand, bentonite, and other materials. According to *Design of Small Dams*

(p. 195), "Foundation grouting is a process of injecting under pressure a fluid sealing material into the underlying formations through specially drilled holes to seal off or fill joints, fractures, fissures, bedding planes, cavities, or other openings." The Tieton Dam embankment included a puddled-clay core one-third the thickness of the hydraulic head constructed against the upstream side of the concrete core wall. The remainder of the dam was constructed using the semi-hydraulic fill method in which the earthfill is dumped at the upstream or downstream embankment shoulder and is sluiced with jets of water, washing the fines into the center pool.

McKay Dam, completed in 1926 with a maximum height of 160 feet above the streambed, rested almost entirely on bedrock and was constructed of compacted sand and gravel. The upstream slope at 1.75:1 is the steepest ever constructed on one of Reclamation's embankment dams and was covered with a monolithic concrete slab tied to bedrock with a concrete cutoff. Three cutoff walls were constructed across McKay Dam's foundation contact, and the foundation beneath each of the walls was grouted. Steps were cast into the upper part of the upstream concrete facing to break up the wave runup (unlike the smooth concrete-panel facing at Belle Fourche Dam). The concrete facing was very hard to construct and the construction engineer advised against using that design again.

Guernsey Dam, completed in 1927 with a maximum height of 105 feet above the streambed, rested on a pervious foundation of unknown depth. Because of the foundation, the embankment section included an upstream "blanket" and a large downstream rockfill. The central portion of the embankment included an inclined impervious core zone confined by zones of sluiced sand and gravel located upstream and downstream of the core. This was the last hydraulic fill embankment constructed by Reclamation. A new concept used at Guernsey Dam was the incorporation of the upstream cofferdam into the embankment section. A partial cutoff trench was excavated and backfilled with the impervious earthfill.

American Falls Dam, also completed in 1927 with a maximum height of 75 feet above the streambed, was a combination concrete gravity and earthfill structure. The bedrock foundation beneath its reinforced concrete core wall was grouted.

Echo Dam, completed in 1931 with a maximum height of 130 feet above streambed, was another zoned embankment. The central core consisted of compacted clay, silt, sand, and gravel; the zones upstream and downstream of the core consisted of sand and gravel; and the downstream toe zone consisted of conglomerate rockfill rolled in 12-inch layers. The excavated cutoff trench was about 25 feet deep to bedrock and included a concrete cutoff wall. The cutoff trench was located well upstream of the central core and was connected to it by a thick blanket of the compacted core material. The earthfill materials were hauled to the damsite using gasoline-powered trucks, the first such use on one of Reclamation's embankment dams. Compaction of the embankment materials was accomplished using a sheepsfoot-type tamping roller for the first time on a Reclamation dam. The sheepsfoot tamping roller was an important development in the evolution of earthfill compaction because of the kneading action produced by the steel knobs or "feet" fabricated around the roller drum. Water and/or sand were usually placed inside the steel drum to increase its weight and thereby the amount of stress applied by the ends of the feet during compaction.

Cle Elum Dam, completed in 1933 with a maximum height of 135 feet above the streambed, was the first instance in which a sheepsfoot tamping roller was specified to be used for embankment compaction (it was used, but was not specified, on Echo Dam). Cle Elum Dam was the last dam designed using just empirical rules and the last one constructed without earthfill testing to verify the quality of the as-built earthfill materials, to evaluate construction practices, and to confirm design assumptions.

Dams generally put more people at risk than any other type of civil works structure. Dam failures tend to be catastrophic, which causes them to be studied very thoroughly to try to explain why the failure occurred and to avoid repeating any mistakes. The dramatic failures of dams like St. Francis Dam at about midnight on March 12, 1928, near Los Angeles, California, tended to produce important changes in the practice of dam engineering. By the end of 1929 several states had enacted laws placing the construction and maintenance of non-Federal dams that imperil the lives and property of others under the supervision and control of the state engineer or other authorized official. With embankment dams, the need to explain why a dam failed when the same basic design had worked elsewhere was a major concern to all civil engineers, as well as the general public. As civil engineering evolved, the increasing knowledge of the engineering design of certain materials (such as wood, steel, and concrete) that are used in constructing civil structures (such as buildings, bridges, and dams) generally improved the overall record with respect to reducing the incidence of structural failure. However, the failure rate with respect to embankment dams did not seem to keep pace with the evolution of those other civil engineering structures, and remained of great concern into the 1920s and 1930s. In general, Reclamation had a very good record with respect to its embankment dams. However, Reclamation's record was not perfect, as evidenced by the rapid drawdown failure of the upstream slope of Belle Fourche Dam in August 1931. While this slumping of the upstream slope material did not breach the dam or release the reservoir, the steep slope did become unstable, and it did fail.

In the years just after World War I, several European engineers began to specialize in the mechanics of soil and rock materials, and thereby began the field that has become geotechnical engineering. Dr. Karl Terzaghi (Honorary Member, ASCE) is generally considered the father of soil mechanics (geotechnical engineering). According to *Karl Terzaghi—The Engineer as Artist* by Professor Richard E. Goodman,[18] Karl Terzaghi graduated from the Technical University of Graz in 1900 with a degree in mechanical engineering, having resisted his grandfather's civil engineering profession. However, after a short stint working as a mechanical engineer, Karl Terzaghi switched and began his lifelong career in civil engineering. After receiving his Doctor of Technical Sciences degree from the Technical University of Graz in 1912, Dr. Terzaghi visited the United States for the next two years. He quickly found his way to a meeting with Service Director F. H. Newell and immediately began an extensive tour of Reclamation projects and dams then under construction. Back in Europe, Dr. Terzaghi began to study the mechanics of soils toward the end of World War I in 1917, working on the problem of earth pressure against retaining walls that had been worked on earlier by Coulomb and Rankine. Dr. Terzaghi's work (in German) was first summarized (in English) in *Engineering News-Record* in 1920, which wrote an editorial preface declaring that characterizing earth as an engineering material is "the outstanding research problem in civil engineering" and that Terzaghi's article "heralds the opening of an avenue of progress." He completed the manuscript for *Erdbaumechanik (Principles of Soil Mechanics)* in April 1924 and, after it was translated from German to English, it was circulated widely in the United States by John R. Freeman (Honorary Member, ASCE). The Massachusetts Institute of Technology quickly offered Dr. Terzaghi the opportunity to develop a graduate course in foundations and soil mechanics. Because of Professor Terzaghi's background and expertise in geology, the "marriage" of geotechnical engineering and geology has been one of his more important achievements. Professor Terzaghi continued to lead in the development of the new field of soil mechanics and foundation engineering in the United States, with a continued special interest in dams until his death in 1963. (In his memory, Mission Dam in British Columbia, Canada was renamed Terzaghi Dam in 1965.) Briefly described, thus began what is now geotechnical engineering. The birth of geotechnical engineering as it relates to embankment dams "arrived" at ICOLD's First Congress on Large Dams meeting in 1933 at Stockholm, Sweden, which was quickly followed by ICOLD's Second Congress on Large Dams meeting in 1936 at Washington, D.C. Reclamation engineers participated in both of these meetings, including Commissioner Mead and Chief Design Engineer Savage.

Reclamation's first engineering publication, entitled *High-Pressure Reservoir Outlets—A Report on Bureau of Reclamation Installations* by J. M. Gaylord, Electrical Engineer, and J. L. Savage, Designing Engineer, was published in 1923.[19] This book of 179 pages included information and reproductions of drawings on the outlet works designed for and constructed at many Reclamation dams, including Minidoka, Belle Fourche, Strawberry, Lahontan, Minitare, Jackson Lake, Sherburne Lake, and McDonald Dams (McDonald Dam was designed and constructed by the Service under an agreement with Interior's Indian Affairs Office). A second engineering publication, entitled *Dams and Control Works*, was published by Reclamation in 1929.[20] This book of 164 pages included information written by Reclamation engineers on various diversion and storage dams, including Tieton, McKay, Guernsey, American Falls, and Echo Dams. A section of miscellaneous articles presented information on topics such as: "Corewalls for Earth and Rockfill Dams," and "Design and Construction of Small Earth Dams." And the Appendix included a reprint of the recent specifications on Echo Dam. Included in the article on "Design and Construction of Small Earth Dams" was a material placement recommendation for two-zone embankment dams. This recommendation called for placement of the selected water-tight material in the upstream portion of the dam, and of the heavy, stable, free draining material such as sand, gravel, and stone in the downstream portion, distributed such that the coarser material was placed on the downstream slope, changing gradually to the finer and more claylike material as the impervious material in the upstream portion of the dam was reached. The importance of the proper placement of soils with fine-grained vs. coarse-grained gradations within a dam embankment became much better understood subsequently in the 1940s and 1950s.

Field and laboratory testing of soil and rock materials also began to emerge during the 1920s and early 1930s. In addition to the pioneering soil mechanics work by Dr. Terzaghi on topics such as soil permeability, others contributed greatly to the evolution of soil and rock testing in the attempt to characterize these materials. Reclamation's Earth Materials Laboratory was established in Denver at the U.S. Customs House in the fall of 1933. The primary duties of the new Earth Materials Laboratory "were to determine the characteristics of proposed embankment and foundation soils, to work with the design section in planning field control tests on the foundation and compacted embankment, and to train construction inspectors in the test procedure."[21] While the subject of soil compaction and optimum moisture content had been written about as early as 1907, Ralph R. Proctor developed a soil test procedure in 1933 that established the principles of soil compaction and moisture content and their application. A four-article series was published by *Engineering News-Record* beginning on August 31, 1933. Proctor's compaction control test standard was quickly adopted by every engineer and organization involved with embankment dams, which was a major milestone in the history of embankment dam design and construction. In addition to performing Proctor's density test, Reclamation's Earth Materials Laboratory used or developed a variety of soil testing equipment and procedures, which included mechanical (grain size) analysis, penetration resistance (on compaction specimens), percolation and settlement, consolidation, shear strength, specific gravity, and soluble solids. The laboratory also began to conduct studies and experimentation on different methods of compaction, on the percolation rates in different soils, on porewater pressure movement through different soils, and on consolidation rates of different soils. The rapid drawdown failure of the upstream slope at Belle Fourche Dam in 1931 indicated that there was still a lot for Reclamation's engineers to learn about soil mechanics and earthfill embankments.

As Period II began, World War I advances in mechanized equipment such as tanks and trucks led to the post-war development of new construction equipment. Gasoline engines were now used to power 5-ton trucks for hauling earthfill materials more quickly and with greater economy. The new 15-horsepower Caterpillar tractor was introduced and could be used to pull a roller for earthfill compaction, a Fresno scraper for moving earthfill, or a bulldozer for excavating and moving earth materials. Further development of larger-sized engines lead to more powerful Caterpillar tractors and other construction equipment during Period II. As discussed on Echo and Cle Elum Dams, the use of sheepsfoot tamping rollers for compacting earthfill materials on Reclamation's embankment dams began in the late 1920s and early 1930s.

Period III (1934-1944)—Reclamation's History of Embankment Dam Design and Construction

Reclamation's state-of-the-practice in embankment dam design and construction at the beginning of Period III had developed to a fairly high degree of sophistication. Reclamation's projects and dams were often written about in publications like *Engineering News-Record* and its engineers' papers were often published in *ASCE's Transactions*. Reclamation's reputation and those of its engineers were well established in the West and the United States. Reclamation's evolution in concrete dams peaked during Period III with the design and construction of Hoover Dam. While the concrete dams received more notice nationally and worldwide, Reclamation designed and constructed several milestone embankment dams during Period III.

Reclamation's centralized engineering design and construction organization and the Chief Engineer in the Denver Office were well established and empowered. Reclamation's Chief Engineers during Period III were Raymond F. Walter (mentioned earlier under Period II) and Sinclair O. Harper, and J. L. Savage remained the Chief Design Engineer during the entire period.

The embankment dams designed and constructed during Period III involved some revolutionary changes and they were larger and more numerous than ever before. At about the same time, testing of earth materials, construction testing for compaction and moisture control, and engineering design specialization all became part of Reclamation's embankment dam design and construction process. The installation of performance monitoring instruments in Reclamation's embankment dams became standard procedure during this period.

Data from laboratory testing, construction control testing, and performance measurements obtained on Reclamation's embankment dams were collected and analyzed by the specialized embankment dam design group, which determined that soil as a construction material was extremely variable and very sensitive. The data also indicated that the performance characteristics of many types of ordinary soil could not be adequately defined by the existing tests and procedures. Hence, the earthfill construction practices then in use would not necessarily produce the desired consistent performance. While attempting to solve these concerns and problems, the successful empirical design and construction practices historically used with success by Reclamation continued to be followed. Government regulations covering concerns such as working hours, transportation of equipment, safety, and wage rates became part of the process.

Many notable embankment dams were designed and constructed by Reclamation during Period III. These included: Hyrum, Pineview, Agency Valley, Rye Patch, Taylor Park, Moon Lake, Alcova, Caballo, Bull Lake, Midview, Fresno, Green Mountain, Deer Creek, Vallecito, and Anderson Ranch Dams (the latter dam wasn't actually completed until 1947). All of these embankment dams were constructed as compacted earthfill structures. The dams had upstream slopes ranging from 3:1 to 3.5:1 with flatter slopes at the (upstream) toe where material needed to be wasted, and had downstream slopes ranging from 2:1 to 2.5:1, similarly with flatter slopes at the (downstream) toe. These dams were built on a variety of foundations; almost all of them included a cutoff trench excavated down through the overburden soils to bedrock and quite a few of them included concrete cutoff walls in the bottom of the cutoff trench. The cutoff trenches moved toward the center of the dam. The rock(fill) material produced from required excavations, that was unsuitable for use as upstream riprap, was often placed on the downstream slope of the embankment.

Pineview Dam, completed in 1936 with an initial maximum height of about 55 feet above streambed, included a steel sheet pile cutoff in the foundation, which was later determined to be ineffective, causing little if any porewater pressure drop in the seepage percolating downstream. The dam's crest was raised about 29 feet in 1955.

Taylor Park Dam, completed in 1937 with a maximum height of 167 feet above the streambed, was constructed as an embankment dam at a good concrete damsite because of its remoteness. Comparative cost estimates were developed for both types of dam, and they indicated little difference in cost. Contractors were allowed to submit alternative bids, and an embankment dam was the low bid. This reportedly indicated that earthfill construction had developed to the point where it could be cost competitive with concrete dam construction at a damsite suited to either type of dam. A large rockfill zone mantles the downstream slope.

Alcova Dam, completed in 1938 with a maximum height of 185 feet above the streambed, was a fairly complex embankment dam. The foundation consisted of sedimentary rock dipping downstream that had quite different permeabilities, artesian pressure in one bedrock layer, and hot sulfurous groundwater. An extensive "U"-shaped grout curtain was constructed in the foundation and up the abutments to control seepage and uplift. A concrete gallery was constructed on top of the excavated bedrock to provide access for drilling drain holes and to perform additional foundation grouting if the need arose. Alcova Dam was thoroughly instrumented with the new hydrostatic pressure indicators at three sections of the embankment to monitor porewater pressures. A large rockfill zone mantled the downstream slope.

Fresno Dam, completed in 1939 with a maximum height of 75 feet above the streambed, was built on a very soft foundation of questionable strength. Consolidation of the foundation and settlement of the embankment became major problems as construction progressed. A theoretical approach and the results of plate bearing tests of the foundation were used to estimate the total settlement, which was estimated to be relatively minor. However, the actual settlement has been in excess of 8 feet, about half of which occurred during construction. The base of the dam embankment was widened, primarily to avoid abrupt changes in the stress in the foundation and to distribute the load from the embankment. Piezometers were installed in the embankment for the first time to monitor the development of construction porewater pressures in the earthfill. The control of embankment compaction and earthfill moisture content proved to be effective in controlling the earthfill porewater pressures.

Green Mountain Dam, completed in 1943 with a maximum height of 274 feet above the streambed, was the highest embankment dam yet built by Reclamation. Collectively, Green Mountain, Deer Creek, and Vallecito Dams marked Reclamation's initial use of geological data in formulating the embankment dam's design. The alignment of Green Mountain Dam was shifted downstream to avoid an old landslide in the left abutment. The upstream foundation was excavated to bedrock to remove potentially unstable foundation material. Shale bedrock unexpectedly deteriorated rapidly on exposure to the air, which was addressed by spraying an asphalt coating on the shale immediately after it was cleaned off. This procedure became standard practice on Reclamation dams whenever shale is encountered. The borrow material was processed to remove the cobble-size (plus 3-inch) particles from the earthfill used to construct the embankment. The compacted earthfill at Green Mountain Dam achieved the highest dry density yet at 132 lb/ft^3. Even at this high density, construction-induced porewater pressures in the embankment caused by the weight of the fill were excessive. Studies were begun to discover what could be done to avoid this effect, with the finding that slight reductions in moisture content in the earthfill caused a marked reduction in the earthfill porewater pressures. Construction practices on Reclamation's embankment dams were changed accordingly.

Anderson Ranch Dam, started in 1941 and completed in 1947 with a maximum height of 344 feet above the streambed and with a cutoff trench excavated a maximum of 112 feet to bedrock, set a new record as the World's highest embankment dam. The scheme developed on Green Mountain Dam to carefully control the earthfill moisture content to avoid excessively high porewater pressures was followed on Anderson Ranch Dam, but it wasn't until near the end of construction that the moisture content control effort effectively controlled the porewater pressures. The designed upstream and downstream slopes gradually flatten from crest to toe, going from 3:1 to 3.5:1 on the upstream slope and from 2:1 to 2.5:1 to 8:1 on the downstream slope. This was done in an attempt to balance the cost savings from minimizing the embankment volume (steeper slopes) vs. the need to maintain adequate slope stability (flatter slopes). In 1941, the design of the embankment slopes on Anderson Ranch Dam was based with some confidence on the results of the slope stability analyses and the earthfill strength data developed by Reclamation's Earth Materials Laboratory. The contractor on Anderson Ranch Dam introduced a number of innovations during construction, including the use of a belt conveyor system for transporting the borrow material to the embankment, with facilities for adding moisture to the material moving along the belt conveyor.

After Dr. Terzaghi and others began to develop geotechnical engineering during Period II, and after the First and Second Congress on Large Dams meetings in 1933 and 1936, Reclamation's engineers joined the national and worldwide efforts in advancing the new field as it related to embankment dams. Reclamation continued to develop and make available information on its engineering work. A second edition of *Dams and Control Works* was published in February 1938.[22] This soft-cover 261-page book, again written by Reclamation engineers, contained three parts: One: Storage Dams; Two: Diversion Dams; and Three: Special Articles. Part 3 still included an article by engineer F. F. Smith on "Design and Construction of Small Earth Dams." Paragraph 5 of that article contains the statement:

> Among Engineers charged with the responsibility for the safety of large earth dams, it is appreciated that the outworn empirical methods have given way to thorough preconstruction investigations, careful theoretical design, and construction on known and definite principles of soil mechanics.[23]

A figure in the article on page 254 portrays "Methods of Zoning Earth Dams," and notes that zones 2 and 3 (zone 2 flanks the zone 1 impervious core and zone 3 is located between zone 2 and the rockfill zone on the downstream slope) "are roughly graded from fine material at the inner slopes to coarse at the outer slopes." This grading from finer grained material at the zone 1 core to coarser grained material toward the outer slopes was generally used on Reclamation's embankment dams, and provides the filtering action necessary to prevent soil "internal erosion" (piping). Dr. Terzaghi seems to have started the work to develop rational filter criteria. The results of his work and the research work by George E. Bertram with the assistance of Dr. Terzaghi and Professor Arthur Casagrande (Honorary Member, ASCE) resulted in a paper by Bertram[24] that is generally given the credit as the first document on filter criteria. The Corps conducted its own research into filters in the early 1940s.

Field and laboratory testing of soil and rock materials continued to be refined in response to the need of designers to better characterize those materials for potential use in embankment dams. As noted above in the discussion of Anderson Ranch Dam, the Earth Materials Laboratory was able to provide the engineering data necessary to optimize the design of the embankment slopes to be constructed.

Reclamation's instrumentation for and monitoring of embankment dams continued to be improved, with the development and installation in 1935 of 13 water level indicators (WLI) at Hyrum Dam and 12 more WLIs at Agency Valley Dam. The water level indicators were a combination manometer and piezometer, but it was not sufficiently accurate. This led to the development of the hydrostatic pressure indicator (HPI), a modification of the Goldbeck cell, which were installed at Caballo Dam, Alcova Dam, and several other dams in 1938 and 1939. The hydrostatic pressure indicator used a thin gold-plated monel-metal diaphragm, which used air pressure on one side to balance and measure the porewater pressure on the other side of the diaphragm. The HPIs were installed in the embankment as it was constructed, and copper tubing was run in trenches from the instrument to the embankment surface where a recording apparatus could be attached and operated to measure the porewater pressure. Reclamation developed the more-rugged hydraulic piezometer that could be installed in either the foundation or the embankment; the first 72 hydraulic piezometers were installed at Fresno Dam in 1939. Reclamation also developed the internal vertical movement device, which was first installed at Caballo Dam in 1936. The device was installed as the embankment was constructed and allowed the vertical consolidation behavior of the embankment to be measured at 5- or 10-foot intervals and also measured the settlement of the foundation at the bottom.

During Period III the equipment available for the construction of embankment dams continued to improve in size, power, speed, and efficiency. The rockfill zones included in these dam embankments could now be constructed because the construction equipment now permitted the handling of larger and larger sizes of rock particles, which were usually obtained from the required excavations for the outlet works and/or spillway. The improved construction equipment and improved techniques for dewatering below the groundwater table allowed the excavation of cutoff trenches through overburden soils to become larger and deeper where necessary.

Period IV (1945-1975)—Reclamation's History of Embankment Dam Design and Construction

Reclamation's state-of-the-practice in embankment dam design and construction at the beginning of Period IV had developed to quite a high degree of sophistication. Reclamation's projects and dams were generally written about in engineering and construction publications as indicative of the state of the practice. The reputations of Reclamation and its engineers continued to grow as more milestone embankment dams were designed and constructed during Period IV. Reclamation's Chief Engineers during Period IV were Walker R. Young, Leslie N. McClellan, Grant Bloodgood, (both McClellan and Bloodgood were also Assistant Commissioners), Bernard P. Bellport, and Harold G. Arthur (both Bellport and Arthur were also titled Director, Office of Design and Construction).

The embankment dams designed and constructed during Period IV generally involved more difficult and complex damsites than had been built on before, and the resulting designs were more complex. After World War II, a new rush of dam construction occurred because of the delays caused by the war. The multi-purpose dam and project came into being at Reclamation, expanding its previous focus on irrigation projects and storage dams. Significant improvements were made to the construction equipment available at the start of Period IV.

Laboratory testing of earthfill materials saw new improvements in the quality and size of the apparatuses and instrumentation available for conducting soil and rock testing, aided especially by the introduction of computers for automated data acquisition during testing. Starting around 1957, Reclamation started to use computers in laboratory testing and in the analysis of slope stability. Larger sizes of testing equipment allowed research and development of data on the effects of larger-size particles on the shear strength of the true matrix of earthfill materials being used in embankment dams. The improved instrumentation used in monitoring the testing allowed them to be run more slowly and allowed for the measurement of porewater pressures generated during shearing of the saturated specimens. Reclamation's research into filters was conducted by K. P. Karpoff, which led to *The Use of Laboratory Tests to Develop Design Criteria for Protective Filters* published in 1955.[25]

In October 1961 Waco Dam in Texas, a Corps dam, suffered a slope failure during construction that dropped the crest 18 feet vertically and caused horizontal movements of up to 26 feet downstream. The slope failure was caused by a combination of high porewater pressures in the foundation clay shale generated by the weight of the overlying embankment that were transmitted through a sand layer and the failure of the low shear strength clay-shale foundation. Research on testing the Waco Dam foundation clay-shale material and improvements in slope stability analyses resulted from that event (this became important to Reclamation at the end of Period IV and the beginning of Period V).

Sheffield Dam near Santa Barbara, California, had failed in 1925 due to earthquake-induced soil liquefaction in the dam's foundation. Reclamation became more concerned about the seismic stability of its embankment dams in the late 1940s and early 1950s, and a technical memorandum entitled *Seismic Stability of Earth Dams*[26] by Civil Engineer Elbert E. Esmiol (Life Member, ASCE and USCOLD/USSD) was published in April 1951. Several large earthquakes occurred during Period IV, which led to the development of new soil tests and methods of analysis, trying to model the loading of and the response by the various soils that occurred during those earthquakes. The powerful earthquakes that occurred at Nigata, Japan, and in Alaska in 1964 caused geotechnical engineers to begin research on how to model the soil behavior called "liquefaction" that was exhibited by sandy soils during those events. The near-failure and breaching of Lower Van Norman (San Fernando) Dam during the 1971 earthquake that hit the Los Angeles area caused a renewed burst of research into soil liquefaction, field and laboratory testing, and modeling of the deformations that occurred in the upstream portion of the Lower Van Norman Dam, a hydraulic-fill embankment. Reclamation's Soils Engineering Branch participated in the post-earthquake evolution of field and laboratory testing of liquefaction-susceptible sandy soils. Starting around 1962, computers had begun to be used to analyze soil stresses with the newly-developed finite-element method of analysis. This analysis method was subsequently upgraded to allow the Lower Van Norman Dam embankment and foundation to be modeled, and to estimate the deformations produced by the earthquake shaking for comparison with the actual deformations.

Many embankment dams were designed and constructed by Reclamation during Period IV. These included: Davis, Granby, Martinez, Box Butte, Scofield, Shadow Mountain, Cascade, Dixon Canyon, Spring Canyon, Soldier Canyon, Long Lake, Dry Falls, O'Sullivan, Jackson Gulch, Enders, Medicine Creek, Heart Butte, Bonny, Cedar Bluff, Shadehill, Dickinson, Trenton, Kirwin, Webster, Cachuma, Carter Lake, Glen Anne, Lauro, Rattlesnake, Tiber, Jamestown, Palisades, Sly Park, Wanship, Lovewell, Casitas, Vega, Trinity, Navajo, Fontenelle, Merritt, San Luis, Soldier Creek, Pueblo, and Teton Dams. These Period IV embankment dams generally had upstream slopes that ranged from 2.5:1 to 3.5:1, with flatter slopes ranging from 4:1 to 20:1 at the toe where excess material could be wasted. The steep 2.5:1 upstream slopes were used only where an upstream rockfill zone created the necessary strength and stability. The downstream slopes ranged from 2:1 to 2.5:1, similarly with flatter slopes ranging from 3.5:1 to 20:1 at the toe. These dams were built on a variety of foundations; all of them were either founded on bedrock or they included a cutoff trench excavated down through the overburden soils to bedrock, and quite a few of them included concrete cutoff walls in the bottom of the cutoff trench. The cutoff trenches remained near the upstream center of the dam. The rockfill material from required excavations was generally placed and compacted in the outer slopes of the embankment.

Granby Dam, completed in 1948 with a maximum height of 235 feet above the streambed, encountered several construction problems that were successfully dealt with. A significant change in the borrow source for the embankment was accomplished with little adverse effect on the schedule. An attempt was made to use the surface mapping of the damsite's geology instead of the usual amount of investigative drilling; however, the use of this approach (used elsewhere) proved to be inappropriate due to the complex geology of the damsite. The construction experience on Granby Dam was discussed in F. C. Walker's publication:

> It was necessary to perform additional grouting after the structure was placed in operation. However, this grouting was accomplished so economically that portions of other dams have since been left ungrouted until actual performance indicates a need for such treatment.[27]

This insight into Reclamation's foundation grouting design philosophy by the then Head of the Earth Dams Section becomes more meaningful when Fontenelle and Teton Dams are discussed.

Davis Dam, which spans the Colorado River, was completed in 1950 with a maximum height of 138 feet above streambed. This dam represented an important advancement because of the diversion scheme for bypassing the large flow of the river around the damsite. That diversion was accomplished by excavating an open channel through the left abutment that was later closed by the construction of a concrete dam, which contained the spillway and the hydroelectric powerplant penstocks.[28]

Construction of Enders, Medicine Creek, and Heart Butte Dams and several other embankment dams were all begun around 1946 and 1947 in the Great Plains area where the foundations generally consisted of relatively weak Cretaceous and Tertiary formations of sand, silt, and/or clay. These formations tend to be fairly permeable if sandy or structurally weak if clayey. The valley floors are generally broad and are covered with moderately deep alluvium. The available borrow materials usually ranged from sandy silts to silty clays, with both gravel and rock (suitable for use as riprap) scarce to nonexistent. These damsites also had stream flows that were highly variable, with large floods possible. It proved to be cheaper to increase the size of the reservoir to increase flood-storage capacity rather than build a larger spillway.

Cachuma (Bradbury) Dam, completed in 1953 with a maximum height of 206 feet above the streambed, was constructed in a highly seismic area close to where Sheffield Dam had failed during an earthquake in 1925. The design of the embankment dam was therefore more conservative than otherwise would have been necessary. A large amount of siltstone and shale rockfill was produced by the spillway excavation, and this otherwise unsuitable material was used by enclosing it entirely within the downstream sand and gravel zone. In one of the first applications of this type, a concrete "grout cap" was constructed at the bedrock surface in the center-bottom of the cutoff trench at Cachuma Dam to provide firm support for the curtain grouting of the foundation beneath the dam.

Tiber Dam, completed in 1956 with a maximum height of 196 feet above the streambed, was built on a shale foundation that contained numerous seams of low shear strength bentonite clay. Hence, the foundation shear strength was uncertain. The earthfill materials available for use as the embankment's central core varied widely in characteristics and shear strength, which was expected to be low. The embankment cross section therefore reflected these concerns with a waste material disposal zone between the upstream cofferdam and the upstream slope, and with downstream slopes ranging from 2.25:1 near the crest to 5.5:1 toward the toe. The embankment also included zones flanking both sides of the core that transition between the finer-grained clay, silt, sand, and gravel core founded on bedrock and the coarser outer shells that consisted of sand, gravel, and cobbles.

Palisades Dam, completed in 1957 with a maximum height of 260 feet above the streambed, was one of the largest embankment dams yet built by Reclamation. The embankment volume of over 13,500,000 yd^3 caused the design to use nearby borrow materials that might otherwise have been rejected. The borrow soils available were pervious sand and gravel alluvium on the valley floor and impervious soils along the abutments, which had moisture contents either too high or too low with respect to optimum moisture for compaction. There was also some concern about potentially high construction porewater pressures created by the weight of the fill. The design was adjusted to place the better but wetter borrow soils in the lower and central parts of the embankment and the drier but poorer borrow soils in the upper and outer parts of the embankment, while still maintaining adequate slope stability.

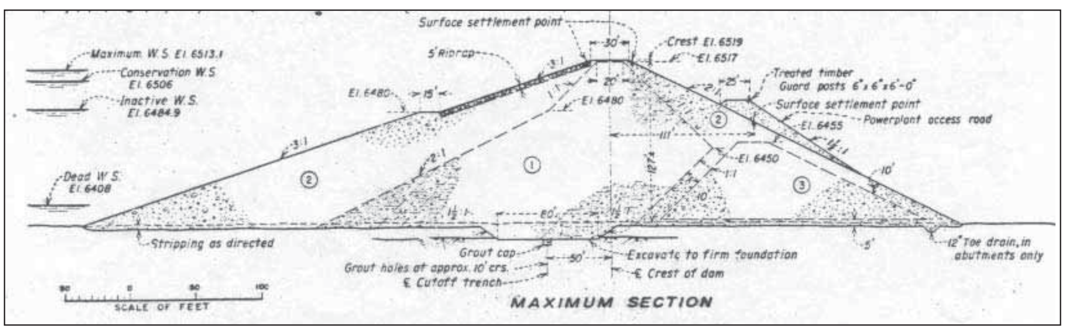
Sly Park Dam, completed in 1954 with a maximum height of 175 feet above the streambed, was one of the first and few rockfill embankment dam designs built by Reclamation. The upstream rockfill slope was 2.5:1 and the downstream rockfill slope was 2:1. Because of the size of the rockfill particles, the rockfill material could not be tested in the laboratory. The design therefore had to assume that the shear strength should reflect the natural slopes of the loose rock in the vicinity (the angle of repose). Again, the central core of compacted silt, sand, and gravel was flanked by transition zones, consisting of quarry fines in this case. Because of the difference between the properties of the compacted central core and the rockfill shells, differential consolidation between these zones later caused longitudinal cracks along the crest.

Although vibratory rollers had been developed for compacting cohesionless soils for roads in Europe in the 1930s, they were first used to compact rockfill dam materials at Quoich Dam in Scotland around 1958. In the United States, the use of vibratory rollers for compaction of rockfill materials was first attempted by the Corps at the 445-foot-high Cougar Dam in Oregon, built between 1959 and 1964. Reclamation first used smooth steel-drum vibratory rollers to compact a sand and gravel zone at Navajo Dam in 1959.[29]

Trinity Dam, completed in 1962 with a maximum height of 465 feet above the streambed, is the highest embankment dam ever designed and constructed by Reclamation, and its volume of 29,400,000 yd^3 made it the largest yet built. Almost all of the overburden material was excavated such that the embankment rested almost entirely on bedrock. The embankment contained four zones, grading from the central core to outer toe zones of rockfill. The upstream slope ranged from 2.5:1 in the upper slope to 4:1 in the lower rockfill toe zone. The downstream slope ranged from 2:1 near the crest to 3:1 in the lower rockfill toe zone. The upstream and downstream rockfill toe zones were added to improve stability; the rockfill was placed in 3-foot-thick layers (without compaction). A belt conveyor system over 10,000 feet long, that dropped 1,000 feet in elevation and handled 1,850 yd^3/hr, moved a total of about 10,000,000 yd^3 of earthfill material from the borrow area to the damsite.

Navajo Dam, completed in 1963 with a maximum height of 388 feet above streambed, had a miscellaneous earthfill zone downstream of the central core that was completely enclosed within a zone of “selected sand, gravel, cobbles, and boulders.” That selected sand, gravel, cobbles, and boulders zone formed an inclined transition/drain zone between the core and the miscellaneous earthfill and formed a blanket/drain zone against the downstream bedrock foundation.

Fontenelle Dam, completed in 1964 with a maximum height of 128 feet above streambed, included: irrigation canal outlet works in both abutments, a river outlet works near the middle of the dam capable of passing 18,700 ft^3/s, a hydroelectric powerplant, and a right abutment overflow spillway of 20,000 ft^3/s capacity at full pool. The river outlet works was large because it was less costly than increasing the size of the spillway. The embankment cross-section is shown in 2.11. The embankment zoning included: the zone 1 core, the zone 2 chimney and blanket drain of selected (pit run alluvium) sand, gravel, and



2.11. Fontenelle Dam section.

cobbles, and a zone 3 miscellaneous fill that was completely enclosed within the Zone 2. The surface of the bedrock foundation was far more broken than had been anticipated, so the cutoff trench was deepened by 6 feet. The foundation and abutments were grouted by a single-row grout curtain installed through a grout cap. Grout “takes” in the upper 65 feet of the foundation were very large and a second line of grout holes was placed in the vicinity of the river outlet works and in the right abutment to perform additional grouting. The grouting program included a total of 45,900 linear feet of drill hole and 143,000 ft^3 of cement grout pumped into the foundation, for an average grout take of 3.1 ft^3 per foot of hole. Reservoir filling was to be very slow so that if any seepage leaks occurred, they could be plugged before permanent operations commenced—remember the previous reservoir filling and additional grouting experience on Granby Dam.

There was no surface treatment of the foundation rock beneath the zone 1 core, such as slush (lean cement) grouting of surface cracks, and smoothing of the foundation with dental concrete.

First filling of the 345,000 acre-foot reservoir commenced in April 1964. During the summer of 1964, after the reservoir had risen to a depth of about 49 feet, seepage appeared in the floor of an exhausted borrow area 2,000 feet downstream of the dam and stabilized at a flow of 6 ft^3/s. The reservoir continued to fill through the spring runoff from the heavy snowpack winter of 1964-1965 (which produced a peak reservoir inflow of 17,560 ft^3/s) until it reached a depth of about 85 feet in early June 1965. Seepage then began to discharge from a rock cut in the spillway discharge channel and from a cliff face about 0.6-mile downstream on the left abutment. The seepage flowing from the downstream borrow area also appeared to have increased. The reservoir began to spill on June 15th and the rate of total seepage increased to about 70 ft^3/s. A small slough occurred at the edge of the embankment on the left side of the spillway chute at about the mid-height of the dam on June 29th, with about 1 ft^3/s issuing from a crack in the rock beneath the chute. On the morning of September 3rd, a wet spot was observed on the downstream slope of the dam at about mid-height near the right abutment about 100 feet to the right of the slough that occurred in June. By mid-afternoon, seepage water started flowing from the wet spot area, causing erosion and sloughing of the dam embankment material. The flow that evening was estimated at about 5 ft^3/s. Local officials were then alerted to stand by, ready to evacuate downstream residents. The next morning (September 4th), the seepage flows had increased to about 21 ft^3/s and an estimated 10,500 yd^3 of material had

2.12. Fontenelle Dam: Large sinkhole on downstream slope.

been eroded from the downstream slope (see 2.12). Rockfill was dumped into the hole on the downstream slope, trying to stop the erosion, and the seepage flows appeared to stabilize. On the morning of September 5th, it was decided to fully open the outlet works, and by the morning of the 6th the reservoir level had dropped 8 feet from the initial level. That afternoon, an area on the dam crest about 20 feet in diameter near the upstream edge collapsed (see 2.13) and dropped about 30 feet, exposing bedrock on the abutment side of the cavity. The reservoir continued to drop about 4 feet per day until the pool was low enough to halt the seepage.

2.13. Fontenelle Dam: Crest sinkhole.

There were several causes for the near-breaching (and near-failure) of Fontenelle Dam, which was barely avoided because of the large outlet works capacity. According to Chief Engineer Bellport's "appraisal of the accident" included in his paper *Bureau of Reclamation Experience in Stabilizing Embankment of Fontenelle Earth Dam*[30] presented at the 1967 ICOLD Conference in Istanbul, Turkey, "It is apparent that the weak spot was in the abutment and not the embankment. Many dams have been placed on similar foundations.… With steep abutments, it is difficult to obtain adequate shallow grouting because of the low pressures that must be used to prevent movement in the foundation."[31] The single row grout curtain was judged to have been inadequate, given the nature of the sedimentary shale and sandstone bedrock jointing in the abutments. The problem was (supposedly) fixed by a grouting program consisting of eight lines of grout holes in the steep right abutment; a total of 80,000 feet of hole was drilled and an additional 200,000 ft^3 of grout were pumped into the abutments during August-December 1966. Bellport commented in the paper that

> In the 20-year span from 1940 to 1960, increasing boldness in reducing the number of lines and amount of grout seemed to be proving a philosophy that grouting was mostly superfluous. At the Bureau of Reclamation too, in situations where deficiencies could be readily

> remedied, the process of "try and see" was being used with increasing success until the situation at Fontenelle Dam was encountered.[32]

> Further,

> This difficulty occurred on first filling of the reservoir which was unusually rapid due to extremely large inflows and the fact that the outlet work was not being used so that some repair work could be performed. This experience illustrates the need for slow, controlled filling of reservoirs where unfavorable foundation conditions are known to exist.[33]

Within Reclamation, it appears that information on the near failure of Fontenelle Dam may not have been widely distributed, but other organizations, such as the Corps, reportedly changed some of their embankment dam design and construction practices after reviewing this incident. Fontenelle Dam will be discussed further under Period V.

Merritt Dam, completed in 1964 with a maximum height of 120 feet above the original ground surface, was the first embankment dam that used "soil cement" instead of rock riprap to protect the upstream slope. Merritt Dam is located on the Snake River in north-central Nebraska where the usual rock riprap material was not economically available. Reclamation had developed and successfully used soil cement on a test section constructed in 1951 at Bonny Reservoir in eastern Colorado. Since its first success at Merritt Dam, soil cement slope protection has been used on twelve more embankment dams by Reclamation and on countless other structures.

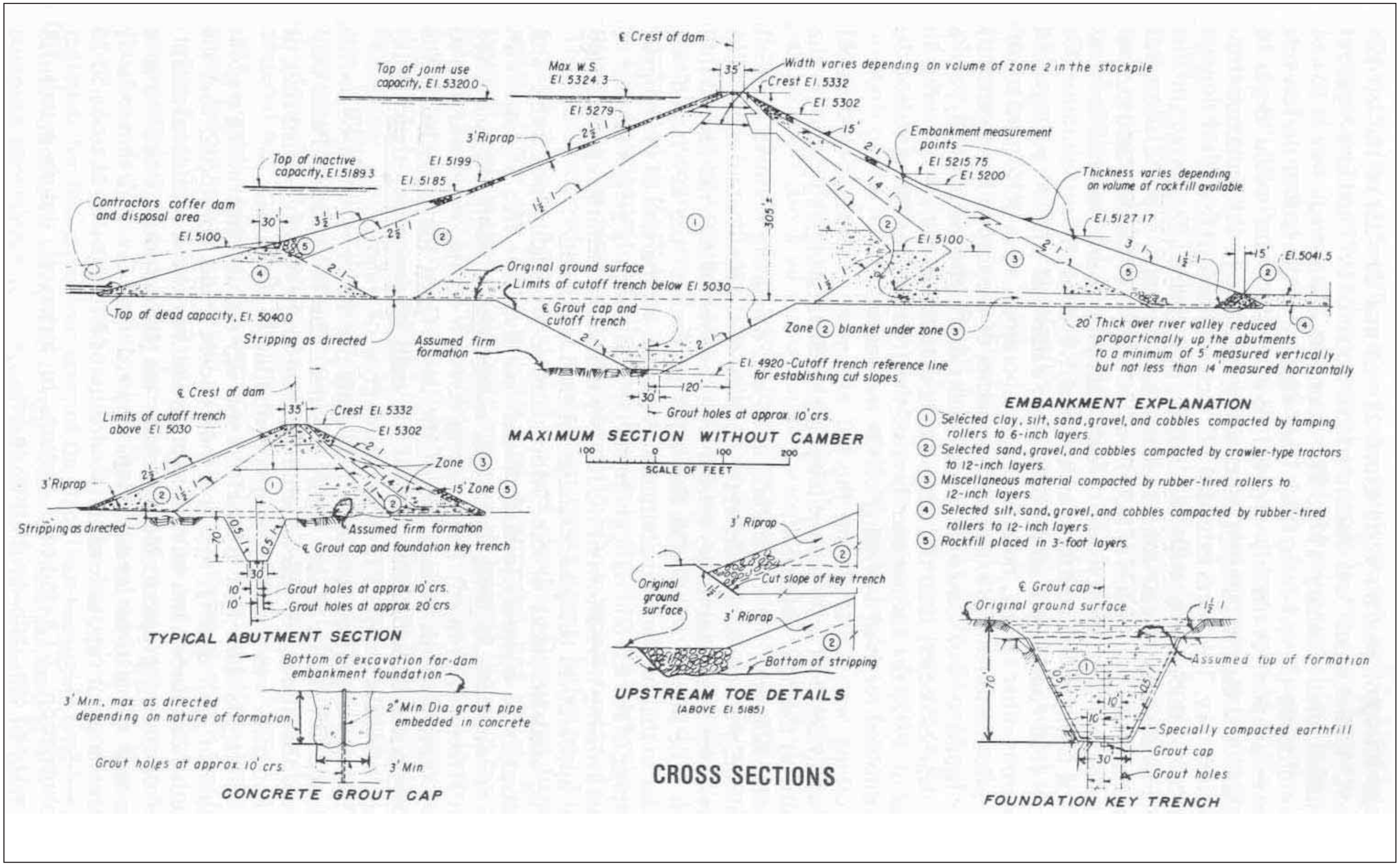
San Luis Dam, completed in 1967 with a maximum height of 244 feet above the original ground surface and a volume of over 77,000,000 yd^3, is the largest embankment dam by volume ever designed and constructed by Reclamation. The embankment included a central impervious core with a volume of about 42,000,000 yd^3. The borrow material was excavated using a Bucyrus-Erie wheel excavator with a 30-foot-diameter digging wheel equipped with ten 2½ yd^3 buckets. This machine had a capacity of about 4,000 yd^3/hr and loaded a 100-ton Euclid bottom-dump truck every 45 seconds. In September 1981 a rapid-drawdown of the reservoir led to a slide in the upstream slope that was caused by a weak clay layer in the foundation. The slide was about 1,300 feet long and involved the reconstruction of the upstream slope and construction of a berm along the toe, with a total volume of about 1.4 million yd^3.

Soldier Creek Dam, completed in 1973 with a maximum height of 251 feet above streambed, was built to enlarge the reservoir originally impounded by the 1913-era Strawberry Dam, which was then breached when the water on both sides equalized. The design and construction of Soldier Creek Dam were similar to Fontenelle Dam. Soldier Creek Dam was one of seven dams (both embankment and concrete dams) selected by the Department of the Interior for a post-Teton 1977 study by W. A. Wahler & Associates to review recently completed

Reclamation dams. Soldier Creek Dam will be discussed further in the Period V section.

Pueblo Dam, completed in 1975 with a height of 165 feet above original ground, is a composite dam consisting of a concrete massive-head buttress structure containing the 550-foot- long spillway, flanked by two earthfill embankments. The concrete structure is 1,750 feet long and consists of 23 buttresses with a maximum height of 176 feet. The two wing embankments wrapped around the ends of the concrete structure and consist of the 3,570-foot-long left embankment and the 4,910-foot-long right embankment. Bedrock at the damsite consists of flat-lying Cretaceous sediments in alternating units of sandstone, limestone, and shale. The concrete dam section was founded on Dakota sandstone and the embankments rest partly on alluvium in the valley bottom and on Graneros shale on the gently rising abutments. The Dakota sandstone contained a few discontinuous lenses and seams of shale. The Graneros shale contained a number of seams of bentonite clay up to 6 inches thick. When the left embankment had risen to within about 20 feet of the final crest elevation in November 1973, the inclinometer casing located at the downstream toe at station 90+00 indicated a downstream shear deformation through the casing that prevented the lowering of the inclinometer instrument. Additional inclinometer casings were installed along the downstream toe of the left embankment, which finally indicated the deformation had stopped, after reaching a total of about 6 inches of downstream deformation. There were no piezometers installed in the shale or the bentonite clay seams prior to embankment construction that might have indicated the amount of construction-induced porewater pressure in the foundation. Sampling and laboratory testing of the Graneros shale were performed, and finite element analyses were conducted to help judge whether a long-term stability problem was indicated by this foundation deformation. This left embankment deformation in the foundation, which occurred during construction, appears to have been similar to what occurred during construction at Waco Dam in 1961, although not to the same degree. The left and right embankments were both completed and the dam and reservoir were put into service. Pueblo Dam will be discussed further in the Period V section.

Teton Dam was constructed between February 1972 and November 1975 with a maximum height of 305 feet above the streambed. The embankment cross-section was remarkably similar to that of Fontenelle Dam (see 2.14). The wide zone 1 core consisted of silt, flanked upstream and downstream by zone 2, which consisted of (pit-run alluvium) selected sand, gravel, and cobbles. There was also a zone 3 miscellaneous earthfill zone downstream, with zone 2 constructed as a chimney filter/drain and as a 20-foot-thick drainage blanket beneath the zone 3 and up the abutments. The outlet works at Teton Dam consisted of the river outlet works with a capacity of 3,400 ft^3/s and an auxiliary outlet works with a capacity of 850 ft^3/s. The construction schedule required that the river outlet works be operational by May 1, 1976, but the contractor was behind schedule and only the auxiliary outlet works were operational to control reservoir filling.



2.14. Teton Dam sections.

Foundation grouting at Teton Dam consisted of 3 lines of grout holes up to 310 feet deep. A test-grouting program was conducted in 1969 and was to inject about 260,000 ft^3 of grout into the foundation. The actual test grouting program pumped twice that amount of grout during the pilot grouting program, and just two of the test holes took 16,000 sacks of cement and 18,000 sacks of sand, for an equivalent total of about 34,000 ft^3 of grout. During actual construction, the grout was injected into 118,179 lineal feet of drilled holes and totaled: 496,515 ft^3 of cement, 82,364 ft^3 of sand, 132,000 pounds of bentonite, and 418,000 pounds of calcium chloride. Looking at just the cement and sand grout materials, the above figures equate to about 4.9 ft^3 per foot of drill hole, or an increase of over 50 percent compared to the initial grouting done at Fontenelle Dam. Beneath the zone 1 core, the rock foundation surface was cleaned using air and water jets and some open joints and cracks in the bottom of the key trenches and the cutoff trench were treated by installing pipes and grouting with a grout slurry, or by filling with specially compacted zone 1 material. Surface grouting stopped at elevation 5205.[34] The instrumentation installed at Teton Dam consisted of surface settlement points and strong motion accelerographs; there were no piezometers installed in the dam embankment or foundation. Reclamation's embankment dam design engineers made only two visits to the damsite during construction; the construction liaison engineer made six visits during construction.

Data on the dam obtained during subsequent investigations were summarized in the paper "Teton Dam: Summary of Technical Investigations" by D. J. Duck, R. W. Kramer, and L. W. Davidson that was presented at the 13th ICOLD Congress in New Delhi, India, in 1979.[35] The zone 2 chimney filter and drainage blanket located downstream from the core was intended to: filter the zone 1, prevent water from attacking the zone 3, reduce seepage pressures, and transmit seepage flows to the downstream toe. The permeability of the zone 2 material was not tested prior to construction. The zone 2 contained 2 to 12 percent silt fines, average 4.5 percent; had been placed at a relative density ranging from 80 to 120 percent, average 94 percent; and had a permeability that ranged from 0.7 to 39.3 x 10^{-6} cm/s, average 9.4 x 10^{-6} cm/s. The zone 1 silt had a mean horizontal permeability of 5 x 10^{-6} cm/s, which was just a bit lower than the average for the zone 2 material.[36] These permeability numbers indicate that the zone 2 filter/drain material was nearly as impervious as the zone 1 core material. According to Peter Aberle, Field Engineer on Teton Dam construction, when it rained during construction, the water would pond on the zone 2 surface.[37] It appears that the as-constructed zone 2 did not have sufficient permeability to function as the intended blanket drain.

First filling of the 288,000 acre-foot reservoir commenced in October 1975 with the reservoir at elevation 5060. The design considerations required that the reservoir not be filled faster than 1-foot per day above elevation 5200. In early March 1976, with the reservoir 135 feet deep at elevation 5170, the filling rate limit in the design considerations was "relaxed" and filling rate of 2 feet per day was "allowed" to accommodate the high reservoir inflows from a large snowmelt runoff. However, they had no other option but to relax the reservoir filling rate limit and accept the 2-foot-per-day rate of rise—the river outlet works weren't yet operational! By early May 1976 the reservoir was 185 feet deep. The decision was "made" (note once again the inoperable river outlet works) around May 13th to fill the reservoir to the spillway crest, which led to an average filling rate of about 3 feet per day, and a maximum rate of 4.3 feet per day. Teton Dam failed catastrophically on June 5, 1976, when the reservoir had reached the spillway approach channel at elevation 5301.7. The failure of this embankment dam killed 11 people, left 25,000 people homeless, inundated partially or completely an area of about 300 mi^2 that extended 80 miles downstream, and did property damage estimated at about $400 million. This dam failure changed the Bureau of Reclamation in many, very significant ways. The construction of Teton Dam therefore completes Period IV. The failure of Teton Dam will be discussed further in the Period V section.

During Period IV, Reclamation's engineers continued to enjoy national and worldwide acclaim as they helped to advance the new field of geotechnical engineering and its sub-specialty of embankment dams by conducting research and publishing reports and professional society papers. Reclamation continued to develop and make available information on its engineering work. A total of 6,000 copies of the "tentative edition" of Reclamation's *Earth Manual* were printed and distributed in 1951, followed quickly by another 28,000 copies of the "first formal edition." The *Earth Manual* was a huge success worldwide and was in great demand. A First Edition—Revised, Second Printing was printed and distributed in 1968 with 783 pages. The *Earth Manual* combined and revised three earlier manuals: the *Earth Materials Laboratory Test Procedures; the Field Manual for Rolled Earth Dams*; and the *Earth Materials Investigation Manual*. The *Earth Manual* was prepared by Reclamation's engineers in the Earth Dams Section, Dams Branch, Division of Design, and in the Soils Engineering Branch, Division of Research, with editing and coordination performed by John (Jack) W. Hilf of the Earth Dams Section. Reclamation's *Design of Small Dams* was published and distributed in 1960, with a Second Edition released in 1973.

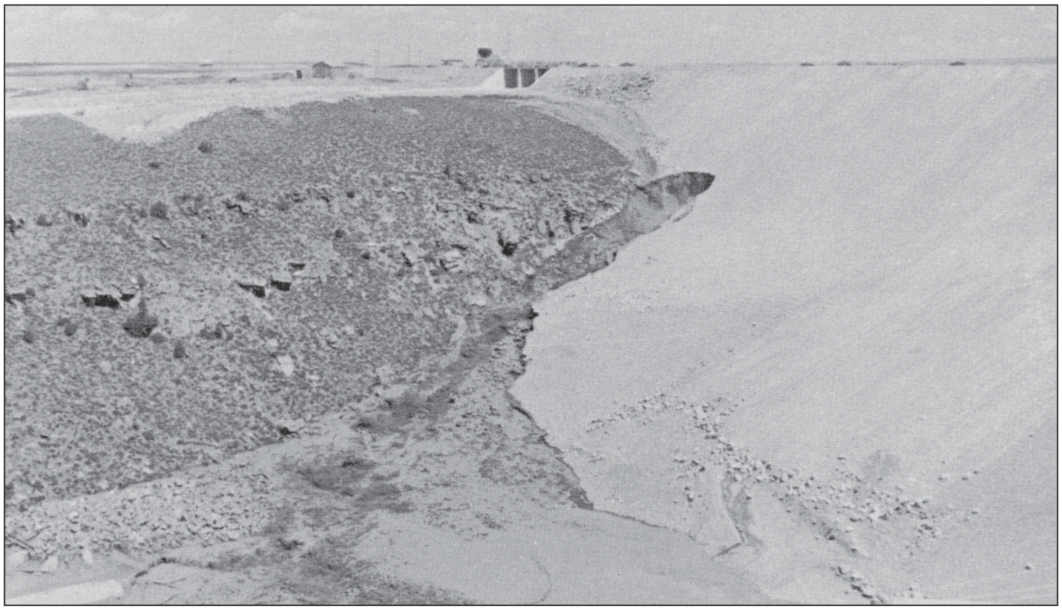
Reclamation's instrumentation for and monitoring of embankment dams continued to be improved during Period IV. During the 1950s, several modifications were made to the piezometers used on Reclamation's embankment dams. The tubing used between the hydraulic piezometer tip and the embankment surface was updated to polyethylene tubing. In the 1960s, the tubing was updated again to polypropylene. Reclamation researched and developed the use of carborundum disks in the hydraulic piezometer tips in the 1950s for improved measurement of porewater pressures. In 1959 the use of ceramic filter disks in the piezometer tips was first attempted by Reclamation at Steinaker, Sherman, and Merritt Dams. The first strong-motion earthquake instrument was installed at Hoover Dam in 1937, and Cachuma (Bradbury) Dam was the first embankment dam to have one installed in 1954. There are now over 20 embankment dams instrumented with such devices. As noted earlier, Reclamation seems to have cut back on the amount of instrumentation installed in its dams during Period IV.

During Period IV, the variety of equipment available for the construction of embankment dams continued to improve in size, power, speed, and efficiency. As already mentioned, the wheel excavator used at San Luis Dam produced 4,000 yd^3 per hour, and the earthfill haul trucks used there were 100-ton capacity bottom-dump wagons. The versatile front-end wheel loader with a bucket of up to 12 yd^3 capacity was added to the construction equipment available. Earthfill compaction rollers and scrapers became self-propelled instead of having to be towed behind a Caterpillar bulldozer or tractor. After its initial use at Cougar Dam, the vibratory roller, both the smooth drum and later the tamping pad-foot varieties, became available for improved compaction of earthfill and rockfill materials.

Period V (1976-2002)—Reclamation's History of Embankment Dam Design and Construction

At the start of Period V, the failure of Teton Dam on June 5, 1976, began a chain of events during which Reclamation's design and construction organizations changed dramatically. As already mentioned, the first filling of the reservoir was very rapid, due to the earlier-than-usual high inflows from a heavy snowpack in the mountains upstream. The reservoir inflow peaked at around 4,000 ft^3/s in mid-May. It should be noted again that Teton Dam's main river outlet works in the left abutment, with a full-pool capacity of 3,400 ft^3/s, was not yet operational because the regulating gate had not yet been received from the manufacturer. Only the auxiliary outlet works in the right abutment, with a capacity of only 850 ft^3/s, could be used to control the rate of reservoir filling, or to lower the reservoir water surface in the event of a Fontenelle Dam type of emergency drawdown situation. Hence, even if the main river outlet works had been operational, the releases from the combined outlet works would have been about equal to the inflows and would not have been able to drop the reservoir pool as had been the case at Fontenelle Dam.

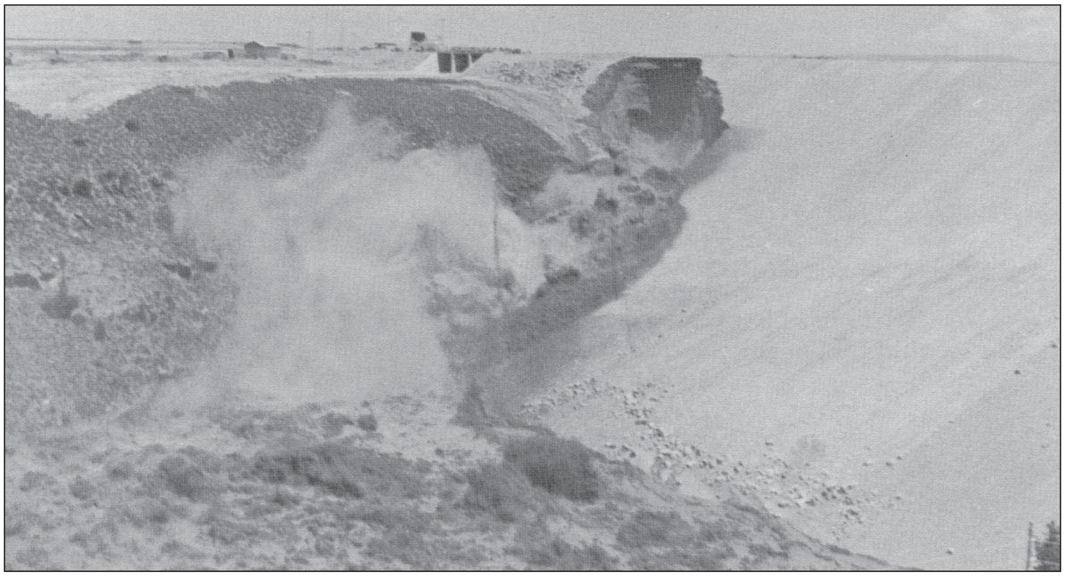
On June 3rd, with the reservoir at about elevation 5300, two small seeps flowing about 60 and 40 gal/min were found 1,300 and 1,500 feet, respectively, downstream of the dam at the base of the right abutment. On June 4th, a small seep was found flowing about 20 gal/min at the base of the right abutment about 150 to 200 feet downstream from the toe of the embankment. At about 7:00 A.M. on June 5th, a survey party observed a leak coming from the right abutment at the top of a berm at elevation 5045. It was immediately reported to one of the field engineers who drove to the dam, and at 8:15 A.M. he estimated the leak to be flowing 20 to 30 ft^3/s. At about 9:10 A.M., a slightly muddy leak was observed exiting from the right abutment at elevation 5200, flowing about 2 ft^3/s. The lower leak at elevation 5045 was estimated to be flowing 40 to 50 ft^3/s at about 9:30 A.M. Between 10:00 and 10:30 A.M., a wet spot was observed on the downstream slope of the dam at elevation 5200 and about 15 to 20 feet from the right abutment. The wet spot quickly increased to a flow of 10 to 15 ft^3/s and was eroding the material on the downstream slope. At about 10:30 A.M., a loud sound (roar) was heard, followed by the sound of rapidly running water. At about 11:00 A.M., a whirlpool formed in the reservoir about 150 feet from the right abutment and its diameter rapidly began to expand. By about 11:20 A.M., attempts to bulldoze rockfill into the opening (as had been done at Fontenelle Dam) proved futile (see 2.15).



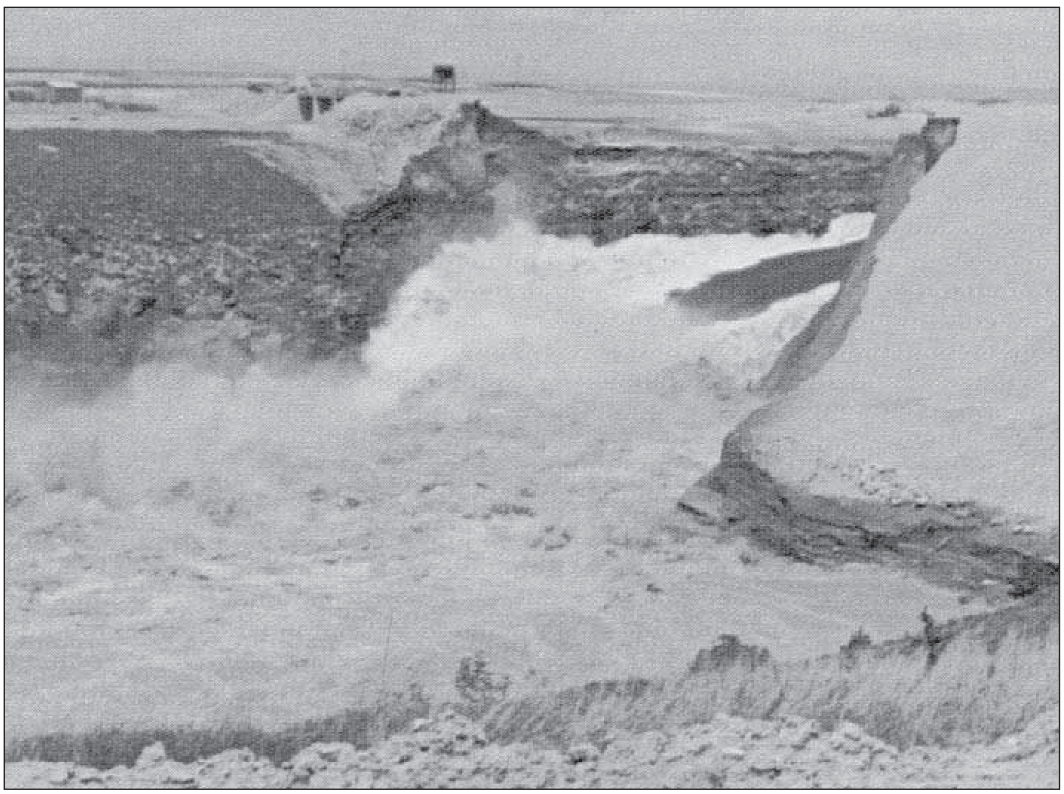
2.15. Teton Dam: Downstream sinkhole at about 11:20 A.M.

A sinkhole developed on the downstream slope shortly before the embankment crest collapsed at 11:55 A.M. (see 2.16), and the dam was breached two minutes later at 11:57 A.M. (see 2.17). This sequence of observed new seepage, wet spots, erosion, sinkhole, whirlpool, crest collapse, and embankment breaching took only five hours from start to finish and the complete release of the reservoir followed. By 5:00 to 6:00 P.M. that same day, the reservoir had completely emptied.

On June 8, 1976, just three days after the failure of Teton Dam, the Under Secretary of the Interior, D. Kent Frizzell, established the Department of the Interior Teton Dam Failure Review Group (IRG) that was formed to examine the causes of the dam's failure and to make recommendations as appropriate to prevent the recurrence of such failures. The IRG was directed to "review the following aspects of the failure: geologic, engineering, design, construction, hydrologic factors, and all other pertinent background information and testimony." The IRG was composed of representatives from several Federal Government agencies, such as the Soil Conservation Service, the Tennessee Valley Authority, and the U.S. Army Corps of Engineers. The Secretary of the Interior, Thomas S. Kleppe, and the Governor of Idaho, Cecil D. Andrus,



2.16. Teton Dam: Crest collapsed at 11:55 A.M.



2.17. Teton Dam. Dam completely breached.

empowered another review group of experts not associated with the Federal Government, who were referred to as the "Independent Panel to Review Cause of Teton Dam Failure" (Independent Panel). The IRG and the Independent Panel operated simultaneously from June to December 1976, with field investigations coordinated and the results shared by the two groups. The Independent Panel's report *Failure of Teton Dam* was published in December 1976.[38] The IRG's *Failure of Teton Dam—A Report of Findings* was published in April 1977,[34] and its *Failure of Teton Dam, Final Report* was published in January 1980.[39] The reports/conclusions of the IRG and the Independent Panel were in general agreement, concluding that the failure of Teton Dam had been caused by:

> 1. Internal erosion (piping) of the core of the dam deep in the right foundation key trench, with the eroded soil particles finding exits through channels in and along the interface of the dam with the highly pervious abutment rock and talus, to points at the right groin of the dam;
>
> 2. Seepage moving through openings that existed in inadequately sealed rock joints, and that may have developed through cracks in the core zone in the key trench;
>
> 3. Once started, piping progressed rapidly through the main body of the dam and quickly led to complete failure; and
>
> 4. The design of the dam did not adequately take into account the foundation conditions and the characteristics of the soil used for filling the key trench.

Regarding Cause No. 1 above, it should be noted that the apparently impervious zone 2 blanket drain material probably confined the seepage flows and eroded zone 1 core material within the abutment channels, joints, fractures, and cracks all the way to the right groin downstream, and prevented the safe, proper interception and collection of the seepage flows. The nature of the damsite geology, the design of the dam embankment, the treatment(s) of the foundation bedrock surface and open joints (or lack thereof), the characteristics of the embankment materials, the defensive measures taken to control seepage and piping erosion, and the construction practices at Teton Dam were all too similar to those involved on Fontenelle Dam. The IRG and the Independent Panel both recommended that Reclamation should take certain specific measures to prevent the recurrence of another dam failure:

> 1. An independent board of review should be convened for each major dam project to review both design and construction at frequent intervals;
>
> 2. Design decisions should be formally documented;
>
> 3. Design personnel should remain involved with a project during construction, including frequent scheduled site visits; and
>
> 4. Major dams and their foundations should include an instrumentation program to monitor construction and post-construction behavior. Instrumentation data should be promptly interpreted and evaluated.

In a July 20, 1976, letter, the Comptroller General of the United States was asked by U.S. House of Representatives' Environment, Energy, and Natural Resources Subcommittee to examine the dambuilding procedures and practices used by the Bureau of Reclamation and the Corps of Engineers. The resulting report *Actions Needed to Increase the Safety of Dams Built by the Bureau of Reclamation and the Corps of Engineers* was published on June 3, 1977.[40] The Comptroller's report discussed several concerns involving the dam designers, recommending that

> We recommend that the Secretary of Interior direct the Bureau of Reclamation to establish written procedures to better ensure that design intent is achieved. In so doing the Bureau should: (1) evaluate and implement ways to improve the clarity of instructions, specifications, and drawings; (2) evaluate and implement ways to better ensure that onsite personnel fully understand the intent of the designers, and (3) develop and implement policies and procedures calling for more frequent onsite inspections by designers during construction.[41]

The Comptroller's report also noted the comments made in the paper by Chief Engineer Bellport about the lessons learned after the near failure of Fontenelle Dam, and recommended that

> Thus, by averting a disaster at Fontenelle, the Bureau had seemingly learned a valuable lesson regarding reservoir filling. Yet, at Teton Dam, over 10 years later, the lesson was not applied.

and

> We believe that the failure of Teton Dam and the near failure at Fontenelle Dam should clearly illustrate to dambuilders the importance of (1) a slow, controlled filling rate during first filling to closely monitor the behavior of the dam and (2) an operable outlet of sufficient size to release enough water to lower the reservoir level when emergencies arise affecting dam safety.[42]

Reclamation's organization and its state-of-the-practice in embankment dam design and construction at the beginning of Period V, which were thought to have been developed to as high a degree of capability and sophistication as any dam-building organization in the World, were immediately put under the proverbial microscope. In April 1977 President Jimmy Carter ordered all Federal agencies that build, maintain, or operate dams to review their dam safety practices. Reclamation Commissioner R. Keith Higginson named a team to review Reclamation's dam design and construction procedures, and charged the team "to review expeditiously all factors relevant to safety of dams in the Bureau's plan-design-construct-operate process and to develop recommendations which would assure that Bureau procedures follow acceptable standards…" On March 31, 1977, the Department of the Interior contracted with W. A. Wahler & Associates to conduct a program entitled "An Emergency Study of Seven

Completed Bureau of Reclamation Dams." All seven dams were recently completed structures, both earthfill and concrete dams. The seven dams studied by W. A. Wahler & Associates were: Crystal, Mountain Park, Mt. Elbert Forebay, Nambé Falls, Pueblo, Ririe, and Soldier Creek Dams.[43] On November 29, 1977, Commissioner Higginson announced a reorganization plan in which the decentralized field structure was retained, and the Denver Office became Reclamation's center for technical review and support. On November 6, 1979, under Commissioner Higginson, Reclamation changed its name to the "Water and Power Resources Service," but changed it back to the Bureau of Reclamation on May 20, 1981, under Commissioner Robert N. Broadbent.

Reclamation's Chief Engineers (now with different titles, which began as Director, Office of Design and Construction) during Period V were Harold G. Arthur, Robert B. Jansen (title was changed to Assistant Commissioner for Engineering and Research on February 1, 1978), Rodney J. Vissia, James Cook (acting for 3 or 4 months in 1982), Darrel W. Webber, Felix W. Cook, Sr. (the title was changed once again in October 1994 to Director, Technical Service Center), and by Michael J. Roluti.

While Reclamation still had many dams and projects in its "pipeline" awaiting funding and construction at the start of Period V, environmental "clouds" had been gathering on the horizon in both numbers and power and they wanted to put a halt to the continued construction of new dams. The embankment dams that Reclamation designed and constructed during Period V generally involved even more difficult and complex damsites than had been built on before, and the resulting designs were more complex. Part of this increased design complexity was a direct result of the findings and recommendations by the IRG, the Independent Panel, and the Comptroller on the failure of Teton Dam.

The Wahler Reports on seven of Reclamation's recently constructed dams presented some fairly alarming conclusions and recommendations. For example, on Soldier Creek Dam, the Wahler Report concluded that "there may be significant risk of serious distress and/or failure associated with filling the reservoir behind Soldier Creek Dam." And on Pueblo Dam, the Wahler Report concluded that "the reservoir behind Pueblo Dam should not be permitted to rise significantly above its present level until certain supplementary investigations and/or actions have been completed." After the findings of the Wahler Reports were presented to the Department of the Interior (and Reclamation), Reclamation responded by beginning its own reevaluation of these seven dams, which included field and laboratory investigations, new evaluations of the design and construction, etc. With the conclusions and recommendations resulting from the two Teton Dam failure reviews needing to be implemented, Reclamation made dramatic changes in its design and construction organizations.

In 1978 Reclamation instituted its new Safety Evaluation of Existing Dams (SEED) Program under the Division of Dam Safety and reporting directly to the Assistant Commissioner —Engineering and Research (ACER). The SEED Program began a comprehensive review of dam design, construction, and operation records; analysis of material data; field inspections; and study of any apparent deficiencies. The Denver Office's engineering staff was increased to handle the enlarged program. A Technical Review Staff, also reporting directly to ACER, was added to the Denver Office and was tasked with independently reviewing all new dam and major structure designs, modifications to existing dams and major structures, and the SEED Program. Reclamation also hired independent consulting engineers and other professionals to review and approve Reclamation's dam design and construction work.

The work by the Denver Office to respond to the embankment dam concerns raised in the Wahler Reports included field investigations that produced embankment and foundation samples, which needed laboratory testing to develop information on their engineering properties. This additional engineering workload and the laboratory testing workload for projects already planned led to an increase in the size and capability of the Denver Office Laboratory. Improved electronics and computers were involved with the upgrading of the Laboratory's capability. New testing equipment was needed in a few cases because of the nature of some of the dam foundation problems encountered and for testing new materials such as synthetic geomembranes and geotextiles. For example, the weak clay seams in the foundation shale at Pueblo Dam required testing for residual shear strength, which Reclamation had never done before.

During Period V, Reclamation continued to design and build some notable embankment dams in the West. These Period V embankment dams included: Mt. Elbert Forebay, Twin Lakes, Palmetto Bend, Funks, Wintering, Red Fleet (Tyzak), Stateline, Choke Canyon, Sugar Pine, Ridgway, Calamus, McPhee, McGee Creek, San Justo, Brantley, Davis Creek, Jordanelle, New Waddell, and Buckhorn Dams. The Period V embankment dams generally had upstream slopes that ranged from 2:1 to 3.5:1 and downstream slopes that ranged from 2:1 to 1.5:1, with the steepest slopes at Jordanelle Dam.

These dams were built on a variety of foundations, but after the foundation problems that in part caused the failure of Teton Dam, the foundation treatments constructed during Period V were more aggressive and more "complete" than those previously constructed. This included design details and features such as: more aggressive cleanup and mapping of foundations, foundation shaping to flatten steep slopes and remove bedrock overhangs, more dental concrete backfill to shape abutments, lean cement (slush) grouting of surface joints, thorough blanket grouting in the upper 20 to 30 feet of the foundation-core contact zone, more lines of curtain grouting, and removal of more poor-quality bedrock in the foundation. The concrete grout cap used at Fontenelle and Teton Dams was also eliminated, grouting from the rock surface, removing any damaged surface rock, or using a reinforced concrete slab so that grout pressure can be applied to near-surface rock. Blanket grouting is then done after the curtain grouting has been completed.

The embankment dam designs changed in several important ways during Period V. The chimney filter/drains placed between the core and the downstream shell material were revised to use processed materials instead to ensure the prevention of internal erosion/piping. A processed transition/filter zone was used between the core backfilling the cutoff trench and the downstream alluvium. Blanket drains were used against the downstream foundation. Processing of borrow soils or the use of imported soil materials to supply the filter gradation(s) necessary was used more aggressively in the chimney filter/drains and the blanket drains. These filters included 1, 2, or even 3 zones of different soil sizes and gradations where necessary to prevent potential internal erosion/piping. These filter/drain systems were interconnected and drained by a perforated toe drain pipe with emphasis on monitoring seepage flows. There was also more emphasis on inspection manholes and monitoring devices in the toe drain system, and more emphasis on the use of relief wells for deeper seepage collection. The design of the embankment constructed adjacent and around concrete structures such as outlet works and spillways changed, eliminating the seepage collars around conduits to facilitate compaction by the tires of heavy equipment rolling next to the conduit instead of regular compaction equipment such as tamping rollers. Processed filters and drains were also placed around the downstream section of the conduits. New synthetic materials such as geomembranes and geotextiles were used in modifications constructed at several embankment dams. Several of the embankment dams noted above, including San Justo and Jordanelle Dams, were constructed close to major "active" earthquake faults in California and Utah, respectively. Starting with the early work by Esmiol, [26] Reclamation has continued to investigate and develop appropriate design requirements for its embankment dams in the earthquake-prone western U.S. that have been used by many others worldwide.

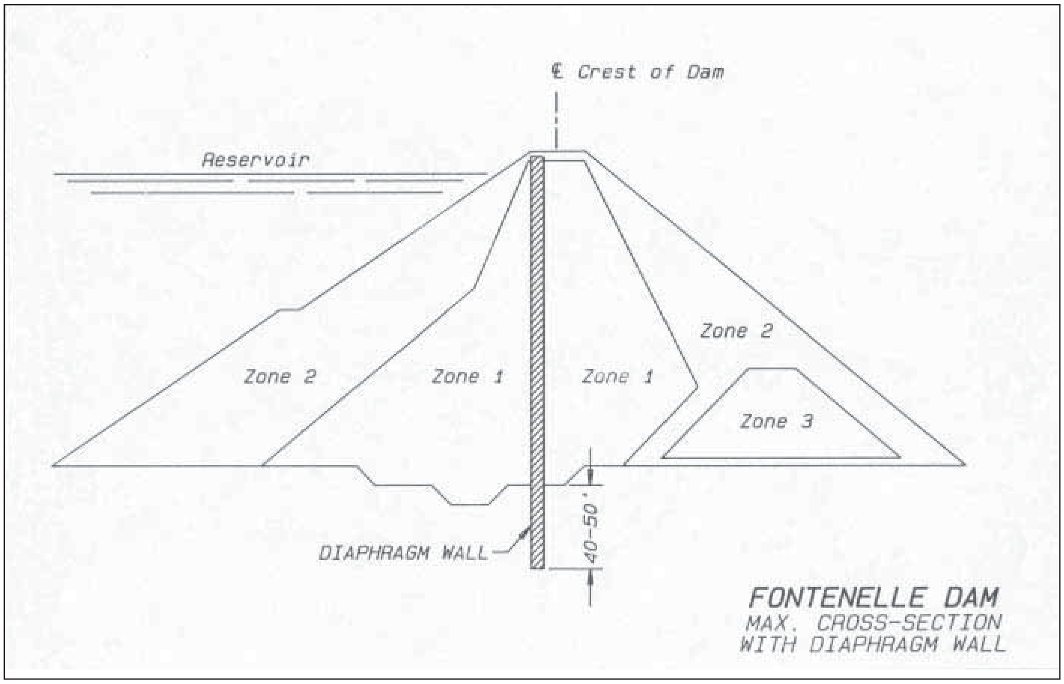
Like other dam-safety programs nationwide, the results of Reclamation's Safety Evalualtion of Existing Dams (SEED) Program and the reevaluation of the existing dams determined that quite a few existing embankment dams needed to be modified to improve their condition and to ensure their continued safe operation. A partial list of Reclamation's modified embankment dams includes: Jackson Lake, Helena Valley, Soldiers Meadow (not built by Reclamation), Fontenelle, Navajo, Casitas, Soldier Creek, Pueblo, Lost Creek, Twin Buttes, Twin Lakes, San Justo, Horsetooth (modification under construction), and Pineview (modification being designed) Dams. Reclamation has also been involved with the analysis, design, and construction of modifications to several Bureau of Indian Affairs (BIA) embankment dams, including Black Lake, Pablo, and McDonald Dams on the Flathead Indian Reservation in Montana, and dams belonging to the National Park Service.

Red Fleet (Tyzak) Dam, completed in 1978 with a maximum height of 145 feet above streambed, was one of the first embankment dam designs started by Reclamation after the failure of Teton Dam. Its design cross-section included the new defensive features: a two-stage transition zone and chimney filter/drain, a transition/filter zone between the core backfilling the cutoff trench and the downstream alluvium, and a processed sand and gravel drainage blanket beneath the downstream shell.

Mt. Elbert Forebay Dam, completed in 1980 with a maximum height of 92 feet above the stripped foundation, was built above Twin Lakes as part of a pumped-storage hydroelectric project. The original forebay reservoir was lined with compacted earthfill, but excessive leakage was detected and it could have triggered an ancient landslide, endangering the powerplant at the edge of Twin Lakes Reservoir below. The design was changed to add about 290 acres of 45-mil-thick reinforced chlorinated polyethylene geomembrane liner covered by 18 inches of earthfill.

Pueblo Dam was identified in the Wahler Report as needing certain supplementary investigations and/or actions while restricting its reservoir level. Field investigations were performed and samples of the Graneros shale and bentonite clay seams were obtained for laboratory testing, along with work to resolve several other concerns. Soil testing was performed to determine the residual shear strength of the bentonite clay and the test data were used to re-analyze the stability of the left embankment. The analysis results indicated the downstream slope stability was inadequate and the left embankment had to be modified to increase its stability. An earthfill berm 2,500 feet long and 35 feet high was constructed along the downstream toe of the left embankment in 1980-1981. Subsequent analysis of the concrete buttress dam section and a concern about the low strength shale seams in part of its sandstone foundation resulted in some recent (1999-2000) modifications to improve its resistance to sliding along the shale seams.

Soldier Creek Dam was identified in the Wahler Report as having certain deficiencies that individually or in combination could jeopardize the safety of the dam. Field and laboratory investigations were conducted and Soldier Creek Dam was re-analyzed by Reclamation. The results confirmed that several concerns raised by the Wahler Report were sufficiently serious that modification of the dam embankment was justified. A lack of instrumentation made it difficult to evaluate the performance of the dam embankment, which led to the installation of over 25 piezometers in the embankment and foundation. The foundation bedrock surface preparation and the lack of proper treatment with lean cement (slush) grout placed in surface cracks, shaping, and dental concrete were of concern. The single-row grout curtain also caused concern. The nature of the zone 1 core material and the fact that it was placed directly against the untreated foundation bedrock caused concern. The permeability of the unprocessed zone 3 chimney filter/drain and blanket drain material caused concern, as did the fact that the chimney filter/drain and the toe drains did not extend all the way up to the full-reservoir water surface. Embankment and foundation drainage modifications were constructed in 1983-1984 to address these problems.[44]

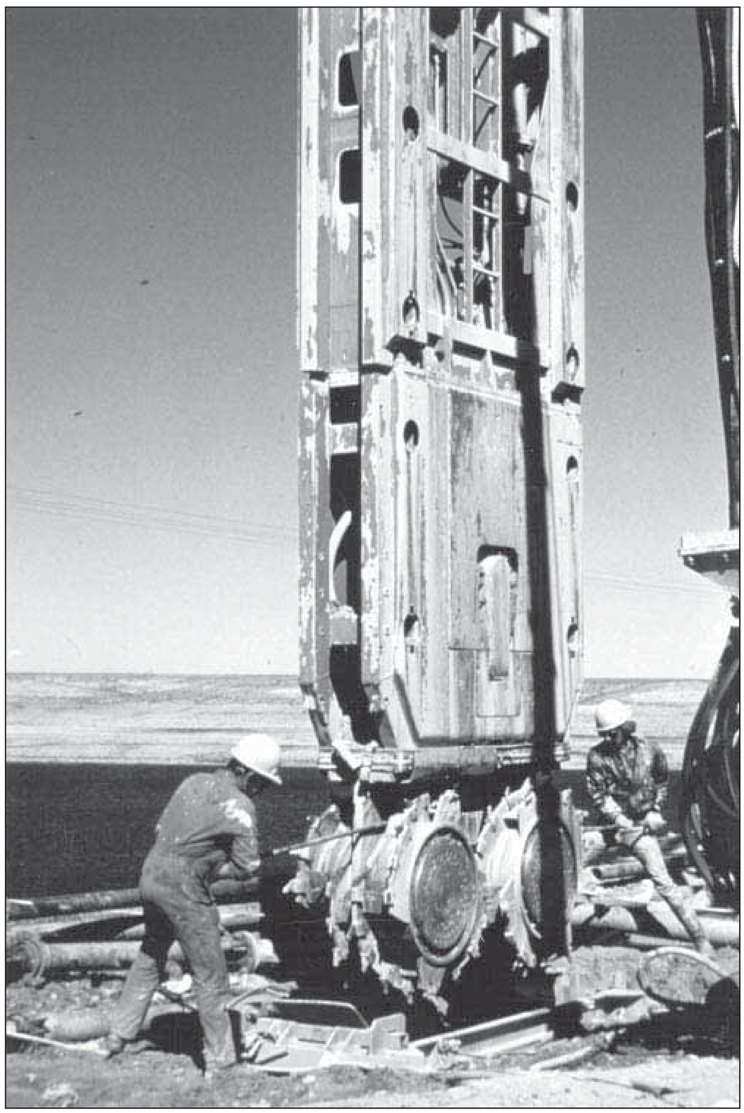


2.18. Fontenelle Dam: Section of embankment with diaphragm wall.

Fontenelle Dam continued to have seepage and internal erosion/piping problems after it was supposedly fixed by the additional abutment grouting performed in 1966. Instrumentation monitoring data in 1983 indicated that a potential dam safety problem was developing, and the decision was made to modify the dam by installing a continuous concrete diaphragm wall through

2.19. Fontenelle Dam: Diaphragm wall construction.

the dam and into the foundation. There were several aspects of the existing Fontenelle Dam embankment's design that were judged to have been partly responsible for the failure of Teton Dam, such as vertical to overhanging abutment cliffs, extensive joints and cracks in the abutments, no processed material placed as a chimney to filter the erodible silty zone 1 core as protection against internal erosion/piping, and silty core material placed directly against open, unsealed bedrock joints, cracks, and crevices. Only one solution was judged to be capable of alleviating all of these potential problems, and construction of a concrete diaphragm wall from the crest of the dam down through the embankment and the upper highly-fractured bedrock was selected as the appropriate modification (see 2.18). The concrete diaphragm wall had to avoid damaging the river outlet works near the middle of the embankment and the spillway on the right abutment. The concrete diaphragm wall modification was constructed between 1987 and 1989. 2.19 and 2.20 show the rockmilling equipment used to excavate embankment and rock for the diaphragm wall at Fontenelle Dam.



2.20. Fontenelle Dam: Hydromill rock excavator for diaphragm wall.

Black Lake, Pablo, and McDonald Dams are BIA dams on the Flathead Indian Reservation in Montana; Reclamation had designed and constructed Pablo and McDonald Dams between 1905 and 1920. At BIA's request, Reclamation investigated and prepared Safety Evaluation of Existing Dams (SEED) reports on these three dams, along with the other 14 dams on the Reservation. Under a contract with the BIA, the Confederated Salish and Kootenai Tribes entered into an agreement with the TSC for Reclamation to perform field investigations, laboratory testing, and engineering evaluations to determine the adequacy and safety of the dams on the Reservation. Starting with the dam of greatest initial concern, the investigation and analysis of Black Lake Dam indicated it needed to be modified to prevent a piping/erosion failure. The original Black Lake Dam had failed by internal erosion/piping in 1967, and the replacement embankment dam was judged to have several serious deficiencies that could result in another piping/erosion failure. Black Lake Dam was modified in 1992 by the construction of a geomembrane liner installed along the upstream right abutment, across the upstream slope of the embankment, and as a liner beneath part of the reservoir upstream of the dam. A downstream drainage berm is scheduled to be constructed in the near future and will hopefully remediate the current situation.

Pablo Dam was investigated and analyzed next, and it was determined that the upper portion of the embankment was susceptible to seepage, internal erosion/piping, and potential failure. The upper portion of the dam was more pervious because two embankment raises had been constructed and had used more pervious earthfill material than the original embankment. A geomembrane liner was constructed in 1993-1994, covering the upper embankment to control/prevent the seepage that had been percolating through it.

McDonald Dam was the third embankment dam investigated and analyzed. It was located about ½-mile upstream of the Mission fault, which had experienced a major earthquake about 7,700 years ago, and which was judged capable of producing a magnitude 7½ earthquake at any time. The dam embankment had been constructed by Project Manager/Engineer Frank Crowe (Honorary Member, ASCE) using dumped and sluiced earthfill, with a puddled core created by sluicing the dumped earthfill (see 2.21). The embankment and an outwash foundation beneath part of the dam were judged susceptible to liquefaction and excessive deformation. Various alternatives were developed and evaluated, with the final decision reached to completely replace the existing dam embankment, spillway, and outlet works. These modifications were designed by Reclamation which also provided the construction management services. It should be noted that the Construction Engineer for McDonald Dam

2.21. McDonald Dam: Original dam in 1920.

Modification was on the Design Team. The new McDonald Dam embankment was a completely different embankment design. The new embankment cross-section included: a textured geomembrane covered by earthfill and riprap on the upstream slope, an impervious earthfill zone behind the geomembrane, followed by an inclined processed chimney filter/drain, all of which rest against a large miscellaneous earthfill zone that sits on top of a blanket drain consisting of processed drainage material sandwiched between two layers of the processed filter material. The instrumentation consisted of piezometers in the embankment and foundation, embankment measurement points, and weirs to monitor seepage flows. These McDonald Dam modifications were constructed in 1994-1995 and 1999-2000 (see 2.22), after which its behavior during resumed filling of the reservoir in 2000 and beyond went very well.[45]

2.22. McDonald Dam: New dam in 2000.

At the beginning of Period V, the failure of Teton Dam and the results of the IRG, Independent Panel, and Comptroller reviews resulted in many organizational changes as already discussed. Several of Reclamation's embankment dam design engineers retired, leaving a small cadre of experienced engineers to work with the new staff of engineers then being hired to work on Reclamation's new dam safety program and on the embankment dam design work already in the "pipeline." That work has been going on for over 20 years now and is expected to continue for some time. Reclamation's current dam safety program includes conducting in-depth reviews, referred to as Comprehensive Facility Reviews (CFR), which are performed mostly by in-house senior engineers every six years. The CFRs include an examination of the dam and evaluations of: the dam's design, analysis, and construction; its structural behavior; its seismic and hydrologic hazards; its potential failure modes; its failure consequences; a risk analysis; and its performance parameters. Reclamation has continued to develop, revise, and make available information on its engineering work. The *Earth Manual* is now in its third edition, with *Part 2* published in 1990 and *Part 1* published in 1998.[1] *Part 1* of the *Earth Manual* (now containing 1,270 pages) includes updated information on properties of soils, field and laboratory investigations and test procedures, construction quality control testing of earthfill materials used as foundations and for dams, canals, and other types of structures built by Reclamation. *Part 2* (now containing 329 pages) includes updated information on properties of soils, field investigations, and control of earth construction. Reclamation's *Design of Small Dams* was revised and published as a "revised reprint" in 1977 and was revised again and published as the Third Edition in 1987.[2] In the 1980s, Reclamation developed its *Design Standards,* with *Design Standards No. 13—Embankment Dams*[6] covering all of the embankment dam design issues and concerns; they are all continually updated. Reclamation has continued to make its technical publications available to the public. Reclamation has recently embarked on a new program, generally referred to as risk-based analysis of existing structures, to help with its decision-making process.

Reclamation's instrumentation for and monitoring of embankment dams continued to be improved during Period V. Since their first installation at Fresno Dam in 1939, almost 2,800 hydraulic twin-tube piezometers have been installed at Reclamation's embankment dams. Pneumatic piezometers have more recently been used to measure porewater pressures and vibrating-wire piezometers are now the piezometer of choice installed at Reclamation's embankment dams. In addition to piezometers, other instrumentation often installed at Reclamation's new and modified embankment dams includes: observation wells, seepage weirs, embankment measurement points, strong-motion accelerographs (in earthquake-prone areas), and inclinometer casings with inclinometers to monitor known slide areas. One important aspect of current instrumentation is the use of automated monitoring systems at Reclamation's dams, allowing timely monitoring of embankment dams in remote locations where winter access can be a problem. Such automated monitoring systems also allow the data to be used by early warning systems. The monitoring data are collected by the TSC's Structural Behavior and Instrumentation Group which automatically interprets and evaluates the data in a timely manner and alerts the appropriate design groups if any of the instrumentation data cause concern. Reclamation published its *Embankment Dam Instrumentation Manual* in 1987.[46]

As usual, during Period V, the variety of equipment available for the construction of embankment dams continued to improve in size, power, speed, and efficiency. For example, 2.23 and 2.24 show the construction of New Waddell Dam (1986-1992) and the size of the equipment currently used to construct embankment dams. Compare the end-dump truck in 2.24 and its 35 yd^3 capacity to the train of 4 yd^3 side-dump cars used to construct Belle Fourche Dam in 1909 shown in 2.7. Also compare the large excavator in 2.24 and its

2.23. New Waddell Dam construction.

2.24. New Waddell Dam: Construction equipment.

12 yd^3 bucket with the steam shovel at Belle Fourche Dam with its 2½-yd^3 bucket shown in 2.7. During Period V, synthetic materials such as high-density polyethylene (HDPE) and polypropylene were developed into new products, such as corrugated pipe, geomembranes, and geotextiles, that were promptly put to use on embankment dams where judged appropriate. New types of equipment related to these new materials and products were developed, and quality control tests, testing equipment, and detailed test procedures were developed, with Reclamation's significant participation in these developments.

Conclusion

The information presented in this paper has summarized the U.S. Bureau of Reclamation's embankment dam design and construction history. During the past century, Reclamation has designed and built some of the most significant embankment dams in the West. Reclamation and its dam engineers produced many successes and a few failures during that period. Reclamation and its civil engineers, through the study of both success and failure and the sharing of the knowledge gained with all professionals worldwide, have indeed played a significant role in the evolution of embankment dam design and construction during the past century. Starting before World War II, Reclamation has provided technical assistance to more than 80 countries and has trained more than 10,000 international colleagues. It is hoped that the lay reader of this paper has gained some appreciation of Reclamation's history and just how remarkable the evolution of embankment dam design and construction has been. It is also hoped that the design and construction engineers reading this paper have gained some understanding of Reclamation's embankment dam design and construction history, and of the reasons for doing all embankment dam work with the utmost knowledge, care, and caution. One of the most important lessons learned from the failure of Teton Dam involved the need for embankment dam designers and construction engineers to work as a team, with their primary concern being the need to design and build the very best and safest dam possible.

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Historical Development of Durable Concrete for the Bureau of Reclamation

By:
Timothy P. Dolen

Introduction

Bureau of Reclamation infrastructure stretches across many different climates and environments in the seventeen western states. Many of the dams, spillways, pumping plants, power plants, canals, and tunnels are constructed with concrete. These structures were built from Arizona to Montana, across the plains and in the mountains and deserts. Concrete structures had to remain durable to resist both the design loads and the natural environments of the western climate zones. Many natural environments can be quite destructive to concrete and the earliest Reclamation projects were faced with a variety of durability problems. The state-of-the-art of concrete construction advanced from hand mixing and horse and wagon transporting operations to automated mixing plants, underwater canal construction, and pumping and conveyor placing. This paper first overviews the challenges facing concrete construction in the beginning of the twentieth century. It then traces the Bureau of Reclamation's role in the development of durable concrete to resist the environments of the west.

What is Concrete?

Before we begin, we must first understand what is concrete, the most versatile building material. The American Concrete Institute defines concrete as

> a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate, usually a combination of fine aggregate and coarse aggregate; in Portland-cement concrete, the binder is a mixture of Portland cement and water.[1]

The earliest concretes date at least as far back as early Roman times including the aqueducts and the historic Pantheon in Rome. These concretes did not use Portland cement as a binder. Rather, they used combinations of lime and pozzolanic sands mixed with broken rocks and shards of pottery.

Most twentieth century concretes are composed of about seventy-five percent aggregates by volume and about 2 percent "portland cement paste." The paste is the binder and contains cementitious materials and water. The cementitious materials include primarily Portland cement and sometimes an additional cementing material such as a pozzolan. Pozzolans are finely ground, calcined (heated to a high temperature) materials that react with lime to form compounds similar to Portland cement. Natural pozzolans are heated by events like volcanoes. Artificial pozzolans are calcined in a kiln or furnace, such as fly ash. The ratio of water to cementitious materials is about 1.5:1 by solid volume or 1:2 by weight. The individual components are mixed wet for about 5 to 10 minutes, then placed in forms to harden into their final shape.

The chemical process that turns the wet concrete into a hardened mass is called "hydration," a reaction between the cement and water that forms strong chemical bonds. Concrete does not get hard by drying like some clay bricks and lime mortars. It must retain the moisture to allow the cement to chemically hydrate; usually for about one month. The best concrete is one that stays continuously moist at a temperature of about 40 to 70 degrees Fahrenheit, such as the center of a mass concrete dam. The strongest concrete contains just sufficient water to chemically react with the available cement, about 25 to 40 percent water to cement by weight. The weakest concretes are those that contain excess water or prematurely dry out, stopping the reaction from continuing. Pozzolanic materials do not naturally harden through hydration with water; they must have added calcium hydroxide, or lime, to allow the reactions to take place. Fortunately, one of the chemical by-products of cement hydration is calcium hydroxide. Thus, added pozzolan when combined with cement and water makes for even stronger and often more durable concrete. Cement hydration also generates heat and can lead to temperature cracking when the interior mass wants to expand while the exterior contracts as it cools. Thus, any means of reducing the cement content reduces the potential for cracking.

The durability of concrete depends on the durability of its constituents: cement paste and aggregates. A concrete with strong paste may not be durable if combined with poor aggregate, and vice versa. One of the most important parameters is the "porosity" of the paste, which is a function of the amount of water relative to the cementitious materials. Excess water can dilute the cement paste leaving a more porous medium. This can be attacked more easily by deleterious substances and physical processes. The climate is a significant factor influencing the long-term durability of concrete structures. One of the reasons the ancient structures have survived is because they were constructed in relatively dry, temperate climates.

Early Obstacles to Durable Concrete

The turn of the twentieth century presented numerous obstacles to constructing durable concrete structures, one of which was population expanding across America into harsh climate zones. The quality of concrete was impaired by limitations of the quality of the materials and the methods of construction. In some instances, limitations on the quality of the basic concrete materials: cement, sand, and gravel, and the proportioning of ingredients impaired quality concrete construction under the severe exposures and harsh climates of the West. In other instances, the methods of batching, mixing, placing, and protecting the concrete limited the rate of construction and the overall quality of the structures. Lastly, the methodology behind concrete design and construction was just developing and was not well documented or distributed throughout the industry. A number of significant events and innovations during the twentieth century contributed to the development of concrete as a durable engineering material resulting in what is now considered "modern concrete." First, let's look at durability environments and then the state-of-the-art developments related to constructing durable concrete.

Mechanisms of Deterioration in the Western United States

There are about a half dozen environments that aggressively attack Portland cement concrete. These include the following:

- Sulfate environment
- Alkali-silica or alkali-carbonate environment—"alkali-aggregate reactions"
- Freezing and thawing environment
- Acid environment
- Chloride (corrosion) environment
- Wetting and drying environment

Concretes that remain durable under these conditions were proportioned in some way to withstand the elements, either accidentally or purposely. Some advances in the development of durable concrete resulted from observations of concretes that essentially used chemically resistant cements or "accidentally" introduced beneficial admixtures, and comparing them with those that rapidly fell to pieces.

The three most critical natural deterioration mechanisms affecting Reclamation structures are **sulfate attack, alkali-silica reaction, and freezing-thawing attack**. These three mechanisms are described in the paragraphs that follow. In many cases, concrete deterioration is caused by a combination of aggressive environments, such as wetting and drying in concert with sulfate attack in some California desert climates or freeze-thaw attack and alkali-silica reaction in the northwest. Here, micro-fractures caused by one destructive element allow moisture to more easily penetrate the paste and contribute to a secondary reaction. One environment common to United States highways and bridges is chloride/corrosion of reinforcing steel and the resulting deterioration. It was not a major deterioration mechanism for Reclamation concretes due to the absence of chlorides, that is, until some rather dramatic failures of precast, prestressed concrete pipe in the 1990s.

Sulfate Attack

Sulfate attack is a chemical degradation of cement paste caused by high concentrations of sulfates in soils and groundwater. Sulfate attack is caused by chemical interactions between sulfate ions and constituents of the cement paste. The disintegration appears to be caused by chemical reactions with cement hydration products and the formation of a secondary compound, ettringite, accompanied by a large volumetric expansion and cracking of the concrete. Sulfate attack was also known as "cement corrosion" in the early 1900s and is very common in the white "alkali flats" of the arid western states and in seawater, particularly tidal zones. Sulfate attack was noted in Reclamation structures on the Sun River Project in Montana in 1908, shortly after the formation of the U.S. Reclamation Service.[2] 3.1 shows the disintegration of a concrete canal lining in the Central Valley Project only five years after construction.[3] Early observations in these failures identified certain cement brands as being more resistant to deterioration in these environments than others. "Bad" cements were less resistant and avoided if possible in favor of more resistant "good" cements.

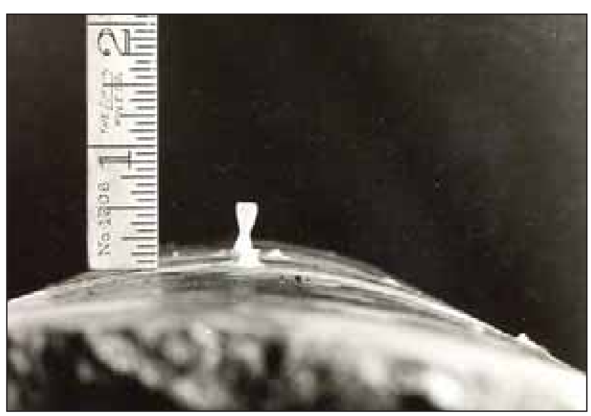
3.1. Concrete canal lining on the Central Valley Project.

Alkali-aggregate Reactions

Alkali aggregate reactions (AAR) are the chemical reactions between certain specific mineralogical types of aggregates (either sand or gravel) and the alkali compounds (generally less than 2 percent of the cement composition) of cement in the presence of moisture.

> Typical manifestations of concrete deterioration through alkali-silica reaction are expansion; cracking, which frequently is of such nature the designation "pattern" or "map" cracking; exudations of jelly-like or hard beads on surfaces; reaction rims on affected aggregate particles within the concrete; and sometimes popouts.[4]

The reaction products have a swelling nature, leading to tensile stresses that cause cracking within the concrete. The cracking may allow moisture to more readily be absorbed by the silica gel or accelerate freezing and thawing damage.



3.2. Alkali-silica reaction within concrete.

Alkalies in cement can react with certain "glassy," siliceous aggregates such as opals, chalcedony, cherts, andesites, basalts, and some quartz; termed alkali-silica reaction or ASR, and certain specific carbonate aggregates called alkali-carbonate reaction.[5] Alkali-silica reaction, shown in 3.2, was probably first experienced by Reclamation at American Falls Dam in Idaho, completed in 1927. However, extensive freezing and thawing deterioration and poor quality construction practices masked ASR as a primary cause of deterioration at American Falls Dam. Some structures, such as Parker Dam and Stewart Mountain Dam, suffered early rapid expansion and distress, and then became relatively stable after a few years as the available alkalies and reactive aggregates were consumed early in the process. Other structures, such as Seminoe Dam, are showing continued expansion and resulting distress even 50 years after construction.[6]

Freezing and Thawing Deterioration

Freezing and thawing (FT) deterioration is the deleterious expansion of water within the cement paste resulting in destruction of the concrete. Water present in the cement paste expands about 9 percent upon freezing. When confined within a rigid, crystalline micro-structure, the expanding ice crystals can exert pressures far exceeding the tensile capacity of the paste, causing cracking and ultimately failure of the concrete. The concrete must be nearly saturated when it undergoes the freezing for this form of deterioration to take place. Repeated cycles of freezing and thawing are common in Reclamation water conveyance structures. Areas subject to cyclic freezing, such as the spillway shown in 3.3, and particularly those in fluctuating water surface levels, or in splash or spray zones are the most susceptible to deterioration.[7] Freeze-thaw deterioration is most pronounced in more porous concrete having a high water to cement ratio and those concretes without purposely entrained, air bubbles; the very same concretes commonly used in early twentieth century construction. Freeze-thaw deterioration was first identified early in Reclamation history under the general term of durability of concrete without specific causes or solutions. This form of damage is present in the colder and mountainous regions and non-existent in the desert southwest. A mixture placed on the All-American Canal would have no problems, but, the very same concrete placed on the Yakima Project would be severely affected.

3.3. A spillway showing results of cyclic freezing and thawing.

Developing the State-of-the-Art of Concrete Technology

Even with quality materials, durable concrete could not effectively be mixed and placed in the larger Reclamation structures without new construction practices and equipment. The historical development of durable Reclamation concrete can roughly be divided into four generations with regard to both materials and methods of construction. Each generation contributed to the knowledge base of the developing state-of-the-art. The first generation of Reclamation concrete technology covers from its inception in 1902 until about World War I. These practitioners were the first "pioneers" of Reclamation concrete construction. The next generation, from 1918 until the late 1920s, began developing concrete as an engineering material. The Boulder/Hoover generation began in the late 1920s and continued up to World War II. This generation solved many of the fundamental problems encountered in massive concrete construction and developed many of the standardized quality concrete construction practices. They uncovered the mysteries of sulfate attack, alkali-aggregate reaction, and freezing and thawing durability, leading to the first truly engineered, modern, durable concretes. The postwar generation incorporated the basic concepts of modern concrete to a multitude of applications for dams, pumping and power plants, canals, and tunnels under a variety of differing site conditions. This is the first long-lasting, concrete infrastructure.

The Early Years—The Concrete Pioneers (1902-1918)

The first generation of concrete practitioners developed the technology largely through trial and error and continued observation. The earliest concrete was composed of poorly manufactured cements, unprocessed aggregates, and was mixed by hand or small mixers. The materials themselves; cement, sand, and gravel were subject to great variability. The concrete mixture was proportioned by "recipe" based on previous experience, not necessarily as an engineered material. Many early Reclamation projects were somewhat isolated geographically and there was less communication beyond regional boundaries. A change in location or structural design was not necessarily followed with an appropriate change in concrete mixture design, resulting in spotty performance. Labor was cheap, equipment and cement were expensive. The resulting mixtures contained the least amount of cement necessary to meet low strength requirements, at least by today's standards. Concrete was largely transported by wheelbarrows and compacted in place by manual tamping, spading, and rodding. The production rates were very slow, resulting in frequent "cold joints" or unplanned flaws that allowed seepage and subsequent deterioration.

A major change in building technology, the introduction of steel-reinforced, concrete structures, at first did not improve concrete quality. Pre-1900 structures were more massive and used a stiffer concrete that was tamped into place. The resulting concrete was less permeable and somewhat more resistant to the elements due to its low porosity; water simply had difficulty entering the matrix to cause damage. Reinforced concrete structures took advantage of the tensile strength capacity of the steel and the sizes of structural members were reduced. In addition to thinner structures, the reinforcing steel interfered with the placing and tamping practices. As a result, water was added to the concrete mixture to make it more fluid and thus easier to place. However, more cement was not necessarily added, and the weaker more porous concretes started falling apart in the field in only a few years.[8] The favorite phrase of concrete construction workers "add more water" likely came about during this era and a century later concrete technologists still shudder at the request!

The earliest Reclamation construction projects did not have the benefit of a developed methodology and specific equipment for concrete construction. Construction practices gradually improved during the first Reclamation construction era. Many structures fortunately utilized techniques that have helped them resist degradation. Theodore Roosevelt Dam in Arizona utilized a masonry facing and cyclopean concrete methods: large "plum stones" were placed followed by smaller cobbles and boulders and then the concrete was added to fill the remaining voids. This construction technique left large stones across the construction joint surface that reduced shear planes. The mixtures had a low cement content on a per cubic yard basis that reduced thermal cracking and the cost.[9]

One construction advance called "chuting," shown in 3.4, resulted in poor quality concrete. An "improvement" over the back-breaking manual hauling by buckets, long chutes were used to transport concrete to the forms. This permitted a centralized concrete batching and mixing location and larger batches could be fed to sometimes intricate, gravity-fed, chute systems. Water was added to make the concrete flow down relatively flat sloping chutes. The extra water diluted the cement paste in the concrete. These mixes were much weaker and had poor durability. To discourage this practice, engineers finally specified that the slope of the chutes could not be flatter than about 35 degrees from horizontal.[10]


3.4. "Chuting" of concrete resulted in poor quality concrete.

The developing state-of-the-art had a few "hiccups" along the way. "Sand-cement" was introduced to reduce the cost of cement by inter-grinding crushed rock flour during the manufacturing process.[11] The finely ground rock flour was introduced as a "pozzolan" to react with the cement for increased strength, and indeed, the sand-cement mixtures had higher 7- and 28- day compressive strengths compared to the control mixtures. However, the compressive strength development did not continue much after 28 days as is more typical of Portland cement plus real pozzolans. Thus, the problem was the finer ground sand-cement reacted faster, but did not act as a pozzolan because the rock flour was not calcined. Arrowrock Dam, in Idaho, constructed using sand-cement in 1915, was rehabilitated with a higher strength concrete facing in the mid-1930s to stop continued freezing and thawing damage.[12]

First generation Reclamation concretes were vulnerable to sulfate attack, ASR, and FT deterioration. In spite of these problems, some concretes seemed remarkably durable. Engineers and scientists began examining concrete materials to try to improve the quality. Studies conducted at the Lewis Institute in Chicago beginning in 1914 shed new light on the engineering properties of concrete.

The Abrams Generation (1918-1928)

The first major advance in concrete technology during the twentieth century occurred about 1918 with the publication of Duff Abrams's "Design of Concrete Mixtures."[13] Abrams improved on the recipe proportioning methods through deliberate design practices with proportioning methods and mix design tables. Abrams's classic research and his "water to cement ratio law" provided the foundation of concrete mix design still followed today. He found concrete strength and thus quality could be controlled by the relative proportions of water and cement. He also found it was possible to design mixes for the same strength using different materials. Concrete mixes could be designed and proportioned to meet a variety of conditions and structural requirements. Stronger concretes were developed to resist deterioration by the environment. Researchers began investigating the fundamental physical-chemical reactions that were needed to advance the state-of-the-art. One of the first inroads to developing durable concrete took place with the identification of the chemical reaction products of cement hydration, and development of a method to compute the relative proportions of each constituent in cement by Bogue in 1927.[14] This important step was necessary to formulate different compositions of cement. Without the knowledge of its composition, it was not possible to purposely change materials and manufacturing processes to enhance the performance of Portland cement.

Concrete manufacturing methods also improved during the 1920s, including centrally batched and mixed concrete plants and systems to haul and transport concrete to the site, as shown in 3.5. The daily output of concrete plants increased, resulting in fewer cold joints. The horse and wagon was being replaced by the locomotive and trucks. Larger projects were constructed, and more-mechanized processes were developed. Still, the process of consolidating concrete was left to the common laborer through rodding and spading.

3.5. Delivery of concrete by truck from a centrally located concrete plant.

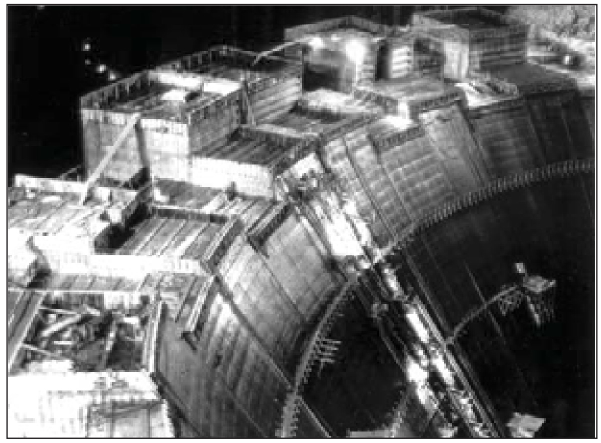
The first methods to consolidate concrete with mechanical equipment were just being developed. Better treatment of cold joints was developed during this time, improving the continuity between adjacent placements. For the first time, control tests were used to design and monitor concrete mixtures within specific parameters. Abrams's generation of concrete technologists provided the foundation of knowledge for the next generation, beginning with the decision in December 1928 to construct Boulder (Hoover) Dam on the mighty Colorado River.

Boulder Dam / The "Hoover Generation" (1928-1945)

In 1928, the Boulder Canyon Act ratified the Colorado River Compact and authorized construction of Hoover Dam.[15] The size of Hoover Dam required a completely new technology for large-scale concrete design and construction. The Hoover generation raised concrete materials technology, design methods, and concrete construction technology to unprecedented heights. This generation of concrete technologists formulated large-scale research and development programs of special cements to meet the specific engineering properties for massive concrete structures. They answered some fundamental questions about cement chemistry and the effects on mass concrete. Solving these questions required close cooperation and communication between government agencies, manufacturers, contractors, and private and academic research institutions. The application of scientific methods to solve complex durability problems led to what we now know as "modern concrete."

One of the first steps required for concrete for Hoover Dam was to investigate the composition of cement to reduce the amount of heat generated as it hydrated. Extensive research on cement composition resulted in developing a low-heat cement for mass concrete, now known by the American Society of Testing and Materials (ASTM) as Type IV cement. The hydration product "tri-calcium aluminate," abbreviated in a simplified form as "C_3A," was found to be one of the principal compounds that generates heat during the hydration process. Reclamation specified the chemical composition of cement supplied to Hoover Dam in 1933 to assure a low heat of hydration. The low-heat cement also had improved durability because the low C_3A cements had better resistance to sulfate attack. This improved resistance to sulfate attack was the basis for specifying less than 5 percent C_3A for cement used on the Kendrick Project in 1938; another forerunner of the ASTM Type V (sulfate-resisting) cement.[16]

Construction of such large projects as Hoover and Grand Coulee Dams could not have been accomplished without advances in concrete aggregate processing, concrete manufacturing, transporting, and placing. The use of block construction techniques, shown in 3.6, and artificial post-cooling reduced the potential for thermal cracking. Specialized concrete batch plants with rail transporting and "high-lines" or cableways, were used to transport and place large quantities in round-the-clock operations. One of the underappreciated advances in concrete quality developed by eliminating the back-breaking "tamping" techniques of consolidation with the high-frequency, mechanical concrete vibrator shown in 3.7.[17] Vibrators allowed a lowered unit water content of the mixture and thus lowered the cement content. The concrete generated less heat and became less porous, while costing less.



3.6. Block construction techniques reduced the potential for thermal cracking.

The size of Hoover Dam required not only significant advances in construction equipment and materials processing but also in construction project management and process quality control techniques. The designers and constructors of Hoover and Grand Coulee Dams were diligent, meticulous, **and** to some degree lucky. Fortunately, one of the chemical processes that could cause expansion, cracking, and deterioration of concrete; alkali-aggregate reaction, was avoided at Hoover Dam. The cements furnished to the dam had a high alkali content and fortunately, the concrete was mostly free from potentially reactive aggregates; though not by design, because the alkali-aggregate phenomena had not yet been identified and studied.[18]

3.7. The use of vibrators allowed a lowered unit water content of the concrete mixture.

Two of the indirect products of the Hoover generation were the founding of the Concrete Laboratory in Denver, Colorado, in 1931 and the first printing of the *Concrete Manual* in 1936. The Concrete Laboratory and *Concrete Manual* grew out of the need for a better understanding of the behavior of concrete and the control of concrete construction. Over 100,000 copies of the *Concrete Manual* have been printed in nine editions and at least four languages. "Concrete schools" were developed for training engineering and field personnel, and have continued to this day. Reclamation concrete technologists were active participants in ASTM and ACI, serving as both committee chairmen and as president. This commitment to voluntary standards organizations continues today.

As the United States entered World War II, the last two pieces of the durability puzzle were identified and finally corrected. Alkali-aggregate reaction was encountered by Reclamation at American Falls Dam, and about 150 miles downstream of Hoover Dam at Parker Dam. While American Falls Dam was undergoing rehabilitation from a variety of causes, Parker Dam was just being completed in 1937. Within two years, cracks appeared in the dam.[19] The cracking at Parker Dam was severe enough to warrant a large scale research investigation and a blue ribbon panel of consultants. In the end, the chemical reactions between certain altered andesites and rhyolites in less than 2 percent of the aggregates and the alkalies in the cement fostered a deleterious, expansive reaction called alkali-silica reaction, known as ASR[20]. First observed in Pennsylvania in the early 1920s at the Buck Hydroelectric Plant, ASR became a noticeable problem throughout the country in the 1930s and early 1940s.[21] The solution to ASR was to use petrographic techniques to identify those aggregates with the potential for expansion and to specify a 0.6 percent limit of alkalies in the cement.[22] Reclamation quickly instituted the low-alkali limit for concrete with potentially reactive aggregates by April of 1941.[23]

The last major advance in developing durable concrete was the result of both accident and observation in 1938. In New York State certain highway pavements were observed to have superior performance when a particular brand of cement was used in the concrete. The highway departments began specifying this particular brand of cement for all their highway construction without fully understanding the reason for superior performance. Microscopic examination of the concrete revealed a paste structure containing tiny, entrained, air bubbles brought about by using beef tallow in the cement kilns during manufacturing.[24] This produced the first "air-entrained" cement, accompanied by significantly improved freezing and thawing resistance compared to other cements. The microscopic air bubbles absorbed the expansive forces of freezing ice crystals within the paste, preventing micro-cracking. Though not a direct player in the initial identification of entrained air, Reclamation began testing concrete for freeze-thaw durability in the mid-1930s. This included evaluating concrete, aggregate quality, and other additives, some of which may have accidentally entrained air. The perceived superior durability of Grand Coulee Dam concrete in the 1930s may have resulted from specifications allowing grinding aids during cement manufacturing that may have entrained some air.[25] Anecdotal evidence points to other accidental introductions of air in concrete in the United States as early as the 1920s. These concretes were quickly rejected due to lower density and compressive strength! Higginson even refers to the possibility of forms of entrained air in stucco specified by Marcus Vitrivius Pollio in the first century A.D.[26] Reclamation quickly changed their specifications and changed to air-entrained concrete by 1942.[27] By the end of World War II, Reclamation had finally overcome the three primary causes of concrete durability problems in the West, resulting in what is considered "modern concrete;" an engineered concrete capable of resisting the physical and chemical forces of nature.

The Post-War Generation: "The Constructors" (1945-1990)

The post-war generation of concrete technologists applied the fundamentals of modern concrete to "customize" it for a variety of new applications and over a wide range of different environments. This generation began as post-war citizen soldiers returned to the United States and continued through the cold war. These people were the constructors. During the fifties and sixties Reclamation was completing "a dam a year." Large, thick arch dams became high-strength, double curvature, thin arch dams. Projects were constructed across the desert and through 14,000 foot high mountain ranges. Some of the largest water development and distribution systems were completed during this era, the Central Arizona and Central Utah Projects. The concretes used new additives to achieve greater durability, economy, and performance. These concretes should remain durable through the next century.

One of the most significant contributions of this generation improved durability and also made concrete less expensive. The purposeful addition of natural pozzolans in the early twentieth century was done somewhat as a cost-saving measure and later to reduce the temperature rise of mass concrete. The Bureau of Reclamation began investigating a power plant by-product, fly ash, in the 1930s and 1940s as a substitute for natural pozzolans in mass concrete. The first large-scale specified use of fly ash was at Hungry Horse Dam in 1950.[28] Reclamation continued research on fly ash, yielding other benefits such as improving the sulfate resistance of concrete. In the 1970s cement shortages prompted Reclamation to begin using fly ash in normal structural concrete and canal linings to save cement. The U.S. Environmental Protection Agency's implementation of the Resource Conservation Recovery Act, beginning in 1980, strongly encouraged the reuse of recycled materials, including fly ash in concrete.[29] The long-term benefits of using fly ash will continue for generations as these concretes are less porous and more resistant to sulfate attack and alkali-silica reaction, even more than with sulfate-resisting, low-alkali cements.[30]

The advances in construction equipment design dramatically increased concrete production during this time. Large-size canal linings are now placed at ten times the rate as in the early days. Instead of adding water to increase fluidity, superplasticizers are now added to make concrete flow like water, yet be twice the strength of its predecessors. Concrete linings were even placed under water to reduce leakage in unlined canals.[31] Concrete vibrators capable of consolidating 25 to 50 yd^3 of concrete per hour were replaced by 10-ton, vibratory rollers capable of placing 500 yd^3 per hour in roller-compacted concrete (RCC) dams.[32] It is interesting to note that the earliest Reclamation concretes were of such a consistency that they had to be manually "rammed" into place. The era of Reclamation concrete dam construction concluded at Upper Stillwater Dam using RCC of such consistency that was mechanically "rammed" into place!

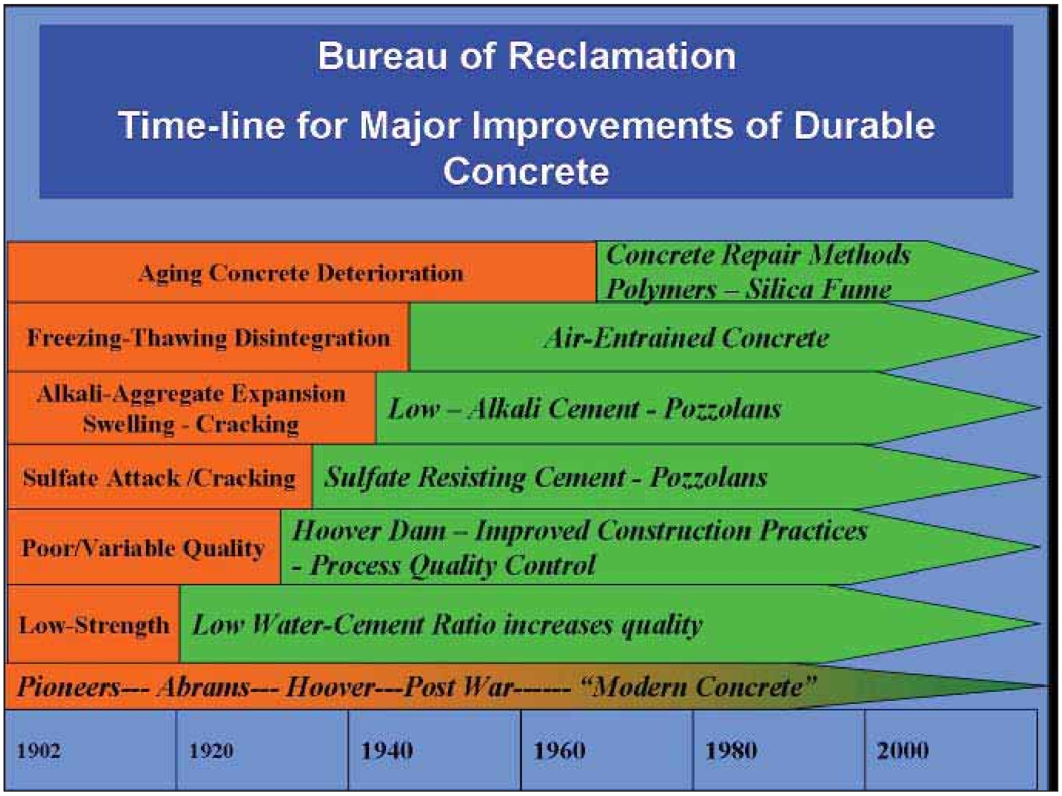
The Present Generation and Beyond (1990-)

By about 1990, the last large dams were being completed and a new era was underway. Most of Reclamation's construction program is now devoted to rehabilitation of existing structures. The Reclamation Safety of Dams Act of 1978 provided the Secretary of the Interior with the authority to construct, restore, operate, and maintain new or modified features at existing Federal Reclamation dams for safety of dams purposes.[33] As the inventory of dams was closely examined, it became apparent that many dams were in need of attention. The safety of dams program recognized dams constructed prior to changes in the state-of-the-art in dam design and construction were candidates for funding under this act. In addition to dam safety needs, many aging Reclamation structures were in need of some type of repair due to the ravages of time. An example is Tieton Dam, 3.8, constructed in Washington in 1925. The concrete lined spillway suffered from serious freezing and thawing deterioration. It was first rehabilitated in the 1970s and again in 1999 with operations and maintenance funding. Concrete canals, power and pumping plants, and appurtenant structures are also being rehabilitated throughout the West. The present generation of concrete technologists benefited from four generations of research and development. They must continue to apply the hard won practical knowledge of their predecessors to maintain the existing infrastructure well into the twenty-first century.

3.8. Tieton Dam spillway rehabilitated in 1999.

Conclusions

This paper reviewed the most significant causes of concrete deterioration and Reclamation's role in improving the technology to the current state-of-the-art. Without durable concretes, Reclamation could not have developed the western water resources infrastructure we enjoy today. The development and rapid implementation of these advances kept Reclamation at the forefront of the state-of-the-art through the twentieth century. This has extended the long-term service life of our infrastructure well into the twenty-first century. 3.9 summarizes many of the steps encountered in developing durable, modern concrete. Although the list of accomplishments is long, the author nominates the following as the "top



3.9. Timeline for major improvements in concrete quality and the development of Reclamation durable concrete.

five" contributions to durable concrete in the twentieth century (in chronological order):

1. Abrams' design of concrete mixtures and "water-cement ratio law"—Abrams applied engineering practices to concrete mixtures and he was the first to institutionalize control of the water content to improve concrete quality.

2. Development of special cements to improve concrete quality, such as low-heat and sulfate resisting cements.

3. Development of the internal vibrator to consolidate concrete—this equipment significantly reduced the water content of concrete, making it less permeable.

4. Determining the causes of and solutions to alkali-aggregate reaction and freezing and thawing attack—using scientific methods such as petrographic mineralogical examination and long-term testing to identify the parameters which affected the durability of concrete under these conditions.

5. Incorporating fly ash in Reclamation concrete construction—fly ash improved concrete workability, decreased the porosity of the

cement paste, and improved its resistance to sulfate attack and akali-silica reaction.

The modern concrete of today incorporates all of the advances of the past century. An example of 1 cubic yard of modern concrete will include the following ingredients and their proportions:

Table 1. Bureau of Reclamation “modern concrete” - one cubic yard of concrete.

Ingredient	Mass (lb/yd^3)	Volume (ft^3/yd^3)	ASTM Specification	Comments
Air	5 percent	1.3	C 260	Air-entraining admixture for freezing and thawing durability
Water *	220	3.5	C 94	Sufficient for 3 inch slump
Cement *	390	2.0	C 150	Type II, moderate sulfate resisting with less than 0.6 percent alkalies to resist alkali-silica reaction
Pozzolan *	100	0.7	C 618	Class F, “R Factor” less than 2.5 for improved sulfate resistance, and decreased potential for ASR
Sand	1080	6.6	C 33	Fineness Modulus of 2.75
Coarse Aggregate	2120	12.9	C 33	1-1/2 inch maximum size aggregate
Total	3910	27		

* Water to cement plus pozzolan ratio = 0.45 for superior durability in sulfate and freezing and thawing environments. Water reducing admixture included.

The Author’s Closure:
The Challenge for the Twenty-first Century—Identify, Protect, Preserve

Reclamation must now face the critical task of maintaining the existing infrastructure to meet the needs of the twenty-first century. The aging of concrete structures will require a major investment for continued operation. The most immediate needs are to protect concretes constructed before the “big three” durability issues were solved. Unfortunately, this only narrows the field down to about the 50 percent of our inventory constructed before World War II. Of these structures, those constructed before about 1930 are in need of the most urgent attention. A decision support system for aging concrete is under development to evaluate the earliest structures and present information on their long-term, service life potential.[34] With this information, Reclamation intends to present the status of our concrete infrastructure on a time-line to prioritize funding for protection before deterioration processes damage these facilities beyond repair.

I was fortunate to have as a mentor one of the great Reclamation concrete technologists of his time, Mr. Edward Harboe. Whenever I had a question, I would stop and talk to Ed because I knew he either had the answer or knew where to find it. Within a couple of hours, Ed would stop by after digging through his files to come up with the results of a long-ago study. In my opinion, many of our questions have already been answered by our predecessors. We must continue to preserve and to pass on the knowledge base that is our history. I would like to dedicate this paper to Ed and the many pioneers of Reclamation concrete construction, with special recognition the late Mr. G. W. "Bill" DePuy, my old boss, who passed away on January 3, 2002.

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History of Drainage in the Bureau of Reclamation: A History of Subsurface Drainage in the Bureau of Reclamation

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Abstract

In the early days of the Reclamation Service, the criteria for irrigability of lands generally consisted of two elements: 1. Is water available?, and, 2. Can we get it to the land? Within a few years, many of the early projects were experiencing reduced agricultural productivity and reduced ability to repay construction loans because their soils were becoming waterlogged and saline. By 1915 construction of subsurface drainage facilities had been initiated on several projects. However, at the time, subsurface drainage was more of an art than a science. Much of the world's experience with agricultural drainage had been gained in humid areas which are quite different than arid areas. With no standards and limited knowledge of ground water movement, these early drainage efforts met with varying degrees of success.

Faced with large areas of nonproductive land, several irrigation districts requested and were granted deferments in their repayment contracts. Congress responded over a period of some 30 to 40 years by passing a series of laws that progressively attempted to correct the deficiencies in Reclamation's project formulation procedures. The Fact Finders' Act of 1924 initiated the economic land classification in which lands were charged according to their potential productivity. The Omnibus Adjustment Act of 1925 reduced the repayment obligations for several districts due to nonproductive lands. The Reclamation Act of 1939 provided for periodic reclassifications to adjust classifications based on current productivity. The Interior Department Appropriation Act of 1954 required the Secretary of the Interior to certify sustainable productivity of the lands by means of irrigation. This law provides that the Secretary of the Interior must certify to the Congress that lands to be developed for irrigation are suitable for sustained productivity under irrigation. This means that the lands must be drainable at a cost that is economically feasible within the limits of the repayment capacity of the lands.

To meet this challenge, Reclamation drainage engineers developed scientific methods for conducting soil and water investigations and mathematical procedures for the design of subsurface drainage facilities. Reclamation first adopted existing steady-state methods for drain design and later developed the more accurate transient state procedures that are in use today. The methods and procedures developed by Reclamation have proven to be successful not only in correcting problems that develop on irrigated lands but also in predicting the drainage requirement before water is applied to the land.

Reclamation drainage engineers were also involved in the development of modern construction practices and in the development of modern materials such as corrugated perforated plastic pipe which is used in drain construction today.

Even armed with the legal authority and the technical knowledge to develop sustainable irrigation projects, good drainage practices were not always followed. Political decisions that run counter to the best available technical knowledge have contributed to such actions as the Riverton Third-Division buy-back and subsequent resale, and the utilization of Kesterson Reservoir as a terminal storage facility for return flows. Agriculture in California's fertile Central Valley remains in jeopardy because the planned outlet drain has never been constructed. The curtailments on the Oahe and Garrison Diversion Projects were in part due to misconceptions regarding drainage. While these decisions did not make use of the best technical expertise, they are nonetheless an integral part of Reclamation's drainage history.

By the 1950s, Reclamation had gained recognition as a world leader in the field of subsurface drainage. Reclamation drainage engineers have been responsible for the construction of several thousand miles of subsurface drains that maintain the productivity of over a million acres of irrigated land in the western United States. They have also been actively engaged in successful drainage projects in many countries around the world.

This paper includes brief discussions of how the need for drainage helped to shape Reclamation law as we know it. It also summarizes the development of scientific methods to ensure success. Some of the early projects that suffered drainage problems, and the challenges and successes in providing drainage, are also discussed. Reclamation has introduced these methods to solve irrigated drainage problems at the international level. We will address the international experience, and how the same methods and procedures are now being used to design corrective drainage facilities for dams and other major structures and to support environmental enhancement programs.

Introduction

Drainage of irrigated lands by the Bureau of Reclamation began shortly after the passage of the Reclamation Act in 1902. However, not until the late 1940s and early 1950s did engineers in the Bureau of Reclamation begin pioneering efforts to develop the technology of drainage of irrigated lands into a modern engineering science. (USBR 1993)

In the early days of Reclamation, the criteria for bringing land under irrigation were quite simple. If water was available and if it was economically feasible to get it to the land, the land was irrigable. Within a few years of development, waterlogging and salinity became serious problems for some of the irrigation districts. Beginning in 1911 the Huntley Project on the Yellowstone River in Montana constructed subsurface drainage systems that were very successful in returning the lands to full productivity. However, subsurface drainage was more of an art than a science at the time. Much of the world's experience with agricultural drainage had been gained in humid areas which are quite different than arid areas. A lack of standards and limited knowledge of ground water movement led to early drainage efforts which met with varying degrees of success. Huntley is located on coarse alluvial deposits that drained easily and were very forgiving if the drain was not placed in exactly the right location, orientation, and depth. For other projects, such as Belle Fourche in western South Dakota, the solutions were more difficult. Attempts at drainage met with limited success at best and in many cases they were completely unsuccessful.

Faced with large areas of nonproductive land, several Irrigation Districts requested and were granted deferments in their repayment contracts. Over the years, Congress passed various acts aimed at developing a sustainable irrigated agriculture in the western United States.

In order to ensure development of lands that could be kept in production within economic limits, Reclamation drainage engineers realized that they needed better methods of measuring soil permeability, a better understanding of soil salinity factors, and better drain spacing procedures. Working in cooperation with the U.S. Salinity Laboratory and other researchers who were struggling with the same issues, they adopted state-of-the-art standards for soil salinity, sodicity, and toxicity to various trace elements. Various in-situ permeability tests were developed and perfected. They adopted the steady-state drain spacing formula or ellipse equation as it is often called. Although several authors have published the same formula in different forms, Reclamation typically uses William Donnan's version which was published in 1935. While the Donnan formula is generally considered acceptable in the industry, it does not account for variations in irrigation practices nor does it account for specific yield, the natural water storage capacity of soils. To address these deficiencies, Reclamation engineers developed transient state procedures that more accurately defined the required spacing and provided for risk analyses of drain systems. The first version of the transient state procedure, published in 1953, underwent various modifications for about the next 15 years.

When the Chief Engineer's Office was established at the Denver Federal Center in 1948, it included the Drainage Engineering Section. This marked the first centralized effort to address drainage issues in Reclamation. Design standards were developed in order to achieve consistency of methods throughout Reclamation. The location, depth and orientation of pipe drains were designed to achieve the greatest system efficiency. Materials used and gradation and placement of envelope materials were controlled by standards, as were construction deviation tolerances. The standards were generally monitored and enforced by the Denver Office drainage staff.

Within the organizational framework of Reclamation, the drainage discipline has been unique in that it has been intimately involved in every phase of irrigation projects, from the preliminary planning through design and construction and, finally, operation and maintenance (O&M). The office originally designated Drainage Engineering Section later became the Drainage and Ground Water Division, and later still the Drainage and Ground Water Branch of the Engineering and Research Center. From 1953 to 1994, the Reclamation Instructions required each Regional Director to have a Regional Drainage Engineer on staff. This person was to ensure that the Drainage and Ground Water organization in the Region was properly staffed and that Reclamation drainage policy was followed. On the organizational charts of that period, the Drainage and Ground Water Branch was located in the Planning Division in two of the seven Regions, in the Construction Division in one Region, and in the O&M Division in four Regions. The functional statements were nearly identical in all of the offices. There has never been a Drainage Office in Washington, D.C., but for many years there was a Drainage Liaison position in the Planning Division.

Construction techniques have evolved over the years, sometimes in response to Reclamation design standards. Contractors developed new and better ways to handle envelope materials and to maintain grade within the limits of specifications.

In the late 1960s, the plastic pipe industry developed corrugated polyethylene and polyvinyl chloride tubing for use in agricultural drains. Reclamation's Open and Closed Conduit Systems (OCCS) research program was deeply involved in writing corrugated flexible plastic pipe standards.

From the 1950s, through the 1980s, Reclamation's drainage program was heavily involved in irrigation and drainage projects all around the world. The methods and procedures developed for use in the western United States proved to be useful wherever we went, and the experience gained in other countries was used to modify and bolster the domestic program.

In 1978 the *Drainage Manual* containing "the engineering tools and concepts that have proven useful for planning, construction, and maintaining drainage systems for successful long term irrigation projects" was published as a Department of the Interior water resources technical publication.

4.1. In October 1913 a Pioneer traction engine pulled an Austin elevating grader digging drainage ditches on the Milk River Project near Malta, Montana.

In recent years, the methods and procedures that were developed for agricultural drains are gradually being accepted for use in control of seepage from dams, slope stabilization, and other non-agricultural applications.

Legislation

Fact Finder's Act (December 5, 1924), (ch. 4, 43 Stat. 672)

The status of some Federal Reclamation projects of the western United States in the early 1920s was dire. Waterlogging and salinity problems were widespread and such conditions had not been anticipated. Lands were failing, farmers were failing, and costs for corrective measures were far greater than the costs originally anticipated. The U.S. Government decided to take action in the Fact Finder's Act of 1924, which charged the Secretary of the Interior, the cabinet official responsible for federal irrigation development, that irrigable lands shall be classified with respect to their capacity to support a farm family and pay water charges. The Secretary was also empowered in that act to apportion equitably the total costs assessed against the irrigable lands so that they all would pay in accordance with their productivities. Thus, a federal irrigation development would be composed of lands having varying productivities and payment capacities, but all would have to be able to support a farm family and pay operation and maintenance costs.

Omnibus Adjustment Act (May 25, 1926)

This act adjusted water right charges on specified projects (Belle Fourche, South Dakota; Boise, Idaho; Carlsbad, New Mexico; Grand Valley, Colorado; Huntley, Montana; King Hill, Idaho; Klamath, Oregon; Lower Yellowstone, Montana-North Dakota; Milk River, Montana; Minidoka, Idaho; Newlands, Nevada; North Platte, Nebraska-Wyoming; Okanogan, Washington; Rio Grande, New Mexico-Texas; Shoshone, Wyoming-Montana; Sun River, Montana; Umatilla, Oregon; Uncompahgre, Colorado; and Yakima, Washington.) The adjustments were deductions from the total repayment of projects' costs because of unproductive lands determined by land classification. Lands that were found to be permanently unproductive, generally due to waterlogging and salinity, were excluded from the projects.

Reclamation Project Act of 1939 (August 4, 1939) (ch. 418, 53 Stat. 1187)

This act provides that the Secretary of the Interior is authorized to require provisions in Reclamation water contracts for proper accounting, to protect the condition of project works, and to protect project lands against deterioration "due to improper use of water." The contracts will also require advance payment of adequate operation and maintenance charges. This act requires the classification or reclassification of project lands from time to time but not more often than at 5-year intervals "as to irrigability and productivity those lands which have been, are, or may be included within any project." The reclassification is to be done only at the request of the water users association or other authorized representatives of the water users.

Interior Department Appropriation Act, 1953 (July 9, 1952) (ch. 597, 66 Stat. 445)

This was the first law that requires the Secretary of the Interior to certify to the Congress that an "adequate soil survey and land classification has been made and that the lands to be irrigated are susceptible to the production of agricultural crops . . ." before any appropriation for any of the construction items for a project is available. This requirement was repeated in the Interior Department Appropriation Act of 1954 and is generally cited under that law.

Interior Department Appropriation Act, 1954 (July 31, 1953) (ch. 298, 67 Stat. 261)

This act provides that no appropriation for any of the construction items for a project is available until the Secretary certifies to the Congress that an adequate soil survey and land classification has been made and that the lands can be successfully irrigated.

Drainage and Minor Construction Act (D&MC) (June 13, 1956) (ch. 382, 70 Stat. 274)

The so-called D&MC Act provides for funding up to $200,000 per year for irrigation districts to correct minor deficiencies that developed after the transfer of facilities to the district for operation and maintenance. The district enters into a contract with the United States to construct or repair minor facilities not to exceed $200,000 per year. One of the more common deficiencies is inadequate subsurface drainage. The law allows districts to construct drainage facilities as the need develops over time. In some instances, it has been used in conjunction with a much larger rehabilitation and betterment (R&B) contract in order to get the most benefit from the dollars spent. The D&MC loan is repayable at the rate established by the district's primary repayment contract and usually is tacked on to the end to extend the time of repayment rather than increasing the amount of the payments.

Food Security Act of 1985 (99 Stat. 1354; 16 U.S.C. 3801-3862)

The Food Security Act of 1985, otherwise known as the Swampbuster Act, makes producers ineligible for certain U.S. Department of Agriculture farm program benefits if they convert wetland and use it to produce agricultural commodities after December 23, 1985. The problem then becomes determining what constitutes a "jurisdictional" wetland. The USDA Soil Conservation Service (renamed National Resources Conservation Service) was charged with making that determination on a case-by-case basis. Rules for making the determination were published in the *Federal Register* on September 17, 1987, and by October 1, 1987, wetland determinations had been made on about 750,000 acres on 34,000 farms. (Schnepf)

The Swampbuster Act did not have a profound impact on Reclamation's drainage program because our mission is to maintain agriculturally productive lands in a productive state, rather than draining jurisdictional wetlands. Nevertheless, it changed the process in that every proposed drainage project is now subject to Swampbuster rules and we must be vigilant in avoiding incidental drainage of wetlands.

Garrison Diversion Unit Reformulation Act of 1986 (May 12, 1986) (100 Stat. 418)

This Act requires that Reclamation conduct investigations and provide an estimate of any trace elements or toxic substances which may be present in return flows from irrigation. In order to make this estimate, it is necessary to explore the entire soil profile through which the drainage water from the project will flow.

Federal Reports Elimination Act of 1998 (November 10, 1998) (112 Stat. 3280)

This act eliminated the certification of land classification requirements by striking pertinent language of the 1953 and 1954 Appropriations Acts and Section 10 of the Garrison Diversion Unit Reformulation Act. Reclamation may seek to reestablish the certification through legislation.

Development of Transient State Drain Spacing Procedures

The Bureau of Reclamation used a steady-state equation known as the ellipse equation to determine spacing between drains until the early 1950s. An adjustment to the equation is made to account for dissimilar flow conditions where drains are placed directly on an impermeable soil layer ("on barrier") rather than at some distance ("above-barrier"). The validity of the drain spacing obtained by use of the ellipse equation is dependent upon the assumed steady recharge of water to the water table. The steady-state assumptions seldom represent the conditions produced by intermittent irrigation applications nor do they account for water storage capacity of the soil profile.

Reclamation drainage engineers believed that more precise drain spacings could be computed using an equation that reflected the typical pattern of irrigation applications with alternate drain-out periods and would also account for storage capacity. Reclamation drainage staff embarked on an initiative to develop a drain spacing procedure which would be applicable to widely varying soil and ground water conditions.

During the 1940s and 1950s drainage field personnel were making many drainage investigations of soils across the western United States. The information collected during these investigations included the capacity of the soils to transmit water; the amount, source, movement, and chemical characteristics of the water to be transmitted; and the available hydraulic gradients. The data they were accumulating were sent to the Chief Engineer's Office and were used by Drainage Division staff to develop the transient state spacing procedure.

Ray Winger initially conceived the transient state spacing theory and recruited Robert E. Glover to develop the mathematics. (Winger 2001) Glover had previously worked on the heat flow formulas that were used to cool the concrete at Hoover Dam. (Cunningham) Because the physics of heat flow is very similar to the physics of ground water movement, Glover was able to adapt the heat transfer formulas for cooling a flat slab with initial uniform temperature distribution to the problem of ground water movement to a drain.

In 1953 the transient state procedure used an initial flat water table for drains above the barrier and second degree curve for drains on the barrier. (Dumm 1953) Winger and Glover worked together to adjust the shape of the curve based on field data from the Redfield Research Farm on the Oahe Unit in South Dakota. William Ryan installed and monitored wells on the drainage research plots at the Redfield farm to determine the water table response to various recharge and drawdown events. (Winger 2001)

In 1959 the Office of Drainage and Ground Water Engineering sent a memorandum to all Regional Directors presenting new formulas which redefined the initial shape of the water table between drains to more closely match conditions found on functioning drains in the field. (Maierhofer) This description of the initial water table condition for the drain spacing solution is important because it more accurately predicts the height of the water table than the formula with a flat initial water table and relates the behavior of the water table to time, physical subsurface characteristics, and drain spacing. The validity of this new concept of water table shape over a subsurface drain was checked extensively using data from Australia, Canada, and the western United States. Good correlation was found between the computed and measured values. (Dumm 1962)

In 1966 W. T. Moody wrote a computer program that used a stable finite-difference formulation to solve the nonlinear differential equations for various depths to barrier from zero to infinity and a fourth degree parabola initial water table condition. This is the first time the fourth degree parabola initial water table shape was applied to the drain on barrier case. This is the basis for the drain-out curves that were published in the *Drainage Manual*. (Cunningham) The curves serve as a tool for designers, eliminating the need to slog through the rigorous mathematics for each new drain spacing effort. The intermediate curves have largely been underutilized by the drainage community although recent authors are discovering this important work.

The success of the development of the transient state formula in design of drains is due to the flexibility of the drainage engineers at that time. They were willing to apply the theoretical to the practical and use the results to refine and redefine the theoretical. Glover, Maierhofer, Dumm, Winger, and Moody were also willing to look at field results and revamp the formulas for transient state drain spacing.

Development of Design Standards

It has been said that drainage is as much an art as a science. As quaint as this sounds, as long as it was true failure to achieve satisfactory results would always be a probable outcome of building complex drainage systems. On the Shoshone Project, for instance, many drains were placed at 12 to 14 feet below ground, depending on how deep the contractor could bury them. This was done in the early 1950s in the belief that deeper was better without regard to scientific examination of the soil profile. The problem was that the shale barrier was at 8 to 10 feet—above the drain—in most locations. As a result, the drains are painfully inefficient. Although the drains do seem to work as well as they would at the barrier depth, the spacing is too wide, because it was based on the deeper depth.

Reclamation adopted the attitude that failure was unacceptable. The cost was just too great. With this motivation, Reclamation set out to establish design standards that would be as close to fail-safe as good science and responsible economics would permit.

The Function Statement of the Drainage Section, Chief Engineer's Office, in 1948 charged the Section with the task of developing Reclamation-wide standards for drainage. Design standards were needed to establish consistency and to protect the taxpayers and the water users from spending large sums of money for facilities that offered a low rate of success. Over the years, Reclamation's policy toward ground water control has evolved to a stated policy that ". . . drainage construction is an integral part of all irrigation projects." Typically, projects must demonstrate favorable cost-benefit ratio before they are funded for construction. The cost/benefit factor includes costs for providing subsurface drainage.

The collector drains have always been considered a project cost, but the relief drains are not always so. In 1951, a general Reclamation Policy was established that ". . . construction of project drains on farm should be precluded or definitely restricted and that the land owner should assume responsibility for such construction the same as for other on farm development." (USBR 1954) This policy was reviewed and modified in 1963 to allow the cost of drains to ". . . be considered, depending upon the circumstances, as a project, or a farm cost." (USBR 1963) Since that time, on farm drainage costs are decided during the planning stage of all projects. Since subsurface drainage problems tend to indiscriminately cross property lines and are usually contributed to by the distribution system, drainage is nearly always considered to be a project cost.

Among the original set of design standards was the placement of a graded sand-gravel envelope around all pipe drains. While gravel envelopes were used as early as 1911, their use was inconsistent and there was no specific gradation. Design criteria for envelope design, based on hydraulic flow properties as well as filter properties, were published in 1970. (Winger and Ryan) The resulting envelope enhances the flow of ground water into the drain while excluding soil particles which would clog the drain pipe. Along with the advent of plastic pipe came a plethora of synthetic envelopes that were cheaper and easier to install. Beginning in the 1970s, Reclamation tested many of these envelope materials. Every attempt to replace the sand-gravel envelope with synthetic geotextiles, fabrics, beads, or mats has resulted in inferior performance or complete failure of the drains. Each research effort concluded that the sand-gravel envelope, even with the greater cost compared to synthetics, is very inexpensive insurance.

The emergence of corrugated plastic pipe for use in subsurface drains represents the most significant change in design standards since the standards were developed. In 1968 the first test sections of 6-inch-diameter plastic pipe were installed in the Kansas River Projects and in the Columbia Basin Project in Washington. Within 4 years, plastic had become the most popular material for small diameter drains and, within 20 years, sizes up to 42-inch-diameter were available. Concrete pipe is still used in some instances, but clay tile has all but vanished, and asbestos cement was eliminated when asbestos was classified as a hazardous substance.

The advent of plastic pipe allowed for curvilineal design of drains to better fit topographic features and eliminated the need for certain manholes. It also speeded the construction process as pipe is laid as a continuous unit rather than in 3-to-5 foot segments. It also opened the door to high-speed trenchers, which at the time were not large enough to handle rigid pipe sections.

The Reclamation drainage community is concerned with protecting the resources that Reclamation develops. If we develop flourishing irrigation enterprises only to see them deteriorate into salt beds and low value marshes, we have failed in our mission. Reclamation's design standards and procedures, as described in 1977, (Frogge and Sanders) have remained nearly unchanged since that time.

Evolution of Construction Practices

The construction of drains over the last century has taken as many forms as contractors and engineers could conceive. The following discussion is by no means a complete history of the evolution of construction techniques for drainage, but includes what the authors are familiar with or could find in the literature.

When the first drainage problems developed on Reclamation projects, the solution was to excavate open ditch drains using a horse-drawn earth-moving implement sometimes called a "tumblebug." The tumblebug was pulled by 4 or 6 horses or mules. As it was pulled along, it would scrape up about 1/3 of a cubic yard of earth. When it was full, the operator moved a lever to raise the blade for transport to the waste area, usually the drain bank. To unload, the operator pulled another lever and the implement tumbled to an upside down position, spreading its load over a short distance.

Some early subsurface tile drains were laid in an open trench and backfilled to make a subsurface drain. One such undertaking on the Huntley Project on the Yellowstone River just east of Billings, Montana, in 1912 lasted 4 months, from June 1 through September 30. The Contractor was paid $2,618.40 while his costs were $2,602.64 leaving a profit of $15.76. (USBR 1912) However, even in that time better methods were available. The ancestor of modern trenching machines was introduced on the Huntley Project in 1912. It was an Austin trenching machine that excavated a trench up to 8 feet in depth. It was joined a year later by a Parsons trenching machine with similar capability. Construction of 2500 feet of tile drain in one month's time was considered good progress. Neither machine carried a shield for laying the pipe, so where trench walls would not stand, shoring was constructed behind the machine. Where the grade line was deeper than 8 feet, laborers dug the last increment by hand, 2 to 4 feet in places. (USBR 1913)

In the summer of 1913 laborers were hard to find, so the wage rate was raised from $2.50 a day to $2.75 and rubber boots were furnished. The construction crew consisted of 30 to 40 men and from 2 to 8 teams of horses or mules. (USBR 1913)

Another early mode of excavation was the steam shovel, the precursor of modern backhoes. By the 1950s most open drains were excavated by modern drag lines which are particularly well suited to ditch excavation.

Subsurface pipe drains were first installed by digging an open ditch, laying a bedding for the pipe, placing the pipe by hand, covering it with a gravel envelope, and finally backfilling the ditch. Often the bedding consisted of wooden cribbing placed in the trench to support the pipe. The wooden cribbing was later replaced by coarse gravel material which will stabilize a trench that displays quicksand conditions. Surprisingly, open ditch methods of construction are still used in many cases, although the excavation equipment has generally changed to large backhoes.

In 1951 a trenching machine appeared on the Delta-Mendota Canal in the Central Valley Project. This machine towed a sled-mounted shield for laying pipe and gravel envelope. The forward movement of the trencher was assisted by a cable winch with a block and tackle arrangement hooked to a deadman dozer. This avoided slippage of the tracks which would quickly dig into the boggy ground and the trencher would become stuck. Similar arrangements were used to assist trenchers to move over boggy ground as late as the mid-1970s. In 1955 trenching machines were working in the Gila Project in Arizona and the Heart Mountain Division in Wyoming. Both machines were ladder-type excavators and had shields for placing the gravel envelope and pipe. The Cook and Butler machine on the Gila Project was mounted on a halftrack with large steel wheels on the front. The wheels made traversing boggy ground nearly impossible. Another design problem was that the shield was rigidly attached to the machine, which prevented separate control of the shield and the trencher. The machine was still in use as late as 1969. The Heart Mountain machine was a Parsons model 310. It was track-mounted and the shield was completely separate from the trencher, having its own set of tracks and being towed rather than carried.

The Jetco wheel trencher was developed specifically for conditions on the Columbia Basin Project where rock-like caliche layers must be excavated. The wheel was 16 feet in diameter and could excavate a trench to a depth of 12 feet. In the Republican Valley of Nebraska and in California's Imperial Valley, quicksand conditions presented the most difficult conditions. There, Buckeye trenchers with ladder excavators and wide floatation tracks were developed. The Buckeye machine with its trench shield attached was 50 feet long and weighed 50 tons. It could place drains in fairly boggy conditions at a depth of 10 feet. It carried two large diesel engines, one to move the machine forward and run the digging mechanism and one to run the hydraulic pumps to adjust the depth of the digger and the shield.

Both the Jetco and the Buckeye carried a trench shield in which the concrete or clay tile sections were placed by hand. A hydraulic lift was used to lower 2.5-foot lengths or "joints" of pipe into the shield where a man placed it in position on a set of steel rails. A hydraulic ram pushed the pipe tight against the preceding joint and held it there as the machine moved forward. When the machine had traveled the length of the pipe joint, the man in the shield sounded a horn and the operator stopped the machine to allow another joint of pipe to be lowered into place. The machine moved a pace of about 50 feet per hour, including the stops. Later a dual ram apparatus was introduced which allowed continuous forward movement as the joints were handled. The pace accelerated to a dizzying 300 feet per hour.

Besides the rails, the hydraulic ram and cramped quarters for a man to work in, the shield contained a chute for placing the gravel bed for pipe to lie on and another chute to place gravel around and over the pipe before it left the shield and was subject to trench wall caving. Often there was a spool mounted on the back of the shield to dispense a continuous sheet of plastic or asphalt saturated felt along the top of the pipe. This so-called blinding was thought to prevent soil from being washed into the pipe along with the drain water. That practice was discontinued when the hydraulics of the system became better understood. Most shields also carried a hopper for gravel material so that a continuous feed of gravel was made as the pipe was laid. With the advent of plastic drain pipe, there was no longer a need for a laborer to ride inside the shield. The man and machinery inside the shield were replaced by a chute through which the continuous pipe is fed so that the pipe and gravel envelope emerge from the rear of the shield as a single unit. The machines were not manufactured for placement of a gravel envelope around the pipe as Reclamation standards require. Contractors typically found it necessary to modify their new machines by attaching shields, strengthening bearings and shafts, and adding special controls before the new machine ever went to the field. This procedure is still common in the industry.

In 1970 a German-made Hoess Machine was introduced in the Republican Valley. The Hoess was a smaller, lighter weight machine with a high-speed chain digger. Although the machine could not lay solid pipe joints, it could lay continuous 4-, 6- and 8-inch plastic tubing at 7 feet deep at a pace of 1200 feet per hour. Several more years would pass before larger-diameter plastic pipe was approved for use. Many contractors preferred to stay with their old machines rather than have two large machines on the job. By the end of the 1970s plastic pipe was approved in diameters up to 18 inches. The need for greater depth and larger shields to accommodate the larger pipe meant that many contractors simply converted their old machines rather than investing in the new smaller ones. During this time, several European companies introduced the larger high-speed trenchers that are now in use. Forward speeds of 2,000 feet per hour are now common.

In addition to the accelerated rate of construction, field drainage engineers found that trenching machines provided a superior product when working in unstable soil conditions. (Frogge and Sanders) In 1974 the first drains for which a trenching machine was required by the construction specifications were constructed down the center of a primary street in Loup City, Nebraska. The purpose of this requirement was to ensure that the gravel envelope was placed in direct contact with undisturbed soil to form a strong hydraulic connection between the soil profile and the drain. Construction specifications requiring the use of trenching machines that excavate the trench, lay the pipe and the gravel envelope are becoming a common practice where construction costs are high and the consequences of failure unacceptable.

A longstanding problem for contractors building subsurface drains is operating heavy equipment on wet ground. In many cases, the drains are designed to remove excess water from land that has become perpetually marshy. A drain contractor in the Kansas River Projects solved this problem by constructing through such areas in midwinter when there was a foot or more of frost. Using a concrete saw, two cuts were made through the frost layer, one foot on each side of centerline. The blocks of frozen soil were removed with a backhoe making a slot for the trenching machine to work through. This operation required great caution to avoid placing frozen chunks in the backfill, which is forbidden by the specifications. Another solution was the use of flotation tracks. In the early 1980s, a Hollanddrain trencher having tracks that were 4 feet wide was used on the Riverton Project. It could easily trench through ground so soft that walking was difficult.

With the early trenching machines, grade control was done one pipe joint at a time and the digger was adjusted as needed. As speed increased, contractors began using a string line which the operator tried to follow (with varying degrees of success) to maintain grade. Another approach to grade control was a line of targets. This line of targets was set up in the field at an exact elevation above the grade line. The operator sighted on these targets and lined up two targets attached to the digging apparatus with the line of targets in the field. The targets were more reliable than the string lines, but still required a skilled operator to maintain an acceptable grade on the drainpipe. Along with the high-speed trenchers came laser-controlled grade where the operator adjusted the machine according to a red laser dot that was aimed at the control panel. Often the laser beam would be warped by the heat of the trenching machine's engine, making the dot much larger than the permissible deviation from grade. Sometimes the dot would disappear entirely. That system was quickly replaced by laser planes that project a plane of laser light on the correct slope over the entire field by a revolving laser sending unit. The plane is intercepted by sensors on the trenching machine; the sensors signal the hydraulic controls several times per minute to adjust the digger and the shield up or down as needed. Interference from engine heat has been overcome by placing the sensors on masts, several feet above the machine.

The September 1955 issue of *Intermountain Industry Magazine* featured a machine developed by Sumner G. Margetts & Company of Salt Lake City, Utah, claiming it was “The only machine of its type in the world (government approved).” The manufacturer was not identified and photos appear to be different from any of the machines discussed earlier in this writing, indicating that at that time there were at least 4 such machines in existence. However, as revolutionary as these giant machines were they never became common construction industry equipment. A total of 12 machines were reported to be in operation in 1977, (Frogge and Sanders) and in the United States, there are currently less than 10 operable machines with a depth capability greater than 8 feet.

Operation and Maintenance

As noted earlier, the Drainage and Ground Water function organizationally resided in the Operation and Maintenance (O&M) Division in four of the seven Regions for nearly 50 years. This was due in part to the reality that drainage problems usually arose after the projects had been transferred to the O&M Division. However, regardless of their position on the organizational chart, the maintenance of drains after construction was the responsibility of the Regional Drainage Engineer with the support of the Projects Office Drainage Branches.

The same observation well network that is used for planning and design is used to monitor the effectiveness of drain systems after they are built. Usually, the records of ground water fluctuation are maintained by the same drainage personnel who installed the wells. Most drainage offices in the 1950s, 1960s, and 1970s maintained handwritten or typed records of all the well readings within their project area. The wells were measured 2 to 12 times a year, depending on the relative need for detail. Hand-drawn hydrographs of the measurements were updated annually and kept in three-ring binders for ready access. In more recent times, the records are usually kept electronically, and, thanks to modern software, hydrographs are printed as needed. The hydrographs are used to forecast emerging drainage needs in time to plan and execute corrective measures before they became a serious economic burden on the landowners or the irrigation district. The hydrographs are also useful in diagnosing deficiencies in existing drainage works.

In projects where drainage was a major factor, drainage personnel typically participated in scheduled reviews of maintenance along with the distribution system O&M experts. When problems developed in drainage systems, the drainage staff advised O&M forces on methods of repair and, in many cases, actively participated in the repair, as they still do. Through the years, these kinds of activities have aided in verification of design criteria and methods.

Early Experience

Many of the first wave of Reclamation projects experienced severe drainage problems within a few years. Efforts to correct drainage deficiencies met with varying degrees of success. The experiences of some of these early projects are recounted here.

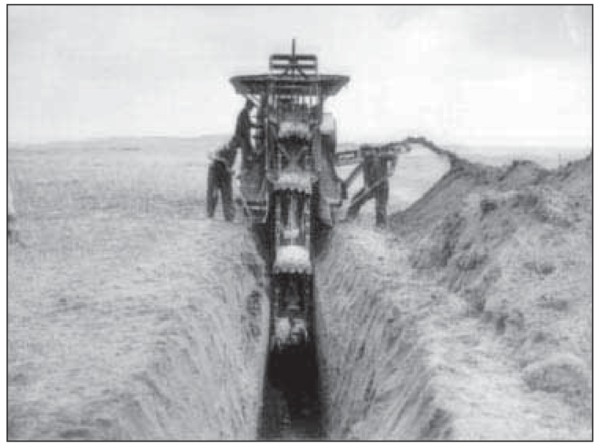
Belle Fourche Project

The Belle Fourche Project was among the first Reclamation projects to be developed. The project was initiated with studies in 1903 and authorized in 1904. By 1910 many of the facilities were in place and water was being delivered. However, by 1912, seeped areas totaling 1,420 acres were scattered over most of the project. By 1914 the seeped areas had grown to 2,500 acres and, by 1917 they were estimated to be 35,000 acres. Small drainage districts were formed and managed to get several thousand acres relieved of water charges. Notes from a landowners meeting in 1920 state, "It begins to look like the only way to accomplish drainage of the project would be to have an order from the Secretary of the Interior with provision that the costs be charged to Operation and Maintenance of the Project." (USBR 1920) The district requested and was granted a delay in the repayment contract. The 1926 Omnibus bill provided an adjustment to water charges due to drainage deficiencies.

From 1917 to 1930 a drainage construction program was carried out to correct the problems. Some 230 miles of drains, mostly open ditch, were constructed. Over the years, the Soil Conservation Service constructed buried pipe drains on many of the fields. Even that effort was not fully successful in relieving the drainage problems. Improved irrigation practices have helped. In 1984 the District entered into a Rehabilitation and Betterment (R&B) contract with Reclamation. Work done under the R&B put most smaller irrigation laterals in pipe and lined many of the larger ditches, thus eliminating many sources of seepage. In the1990s a land reclassification placed some of the more unproductive lands into class 6 (nonirrigable). All of these actions have improved the overall situation, but parts of the district suffer from unresolved drainage problems to this day.

Huntley Project

Huntley Project was authorized in 1905 and many of the facilities were completed by 1908. As was the case on the Belle Fourche Project, within a few years serious waterlogging problems developed—but with a much happier outcome. In 1911 there were 160 acres of waterlogged land and "another 40 farms where seepage has shown up." (USBR 1911) Even as drains were being constructed and successfully relieved seepage problems, the problems continued to grow. In 1914 there were 1,426 acres "waterlogged" and 8,000 acres "threatened" (USBR 1914), but by 1920 construction had caught up with demand and the problem was well under control.



4.2. An Austin trencher digging a drain on the North Platte Project in 1917.

From 1911 to 1920 some 65 miles of drains were constructed, most of which were clay tile. Eventually, the total drainage on the project reached 186 miles. (USBR 1981) The manholes or "trap boxes" as they were called, were 3 feet square, made of creosote-treated wood, with 6-inch by 6-inch vertical timber corners and sides consisting of 2-inch planks. Some of these manholes have been replaced by corrugated metal pipe, but many of them are still in use. As to the effectiveness of the drains, they were nearly 100 percent successful and continue to function with minimal maintenance.

Newlands Project

The USBR Dataweb provides the early project history:

> The United States Geological Survey (USGS) began investigations into possible irrigation projects in the Truckee and Carson River Basins in the late 1880s. In 1902, the newly organized United States Reclamation Service took over investigations. On March 14, 1903, the Secretary of the Interior authorized the Truckee-Carson Project, making it one of the first projects authorized for construction by the Reclamation Service.
>
> Work on the Truckee-Carson Project began in mid-1903. The original plan proposed reclamation of over 300,000 acres of land in western Nevada. *(Eventually the service area included about 73,000 acres. (USBR 1981))*… The first water deliveries to project settlers began in February 1906. …

As early as 1908 it had been recognized that there were serious problems throughout the project. In spite [of] the Reclamation Service's belief that soils would support a wide variety of crops, that sufficient water would be available to farms, and that markets existed for produce, many entrymen soon discovered that a forty-acre farm was too small to produce an adequate income, that irrigation water did not drain properly, and that little water was available during the later part of the irrigation season. By 1912, large areas on the project were saturated and unusable, and farm prices were much lower than expected. Drainage ditches excavated in 1906 did not sufficiently drain irrigated fields, and the water table was very near the surface, saturating the root zone.

Lack of adequate drainage was a significant impediment to successful farming in the region. Area water users formed an informal organization and began to demand that the Reclamation Service provide a solution to the drainage problem. Conflicts over who was responsible delayed resolution of the situation. The water users claimed that the Reclamation Service had promised adequate drainage, while the Reclamation Service contended that the problem was due to over-irrigation and that the farmers should assume the cost of constructing a drainage system. Offers by the Reclamation Service to correct the drainage problems with the costs paid by the water users were overwhelmingly rejected.

In 1916, after several years of resisting the formation of a formal water users organization, the Reclamation Service proposed to begin work on a drainage system as soon as an irrigation district could be formed that could contract for payment of the costs of the drainage system. In March 1917, the Nevada Legislature passed a bill approving formation of the irrigation district, and on November 16, the Truckee-Carson Irrigation District (TCID) was created by a vote of nine-to-one in favor of organization.

A contract for construction of a drainage system was not approved until 1921, and a second contract had to be approved in 1924. By 1928, when work under the contracts was complete, more than 230 miles of drains had been excavated. …

Following World War I, conditions on many Reclamation projects had become so bad with many farmers unable to fulfill their payment obligations that the Secretary of the Interior appointed a fact finding commission to investigate the situation and make recommendations. The commission determined that by 1926, $7,899,479 had been spent on the Newlands Project. Of that amount, the commission determined that $4,437,820 had been spent without proper cause and that the water users should not be responsible for repayment of that amount. The Omnibus Adjustment Act of 1926 relieved the water users of that amount and gave them forty years to repay the remaining $3,281,999. (USBR Dataweb)

Although the drainage system was considered complete upon completion of the contracts in 1928, drainage work continued at a slower pace. In a trip report dated October 28, 1964, Ray J. Winger, Jr., reported ". . . a total of about 335 miles of open drains." Winger also noted that they observed several small areas of 100 acres or so that needed additional drainage for good production. He was told that the farmers do not want drainage because they believed they were benefiting from subirrigation. He noted that, "Under these circumstances, the lands are becoming salinized. Without drainage they will eventually become sufficiently saline to limit or preclude crop production." (Winger 1964) His conclusion was apparently acted on because a 1985 land classification report by Reclamation says, "A maze of nearly 400 miles [additional 65 miles] of open drains and 4 miles of closed drains presently serve the Newlands Project." (USBR 1985)

A unique feature of the Newlands Project is the concept of so-called "bench and bottom lands" based primarily on subsurface drainage characteristics which were not clearly defined until some 60 years after the concept was initiated. In 1925, following a series of legal actions and hearings that began in 1913, a temporary restraining order was issued. Under the restraining order farmers on the project were to receive, after transportation losses, 3.5 acre feet of water per acre for bottom lands and 4.5 acre feet of water per acre for bench lands. The restraining order neither defined nor identified project bench and bottom lands. In 1944 a final decree simply restated the restraining order. Legal actions continued through the years and a 1986 Court Order directed the Secretary of the Interior to prepare and submit a "revised initial designation of Bench and Bottom lands in the Newlands Project." The new map was to be based on two criteria, including waterholding capacity of the soils and the "seasonal high water table." In 1990, Reclamation drainage personnel produced a "final draft" report which included detailed maps and legal descriptions of the designations.

Challenges Met

Examples of early Reclamation drainage history are too numerous and varied to include them all in this paper. A few of the more outstanding experiences are presented here.

Riverton

The Riverton Project consists of three divisions. Construction began on the first and second divisions in 1921, and first water was delivered in 1925. Drainage problems developed on some of the lands almost immediately. In the 1930s and 1940s, a few open drains were constructed along farm boundaries but were largely ineffective in controlling the seepage because the spacing was too wide. In the 1950s additional open drains were constructed midway between the original drains, but still the spacing was too wide because the open drains were constructed to keep crop producing areas at an optimum. All of this was done prior to the development of the transient state drain spacing procedures. Meanwhile, construction began on Third Division in 1947, and public notice number 26 opened 55 farm units for homestead. An additional 50 farm units were opened in 1950, and 54 units were opened in 1951. Since certification of irrigability was not yet law, no drainage studies were conducted prior to settlement.

As newcomers, mostly returning veterans from World War II, colonized the First and Second Divisions in greater numbers, Reclamation heard some bad news about the Third Division. The Third Division, a foundation of promise for post-war homesteaders, had a false bottom. A 1951 soil survey reclassified large areas of shallow soil in the Third Division as Class 6-nonirrigable. This acreage drained poorly and was susceptible to waterlogging and salinity severe enough to prevent cultivation. Congress passed Public Law 258 in 1953 permitting homesteaders on inadequate farms to amend their existing properties with vacant lands on the same project. Public Law 258 also allowed farmers to exchange their units for land on other Reclamation projects. Every landowner on a Reclamation project in the West could file a claim under Public Law 258, but the law specifically helped farmers working unproductive acreage on the Riverton Project. (USBR Dataweb) Within a few years, all or parts of every farm unit in Third Division were suffering from waterlogging and salinity problems. The problem was attributed to poor irrigation practices as well as natural drainage deficiencies of the land. Many of the farms were located downslope from other farm units, so they had to deal with return flows from neighbors as well as their own irrigation applications.

Another problem faced by Riverton farmers and by drainage engineers trying to correct problems was sodium in the soils. Some of the lands contained high levels of sodium, which can cause the soil structure to break down leaving the land impossible to drain adequately. Although the problem may develop on any project in semiarid climates, the Riverton Project seemed to be particularly susceptible.

Enactment of Public Law 258 resulted in many farmers leaving Wyoming. Those who relocated under the provisions of Public Law 258 settled on the Columbia Basin Project in Washington, the Minidoka Project in Idaho, and the Gila Project in Arizona. Those staying in Riverton added vacated land to their existing acreage. Public Law 258 stabilized the Riverton Project as remaining homesteaders increased the size of their units and subsequently improved themselves financially. Those determined to farm the Third Division formed an irrigation district in August 1957. By the dawn of the 1960s, a Bureau "Project History" lamented their decision: "The ratio of operating expenses to prices received for crops and livestock continued unfavorable." (USBR Dataweb)

By the early 1960s, the situation on the Third Division required the Government to make a hard decision. Reclamation proposed to buy out the homesteaders and write off most of the $20.5 million on the Federal books. A congressional delegation came to Riverton in October 1961 to hear local grievances. The testimonials the delegation heard "were adverse and favored abolishing the project." Reclamation responded by threatening to shut off water to the Third Division if growers refused to sign a repayment contract. One farmer, Marvin H. West, stated to a Denver newspaper in 1962, "10 to 12 years should prove the feasibility of these places. We have not made a living or showed any repayment ability in that time." (USBR Dataweb)

The growers' anger was enough to persuade the government in 1964 to pass Public Law 88-278 authorizing Federal purchase of Third Division lands. The Bureau bought back 78 units totaling about 22,000 acres. Farmers from the Midvale Irrigation District leased certain sections of the land over the next 6 years. In September 1970 Public Law 91-409 consolidated the three divisions of the Riverton Project. Besides employing power sales to pay rehabilitation costs on project works, the bill restored 8,900 irrigable acres of the Third Division to private ownership, with provision that no further Federal funds would be provided for drainage works. In January 1971 the Third Division Irrigation District ceased operations. The following month, the Government auctioned 43 units to farmers of the Midvale Irrigation District. By spring, the farmers petitioned the 43 units into Midvale. In December the Government executed a new amendatory repayment contract with Midvale. (USBR Dataweb)

In 1976, the Midvale Irrigation District entered into a Rehabilitation and Betterment (R&B) contract with Reclamation to upgrade certain facilities and to provide adequate subsurface drainage for the First and Second Division lands. Over the next 10 years, some 200 miles of subsurface drains were constructed. Many of the original open drain ditches, which had eroded to several times their design width, were replaced with more effective subsurface drains and backfilled, reducing maintenance costs and increasing the tillable acreage. In an odd twist, a provision of the law authorizing the R&B contract precluded expenditures of any of the funds for drainage works on Third Division lands.

A reclassification of the Midvale Irrigation District in 1999 confirmed that for the most part, the entire project was experiencing good productivity. Although small scattered parcels of land were placed in a non-irrigable class due to the sodium content of the soil being too high to permit economical drainage, waterlogging and salinization are under control within the project lands.

4.3. A CCC enrollee painting a pipe siphon across an open drain on the Gem Irrigation District, Owyhee Project, during February 1939.

Kansas River Projects

A series of irrigation projects in the Republican River Valley from Trenton in southwest Nebraska to south of Courtland, Kansas, were completed around 1960. By 1965 waterlogging was becoming prevalent in many areas along this 200 mile reach of the river. Drain construction began in 1966 and more than 200 miles of drains had been constructed in the Republican River Valley by 1975.

The Bostwick Division, Kansas, is a 40,000 acre project located mostly on uplands around the town of Courtland. On July 3, 1967, a field review of drainage needs was conducted by representatives of the Chief Engineer's Office, the Region 7 Office, and the Kansas River Projects Office. During that review, Mr. Lee Dumm of the Chief Engineer's Office noted that the water table was in a delicate state of dynamic equilibrium and that sooner or later a spell of unusually wet weather would probably upset the balance, creating serious problems. His prediction came true sooner rather than later. The fall of 1968 brought heavy precipitation that continued through the winter and into the summer of 1969. By August 1969 fully 90 percent of the 27,500 acres under irrigation were seriously affected by high water tables, and about 2,000 acres were not farmed. In 1970, a 12-person office consisting of an investigations crew, a survey crew, an engineer, and a construction inspection crew, was opened in Superior, Nebraska, with the specific purpose of constructing drains on the Kansas-Bostwick Unit and the lower half of the Nebraska-Bostwick Unit. By 1981 when the Superior Field Engineering Office closed, more than 250 miles of pipe drains and 50 miles of open ditch drains had been constructed on the Kansas-Bostwick Unit.

In order for this small group to accomplish this effort in a span of 10 years required some innovative measures. Ground water depth probes were made from ¼-inch iron pipe lined with ⅛-inch plastic tubing. Water level was read by hooking an ohmmeter to the pipe and inserting a wire connected to the other terminal into the plastic tubing. When the wire reached the water surface, it completed the circuit. The probes were easily inserted to a depth of about 5 feet wherever the water table was less than 2 or 3 feet below land surface, which was almost everywhere. The probes allowed a 2-man crew to create ground water surface maps in about one-third the time needed to do it with augers.

Soil profiles were logged using a variation of split tube sampler that was developed by the Superior Office. It was driven directly into the ground without benefit of the hollow stem augers that are usually used. While the tube increased production of the soil logging operation by four to five times, it was specific to the Kansas upland soils and was never successful in other areas of the country or even other areas of the Kansas River Projects.

Another first for the Superior Field Engineering Branch Office was the hiring of Reclamation's first women as field technicians, whose duties included operating small drill rigs. In 1973, Naomi Fritson, a Nebraska farm girl, and

Mary Torpin, daughter of a Hollywood film director, were Engineering Tech students at Curtis Community College in Curtis, Nebraska. They were hired as summer employees. Their 4-month employment with Reclamation constituted one semester of their required curriculum. At the time, it was a significant enough event to rate a spot on the evening news of the Nebraska Television Network.

Columbia Basin Project

The Columbia Basin Project in eastern Washington is the most extensive drainage construction that Reclamation has undertaken in our first century of existence. About 540,000 acres has been developed of what was initially envisioned as a 1-million acre project. The first water was delivered in 1948, and water tables began to rise almost immediately. By the early 1950s the need for artificial drainage was becoming evident. Water table levels rose steadily until they reached a point where drainage was needed on large areas of land to maintain productivity. By 1968 the water table had risen an average of 150 feet over the entire project. (Monteith and Myers)

The extensive need for drainage had not been recognized in the original project formulation, and it was not until 1960 that a large-scale construction program was initiated. (Christopher and Campbell) The Columbia Basin Drainage staff was established in 1954 and, during the peak drain construction period of 1971 to 1976, the staff numbered around 60 full-time drainage personnel. Innovative approaches to field investigations were initiated in an attempt to increase productivity without increasing staff. In the geologic setting of the Columbia Basin, 20 feet was the depth of most drainage borings. The need to increase productivity and lower engineering costs led to the modification of the drill rigs used in field investigations. The small rigs were fitted with a mast and a 20 foot long continuous auger so that 20 foot holes could be drilled without stopping to insert and remove the standard 5-foot auger sections. Seismic equipment was used to locate caliche layers so that borings could be farther apart.

The first drains to be constructed were open ditches to be used as outlets for the pipe drains. In 1961 construction of pipe drains began with a 3-mile segment. This would increase fairly steadily until the peak in 1974 when 195 miles of drains were constructed. By 1979 more than 2,200 miles of drain had been constructed and, by 1995, the total was 2,845 miles. (Hubbs)

Drainage of the lands was complicated by the existence of caliche layers underlying most of the project lands. Caliche is a form of solidified calcium deposit which occurs at depths shallower than the design depth of the drains. Construction equipment was often unable to excavate the caliche until it was blasted with dynamite. The large wheel trenching machines were designed for this type of construction and were quite successful in reducing or eliminating the need to blast.

Drain depths on the Columbia Basin Project are typically 8 to 9 feet, which is 1 to 2 feet deeper than on most Reclamation projects. This decision was based largely on the capability of the local contractors' equipment, although the depth of the outlet drain and the depth to a favorable drain zone in the soil profile may control the depth locally. (Brohl)

Central Valley Project

The Central Valley Project was authorized by Congress in 1937. First water was delivered from the Contra Costa Canal on August 16, 1940. Water deliveries began on the Delta-Mendota service area in 1950 and the first tile drains were constructed on the Grasslands area in the early 1950s. The drains discharged into wetlands. (Most of the following was paraphrased from written communications provided by Michael Delamore, South-Central California Area Office, USBR, and Joel Zander of the Mid-Pacific Regional Office, USBR)

In 1956 the California State Department of Water Resources recommended the state study a "comprehensive master drainage works system" indicating that drainage problems were beginning to develop on a significant scale. Also, Reclamation submitted a feasibility report on the San Luis Unit to Congress. The report included a 300 cubic feet per second earth-lined interceptor drain as part of the "distribution system and drains." On-farm drainage on the San Luis Unit was the responsibility of the landowner, but Reclamation was to provide an outlet drain that could be accessed by irrigators through irrigation district facilities. Construction of the San Luis Drain began in 1968, and Reclamation acquired 5,900 acres of land for Kesterson Reregulating Reservoir. The reservoir was to be operated according to a cooperative agreement with U.S. Fish and Wildlife Service for the conservation and management of wildlife, subject to the primary use of the lands for regulation of drain flows. Water was to be held in the reservoir until final discharge permits were acquired for the drainage water.

On July 1, 1969, U.S. Fish and Wildlife Service (FWS) began managing the lands acquired for Kesterson Reservoir under terms of the agreement. Construction of the reservoir began a year later. In 1972 construction of the first phase of the reservoir and the adjacent drain were completed. However, by February 1975, funds had run out, and construction was stopped with about 40 percent (85 miles) of the drain and the first stage of Kesterson Reservoir complete. Four months later, the first contract for collector drains on Westlands Water District was awarded and construction began on a collector system, encompassing about 42,000 acres of irrigated lands.

In 1977 Public Law 95-46, the 1978 appropriation, increased the ceiling for distribution and drainage systems on the San Luis Unit. Construction was not reinitiated at least in part because discharge criteria had not been established. Attempts to address this critical issue were unsuccessful as the State Water Resources Control Board (SWRCB) had the authority to set discharge requirements but was "not in a position to do so at this time." A March 20, 1978, letter from Reclamation's Regional Director to SWRCB explained Reclamation's position and hinted at the urgency of having discharge criteria established.

In 1978 use of Kesterson Reservoir as interim evaporation ponds for subsurface agricultural drainage flows from Westlands Water District began. The proportion of subsurface drainage flows to surface flows increased yearly until inflows to Kesterson were principally subsurface drainage water in 1981.

In May 1979 FWS began expressing reservations about the quality of the drainage water from San Luis Drain and the possible effects of toxic constituents on receiving waters. A year later, they would notify Reclamation that such effects would need to be evaluated in a Fish and Wildlife Coordination Report and there were concerns over completion of the San Luis Drain.

In 1981 Reclamation began studies to identify any potential toxic constituents in the drain water. The studies found high concentrations of selenium in San Luis Drain and Kesterson Reservoir. Reclamation imposed a moratorium on additional farm drainage connections to San Luis Drain because Kesterson Reservoir was reaching capacity and the outlet had not yet been constructed. Existing farm drains continued discharging through local wetlands to the San Joaquin River. Meanwhile, Reclamation was developing detailed plans for completion of San Luis Drain and, at the same time, reevaluating possible alternatives such as in-valley evaporation, desalinization, discharge to San Francisco Bay rather than Suisun Bay, and no action. Through the early 1980s, Reclamation and several cooperating state and federal agencies and universities spent about $4 million gathering information needed to obtain the discharge permit.

In 1982 FWS found high selenium concentrations in fish at Kesterson Reservoir and discovered higher-than-normal waterfowl mortalities and deformities a year later. Reclamation took action to minimize waterfowl attraction at Kesterson Reservoir by reducing the number of ponds and providing additional water to neighboring wetland areas. In September 1984 a hazing program was started to keep the birds off Kesterson Reservoir. A number of techniques were tried, including periodic shotgun blasts and chasing birds with ATVs. At the same time, 15,000 acre feet of clean water was provided to alternate habitat sites.

In February 1983, because of high rainfall, Reclamation filed an application with the Central Valley Regional Water Quality Control Board (CVRWQCB) for a discharge permit from Kesterson to the San Joaquin River. CVRWQCB responded by acknowledging the need to discharge excess water from San Luis Drain and Kesterson Reservoir and requiring Reclamation to immediately begin a sampling program and submit reports. On January 13, 1984, Reclamation notified CVRWQCB that high rainfall amounts combined with drainage water were threatening the dikes and warning that failure would mean uncontrolled flooding.

On February 2, the application was approved for limited discharge to prevent failure of the dikes, but large discharges were not allowed.

On April 8, 1983, Reclamation requested SWRCB approve a schedule for preparation of a technical report to accompany the application for the discharge permit to Suisun Bay and for the board to act on the application by November 1984. The Board responded on May 4 saying the schedule could not be met but that December 1984 was workable only if the report met acceptance by the scientific community, the SWQCB, and National Pollution Discharge Elimination System (NPDES) permit conditions.

In March 1985 the Department of the Interior announced plans to close Kesterson Reservoir and San Luis Drain and to terminate deliveries to 42,000 acres in Westlands Water District because of concern of violation of the Migratory Bird Treaty Act. A month later the Department reached an agreement with Westlands to continue delivering water to all of the lands in the district, but the drain remained closed. This was followed quickly by landowners filing lawsuits against the United States for taking of their property by seepage of drainage water from Kesterson Reservoir. In November Westlands Water District filed a draft EIR on plans for on-farm management, water recycling and plugging of the farm drains if necessary. By May 1986 Westlands completed plugging of the drains to prevent drainage water from entering San Luis Drain.

On December 30, 1986, the United States and Westlands Water District reached a compromise settlement known as the "Barcellos Judgment" filed in United States District Court as a court judgment. The judgment, among other things, required the Federal Government to develop a plan for drainage service facilities by December 31, 1991. The Judgment stipulates that the drainage facilities shall have

> sufficient capacity and capability to transport, treat as necessary, and dispose of the annual quantity of subsurface agricultural drainage water from the District (not less than 60,000 acre feet and not more than 100,000 acre feet) required to be disposed of by December 31, 2007 …

To help finance construction of the drainage service facilities, the District was required to make annual contributions to a trust fund established under the judgment. These funds were released to the District in June 1992 when the court ruled that the Government had failed to meet the terms of the Barcellos Judgment.

In January 1988, after considerable controversy, Reclamation began dewatering Kesterson Reservoir in preparation for cleanup. The dewatering was completed on April 12 and by November low-lying areas of Kesterson Reservoir had been filled with dirt. However, this did not end the life of the San Luis Drain.

In 1996 the San Luis Drain was reactivated as part of the Grassland Bypass Project. Drainage water from 97,000 acres of agricultural land in the Grasslands

Basin that historically drained to the San Joaquin River is transported through the lower 28 mile segment of the drain. The drain water contains lower concentrations of selenium than did the original drain water that flowed to Kesterson reservoir. The drain carries the water around the Grassland Conservation District to the terminal structure of San Luis Drain and returns to the San Joaquin River through Mud Slough. The selenium load is monitored for compliance with agreed-upon monthly and annual load limits. Fees of $25,000 to $250,000 are levied against the participating irrigation districts when the limits are not met. (Quinn, et al.)

One of the many entities involved in the drainage problems surrounding the fertile Central Valley lands was the San Joaquin Valley Drainage Program (SJVDP). Public Law 96-375 passed in 1980 authorized the San Joaquin Valley Drainage Investigation feasibility study. In August 1984 Governor Deukmejian and Secretary of the Interior William Clark established the SJVDP as a cooperative effort of the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, California Department of Fish and Game, and California Department of Water Resources. The purpose of SJVDP was to conduct comprehensive studies to identify the magnitude and sources of the drainage problem, the toxic effect of selenium on wildlife, and what actions needed to be taken to resolve these issues. By the end of 1990 funds totaling $50 million had been appropriated to support the Program.

In April 1987 SJVDP issued a draft report which discussed ocean disposal possibilities. Public reaction was so strongly adverse that the SJVDP Management Committee narrowed the focus of the program to exclude any disposal of agricultural drainage water or brine outside the San Joaquin Valley. In September 1990 SJVDP issued its final report titled “A Management Plan for Agricultural Subsurface Drainage and Related Problems on the West Side San Joaquin Valley.” In December 1991 four federal agencies, including Reclamation, and four state agencies signed a Memorandum of Understanding for Implementation of the San Joaquin Valley Drainage Program’s Recommended Plan. The major components of the plan are to (1) reduce the amount of irrigation water applied to the field, (2) reuse drainage water, (3) store drainage water in evaporation ponds, (4) cease irrigating lands that have high selenium levels in the subsurface, (5) pump ground water to lower the water table, (6) discharge to the San Joaquin River, and (7) protection, restoration, and provision of substitute water supplies for fish and wildlife habitat.

The controversy over the trace element selenium and how to handle drainage waters containing elevated concentrations has sparked numerous research efforts and other spin-off activities. In September 1986 the Westlands Water District Board approved a $6.6 million drainage treatment plant and a prototype deep well injection unit. After 18 months, the research project was indefinitely postponed because it did not appear to be economically feasible on a large scale. However, in October 1989 the District entered into an agreement with state and federal agencies and universities to begin work on a treatment research center to be located in the district. At about the same time, Panoche Drainage District began construction of a prototype facility to remove selenium from water using an iron absorption process. In June 1989 Westlands began drilling on an 8,100-foot-deep prototype injection well to be used for disposal of drainage water.

Several treatment methods were employed in an effort to reduce selenium in the soil, including field testing of a biological cleanup plan using selenium eating fungi.

The problems associated with high concentrations of selenium in the drainage water at Kesterson Reservoir were the primary reason why the Department of the Interior launched the Irrigation Drainage Program in 1985 with an inventory of more than 600 irrigation projects in the western United States to discover the extent of toxic trace elements in drainage water from the projects. (Department of the Interior, NIWQP website)

In 1992 Reclamation announced that it would award Challenge Grants for demonstration projects of innovative approaches to advance water conservation and address agricultural drainage problems in the Mid-Pacific Region. Challenge Grants addressing drainage problems would be accepted only for the SJVDP study area. Six Challenge Grants investigating various methods of treatment or management of selenium rich drainage water were executed in 1994.

Central Utah Project

In the middle to late 1960s the Central Utah Project (CUP) was one center of activity for Reclamation's drainage forces. Detailed drainage investigations covering nearly 250,000 acres were completed in anticipation of development of the project, which would provide a full water supply to about 33,000 acres and supplemental water to the remainder. The bulk of these lands lay in the Uintah Basin, which is tributary to the Green River, in Emery County in east central Utah, and in the Sevier Basin, a closed dry lake bed in southwestern Utah. The CUP was one of the primary proving grounds for the auger hole permeability test, which has become a standard test for permeability of saturated soils. Several thousand auger hole tests were conducted, some as deep as 25 feet, and a number of minor modifications to the test procedure were initiated. Observation well networks were installed on about a 1-mile grid and monitored weekly. The wells generally consisted of a galvanized downspout with holes punched by a geologist's pick and an endcap for a lid.

For the most part, drainage field crews across Reclamation at the time were mobile. The CUP crews would make a brief visit to the Provo Office each Monday morning to get their assignment for the week, turn in time sheets and conduct any necessary personnel business. They would make the 2- to 4-hour drive back to Provo on Friday evening, on their own time. A CUP field crew generally consisted of 10 to 20 people, including a lead engineer, several subordinate engineers and technicians, and a group of 90-day temporary laborers. The lead engineer's office was a pickup truck containing all the tools and equipment needed for the investigations and briefcases containing reference materials, test forms, and personnel files for the engineer and his crew.

The summer and fall of 1965 found enough Reclamation drainage personnel in the small town of Delta, Utah, to fill all 7 rooms in the only motel and a good part of the only apartment building for a period of about 6 months. In October a football game was played between the Feds and the town in which the Feds scored a narrow victory. On the last day in Delta—before Christmas break—the local restaurant closed to the public and the owner prepared a special Japanese meal for the Reclamation employees in appreciation of their patronage. By 1990 about 50 miles of subsurface drains had been constructed in the Uintah Basin and in Emery County. As of this writing, the Sevier Unit has not been developed.

Oahe Unit

The Pick-Sloan Missouri Basin Plan envisioned two irrigation developments in the Dakotas to compensate the states for the loss of prime agricultural land to the Main Stem Reservoirs, which now form a nearly continuous lake from Yankton, South Dakota, to Williston, North Dakota. The 5 dams, built for flood control and power generation, flooded thousands of acres of rich river bottom lands in the Dakotas. Originally the Garrison Diversion Project and the Oahe Project were each to be more than a half million acres. Construction was begun on both projects in the mid-1970s, but, to date, neither of them has been completed.

Although the Oahe Unit was never completed, it was an important milepost in the history of drainage in the Bureau of Reclamation. Investigations began on the Oahe Unit in 1950 with the exploration of glacial till soils in eastern South Dakota. Water for the project would be pumped from Oahe Reservoir on the Missouri River.

Extensive investigations were carried out in an effort to determine the ability of glacial till soils to support sustained irrigation. The techniques for some of the in-place permeability tests that are standard Reclamation procedure were developed and proven on the Oahe Unit. At the same time Reclamation was developing the transient state drain spacing procedures, and data from the Oahe Unit was being used to help establish the relationships that are used in the calculations.

An exhaustive study of prairie potholes was conducted to understand the connection between the surface water in the potholes and the ground water under and around them. At one point, in an attempt to understand the movement of water in till soils, men were placed in a cage and lowered into large-diameter drill holes in order to log the sidewalls of the hole.

The studies of glacial till soils were in concert with similar studies on the Garrison Diversion Unit in North Dakota and in Alberta, Canada. Each study that was done concluded that the permeability of glacial till soils was inadequate to provide economical subsurface drainage for irrigation. In 1957, based on all available knowledge, the decision was made to bypass the till soils and develop the Oahe Unit on the lake plain soils in the James River Valley some 100 miles east of the Missouri River.

A detailed drainage investigation was carried out on the lake plain soils in an effort to forecast drainage needs for the authorized 190,000 acre project. Soil sampling tubes adapted specifically to the Oahe soils investigations and other specialized tools were handmade by Oahe drainage engineers because no commercial supplier existed. (Burnett and TeKrony)

Because soils at drain depth in the Dakota Lake Plain are very unstable when saturated and construction would be very costly, the plan was to construct drainage facilities along with the water distribution facilities "in the dry." (Burnett and TeKrony) This procedure would also avoid the lag time between the need for drainage and the construction of facilities. Historically, the lag time on most projects was long enough to cause economic hardship for the farmers and the irrigation districts.

Construction of the drainage system before the delivery of water would have been a first for Reclamation. Since drainage construction was to take place prior to the development of high water tables from irrigation, the drainage investigations during the planning stage of the project were completed to design data standards, a much greater level of detail than normal for projects in the planning stage. As it turned out, project opponents gained control of the Conservancy District Board in 1977 and requested that Congress deauthorize the project. The takeover of the Board was bolstered by the fact that thousands of acres of glacial till lands were being impacted by the 100-mile-long canal, but were not allowed to share in the benefits because of their inherent drainage deficiency. Deauthorization never was formalized, but the action nevertheless sounded the death knell for the Oahe Unit. Even though the pumping plant and parts of the Oahe canal were constructed, no further construction funding was provided.

Eastern South Dakota Basins Study

The Eastern South Dakota Basins Study (ESDB) was the most far-reaching drainage study ever conducted by Reclamation. This study was unique in that drainability was the first controlling element in the assessment of potential for irrigation development. The entire area east of the Missouri River in South Dakota was covered by a subreconnaissance-level investigation aimed at locating lands that would sustain irrigation. Soils were logged on a 3-mile grid covering the entire area and about 6,000 in-place permeability tests were conducted. Based on these data and visual observations, the land was divided into four categories according to estimated drainage costs if the land were irrigated. Category I was the least expensive and category IV included lakes, rock outcrops and other areas considered to be nondrainable. The soils logs, permeability results, and category delineations were recorded on aerial photos at a 1,000-foot-per-inch scale, and a narrative report explained the process. The results were published in 1972. The original report and the photos are on file in the Great Plains Regional Office in Billings, Montana.

Oakes 5,000 Acre Test Area

One of the obstacles faced by North Dakota's Garrison Diversion Project was that the project overlapped the continental divide into Hudson Bay drainage rivers. The Canadian Government raised concerns over the possibility of biota transfer from Missouri River waters to the Hudson Bay drainage, where it was feared that the fishing industry might be adversely affected. Among the solutions that were proposed was a closed system concept in which no surface return flows from irrigation would be allowed. In order to test this concept, the Oakes 5,000 Acre Test Area was constructed on the James River south of the city of Oakes, North Dakota. Missouri River water was to be carried through canals to the James River where it would be pumped to irrigate the test area. In the early 1980s, the Oakes Office drainage staff installed monitoring wells on a ¼-mile grid so that the water table could be closely monitored. In 1985 42 miles of pipe drains were constructed to provide adequate subsurface drainage and a terminal seepage pit was constructed to handle all surface return flows. This was followed by construction of the pumping plant and distribution facilities. No water would be allowed to leave the project until it had passed through the aquifer.

As of this writing, the canal system has not been completed and there has never been a full water supply for the test area. However, the drains have provided the opportunity to study various irrigation management schemes and iron ocher problems. The drains have also been effectively used to distribute artificial recharge waters through the aquifer. Spring flood flows on the James River are pumped to the main canal where it is discharged to closed depressions around the project. The pipe drains help to convey water from the depressions to other parts of the aquifer. During the irrigation season, the water is pumped by individual farmers for irrigation.

Wellton-Mohawk

Early history of agricultural development in the Wellton-Mohawk area, in southwestern Arizona, dates back to 1538 when the Pima Indians irrigated some of the bottom land adjacent to the Gila River. In the late 1800s settlers developed irrigation in the area by diverting water from the Gila River, but alternating floods and drought encouraged them to turn to pumping the abundant supply of ground water. This worked well for a time, but, by 1934, Wellton-Mohawk farms were facing another hazard. Excessive salt appeared in many wells and the water table had declined alarmingly. One after another, farms were abandoned as water and soil became too saline for successful farming.

In 1937 the Wellton-Mohawk Division was authorized as a Reclamation project. Construction of the irrigation features was started in August 1949. On May 1, 1952, water from the Colorado River was turned onto the Wellton-Mohawk fields for the first time. However, importation of water from the Colorado River caused the water table to rise and threatened crops. (USBR Dataweb)

Conventional drainage was contemplated, but investigations revealed that conventional drains would not be effective due to artesian pressures in the aquifer. (Tapp) The solution was to lower the water table by pumping the aquifer. Drainage wells were constructed to remove the excess ground water, and the drainage water was discharged into the Gila River. The drainage water was highly saline, initially averaging about 6,000 parts per million. Late in 1961, the Wellton-Mohawk Main Conveyance Channel was constructed for the entire length of the Wellton-Mohawk Division to carry drainage water from about 67 wells. Additional wells were installed in 1963 to allow for selective pumping to reduce the salinity of the effluent during the winter months and to provide drainage to other areas with high ground water. (USBR Dataweb)


4.4. About 1959 Reclamation experimented with using dynamite to clean drains on the Lower Yellowstone Project.

The Wellton-Mohawk Division is unique in Reclamation as it is the only major drainage project that relies on pumping wells rather than horizontal drains to control ground water levels. The concept works well with the single drawback that operation, maintenance, and replacement costs are very high compared to conventional drain systems.

National Irrigation Water Quality Program

Subsurface drainage from Reclamation irrigation projects was generally considered to be a beneficial side effect of irrigation as long as salinity levels in the water were not excessive. Even the high salinity waters were often welcomed by the managers of wildlife refuges. When unusually high numbers of waterfowl deaths and deformities were found at California's Kesterson Reservoir National Wildlife Refuge in 1982, FWS began an investigation which continued through 1985. The problem was attributed to high levels of the element selenium in the water and sediments of the reservoir. At very low concentrations selenium is benign or even beneficial, but at high concentrations it can be toxic to biological communities. The source of selenium in Kesterson reservoir was determined to be drainage water from irrigation, which was the primary water supply for the reservoir. This revelation was to have far reaching impacts to Reclamation's drainage program. A more detailed discussion of Kesterson Reservoir and reasons for the buildup of selenium is included in the Central Valley Project section of this paper.

Congressional interest and widespread media attention, including several television programs and more than 100 newspaper and magazine articles, prompted the Secretary of the Interior to open an investigation of the possible toxic effects of irrigation drainage water in the western United States. The investigation resulted in the National Irrigation Water Quality Program (NIWQP). NIWQP focused on areas important to migratory birds and endangered species and public water supplies receiving water from DOI irrigation projects. NIWQP, which is ongoing, is a 5-phase program. The studies are conducted by a core team of DOI agencies including FWS, Geological Survey, and either Reclamation or the Bureau of Indian Affairs (BIA), depending on which agency sponsored the project involved.

Phase 1, Site Identification, was essentially complete by 1989 (more sites could possibly be identified in the future). Based on existing information, sites likely to have irrigation-induced toxicity problems advanced to Phase 2, Reconnaissance Investigations. If selenium levels found posed a possible threat to fish and wildlife resources, the site moved on to Phase 3. Phase 3, Detailed Studies, consists of field studies to measure the extent of any adverse biological impacts. Where adverse impacts are found, the site advances to Phase 4, Remediation Planning, and then to Phase 5, Remediation Implementation. FWS was the lead agency in phases 1, 2, and 3 with Reclamation or BIA having the lead role in phases 4 and 5.

A survey of about 600 irrigation projects and wildlife areas was completed in phase 1. Thirty-one sites moved to Phase 2, eight sites to Phase 3, five sites to Phase 4 and two sites are currently in Phase 5. All of the sites involved in Phases 4 and 5 are Reclamation projects. The two Phase 5 sites are Middle Green and Kendrick. The Middle Green centers around Stewart Lake State Wildlife Area, which receives a large part of its inflow from subsurface drains on the Jensen Unit of the Central Utah Project. Drainage water containing high concentrations of selenium are believed to be the source of selenium found in the lake sediments. In 1999 facilities were constructed to route the pipe drains around the lake so they discharge directly to the Green River, where the water is quickly diluted to naturally occurring concentrations. A number of "cleanup" techniques are being tested to remove selenium from the lake sediments. The Kendrick site is being addressed by eliminating return flows to two small closed basins and providing flow-through water to flush two others. In addition, Reclamation will construct replacement wetlands at locations away from selenium sources.

Research

Since the Chief Engineer's Office was established, Reclamation Drainage and Ground Water personnel have been involved in applied research into every aspect of subsurface drainage. Some of the subjects are:

- water movement through soils
- field permeability testing
- salt balance in the root zone
- quality of return flows
- drain spacing, location, and depth
- orientation of drains with respect to natural hydraulic gradient
- influence of irrigation practices on drainage
- how water enters drain pipes
- envelope design
- biological and mineral clogging of drains
- construction methods
- construction costs
- materials used in pipe drains
- drain cleaning techniques
- well construction and rehabilitation

The purpose of the research was to check scientific theories, improve constructability and maintenance techniques, and validate current practices. Analog, physical, and digital models were used extensively in the various research studies.

The complicated processes by which water moves through soils have been a focal point of research efforts since Reclamation first viewed subsurface drainage as a science. In many cases cooperating with other agencies or universities, researchers studied flow through saturated and unsaturated soils, between different soil textures, and through preferential flow paths. Sand tanks were constructed where water movement could be observed and 16-mm movie films were made of the processes for training purposes.

In 1978 a 16-mm movie titled "Subsurface Drainage" was produced in cooperation with Washington State University. The film used sand tanks with manometers to show how water moves through soil profiles to buried drains, and how a shallow saline water table can harm or even kill growing plants. This film has since been copied to video tape for use in standard VCR units.

The Oahe Project in the early 1950s was the impetus for some of the most important research in the drainage discipline. The drainage requirements for Oahe were known to be extensive and the plan was to construct drainage facilities in conjunction with the distribution facilities. In that way, the financial burden on the farmers and the irrigation districts resulting from the normal lag time between the need for and the provision of drainage could be avoided. Mathematical theories for the transient state drain spacing equations were developed in response to this need. Analog models were used first to verify the theories and later field measurements would validate the procedures.

Field tests for hydraulic conductivity, or permeability, that had been developed in the 1940s were adopted, tested, and, in some cases, modified to meet specific needs of Reclamation projects. These tests were also subjected to analog model verification as well as field testing.

Many analog models and digital models have been constructed in an attempt to predict return flow quantity and quality from various projects. Reclamation has worked closely with the U.S. Department of Agriculture Salinity Laboratory to establish safe root zone salinity levels and leaching requirements needed to maintain acceptable salinity levels.

Drainage on sloping land was investigated in the early 1970s by constructing a sand tank in the Hydraulics Laboratory. The tank was 60 feet long, 2.5 feet deep and 2 feet wide and was mounted on a platform that could be tilted at slopes between zero and twelve percent. The wood frame tank was fitted with Plexiglas panels so that observers could see what was occurring outside the drains. The tank was later used to study sediment accumulation in drains with sags built into the grade.

Analog models were used during the 1960s and 1970s to predict the effects of placing interceptor drains on an angle to the natural hydraulic gradient on sloping land. Field verification was done in the Columbia Basin and on the Kansas-Bostwick Unit in Kansas.

Drainage staff participated in the Irrigation Management Service (IMS) studies that were done beginning in the 1960s. IMS studies were conducted on several projects and in every region to determine the fate of irrigation water that was applied to fields. All water entering the field through irrigation or precipitation was measured, consumptive use was estimated using state-of-the-art consumptive use formulae, root zone moisture levels were measured, and tail waters leaving the field were measured. Cooperating irrigators were assisted in management of their irrigation water to the benefit of production and reduction in water usage. Reclamation phased out the program in the late 1970s, but the practice is carried on by private industry for the benefit of private irrigators as well as those on federal projects.

Analog and sand tank models were used to study the way water enters clay tile and concrete drain pipe that had open joints for water to enter and how it enters perforated plastic pipe. Standards were set for the length of the clay tile and concrete pipe between open joints for various diameters of pipe. The larger the diameter of a pipe, the longer the pipe section can be. This research included establishing gradations and thicknesses for gravel envelopes around drain pipes. Sand tank models to study envelope and pipe perforation design are still in progress.

In the 1970s clogging by iron ocher caused by bacteria growth was noted at several locations. Reclamation initiated a cooperative program with Dr. Harry Ford, a renowned expert on ocher-forming bacteria, of Florida State University. The result was early identification of problem soils and various means of treating the problems that develop.

In the 1970s the "Open and Closed Conduit Systems" research program was used extensively to study various methods of construction, including the introduction of high-speed trenchers and trenchless drain construction or "plow drains." The program was also used in the development of standards for plastic pipe drain materials. Video inspections of installed drains were used to determine deflection and other problems associated with pipe strength. Working closely with the corrugated plastic pipe industry and the Soil Conservation Service, U.S. Department of Agriculture, who were also developing a progressive drainage program, standards were developed for pipe strength and other properties. Mr. Ray J. Winger Jr. Chief of the Drainage and Ground Water Branch in the Engineering and Research Center from 1972 to 1981, was inducted into the Drainage Hall of Fame for his contribution to the advancement of plastic pipe for use in agricultural drains.

In the 1980s a 12-inch-diameter hemispheric demonstration well was constructed in the Hydraulics Laboratory. The well was completed as an actual well except that it was fitted with a Plexiglas plate across the flat side so that observers could see what occurred in the aquifer and gravel pack outside the well during various rehabilitation treatments.

Not every research venture ended in new methods or products being adopted. Through the 1970s Reclamation tested "no envelope" and thin synthetic envelopes under various conditions in California, Kansas, Wyoming, Washington, and Montana. In every case, the drains either failed completely or performed poorly compared to a sand/gravel envelope. In 1976 and 1978 ABS plastic pipe was installed at two locations in the Republican River Valley. ABS was a lightweight, thick-walled pipe formed in 5-foot long sections with bell and spigot joints. In both cases, the pipe failed to retain its shape after being in place for less than 1 year. In 1974 a "trenchless" plow was used to install drains near Courtland, Kansas. The drains failed to control the water table and had to be replaced by conventional drains. In 1989, a thick or "voluminous" synthetic envelope consisting of styrofoam beads held in place by a nylon net was installed on a drain in central Nebraska. Hydrostatic pressure forced the beads into the pipe perforations and thoroughly plugged them, preventing any water from entering the pipe. These learning experiences have not deterred the Reclamation drainage staff from being receptive to new products and ideas.

International Influence

Since the Chief Engineer's Office was established in 1948, Reclamation Drainage and Ground Water staff have been involved in assisting other countries in developing responsible drainage programs. The first foreign assignments for drainage staff were in Pakistan, India, Thailand, Peru, Egypt, Taiwan, Sri Lanka (formerly known as Ceylon), Afghanistan and the Philippines. Much of the data used to develop root zone moisture and salinity concepts was collected on assignments to Spain, Turkey, Australia, and other countries. Assignments to the African continent began when African nations gained independence from colonial rule: Senegal, Sudan, Somalia, Kenya, Tanzania. Our largest foreign involvement occurred during the 1970s, when we were involved in drainage and ground water activities throughout the developing world—South America, Africa, and Asia.

The foreign assistance focus has been to educate foreign nationals on the importance of understanding agricultural irrigation and the need to minimize land salinization or waterlogging of the soils. An economic land classification which considers drainage costs is central to protecting the land resources from permanent degradation and ensuring that the lands being developed are productive enough to provide the farmer with a living wage. Another area of emphasis is the importance of operation and maintenance of all facilities, including drains.

The individual assignments of a few weeks up to several years in length were typically financed by World Bank, Asian Development Bank, or the U.S. Department of State under the Aid to Developing Countries Program.

In the 1970s Ray J. Winger Jr. of the Engineering and Research Center participated in technical meetings of the U.S. and U.S.S.R. Specialists Working group on Cooperation in the Field of Water Resources. The topic "Plastics in Hydrotechnical Construction" and subtopic "Investigating the Effectiveness of Utilizing Plastic Pipe in Irrigation and Drainage" were part of the U.S.-U.S.S.R. Agreement on Science and Technology of May 24, 1972. Materials and specifications were exchanged, field experiments were conducted in each country, and meetings and field reviews were held in each country. The results of these experiments are incorporated into Reclamation's technical drainage policy.

Reclamation drainage staff served as consultants to the Prairie Farm Rehabilitation Administration, Department of Agriculture, Canada in the 1950s. A field review and comment on the drainage and related salinity and waterlogging problems in Alberta and Saskatchewan Provinces were requested by the Canadian government.

Through the 1980s and early 1990s Reclamation drainage engineers participated in an informal discussion group known as the Northern Plains Water Management Workshop. The workshop was made up of engineers and soil scientists from various universities and government agencies from the Dakotas, Montana, Alberta, and Saskatchewan. The workshop had no formal structure, no officers, and no budget, but they would gather once a year at some facility and spend 2 to 3 days discussing the problems, research needs, and breakthroughs in irrigation of glacial till soils. The place and time of the gathering depended on someone volunteering to be the host.

Publications

Drainage Manual

Drainage engineering was in its infancy during the 1940s through 1960s, and standard procedures for investigation and design had not been adopted. The purpose of the *Drainage Manual* was to present engineering tools and concepts that had proven useful in planning, constructing, and maintaining drainage systems for successful long-term irrigation projects. The first drafts of the manual were in limited circulation within Reclamation in the early 1960s, but new procedures were being developed so rapidly that it was very difficult to arrive at a final draft. It was not until the deluge of new concepts began to subside that the manual was published as a hardcover book. The first edition was published in 1978. The manual was then quickly accepted as an authoritative publication by many in the world drainage community, and it is used now as a textbook by several universities. A revised reprint in 1993 contains only a few substantive changes.

The *Drainage Manual* is used throughout Reclamation as a guide to performing drainage investigations, and the design, construction, and operation and maintenance of drainage systems for irrigated lands. The manual is gradually gaining acceptance as a guide to other drainage applications such as dam toe drains and slope stability.

Ground Water Manual

The *Ground Water Manual* was developed as a guide to field personnel in the more practical aspects and commonly encountered problems of ground water investigations, development, and management. It standardized Reclamation's procedures for ground water. The manual was developed over a period of years. Its contributors included personnel from the Bureau of Reclamation, other agencies, foreign governments, and many individual scientists and engineers.

Comprehensive Construction Training Program

In 1987, Reclamation's drainage and ground water personnel from several projects and regional offices contributed to the Comprehensive Construction Training Program by producing two modules titled *Buried Pipe Drains* and *Well Construction*.

Plastic Pipe Specification

With the introduction of plastic pipe for subsurface drains in the late 1960s came a need to ensure reliability of the new product. Research and testing conducted by Reclamation led to the need to develop standards for the strength and performance of the pipe. As larger diameters of pipe became available, new specifications were written to accommodate these sizes. By the early 1990s, American Society of Testing and Materials (ASTM) and American Association of State Highway and Transportation Officials (AASHTO) had developed parallel standards for the same product. On February 1, 1995, Reclamation produced a new document titled "M-20: Standard Specifications for Corrugated Polyethylene and Polyvinyl-Chloride Drainage Pipe" which combines all of the former specification documents and relies heavily on ASTM and AASHTO while retaining certain standards that are more stringent than ASTM or AASHTO.

Spin-off Applications

Not all of the drainage and ground water work is in the agricultural arena. Often dams, pumping plants, large canals, and other structures require subsurface drainage facilities to stabilize foundations and prevent damage from sloughing earthen slopes or seepage water.

Safety of Dams

It has long been recognized that most earth dams and some concrete dams need adequate toe drains to maintain a stable foundation. It was not until the 1980s that agricultural drainage experts began to have involvement in the design and construction of drains where the cost of failure could be measured in human lives. Replacement of the toe drains at Sherman Dam in Nebraska was the first such venture for the agricultural drainage staff. Then slowly came Canyon Ferry Dam in Montana, Diamond Creek Dike at Buffalo Bill Dam in Wyoming, Bonny Dam in Colorado, and Glendo Dikes in Wyoming. Success in these projects has demonstrated that the science of ground water engineering is not limited to agricultural applications. While adaptations need to be made to deal with the greater hydraulic gradients and the greater risk in the case of failure, the same basic concepts, materials and construction techniques are applicable.

Canal and Structure Stabilization

Toe drains are constructed along major canals for a variety of reasons. Slope stability, waterlogging of agricultural lands, and salinity control have all been accomplished by use of subsurface drains. McClusky Canal on the Garrison Diversion Unit in North Dakota experienced slope stability problems through cut sections 100 feet or more in depth. The canal was constructed in the 1970s and suffered chronic sloughing of the banks into the canal prism. Attempts to solve the problems using horizontal wells placed with an "Aardvark" horizontal drilling machine proved futile. After 10 to 15 years of severe maintenance problems, drainage personnel in the Garrison Diversion Office provided solutions to these problems by applying their knowledge of agricultural drainage in till lands.

The New Rockford Canal in North Dakota was constructed in the mid-1980s and marked the first example of canal toe drains being constructed as part of the canal contract specifically to protect agricultural lands from seepage from the canal.

The Courtland Canal along the Nebraska-Kansas border is perched atop the steep river bluffs and causes serious waterlogging problems in the irrigated fields below. Most of these problems have been relieved by use of interceptor drains at the base of the bluffs. However, the volume of water coming from the canal overwhelmed the first attempts at interception in the mid-1960s. Additional drainage works were constructed periodically for the next 20 years. A field review in the summer of 2000 concluded that the problems have finally been essentially solved.

Agricultural drainage techniques were used in 1980 to prevent the Yellowstone River from washing out the Terry Pumping Plant. As the slope progressively sloughed, the river threatened to cut a new channel behind the 60-cubic-foot-per-second pumping plant. Field investigations and transient state computations revealed the source of the problem, and it was solved by constructing a simple agricultural drain.

Again in 1990 concepts that were developed for agricultural drainage came to the rescue of a 50-foot-wide, 22-foot-high drop structure that carries 2,300 cubic feet per second at full capacity. The East Drain Terminal Drop structure below Palmetto Bend Dam on the gulf coast of Texas is subjected to extreme variations in hydrostatic pressure as tides move in and out. Perforated plastic pipe drains at the sides of the structure and a graded gravel bed at the bottom successfully relieved the stresses on the structure.

Wetlands Applications

As the focus of Reclamation activities has shifted from construction to water management, drainage and ground water personnel have used the knowledge gained over the past 50 years to incorporate wetland construction and management into their realm of expertise. In the Bay Delta, programs associated with the Central Valley Project in California, the Platte River Recovery Program in central Nebraska, and the National Irrigation Water Quality Program, the same concepts that were developed for drainage are being used by drainage personnel to create and enhance wetlands.

Conclusions

In our first century, Reclamation has constructed over 13,000 miles of surface and subsurface drains to protect an estimated 1 million acres of irrigated land from damage due to waterlogging and salinity. This does not include the miles of drains or acres protected on projects that treat drainage as a farm development cost.

The first 50 years were typified by struggles to cope with technical unknowns as scientists, engineers, farmers, irrigation managers, and politicians attempted to develop water projects to attract settlers to the American West. During the last 50 years, we have seen the uncertain art of drainage evolve into a science which removes most of the technical unknowns from the drainage of irrigated lands and allows development of sustainable agriculture to occur in a controlled manner.

Changing social values in the last quarter century have preempted some very promising irrigation developments. We have seen our focus change from developing new agricultural lands to maintaining existing water resources and environmental assets for the good of all society. We want to take note of a common thread that repeatedly appeared in the references used for this paper. It was the concern that Reclamation employees have always had for the environment. Well before the time of U.S. Environmental Protection Agency and most environmental groups, Reclamation drainage engineers were concerned about the quality of water that flowed from the drains and the effect that it would have on wildlife and other downstream users. Drainage engineering also has provided the agricultural community with the comprehension and capability to keep irrigated farm land in productivity and avoid exploitation. The twentieth century has been the first time in history that large-scale irrigation has not been marked by a majority of lands that became waterlogged, salinized, and abandoned.

The lessons learned and the science that was developed around Reclamation's experience in drainage and ground water will be useful to future developments in the United States and around the world as developing countries endeavor to feed and clothe their people.

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Evolution of the Hoover Dam Inflow Design Flood: A Study in Changing Methodologies

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Abstract

Over the years many changes have taken place in estimating the maximum flood potential at Bureau of Reclamation dams. This paper traces the technological changes by using the Hoover Dam flood studies as an example.

The largest recorded flood in the Black Canyon of the Colorado River, which is the site of Hoover Dam, occurred in July 1884. It was estimated to have a peak discharge of about 300,000 ft^3/s. The Bureau of Reclamation and the Geological Survey determined the magnitude of the 1884 flood based on high water marks in the Black Canyon; flood observations at Lees Ferry; and gage height observations at Grand Junction, Colorado, and Yuma, Arizona. The five-month volume of the flood was estimated to be about 30,000,000 acre-feet. The 1884 flood was considered a "near maximum flood" and became the basis for the design of the spillways and flood control space in Hoover Dam.

In 1990 the Bureau of Reclamation revised the probable maximum flood studies for the Colorado River Basin and for Hoover and Glen Canyon Dams. The Dam Safety Office identified the need for the study when flood operations during the 1983 flood required operating the spillways and resulted in considerable damage to the concrete lining of the spillways. The flood hydrology data used for the original dam design were not found to conform to current technical methodology for estimating the probable maximum flood.

New hydrologic studies were conducted using a hydrologic model to convert precipitation to runoff. The design storm was developed from historical storm data that indicated the possibility of two large rain events occurring within a few days of each other. For Hoover Dam the most critical situation could occur in August, when a Pine and Cedar Mountains-centered storm follows a San Juan Mountains centered storm by seven days. This storm sequence would produce a probable maximum flood at the dam with a peak discharge of 1,130,000 ft^3/s and a 60-day volume of 9.3 million acre-feet.

Oftentimes, technological change has resulted in the need to modify dams to ensure public safety. In this case, routing the probable maximum flood through Lake Mead does not overtop the dam and results in a maximum water surface that is still three feet below the top of the parapet wall. However, about 100 of Reclamation's dams are unable to safely accommodate the probable maximum flood.

Introduction

A large flood resulting from late season snowmelt in the spring and summer of 1983 required operation of the Hoover Dam spillways. During this operation, damage to the concrete lining of the spillways occurred, leading to the assessment of potential modifications to alleviate the problem. As a part of this analysis, the Flood Section of the Bureau of Reclamation evaluated the adequacy of the hydrologic engineering aspects of the dam. Additional high runoff occurrences in 1984 and 1986 kept the flood issues at Hoover Dam in the forefront.

Upon reevaluation, the hydrologic data used as a basis for sizing the dam, the outlet works capacity, and the allocated flood storage/surcharge space were not found to conform to the current state-of-the-art with respect to operational criteria and technical methodologies. These data also do not reflect recent hydrologic and meteorological data acquired since the original design was completed. Previous design flood investigations were crudely developed from high water marks left from large historical flood events. More recent investigations account for the effects of upstream basin development and reservoir regulation, as well as the knowledge gained from the many large storms that have occurred over the basin since the dam was built.

Basin Description

The Colorado River above Hoover Dam drains an area of 167,000 mi^2. The drainage basin includes parts of Wyoming, Colorado, Utah, New Mexico, Arizona, and Nevada. Approximately 108,000 mi^2 of the drainage basin are above Glen Canyon Dam.

Many dams and reservoirs have been constructed in the basin over the years. The larger reservoirs are formed from water impounded by Fontenelle, Flaming Gorge, Blue Mesa, Morrow Point, Crystal, Dillon, Navajo, Glen Canyon, and Hoover Dams.

The basin is arid to semi-arid with an average annual rainfall of about 10 inches. The annual precipitation varies from over 40 inches in the higher mountainous areas to less than 3 inches near Hoover Dam. Long cold winters and cool short summers characterize the climate of the mountains in the basin. In the lower areas the winters are mild and short, and the summers are long and warm. The temperature extremes in the basin range from −45°C to 46°C. The average annual runoff is less than 1.5 inches for the entire basin. Most of this runoff is produced in the upper basin areas. Snow accumulation normally begins in October in the high mountains and in some years continues through May.

Basis for Original Spillway Design

Hoover Dam (also known as Boulder Dam) was sized using streamflow records in existence prior to 1929. Reliable recorded streamflow records for the Colorado River at Yuma, Arizona, began in 1902. Less reliable gage heights were also available at the Yuma site for the earlier period from 1878 through 1901. The largest recorded flow was 210,000 ft^3/s on June 26, 1920. The maximum historic discharge, since the river was first occupied by civilized man in 1856, was believed to have occurred in the summer of 1884 and was estimated to range from 250,000 to 350,000 ft^3/s.[1]

On the basis of the flood data and other safety considerations, a spillway capacity of 400,000 ft^3/s with the reservoir water surface at the crest of the dam (elevation 1232.0 feet) was provided to prevent any possibility of the dam being overtopped by an unprecedented future flood. The total discharge capacity of the dam was 520,000 ft^3/s, which included the spillway capacity along with the outlet works release capacity of 100,000 ft^3/s and the power plant release capacity of 20,000 ft^3/s.[2]

The total reservoir capacity is 30.5 million acre feet, which includes 9.5 million acre feet of flood control storage. The design and construction reports for the *Diversion, Outlet, and Spillway Structures* indicate that the intent of the design was to accommodate not only the largest possible flood but also a flood resulting from a dam failure upstream. The report states, "The ponding effect of the flood storage, combined with the 520 thousand second-feet of discharge capacity, provides for an estimated inflow into the reservoir of nearly 1 million second-feet for several days without overtopping the dam. The provision for so large an inflow into the reservoir was based on the criterion that the dam must be entirely safe for any flood condition, even though the flood might be caused by the failure of a dam at some upstream location."[3]

Original Flood Study

E. B. Debler, Hydraulic Engineer with the Bureau of Reclamation, conducted the original flood studies that were used to size the spillways and flood control space for the dam. In 1930 he wrote *Hydrology of the Boulder Canyon Reservoir*. Data that were used in the analysis consisted of stream gage records, high water marks, and newspaper accounts.[4]

Prior to construction of the many major dams now located in the Colorado River basin, high flows in the lower portion of the basin occurred frequently. Between 1878 and 1929, peak flows were estimated to exceed 100,000 ft^3/s twenty-three times and 200,000 ft^3/s three times in the vicinity of Hoover Dam. The Geological Survey and Bureau of Reclamation estimated the peak discharge for the 1884 flood as 250,000 and 300,000 ft^3/s, respectively. These estimates were based on high water marks in the Black Canyon, gage heights at Grand Junction and Yuma, newspaper accounts, and a flood observation at Lees Ferry.[5]

The Geological Survey estimated that the 1884 flood had a peak of 250,000 ft^3/s at Lees Ferry. A high water mark given by a local resident was compared with gage heights for the Lees Ferry gage. The rating curve that was used is unknown. Since the largest gaged flow at this site was 114,000 ft^3/s, the rating curve that was provided by the Geological Survey for this station was extended to estimate the 1884 peak. Several extension techniques were explored to try to reproduce the Geological

Survey flood estimate. Reclamation engineers could get close to their estimate but could not reproduce it. Therefore, Reclamation decided to develop its own estimate of the 1884 flood.[6]

Newspapers of 1884 contain numerous references to heavy snows throughout the basin. The *Gunnison Daily Review Press* reported in mid-May snow from two to five feet deep at several locations between elevations of 9,000 and 10,000 feet. The normal snow depth for the Gunnison watershed was about 18 inches for the end of April. Other newspaper accounts indicated that this condition was widespread over the upper basin.[7]

Only one precipitation station was available for the upper basin in 1884. It was located at Fort Lewis, La Plata County, in the San Juan basin. At this station precipitation was about 40 percent above normal from October through May, and temperatures were below normal during the spring months.[8]

Flows in upstream tributaries were at all-time highs. The Gunnison River, Colorado River at Fruita, and Green River at Green River were at their highest known stages in 1884 and were reported in 1929 as the highest of all time. High flows were also reported in Utah by the Salt Lake City newspapers. Inhabitants reported that high flows continued for weeks.[9]

Based on these accounts and various flow records, Reclamation concluded that the peaks at Green River, Utah, and on the Colorado River at Fruita occurred simultaneously. Mr. Robert Follansbee, District Engineer with the Geological Survey, estimated the flow at Fruita to be 125,000 ft^3/s and at Green River to be 95,000 ft^3/s. After making an allowance for the lower streams, the discharge at Black Canyon was estimated as 300,000 ft^3/s.[10]

To check the 1884 flood peak Reclamation used the gage height at Yuma and channel cross section to compute the associated discharge. Based on 1920 and 1921 flow velocity data, a mean velocity of 7.2 ft/s was used for the hydraulic calculations. The discharge was estimated as 250,000 ft^3/s at Yuma. Since flows at Black Canyon were greater than at Yuma due to channel storage in the lower reaches, the Yuma discharge was increased by 19 percent to arrive at the Black Canyon discharge of 300,000 ft^3/s.[11]

Flows, which formed the basis of a flood frequency analysis, were estimated at Black Canyon using data from the gages at Yuma, Topock, Hardyville, Boulder Canyon, Bright Angel, Lees Ferry, and some unidentified main tributaries. Empirical relationships were used to transfer peak flows to Black Canyon. Flows for 1878 through 1901 were solely based on the flow at Yuma. Later years, 1902-1929, relied on comparisons between gages and considerable engineering judgment to develop the annual peaks at Black Canyon. The flow data were plotted on probability paper using methods developed by H. Alden Foster and R. D. Goodrich.

The results are shown on Table 1. The 1884 flood was determined to be about a 500-year flood.[12]

Table 5.1. 1930 Flood Frequency Analysis for Hoover Dam
Source: U.S. Department of Interior, Bureau of Reclamation, Colorado River Basin Probable Maximum Floods - Hoover and Glen Canyon Dams, (Denver, 1990), 9.
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Peak Flow (ft^3/s)	Return Period (Years)	Annual Exceedance Probability (Percent)
130,000	5	20.00
160,000	10	10.00
190,000	20	5.00
230,000	50	2.00
260,000	100	1.00
320,000	500	0.20
360,000	1,000	0.10
450,000	10,000	0.01

The volume of the 1884 flood was estimated as 30,450,000 acre feet for the period May 3 through August 22. Flow records were reconstructed for the Yuma gage to develop the volume estimate. When the inflow design flood was developed, the duration of the flood was extended to include April through the end of August by using comparisons with other high runoff years. Table 2 displays the monthly volumes of the inflow design flood. As indicated on the table, the inflow design flood volume increased to 33,200,000 acre feet after adding additional spring flows and extending the period from April through August.[13]

Table 5.2. 1930 Inflow Design Flood Volumes for Hoover Dam
Source: U.S. Department of Interior, Bureau of Reclamation, Colorado River Basin Probable Maximum Floods - Hoover and Glen Canyon Dams, (Denver, 1990),[10]

Month	Volume (Acre-feet)	Mean Monthly Flow (ft^3/s)
April	2,000,000	33,610
May	5,000,000	81,320
June	11,850,000	199,160
July	11,350,000	184,590
August	3,000,000	48,790
Total	33,200,000	

1990 Probable Maximum Flood Study

Reclamation revised the inflow design flood for Hoover Dam in 1990. Meteorological studies were conducted by Morrison-Knudsen Engineers and are documented in the report entitled, *Determination of an Upper Limit Design Rainstorm for the Colorado River Basin Above Hoover Dam*. Reclamation performed the hydrologic analysis, and the results of this study are documented in the report, *Colorado River Basin Probable Maximum Floods - Hoover and Glen Canyon Dams*. The following sections of this paper describe these studies in more detail.[14]

Meteorological Analysis

Modern procedures for developing a probable maximum flood involve development of the probable maximum precipitation (PMP) and rainfall-runoff modeling. Probable maximum precipitation is generally defined as "theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year." Traditionally the PMP storm is developed by transposing moisture maximized storms to various locations in the basin. Then differences in orographic effects between the storm location and the selected storm centerings are accounted for either by a transposition index or by storm separation techniques. For Hoover Dam, a slightly different approach was taken due to the very large drainage area, extreme variation in orographic effects, and deficiency of large-area storms.[15]

Upper limit design rainstorms (ULDRS) were developed for three locations in the Colorado River drainage above Hoover Dam. The term, ULDRS, was used to emphasize that there are differences in the procedures used to develop these storms from those used to develop the traditional PMP for smaller area sizes. Specific storm analyses involved determination of the ULDRS magnitude, spatial and temporal distributions, storm sequencing, and seasonal variation.[16]

As with any study of this nature, it was first necessary to assemble an exhaustive listing of all known major storms that have occurred in or near the region surrounding the Colorado River Basin above Hoover Dam. Due to the large drainage area and the availability of extreme precipitation estimates from *Hydrometeorological Report No. 49* for areas less than 5,000 mi^2, the search for critical storm data concentrated on finding severe rainfall events covering larger areas. Of the 20 storms for which detailed meteorological investigations were performed, 13 storms were analyzed to provide the necessary depth-area-duration data.[17]

Since the study basin is located in a region of complex topography, which produces a significant effect on total storm rainfall, it was necessary to estimate likely storm centerings and associated "generic" isohyetal patterns prior to development of the ULDRS. An important consideration in the development of likely storm centerings was the location of Glen Canyon Dam in relation to Hoover Dam. The objective was to provide the necessary design storms that would affect not only Hoover, but also the two dams operating in combination. Examination of the isohyetal patterns of rainfall associated with major storms occurring in the drainage was particularly useful in identifying three storm centerings and their related isohyetal patterns. The three storms were located in the San Juan Mountains (Colorado), Boulder Mountains (Utah), and Pine and Cedar Mountains (Utah).

The ULDRS magnitude for each of the three storm centerings was evaluated by two separate methods. The first approach is commonly referred to as the storm separation method, where observed areal storm precipitation is separated into components (convergence and orographic). Each precipitation component is treated and evaluated separately, and later recombined, to provide total design storm precipitation. The second approach used the traditional method of storm moisture maximization and transposition. After evaluation of the assumptions and uncertainties involved in application of each approach, the results were averaged to produce the final ULDRS magnitude.

Due to the large basin and storm areas involved, it was necessary to describe the spatial distribution of average areal ULDRS precipitation. Hydrologic trials were conducted using preliminary average areal precipitation. A storm area of 40,000 mi^2 was critical for development of the maximum inflow to Hoover Dam. The ULDRS magnitude was estimated as averaging from 6.93 to 7.29 inches in depth for 72-hour storms for the three locations.

Critical inflow to the dams could result from a series of storms occurring in sequence. Investigations were conducted to define the relationship between storm magnitude and dry-period interval separating the sequenced storms. A relationship between the days separation between storms, and the magnitude of areal rainfall both prior and subsequent to the main storm was developed.

To adequately assess the flood potential, it was necessary to define the magnitude of the ULDRS event for the period from May through October. It is during this period that the greatest flood threat on the Colorado River above Hoover Dam would likely result from the combination of the ULDRS event with the snowmelt hydrograph. The ULDRS event for all three centerings could occur with the same magnitude during the period from August 1 through October 31. Prior to August, the seasonal variation of the ULDRS would indicate a decrease in rainfall potential.

Hydrologic Analysis

Selection on an inflow design flood (IDF) is generally based on an incremental hazard evaluation downstream for the dam. “The IDF is the flood flow above which the incremental increase in water surface elevation downstream due to failure of a dam or other water retaining structure is no longer considered to present an unacceptable additional downstream threat." In this case, the probable maximum flood (PMF) was selected as the inflow design flood because if the dam failed, it would result in catastrophic consequences, including loss of life. The PMF is defined as "the maximum runoff condition resulting from the most severe combination of hydrologic and meteorologic conditions that are considered reasonably possible for the drainage basin under study."[18]

Reclamation used the Flood Hydrograph and Routing (FHAR) computer program to convert excess precipitation to runoff and generate the flood hydrograph for the ULDRS. FHAR, which was developed by Reclamation, uses unit hydrograph theory. The program derives the flood hydrograph by applying increments of excess precipitation to the unit hydrograph. The unit hydrograph is computed from the dimensionless graph, given the basin area, lag time, and unit time.

The lower and upper basins were divided into 99 subbasins for the analysis. In general, subbasin delineation was made by following major tributary boundaries. Subbasins that had similar characteristics of elevation, slope, land use, and drainage pattern were combined where possible. The size of the subbasins was limited to areas of less than 5,000 mi^2.

Field trips were made to become familiar with the subbasins. Soil and geologic conditions, land use, vegetation type and cover, and basin roughness and steepness were examined to better estimate loss rates and lag coefficients. These observations were used for all subbasins visited.

Loss rates are a measure of the precipitation lost to infiltration, evaporation, transpiration, absorption, and minor depression storage in the basin. In general, the lower basin near Lake Mead and the north-side tributaries to the lake are areas of low infiltration and are subject to flash flooding. The other areas and tributaries, especially Kanab Creek, Kaibab Creek, and most of the Little Colorado River basin had somewhat higher loss rates. In these areas, the vegetative cover was heavier, and the loss rates appeared to increase with elevation rise. Most of the Little Colorado River basin showed very little evidence of flash flooding or stream channel development.

In the upper basin, those areas tributary to Lake Powell were very desert-like and exhibited signs of flash flooding. The loss rates appeared quite low, and the vegetative cover was very sparse. Some portions of the lower Green River subbasin had extensive outcrops of Mancos Shale. The upper basin areas exhibited a similar increase in vegetation and loss rates with elevation rise.

In applications of the unit hydrograph approach, the Reclamation lag equation is used in determining the lag time of the flood hydrograph. Lag time is defined as the time from the center of mass of unit rainfall excess to the time that one-half the volume of unit runoff from the drainage basin has passed the concentration point. The lag coefficient is a measure of the hydraulic efficiency of a basin to transmit water, which reflects overall basin roughness, steepness, and vegetative cover. Lag coefficients for the basins above Hoover ranged from 1.3 to 5.5.[19]

The dimensionless unit hydrograph was used to calculate the flood hydrograph for each subbasin. The basin above Hoover Dam includes three basic types of terrain—deserts, foothills, and mountains. Data gathered from the field reconnaissance and from analysis of basin features shown on topographic maps were compared with similar data for basins where unit hydrographs had been developed from observed flood hydrographs. Separate dimensionless graphs were used for each type of topography. The following three dimensionless graphs were used in the study: (1) Salt River for the desert areas, (2) Buckhorn for the foothill areas, (3) Uinta for the mountainous areas.[20]

The Tatum method was used to route flood hydrographs from one subbasin to the next downstream subbasin, and to combine them with additional flood hydrographs as the floods move downstream. The Tatum method is a successive average lag procedure. It is commonly used to route hydrographs through channels, which have no appreciable storage or large tributary inflows, or where costs of obtaining channel cross-section and other data needed for more sophisticated methods are prohibitive. FHAR uses the modified Puls method to route floods through reservoirs or through short stream reaches in which the time of travel and wedge storage is negligible.

Antecedent Flood

The antecedent flood is that flood, and associated climatic conditions, affecting the basin prior to the onset of the upper limit design rainstorm. For this study, the antecedent flood is a 100-year snowmelt event. This flood is not nearly as large as what might be expected as the probable maximum snowmelt flood, but the volume is still very large when compared to the volume of the ULDRS flood event. In order to model operations of the reservoirs of the Colorado River above Hoover Dam, daily flows were required for a complete calendar year. The 100-year base snowmelt flood, which was developed statistically, had an annual volume of 25,375,000 acre feet into Lake Powell and 1,281,000 acre feet as intervening flow into Lake Mead from the contributing drainage area downstream of Lake Powell.

Reservoir Operations

The reservoirs in the Colorado River Basin are operated as an integrated system. The system has a total flood control space requirement of 5,350,000 acre feet, which must be evacuated from storage by January 1. At least

1,500,000 acre feet of that space must be in Lake Mead, which is the only facility in the system with exclusive flood control space. One of the primary goals of the flood control operations for the Colorado River system is to keep the exclusive flood control storage at Hoover vacant year-round to regulate potential rain floods.[21]

The 1982 field working agreement between Reclamation and the Corps of Engineers for flood control operations of Hoover Dam and Lake Mead establishes the reservoir operating criteria. Two sets of operating rules are used to operate the system. During the space-building or drawdown season, which extends from August through December, the objective is to gradually drawdown the reservoir system to create space for next spring's snowmelt runoff. During the runoff forecast season, from January through July, the forecasted maximum inflow hydrograph is routed through the reservoir using predetermined release rates, so that the reservoir system is full by July 1.[22]

Using the 100-year snowmelt flood values, routing studies were performed to simulate reservoir operations during the antecedent flood event. The Colorado River system operation was modeled bimonthly beginning January 1 to reflect proper operations during a forecasted 100-year snowmelt flood. Runoff forecast errors were subtracted from the actual inflows through July 31 in order to make operational decisions that reflect a reasonable degree of conservatism. The results of these investigations produce the starting elevations that were required to route the ULDRS flood event.

Probable Maximum Floods

Determination of the probable maximum floods for Hoover Dam involved generating seasonal flood hydrographs by applying the results of the meteorological investigation. Numerous combinations of ULDRS centerings and storm separations were evaluated to determine the most critical hydrologic conditions for the dam. The ULDRS flood hydrographs were combined with the snowmelt antecedent flood to determine the most critical hydrologic condition at the dam. Results of these analyses produced PMFs for the critical May through August storm season.

The most critical flood situation for Hoover Dam occurs when the San Juan storm is followed by the Pine and Cedar Mountain storm. The flood hydrographs developed for the upper basin were routed through Glen Canyon Dam, and combined with concurrent runoff and intervening base flow hydrographs for the area between Glen Canyon and Hoover Dams. The resulting PMF had a peak inflow of 1,130,000 ft^3/s and a 60-day volume of 9.3 million acre feet.[23]

Discussion

Reclamation's approach toward estimating the inflow design flood for Hoover Dam has changed dramatically over the years, moving from simple hand calculations to more complex computer simulations. The original flood study for Hoover Dam relied on high water marks and gage heights to construct the largest possible flood for design. The analysis assumed that the largest flood had already occurred in the basin and was reflected in the historical record. Even today, the 1884 flood is still the largest flood on record in this basin. When put in a statistical context, it was estimated to have a return period of about once in 500 years. By modern standards, this is considered an unsafe design standard. However, the engineers who designed the dam sized the spillways and outlet works to pass the peak of this flood without taking credit for the additional flood regulation provided by the storage space in the reservoir. These very conservative design decisions produced a dam that is still safe when tested against today's design criteria.

The magnitude of the differences between the two studies can be determined by comparing the peak discharge and the 60-day volumes. The 1930 flood study produced an inflow design flood with a peak discharge of 300,000 ft^3/s and an approximate 60-day volume of 23,200,000 acre feet. The 1990 PMF had a peak discharge of 1,130,000 ft^3/s and a 60-day volume of 9,300,000 acre feet. So even though the peak discharge of the 1990 PMF is nearly four times as large as the 1930 IDF, the volume is less than half the 1930 volume.

An additional 60 years of data have been collected since the 1930 study was completed. Because PMF procedures attempt to produce the maximum flood possible at a site, one would expect additional data to result in larger flood values in the 1990 study. Since most of the volume comes from snowmelt, one could speculate that the 1884 flood was predominately a snowmelt flood with a return period much greater than the once in 100 years, which was used as the antecedent flood in the 1990 study. This could account for the smaller peak and larger volume in the 1930 analysis.

The dams and reservoirs that have been built upstream of Hoover could also be responsible for some of the volume differences. Hoover Dam was one of the first major structures on the Colorado River. The other large dams, which were built after 1930, can store much of the flood volume. Normal reservoir operations use flood forecasting to regulate snowmelt floods by vacating reservoir storage prior to the occurrence of the flood peak. This helps maximize power generation and minimize flood damages in the basin, and reduces the volume of water into Lake Mead.

Since Hoover Dam was built, engineers and hydrologists have collected a lot of data and gained additional understanding of meteorological, hydrologic, and statistical processes. Climate and streamflow data available for analysis has increased dramatically in both quantity and quality. Computer technology now allows analysis of detailed storm patterns and construction of rainfall-runoff models in order to obtain a better understanding of the hydrology of the Colorado River. This allows the engineer to run numerous computer simulations to determine the most critical hydrologic condition for the dam.

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A Struggle of Needs: A History of Bureau of Reclamation Fish Passage Projects on the Truckee River, Nevada

By:
Rick Christensen and Brent Mefford

Abstract

The Truckee River flows from the Sierra Nevada Mountains of California eastward to Pyramid Lake, Nevada. The river basin experienced explosive growth in the mid-to-late 1800s when gold was found in California and Nevada. The gold rush was followed by an influx of farmers and ranchers to the area. In about 1905 Reclamation constructed the Truckee-Carson Irrigation Project, one of the agency's first water diversion and storage projects. Pyramid Lake and the Truckee River are home to two important fish that are lake dwellers and stream spawners. This paper follows the history of Reclamation's fish passage projects designed to protect this important fishery.

Background

The Truckee River originates in Lake Tahoe in the Sierra Nevada Mountains of California and runs east into Nevada. The river forms Pyramid Lake where it flows into a large natural sink that lies about 50 miles east of Reno, Nevada. Being a terminal lake, the water quality of Pyramid Lake is slightly saline, however, the lake supports several fish species among which are two notable lake dwellers and stream spawners, cui-ui lake suckers (*Chasmistes cujus*) and Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*). Both of these species migrate up the Truckee River to spawn during high spring flows. Prior to the 1900s, cui-ui likely spawned as far as twenty-five miles upstream, and Pyramid Lake Lahontan cutthroat trout spawning reached into the Sierra Nevada Mountains. Historical flows in the Truckee River vary between 1,000 and 2,000 cubic feet per second (ft3/s) during the spawning runs in normal years, with flows in excess of 3,000 ft3/s in wet years. For nearly one and a half centuries, demand for waters of the Truckee River by immigrants to the area has impacted the unique fisheries native to this closed basin ecosystem. And for nearly as long, attempts have been made to protect fish in the presence of a growing demand for water. However, during the 1900s, fish protection could not keep pace with the growth of urban and agricultural water demand. The last spawning run of the Pyramid Lake Lahontan cutthroat trout occurred in about 1938, and the trout was thought extinct by 1940. In 1967 the U.S. Fish and Wildlife Service[1] listed the cui-ui sucker as endangered. This paper follows the progression of Reclamation fish passage projects on the lower Truckee River that accompanied a century of water development.

Early History

The river and its fisheries were impacted suddenly when gold was discovered near Virginia City, Nevada, in 1859. For the next forty years the Truckee River experienced rapid changes along its path. Joe Simonds[2] depicts the rapid early growth and its impact on the river as follows:

> The Comstock Lode, as it would come to be called, began an influx of settlers to northern Nevada that would place heavy demands on the region's natural resources, including water and timber. Water to supply the growing needs of the Comstock's' mines was diverted from the Truckee River and Lake Tahoe Basins, marking the beginning of interbasin water diversions. The demands for lumber to supply the mines and railroads led to the rapid growth of logging and milling operations throughout the Sierra Nevada. Before long, the rivers and streams in the area became clogged with sawdust and logging debris, preventing fish migration and seriously degrading the quality of water in the Truckee River.
>
> In 1861, Congress granted Nevada territorial status. Among the first acts of the Territorial Assembly was to pass a requirement that all dams constructed in Nevada allow for the natural transit of fish. Unfortunately, this requirement was frequently overlooked.
>
> In the early 1860s, the first irrigation ditches began to appear. The Pioneer and Cochran Ditches diverted water from the Truckee River to irrigate lands in Truckee Meadows. Numerous dams were constructed on the Truckee River to divert water for irrigation or to power mills. In 1870, the California Legislature authorized the Donner Lumber and Boom Company to improve the channel of the Truckee River from the outlet of Lake Tahoe to the California/Nevada state line. The company constructed a rockfilled timber crib dam at the outlet of the lake, controlling the outflow of the lake for the first time. Throughout the later part of the 1800s, growth along the Truckee River continued at a rapid pace. More dams were constructed, increasing diversions from the river and further limiting migration of fish.

By about 1900 the federal government through the United States Geological Survey and, later, the United States Reclamation Service was investigating a large scale irrigation project involving the lower Truckee and Carson Rivers. In 1903 the Secretary of the Interior authorized the Truckee-Carson Irrigation Project (Newlands Project). On the Truckee River, the project included storage reservoirs on the upper river and a diversion dam on the lower river, 6.1. The diversion dam, initially called the Truckee River Dam, was renamed Derby Diversion Dam. Derby Diversion Dam diverts water from the Truckee River basin through a canal to Lahontan Reservoir on the Carson River. The thirty-one foot high dam providing about fifteen feet of hydraulic head was completed in 1905, 6.2. The dam has an embankment that runs across the river valley to a 155-foot-wide concrete buttress gated spillway that spans across the

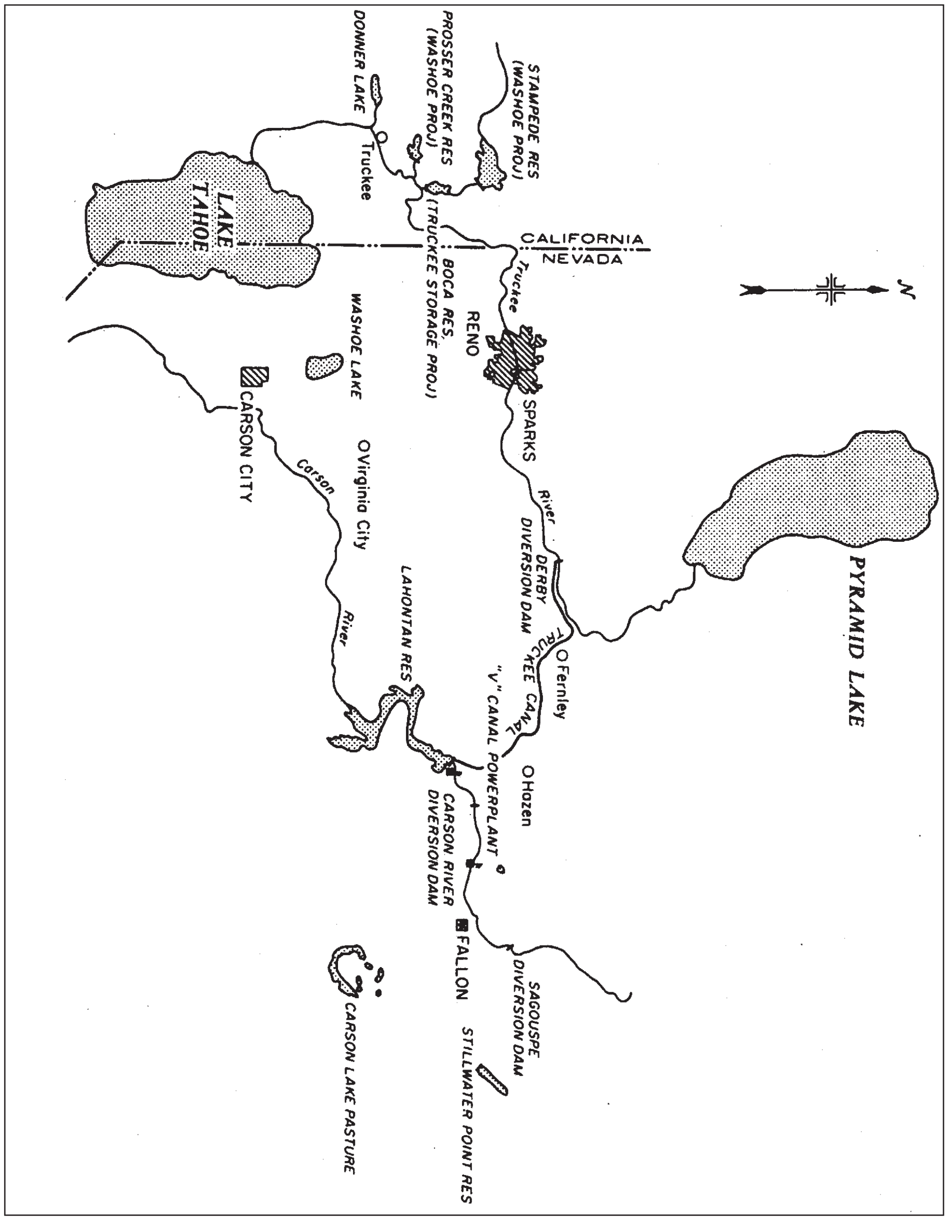
Truckee River channel. The spillway originally consisted of 16, 5-foot by 5-foot cast iron slide gates separated by 5 foot-wide-piers. The impact of the dam on fish moving upstream to spawn was recognized early in the project. It is believed a weir and pool fishway was constructed on the right abutment shortly after the dam was completed. This fishway was replaced in 1913 with another pool and weir fishway constructed downstream of the first spillway gate, 6.3. The 1913 fishway was a wood flume containing flashboards (weirs). The fishway provided a series of 16, 6-ft-long by 10-ft-wide pools, each pool dropping about one foot to the next. The height of the flashboards was adjustable to accommodate large changes in river flows. The 1913 fishway was not unlike many of today's pool and weir fishways. There are no records of fishway effectiveness or how long the fishway remained in service.

Despite these early attempts to provide fish passage, there is little doubt Derby Diversion Dam was one of several significant factors that led to the extinction of the Pyramid Lake Lahontan cutthroat trout by the 1940s. For the next half century following the extinction of the Pyramid Lake Lahontan cutthroat trout there was little pressure to provide effective fish passage at Derby Diversion Dam. In the early 1970s another species of Lahontan cutthroat trout was reintroduced to Pyramid Lake. This population has largely been sustained by hatchery spawning. The goal of the Pyramid Lake Paiute Tribe and many public and private organizations is to restore spawning Lahontan cutthroat trout to the Truckee River. To this end, in 2000 Reclamation announced a plan to design and construct a new fishway on Derby Diversion Dam. Working with the U.S. Fish and Wildlife Service, Reclamation designed a rock channel fishway that will allow passage of Lahontan cutthroat trout, cui-ui, and other resident fish species currently held below the dam. The rock fishway will consist of a 940 ft long channel sloping 1.8 feet every 100 feet, 6.4. Flow down the channel will be controlled by a series of boulder weirs that create pools upstream and small drops downstream. Each weir is formed by placing boulders about 1 ft apart in an upstream pointing chevron pattern. The boulder weirs create a hydraulic control that produces a drop in water surface of about 0.4 ft, producing a maximum passage velocity of about 5.0 feet per second (ft/s). The fishway was scheduled for construction in 2002-2003.

The River's End

The problem of fish passage on the lower Truckee River is not limited to Derby Diversion Dam. The confluence of the Truckee River and Pyramid Lake is a critical location where fish passage has often been blocked by the influences of man and nature. An excerpt from the Nevada Governor's address to the Legislature in 1875 cited the start of many efforts to deal with passage issues that have occurred at the river's end.[3]

> A subject of importance to many citizens of the state,… is the preservation of the fisheries of the Truckee River...unless preventative



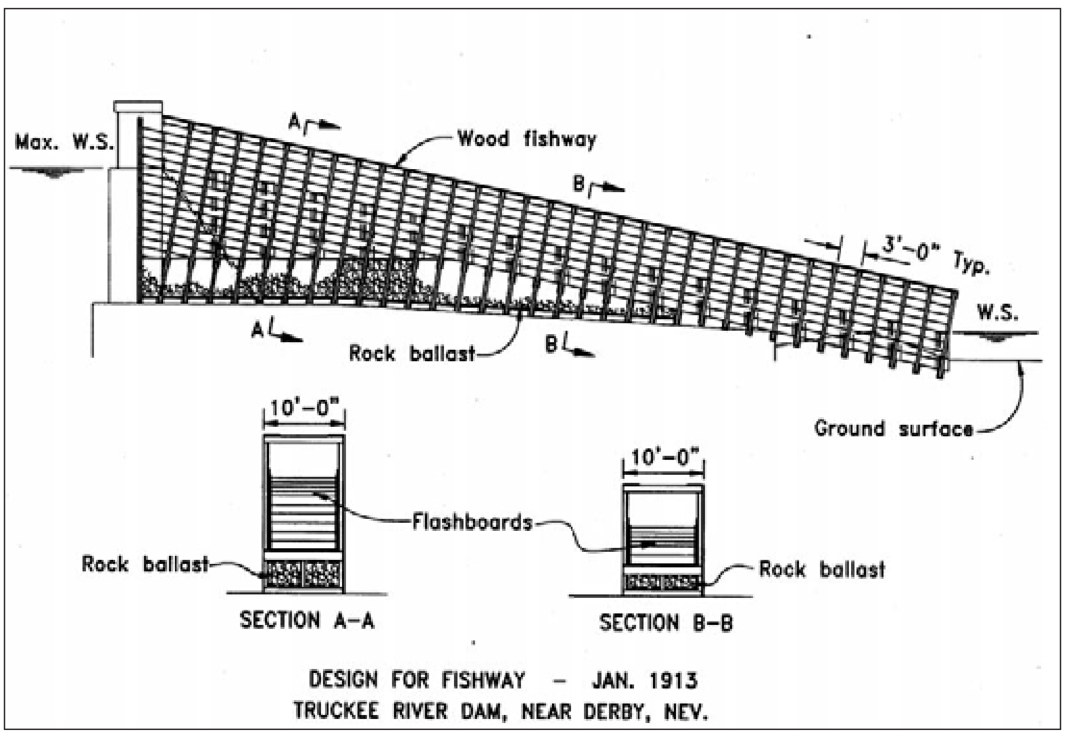
6.1. Map of the Newlands Project.

measures are soon adopted and rigidly enforced, their certain destruction is imminent.... To the Indians there residing (Pyramid Lake) the fisheries are a valuable source of food, employment and profit.

The mouth of the Truckee, where the river empties into the lake, is closed by a bar of sawdust at least a mile in length, three hundred yards in breadth and three feet in depth… I saw hundreds of fine trout dead and rotten upon the shores. The air was poisoned with the stench of their decay.

With the construction of Derby Diversion Dam and other upstream diversions the passage problem at the river's end changed from sawdust to a declining lake elevation. The average annual inflow to Pyramid Lake for the period of 1918 to 1970 was approximately 250,000 acre feet, while the average annual evaporative loss is approximately 440,000 acre feet.[4] In 1967 Pyramid

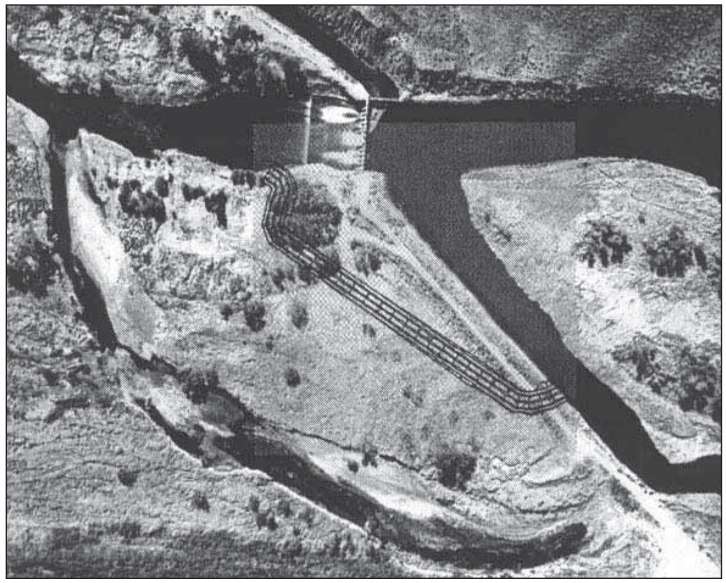
6.2. View of Derby Diversion and Truckee River.



6.3. Pool and weir fishway constructed at Derby Diversion Dam in 1913.

Lake's water level reached its lowest recorded level—more than 87 feet lower than it was in 1906 when Derby Dam diversions began. This lowering was due to the increased diversions of water out of the Truckee River, the natural evaporative loss at Pyramid Lake, and also due to some major droughts within this period.

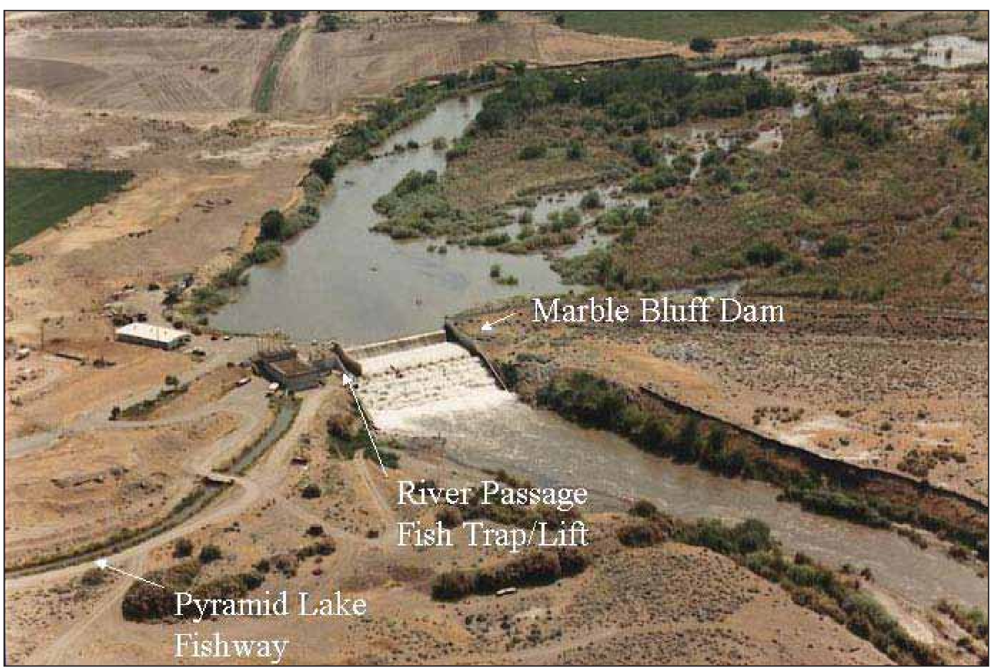
As the water level in Pyramid Lake began to fall in the early 1900s, the gradient of the Truckee River steepened in the lower river and exposed a large flat delta area at the mouth of the river. This made upstream migration of the Pyramid Lake fish difficult.



6.4. View of proposed rock channel fishway overlaid on a photograph of Derby Diversion Dam.

The first major structural effort to improve fish migration up the Truckee River was started by the Bureau of Indian Affairs in 1942 when it started construction of a diversion dam and fishway channel near the site of the present Marble Bluff facilities. However, World War II interrupted construction, and the dam was washed out during flood flows in 1950.

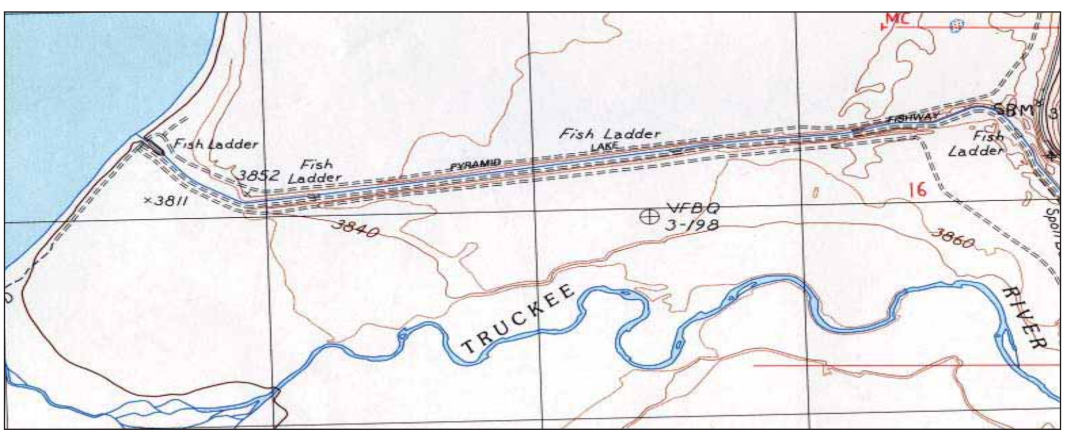
In 1975 Reclamation completed construction of Marble Bluff Dam and Pyramid Lake Fishway. The dam was designed as a grade control structure to stabilize the lower Truckee River gradient. The fishway was designed to provide fish passage from the lake to the river upstream of the river delta. The dam is



6.5. View of Marble Bluff Dam and the exit of Pyramid Lake Fishway.

located approximately three miles upstream of Pyramid Lake, 6.5. The 35 foot high dam is a 1440-foot long, earth filled embankment with 150-foot long, centered, uncontrolled concrete ogee crest spillway with gated sluiceway. The spillway and sluiceway pass flow down a baffled apron drop to the downstream river channel. Storage at the dam is negligible, as the facility was not intended to store water.[5]

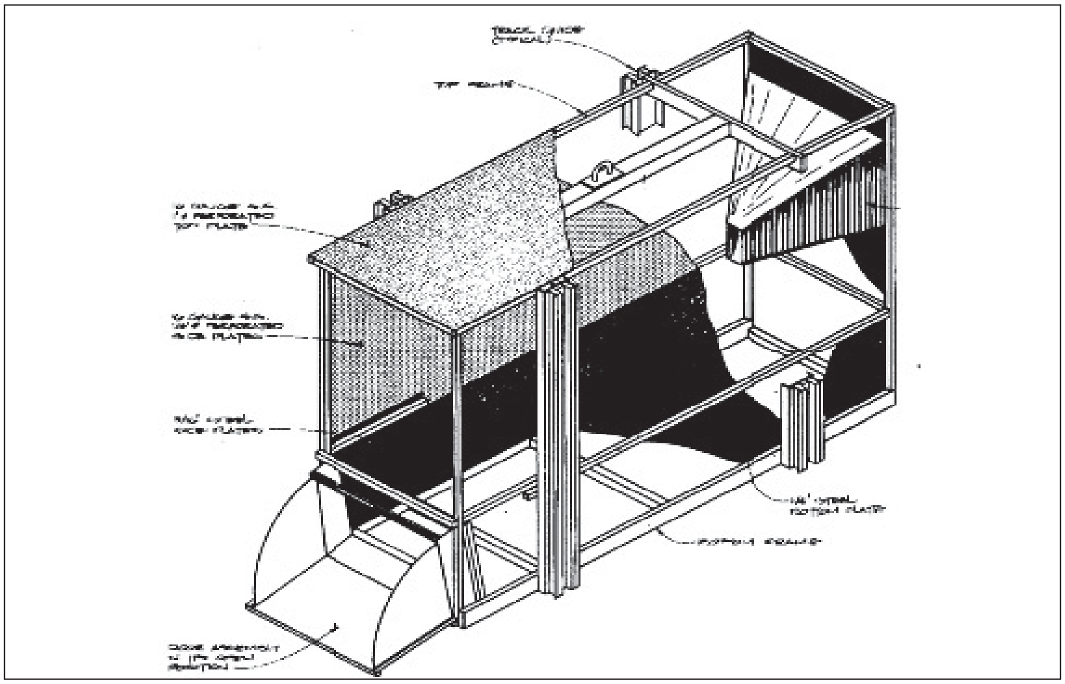
In conjunction with the dam's construction, a fish handling facility and two different paths for fish passage from the lake to the river above the dam were constructed. The primary purpose of the fish handling facility was to trap, examine, and document fish that migrated from Pyramid Lake into the Truckee River.[6] Two fish passage paths were needed as river access for fish is often blocked, for lake elevations below about 3800 feet, by a large sediment delta at the junction of the river and lake. Historically, when exposed, the delta causes the river to fan out into a shallow braided channel that blocks fish passage up the river. For these conditions, a direct route was constructed from the lake to upstream of Marble Bluff Dam, called the Pyramid Lake Fishway. The Pyramid Lake Fishway combined five fish ladders and about three miles of fishway channel to provide a maximum elevation gain of about seventy-six feet between the lake and the river upstream of the dam. Typical salmon style fish ladders with weir/orifice baffles were designed for the fishway, 6.6. Each fish ladder was sloped at a grade of one foot vertical to ten feet horizontal (10% grade), while the fishway channels linking the fish ladders were sloped at one foot vertical in 10,000 feet horizontal. The fishway was designed to pass up to 50 ft^3/s at a flow depth of 4 feet and flow velocity of 1 ft/s. The weir/orifice baffles in each fish ladder were spaced 10 feet apart, provided an approximate 1 foot drop across each baffle, and a passage flow velocity of 8 ft/s.



6.6. Location map showing Marble Bluff Dam and Pyramid Lake Fishway.

For years when Pyramid Lake elevation covers the sediment delta, fish can move up the Truckee River to the dam and must be passed over. Fish passage over the dam was originally achieved by constructing a fish trap with a mechanical hoist lift system to raise the trapped fish over the dam.

The trap, 6.7, was lowered into a sump at the head of a fish attraction channel located on the right bank of the downstream river channel. Fish moved up the attraction channel following attraction flows and passed into the fish trap. Operators judged when to raise the trap with the mechanical hoist. The original system was designed such that all fish entering the trap/lift system must pass through the fish handling facility. In 1987 the trap/lift system was modified by the U.S. Fish and Wildlife Service to allow the lifted fish to be released directly to the



6.7. Schematic of the Marble Bluff Dam fish trap used to lift fish over the dam from 1987 to 1997.

upstream river, via the upper fishway channel.

Neither of the original Marble Bluff Dam fish passage facilities functioned as intended. During the first years of fishway operation, the ladder baffle design and head drop were found to be a poor match for cui-ui behavior and swimming strength. The cui-ui displayed a strong bottom oriented behavior in the fishway that was contrary to passing over a weir and the 8 ft/s flow velocity was found to be too high for many cui-ui. Cui-ui attempting to move up the fishway at times crowded so densely that many fish were smothered. To improve fish passage, U.S. Fish and Wildlife Service added a fish exclusion gate at the fishway entrance to regulate the number of fish entering the fishway and modified the fish ladders. In each fish ladder, weirs were added halfway between the original ladder baffles to reduce the drop over each baffle to 0.5 foot and slow down the passage velocity to about 5 ft/s. Passage of the cui-ui improved, however, fish passage efficiency remained low.

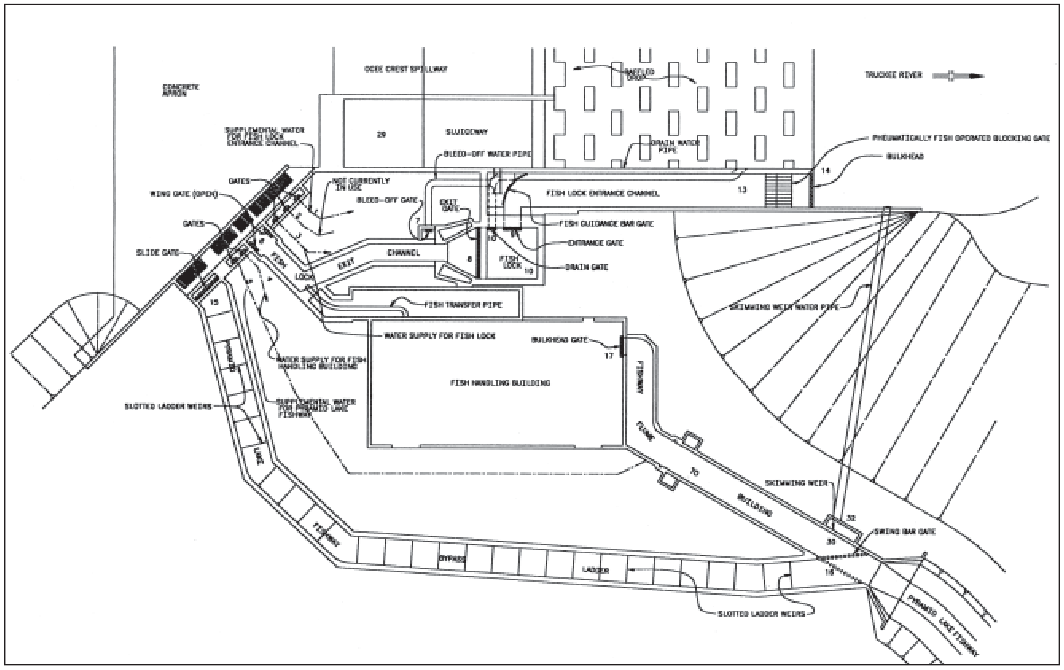
The fish trap/lift system also had numerous operational problems and limitations. The biggest limitation was that the system was too slow, resulting in fish over-crowding, delays, and mortality.

In 1993, two thousand cui-ui died in the river trap due to a mechanical failure.[7] Both fish passage structures were progressively modified by U.S. Fish and Wildlife Service in a continual effort to improve fish passage at the site. However, fish passage for the cui-ui and Lahontan cutthroat remained a significant problem.

The period from the mid 1980s through the 1990s brought floods accompanied by large cui-ui runs that the fish passage facilities couldn't handle and periods of drought with few spawning fish. High water years in the mid-1980s raised Pyramid Lake to an elevation submerging the Pyramid Lake fishway entrance and opening up river passage to the dam. During these high water years, thousands of fish moved up the river to the dam overwhelming the ability of the fish trap to pass fish. This period of high water was followed by a period of lower than normal winter precipitation from 1988 to 1992. The lake declined to elevation 3797 feet prior to the spring runoff of 1993. For these five years of operation, the entire flow (30-50 ft3/s) of the lower Truckee River was diverted into the Pyramid Lake fishway during the spawning run seasons. Lahontan cutthroat trout ascended the fishway in 1988-1990 with the runs ranging from just over 100 fish to a high around 450 fish in 1989.[8] During this timeframe, only in 1989 did cui-ui migrate up the fishway to the fish handling building, and these seventy-one fish were transported to the Tribal Hatchery at Suttcliff, Nevada. Due to the continued drought in 1991 and 1992, bar racks were installed at the terminal ladder to prevent fish from migrating into the fishway. Water releases from upstream storage during this five year drought period were minor and intermittent. This dry period was followed by a record wet winter in 1992-1993. Even though the lake was low, both the fishway and the river trap were operated that year. It was estimated that on April 3, 1993, tens of thousands of cui-ui entered the terminal ladder. This mass movement of fish exceeded the rate that cui-ui could ascend up the ladder resulting in cui-ui being killed due to crowding and suffocation, and no fish passed on up the fishway to the river. A second and even larger run started on May 29th. To keep the fish from again overcrowding, fishery personnel netted cui-ui from the entrance ladder, to reduce their numbers. These fish were then transported and released upstream of Marble Bluff Dam. During the 1993 spawning run, over 18,000 cui-ui and 108 Lahontan cutthroat trout were passed upstream of Marble Bluff Dam from the fishway, river trap by netting and transporting, while approximately 4000 cui-ui died due to overcrowding in the fish ladders and a mechanical failure in the river trap. Prior to the spawning run of 1994, Fish and Wildlife Service again modified the entrance ladder and river trap to reduce the mortality rate of the migrating cui-ui. The 1994 fish runs resulted in 66,425 cui-ui and seventy-nine Lahontan cutthroat trout being passed upstream of Marble Bluff Dam with about 250 cui-ui killed at the entrance ladder.[9]

In 1995, the Bureau of Reclamation assisted a team of federal, tribal, state, and local organizations in addressing the fish passage problems at Marble Bluff

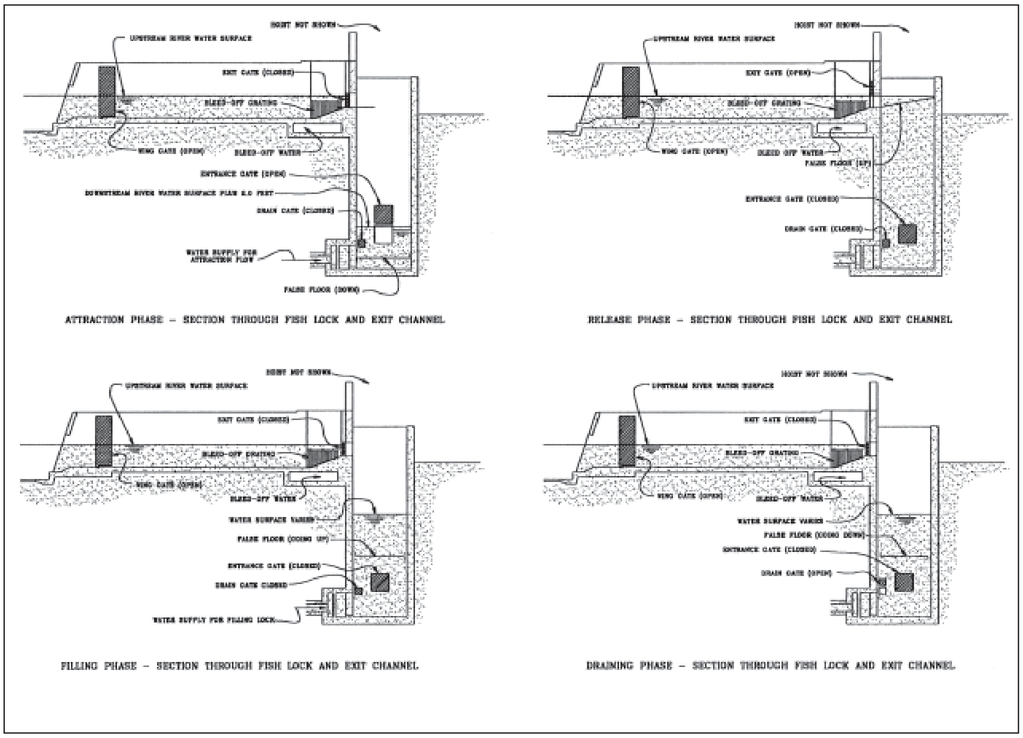
Dam.[10] The main objective was to improve passage over the dam. An identified objective was an estimated fish passage capacity of 300,000 fish during a three-day period to prevent migration delays at the dam. By 1998 this process had resulted in the Bureau of Reclamation replacing the fish trap/lift system with a hydraulic fish lock, and constructing a new fishway channel exit ladder, 6.8. This was the first time that a hydraulic lock was built for fish passage by the Bureau of Reclamation.



6.8. Plan view of Marble Bluff fish lock and Pyramid Lake Fishway exit ladder.

Reclamation's Fish Lock

A hydraulic fish lock is simply a water elevator which operates similar to a boat lock. The sequencing of events required during passage of fish through the lock is shown in 6.9. Each lock cycle is divided into four phases: fish attraction, lock filling, fish release, and lock draining. In the fish attraction phase, flow attracts the migrating fish into the fish lock chamber. After a preset time, the fish entrance gate is closed and the lock is filled with water (lock filling phase). When the fish lock is approximately full, a fish crowder is raised by a hoist and the lock exit gate opened (fish release phase). The fish crowder moves fish up near the surface and into the fish lock exit channel. Once the fish are out of the lock, the exit gate is closed, the false floor lowered, and the fish lock chamber drained (draining phase). The lock cycle then repeats. The system is operated manually or automatically via a software based control system linked to water level and gate position sensors. The new hydraulic fish lock required modifying the existing 15 foot by 15 foot fish trap/lift concrete well and building a new fish lock exit channel. The existing fish attraction channel was lengthened and a fish barrier gate was added to provide a method of controlling fish access to the fish lock.



6.9. Marble Bluff Dam fish lock operating phases.

Soon after the fish lock design was finished, nature again changed flow conditions at the river's end. In January 1997 a large flood on the Truckee River (23,000 ft^3/s) scoured the river channel downstream of Marble Bluff Dam lowering the river elevation by several feet leaving fish access to the fish lock facility in question. It was decided that the pre-flood elevation of the river downstream of the dam had to be recovered if the existing trap/lift structure was to be modified into a fish lock. The problem was solved in 1998 when a nearly 450-foot-long by 2-foot-high rock ramp was constructed in the river channel about 300 yards downstream of the dam. The rock ramp was designed to imitate a natural riffle so as not to block fish passage to the dam.

In 1998 the *Reno Gazette-Journal*, ran a story that exclaimed "Cui-ui spawning the biggest in years."[11] The journal further reported that this was the largest spawning run since Marble Bluff Dam was built. It was estimated that the new fish lock can move 3,500 fish at a time, compared to only 600 to 800 fish at a time by the old fish trap/lift system. In its first year the lock passed over 400,000 spawning cui-ui upstream of Marble Bluff Dam. A year later an estimated 600,000 cui-ui passed through the fish lock with no apparent delay.

A Look to the Future—Rebuilding the Pyramid Lake Fishway

Construction of the fish lock required removing the upstream-most fish ladder on the Pyramid Lake fishway (exit ladder) and presented the opportunity to design and construct a replacement fish ladder tailored to cui-ui. Fish ladder construction was preceded by hydraulic tests of several fish ladder designs at Reclamation's Water Resources Research Laboratory in Denver, Colorado. These tests resulted in a unique fishway ladder design tailored to the behavior and swimming capabilities displayed by the cui-ui sucker. A dual-slot-chevron shaped baffle design was chosen, 6.10. The new fish ladder's slope is about one-third that of the ladder it replaced (3.1% grade) and holds flow velocity to about 4 ft/s.[12] The fishway channel with the new bypass fish ladder is still not considered fully operational as the fishway still contains four old weir/orifice style ladders along its route to the dam. Rebuilding the Pyramid Lake fishway channel to an effective fishway for both cui-ui and Lahontan cutthroat trout remains a major task to fulfilling the original goals of the Marble Bluff Dam and fishway project.

6.10. Marble Bluff Dam Fishway exit Ladder.

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Explaining Hoover, Grand Coulee, and Shasta Dams: Institutional Stability and Professional Identity in the USBR

By:
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Abstract

Between 1923 and 1943 the U.S. Bureau of Reclamation (USBR) changed dramatically. In 1923, after two decades of operation, the USRS was small and embattled. It had 27 irrigation projects, 3700 full-time employees, and a budget of $20.6 million. In contrast, in 1943 the USBR could have celebrated 20 years of growth and success and anticipated more. In 1943, the USBR had *52* projects. It had increased its staff to 6500, or more than doubled it. Even more impressively, it had increased its budget to $91.7 million, or to almost 4½ times 1922's budget. One of the big changes in the USBR was the construction of large multiple purpose dams—Hoover, Grand Coulee, Shasta, and, after World War II, many more. Multiple purpose dam building, of course, did not arise out of the blue in the 1920s. USBR engineers took utilitarian conservation ideas, espoused by Progressive Era scientists, engineers, and politicians, and implemented them by building large multiple purpose dams.

I explain the advent of multiple purpose dam building, and the growth of the Bureau of Reclamation, in terms of a stable agency leadership and its professional culture. Clearly, the Depression and the New Deal government provided the means that developed rivers, hired new staff, and, generally, fueled agency growth. President Roosevelt, Secretary of the Interior Ickes, Washington Senator Dill, and others involved in directing relief funds to water development did not, however, determine the features of the techno-environmental systems that rivers would become. USBR engineers drew on engineering paradigms, common solutions that could be fitted to new problems, to refine both the production practices and design choices of river development and create these systems. These men gazed at the world through engineers' glasses and saw disorderly construction sites and disorderly rivers. In response, they applied the tools of their trade and rationalized construction sites and rivers. The result was multiple purpose dams, conservation ideas put into practice, and an expanding USBR.

Biographical data establish the stability of the USBR's leaders in the 1920s and 1930s, their virtually exclusive orientation towards engineering, and links between this group and Progressive Era engineering reforms. Two features of the careers of USBR leaders particularly indicate the stability of the group in the 1920s and 1930s: the long length of their employment with the USBR and the dates and reasons that men left. Education and professional affiliation reveal the group as one of professional engineers. With respect to Progressivism, the biographical data show possibilities. These engineers were in the right places at the right times to be exposed to Progressive ideas about conservation of natural resources and scientific management. They were educated in the Progressive Era. More importantly, these men began their careers at the USBR in its first decade. They trained into their profession under Director Fredrick Newell and Chief Engineer Arthur Powell Davis, both notable figures in the conservation and engineering reform movements.

As with many groups of engineers in this period, this stable group of engineers with links to Progressivism embraced industrial practices and rationalization. They applied these paradigms to both the processes of building dams and to the designing of river systems. To illustrate the industrialized and rationalized elements of dam building and river development plans, I compare these activities with scientific management. I chose Taylorism as a framework for comparison because F. W. Taylor laid out an explicit program for rationalizing workplaces that can serve as a way to distill the broad ranging changes of industrialization and rationalization. Further, Taylorism was broadly discussed and debated in this period, so these concepts would have been part of the intellectual resources of the USBR leaders as they engaged in river planning and directed dam construction. Taylor sought to standardize and routinize everything in a factory—production processes, spatial layout of factories, machines, and, especially, workers. To do this, he created expanded roles for engineers. Not only would mechanical engineers invent and refine factory machinery, but they would also oversee factory operations.

By analyzing the construction methods used at Grand Coulee Dam, I show that the USBR and its contractors set up a process, like Taylorism, that placed engineers in the center, emphasized flow, and refined machinery. During the construction of a dam, USBR employees provided important management oversight through drawings and inspectors. Contractors set up flowing processes construction systems, such as a set of trucks and conveyor belts to remove the "overburden" from the dam site. The USBR employed experts to study and refine the machinery used in the construction of dams, for example concrete mixers.

As with construction sites, Federal engineers developed the ideas about river development, advocated by Progressive Era conservationists, into a set of technical practices, structures, and new landscapes with analysis and management techniques similar to those used by F. W. Taylor and his followers. Like Taylorism, conservation included places for professional engineers in large organizations. Planning and constructing large dams prompted growth of engineering organizations. When engineers changed free-flowing rivers into series of lakes, they used the same kind of spatial logic as Taylor's rearrangement of machinery on factory floors. The USBR's Denver office specialized in designing, analyzing, and refining the main technology of comprehensive river development—multiple purpose dams—just as Taylor worked on making faster and more precise machine tools. While Taylor stretched rationalization to encompass workers, comprehensive planning stretched rationalization to encompass another new area—large natural systems.

When Interior Secretary Hubert Work called for an investigation and reorganization of the U.S. Reclamation Service (USRS)[1] in 1923 and Interior Secretary Harold Ickes repeated the exercise in 1943, the institution that they targeted could hardly have been more different. In 1923 after two decades of operation, the USRS was small and embattled. By 1922, it had constructed twenty-seven irrigation projects, had 3,667 full-time employees, and $20,603,793 in funds to spend. Its major constituency, the farmers who worked the USRS's irrigated land, was in open revolt. The cost of creating irrigation farms had far exceeded rosy government estimates, and, with the revival of European agriculture in the wake of World War I, markets for American farmers collapsed. In contrast, in 1943 the USBR could have celebrated twenty years of growth and success and anticipated more. In 1943 the USBR had fifty-two projects. It had increased its staff to 6,543, or more than doubled it. Even more impressively, it had increased its budget to $91,665,613, or to almost 4½ times 1922's budget. Further, this growth included the construction of Hoover,[2] Grand Coulee, and Shasta dams—the first set of monumental multiple purpose structures and the entree to integrated development of rivers after World War II.[3]

Given the weakness of the USRS as an organization in the early 1920s, the institutional success of the USBR in the 1930s and 1940s begs explanation. The Depression is surely part of the story. The severe economic problems of the 1930s and the willingness of Franklin Roosevelt's administration to spend money in an attempt to solve them provided great opportunities for men with plans. However, dams were not the only way, or even a particularly important way, for the federal government to spend money.[4]

One might argue that the multiple purpose dams themselves adequately provided the rest of the story of the USBR's success. The concept of a multiple purpose dam is clearly well suited to the American political system. Each dam offers a range of services—navigation improvement, irrigation water, flood control, and hydroelectricity, most commonly. Each service can have a constituency and each constituency one or more votes to fund a dam in Congress. However, in the early 1920s, multiple purpose dams were much more an idea than a reality. Engineers had reported favorably on a proposal to build Hoover Dam on the lower Colorado River. However, neither the compact dividing the waters of the Colorado between the tributary states nor the political coalition, which would wrest approval and funding for Hoover Dam from Congress, yet existed. The Army Corps of Engineers had built a hydroelectricity dam and two nitrate plants at Muscle Shoals on the Tennessee River during World War I. Congress, however, would fight over how to dispose of these seeds of the Tennessee Valley Authority until Franklin Roosevelt took office in 1933.[5]

People, as much as money and a new technology, explain the successes of the USBR in the 1920s and 1930s. In this period, a remarkably stable and homogeneous group of men[6] led the USBR. In the first part of this paper, I will show that overwhelmingly the leaders of the USBR between 1923 and 1943 were engineers familiar with Progressive reform engineering. In the second part, I will suggest that the training and professional identification of USBR leaders as Progressive engineers made a significant impact on its development. USBR leaders used experience with and enthusiasm for industrialization, scientific management, and conservation to reshape the organization's activities. Conservation provided a broad conceptual framework for water development by pairing "comprehensive planning" with reservoir construction. Industrialization and scientific management emphasized process-place engineers at the center and study and refinement of all processes and components.[7]

Engineering Leaders

One of the most striking features of the USBR between 1923 and 1943 was the stability and uniformity of its leadership. USBR leaders devoted their careers to government service. Overwhelmingly, they came to the USRS during the Progressive Era with strong ties to engineering through education and professional affiliations.

The organization chart appearing in the USBR's monthly magazine *Reclamation Era* identified the small groups of key figures in the commissioner's office in Washington, D.C., and the chief engineer's office in Denver, Colorado, as well as a larger group of men heading the various irrigation projects and investigations across the West. Standard biographical data, such as found in *Who's Who* and other common biographical sources, was available for fifty-three of the 167 individuals so identified.[8] The field engineers were by far the largest group.[9] Some 125 men held high positions in field offices as opposed to twenty-four men in Denver and seventeen men and one woman in Washington, D.C. However, information was much more readily available on leaders from the commissioner's office and from the chief engineer's office than on field men. Data on thirteen individuals from the Washington group and twenty from the Denver group provided information on over 70 percent of these leaders. The additional twenty field men identified only allow analysis of 16 percent of this group.[10]

The career paths of USBR leaders established a remarkable stability in this group between 1923 and 1943. The longevity of these men as USBR employees paired with when and why they left the USBR indicates the stability of this group. Many of these men worked for the USBR for lengthy periods. Field engineer Frank Banks, who oversaw the construction of Owyhee and Grand Coulee dams, set the challenge with fifty-one years of service. While few rivaled Banks, twenty-five additional men spent twenty years or more as employees of the USBR. This pattern of lengthy service is particularly striking when compared with other groups of federal experts. In agricultural economics, for example, men used employment in the U.S. Department of Agriculture's Bureau of Agricultural Economics in lieu of graduate school. Many of the Bureau of Agricultural Economics' early staff only worked there briefly.[11]

The small number of USBR leaders who departed between 1927 and 1942—ten—and the reasons they left, further indicate stability. Many of these leaders did not leave by choice. Seven of the men died while employed by the USBR. The men in the USBR pushed out the one woman in the group, Mae Schnurr. Schnurr worked her way up through the federal bureaucracy to a position of responsibility under Commissioner Mead—assistant to the commissioner and, on occasion, acting commissioner. After Mead died in 1936, Schnurr was repeatedly demoted until she arranged a transfer to the Office of the Secretary of the Interior in 1941. Even the two leaders who willingly left did not make significantly different career choices. One retired and the other transferred to a very similar position with the Tennessee Valley Authority (TVA).[12]

A clearly defined group of ten engineers did leave the USBR between 1924 and 1926—fallout from reorganization. The Interior Secretary pushed Director Arthur Powell Davis out of the USRS in 1923.[13] He replaced A. P. Davis with David W. Davis, a banker and politician from Idaho. After a brief period of reorganization, D. W. Davis was one of the early 1920s departers. A second, Morris Bien, retired in 1924 at age 65 to pursue a private law practice. The rest followed Chief Engineer Weymouth. Weymouth resigned in 1924 as Elwood Mead, an engineer, replaced David Davis. After slightly over one year in private practice, Weymouth went on to work as chief engineer for J. G. White Engineering Corporation from 1926-1929, for the City of Los Angeles Water Works from 1929-1930, and for Southern California's Metropolitan Water District (MWD) until he retired. All seven of the other men who left the USBR between 1924 and 1926 worked with Weymouth at one or more of these three organizations.[14]

7.1. Frank E. Weymouth.

A stable group, these men also made a very homogeneous group. Homogeneity started at home. Geographically, Commissioners Mead and Page and Chief Engineer Walter all hailed from the Midwest or Plains states, and they exemplified a trend. In all, twenty-two of fifty-three USBR leaders, or 42 percent, came from this region. The Reclamation West[15] and Northeast evenly split a second twenty. Only three men came from each the South and Europe. This geographic distribution, however, shifted over time. When I divided the fifty-three USBR leaders by both birth decades and hiring decades, the eleven born in the 1890s and 1900s and the thirteen hired in 1923 or later more strongly represented the Reclamation West. In these divisions, 36 percent and 38 percent respectively came from federal irrigation states.

In respect to marriage and children, USBR leaders were even more uniform and conservative. The large majority married and had children. Commissioner Mead, for example, married Florence Chase in 1882 and, after she passed away, married Mary Lewis in 1905. In all, Mead had six children. While most USBR leaders had fewer children: biographical sources identified none as life-long bachelors and only three as childless. Information on family, however, was reported less frequently than many of the data on these leaders. No information on marriage or children appeared for roughly one-third of these individuals.

Similarities multiplied at work. The typical USBR leader was born in the 1880s (42 percent), attended a land-grant university (70 percent), majored in civil engineering (42 percent), completed his education with a bachelor's degree (62 percent), began working in the Progressive Era (74 percent), belonged to the American Society for Civil Engineers (62 percent), worked for the USBR for 20 years or longer (68 percent), and ended his career at the USBR (51 percent). A closer look at this data suggests not just similarities, but patterns linking USBR leaders to Progressivism and engineering reform more specifically.

USBR leaders were Progressive engineers. Dates of birth, education, first employment, and hiring by the USRS place the beginning of these men's careers firmly in the Progressive Era. The first leaders of the USRS pursued reform goals and taught the leaders of the 1930s and 1940s their jobs in an atmosphere of activism. Further, the careers of the latter group demonstrated a commitment to public service indicative of engineering reformers.

Dates place the USBR leaders of 1923-1943 as young professionals during the Progressive Era. USBR leaders were born between 1858 and 1905. The largest portion was born in the 1870s (nine) and, especially, the 1880s (twenty-two). Age meant that the men attended college and began their careers in the Progressive Era. Thirty-one of fifty-three graduated with a bachelor's degree between 1900 and 1919. The addition of the few men who did not have a college degree and those for whom education information is not available meant that even more began working in these two decades—thirty-nine of fifty-three.

More specifically, the leaders of the 1920s and 1930s began working for the USRS in the reformist atmosphere of its first decade. The USRS hired thirty-four of the fifty-three between 1902 and 1912—the first decade of the organization's existence. In these early years, reform-minded men led the USRS and trained the future leaders into their profession. Before 1923, the USRS had two heads—Frederick Haynes Newell and Arthur Powell Davis. Both these men began their careers in the U.S. Geological Survey under John Wesley Powell, a colorful explorer, administrator, and founder of the conservation movement. Newell helped Nevada Senator Newlands and other western senators draft the Reclamation Act and became the first director of the USRS. He was a leader of the conservation movement and, as part of the major effort of Progressive engineers directed at their own profession, advocated unifying engineers in one professional society through his Committee on Cooperation and the American Association of Engineers. In 1914 a financial house cleaning in the USRS led to Newell's firing. Newell's chief engineer and Powell's nephew, Arthur Powell Davis, moved into the top leadership position, Davis too pursued conservation. He formulated an early reform tradition plan for the development of the lower Colorado River.[16]

A commitment to government service evident in the careers of the USBR's second generation of leaders suggests that these men did indeed adopt some of the values of their mentors. Both career paths and number of years spent in the USBR show a commitment to government engineering. Of fifty-three men, thirty-one—over half—either spent their entire career with the USBR or ended it there. Another 13 gave long periods of service at the beginning or in the middle of careers. Only five worked for the USBR for less than 10 years.

Unlike one strain of Progressive engineering reformers, USBR engineers demonstrated a commitment to government service without condemning corporations or corporate work. Morris Cooke represented the anti-corporate strain in engineering reform. A member of the inner circle of the founder of "'scientific'management," F. W. Taylor, Cooke began his career by applying scientific management ideas to the running of a government agency, as Director of Public Works in Philadelphia, and to the operation of a professional society, the American Society of Mechanical Engineers. These efforts convinced Cooke of the dishonesty of corporations, and especially electrical and other utility companies. He campaigned against utility influence in the American Society of Mechanical Engineers in the mid-1910s and, in the New Deal, headed the Rural Electrification Administration, one of Roosevelt's efforts to curb the excesses and go beyond the self-imposed limits of electrical utilities.[17]

USBR leaders, in contrast, worked closely with corporations in relevant fields and did not see former corporate employment as a ban to a job in the USBR. Starting in 1925 the USBR organized most of its major construction work by contract and, as a result, worked closely with corporate executives and engineers. For example, between 1934 and 1943 two successive groups of general contractors made Grand Coulee Dam a massive and concrete reality from a set of plans.[18] A consortium of Silas Mason Company of New York; Walsh Construction Company of Davenport, Iowa; and Atkinson-Kier Company of San Francisco won the first contract. Kaiser Construction Company of Seattle, Morrison Knudsen Company of Boise, Utah Construction Company of Ogden, J. F. Shea Company of San Francisco, Pacific Bridge Company of San Francisco, McDonald and Kahn of San Francisco, and General Construction Company of Seattle joined the first group to complete construction. Below I describe how USBR engineers and their contractors interacted during routine construction and how they could collaborate to experiment on, and improve production processes. In terms of careers, many USBR leaders—thirty-two or almost two-thirds—worked for private companies at some point in their careers. A handful worked for the large electrical companies Cooke and other reformers found especially repugnant. For example, Leslie McClellan, the USBR's chief electrical engineer, worked briefly for Southern California Edison. Robert Monroe, another Denver office man, worked for Pacific Gas & Electric before coming to the USBR.[19]

Between 1923 and 1943 a remarkably stable and homogeneous group of men steeped in Progressive Era reform movements provided the leadership for the USBR. Additionally, the ties between these men, the USBR, and engineering cannot be overstated. The domination of the USBR by civil engineers, rather than experts on water resources or irrigated agriculture, was a contingent historical phenomenon.

Other groups with technical expertise critical to the planning, construction, and operation of irrigation projects were available as choices to staff the new USRS. Experts in the U.S. Geological Survey, with stronger ties to geology, hydrography, and geography than to civil engineering, dominated federal debates over irrigation in the nineteenth century. Experts in the U.S. Department of Agriculture worked with Wyoming Senator Francis E. Warren to prepare an alternative to the bill prepared by Senator Newlands and engineer Newell, which created the USRS. Still, engineers, rather than experts in other related areas, led the USBR. The structure of the USBR, the fields of education of USBR leaders, and the professional affiliations of these men show their disciplinary ties to engineering generally, and civil engineering in particular. Further, these leaders had much in common with other engineers in this period: regional affiliation, educational institutions, level of education, and international work.[20]

An organization chart from the 1920s or 1930s immediately reveals the importance of engineering in the USBR. The USBR was a very strict hierarchical organization with engineers in all leadership positions, except for a small legal branch parallel to the main engineering organization. Physically, space separated the USBR engineers. A commissioner and a small staff led the USBR from Washington, D.C. By far, however, most of the employees and leaders worked in the West. The chief engineer's office in Denver served as the technical hub for the USBR. In addition, each irrigation project had a field office.

A commissioner—typically with substantial engineering experience—led the USBR. From Washington, D.C., commissioners and their small staff primarily interacted with others in the capital—members of Congress, Interior Secretaries, and other upper-administration officials. The USBR had three commissioners between 1923 and 1945. David W. Davis broke virtually all USBR patterns. Interior Secretary Hubert Work appointed this banker and former governor of Idaho commissioner in hopes that a businessman could place the USRS on a more sound financial footing. Davis only stayed with the USBR for a few years. Engineering training and long careers in public service made the other two commissioners typical of leaders of the USBR. Elwood Mead took the commissioner's office in 1924. It was his final position in a lengthy career in water resources. After working on a survey team during his teenage years, Mead earned bachelor's and master's degrees at Purdue University and a bachelor's in civil engineering at Iowa State College in the early 1880s. A short tenure as professor of irrigation engineering at Colorado Agricultural College led to the position of State Engineer of Wyoming during the 1890s. In

7.2. Secretary of the Interior Hubert Work and Commissioner Elwood Mead at the site of the Stony Gorge Dam on the Orland Project, California, in 1927.

Wyoming Mead participated in writing water law that made the state the sole owner of all water. This legislation became the basis for revising water rights doctrine in several western states. Subsequently, Mead promoted irrigated agriculture through the following positions: director of irrigation investigations in the U.S. Department of Agriculture; chairman of the State Rivers and Water Supply Commission in Victoria, Australia; and director of the state planned irrigation communities at Durham and Delhi, California. He also worked as a professor at University of California, Berkeley. When Mead died in 1936 Interior Secretary Harold Ickes appointed civil engineer John C. Page acting commissioner and then commissioner. Page was a much less well-known engineer. Other than a year as assistant city engineer of Grand Junction, Colorado, Page spent his entire career in USBR. His training consisted of a bachelor of science from University of Nebraska and a year of graduate study at Cornell University. Page's work in the early 1930s as the second in charge of the field office for Hoover Dam moved him from USBR staff to USBR leadership.[21]

Designation of a chief engineer as the USBR's second-in-command further focused the USBR around engineering. The chief engineer held final authority for all technical matters—construction, design, and research—but focused on overseeing construction. Denver, Colorado, housed the chief engineer and his engineering staff, which grew dramatically between 1923 and 1943. In the early 1920s, a few senior engineers coordinated USBR engineering from Denver. By the 1930s, a leadership staff of nine—an assistant chief engineer, a chief designing engineer, an assistant chief designing engineer, a chief electrical engineer, a designing engineer of dams, a designing engineer of canals, a mechanical engineer, and an engineer on technical studies—oversaw a staff of over 750.[22]

Three men held the job of chief engineer between 1923 and 1943. Like the commissioners, in both education and public service, the chief engineers had strong links to engineering and engineering reform. A civil engineer from the University of Maine (1896), Frank Weymouth served his last of twenty-two years with the USBR in 1924. When Weymouth left, Chicagoan Raymond (Ray) Walter became chief engineer. Walter joined the USRS as a freshly minted civil engineer from Colorado State College in 1903, one year after conservationists and western congressmen created the USRS. He held the position of chief engineer from 1924 until his death in 1940. Walter's long-time assistant chief engineer and another career USBR man, Sinclair Ollason Harper, held the top position in Denver from 1940 to 1944. Harper received his bachelor's in civil engineering from the University of California.

After the chief engineer, the most important man in Denver was John (Jack) Savage, the chief designing engineer. While Chief Engineer Walter focused on construction, Savage oversaw all aspects of design, planning, and research in the USBR. Savage too followed the typical education and career pattern. Except for eight years with a small consulting engineer firm, Savage spent his entire career with the USBR. His formal training consisted of a bachelor of science in civil engineering from the University of Wisconsin. Savage's achievements, however, exceeded most USBR engineers.' He held three honorary doctorates. The National

Academy of Sciences and the American Academy of Arts and Science elected him a member. The four engineering founder societies—the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers—awarded Savage the John Fritz Medal for notable achievement in 1945. In addition, the Concrete Institute awarded him its Turner gold medal for his work on hydraulic structures.

7.3. Raymond F. Walter while he served as Chief Engineer of the Bureau of Reclamation.

Beyond the central staffs in Washington, D.C., and Denver, the USBR detailed engineers to oversee construction and operation of projects. This group—the largest by number—consisted of surveyors, construction inspectors, and "office engineers." These last drafted, made cost estimates, and performed other engineering office tasks. Frank Banks, described by Chief Engineer Walter as "our best construction engineer,"[23] followed the education and career path of other USBR leaders. Banks studied for his degree in civil engineering at the University of Maine. He joined the USRS immediately upon graduation in 1906 and retired in 1957, after 51 years of service. He supervised the construction of several USBR major dams including Owyhee Dam in Oregon in the 1920s and Grand Coulee Dam in Washington State in the 1930s.[24]

Finally, the USBR hired consulting engineers to monitor major construction endeavors like Hoover and Grand Coulee dams. These men met as a board a couple of times a year to review designs and specifications, to inspect the quality of the work and procedures, and to provide opinions on issues raised by the USBR regular staff. For example, the USBR's consulting board for Grand Coulee Dam consisted of Columbia University Professor of Geology Charles Berkey; retired Stanford Professor of Mechanical Engineering and Fluid Mechanics William Durand; Seattle consulting engineer and former USBR employee Joseph Jacobs; and Dayton, Ohio, consulting engineer Charles Paul, also a former USBR engineer.[25]

The education and professional affiliations of USBR leaders cemented the connection between the engineering organization and the broader profession of civil engineering. USBR men primarily chose civil engineering as their field of education—twenty-two men or 42 percent. Another thirteen men selected other engineering fields. Electrical and mining at four each were the best represented. The single man with topographical engineering as a major suggests the weakness of remaining ties to the disciplines of the U.S. Geological Survey. Unfortunately, biographical sources did not reveal the field of study for more than 20 percent of the USBR leaders.

7.4. June 23, 1929, the Board of Engineers for Hoover Dam posed on a viewpoint above the Black Canyon Damsite. Probably left to right: A. J. Wiley and Louis C. Hill, consulting engineers; Chief Designing Engineer J. L. Savage, Bureau of Reclamation; Chief Electrical Engineer L. H. McClellan, Bureau of Reclamation; Designing Engineer B. W. Steele, Bureau of Reclamation; and Project Construction Engineer Walker R. Young, Bureau of Reclamation.

Participation in professional societies maintained the connection to engineering, and especially civil engineering. USBR leaders belonged to honor societies, professional organizations, and social clubs for engineers. Tau Beta Pi (an engineering honor society), Chi Epsilon (the civil engineering honor society), and Sigma Xi (a science and engineering research honor society) elected thirteen USBR leaders as members. Thirty-seven men (70 percent) belonged to at least one professional organization. By far, the American Society of Civil Engineers claimed the most USBR men—thirty-three. Societies representing other areas of engineering, such as the American Institute of Electrical Engineers (5) and the American Concrete Institute (5), only claimed a handful of men. Roughly one-quarter of the men also belonged to regional organizations for engineers and scientists. Among these were the Colorado Society of Engineers (7), the Commonwealth Engineers Club in San Francisco (3), and the Cosmos Club in Washington D.C. (3). Membership in professional organizations associated with geology and agriculture again show only very weak ties between USBR leaders and these closely related areas of expertise. Two of the leaders belonged to American Geophysical Union, and one of these men also belonged to American Meteorological Society. One additional man belonged to the semi-popular National Geographic

Society. In terms of agriculture, only three men belonged to the American Society of Agricultural Engineers (ASAE).

The similarities between USBR leaders and other groups of engineers further show how engineering dominated the USBR. The best quantitative information on another group of American engineers in the 1920s and 1930s comes from Deborah Fitzgerald's *Every Farm a Factory*. Fitzgerald describes agricultural engineers and these men shared many, but not all, characteristics with USBR leaders. Fitzgerald reports on a group of founders, officers, or council members of the ASAE between 1907 and 1930. The founders were men of the same generation as the USBR leaders. They were born in the 1880s and attended college in the first decade of the twentieth century. They also took degrees in engineering fields and, far from rejecting business ties, moved easily in and out of commercial employment. Further, both groups overwhelmingly attended the same kinds of institutions of higher education, finished their education at the same level, and worked internationally for part of their careers.[26]

The tie between USBR leaders, engineers more generally, and engineering reform was to a type of education institution and the profession generally, rather than one specific university. USBR leaders attended state schools—thirty-seven or 70 percent. They chose universities all across the West and Midwest. ASAE founders likewise chose land-grant schools, although all midwestern. Neither group came out of a unique strong department at a single university. Two groupings, however, did exist among USBR leaders. Six men came from the University of Maine. Frank Weymouth—later chief engineer and clearly more of an institution builder than many in the USRS—returned to his alma mater, Maine, to speak about his work with the USRS in 1904. His visit recruited Francis Crowe to work for the USRS that summer (and Crowe would return after graduation). The following school year Crowe spoke about the West and reclamation with enthusiasm. The tales of Weymouth and Crowe led several other young men from Maine to join the USRS.[27] Less surprising, given the location of the chief engineer's office, a group of men also came to the USBR from the universities in or near Denver. Three took undergraduate degrees at Colorado State College, two at the Colorado School of Mines, and one at the University of Colorado.

In level of education, USBR leaders followed general patterns for engineering. For many of the men, 72 percent, the bachelor's degree completed their formal education. Likewise, Fitzgerald found that a substantial portion of ASAF founders and leaders had college degrees. USBR men in the commissioner's office, as a group, did have more education than their USBR peers or ASAE leaders. Two held a second bachelor's degree and three held master's or professional degrees. One additional man had done one year of graduate work. These men were six of the eleven total who had undertaken schooling beyond the bachelor's and 46 percent of the thirteen individuals from the Washington Office.

Many American technical professionals of the early decades of the twentieth century consulted or worked internationally. Fitzgerald examines the experience of agricultural experts in the Soviet Union. Twenty USBR leaders—five from the Washington office, nine Denver office men, and six of the men from field offices—worked internationally too. They worked on a range of international projects. These included planning irrigation communities in Australia, building waterworks in Mexico, and working on the Panama Canal. The Near East, Far East, British Empire, and Central and South America all provided opportunities for USBR men.[28]

In all, a special group of men led the USBR during the 1920s and 1930s. All of the USBR's main hierarchy—commissioners, chief engineers, Denver office department heads, and the top staff of large projects—was a stable and uniform group of men affiliated with engineering and, more particularly, Progressive engineering reform. Long tenure of USBR leaders created stability and few departures in the late 1920s and 1930s, in particular, reinforced this trend. The USBR uniformly hired western or midwestern family men for its leaders. Strong patterns in education and career paths further demonstrated the uniformity of the group and linked them to engineering and, especially, Progressive engineering reform. Virtually all of these men finished their formal education with undergraduate degrees in engineering from land-grant universities during the Progressive Era. They maintained ties to engineering through professional societies, most commonly the American Society of Civil Engineers. Long careers in public service further suggest they adopted values of their engineering reform mentors. USBR leaders did not, however, belong to the anti-corporate wing of Progressive reform engineering. The USBR worked closely with corporate contractors, and many USBR leaders worked for private companies at some point in their career.

Engineering Rivers

This group of stable and uniform Progressive engineers drew on the important experiences of their disciplines as they remade the USBR in the 1920s and 1930s. The sibling Progressive reform movements of conservation and scientific management, as well as industrialization more generally, were the most important of these experiences. USBR men used scientific management, and some of the more general principles of industrialization, to refine conservation and create both industrialized dam construction and industrialized rivers.

Over the nineteenth century, industrialization fundamentally changed the production of goods and ways of life in the United States. Items made by artisans, such as guns and shoes, or in homes, such as cloth or butter, became goods produced in factories. For example, skilled armorers making complete guns gave way to armories. In the latter, semi-skilled men or boys used special purpose machine tools to produce standardized parts to assemble into guns. Compared to earlier ways of making things, factories were specialized, mechanized, capital-intensive, market-oriented, and big.[29]

At the turn of the century, engineers formulated rational management systems, as the finishing touch to this transformation. Many engineers worked on such systems but "scientific management," as propounded by Frederick W. Taylor, was the best known and, in many ways, epitomized this movement. A son of a Philadelphia aristocrat, Taylor became a mechanical engineer by apprenticing to the eminent businessman-engineer William Sellers and completing a correspondence course at the Steven's Institute of Technology. A zealot for "efficiency," Taylor sought to standardize and routinize everything in a factory—machines, production processes, and, especially, workers.[30]

Taylor's general approach included tuning-up all the work processes and machinery in a factory and implementing an exceedingly detailed management regimen. To refine work processes, experts would observe and time the motions of workers. The experts then broke down complex processes, refined movements, assigned optimal times, and provided workers with explicit instructions on how to perform tasks. Taylor tried to sweeten these changes for workers by tying the reformulated work to incentive pay scales. Refining machinery entailed replacing belting to make it uniform, installing high-speed tool steel, and arranging machinery on a factory floor so that work could flow from one to the next and so on through the factory. The most visible parts of Taylor's management reforms were planning offices. In these spaces, engineers oversaw the operations of a factory and coordinated sets of cards, which tracked items around the shop floor. Finally, Taylor called his system scientific because he believed that analysis would provide a unique "one-best-way" to reorganize a workplace and the process occurring within it.

Drawing on experiences from industrialization and Taylorism, the USBR and its contractors built dams in a fully industrialized and Taylorized fashion by the 1930s. The USBR and its contractors split the tasks of building large dams. The USBR managed and refined work processes, such as pouring concrete. The contracting corporations handled the construction plant and workers.

Dam sites lacked a space labeled a planning office, but, during the construction of a dam, USBR employees primarily provided the management oversight, which Taylor placed in planning offices. The USBR used drawings and inspectors to manage construction of dams in the 1930s. For example, in building Grand Coulee Dam, the USBR created at least three distinct sets of drawings to guide the process. First, preliminary studies, such as the one conducted by Major John Butler of the Army Corps of Engineers between June 1928 and July 1931, contained a handful of general drawings to convey the concept behind a proposal.[31] For the Grand Coulee site, the printed version of Butler's report contained an eleven-page description of a high dam and hydroelectric power plant and two drawings: one plate with a plan and an elevation for a dam cresting at elevation 1266.6 feet and one plate with sections of the same structure.[32] Second, junior engineers in the USBR' s Denver office prepared a more detailed set of drawings and specifications for contractors to use in preparing bids. There were two separate major contracts for Grand Coulee Dam and two sets of specifications. The second document, from 1937, covered the completion of the dam from roughly low water level to its full height, the base of a facility to pump irrigation water, and one power plant to generate hydroelectricity. This document used 161 pages and 122 drawings to describe the undertaking in much greater detail than Butler.[33] Third, during the process of construction, USBR engineers in Denver made numerous detail drawings that superseded those in the specifications. Every particular of the dam would be laid out in a series of drawings. For Grand Coulee Dam, the Denver Office sent these drawings to USBR Construction Engineer Frank Banks at the site office. He, in turn, gave the drawings to the contractors. Nothing happened on the dam without authorization from Denver. For example, in January 1936 the contractors and Banks negotiated with the Denver Office over the pouring schedule for a section of the downstream edge of the dam but could not go ahead without drawings from Denver. H. Leslie Myer, the contractors' general manager, worried that any delay in pouring this section would delay the entire dam. Correspondence only gradually brought agreement on a modified plan. Banks wrote several times requesting drawings to prevent delay before the Denver engineers approved a plan and sent the illustrated guidelines.[34]

Inspectors provided the second key mechanism of engineering oversight in the Taylorist fashion by guaranteeing that contractors followed directions communicated through drawings. A USBR project office employed many inspectors who worked shifts alongside construction men. Inspectors primarily oversaw the pouring of concrete for the dam and the grouting of its foundation. (Foundation grouting was a procedure in which technicians pumped very thin cement into deep holes drilled into the bedrock under a dam to seal any cracks in the rock.) Inspectors verified the quality of these operations. For example, contractors poured Grand Coulee Dam in blocks and engineers reviewed the setup for each before pouring. First, men placed wood and metal forms capable of holding 265 cubic yards to 463 cubic yards of concrete. The largest forms measured 50 feet by 50 feet by 5 feet. Second, workers installed hardware for the block, including pipes for grout, metal sheets to manage the flow of grout in the structure, pipes to carry water to cool the concrete as it set, and pipes for drainage. Third, they cleaned the concrete and metal surfaces. This step insured that the new block bonded to those surrounding it. USBR inspectors checked the performance of all these tasks and issued an OK valid for three hours. If the contractor did not place the concrete in that time, USBR men had to reinspect.[35]

The Taylorist style of management conducted by the USBR matched the extensively mechanized, flow-oriented, and capital intensive construction plant erected by the contractors. The contractors employed partially or completely mechanized systems to remove the dirt, rock, and debris down to bedrock at the dam site; to prepare materials for and mix concrete; and to convey concrete to the dam. Unwanted materials flowed out of the site and needed ones flowed into it. To clear the dam site, contractors brought in a fleet of shovels, bulldozers, and dump trucks. The trucks moved debris to a conveyor system with four 60-foot feeder belts serving a mile long main belt, which transported materials to Rattlesnake

Canyon. After clearing the dam site, producing and placing concrete dominated construction. The basic components of concrete are gravel, sand, cement, and water. Contractors mined gravel and sand at a location 1.5 miles from the dam site. From pits, a mechanized system washed, screened, and separated the raw materials into three grades of sand, four grades of gravel, and waste. Two automated concrete mixing plants—one on each side of the river—combined sand, gravel, cement that had arrived by rail, and water in set ratios to make concrete. Locomotives hauled buckets of concrete from the mixing plants onto a trestle over the dam. Crane operators, high above the dam, picked up the buckets and swung them down to the next block to be filled. At the block, men dumped the buckets and urged the concrete into place with electrical vibrators.[36]

In addition to Taylorist oversight of production and a Taylorist mechanized, flow-oriented, capital-intensive workplace, the USBR employed experts to study and refine work processes, much as Taylor and his colleagues used time and motion studies to modify workers' performance. USBR men, however, could not analyze workers. In 1911 molders struck the Watertown Arsenal when Carl Barth, one of F. W. Taylor's inner circle, attempted to reorganize the foundry. Ultimately, Congress banned the use of stopwatches to analyze workers and incentive pay systems in federal workplaces. Instead of workers, USBR men took on machinery. Work with cement mixers exemplified this impulse to refine. The two plants for making concrete—Westmix and Eastmix—each had four mixers that could each hold four cubic yards (a total of thirty-two cubic yards). During the winter of 1936-1937, USBR engineers and the contractors' men collaborated on redesigning these mixers to increase mixing speed. They built model mixers of one-thirteenth capacity and tested them at a laboratory at the Grand Coulee Dam site. The USBR engineers tested between fifty and sixty different arrangements of mixer blades seeking the shortest time to produce a uniform product. The best design reduced nine blades to three and reoriented them. These new arrangements shortened mix and discharge time by 16 percent. Since the second contract alone required mixing 5,800,000 cubic yards of concrete thirty-two cubic yards at a time, this timesaving was substantial.[37]

While the comparison of a factory floor and a construction site is fairly direct, an analogy between a factory floor and a river is necessarily much more abstract. At the damsite, USBR engineers provided expert oversight, the contractors built a mechanized and rationalized construction plant, and the two groups worked together to investigate ways to refine the equipment. Similarly, Taylorism experts implemented planning offices, organized shop floors, and tuned up processes, machinery, and workers. With multiple purpose dam building, federal engineers combined ideas about river development advocated by Progressive Era conservationists with analysis and management techniques similar to Taylorism.

While engineers formulated around scientific management, a broader group of scientists, engineers, and politicians brought conservation to the fore as a set of "scientific" ideas to govern the management of natural resources during the Progressive Era. Championed by forester and politician Gifford Pinchot, conservation called for the maximum sustained use of natural resources, such as forests, grazing lands, rivers, and oil and mineral deposits. As with scientific management, technical experts—engineers, foresters, geologists, etc.—implemented the programs to achieve the goals of conservation. Conservationists called for two major changes in river development. Comprehensive planning provided schemes that combined navigation, flood control, irrigation, hydroelectricity, and other improvements. Construction of reservoirs captured seasonal floods and made "wastewater" into a critical supplement to water supply in arid regions.[38]

In order to implement conservation ideas about river development, in a Taylorist style, federal engineers began by measuring rivers. Rather than stopwatches, engineers, like John Butler, used gaging stations, topographical maps, and geological assessments of potential dam sites to assess the river's current practice and as a basis for constructing a new "rational" river. Butler invested over half of his funds for studying the upper Columbia River (the river above its confluence with the Snake River) in collection of data and preliminary analysis of water supply, topography, geology, and land classification. Gaging produced quantitative data on the monthly discharge at 21 locations and on the stages of five lakes. Topography provided an overall profile of the river. Finer topography and core drilling (removing columns of rock to assess the structures) provided more specific data on 12 potential dam sites. Land classification ranked land near the river by its quality for irrigation farming.[39]

To redesign the river, as Taylor redesigned workers' movements and machinery, Butler combined this information with broad conservationist goals. Butler began with the canonical conservation goal for river development: the intention to consider all of the possible uses of water and their interactions. Butler stated:

> The purpose of this report is to formulate plans for the most effective improvement of Columbia River for the purposes of navigation, and for combining such improvement with the most efficient development of the potential water electricity, the control of floods, and the needs of irrigation.[40]

Adapting this general mandate to the Columbia River, Butler quickly concluded that production of hydroelectricity and irrigation of the Columbia Basin, a large arid area southwest of Spokane, Washington, would be the most valuable uses of the upper Columbia River. Navigation was unlikely to be cost effective, and the upper river had few flooding problems. With knowledge of the water supply and an assessment of water needs, Butler set aside water for the irrigation of the Columbia Basin. He then used knowledge of topography and geology to identify a set of dams that would allow full use of the remaining water for producing hydroelectricity. Butler sketched a plan in which each dam backed water to the foot of the next, so that all the potential energy created by change in elevation could be converted into hydroelectricity. This approach gave rivers planned in the early twentieth century a characteristic stair-step, or chain-of-lakes, profile—the conservationists' "one-best-way" to develop a river. Geology narrowed the possible dam sites to those suited to hold large structures. Ultimately, Butler proposed five hydroelectric dams; an electricity and irrigation project at the head of the Grand Coulee; three storage reservoirs in the headwaters of tributaries to the Columbia River; and two sets of locks and lateral dams to improve navigation, if increased river use justified these last structures at some point.[41]

Butler, his staff, and his counterparts in the USBR provided the expertise, called for by both Taylor and conservationists. Butler headed eighteen men from five fields who conducted the upper Columbia River study. Butler's acknowledgements indicated a permanent staff of eight men: five members of the American Society of Civil Engineers, two members of the American Institute of Electrical Engineers, and one man identified simply as an irrigation engineer. Butler also drew on the advice of ten consultants: four civil engineers, two electrical engineers, three geologists, and one economist. Similarly, the USBR placed studies of potential new irrigation projects in the hands of a senior field engineer and a small staff. Men from the Denver office often provided consulting services on dam design and in other areas.[42]

While field staff analyzed and refined the river, the Denver office specialized in analyzing and refining the main technology of multiple purpose river development—dams. During the 1920s and 1930s as the Denver office grew, it substantially expanded investigation and analysis. First, the USBR developed two methods for analyzing stresses and strains in dams. Using mathematics, USBR engineers developed the trial-load method of analyzing arch dams as part of designing Hoover Dam. When a dam curves from side to side, as Hoover Dam does, some or all of the weight of the water behind the dam is transmitted to the abutments (canyon sides) through arch action, rather than to the foundation under the dam by gravity effects. Trial-load analysis provided a more accurate approach to calculating the extremely complicated stresses and strains in a potential structure due to this dual distribution of forces. In parallel with trial-load analysis, USBR engineers developed a program of photoelastic analysis using models to determine stresses and strains on potential structures. Beginning in 1927 the USBR built models of dams at a facility at the University of Colorado in Boulder. The engineers constructed the earliest models—those of Stevenson Creek Test Dam and Gibson Dam—out of concrete and used a rubber pouch filled with mercury to simulate the weight of a reservoir. They used optical instruments and a system of gages to measure stress and strain in the models. For Grand Coulee Dam, the combination of mathematical and photoelectric analyses led USBR men to add twist adjustment slots near each abutment to reduce twist forces in the structure.[43]

The second major experimental program for refining dam technology developed in this period used hydraulic models. Building on a European tradition, USBR men began making models of dams in metal and wooden beds and running water over them to observe the qualitative effects of elements of the structure on water flow. The USBR men located their first laboratories at Colorado State College (now University) in Fort Collins and in Montrose, Colorado. For Grand Coulee Dam, the USBR men used hydraulic experiments to refine the "toe" of the dam. At the downstream edge of Grand Coulee Dam, the structure must dissipate the substantial energy of a large river pouring off a 430 ft prism of concrete. The shape of the toe determines whether the water digs a hole under the dam, digs at the dam's edge, geysers up in the air, boils and then joins the flow at the base of the dam, or any number of better and worse possibilities. After observing models of several different options, engineers chose a curved toe with a 50-foot diameter bucket for the base of Grand Coulee Dam. USBR men also used a hydraulic model to plan the order of pouring Grand Coulee Dam. This work reduced the damage to the riverbanks above and below the dam site caused by the hydraulic characteristics of the partly complete structure.[44]

Finally, the USBR used a materials laboratory to tune up dams. The primary work of this facility was concrete analysis. Originally located at the University of California, USBR men and their academic collaborators studied cement and concrete to reduce shrinkage during drying, which could cause uneven distribution of forces and cracks in a structure. Out of such work, USBR men developed a system of embedding thin water pipes throughout very large structures to speed concrete cooling. They also wrote new specifications for cement.[45]

Gazing at the world with vision sharpened by engineering training, USBR leaders saw disorderly construction sites and disorderly rivers. They drew on the experiences and enthusiasms of their profession—industrialism, Taylorism, and conservation—to fix the problems they saw. Construction sites looked a lot like a factory floor where engineers could be put in charge, work could be mechanized and made to flow, and components could be analyzed and tuned for speed. USBR engineers placed themselves at the metaphorical center managing construction with drawings and inspections. From removing dirt to delivering concrete, contractors, such as Morrison-Knudsen and H. J. Kaiser, used trucks, conveyor belts, and cranes to make materials flow out of and into dam sites. USBR engineers and contractors collaborated to analyze not workers but machines, such as concrete mixers, to tune-up and speed work.

Rivers looked less like factories. Still, USBR leaders fused ideas from conservation and Taylorism in the planning and building of the first generation of multiple purpose dams. As with Taylor and his program, USBR engineers placed experts in control, analyzed and rationalized both processes and components, and believed single "best" solutions existed for the problems they tackled. They used the conservation concepts of comprehensive planning and increasing water supplies through storage as the framework in which to seek Taylorist solutions. First, groups of engineers gaged water supply, mapped terrain, examined beds of rivers, and classified lands. They used this analytic deconstruction and the concept of comprehensive planning to create a new water system tuned to supply the water resources in a single best way. For example, the whole Columbia River, reconceptualized as a signature chain-of-lakes, would use 92 percent of possible head for an installed capacity to produce 8.5 million kilowatts of electricity while providing water to irrigate 1.6 million acres and providing a 9-foot navigation channel 200 miles inland along the Washington-Oregon border.[46] Second, engineers turned their rationalizing attention to dams, the technological backbone of new rivers. For dam building, they conducted mathematical and experimental analyses to maximize desired performance—a safe structure with good hydrodynamics—while minimizing cost.

Conclusions

In this paper, I have demonstrated that between 1923 and 1943 a very stable and uniform group of engineers with a Progressive pedigree led the USBR. I have also suggested that the significance of this finding lies in the ways that these men drew on the experiences and enthusiasms of engineering, especially industrialization, Taylorism, and conservation, as the USBR grew and instituted multiple purpose dam building. In the Taylorist fashion, USBR men created central managerial spaces for themselves, analyzed and rationalized large processes and their components, and undertook this work with a faith that it would produce unique optimal solutions. They did this to both dam construction sites and to the planning of water resources. In the latter, USBR leaders fused Taylorism and conservation to take multiple purpose dam building from an idea to a reality.

Philosophers of science traditionally end papers with a promissory note that acknowledges important areas for future research. While I am no philosopher, I would like to note that the second part of this paper suggests an important area for additional research. The USBR was certainly not the only dam builder in this period nor the only one to employ industrialized and Taylorized construction plants. A broader consideration of the technologies and industrialization of dam construction would trace the shift from brick or stone and mortar dams built primarily using animal and human power to concrete dams whose construction relied on internal combustion engines and electricity.

Table 7.1: Sources on engineers

Name	Office	Source
Banks, Frank Arthur	Field	"Banks, Frank Arthur." In *Who Was Who in America, Vol. 3,* 47. Chicago: Marquis Who's Who, 1960.
Bashore, Harry	WDC	"Bashore, Harry William." In *Who Was Who in America with World Notables, Vol. 5, 42.* Chicago: Marquis Who's Who, 1973.
Bien, Morris	WDC	"Morris Bien." *Reclamation Record* 6 (March 1915): 121 and "Morris Bien 1859-1932." *Reclamation Era* 23 (August 1932): 147.
Bissell, Charles A.	WDC	"Charles A. Bissell Retires with Honors." *Reclamation Era* 42 (February 1952): 45.

Boden, Oscar G.	Field	Goodman, D. L. "Oscar G. Boden--Builder of Life-lines: Reclamation's Hall of Fame Nomination No. 12." *Reclamation Era* 42 (February 1952): 30-3 1, 38.
Brown, Hugh A.	WDC	Davis, A. P. "The Editor of the Reclamation Record." *Reclamation Record* 7 (October 1916): 469-70 and "Hugh Arbuthnot Brown, 1877-1932." *Reclamation Era* 23 (September 1932): 157.
Bunger, Mills Emerson	Field	"Bunger, Mills Emerson." In *Who's Who in the West,* 98. Wilmette, Illinois: Marquis Who's Who, 1980.
Burch, Albert Nelson	Field	Perkins, W. A. "Albert Nelson Burch, M. ASCE." *ASCE Transactions* 101 (1936): 1532- 1533.
Calland, Robert S.	Field	"Appointments and Retirements." *Reclamation Era* 47 (February 1957): 19.
Cole, C. M.	Field	"C. M. Cole." *MWAK Columbian* (24 July 1936): 3.
Crowe, Francis Trenholm	Denver	Harper, S. 0., Walker R. Young, and W. V. Greeley. "Francis Trenholm Crowe, Hon. M. ASCE." *ASCE Transactions* 113 (1948): 1397-1403.
Darland, Alvin F.	Field	Alvin F. Darland to James O'Sullivan, 20 September 1933, 29:Personnel 1933, Columbia Basin Commission Papers, Washington State Archives, Olympia, Washington.
Davis, David W.	WDC	"Davis, David William." In *The National Cyclopaedia of American Biography, Vol. 46,* 435- 436. New York: James T. White and Company, 1963.
Day, C. M.	Denver	"C. M. Day, Chief Mechanical Engineer, Denver, Dies." *Reclamation Era* 27 (March 1937): 68.
Debler, Erdman B.	Denver	"Debler, Erdman B." In *Who Was Who in America, Vol.* 7, 147. Chicago: Marquis Who's Who, 1981.
Dibble, Barry	Denver	"Dibble, Barry." In *Who Was Who in America, Vol.* 4, 248. Chicago: Marquis Who's Who.
Golzé, Alfred Rudolf	WDC	"Golzé, Alfred Rudolf." In *Who's Who in America,* 1236. Wilmette, Illinois: Marquis Who's Who, 1978.
Harper, Sinclair Ollason	Denver	"Harper, Sinclair Ollason." In *Who Was Who in America, Vol.* 7, 255. Chicago: Marquis Who's Who, 1981.
Hinds, Julian	Denver	"Hinds, Julian." In *Who Was Who in America, Vol. 6,* 194. Chicago: Marquis Who's Who, 1976.
Houk, Ivan	Denver	McWhinnie, Robert C. "Ivan Edgar Houk, F. ASCE." *Transactions of the ASCE* 138 (1973): 628-629.
Keener, Kenneth Bixby	Denver	"Honorary Degrees Conferred on Reclamation Officials." *Reclamation Era* 30 (September 1940): 262-263.
Koppen, Charles Edward	Field	"Edward Charles Koppen 1879-1940." *Reclamation Era* 31 (January 1941): 13.
Kreutzer, George Charles	WDC	Mead, Elwood, and R. F. Walter. "George Charles Kreutzer, M. ASCE." *ASCE Transactions* 95 (1931): 1526-1528.

Lowry, Ralph	Field	"Lowry, Ralph." In *Who Was Who in America with World Notables, Vol. 8,* 253. Chicago: Marquis Who's Who, 1985.
McCasland, Stanford Paul	Field	"McCasland, Stanford Paul." In *Who's Who in the West,* 478. Wilmette, IL: Marquis Who's Who, 1980.
McClellan, Leslie Newman	Denver	"McClellan, Leslie Newman." In *Who Was Who in America with World Notables, Vol. 8,* 268. Chicago: Marquis Who's Who, 1985.
McPhail, Harvey Franklin	Denver	"McPhail, Harvey Franklin." In *Who Was Who in America, Vol. 9,* 244. Chicago: Marquis Who's Who, 1989.
Mead, Elwood	WDC	"Mead, Elwood." In *The National Cyclopaedia of American Biography, Vol. 26,* 44-45. New York: James T. White and Company, 1937; Conkin, Paul K. "The Vision Of Elwood Mead." *Agricultural History* 34 (April 1960): 88-97; and Kluger, James R. *Turning on Water with a Shovel: The Career of Elwood Mead.* Albuquerque: University of New Mexico Press, 1992.
Miner, James Henry	Field	Sharkey, Fred J. "James Henry Miner, Assoc. M. ASCE." *ASCE Transactions* 109 (1944): 1576-1577.
Mitchell, L. H.	WDC	"L. H. Mitchell Dies." *Reclamation Era* 46 (May 1956): 50.
Monroe, Robert Ansley	Denver	"Monroe, Robert Ansley." In *Who Was Who in America, Vol. 8,* 286. Chicago: Marquis Who's Who, 1985.
Moore, John S.	Denver	"John S. Moore Promoted." *Reclamation Era* 31 (February 1941): 50.
Moritz, Ernest A.	Field	"Moritz, Ernest A." In *Who Was Who in America, Vol.* 7, 414. Chicago: Marquis Who's Who, 1981.
Munn, James	Denver	"James Munn, 1865-1939." *Reclamation Era* 29 (June 1939): 155.
Nalder, William H.	Denver	"Bureau Design Engineer Ends 43 Years Service." *Engineering News-Record* 149 (30 October 1952): 52.
Neeley, Parley R	Field	"Neeley, Parley R." In *Who's Who in Engineering,* edited by Gordon Davis, 577. Washington, D.C.: American Association of Engineering Societies, 1988.
Nelson, Wesley P.	WDC	"New Appointments in the Bureau of Reclamation: Roy B. Williams, J. Kennard Cheadle, and Wesley P. Nelson." *Reclamation Era* 27 (September 1937): 200-201.
Nielsen, Edwin George	Field	"Nielsen, Edwin George." In *Who's Who in America,* 2402. Wilmette, Illinois: Marquis Who's Who, 1978.
Page, John Chatfield	WDC	"Page, John Chatfield." In *Who Was Who in America, Vol. 3,* 660. Chicago: Marquis Who's Who, 1960.

Parker, Horace A.	Field	"H. A. Parker Now Irrigation Engineer, Columbia Basin Project." *Reclamation Era* 29 (January 1939): 20.
Preston, Porter Johnstone	Field	"Porter J. Preston Retires." *Reclamation Era* 31(1941): 51 and "Preston, Porter Johnstone." In *The National Cyclopaedia of American Biography, Vol. 39,* 356. New York: James T. White and Company, 1954.
Rawn, A. M.	Field	'Rawn, A. M." In *The National Cyclopaedia of American Biography, Vol. 55,* 194-195. New York: James T. White and Company, 1974 and "Rawn, A. M." In *Who Was Who in America with World Notables, Vol. 8,* 332. Chicago: Marquis Who's Who, 1985.
Savage, John Lucian	Denver	McMechen, Edgar C. "The Billion Dollar Engineer." *Reclamation Era* 27 (April 1937): 82- 84; *John Fritz Medal: Biography of John Lucien Savage, Medallist for 1945.* New York: John Fritz Medal Board, 1945; "Savage, Dr. John Lucian." In *American Men of Science, 11th edit.,* 4669. New Providence, New Jersey: R. R. Bowker, 1968; Wolman, Abel and W. H. Lyles. "John Lucian Savage." In *Biographical Memoirs: National Academy of Sciences, Vol. 49,* 225-239. Washington, D. C.: National Academy of Sciences, 1978; and Rhodes, Benjamin D. "From Cooksville to Chungking: The Dam-Designing Career of John L. Savage." *Wisconsin Magazine of History* 72 (1989): 243-272.
Schnurr, Mae A.	WDC	Pfaff, Christine. "Mae Schnurr: A Woman's Rise to Prominence." *Prologue* 29 (Fall 1997): 232-242.
Sharkey, F. J.	Field	"F. J. Sharkey." *MWAK Columbian* (31 July 1936): 3.
Snell, Roy Martin	Field	Given, J. A. "Roy Martin Snell, M. ASCE." *ASCE Transactions* 106 (1941): 1679-1680.
Walker, Albert Willard	Field	Hosig, Irwin B. and H. P. Wangen. "Albert Willard Walker, Assoc. M. ASCE." *ASCE Transactions* 109 (1944): 1580-1582.
Walter, Raymond Fowle	Denver	"Walter, Raymond Fowler." In *Who Was Who in America, Vol. 1,* 1295. Chicago: The A. N. Marquis Company, 1942.
Weiss, Andrew	Denver	"Andrew Weiss." *Civil Engineering* 43 (January 1949): 55-6.
Weymouth, Frank Elwin	Denver	"Weymouth, Frank Elwin." In *Who Was Who in America, Vol. 1,* 1326. Chicago: The A. N. Marquis Company, 1942.
Williams, Charles Page	Denver	"Williams, Charles Page." In *Who Was Who in America, Vol. 3,* 920. Chicago: Marquis Who's Who, 1950.

Williams, Roy B.	WDC	"New Appointments in the Bureau of Reclamation: Roy B. Williams, Kennard Cheadle, and Wesley P. Nelson." *Reclamation Era* 27 (September 1937): 200-201 and "Gold Medals for Enginers [sic] Williams and Patch." *Reclamation Era* 39 (December 1949): 233.
Young, Walker Rollo	Denver	"Young, Walker Rollo." In *Who Was Who in America with World Notables, Vol. 7,* 633-634. Chicago: Marquis Who's Who, 1981.

Table 7.2: Abbreviations used in footnotes	
CE	Office of the Chief Engineer, Denver, Colorado, RG 115
EC-CB	General Correspondence Files 1902-42 (Engineering), Columbia Basin, CE, RG 115
Entry 10	Entry 10 Project Histories, Feature Histories, and Reports 1902-1932, WDC, RG 115
Entry 7/30-45-CBP	Project Correspondence File 1930-1945, Entry 7 General Administrative and Project Records 1919-1945, WDC,RG 115
RG 115	Records of the Bureau of Reclamation, Record Group 115, National Archives-Rocky Mountain Region, Denver, Colorado
WDC	Office of the Commissioner, Washington, D.C., RG 115
Citations to collections may include box number, box and folder numbers, or box number and file name. This information will come after the document information and prior to the collection information. It will be abbreviated box number:file designation (e.g., 3 or 3:21 or 3:Monthly Reports).	

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Endnotes

1. As part of the reorganization, the USRS's name was changed to the U.S. Bureau of Reclamation (USBR). Throughout this paper, I will use USRS to refer to events and periods before 1923 and USBR to refer to events and periods in 1923 or later and to refer to things which fall into both periods.
2. Called Boulder by USBR engineers from 1918, the Interior Secretary named this dam Hoover when he announced its construction in 1930. The next Interior Secretary, Harold Ickes, changed the name back to Boulder Dam in 1933. Congress restored the name Hoover Dam in 1947. William E. Warne, *The Bureau of Reclamation,* Praeger Library of U.S. Government Departments and Agencies, no. 34 *(New* York: Praeger Publishers, 1973), 36. For simplicity, I will refer to it as Hoover Dam throughout.
3. Figures come from *Twenty-First Annual Report of the U.S. Reclamation Service, 1921-22* (Washington, D.C.: Government Printing Office, 1922); "Annual Report of the Bureau of Reclamation," in *Annual Report of the Secretary of the Interior for the fiscal year ended June 30, 1943*. (Washington, D.C.: Government Printing Office, 1943); and Karin Ellison, "The Making of a Multiple Purpose Dam: Engineering Culture, the U.S. Bureau of Reclamation, and Grand Coulee Dam,

1917-1942" (Ph.D. dissertation, Massachusetts Institute of Technology, 2000), 265-6. I use 1922 because the USBR did not report personnel statistics in its annual report between 1923 and 1936. For a discussion of the 1923 investigation and the status of projects at that time see: Brain Q. Cannon, "'We Are Now Entering a New Era': Federal Reclamation and the Fact Finding Commission of 1923-1924," *Pacific Historical Review* 66 (May 1997): 185-211.

4. On the place of dam building in New Deal policy see: Ellison, "Making of a Multiple Purpose Dam," 193-226.

5. On Hoover Dam see: Norris Hundley, Jr., "The Politics of Reclamation: California, the Federal Government, and the Origins of the Boulder Canyon Act-a Second Look," *California Historical Quarterly* 52 (1973): 292-325, and Joseph E. Stevens, *Hoover Dam: An American Adventure* (Norman: University of Oklahoma Press, 1988). On the origins of the TVA see: Paul K. Conkin, "Intellectual and Political Roots," in *TVA: Fifty Years of Grass-Roots Bureaucracy,* ed. Erwin C. Hargrove and Paul K. Conkin (Urbana: University of Illinois Press, 1983), 3-34, and Preston J. Hubbard, *Origins of the TVA: The Muscle Shoals Controversy, 1920-1932* (Nashville: Vanderbilt University Press, 1961).

6. The USBR leaders were virtually all male- 166 of 167. Given their overwhelming maleness, I will refer to the USBR leaders as men.

7. In the original paper the author thanked "Deborah Fitzgerald for sharing a copy of her forthcoming book: Deborah Fitzgerald, *Yeoman No More: The Industrialization of Agriculture in America* (New Haven: Yale University Press, forthcoming). She argues that one factor in the industrialization of American agriculture was the work of agricultural engineers. These engineers took the farm as the focus of their profession and encouraged changes that mirrored Taylorism. The second part of this paper is an extension of that argument to the civil engineers employed by the USBR between 1923 and 1943. Of course, the limits of and errors in the extension of Fitzgerald's argument are my own doing." Editor's note: while at the press there was a change of title, and this book was actually published as *Every Farm a Factory: The Industrial Ideal in American Agriculture* (New Haven: Yale University Press, 2002).

8. Except for the small number of people clearly identified as legal or clerical staff, the 167 individuals are all the individuals found by checking this tabulation once each year between 1923 and 1943. I omitted the legal and clerical staffs because they are identified small divisions of the USBR separate from the main organization. I generally checked tabulations from January or December issues of *Reclamation Era.* Breaks in publication during the worst of the Depression and during World War II, as well as decisions made in binding the set of *Reclamation Era* to which I had access while researching this paper, account for variations from this general approach. The specific volumes I consulted were: June 1923, January 1924, December 1924, December 1925, January 1927, December 1927, January 1929, January 1930, January 1931, January 1932, January 1933, February 1935, January 1936, January 1937, January 1938, January 1939, January 1940, January 1941, and January 1942.

9. I assigned each leader to a group by the highest office in which he served during this period. Harry Bashore, for example, worked for the USBR for 39 years advancing from a junior engineer on the North Platte Project to commissioner. He appears in the Washington, D.C., category because his highest position between 1923 and 1943 was as assistant commissioner in Washington.

10. All biographic and quantitative data on USBR leaders comes from the sources listed in Table 1.

11. Fitzgerald, *Yeoman No More,* 43-4. (See note 7 above.)

12. Porter Johnstone Preston retired in 1940. Robert Ansley Monroe transferred to the TVA in 1937. Indeed, given the technical collaboration between the USBR and the TVA in the 1930s, surprisingly few men made Monroe's choice. The USBR's Denver office designed Norris and Wheeler dams for the TVA. When these dams went into construction and TVA established its own design team, the new organization was willing to hire men from the USBR. For a very brief mention of the USBR's work for TVA, see: Edgar C. McMechen, "The Million Dollar Engineer," *Reclamation Era* 27 (April 1937): 82-4.

13. The head of the USRS was a director rather than a commissioner.

14. On the reorganization in 1923-1924, see: Cannon, "Entering a New Era."

15. The original states and territories in which the USRS operated were Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming. Texas was added in 1906. Michael C. Rob-

inson, *Water for the West: The Bureau of Reclamation 1902-1977* (Chicago: Public Works Historical Society, 1979), 17-18.

16. "Newell, Frederick Haynes," in *The National Cyclopaedia of American Biography* (New York: James T. White and Company, 1933), 162-3; Donald C. Jackson, "Engineering in the Progressive Era: A New Look at Frederick Haynes Newell and the U.S. Reclamation Service," *Technology and Culture* 34 (July 1993): 539-74; Edwin I. Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Cleveland: The Press of Case Western Reserve University, 1971), 109-27; "Davis, Arthur Powell," in *The National Cyclopaedia of American Biography*, vol. 24 (New York: James T. White and Company, 1935), 116-7; Gene M. Gressley, "Arthur Powell Davis, Reclamation, and the West," *Agricultural History* 42 (1968): 241-57; Hundley, "Politics of Reclamation;" and Ellison, "Making of a Multiple Purpose Dam," 70-7.

17. Layton, *Revolt of the Engineers,* 154-78 and Deward Clayton Brown, *Electricity for Rural America: The Fight for the REA,* Contributions in Economics and Economic History, no. 29 (Westport, Connecticut: Greenwood Press, 1980).

18. I use Grand Coulee Dam as an example throughout this paper because it was one of the USBR's largest undertakings in the 1920s and 1930s. Also, as a major undertaking following and overlapping Hoover Dam examples from its construction illustrate how the USBR institutionalized some of the practices used for Hoover Dam. For more complete accounts of the planning and construction of Grand Coulee Dam see: Ellison, "Making of a Multiple Purpose Dam" and Paul C. Pitzer, *Grand Coulee. Harnessing a Dream* (Pullman: Washington State University Press, 1994).

19. "Reclamation Engineering Number," *Reclamation Era* 30 (July 1940): 193. For descriptions of construction Hoover and Grand Coulee Dams, see: J. E. Stevens, *Hoover Dam* and Pitzer, *Grand Coulee.*

20. On the U.S. Geological Survey in the nineteenth century, see: Thomas G. Manning, *Government in Science: The U.S. Geological* Surve*y, 1867-1894* (Lexington: University of Kentucky Press, 1967) and A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge: Belknap Press of Harvard University Press, 1957), 195-214 and 232-6. On irrigation in the nineteenth century and the creation of the USRS, see: Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902,* Histories of the American Frontier (Albuquerque: University of New Mexico Press, 1992), 273-325.

21. For a brief description of the responsibilities of the commissioner, chief engineer, and project managers, see "Division of Functions of Bureau put into Effect," *Reclamation Record* 14 (November-December 1923): 312. In addition, Warne, *Bureau of Reclamation,* 21-5 describes the function of the commissioner's office in the early 1970s. While the subdivisions within the Interior Department and the USBR's Washington, D.C., office differed in the 1920s and 1930s from those described by Warne, the basic tasks were the same.

22. Warne, *Bureau of Reclamation,* 25-7 and Robinson, *Water for the West,* 56, 71-3, and 75.

23. R. F. Walter to E. Mead, telegram, 28 July 1933, 478:101.03, Entry 7/30-45-CBP, WDC, RG 115. See Table 2 for abbreviations used in footnotes.

24. The USBR engineers compiled "Annual Project Histories," which, in part, described field staff and their activities. See, for example, USBR, "Columbia Basin Project: Annual Project History," vol. 1, 1934, Entry 10, WDC, RG 115. "H. A. Parker Now Irrigation Engineer, Columbia Basin Project," *Reclamation Era* 29 (January 1939): 20 also describes the work of a field engineer. F. A. Banks, "Problems in Handling Large Construction Work by Contract," New *Reclamation Era* 20 (December 1929): 182-5 describes the tasks and pitfalls of serving as a project superintendent.

25. The "Annual Project Histories" also describe the activities of the consulting boards. See, for example, USBR, "Columbia Basin Project," 1934, Entry 10, WDC, RG 115, 35-37. See also: "Berkey, Charles Peter," in *Who Was Who in America*, vol. 3, (Chicago: Marquis Who's Who, 1960), 70; "Durand, William Frederick," in *Who Was Who in America,* vol. 3, (Chicago: Marquis Who's Who, 1960), 244; and "Paul, Charles Howard," in *Who Was Who in America,* vol. I, (Chicago: The A. N. Marquis Company, 1942), 945.

26. Fitzgerald, *Yeoman No More, 82-6* (see note 7 above).

27. S. 0. Harper, Walker R. Young, and W. V. Greeley, "Francis Trenholm Crowe, Hon. M. ASCE," *ASCE Transactions* 113 (1948): 1397-8.

28. Fitzgerald, *Yeoman No More,* 179-207 (see note 7 above).

29. A vast literature discusses the transition to industrial production. Fitzgerald synthesizes this literature concisely and accurately: Fitzgerald, *Yeoman* No *More,* 16-24. On early factory production of guns, see: Merritt Roe Smith, *Harpers Ferry Armory and the New Technology: The Challenge of Change* (Ithaca: Cornell University Press, 1977).

30. For a description of the main elements of Taylorism and how agricultural engineers adopted them see: Fitzgerald, *Yeoman* No *More,* 93-9. Other concise discussions of Taylorism include: Layton, *Revolt of the Engineers,* 134-53 and Thomas Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin Books, 1989), 184-203. Important longer discussions include: Hugh G. J. Aitken, *Scientific Management in Action: Taylorism at Watertown Arsenal, 1908-1915* (Princeton: Princeton University Press, 1985); Samuel Haber, *Efficiency and Up1ift: Scientific Management in the Progressive Era, 1890-1920* (Chicago: University of Chicago Press, 1964); Daniel Nelson, *Frederick W. Taylor and the Rise of Scientific Management* (Madison: University of Wisconsin Press, 1980); and Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency,* The Sloan Technology Series (New York: Viking, 1997).

31. In a study of the Columbia River as a whole, Butler was the first to print a plan for Grand Coulee Dam substantially as it would be built. USBR engineers adopted Butler's data and analysis with very minor modifications as they worked with Washington congressmen on legislation in 1932, which ultimately failed. They again used Butler's materials when President Roosevelt approved the construction of a dam at the Grand Coulee site and told Washington congressmen to work with the USBR to develop the project. The study was published as: Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 73rd Cong., 1st sess., 1933, H. Doc. 103. Editor notes that this was the Columbia River 308 Report of the Corps of Engineers. These reports began in the 1920s when Major Harold C. Fiske initiated comprehensive river basin studies which ultimately resulted in establishment of the Tennessee Valley Authority. More on 308 reports can be found in David P. Billington, Donald C. Jackson, and Martin V. Melosi. *The History of Large Federal Dams: Planning, Design, and Construction* (Denver, Colorado: Bureau of Reclamation, 2005.) The book is available from the Government Printing Office.

32. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* Plates 57 and 58. On studies of the Columbia Basin during the 1920s and the significance of Butler's study, see: Ellison, "Making of a Multiple Purpose Dam," 120-41.

33. U. S. Bureau of Reclamation, *Completion of Grand Coulee Dam, Left Powerhouse, and Foundation for Pumping Plant, Columbia Basin Project, Washington, Schedule, Specifications, and Drawings, Specifications, no. 757* (Denver: W. H. Kistler Stationery, 1937). See also: U.S. Bureau of Reclamation, *Grand Coulee Dam and Power Plant, Schedule, Specifications, and Drawings, Specifications* No. *570* (Denver: U.S. Bureau of Reclamation, 1934).

34. The task of transmitting drawings was important and general enough to require instructions on performing it. See: R. F. Walter to All Field Offices, 7 March 1934, 774:395.30 1/30-6/45, Entry 7/30-45, WDC, RG 115 and Office Memo No. 199, 7 February 1940, 774:395.30 1/30-6/45, Entry 7/30-45, WDC, RG 115. Also, Commissioner Page resisted the idea of changing these procedures for Grand Coulee Dam. See: J. Page to H. J. Kaiser, 7 June 1938, 478:101.03 1930 thru, Entry 7/30-45-CBP, WDC, RG 115. On the episode where the lack of drawings threatened to delay construction, see: H. L. Myer to F. A. Banks, 6 January 1936,444:791-I 1936, EC-CB, CE, RG 115; F. A. Banks to R. F. Walter, 14 January 1936,444:791-I 1936, EC-CB, CE, RG 115; F. A. Banks to R. F. Walter, telegram, 15 January 1936,444:791-I 1936, EC-CB, CE, RG 115; F. A. Banks to R. F. Walter, 15 January 1936,444:791-I 1936, EC-CB, CE, RG 115; R. F. Walter to F. Banks, telegram, 17 January 1936,444:791-I 1936, EC-CB, CE, RG 115; R. F. Walter to F. Banks, telegram, 20 January 1936,444:791-I 1936, EC-CB, CE, RG 115; F. Banks to R. Walter, 23 January 1936,444:791-I 1936, EC-CB, CE, RG 115; Acting Chief Engineer S. Harper to F. Banks, 24 January 1936,444:791-I 1936, EC-CB, CE, RG 115; and Acting Chief Engineer S. Harper to F. Banks, telegram, 24 January 1936,444:79 1-I 1936, EC-CB, CE, RG 115.

35. F. A. Banks, "Significance of Grand Coulee Dam," *The Reclamation Era* 26 (December 1936): 278-9 and "Handling Concrete. In the Blocks at Coulee," *Pacific Builder and Engineer 45* (5 August 1939): 26, 27, 65.

36. The construction magazine *Pacific Builder and Engineer* covered the construction of Grand Coulee Dam in detail. Major articles on the construction plant include: Walter A. Averill, "Moving

a Mountain a Mile at Grand Coulee," *Pacific Builder and Engineer* 41(12 October 1935): 28-38; Robert J. Jenks, "Producing Aggregate for the World's Largest Concrete Structure," *Pacific Builder and Engineer* 41 (7 December 1935): 26-32; "Manufacturing 4,500,000 c.y. of Concrete for Coulee Dam," *Pacific Builder and Engineer 42 (4* January 1936): 30-6; "Handling Concrete"; and "Cranes are Vital Cog in Placing Concrete at Coulee," *Pacific Builder and Engineer* 45 (2 September 1939): 36-9.

37. "Manufacturing Concrete" and Fred K. Ross, "Mixing Time Reduced at Grand Coulee: Reclamation Bureau Works out New Blading Arrangement for Mixers," *Pacific Builder and Engineer 44* (5 November 1938): 28-9.

38. The definitive work on federal conservation in the Progressive Era is: Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920*, Harvard Historical Monographs, vol. 40 (Cambridge, Massachusetts: Harvard University Press, 1959). See also: Clayton R. Koppes, "Efficiency, Equity, Esthetics: Shifting Themes in American Conservation," in *The Ends of the Earth: Perspectives on Modern Environmental History,* ed. Donald Worster, (Cambridge: Cambridge University Press, 1988), 230-51; Joseph M. Petulla, *American Environmentalism: Values, Tactics, Priorities,* Environmental History Series, no. I (College Station: Texas A&M University Press, 1980), 34-9; and J. Leonard Bates, "Fulfilling American Democracy: The Conservation Movement, 1907 to 1921," *Mississippi Valley Historical Review* 44 (1958): 29-57. On conservation ideas as applied to waterways see: Ellison, "Making of a Multiple Purpose Dam," 105-20.

39. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 566-72.

40. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 566.

41. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 1058-67.

42. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 1067.

43. Ivan E. Houk, "Experimental Work on Small-Scale Models of Arch Dams," *New Reclamation Era* 18 (October 1927): 152-4; Elwood Mead, "Research Work of the Bureau of Reclamation," *Reclamation Era 24* (May 1933): 54-55, 57; J. L. Savage, "Dam Stresses and Strains Studied by Slice Models," *Engineering News-Record* 113 (6 December 1934): 720-3; Ivan E. Houk, "Twist Effects in Straight Gravity Dams," *Engineer* 164 (24 December 1937): 702-705; and McMechen, "Billion Dollar Engineer."

44. Jacob E. Warnock, "Experiments Aid Design at Grand Coulee," *Civil Engineering* 6 (November 1936): 737-41 and D. P. Barnes, "Hydraulic Models Aid Design of Reclamation Structures," *Reclamation Era* 27 (February 1937): 34-5.

45. Mead, "Research Work"; McMechen, "Billion Dollar Engineer"; and "Designs and Specifications," *Reclamation Era* 30 (July 1940): 192.

46. House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 6-15.

From Pathfinder to Glen Canyon: The Structural Analysis of Arched, Gravity Dams

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Abstract

Shortly after its 1902 establishment the Reclamation Service embarked upon an ambitious program of designing and building large masonry dams in the West. The design engineers focused attention on the problem of high dams curved in plan such that the behavior was partly as a horizontal arch and partly as a vertical cantilever. This physical reality for dam sites in the first decade of the twentieth century posed a challenge to the analytic talents of engineers and called forth an approach that eventually in the 1920s came to be called the trial-load analysis.

In March 1903 the Reclamation Service hired George Y. Wisner as their structural consultant, and in 1904, with E. T. Wheeler, he embarked on a mathematical study focused on the Pathfinder Dam. Their report, published in 1905, identified the two types of behavior—horizontal arch and vertical cantilevers—and showed how a highly approximate approach could be used to estimate the overall performance of curved masonry or concrete dams. The Service used the result for the design of Pathfinder and used it to check the design for the Theodore Roosevelt Dam.

In a 1921 landmark paper, Fred Noetzli, a Swiss-trained engineer, developed a more complete procedure for the arch-gravity dam analysis which he applied to Pathfinder and found results reassuringly similar to those published by Wisner and Wheeler.

After much published discussion of Noetzli's paper, C. H. Howell and A. C. Jaquith presented, in a 1929 paper, a more extensive procedure and for the first time used the term trial-load as the method of defining the extent of the arch action and that of the cantilever action. Hoover Dam, then under design, did not benefit from this analysis but in the 1950s the trial-load method helped justify the design for Glen Canyon Dam, which unlike Hoover Dam, could not stand safely as a pure gravity structure.

The paper will conclude with some general observations about the role of conceptual design, based on approximate methods of analysis, in the search for structural forms that are sufficiently safe and relatively economical. Also included will be a related discussion about the tension between the massive and structural traditions of concrete design.

The Beginning of Rational Design

Structural engineering as a modern profession begins with the building of iron bridges in the late eighteenth century in Great Britain. It began because of the desire for lighter bridges that could nevertheless be as strong or even much stronger than those built of stone or wood. Starting with the French schools, the *Ponts et Chaussées* established in 1748 and the *Ecole Polytechnique* established in 1794, structural engineering by the early nineteenth century began to have a foundation of a scientific basis where mathematical theory could help predict performance and be, therefore, a guide to designing new forms.

Bridges were the primary focus of early structural theory because they were pure structure, they had the longest spans, and they also had the most dramatic failures. During the last half of the nineteenth century structural theory became formalized, began to be used extensively for buildings, and was taught systemically in the Polytechnic Institutes of Western Europe. By contrast with bridges and buildings, dams did not receive the same intensive attention in schools or in the technical literature. This was so because most dams were low, were built of earth or rock, and thus remained part of a preindustrial technological culture. Throughout the nineteenth century dams received little attention either in the technical literature or in schools of engineering. But at the end of the century three major changes in the United States brought dams into the forefront of engineering: first, cities were expanding at an unprecedented rate and they could not grow without new sources of water; second, the new electric power industry moved rapidly into hydroelectric stations; and, third, the closing of the frontier raised strong social pressure to develop the west in large part through irrigation.

Those social pressures combined with the advanced state of structural theory produced the desire for a more scientific treatment of dams with the belief that they could therefore be more rationally, hence more economically and more safely, designed. Just at this time the new and prototypical twentieth century material, structural concrete, came into general practice to encourage designers to abandon stone masonry and sometimes embankment dams for ones built using the new material. But even where earth or rock dams seemed still preferable, concrete became widely used in spillways, powerhouses, and diversion works.

In addition to these social and technical forces there was the crisis of flood to prompt federal funds for control dams. The political actions that such floods bring naturally result in population growth and urban expansion. As the twentieth century unfolded, the major dam building in the United States and elsewhere began to take a new direction, characterized by high dams, huge reservoirs, and the search for rational methods of analysis as a basis for design. This search led to two competing visions of structural form, one characterized by the structural tradition and the other by the massive tradition which we can rephrase as the battle between form and mass.[1]

Form and Mass in Structure

In the preindustrial world, with the notable exception of the high gothic cathedrals, there was an implicit belief that great works were built as massive structures which were primarily of stone. This aesthetic of mass connoted permanence, opulence, and power; it stood in opposition to the ephemeral wooden structures of peasants and the urban poor. To be monumental was to be safe and handsome. When engineers began to construct skeletal metal bridges in the nineteenth century, they were initially banned from urban settings, and when concrete entered practice in the 1890s it had to be covered in, or formed to look like, stone to be accepted.

It is therefore of no surprise that when large dams entered modern America of the twentieth century, they would reflect that context, especially those dams designed by large municipalities and agencies of the Federal Government. And yet right from the start of federal dam building in concrete, with the founding of the Reclamation Service in 1902, the conflict between form and mass was immediately present and it would remain as a continuing issue, never fully resolved, throughout the century.

In its most elementary form, a dam in the massive tradition consists of a mass of material that, by its weight alone, holds back a volume of water. Such structures are known as gravity dams, an appropriate name because it is the force of gravity pulling vertically down on the dam that provides resistance against pressure exerted horizontally by water in the reservoir. Designs adhering to the massive tradition can be based upon sophisticated engineering analysis, but the basic principle underlying the tradition is simple: accumulate as much material as economically or physically possible, thus insuring that the dam will not tip over, slide or rupture; in turn, the massive dimensions will increase the likelihood that the dam can achieve long-term stability in holding back a reservoir.

A dam in the structural tradition, in contrast to gravity designs, depends upon its shape, and not simply its mass, to resist hydrostatic pressure. For example, an arch dam in a narrow canyon with hard rock sides allows a significant amount of the hydrostatic pressure to be carried by arch action horizontally into the canyon walls. Because of this arch action, the thickness (and hence bulk) of the dam's profile can be much less than a gravity dam of the same height. In essence, the amount of material in (or the mass of) a structural dam is a less important attribute than it is for a massive dam. For a dam adhering to the structural tradition, it is more important to develop a design that takes advantage of shape and not just weight.

The Profile of Equal Resistance

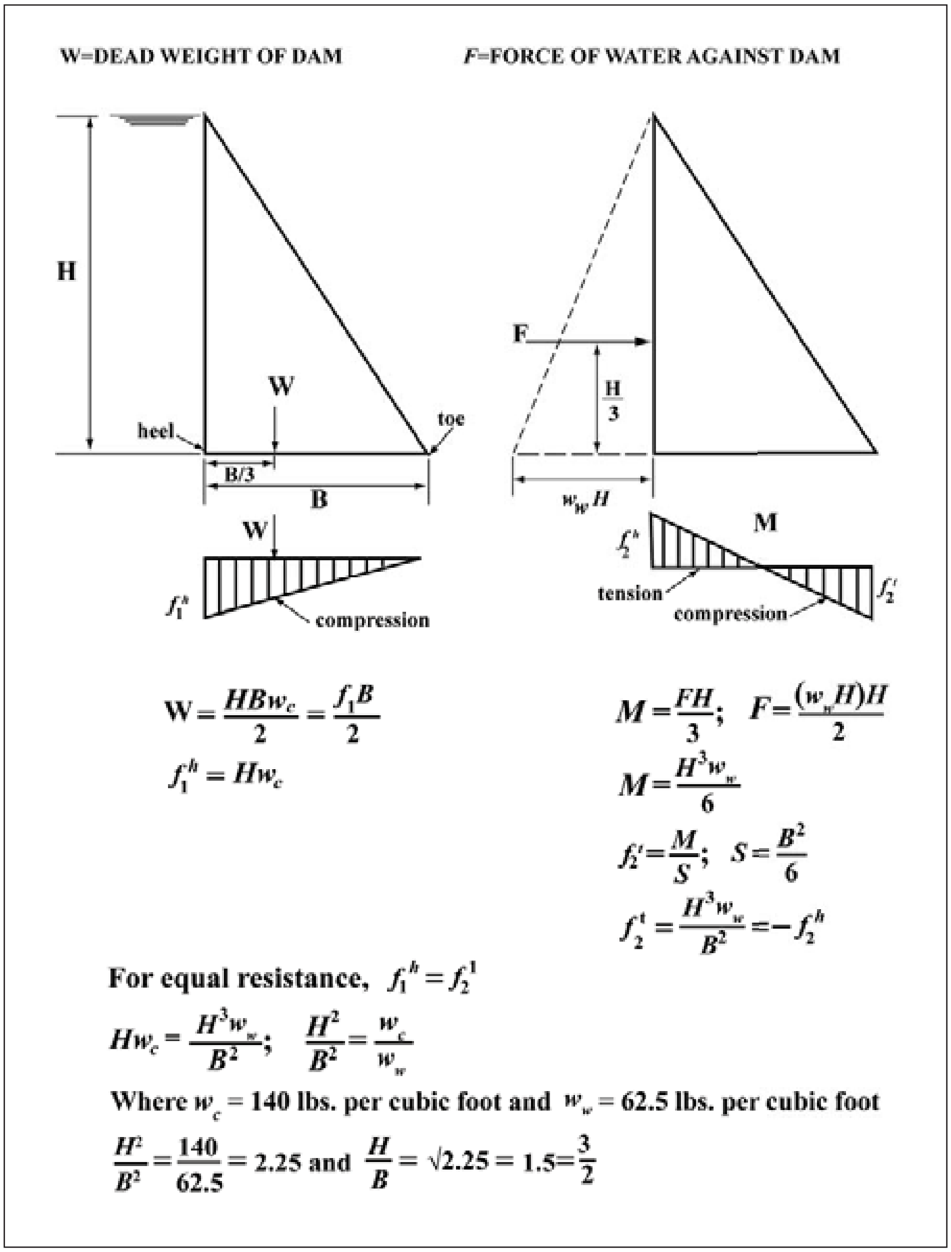
Masonry gravity dams can be built without any reliance upon mathematics, but in the nineteenth century European engineers realized that this type of structure was amenable to a quantifiable approach to design. In the early 1850s a paper published by the French engineer J. Augustine DeSazilly set the course for all subsequent work in this area of gravity dam design.[2] Knowing the hydrostatic force exerted by a given height of water (which weighs about 62.5 pounds per cubic foot) and the approximate weight of masonry used in dam construction (usually about 140-150 pounds per cubic foot), DeSazilly conceived what he termed the "profile of equal resistance." Using basic formulas of statics, he developed a cross-section in which compressive stresses at the upstream face when the reservoir is empty equal compressive stresses at the downstream face when the reservoir is filled. In taking these two extreme conditions, he hypothesized a design that, at least in cross-section, would minimize the material necessary to erect a stable masonry gravity dam.

The profile of equal resistance came from a consideration of two major conditions of dam loading (see 8.1): reservoir empty or reservoir filled. For the former case the dead load of the dam, assumed to be a pure triangle in cross section, caused a maximum vertical compressive stress f_1^h at the heel of the dam (upstream edge) equal to the weight of concrete or stone above that point or $f_1^h = Hw_c$ (Height H times the density of concrete w_c). For the case of the full reservoir, to the vertical stress of case one must add the influence of the horizontal force F due to water pressure. This force causes the dam to bend and thus creates maximum vertical compressive stresses at the toe $f_2^t = Hw_w\left(\frac{H^2}{B^2}\right)$ with equal vertical tensile stress at the heel (see Figure 8.1). The criterion for equal resistance is that the maximum vertical compressive stress for case one be the same as for case two, hence $Hw_c = Hw_w\left(\frac{H^2}{B^2}\right)$ or $\frac{H^2}{B^2} = \frac{w_c}{w_w}$. For example where the density of concrete w_c is taken to be 140 pounds per cubic foot and the density of water w_w to be 62.5 pounds per cubic foot then $\frac{H^2}{B^2} = \frac{140}{62.5} = 2.25$ so that $\frac{H}{B} = \sqrt{2.25} = 1.5$ or 3/2. For example, for a dam 60 feet high the base width would be 40 feet.

The Middle Third

In the early 1870s, the Scot W. J. M. Rankine confirmed the validity of DeSazilly's work; he further observed that a stable gravity dam must have sufficient cross-section so that the combined vector force (or "resultant force") of the horizontal hydrostatic pressure and the vertical weight of masonry will pass through the center (or middle) third of the structure at any horizontal elevation.[3] Should the resultant fall outside the center third, a gravity dam will become susceptible to dangerous cracking because tension (rather than compression) will develop along the upstream edge of the structure; the further outside the center third the resultant passes, the greater the tensile stress and the greater the likelihood that cracking will occur. And if the resultant should fall completely beyond the downstream edge, then the structure will "overturn." Although the "middle third" precept was inherently adhered to by any design developed in accord with De Sazilly profiles, Rankine's work established it as an overt principle of masonry gravity design.[4]

When the stresses for case two are plotted over the dam base we find that they form a triangle with the maximum value at the toe and the minimum (equals zero) at the heel. The centroid of that pressure lies at B/3 from the toe. Likewise for the reservoir empty in case one the centroid lies at B/3 from the heel. Thus, the centroids of all loading cases between one and two lie between those two positions or within the middle third of the dam width B (see 8.2).



8.1. Profile of equal resistance.

The Danger of Uplift and Sliding

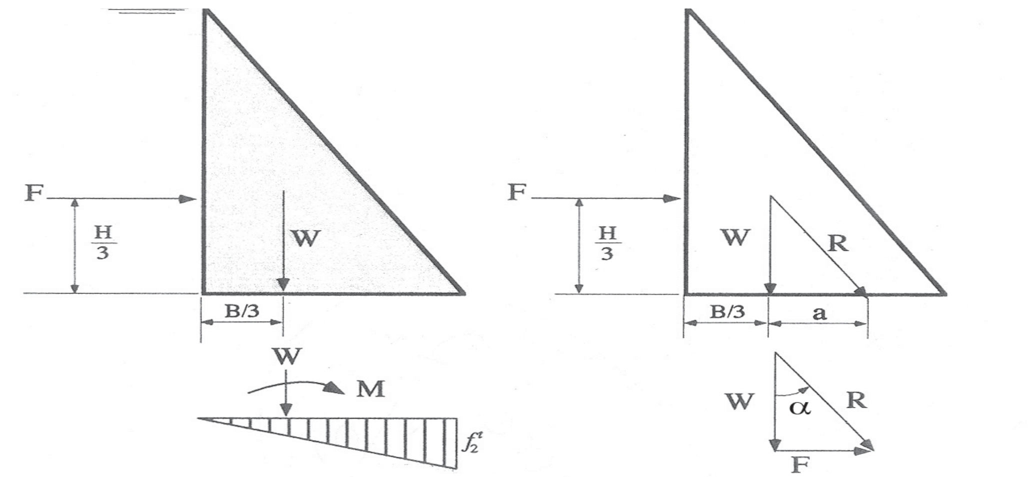
Interest in other issues relating to gravity design did not remain stagnant and this is best reflected in concern over the influence of uplift on the safety of gravity structures. Uplift is a phenomena resulting where water seeps under the foundation (or into the interior of the dam proper) and—because of pressure exerted by water in the reservoir—pushes upward and increases the likelihood that the structure will slide horizontally downstream. Uplift attracted the attention of engineers in the early twentieth century and encouraged both the use of thicker profiles as well as the development of grouting and drainage techniques that would mitigate its occurrence and possible effect.

The 1911 failure of a gravity dam in Austin, Pennsylvania, led the American engineering profession to look more closely at the influence of uplift on dam safety especially as it related to sliding. Figure 8.3 illustrates the forces that influence the horizontal movement of a gravity dam over its foundation. In addition to the force of the water F and weight of the dam W, the water pressure underneath the dam produces uplift U while the cohesion C between dam and rock resists sliding. The friction between dam and foundation (usually rock) tan ϕ will resist sliding in proportion to the vertical force W less the uplift. Neglecting cohesion and assuming full uplift on a dam where B/H = 2/3, the safety factor against sliding is less than one. This result helps explain the Austin Dam failure, where B/H = 0.6 and investigations after failure led to the conclusion of substantial uplift. Part of the solution was to increase B/H and also to drain the base to relieve the pressure (see 8.3) and hence reduce the uplift force to 0.5 or less.[5]

The most significant drawback to gravity designs involved their high cost. While the "profile of equal resistance" offered a mathematically rational basis of design, this did not mean that gravity dams would necessarily be cheap to build. For major municipalities, the economic benefits that accompanied an increased water supply might easily justify the huge expenditures required to build large masonry gravity designs. But once cities such as Boston (with the Wachusetts Dam completed in 1904) and New York (with the New Croton Dam completed in 1907) erected masonry gravity structures as part of major civic improvement projects, the technology came to represent—at least in many people's eyes—the most conservative, the most appropriate, and, if at all economically feasible, the most desirable type of dam. In such dams, the free end (top) of a straight gravity dam will move horizontally as the cantilever bends downstream under water pressure. In this way the water load is carried down to the foundations (on the valley floor) by bending.

Arch and Cantilever Behavior in Dams

Unlike the Croton structure, many dams in narrow valleys have been designed as arches using an elementary mathematical theory based upon the cylinder formula (see 8.4). The dam, curved into an arch between the sides of the valley, will carry water load to the vertical canyon walls, by compression forces calculated from the cylinder formula. As these horizontal arches carry compression they will become shorter and hence move in the horizontal direction downstream. Thus a curved arch dam can carry loads both vertically



$$W = \frac{HBw_c}{2}$$

$$F = \frac{H^2 w_w}{2}$$

$$Tan\,\alpha = \frac{F}{W} = \frac{a}{H/3}$$

$$= \frac{H^2 w_w / 2}{HBw_c / 2} = \frac{H}{B}\frac{w_w}{w_c}$$

$$\frac{3a}{H} = \frac{H}{B}\frac{w_w}{w_c} \quad \text{or} \quad a = \frac{H^2}{3B}\frac{w_w}{w_c}$$

For $w_w = 62.5$ lbs. per cubic foot and $w_c = 140$ lbs. per cubic foot

$$a = \frac{H^2}{B^2}\left(\frac{1}{2.25}\right)\frac{B}{3} \quad \text{so that when} \quad \frac{H}{B} = \frac{3}{2}$$

$$a = 2.25\left(\frac{1}{2.25}\right)\frac{B}{3} = \frac{B}{3}$$

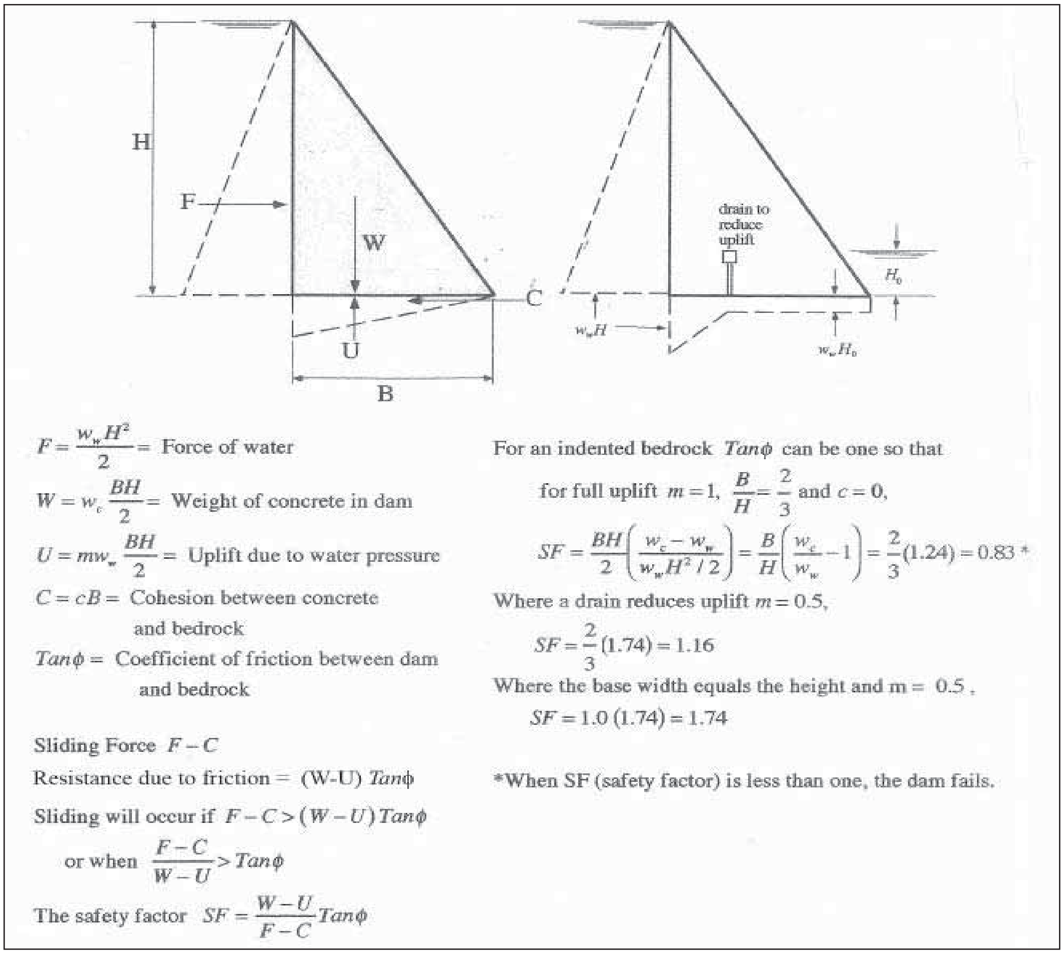
Thus, a defines the middle third of the base. If the resultant R falls outside a, then there will be tension at the heel and the compression at the toe, $f_1^t + f_2^t$ will exceed f_2^h.

8.2. Dam Design: The middle third.

as a cantilever and horizontally as an arch. The challenge to the engineer is to determine how much of the load goes to the canyon floor and how much to the canyon walls.

This issue is crucial to design because much more material is required for safe cantilever behavior than for safe arch action. For example, designers proportioned gravity dams (those assumed to act as cantilevers alone) with a base thickness B equal to about 2/3 of H, the dam height. Where H = 60 ft. and B = 40 ft. the amount of concrete required per foot of dam length would be V = 60 x 40 x ½ = 1200 cubic feet. By contrast an arch dam with H = 60 ft. and R_u = 100 ft. would require a base thickness of about 7.5 feet from the cylinder formula (for f = 350 psi) and hence a total volume of 60 x 7.5/2 = 225 cubic feet or less than 20% of the material required for the gravity or massive dam.

As a result, some engineers, seeing this great advantage of arch dams, had a strong incentive to find a rational way to determine analytically how much load was carried by the arching action and thereby justify designing a safe dam with far less material than a gravity dam carrying load by cantilever action. Engineers

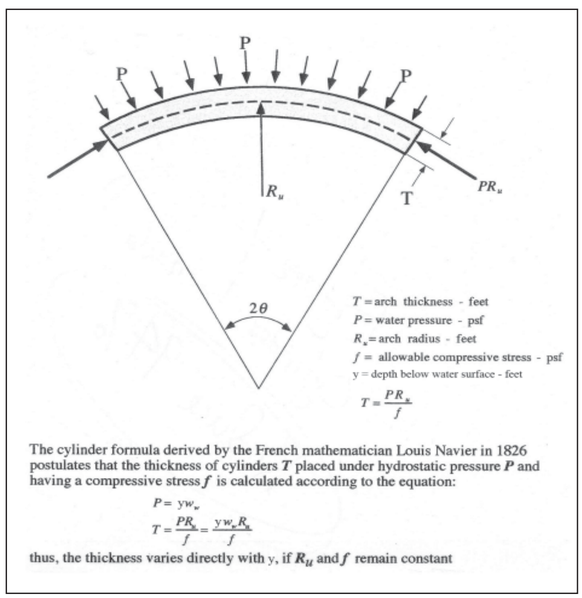


8.3. Uplift and Sliding.

consulting with the newly established Reclamation Service began this process of analysis as early as 1903.

The Wisner and Wheeler Report on Pathfinder Dam

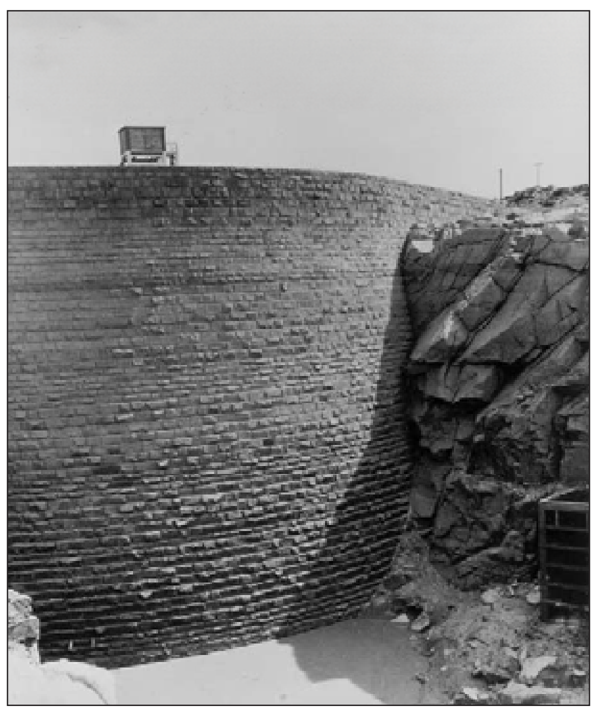
In September 1903, the Reclamation Service held a conference of engineers at Ogden, Utah, where their newly appointed (March 1903) consulting engineer, George Y. Wisner (1841-1906), presented a paper which called for a thorough study of stresses in high masonry (stone or concrete) dams to ensure safety and achieve minimum construction cost.[6] F. H. Newell, the chief engineer of the Service, asked a select committee of four, including Arthur Powell Davis (1861-1933) later to become



8.4. The cylinder formula.

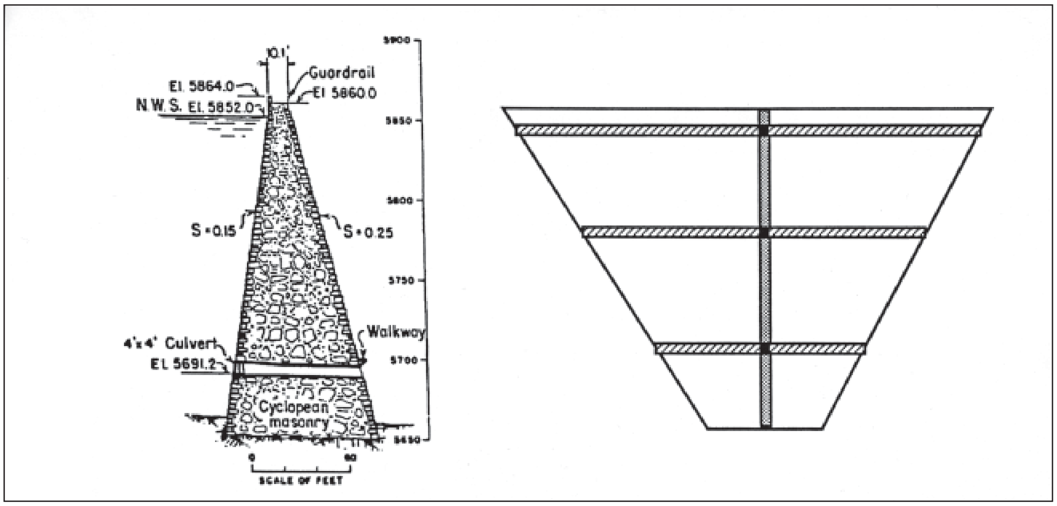
director of the Service, to make him a recommendation which it did formally on October 5, 1904. Its letter spoke of the two high dams proposed for Wyoming (Pathfinder and Buffalo Bill later renamed Shoshone Dam) and of the fact that "no thorough analysis has ever been made of the relative economy and stability of reinforced concrete dams as compared with similar dams of gravity sections.…" They suggested that such an analysis be commissioned by the Service, and they recommended Mr. E. T. Wheeler of Los Angeles for the job.[7] Under the supervision of Wisner, Wheeler began work in January of 1905. Wheeler submitted his final report on May 5, 1905, and Wisner sent that report, preceded by a lengthy discussion of his own, to Newell on May 16. Its importance was considered to be so great that the Wisner-Wheeler paper was published in the August 10, 1905, issue of *Engineering News*. Since this report inaugurated the structural tradition of large-scale dam design within the federal government of the United States, it is essential to explain its substance and its impact.[8]

Although Wisner proposed the study in the light of the Service's new big dams—Roosevelt, Buffalo Bill, and Pathfinder—he and Wheeler actually focused only on Pathfinder (see 8.5), it being the first one to be completed (1909). Wisner described how an arch dam in a narrow valley (he called it "of short span") carried water loads and also how it behaved under wide swings of temperature both with reservoir full and with it drawn down. He then gave Wheeler's report which consisted of the sets of formulas for water loads: one which assumed that the dam carried the water pressure as a series of horizontal arches supported by the side walls of the Canyon. He then computed the horizontal deflection of these arches at their crowns—essentially only the vertical centerline of the dam (see 8.6). Wheeler next took a vertical slice of the dam at this centerline and, assuming it carried all the water pressure as a cantilever, supported only on the floor of the Canyon, he computed its horizontal deflection at various points from base to top of the dam. The arch deflections and the cantilever deflections should have been the same at the same points on the dam, but this two-part calculation did not give such results. Thus Wheeler had to make a second calculation by adjusting the amount of load taken by the arches and that taken by the cantilevers. The first



8.5. Upstream face of Pathfinder Dam on the North Platte River near Casper, Wyoming, is a masonry arch and cantilever section. Source: Bureau of Reclamation.

calculation shows that the free cantilever deflects far more than the arches do in the top portion of the dam while the reverse is true at the bottom. Thus the arches carry more load at the top and the cantilevers carry more load at the base. This redistribution of load would eventually be called the trial-load method of analysis. Moreover, Wheeler found that the Pathfinder Dam could carry all the water load as a series of arches with compressive stresses under 200 psi for a material (stone masonry) whose compressive strength is well over 2000 psi.



8.6. Pathfinder Dam section and elevation diagrams. Wheeler took a vertical slice of the dam as a cantilever and analyzed the deflections. He then analyzed the deflections in a horizontal arch section. He repeated these analyses, distributing load to both the arches and cantilever, until the two sets of deflections were nearly equal.

Next Wheeler studied temperature stresses in the Pathfinder dam. Here he assumed that the temperature dropped 15°F at the top with the reservoir only filled up to 100 feet from the top and that the temperature drop decreased linearly to zero at 120 feet below the top. This drop would cause the arches to bend and deflect in the downstream direction that would cause vertical cracks in the upper arches; and the deflection of the arches above relative to the undeflected cantilevers below would cause vertical bending in the lower parts of the dam and hence horizontal cracks there. This qualitative description helps explain where reinforcing steel needs to be placed (if it were a concrete dam), but it does not give a good quantitative measure. However, by iteration again Wheeler was able to make a more reasonable estimate of the temperature stresses which he then combined with the water load to give one design condition.

Noetzli and the Curved Dams

Strictly speaking, the analysis of Wisner and Wheeler was a trial-load method because it assumed a distribution of loads between arches and cantilevers and then after various other trials it based design on a final iteration. Fred Noetzli (1887-1933), a Swiss trained engineer, summarized the situation in a landmark

1921 paper in which he reviewed the practice of arched dams, gave relatively simple formulas for calculating the cantilever and the arch actions in horizontally curved dams, and then applied his formulations in detail to the Pathfinder Dam. This last part is the heart of his paper in which he compares his semi-graphical approach to the purely analytical calculations presented by Wisner and Wheeler in 1905. He concludes that his "distribution of load between cantilever and arches compares very favorably with that obtained analytically by Mr. Wheeler."[9]

Noetzli then proceeded to discuss the central issues in dam design that went beyond the statics of water-pressure loading: stresses due to temperature change, to shortening of the arches under water pressure, and to shrinkage of the concrete as well as the influence of cracks in the concrete. He showed by simple calculations that these effects were at least as important as those due to the statics of water pressure loading.

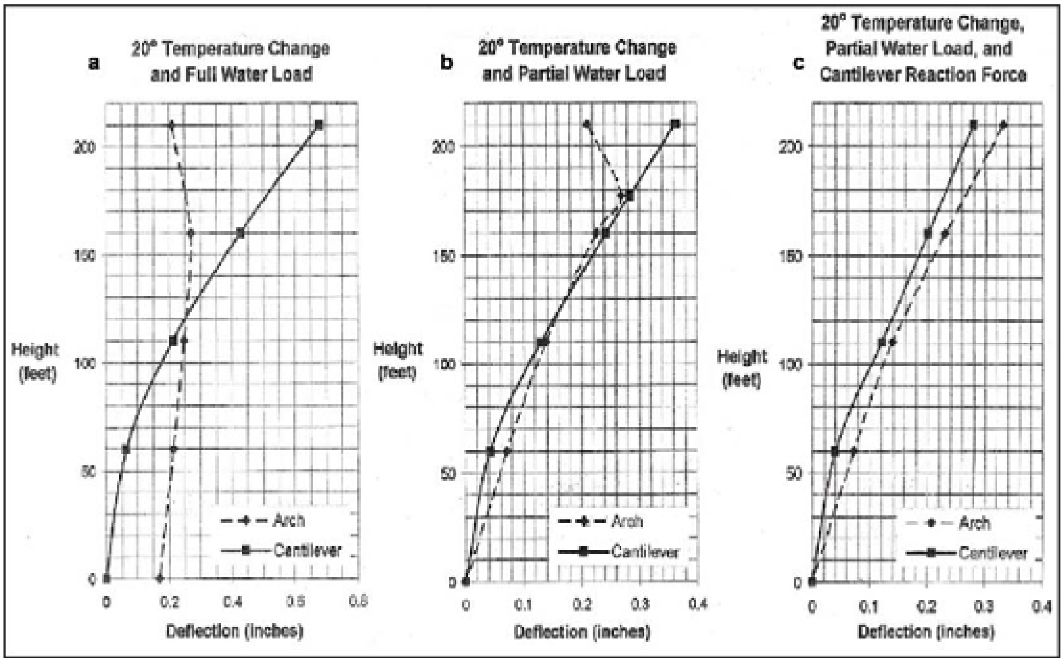
The benefit of analyzing the dam as a set of independent arch and cantilever elements is that one can use simple calculations to determine the deflection of any point along an arch or cantilever element. Cantilever deflections are approximated using the moment area method. The height at which a deflection will occur along the cantilever can be calculated for members with constant and linearly varying cross-sections using simple equations.

The process of determining the load distribution between arches and cantilevers in a given dam is an iterative approach based on finding the height, H^1, above which cantilever action no longer exists and arch action takes all the load. A first approximation of H^1 is made by applying the full water load individually to the arch and cantilever elements. The arch and cantilever deflections will coincide at a single point. The results of an independent analysis of the Pathfinder Dam based on the method outlined by Noetzli in his 1921 paper are shown in 8.7 below. 8.7a shows the intersection of the arch and cantilever elements at a deflection of approximately 0.25 inches. This value is used to calculate the height at which this deflection would occur in an idealized structure. As the actual cross-section of the dam is something between prismatic and triangular, the first approximation of H^1 is taken as the average of the results from the two equations.

The load distribution defined by this new value of H^1, becomes the basis for the second iteration. The deflection of the arch and cantilever elements is calculated as before for the new loading and is shown in 8.7b.

Although the cantilever carries no load above H^1, the deflection continues to increase up to the waterline. In some cases, the calculated cantilever deflection may exceed the arch deflection at the top of the dam, as it does in 8.7b for the Pathfinder Dam. In actuality, however, the deflection of the cantilever and arch must coincide, requiring that the arch must resist any additional deflection of the cantilever. Subsequent iterations involve adjusting the value of H^1 and finding, by trial and error, the additional "reaction" load on the arches required to bring the cantilever deflection approximately into coincidence with the arch deflection, as shown in 8.7c.

Table 8.1 summarizes Noetzli's results for the Pathfinder Dam and the results of the independent check of Noetzli's analysis. Additionally, a finite element model was analyzed using SAP 2000® to check the accuracy of Noetzli's values. These results are also given in Table 8.1. In general, the finite element results compare favorably with those obtained by the simplified hand analysis, indicating the applicability of this method for approximating the behavior of arch dams under the combined effects of temperature and water load.



8.7. Deflection of Pathfinder Dam, based on Noetzli's analysis. Deflection of arches and crown cantilever under combined 20° temperature change and a) full water load, b) under partial water load, and c) under partial water load and reaction from cantilever.

After giving the details of his analysis of the Pathfinder Dam, Noetzli went on to point out that pure gravity dams rarely have a safety factor against overturning of over 2.0 and usually it is close to 1.0 (see 8.8). This surprising claim allowed him to make a strong criticism of such dams, i.e. "no other engineering structure of acknowledged good design has such a small factor of safety as a pure gravity dam."[10]

The paper, which drew vigorous discussions from major figures of the period, established the Swiss engineer as a leading theoretician for dams, and the discussion largely confirmed Noetzli's reputation. Running through Noetzli's writing was the two-part theme, prototypically Swiss, that good design implies form over mass and that analysis—often graphically done—can be greatly simplified to improve understanding as well as to encourage designers to think in terms of form over mass. He was at great pains to stress the historical fact that

Elevation	Noetzli's Results	Independent Check of Noetzli's Trial Load Method			SAP 2000 Analysis
		Arch Defl'n			
	Total (inches)	D_{temp} (inches)	D_{water} (inches)	Total (inches)	Total (inches)
210	**0.320**	0.211	0.121	**0.33**	0.23
160	**0.230**	0.154	0.066	**0.23**	0.15
110	**0.140**	0.11	0.028	**0.14**	0.08
60	**0.070**	0.06	0.012	**0.07**	0.04
0	**0.000**	0.000	0.000	**0.00**	0.00

Table 8.1. Comparison of Pathfinder Dam deflections from several analysis methods.

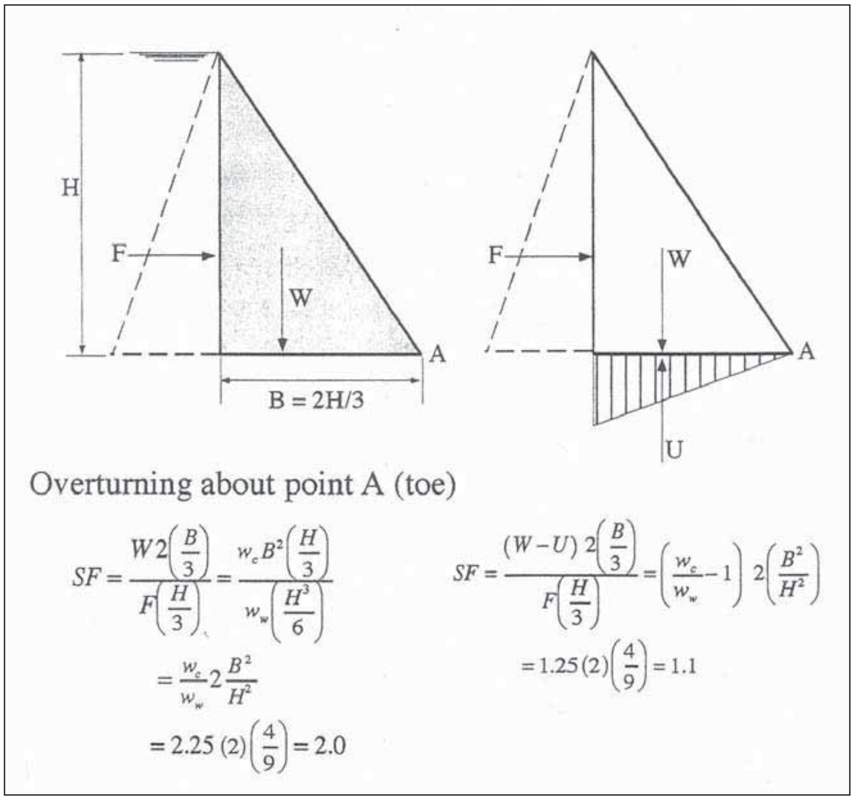
mass did not mean safety, but that form, properly conceived, did so—and with greater economy as well.

Much of the discussion revolved about the relative simplicity of the graphical approach as compared to the complexity of the mathematical one.[11] One factor in the form versus mass debate was the perception that lighter forms needed more rigor in solution.

The Trial-Load Method

The writings on curved dams continued throughout the 1920s as the nation was beginning to move into the largest program of dam building ever attempted. The articles and discussions up to 1929 discussed both arch and cantilever behavior and hence qualify as trial-load methods. However, not until publication of an article in the 1929 ASCE *Transactions* by C. H. Howell and A. C. Jaquith does the method acquire publicly the name of "trial load."[12] Both authors had worked for the Bureau of Reclamation in Denver where they had begun to study the method in 1923.

In the paper they defined the method as one which considers the dam to be made up of a series of horizontal arches and a series of vertical cantilevers with part of the water load carried by the dam considered as arches and part by the dam considered as cantilevers. The arch loads and the cantilever loads are adjusted so that the deflections of the arches are nearly the same as the deflections of the cantilevers at the same points. They distinguish the trial-load method from previous similar methods by the fact that they were considering more than the one single cantilever, which is what Wheeler, Noetzli, and others had done. By considering a series of cantilevers, rather than one cantilever only at the centerline of the dam, the Bureau engineers created a detailed procedure which was used for later dams. In their paper, the authors began by noting the



8.8. Factor of safety against overturning.

variations in the shapes of canyons in which dams appear and thus they established the need to use more than one cantilever for more realistic analysis.

As with Noetzli's paper, the Howell and Jaquith paper brought forward much substantial discussion. Noetzli and Jakobsen both observed that Alfred Stucky had used the trial-load method for a Swiss dam in 1922 although the method was not so named. In fact Robert Maillart had used the same idea in 1902 for a water tank also in Switzerland.[13] Probably the most significant discussion from the point of view of federal dams came from John Savage and Ivan Houk, both of the Bureau. They gave a more detailed discussion of Gibson Dam and gave also results from their analysis of the 405 ft. high Owyhee Dam in eastern Oregon. Savage had assumed a dominant role in the Bureau and was already in 1929 deeply involved with the Boulder Canyon project. But as the dams got higher and higher, the Bureau recognized the need to develop not just mathematical analyses but also physical model testing, and the instrumentation of full scale dams.

The Stevenson Creek Test Dam

During the first three decades of the twentieth century engineers focused intently on concrete arches, creating numerous designs for bridges as well as dams, and stimulating more mathematically complex analytic schemes. In 1924, four of the twenty *Transactions* papers dealt with concrete arches and many of these pages were filled with formulas and tables. The 1925 *Transactions* contained two extensive articles on arch analysis, in total about 20% of the entire volume.

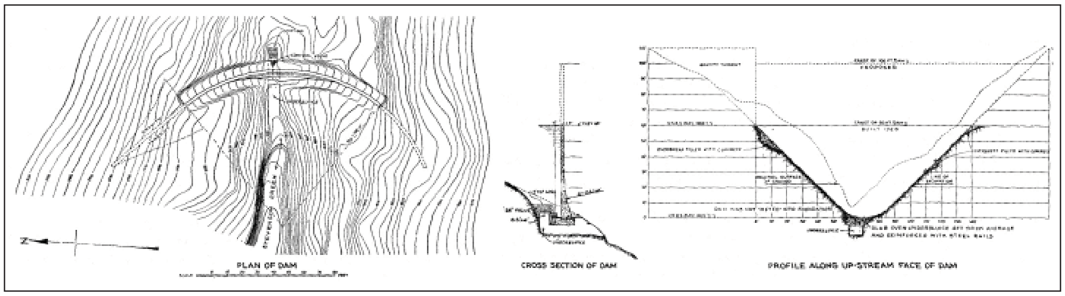
But already by 1922, some engineers became uneasy with so much abstraction and began to worry about field performance as opposed to office abstractions. Particularly engineers in the western states saw the need for a different approach to analysis which led Fred Noetzli to request financial support from the Engineering Foundation for collecting performance data on existing arch dams and for designing new tests and experiments.[14] Noetzli noted the national significance of arch dams by referring to two recent papers on the subject which had won the Croes Medal in 1920 and 1921 (the second highest award given by the ASCE; it recognizes special commendation as a contributor to engineering science). He urged aid for physical testing because "the methods by which most existing arch dams have been designed are defective and more or less unreliable." Noetzli had been worried about the lack of field data and later that year would publish a paper on tests results in full size dams.[15]

It was becoming clear then that the Service would have to play a major role in the project.[16] In December 1923 W. A. Brackenridge, senior vice president of the Southern California Edison Company, proposed the building of a large scale concrete arch dam designed expressly for research, and he further offered to provide a large amount of the money for it as well as the use of his company's facilities. Located on Stevenson Creek, a tributary of the San Joaquin River about 60 miles east of Fresno, California, this dam was approved by the committee and construction began in August of 1925.[17]

The test arch design was startlingly thin. The physical structure was set in a V-shaped canyon, and was 60 feet high with a thickness throughout the top half of only 2 feet tapering from mid-height to the base from 2 feet to 7.5 feet. The arch is of a constant 100 ft. radius throughout (see 8.9).[18] The tests used mechanical strain gages and from these measurements stresses were calculated. Deflection and temperatures were also measured.

Meanwhile engineers had been collecting measurements from existing dams as part of the overall program, and they had found discouraging results because of the difficulties in relating strains and displacements to loading and temperature changes. They debated the materials from the test dam construction and instrumentation at a meeting in Fresno in early December 1925.[19]

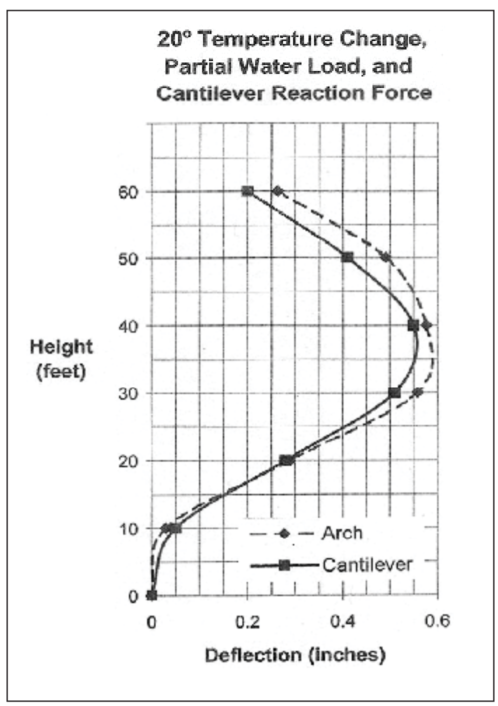
The Bureau was becoming convinced that the test dam alone would not be sufficient and that a series of small scale models ought also to be included in the program.[20] In early 1926 the Commissioner of the Bureau, Elwood Mead, approved funding for part of the work with small scale models.[21] A full report on all this work appeared in November 1927 and on December 8, 1928, a concrete model of the Stevenson Test Dam was loaded to destruction.[22]



8.9. Stevenson Creek Dam: Plan, section, and profile along upstream face.

We can summarize the conclusions reached by the committee in late 1927 under three categories: first, the great strength of the arch dams; second, physical experiments have given data useful to engineers developing mathematical analyses; and, third, arch dams may be designed more economically (by being thinner) in the future.[23]

The full report included an analysis by Noetzli following his 1921 paper. The results are tabulated in Table 8.2. An independent crown-cantilever analysis was also carried out by the authors of this paper, based on the procedure outlined in his 1921 paper. The final deflection of arches and crown cantilever under the combined effects of temperature and water pressure are shown in 8.10. Additionally, a finite element model of the arch under water load was constructed as a comparison to the crown-cantilever method. These results are also tabulated in Table 2, along with actual measurements (excluding temperature effects) taken from the dam itself. As can be seen from the results, the crown-cantilever method overestimates the actual deflections whereas the SAP 2000® analysis is relatively close. However, the crown-cantilever method provides a reasonable and conservative approximation of the behavior.



8.10. Deflection of arches and crown cantilever in Stevenson Creek Dam, based on Noetzli's analysis method.

Hoover and Glen Canyon Dams

During the early planning stages for what became the Boulder Canyon Project, the Director of the Bureau of Reclamation, A. P. Davis, and his staff made an effort to consider a range of possibilities for the design of the big storage dam on the Lower Colorado. Based upon the Service's experiences with the Roosevelt, Elephant Butte, and Arrowrock dams, it is not surprising that a massive concrete/masonry gravity

Elevation	Noetzli's Results	Independent Check of Noetzli's Trial Load Method			SAP 2000 Analysis	Actual measurements from field
		Arch Defl'n				
	Total (inches)	D_{temp} (inches)	D_{water} (inches)	Total (inches)	Crown Def;'n (D_{water} only) (inches)	Crown Def;'n (D_{water} only) (inches)
60	**0.254**	0.242	0.022	**0.264**	**0.275**	**0.370**
50	**0.490**	0.240	0.251	**0.491**	**0.345**	**0.385**
40	**0.578**	0.236	0.341	**0.577**	**0.398**	**0.388**
30	**0.559**	0.227	0.332	**0.559**	**0.355**	**0.355**
20	**0.290**	0.165	0.125	**0.290**	**0.183**	**0.234**
10	**0.030**	0.030	0.000	**0.030**	**0.042**	**0.094**
0	**0**	0	0	**0**	**0**	**0**

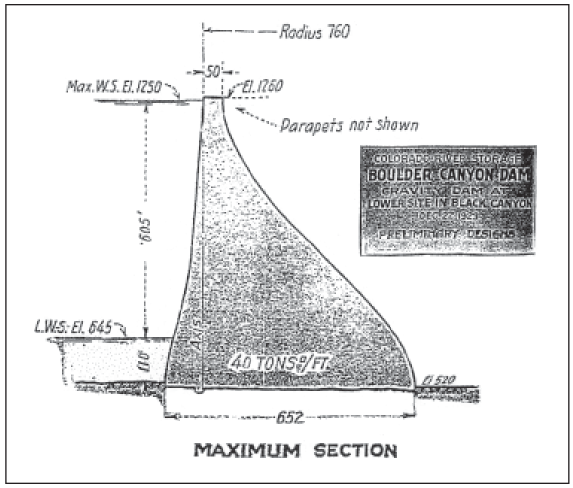
Table 8.2. Comparison of Stevenson Creek Dam deflections from several analysis methods.

design attracted the interest of Davis, his chief engineer Frank Weymouth, dam design engineer John L. Savage, and project engineer Walker Young. At the same time, the Service had experience building massive embankment dams (such as Belle Fourche in South Dakota and Strawberry Valley in Utah) as well as thin arch concrete masonry dams (Pathfinder and Shoshone, both in Wyoming); in this context, the decision to utilize a curved gravity concrete design did not come without some consideration of alternative designs. However, the selection did come quickly and without a laborious public review of alternative designs.

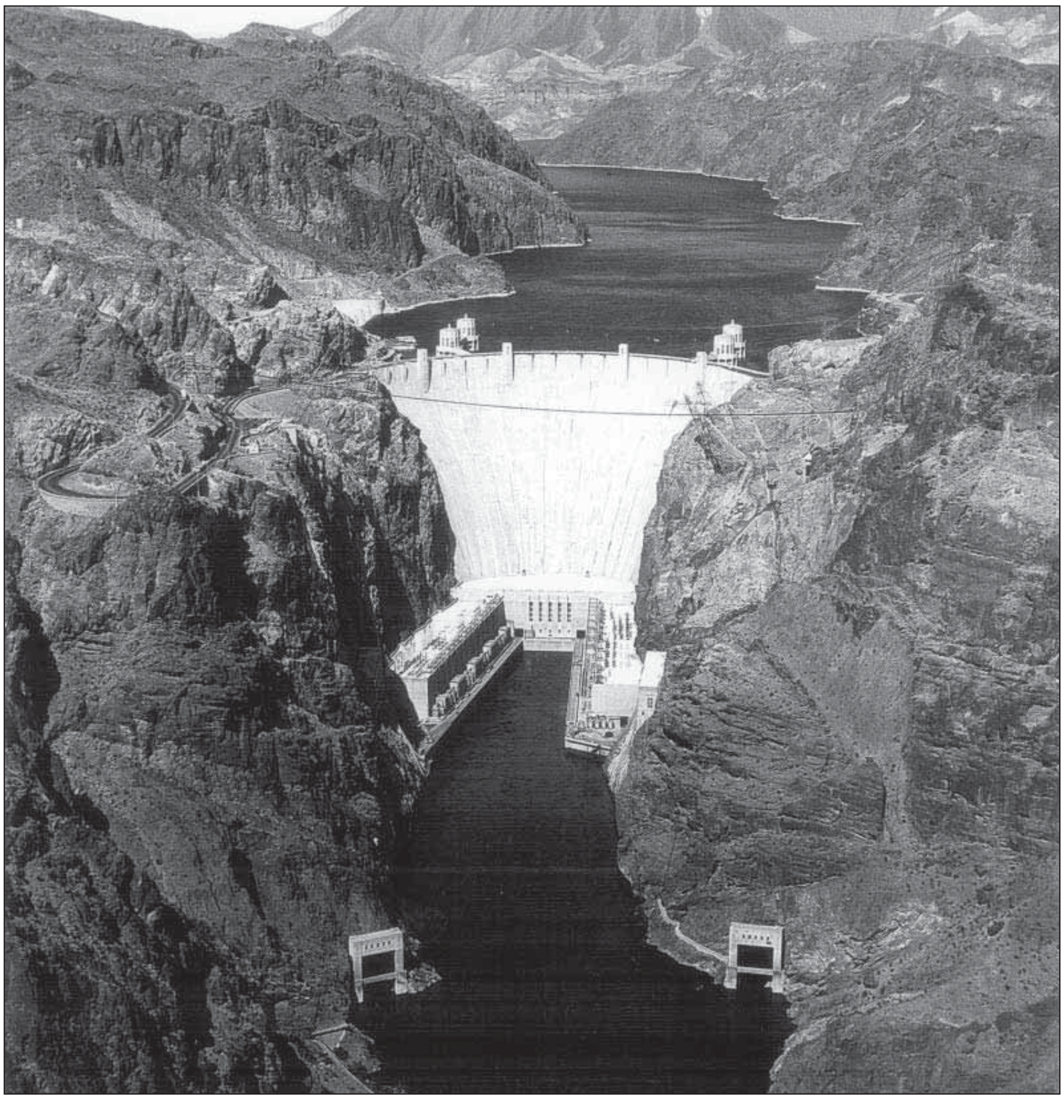
These plans were ultimately carried out and the Hoover Dam was designed as a pure gravity dam (see 8.11), although later the Bureau made a trial load analysis of the structure.

The calculation of the factor of safety against overturning, based on the equations given in 8.8, shows the considerable overturning resistance of the cross-section. Based on the final dimensions of the dam (height H = 727' and base width B = 660'), the factor of safety is $\text{S.F.} = (2.25)(2) \times \frac{660^2}{727^2} = 3.7,$ neglecting uplift. Considering uplift, the factor of safety decreases to $\text{S.F.} = (1.25)(2) \times \frac{660^2}{727^2} = 2,$ still reasonably safe. Although the final design utilizes an arched plan, the additional resistance provided by the arching action is unnecessary to carry the loads imposed on the structure. The final structure is shown as built in 8.12below.

Unlike Hoover Dam, the Glen Canyon design did benefit from the trial load analysis method that had developed in the 1920s and for the site (located on the main stem of the Colorado River only a few miles upstream from the spot marking the division between upper and lower basins), the Bureau made a design for a thin arched dam. The site had long been familiar to the Bureau. In fact, it had figured as a possible alternative to Boulder/Black Canyon in the early 1920s. By the 1950s, the Bureau was eager to begin construction of a huge 700-foot high dam at Glen Canyon that would represent another major step in the development of the Colorado as a source of hydroelectric power for the burgeoning Southwest. Whereas Echo Park lay within a part of the National Park System and thus comprised a site well suited for wilderness advocates to defend, the Glen Canyon dam and reservoir site simply encompassed federally-owned land and thus was



8.11. Hoover Dam, preliminary design of gravity section.



8.12. Hoover Dam: Downstream face showing powerhouses.

easier to justify in terms of inundating for the greater public good. Although the canyon lands upstream from Glen Canyon could certainly have been characterized as a natural (and national) treasure, they held no place in the national public consciousness and no great movement developed to protect them. Thus, when Congress agreed in 1956 to protect Echo Park, wilderness advocates offered little protest against approval of Glen Canyon Dam in what could later be understood as a de facto compromise regarding development of the two dam and reservoir sites.[24]

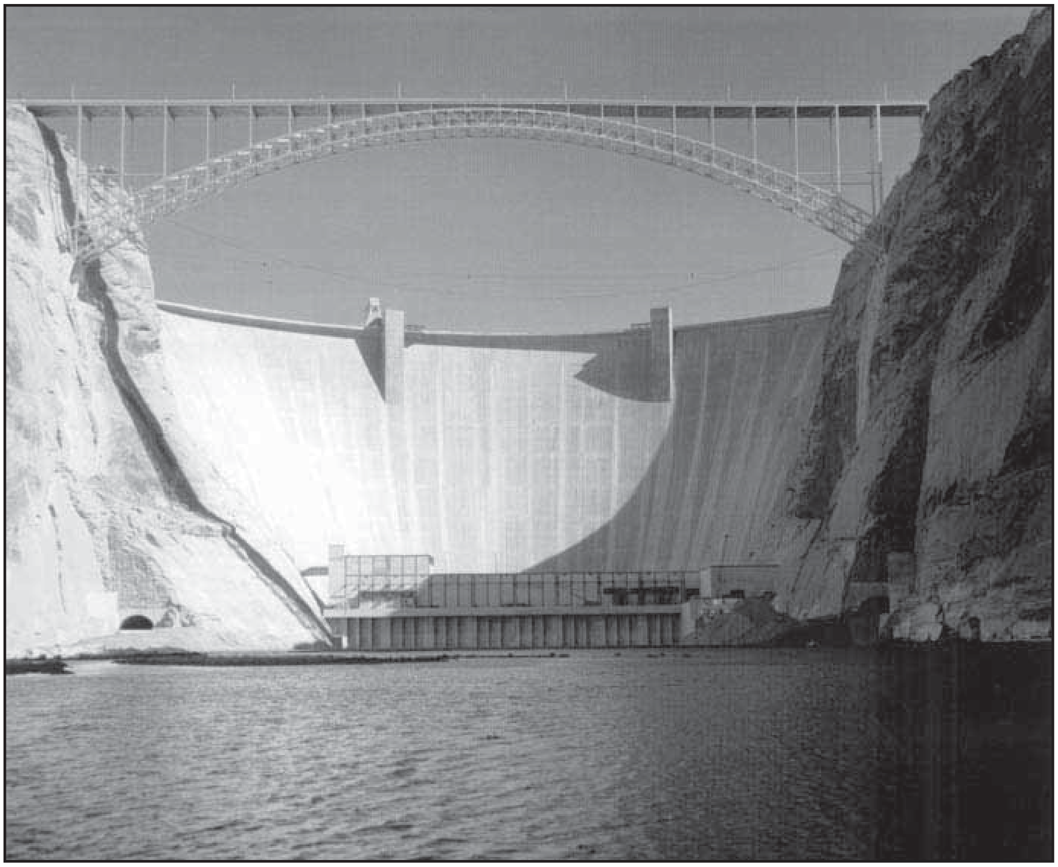
In terms of design, the Glen Canyon Dam differed from Hoover in its use of an arch design featuring a profile insufficient to stand as a gravity dam; in this strictly technological context it diverged from the precedent set by the Boulder Canyon Project and instead drew from the Bureau's work in building thin arch dams that extended as far back as Pathfinder and Shoshone dams prior to 1910. The final structure (see 8.13), with a height of 690 ft. and a base thickness of just 290 ft., had a factor of safety against overturning of just 0.80 without uplift and 0.44 with uplift. Thus the design relied heavily on arch action to resist the loads.

The early version of the trial-load analysis, improved on by Noetzli in 1921 and further refined by Bureau engineers in the late 1920s laid a basis for its use on the Glen Canyon Dam. This confidence helped lead the design engineers to design and construct a dam far thinner than Hoover and thus rely on arch action instead of only cantilever behavior. There were other reasons too. Concrete quality had improved since the 1920's so that 415 psi stress limit at Hoover could be increased 1000 psi for Glen Canyon.[25]

However, compensating somewhat for the improved concrete, the canyon walls at Glen Canyon were sandstone, a weaker material than the granite walls of Black Canyon. Therefore, the stress at the arches abutments was kept at 600 psi by thickening the arches as they approached the canyon walls. The weaker walls also required the injection of a grout curtain to strengthen the foundations and prevent seepage under and around the dam. These are the hidden dam components that are as essential to safety as the more visually obvious shaped and solidity of the concrete structure itself.

Concrete Forms and Complex Analysis

Fred Noetzli, whose primary aim had been to use tests and calculations, predicted in 1924 that gravity dams would be replaced by thin arch structures; he quoted several engineers saying that "the gravity dam is a thing of the past" and "the gravity dam is an economic crime." He held the belief common to many in the 1920s that "engineering science is advancing" and that a more rational analytic base would lead to thinner and less costly structures.[26] But Noetzli did not imply that more rational would necessarily mean more complex. He worked with graphical methods typified by his education at the Federal Technical Institute



8.13. Glen Canyon Dam. View towards downstream face showing powerhouse.

in Zurich. He did not publish the detailed mathematical formulations that had begun to appear in the 1920s and would culminate in the Bureau's 1938 report.[27]

This type of mathematical complexity was criticized sharply by one of the most famous structural engineering teachers, Hardy Cross of Illinois University. In discussing a highly mathematical 1925 paper on concrete arches, Cross noted the uncertainties of loadings, of actual stress, and of foundations none of which were dealt with in the paper which "having swallowed these 'camels' only the 'gnat' of mathematical analysis remains. The 'gnat' should be an hors d'oeuvre and engineers are giving abnormal gustatory attention to it." He goes on to proclaim that "the theories of arch analysis which are now being elaborated in engineering literature are distinctly 'high brow' in that their elaborateness camouflages with erudition uncertainties and inaccuracies which are inevitable."[28]

In spite of Noetzli's hope and Cross's warning, the profession charged ahead with complexity of analysis and the result was that the Bureau of Reclamation dams did not get thinner but thicker until after World War II when the trial-load analysis would be used to justify the Glen Canyon Dam design. A recent summary of this period stated that:

> Many arch dams built at the time showed a tendency for increasing thickness. On the one hand the failure of St. Francis Dam in California in 1928 had raised questions regarding the safety of any proposed dam of large size. On the other hand, it seemed that the excellent results obtained at Stevenson Creek, including a verification of the trial load method, were not carried forward with these arch gravity-type dams.[29]

By 1927 there had emerged well documented traditions of massive and of structural dams. The structural tradition brought forth new methods of analysis both by physical test and by mathematical calculation. The goal had been to build lighter, less expensive, and safer dams. But as the methods of analysis got more complex there seemed to grow an anxiety about uncertainties in the analysis itself and the Federal agencies addressed these worries by designing heavier structures which they believed to be safer even though the lighter ones were performing at least as well.

It seems to be a natural characterization of centralized agencies that they seek to avoid risks, to question innovations, and to justify heavy expenditures by invoking the specter of failure. But behind this apparent criticism, there lay a deep cultural ideology that was characterized by the new and prototypical building material of the twentieth century. American society and indeed western society as a whole reacted to reinforced concrete in a profoundly ambiguous way.

Modern concrete clearly stimulated the search for new forms that would carry loads with less material and at least as much safety as heavier designs. But many engineers, not seeing these possibilities or not valuing them, sought to discredit this search for innovation. They saw concrete as a mere substitute for stone masonry rather than a new material which, when cast monolithically, made the building of integrated structures possible leading to great savings of materials and weight.

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Jackson has been of great help to Professor Billington on the history of dams and Sinead MacNamara also made valuable studies of Hoover and Glen Canyon Dams. Brit Storey has also been of considerable value throughout Billington's study of the Bureau's dams.

Endnotes

1. The concept of 'traditions' as applied to dam design is discussed in Donald C. Jackson, *Building the Ultimate Dam: John S. Eastwood and the Control of Water in the West*, Lawrence, Kansas, 1995, pp. 18-21.
2. J. A. De Sazilly, "Sur un type de profil d'égale résistance proposé pour les murs des reservoirs d'eau," *Annales des Ponts et Chaussees* (1853): 191-222; and E. E. Delocre, "Memoire sur la forme du profil a adopter pour les grande barrsages en maconnerie des réservoirs," *Annales des Ponts et Chaussee, Memoires et Documents* (1866): 212-272. Both of these references are taken from Norman Smith, *A History of Dams*, Secaucus, New Jersey, 1972.
3 Construction of Masonry Dams," *The Engineer* 33 (January 5, 1872): 1-2.
4. When Rankine discussed the significance of the middle third in the 1870s there is no evidence that anyone considered it a reiteration of previously discussed ideas.
5. C. L. Harrison, "Provision for Uplift and Ice Pressure in Designing Masonry Dams," *Transactions ASCE*, Vol 75 (1912), pp. 142-5 with discussion pp. 146-225. For a modern treatment see Max A. M. Herzog, *Practical Dam Analysis*, London 1999, p. 80.
6. Wisner reviews this history in his report, George Y. Wisner, "Investigation of Stresses Developed in High Masonry Dams of Short Span." Report submitted to F. H. Newell, Chief Engineer, USGS, Washington, D. C., May 16, 1905, 22 pages.
7. Letter from Wisner, et al., in Montrose, California, to Newell in Washington, D.C., October 5, 1904; response from Newell to Wisner in Detroit, October 12, 1904; and the recommendation of Wheeler comes in a letter from Wisner and J. H. Quinton to Newell on November 2, 1904. Presumably the final approval came quickly thereafter. For details on A. P. Davis see Charles H. Bissell and F. E. Weymouth, "Memoir for Arthur Powell Davis," *Transactions ASCE*, Vol. 100 (1935) pp. 1582-91.
8. Letter report from Wheeler in Los Angeles to Wisner in Los Angeles, May 5, 1905, 9 pages. Covering letter from Wisner in Los Angeles to Newell in Washington, D. C., May 16, 1905, with the complete report. The published paper appeared as George Y. Wisner and Edgar T. Wheeler, "Investigation of Stresses in High Masonry Dams of Short Spans," *Engineering News*, Vol. 54, No. 60, August 10, 1905, pp. 141-4. Earlier publications did deal with the arch designs but they appeared in obscure publications; for example, L. Wagoner and H. Vischer, "On the Strains in Curved Masonry Dams," *Proceedings of the Technical Society of the Pacific Coast*, Vol. VI, December 1889. Such articles did not have the influence of Wisner and Wheeler.
9. Fred A. Noetzli, "Gravity and Arch Action in Curved Dams," *Transactions of the American Society of Civil Engineers*, Vol. 84 (1921), p. 23.
10. *Ibid*., p. 41. The low factor of safety can be calculated for overturning as follows: For H/B = 1.5 and for no uplift S.F. = 2.00 (assuming a triangular dam section) while for full uplift S.F. = 1.1 (see Figure 8.3).
11. William Cain, "Discussion", *Transactions of the American Society of Civil Engineers*, Vol. 84, pp. 71-91. His analysis was expanded and published as "The Circular Arch Under Normal Loads," *Transactions of the American Society of Civil Engineers,* Vol. 85 (1922), pp. 233-48. Noetzli wrote a discussion to the paper in Vol. 85, pp. 261-4. Also in the discussion William Cain, a professor of mathematics at North Carolina University, compared Noetzli's graphical method to a purely analytic approach given the previous year by B. A. Smith and noted their close correspondence.
12. C. H. Howell and A. C. Jaquith, "Analysis of Arch Dams by the Trial Load Method," *Transactions of the American Society of Civil Engineers*, Vol. 93 (1929), pp. 1191-225.
13. R. Wuczkowski, "Flussigkeitsbehälter". *Handbuch für Eisenbetonbau*, ed. M von Emperger, Berlin, 1907, Vol. 3, pp. 348-351, 407-413.

14. Letter from Fred Noetzli in San Francisco to the Board of Trustees of the Engineering Foundation in New York City, March 3, 1922, 2 pages.
15. Fred Noetzli, "Arch Dam Temperature Changes and Deflection Measurements," *Engineering News-Record*, Vol. 89, No. 22 (November 30, 1922), pp. 930-2.
16. Letters F. E. Weymouth in Denver to Davis in Washington, November 10, 1922, and from Morris Bien (acting director) in Washington to Weymouth in Denver, November 20, 1922. In the fall of 1922 Weymouth asked Davis if the Bureau could not give financial support to the project; the acting director agreed to some support.
17. Report on Arch Dam Investigations, Vol. 1, November 1927, *Proceedings of the American Society of Civil Engineers* (May 1928), pp. 6, 43. In *Bulletin No. 2* (June 1, 1924) the Engineering Foundation noted that the Edison Company had put up $25,000 and another $75,000 was needed.
18. A Progress Report on the Stevenson Creek Test Dam, Bulletin No. 2, Engineering Foundation, December 1, 1925, 8 pages. On December 1, 1925, the Engineering Foundation issued a progress report giving the dam design and the list of contributors, dominated by private industry. The Bureau of Reclamation is not listed although the Bureau of Standards was, largely through the assignment of W. A. Slater, its engineer-physicist.
19. Letter from Julian Hinds in Denver to R. F. Walter in Denver, December 17, 1925.
20. Letter from R. F. Walter in Washington to Elwood Mead in Washington, December 16, 1925.
21. Letters from R. F. Walter in Denver to Elwood Mead in Washington, February 11, 1926, and from Mead in Washington to Walter in Denver, February 19, 1926.
22. John L. Savage, "Arch Dam Model Tests—Progress Report," December 17, 1928.
23. Report, November 1927, op. cit, pp. 8-9.
24. Harvey, *A Symbol of Wilderness*, pp. 280-3, describes how wilderness advocates came to accept the need for Glen Canyon Dam in the mid-1950s; while there was some desire to push for blocking Glen Canyon Dam it was much less vociferous than the effort to protect Echo Park.
25. Glen Canyon Dam and Powerplant, Bureau of Reclamation, Denver, 1970, pp 55-89.
26. Fred Noetzli, "Improved Type of Multiple-Arch Dam," *Transactions of the American Society of Civil Engineers*, Vol. 87, 1924, Closure, p. 410.
27. "Trial Load Method of Analyzing Arch Dams," *Boulder Canyon Project Final Reports, Part V, Technical Investigation, Bulletin 1*, Bureau of Reclamation, Denver, 1938.
28. Hardy Cross, "Discussion of Design of Symmetrical Concrete Arches by C. S. Whitney," *Transactions of the American Society of Civil Engineers*, Vol. 88, 1925, pp. 1075-77. In 1932 Cross would introduce the most significant simplified analysis procedure ever presented for reinforced concrete frame structures. Noetzli worked from a solid math basis but simplified it by graphic statistics (a Swiss tradition). Cain (ref. 11) was a mathematician, not an engineer, and his work is very complex, but Noetzli could understand it easily. The Bureau carried on from Noetzli's simplified approach to develop an elaborate and highly complex mathematical method. Cross criticized all such complexity and sought to develop methods that the average practicing structural engineer could easily use.
29. Eric Kollgaard and Wallace Chadwick, eds., *Development of Dam Engineering in the United States*, Penguin Press, New York, 1988, p. 269.
30. This paper grew out of an MSE thesis by Moira Treacy, *The Development of Concrete Arch Dam Design in the United States and France*, 1998; and a report co-authored by David P. Billington, Donald C. Jackson and Martin V. Melosi, *The History of Large Federal Dams: Planning, Design and Construction*, U.S. Bureau of Reclamation, Denver, 2005, 605 pages, and a book coauthored by David P. Billington and Donald C. Jackson, *Big Dams of the New Deal Era: A Confluence of Engineering and Politics*, Oklahoma 2006, 369 pages.

Origins of Boulder/Hoover Dam: Siting, Design, and Hydroelectric Power

By:
Donald C. Jackson

Boulder/Hoover Dam is the most prominent structure ever built by the Bureau of Reclamation and arguably the most famous dam in the world. Authorized by Congress and President Calvin Coolidge in December 1928, the structure was commonly referred to as Boulder Dam throughout the time it was under congressional debate. In 1930 it was designated Hoover Dam by Ray Lyman Wilbur (President Herbert Hoover's Secretary of the Interior) and construction contracts were issued under that name. In 1933 Harold Ickes (President Franklin Roosevelt's Secretary of the Interior and no great admirer of the prior president) decreed that the name Boulder Dam be used in place of Hoover Dam. In 1947, Congress passed legislation, signed by President Harry Truman, formally designating the structure Hoover Dam, the name it still retains. But whatever the nomenclature, the curved gravity concrete structure was built in essential accord with plans developed in the 1920s—a time when the name Boulder Dam held currency.

9.1. Secretary of the Interior Harold Ickes.

This essay describes: 1) the relation of the dam to agricultural development of the Imperial Valley; 2) the role played by hydroelectricity in the dam's early history; 3) why and when the decision was made to relocate the dam from Boulder Canyon (where it was originally proposed and from whence its original name derived) to Black Canyon, the site of its actual construction; 4) the adoption of a massive, curved gravity concrete design for the structure; and 5) the importance of Los Angeles and urban development to the dam's authorization and construction. These are prosaic goals, perhaps, but worth addressing because of the dam's importance within the history of the Bureau and within the larger history of twentieth century western water development. Because this essay primarily involves events that occurred at a time when the proposed structure was known as Boulder Dam, that is the name used in the following discussion.

Imperial Valley

The conception of Boulder Dam is rooted in a privately-financed project to irrigate Southern California's Imperial Valley. As conceived by the Colorado Development Company in the 1890s, this scheme diverted water from the Colorado River to nourish a huge tract of desert land just north of the California/Mexico border. Much of this land lies below sea level making it relatively easy for water to flow to the valley. Conversely, this distinctive topographical condition also makes the valley susceptible to flooding. In the 1850s, the Anglo-American pioneer Oliver Wozencroft perceived the agricultural possibilities afforded by the topography of the lower Colorado River delta. In particular, Wozencroft realized that the "Alamo River," an ancient silt-filled channel of the Colorado River about 50 miles long had once carried fresh water directly into the expansive valley known as the "Colorado Desert." And he appreciated that, with a little human assistance, it could readily do so again. In the 1890s Wozencroft's idea was picked up by the California Development Company, an enterprise masterminded by Charles Rockwood in partnership with George Chaffey, and marketed as irrigating the bright sounding "Imperial Valley" rather than the more foreboding "Colorado Desert."[1]

Just north of the Mexican border the company dug a short canal (about four miles long) to connect the existing mainstem of the lower Colorado River with the ancient channel. Fitted with wooden headgates designed to regulate flow and block excessive floods, the Alamo Canal provided an effective and inexpensive way to divert Colorado River water into the Imperial Valley. In the short term, the company's plans to "make the desert bloom" proved easy to implement because, in centuries past, nature had accomplished most of the excavation work needed for the lengthy waterway. By 1902 thousands of acres of prime agricultural land was "under the ditch" and the company's prospects appeared bright. However, a serious problem loomed, as the "cut" connecting the Alamo Canal and the mainstem of the Colorado kept clogging with silt, thus impeding water flow to farmers in the valley.[2] Because silt accumulation proved particularly troublesome in the section of the canal closest to the river—and because interests allied with the company sought to move the headgates beyond U.S. jurisdiction in order to more readily irrigate land in Mexican territory—the company excavated a larger, more direct opening to the river at a site a few miles south of the U.S./Mexico border. Completed in 1904, this new cut also relied upon wooden headgates to protect the canal from heavy floods.[3]

To the company's dismay, in June 1905 heavy storms in the Gila River watershed of central Arizona unleashed huge floods into the Lower Colorado, washing away the headgates protecting the Alamo Canal. Soon a tremendous surge of water washed into the Imperial Valley. As flow from the Colorado River accelerated, the Alamo Canal deepened and widened, allowing yet more water to be diverted out of the mainstem. Although the Southern Pacific Railroad (a corporate ally of the California Development Company whose trackage served the valley) dumped trainload-after-trainload of rock to close off the canal entrance, it achieved little short-term effect. Despite appeals to the federal government to help stanch the deluge, President Teddy Roosevelt declined to interfere in what he considered the affairs of a private corporation. Eventually, the flooding was brought under control by the Southern Pacific, but it took almost two years and an expenditure of 2 million dollars to close the breach. In the meantime, thousands of acres of low lying land were inundated under what is now known as the Salton Sea.[4]

In 1909, the California Development Company entered bankruptcy after transferring most of its assets to the Southern Pacific Railroad. In 1911, landowners north of the international border formed the Imperial Irrigation District and five years later the district purchased the water supply system from the railroad.[5] Once the flooding stopped, agricultural production resumed in the valley. Nonetheless, fear that a devastating uncontrolled "break" might recur was never far from the minds of residents and investors alike. Soon the district and its boosters began clamoring for federally-supported flood protection and, in the midst of the uncertainty that followed collapse of the Porfirio Diaz government in 1910, for protection from possible Mexican interference with the valley's water supply.

The Fall/Davis Report

Prior to the end of World War I, the Imperial Irrigation District sought assistance from the federal government for excavation of a completely new canal entirely within U.S. territory (designated the "All-American Canal").[6] As the war ended, the district also sought federal support for construction of a flood control/storage dam somewhere in the lower Colorado River watershed that would protect the Imperial Valley from a recurrence of the disastrous inundation of 1905-07. In holding back flood water, such a dam could also increase water supplies for irrigation in the Imperial Valley.

Although the Federal government had refrained from fighting the floods of 1905-1907, the lower Colorado River had not been ignored by the Reclamation Service. As early as 1902 Arthur Powell Davis (at that time Assistant Chief Engineer of the Service) had considered development of the basin.[7] However, for many years the issue of a major storage dam across the lower Colorado River was overshadowed by other Reclamation Service projects including Roosevelt Dam in Arizona, Arrowrock Dam in Idaho, and Elephant Butte Dam in New Mexico. By the end of World War I these large projects were complete and the Service was seeking new venues for its dam-building skills. In 1915 Davis had ascended to become Director of the Reclamation Service: in that position he appreciated that controlling the lower Colorado could involve construction of one of the most prominent dams in the world. In the words of California water historian Norris Hundley:

> The proposed legislation [for an All-American Canal] immediately caught the eye of Arthur Powell Davis… who saw it as a perfect opportunity to raise anew his dream of harnessing the Colorado River… the canal made sense, concluded Davis, but only if it were part of a larger design. To build such an aqueduct without also constructing dams to control "the flood menace" would doom the canal to a short life… Davis told all who would listen [that the Imperial Valley problem] "is inseparably linked with the problem of water storage in the Colorado Basin as a whole."[8]

As a result of Imperial Irrigation District lobbying and support from Davis, in May 1920 Congress authorized the Reclamation Service to develop preliminary plans for an All-American Canal and a Colorado River storage dam.[9] Known as the Kinkaid Act (it was sponsored by Nebraska representative Moses Kinkaid, Chairman of the House Committee on Irrigation), this law initiated practical planning for Boulder Dam.[10]

In 1922 the Kinkaid Act bore fruit in the form of the "Fall/Davis Report" a major study formally prepared under the auspices of Secretary of the Interior Albert Fall and Director Davis. This landmark report proposed a large dam that would do much more than simply store floods and protect the Imperial Valley. Aware of objections that would arise if project financing was perceived as a federal hand-out, Davis advocated hydroelectric power development as a key part of the project simply because only power revenues could repay construction costs with any degree of certainty. From a strictly practical point-of-view, the development of hydroelectricity made much sense as a dam over 500 feet high and impounding more than 20 million acre-feet of water could generate many millions of kilowatt hours per year. But from a political perspective, the use of power revenues as the primary means of financing the dam was problematic. Specifically, it raised questions about the proper role of the Federal government in the generation and marketing of electricity.

Privately-financed companies controlled America's electric power grid in the 1920s and they viewed askance any legislation that would authorize a huge federally-financed dam to be paid for by hydroelectric power revenues. In the political environment of the pro-business 1920s—when the Republican Party controlled both the White House and Congress—the "public power" issue always loomed over the proposed Boulder Canyon Project. As historian Paul Kleinsorge noted in the 1940s:

> The controversy over the power aspects of the [Boulder Canyon] project, however, was not a dispute that was confined to the relatively local ambitions of [California and Arizona]. It was a clamorous argument that took on the aspects of a nation-wide debate, chiefly because it involved the whole question of whether or not the federal government should enter large-scale power production activities…[11]

In the face of possible objections from private power interests, the Fall/Davis Report nonetheless advocated construction of a high dam and hydroelectric power plant in the vicinity of Boulder Canyon. The Reclamation Service recognized that there were other possible storage dam sites along the length of the Colorado River (including Diamond Creek, Bridge Canyon, and Glen Canyon) but quickly focused on Boulder Canyon because of its large storage capacity and its proximity to prospective water users and electric power consumers in Southern California.[12] Both Boulder Canyon and the nearby Black Canyon (lying about twenty miles farther downstream) featured dramatic, narrow gorges with steep granite walls extending upwards for several hundred feet. While initial investigations focused on Boulder Canyon (hence the name historically attached to the project), Service engineers soon initiated studies at Black Canyon in order to discern the best possible site for the dam.

Selection of the Black Canyon Site

Even prior to the release of the Fall/Davis Report, Davis had considered Black Canyon as an alternative to Boulder Canyon. The two canyons offered similar possibilities of service to southern California, but, because Black Canyon lay about 20 miles farther downstream, it allowed development of a small (yet not insignificant) amount of hydropower that would otherwise be difficult to capture. This issue was directly addressed in a December 1921 letter from Davis to Reclamation Service Chief Engineer Frank Weymouth:

> I am inclined to think it best to make one or more borings at Black Canyon, because a dam at that point would utilize about thirty feet of fall [for power generation] which occurs between that point and our camp at Boulder Canyon, and this fall cannot be utilized in any other way.[13]

At the same time, the Black Canyon dam site was close enough that it could inundate the expansive reservoir site lying above Boulder Canyon; in fact, the Black Canyon site could actually provide for greater storage capacity than the original dam site surveyed in Boulder Canyon. By the beginning of 1922 geological explorations were underway at Black Canyon to discern the quality of bedrock and the depth of excavation necessary for dam foundations.[14] In July Weymouth reported to Davis that initial investigation of the upper end of Black Canyon (termed line "A") did not appear promising, advising him that:

9.2. Arthur Powell Davis while Director of the Reclamation Service.

> The foundation rock at line A in Black Canyon is not suitable for bearing pressures of 40 tons per square foot as used on the granite of Boulder Canyon, [and] the soft and porous structure of some of the rock may render this site entirely unsuitable for such a high dam. In this connection I will say that I am personally very doubtful of the feasibility of a dam 600 feet high in Black Canyon, unless the conditions at the lower site prove to be very much better…[15]

Despite this less than encouraging prognosis, exploratory work continued at the lower end of Black Canyon (line "D"). Conditions at the latter location proved more agreeable to Service engineers and, following a two-day field visit by the Director in November 1922, Davis could advise Weymouth:

> No one doubts the feasibility of the Black Canyon site. The rock in the bottom of line D is much better than that secured at the head of the canyon last year... I think we should make a choice between Black and Boulder Canyons as soon as possible so as to stop expenditures at the site rejected.[16]

With this endorsement by Director Davis, full attention soon shifted to Black Canyon. In early 1924—after Davis had formally resigned and the Service was officially renamed the Bureau of Reclamation—Weymouth officially recommended Black Canyon as the site for the proposed Boulder Dam. As the voluminous 1924 planning study for the project (commonly known as the "Weymouth Report") explained:

> An extensive geological examination has been made… [and while] both dam sites [Boulder and Black Canyons] are excellently adapted to the construction of a very high dam… , the granite of Boulder Canyon is superior to the breccia of Black Canyon for carrying great loads… [nonetheless] the investigations led to the adoption of the lower site in Black Canyon for the reason that it is more accessible [for construction equipment and materials]; the maximum depth to bedrock is less than at the upper site in Boulder Canyon and for the same height of dam the reservoir capacity is greater.[17]

Thus, the selection of Black Canyon was not made because it offered better geological conditions (in fact, based on this criteria, it was judged a bit less desirable than Boulder Canyon). Rather, Black Canyon was preferred because it would allow for a less costly structure (based upon savings in site excavation and in connecting the site to regional transportation networks) and provide for a larger reservoir.

In this light, it is worth recalling that the decision in December 1921 to investigate the Black Canyon site had been rationalized in terms of an additional thirty feet of head available for hydroelectric power production. This rationale was excluded from the recommendation presented in the 1924 Weymouth Report, but the omission was likely made more for political expediency than because the additional 30-foot power drop had somehow been forgotten. Hydroelectric power generation remained at the core of the planning for the "high dam" but—in light of possible controversy related to "Public Power" development—it was often downplayed in the mid-1920s. This is apparent in a description of the proposed dam provided to the engineer/author Edward Wegmann by the Bureau in 1927:

> The primary objects in the construction of this dam are: 1) To permit the use of the normal flow of the Colorado River in the upper Colorado River Basin without injury to prior rights below the reservoir by replacing such diversions from storage. 2) To extend the use of the waters of the Colorado River for irrigation and domestic purposes in and adjacent to the lower Colorado Basin. 3) To provide flood protection for lands along the Colorado River below the reservoir and in the Imperial Valley. The accomplishments of these objects requires a reservoir of large capacity and a high dam, presenting attractive possibilities of power development incidental to the use of water for the primary objects of the reservoir.[18]

Thus, the Bureau's official position was that hydroelectric power production was only "incidental" to the "objects" for building the dam. But, in fact, this was not reflective of the *de facto* role played by hydroelectric power in justifying the financial underpinnings of the dam. As Kleinsorge later observed:

> The generation of electrical energy was given the last place in the list of purposes of the act [authorizing construction of the dam] and last place in the priority of uses. Yet in spite of this ranking it is one of the most important phases of the project. It is through the sale of electric power that the project is to be made a financially solvent and self-supporting undertaking… The fact remains that no other practical method of financing the project had been suggested and if the project could not have been made self-supporting through the sale of electric power it would not exist today.[19]

Legislation calling for "construction of the All-American Canal and a dam at or near Boulder Canyon" was first introduced in Congress in 1922. Known publicly as the Swing-Johnson Act (and more formally as the Boulder Canyon Project Act), it remained in committee for the legislative session and never came up for a vote. Undeterred, Congressman Phil Swing and Senator Hiram Johnson (both of California) revised and resubmitted their bill three more times over the next six years. By the time of its passage in 1928 it called for a dam with a reservoir capacity of at least 26 million acre-feet and a power plant to be built by the federal government but leased to other entities (be they public or private) for operation and power generation.[20]

By the time the final site location for the lower Colorado storage dam was recommended in the 1924 Weymouth Report, so much effort already had gone into the promotion of a "Boulder Canyon Project" that no effort was made to transform the nomenclature to the "Black Canyon Project" or "Black Dam."

Nonetheless, from 1924 on, all work related to Boulder Dam revolved around the lower site (line "D") in Black Canyon and this is where the structure stands today.

The Design of Boulder Dam

During the early planning stages for what became the Boulder Canyon Project, Davis and his staff made an effort to consider a range of possibilities for the design of the big storage dam on the Lower Colorado. Based upon the Service's experiences with the Roosevelt, Elephant Butte, and Arrowrock dams, it is not surprising that a massive concrete/masonry gravity design attracted the interest of Davis, his Chief Engineer Frank Weymouth, and Dam Design Engineer John L. Savage. At the same time, the Service had experience building massive embankment dams (such as Belle Fourche in South Dakota and Strawberry Valley in Utah) as well as thin arch concrete masonry dams (Pathfinder and Shoshone, both in Wyoming). Although the decision to utilize a curved gravity concrete design involved some preliminary consideration of alternative designs, selection of a massive curved gravity design came quickly and apparently involved little laborious review of alternative designs.

9.3. John (Jack) L. Savage, Chief Design Engineer, Bureau of Reclamation.

In late 1920 Davis initiated correspondence with Lars Jorgensen, a European-trained engineer who had become a prominent advocate of thin arch dam design (especially constant angle arch dams). Davis wrote to Jorgensen in order to help determine whether a large thin arch dam might be feasible to build across the lower Colorado.[21] While previously Davis had been prominently associated with massive gravity dams such as Roosevelt and Arrowrock, he also retained an interest in the arch designs (such as those used for the Service's Pathfinder and Shoshone dams in Wyoming) and his interaction with Jorgensen testifies to this point.[22] During the next year, the use of a thin arch design (either constant radius or constant angle) officially remained a possibility, but little action to promote or investigate such a design is evident in available records.[23]

The idea that the Service would rely upon a massive design was publicly expressed by Davis as early as October 1920 (even before he corresponded with Jorgensen) when he wrote to J. W. Reagan, Chief Engineer of the Los Angeles County Flood Control District, in response to a "request for some information concerning tentative plans made for a dam in Boulder Canyon." In his response to Reagan, Davis indicated that "studies have been made for a section of masonry or concrete of the gravity type, and a rock fill and earth section, the latter not being regarded as certainly feasible."[24] In 1924 Volume Five of the Weymouth Report focused specifically on "Investigations, Plans and Estimates" and presented the results of the Bureau's dam analysis undertaken over the preceding four years. In this study, no mention is made of any thin arch designs that may have been considered for the big storage dam. Instead, the Weymouth Report indicated only that "studies have been made of rock-fill and concrete dams of various types," further explaining:

> there is a grave question whether life and property below a dam of such unprecedented height and a reservoir of such enormous capacity should through the construction of a rock fill dam be subjected to a risk which could be removed by the adoption of a concrete dam… With all possible safeguards taken in the construction of a rock-fill of the height proposed it must be admitted that its overtopping would result in certain and sudden destruction with overwhelming disaster in the valley below. The dams adopted are believed to be the safest that can be built—concrete dams of the gravity type built on a curved plan and estimates prepared indicate that the concrete dams could be built at less cost than rock-fills of the same height." [note: the use of the plural 'dams' in this quotation refers to three designs of various heights ranging from about 525 feet to over 700 feet developed for the same site].[25]

Although the Bureau estimated some possible economic advantages for selecting a massive curved gravity design, concerns over the possibility that a rock-fill design might someday be overtopped comprised a key rationale for selecting a curved gravity design. In fact, the Weymouth Report went so far as to advocate a curved gravity design that would not feature any spillway, noting that overtopping could probably be prevented by opening up all possible discharge outlets through the powerhouse and the dam. But even if the flooding overwhelmed the capacity of the discharge outlets, the report reassured that:

> Any overtopping would be of short duration and [designs for the concrete gravity] dams have been designed to pass rare floods over the top with safety which can not be done in the case of a rock-fill dam.[26]

Instead of spillways drilled through the rock abutments, the Weymouth Report proposed that outlet pipes (controlled by huge valves) be built directly into the dam itself. These could draw water from the lower depths of the reservoir and discharge it from the downstream face of the structure. The other means of discharging water from the reservoir would be through penstocks drilled through the rock abutment along the Nevada side of the canyon; these would feed into a hydroelectric power house about a half mile downstream from the dam. In formulating a basic plan for how best to construct the dam, Weymouth also proposed that the same tunnels used to carry water to the powerhouse could provide vital service during construction. Specifically, they were to divert the flow of the Colorado River so that temporary rock-fill cofferdams could protect the site from flooding and facilitate excavation.

By the beginning of 1924 the Weymouth Report laid out the basic features of what would become Boulder Dam. The plan evolved over the next few years and by 1928 important revisions had been made under the supervision of dam engineer J. L. Savage. These included:

1) drilling of diversion tunnels through *both* the Nevada and Arizona abutments (two tunnels on both sides of the river);

2) construction of two "glory-hole" spillways that would connect into the diversion tunnels and insure that the dam would never be overtopped;

3) construction of powerhouses immediately downstream and adjacent to the dam structure on both the Nevada and Arizona sides of Black Canyon; these would tap into the diversion tunnels and to other tunnels connected to outlet towers built directly upstream from the dam.[27]

Clearly, these changes represent important alterations to the Weymouth design and are of central importance in defining the form of the dam/powerhouse/ penstock/ spillway system as it was actually built. But, beyond the drilling of spillway discharge tunnels to feed into the diversion tunnels, they do not constitute anything that cannot be understood as an evolution of the Weymouth design. And even the addition of spillway tunnels represented an uncomplicated (yet certainly creative) expansion of Weymouth's diversion tunnel concept.

During the mid-1920s, the specific character of the Boulder Dam design continued to evolve as more was learned about geological conditions and as the Bureau became interested in utilizing the "Trial-Load" method of design to confirm the safety of the massive curved gravity design. While the "Trial-Load" method of analysis undoubtedly figured into the final dimensioning of the dam's profile, it did not prompt any dramatic changes or modifications.[28] In fact, it is difficult to discern any radical differences between the preliminary profile that accompanied Weymouth's 1924 report and the design as built. Both represent curved gravity designs featuring extremely ample gravity sections and the use of "Trial-Load" techniques of analysis did little in terms of altering the basic form of the design. In the same way, research on scale models of the dam also figured into the Bureau's analysis of structural safety and gave them greater confidence in its stability, but it is difficult to perceive how the basic form of the design was altered by such work.[29]

In May 1928—near the end of the approval process for the Boulder Canyon Project—Congress authorized the formation of a special "Colorado River Board," separate and distinct from the Bureau's own board of consulting engineers, and charged it with providing an independent assessment of the proposed dam's safety and feasibility.[30] At the end of the year, just prior to congressional passage of the Boulder Canyon Project Act, the Colorado River

Board approved the dam's basic design, but recommended that the maximum allowable stresses in the massive structure be reduced from 40 tons per square foot to 30 tsf. Although this might have appeared to the layperson as a rather simple way to increase the strength of the design, to the Bureau it presented a problem because strict adherence to a 30 tsf limit would significantly add to the (already massive) bulk of the dam and significantly increase its cost. Without overtly resisting this directive, the Bureau nonetheless made no meaningful alteration to the existing design. Instead, the Bureau opted to claim that more sophisticated mathematical analysis (in line with the "Trial-Load" method) indicated that the proposed design in fact did not exceed a maximum allowable stress of about 34 tons per square foot and this was considered adequate to meet the 30 tsf criteria. In Mead's words: "It is not believed that the maximum stress as finally calculated will appreciably exceed the 30-ton limit. It is believed that the general plan of the dam can be agreed upon without serious difficulties."[31] The Colorado River Board's recommendation thus had no substantive effect on the final design as the Bureau simply asserted that they could adhere to the 30 tsf limit without making any substantive design changes.[32]

In his 1928 "Revised Plan" for the dam, Savage took care not to criticize the Weymouth Report as being somehow faulty and in need of correction. Rather, he stated that "The Weymouth plan for the dam and power plant… constitutes a preliminary study on which to base an estimate of cost. The plan was not considered as a final design and should not be considered as such."[33] In this context, the design of Boulder Dam cannot be ascribed to any single individual, but instead represents a collaborative effort that extended over several years' time. Davis, Weymouth, and Savage all played important roles in overseeing preparation of the basic design, and, in concert with other Service/Bureau staff members, deserve credit as designers of Boulder Dam.[34]

Los Angeles

The preceding discussion has focused on engineering aspects of the basic dam design. In contrast, the architectural treatment of the dam's surface features was handled in a very different manner and emanated from a source separate from the Bureau's Denver office. During the 1920s the architectural treatment of the dam was assumed to adhere to a neo-classic style featuring design motifs such as eagles with wide-spread wings. In 1931, long after all the major technical issues involving the design had been determined, the Bureau commissioned Los Angeles architect Gordon Kaufmann to develop a more modern appearance for the dam. By simplifying the surface treatment of the design and adopting a monumental "art deco" style, Kaufmann created an evocative, streamlined facade for the massive structure. While the prominence of the dam in American culture is no doubt tied in part to its modernistic design motif, the circumstance of hiring a non-government architect to carry out this work occurred very late in the design process and was very much separate and distinct from the rest of project.[35]

In many ways it is appropriate that the surface treatment for the Boulder/Hoover Dam emanated from a Los Angeles architect because, in the interim between the initiation of the project by Imperial Valley advocates after World War I and its final authorization in the late 1920s, the City of Los Angeles and other southern California communities came to play an increasingly vital role in promoting the Boulder Canyon Project. As early as July 1921 Los Angeles had expressed interest in helping build Boulder Dam in return for control over the hydroelectric power plant.[36] And by 1924 this interest had expanded into a formal water claim filed on the city's behalf for 1500 cubic feet per second of Colorado River flow.[37] With this claim, the City of Los Angeles served as the catalyst for the Colorado River Aqueduct and for what soon evolved into the Metropolitan Water District of Southern California (MWD).

Perhaps most importantly in terms of Congressional approval for the Boulder Canyon Project, the MWD was to comprise the most important customer for hydropower. As noted in the MWD's first annual report:

> It was early recognized that to secure favorable [congressional] consideration [the Boulder Canyon Project] must be self-supporting and that the power to be generated from any development… must find a market which would eventually return all costs of the entire project to the Government. As additional engineering work for a Colorado River Aqueduct was done it became evident that any practicable diversion of the river must… involve pumping. Such pumping was practicable only if a large amount of power could be obtained at low price. This created, at once, a potential market for a substantial part of the power from any major Colorado River development. When these facts… were laid before Congress support for the Swing-Johnson measure became easier to obtain.[38]

Put another way, the need to use huge amounts of electric power to pump water through the Colorado Aqueduct helped convince hesitant Congressmen that Boulder Dam would not become a financial white elephant, generating huge quantities of unmarketable power. The MWD could sign contracts guaranteeing power sales, and, in turn, the Federal Government (and Federal taxpayers) could rest assured that such contracts would be honored because the MWD possessed the right to directly tax land within its service area. In 1930, when Secretary of the Interior Wilbur authorized 50-year leases governing use of Boulder Dam power, 64 percent of the dam's power was reserved for use in Southern California, 36 percent went to the Metropolitan Water District of Southern California to pump water through the Colorado Aqueduct, a little more than 9 percent to the Southern California Edison Company and other private power companies, and about 18 percent to the City of Los Angeles and other municipally-owned utilities in Southern California (Los Angeles and Southern California Edison were to share primary responsibility for operating the dam's power plant). Although Arizona and Nevada were each allotted 18 percent of the dam's power, many years would pass before these states developed markets large enough to utilize their full share.[39]

Thus, the primacy of hydroelectric power that energized Davis' initial promotion of the Boulder Canyon site because of its relative proximity to southern California—as well as the initial investigation of the Black Canyon site because it allowed for the capture of an additional 30-foot water drop — proved key to the dam's legislative and financial success. While the project may have been born out of the flooding of the Imperial Valley by a rampaging Colorado River, its long-term viability rested upon the ability of urban interests in greater Los Angeles to absorb its enormous cost— budgeted at a minimum of $165 million in the 1928 Boulder Canyon Project Act.[40] And because of the tremendous revenue that could be generated by power sales to an urban market, the Bureau could readily adopt a massive curved gravity design requiring more than 4 million cubic yards of concrete.

Fostered by a desire to promote and protect irrigation in the Imperial Valley, Boulder/Hoover Dam ultimately depended upon the urban development of Los Angeles to effect its construction. In this, the dam's history highlights how in the 1920s the Bureau's mission was shifting away from support for irrigated agriculture (as called for in the 1902 National Reclamation Act) and towards a broader involvement in western economic development encompassing hydroelectric power generation and urban growth.

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Endnotes:

1. Norris Hundley, *The Great Thirst: Californians and Water, 1770-1990* (Berkeley: University of California Press, 1993) p. *205;* Mildred de Stanley, *The Salton Sea: Yesterday and Today* (Los Angeles, California: Triumph Press, c. 1966), pp. 17-24; and Kevin Starr, *Material Dreams: Southern California Through the 1920s* (New York: Oxford University Press, 1990), pp. 20-44. The Colorado River drains over 200,000 square miles of land flowing west and south out of the Rocky Mountains. After crossing the Utah/Arizona border and passing the river crossing point known as Lee's Ferry, the Colorado flows westward through the Grand Canyon. Soon afterwards it reaches the Boulder and Black Canyons that straddle the Arizona/Nevada border. Turning southward once it reaches the vicinity of Las Vegas, Nevada, the Colorado River soon forms the 200-mile long border between the states of California and Arizona. Finally, at a distance more than 1000 miles from its headwaters in Wyoming and Colorado, the Colorado River enters, at least it did prior to the erection of large storage dams, the state of Sonora, Mexico and disperses across an expansive delta to the Gulf of California.

2. Starr, *Material Dreams,* pp. 25-9; Beverly Moeller, *Phil Swing and Boulder Dam,* (Berkeley: University of California Press, 1971), p. 5; de Stanley, *The Salton Sea,* pp. 25-7. Economic growth of the valley was rapid and, by October 1903, 100,000 acres were under cultivation, supporting a population of 4,000.

3. Starr, *Material Dreams,* pp. 34-6.

4. Starr, *Material Dreams,* pp. 38-40; de Stanley, *The Salton Sea,* pp. 33-43.

5. Moeller, *Phil Swing and Boulder Dam,* pp. 10-1.

6. Moeller, *Phil Swing and Boulder Dam*, p. 15.

7. Hundley, *The Great Thirst,* pp. 204, 449-50.

8. Hundley, *The Great Thirst,* p. 207.

9. At first, fearing that it might overshadow their efforts to promote an All-American Canal, the Imperial Irrigation District did not embrace Davis' efforts to promote a large-scale storage dam as part of the development of the Lower Colorado River, but this reticence dissolved fairly quickly. See Hundley, *The Great Thirst,* pp. 208-9. The possibility of federal involvement in building some type of storage dam across the lower Colorado River was championed by the indefatigable Congressman Phil Swing who had earlier served as lawyer for the Imperial Irrigation District. As a member of the U.S. House of Representatives throughout the 1920s, Swing assumed responsibility for keeping the All-American Canal/Boulder Canyon Project in the public eye. Working with his counterpart, California Senator Hiram Johnson, Swing kept abreast of all the political nuances related to the Boulder Canyon Project, and he made sure that during the 1920s Congress was presented with a series of Swing-Johnson Acts positing federal authorization of the project.

10. Moeller, *Phil Swing and Boulder Dam, pp.* 17-8; Paul Lincoln Kleinsorge, *Boulder Canyon Project: Historical and Economic Aspects* (Stanford University, California: Stanford University Press, 1941), p.76; the cost of planning studies for Boulder Dam eventually came to about $400,000 with approximately $170,000 of this coming from irrigation interests in Southern California.

11. Kleinsorge, *Boulder Canyon Project*, pp. 281-2; also see Jay Brigham, *Empowering the West: Electrical Politics Before FDR* (Lawrence: University Press of Kansas, 1998) for useful background on the debate over public vs. private power in the pre-New Deal Era.

12. For more on early surveys of Colorado River dam sites see E. C. La Rue, *Colorado River and Its Utilization* (Washington D.C.: Government Printing Office, 1916), USGS Water Supply Paper No. 395; E. C. La Rue, *Water Power and Flood Control of Colorado River Below Green River* (Washington D.C.: Government Printing Office, 1925), USGS Water Supply Paper No. *556;* and Joseph Stevens, *Hoover Dam: An American Adventure* (Norman: University of Oklahoma Press, 1988), p. 270. During debates about the project in the mid-1920s, the possibility of building a smaller-scale, less expensive "flood control" dam (usually at a site designated Mohave Valley near the town of Topock, California) was frequently raised because it could be erected without reliance upon hydroelectric power sales. However, this dam would not have allowed for a significant storage of flood waters for irrigation, domestic water supply or power and thus held little appeal except for people interested in essentially blocking the construction of a large-scale dam on the lower Colorado. The desirability of a Boulder Canyon reservoir over one located at Glen Canyon (located upstream from the Grand Canyon) is prominently stressed in A. P. Davis to F. E. Weymouth, December 18, 1921; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, November 1, 1921-December 31, 1923

13. A. P. Davis to F. E. Weymouth, December 18, 1921; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re: Dams and Reservoirs, November 1, 1921- December 31, 1923.

14. Stevens, *Hoover Dam: An American Adventure*, p. 21, provides a Bureau of Reclamation photograph showing geological test drilling underway in Black Canyon in February 1922.

15. Chief Engineer (F. E. Weymouth) to Director (A. P. Davis), July 7, 1922; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, November 1, 1921-December 31, 1923.

16. A. P. Davis to F. E. Weymouth, November 30, 1922; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, November 1, 1921-December 31, 1923.

17. Bureau of Reclamation, "Report on the Problems of the Colorado River, Volume 5, Boulder Canyon: Investigations, Plans and Estimates," February 1924, p. 3; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 477; Colorado River, Weymouth Report, 1924, part 5.

18. Memorandum from Chief Engineer R. F. Walter to Commissioner Mead, February 21, 1927; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, December 31, 1923-1929.

19. Kleinsorge, *Boulder Canyon Project,* pp. 83-4.

20. Kleinsorge, *Boulder Canyon Project,* p. 78.

21. Lars Jorgensen to A. P. Davis, December 15, 1920; A. P. Davis to Lars Jorgensen, December 23, 1920; Lars Jorgensen to A. P. Davis, December 29, 1920; and A. P. Davis to Lars Jorgensen, January 10, 1921; all in National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, 1920-November 1, 1921.

22. For evidence of Davis's early interest in Jorgensen's design work see the file on "Yuba Dam" (later called Spaulding Dam) built by the Pacific Gas and Electric Company in northern California in 1912-1913 in the, John R. Freeman Papers, MIT Archives and Special Collections, Cambridge Massachusetts.

23. See index attached to F. E. Weymouth (Chief Engineer) to Director (A. P. Davis), December 2, 1921; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, November 1, 1921-December 31, 1923.

24. A. P. Davis to J. W. Reagan, October 5, 1920; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, 1920-November 1, 1921.

25. Bureau of Reclamation, "Report on the Problems of the Colorado River, Volume *5,* Boulder Canyon: Investigations, Plans and Estimates," February 1924, p. 4; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 477; Colorado River, Weymouth Report, 1924, part 5.

26. Bureau of Reclamation, "Report on the Problems of the Colorado River, Volume 5, Boulder Canyon: Investigations, Plans and Estimates," February 1924, p. 6; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 477; Colorado River, Weymouth Report, 1924, part 5.

27. J. L. Savage, "Revised Plan for Boulder Canyon Dam and Power Plant: Memorandum to Colorado River Board," November 24, 1928; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 492; Folder 301.1, Colorado River Project.

28. For early confirmation on how the "Trial-Load" method was used to justify the final design see Elwood Mead, "Memorandum to the Secretary re the Meeting of the Consulting Engineers to Approve Detail Plans of Boulder Dam," December 28, 1929; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Board & Engineering Reports on Construction Features, 1929. Also see U.S. Department of the Interior, *Boulder Canyon Project Final Reports, Part IV - Design and Construction* (Denver: Bureau of Reclamation, 1941), pp. 25-8.

29. Model tests are noted in U.S. Department of the Interior, *Boulder Canyon Project Final Reports, Part IV- Design and Construction* (Denver: Bureau of Reclamation, 1941), pp. 28-9.

30. The Colorado River Board was authorized in May 1928 as Congress debated the fourth Swing-Johnson Act. Concern over the safety of the proposed Boulder Dam was heightened by the

failure of Los Angeles' St. Francis Dam in March 1928 which killed approximately 400 people; the Colorado River Board apparently intended to help assuage fears that a similar fate might befall Boulder Dam. See Moeller, *Phil Swing and Boulder Dam,* pp. 11, 114-5, 118. Also see Donald C. Jackson and Norris Hundley, "Privilege and Responsibility: William Mulholland and the St. Francis Dam Disaster," *California History*, 82 (Fall 2004) pp. 8-48, 72-78.

31. The manner in which the design could be considered as meeting the 30 tsf criteria are described in Elwood Mead, "Memorandum to the Secretary re the Meeting of the Consulting Engineers to Approve Detail Plans of Boulder Dam," December 28, 1929; National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Board & Engineering Reports on Construction Features, 1929.

32. The acceptance by the Colorado River Board of the Bureau's rationale for not revising the design is acknowledged in U.S. Department of the Interior, *Boulder Canyon Project Final Reports, Part IV-Design and Construction* (Denver: Bureau of Reclamation, 1941), p. 25.

33. J. L. Savage, "Revised Plan for Boulder Canyon Dam and Power Plant: Memorandum to Colorado River Board," November 24, 1928, p. 1; National Archives, Denver; Records of the Bureau of Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 492; Folder 301.1, Colorado River Project.

34. 1927 correspondence concerning how design of the proposed Boulder Dam should be credited, reported that the design "was first proposed in the Denver Office of the Bureau of Reclamation under the supervision of Mr. J. L. Savage. Member, A.S.C.E (Designing Engineer, Bureau of Reclamation) and subsequently modified in minor particulars by Consulting Engineer A. J. Wiley Member, A.S.C.E, of Boise, Idaho, and L. C. Hill, Member, A.S.C.E, of Los Angeles, California." Significantly, both Davis and Weymouth, who were unquestionably involved in the evolution of the Boulder Dam Design, were both no longer employees of the Bureau when this letter was written and perhaps were excluded simply for this reason. See Chief Engineer (R. J. Walter) to Commissioner (Elwood Mead) February 21, 1927, National Archives, Denver; Records of the Bureau of the Reclamation, RG 115; General Administration and Project Records, Project Files, 1919-1945; Entry 7; Box 490; Folder 301.1, Colorado River Project, Correspondence re Dams and Reservoirs, December 31, 1923-1929.

35. The best discussion of Kaufmann's work in developing the architectural form of the dam is Richard Guy Wilson, "Machine Age Iconography in the West," *Pacific Historical Review* 54 (1985) pp. 463-93. After undertaking considerable research into the subject, Wilson could only report that: "Why Kaufmann was selected [as architect] remains unknown." p. 476.

36. Moeller, *Phil Swing and Boulder Dam,* p. 24.

37. Charles A. Bissell, *The Metropolitan Water District of Southern California: History and First Annual Report* (Los Angeles: Metropolitan Water District of Southern California, 1939) p. 36.

38. Bissell, *The Metropolitan Water District of Southern California: History and First Annual Report,* p. 38-9.

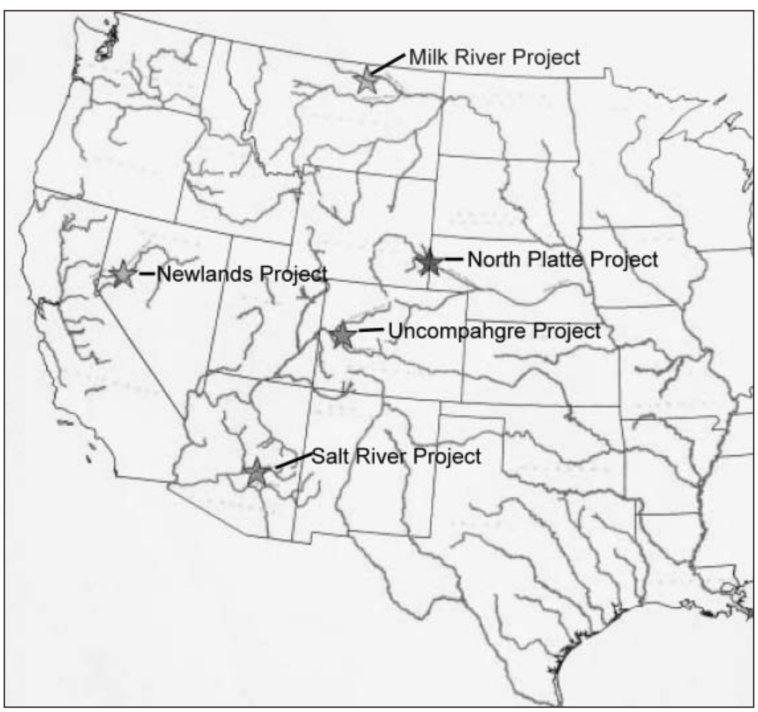
39. A good review and analysis of the Boulder/Hoover Dam power contracts is provided in Kleinsorge, *Boulder Canyon Project*, pp. 146-66.

40. Kleinsorge, *Boulder Canyon Project,* pp. 138-40, provides cost analysis of the Boulder Canyon Project Act indicating that more than $206 million would ultimately be due the Federal Government in repayment.

The First Five: A Brief Overview of the First Reclamation Projects Authorized by the Secretary of the Interior on March 14, 1903

By:
Shelly C. Dudley

While Frederick Jackson Turner might have declared that the frontier was at an end in 1893, countless lands within the American West had not yet been reclaimed or made productive. In the last quarter of the nineteenth century, the federal government surveyed the country in the western states and territories, examining potential diversion and storage sites while calculating irrigable acreage. The U.S. Geological Survey estimated that 30 million acres could be irrigated, but by 1890, only 3.6 million acres were being farmed. Because of the vision of certain individuals who knew that for America to reclaim its arid western lands required the involvement of the national government, the fertile acreage in the Salt River Valley in Central Arizona, the lands in western Nevada, the valley of the North Platte River in Nebraska and Wyoming, the farmers along the Milk River situated in northeastern Montana, and the region along the Uncompahgre River in Colorado would have the necessary water to promote and sustain growth. This is a brief overview of the first five projects authorized by the Secretary of the Interior under the national Reclamation Act from their beginning, to their place today in the settlement of the West.



10.1. Reclamation's first five projects.

John Wesley Powell, Civil War veteran, explorer of the Grand Canyon, surveyor of Western lands, and head of the U.S. Geological Survey, believed that the federal government should reserve lands for the small family farmer and assist in the development of irrigation projects. Powell wanted settlement of the West to be in the hands of the individual homesteader even though it would require support by Washington, yet not all the lands were still available; land speculators claimed much of the potentially good farm acreage. But neither the early small landowning farmer, nor land developers or eastern entrepreneurs, had the necessary resources to finance the construction of dams to store additional water to reclaim the western lands. In his report on arid lands, Powell wrote that he considered the character of the lands themselves, the engineering problems and suggested "legislative action necessary to inaugurate the enterprises by which these lands may eventually be rescued from their present worthless state."[1]

Promoters of western irrigation, including the influential National Irrigation Congress, maintained that the federal government should be involved in developing the arid lands. George Maxwell, a leading spokesman for the national irrigation movement, believed that settlement of western lands by yeoman farmers would solve the social ills of the eastern urban centers with the movement of the population and met with Frederick Newell, chief hydrographer with the U.S. Geological Survey. Newell, a protege of John Wesley Powell, surveyed the arid lands of the West and understood the plight of the homesteader who could not get enough water to irrigate his lands and grow crops to support his family. Maxwell and Newell met frequently with Wyoming Senator Francis E. Warren and Nevada Congressman Francis G. Newlands to devise a plan so that the government could sponsor federally funded water projects."[2]

At the turn of the century many in Congress realized that, without the support of the national government, settlement of additional lands in the West would not be possible; various congressman supported a reclamation act which would provide federal monies to construct irrigation works and further the development of the arid lands. Yet, only after the assassination of President William McKinley and the ascendency of Theodore Roosevelt to the presidency did Congress enact the national Reclamation Act. The statute, by authorizing the use of federal money from the sale of public lands, would make extensive areas of the West suitable for irrigation, provide homes for America's citizens, increase the agricultural production of the nation, and "make beneficial use of two of its national assets, land and water."[3]

Although the national Reclamation Act was not signed until June 17, 1902, government engineers prior to its passage had already investigated the western landscape for potential dam sites and irrigable farmlands. After the measure's enactment, the engineers of the U.S. Geological Survey and then the newly created U.S. Reclamation Service prepared a list of potential projects for the Secretary of the Interior to authorize. The Reclamation Service considered certain criteria, such as water supply, storage facilities, alignment of canals, and selection of feasible lands. While the engineers usually required several years of study to make these necessary determinations, the western settlers were eager to begin the work of reclaiming the land and wanted projects announced as soon as possible.

The Reclamation Service, aware of the current circumstances, recommended five projects that could be clearly defined with the costs and results estimated. As early as 1889 John Wesley Powell had explored the arid lands of the West, noting potential storage dam sites and the fertility of the land. Fellow geological engineer, and later official in the Reclamation Service, Arthur P. Davis surveyed the land in the West by the turn of the century. With this background in place, it would not take long for the first projects to be selected by the Secretary of the Interior.

On March 7, 1903, Charles D. Walcott, Director of both the U.S. Geological Survey and the U.S. Reclamation Service recommended the first five projects to the Secretary of the Interior: Sweetwater (North Platte) situated in Wyoming and Nebraska, Milk River in Montana, Truckee (Newlands) in Nevada, Gunnison (Uncompahgre) located in Colorado, and the Salt River Project in central Arizona. On March 14, 1903, Secretary Ethan A. Hitchcock concurred with the suggestions, stating that the Reclamation Service should concentrate its efforts upon these five projects, secure the lands needed for the dams, reservoirs and appurtenant irrigation works, negotiate with current owners of irrigable lands, and prepare contracts for the construction of the reclamation works.[4]

Each project presented both unique conditions while being similar in other respects. All five projects contained both private and public lands. A few projects had some irrigation works, while others needed the construction of storage dams to provide additional water supply as well as canals and ditches to bring the water to the land. Towns and communities were created within the reclamation projects while the opportunity for others to grow and become major cities became a reality. By examining individually the first five projects, we can appreciate the impact of the national Reclamation Act on western America.

The First Five

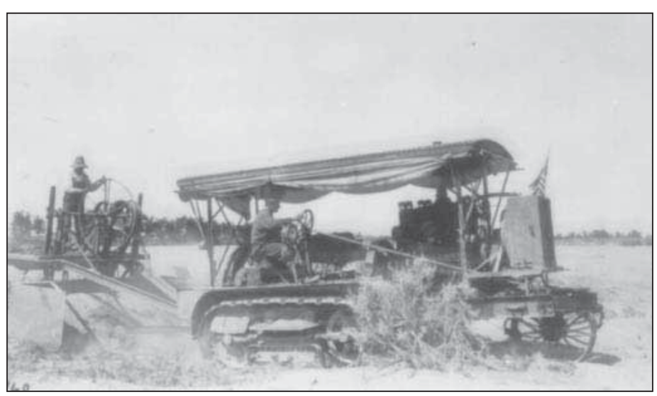
Newlands Project (Truckee)

Is it any wonder the Newlands Project was selected by the staff of the Geological Survey, considering the national Reclamation Act was sponsored by Nevada congressman Francis Newlands and much work was already done in the state by government and private engineers? Even though the money available from Nevada's reclamation fund was the smallest of all the western states and territories, the need was great. At the turn of the century, farmers irrigated approximately 500,000 acres throughout the state, but the potential was limited because a few settlers and cattlemen controlled much of the land around the water sources. The Humboldt, Truckee, Carson, and Walker streams provided most of the water during the winter months, but water storage was necessary for the successful reclamation of the desert lands year round.[5]

As early as 1860 ranchers arrived in the Lahontan Valley in northwestern Nevada and gradually started to farm, with cultivated land reaching 5,000 acres by 1880. The Powell Irrigation Survey examined the resources in Nevada, indicating that the Truckee River could be diverted through a canal to the Lahontan Valley, but beyond this study, no viable action was taken. At approximately the same time, Francis G. Newlands, son-in-law and trustee of the William Sharon estate which held extensive acreage in Nevada, moved to Carson City and started to acquire his own land along the Truckee River in 1889. Newlands expanded his holdings and commissioned surveying parties to examine reservoir and canal sites; the entrepreneur also used reclamation as an issue in his bid for political office. Between1899 and 1900, L. H. Taylor, an engineer and director of the University of Nevada Agricultural Experiment Station, investigated a number of reservoir locations and, after the passage of the Reclamation Act, surveyed additional sites, including those along the Carson and Truckee rivers. Rainfall in the Carson Sink Valley averaged approximately six inches a year, not enough to provide a stable water supply without the construction of storage reservoirs.[6]

The initial irrigation structures of the project designed by the reclamation engineers included the earthen Derby Diversion Dam on the Truckee River, the thirty-one-mile Truckee Canal, with a carrying capacity of 1,200 to 1,500 second feet, the Carson River Diversion Dam, and a distribution system of canals and laterals carrying water to the farm units. The original plan for a storage dam on Lake Tahoe was halted by the property owners along the lake who feared the water levels would fluctuate greatly, so federal engineers constructed the Lahontan Dam and Reservoir in 1911. A legal settlement was finally reached with the Truckee River General Electric Company concerning storage of water at Lake Tahoe, and the federal engineers proceeded with construction of a dam on the lake. As part of its work to insure the productivity of the lands, the Reclamation Service constructed a network of drainage ditches to prevent rising groundwater levels from causing alkali damage to the land and to crops.[7]

With designation of the Newlands Project as one of the first projects, changes occurred that could only happen when enough water is available. Prior to its selection as a reclamation project, Churchill County, being the slowest growing county in the state, contained only 830 people within 4,883 square miles, but within ten



10.2. Levelling land on the Newlands Project.

years Fallon alone, the county seat, boasted a population of 1,000 people in 1913. The community, which had originally served as a supply depot for the nearby mining districts, experienced real growth and a building boom. By 1926 Fallon's residents doubled to 2,000 as the town's population increased due to construction workers on the reclamation project, suppliers providing needed livestock and equipment to Reclamation, and new homesteaders eager to farm the land with the newly developed water. The City of Fallon contracted with the Reclamation Service to supply residents with electricity produced by the Lahontan hydropower plant. The system had grown to such an extent that eighty-five percent of possible customers were receiving power from the reclamation project.[8]

By the mid-1920s alfalfa was the principal crop, still providing for the original livestock industries focused on cattle, sheep, and hogs, while dairy farms started to make an ever growing appearance in the region. Farmers also grew wheat, barley, potatoes, sugar beets, and garden truck with celery and cantaloupes harvested commercially. With the assurance of a stable water supply for growing sugar beets, the Hinze Brothers of California organized the Nevada Sugar Company in 1910 and opened a factory in the center of Fallon, providing new opportunities for the farmers and factory workers.[9]

The acreage on the Newlands Project encompassed over 200,000 acres, and boosters, including the Central and Southern Pacific Railways which owned approximately 10,000 acres, expected to have all that land farmed. Within ten years of the selection of the Newlands Project, however, farmers irrigated just 43,000 acres, and that amount increased to only 45,000 a decade later despite water right applications having been filed for 70,000 acres in 1923. While at least half the farmland held was in private ownership, the remaining public lands were open to homestead entry, providing opportunities for new settlers.[10]

Uncompahgre Project (Gunnison)

First described by Captain J. W. Gunnison in 1853, "as a desert unfit for cultivation and inhabitation only by savages," the southwestern Colorado territory attracted new people beginning with the westward movement of miners. The Ute Indians were forced to give up their lands between 1868 and 1881 and relocate to the Utah Territory, while their homelands opened to the public for settlement. With the development of the mining industry and the necessity for foodstuffs to be near at hand, enterprising farmers seized the opportunity to move into the Uncompahgre Valley and construct ditches, diverting water from the Uncompahgre River to irrigate the crops; the first shipments of hay were delivered to the mines.[11]

The valley contained approximately 175,000 acres of irrigable land and the new settlers believed the river contained enough water for the fertile acres. In the early 1880s the immigrants formed several canal companies, including the Montrose and Uncompahgre Ditch Company and the Delta Ditch Company, constructing over 110 ditches and 475 miles of canals. Besides providing water to the farmlands, a number of these companies delivered water to the burgeoning towns. As was typical in many western regions, the farmers and canal companies overestimated the amount of land that could be irrigated by the 1890s, putting only 30,000 acres under the plow. Water was in short supply, especially during the summer growing season, and there was not enough to irrigate the agricultural lands.[12]

The farmers started looking elsewhere for an additional water supply, at first considering taking water over the divide from the Cimarron River. Then in 1890, F. C. Lauzon conceived the idea of building a tunnel from the Gunnison River to the Uncompahgre Valley. Although the U.S. Geological Survey conducted a reconnaissance survey of this project, the implementation of any plan involving the construction of a tunnel was beyond the means of the people in western Colorado. The Colorado Legislature was approached about assisting in this project, and in 1901 the Legislature set aside $25,000 for the construction of the tunnel. That same year, Frederick Newell allocated $4,000 to survey the tunnel and canal location. The Geological Survey mapped the region as well as conducted several additional surveys, including the geologic structure of the tunnel route and the elevations of the region. The State of Colorado started construction on the tunnel in the fall of 1901, but the project was abandoned due to lack of funds.[13]

On Secretary of the Interior Ethan Hitchcock's initial list of five projects was the Gunnison Project. Beyond the initial expenditures made on surveying possible irrigation sites in southwestern Colorado, Walcott may have had other reasons for suggesting the Uncompahgre Valley as the location of one of the first reclamation projects selected. Congressman James Shafroth of Colorado, besides being a member of the House Committee on Irrigation, met extensively with Representative Newlands, Senator Henry Hansbrough of North Dakota, and Senator Warren and Congressman F. W. Mondell of Wyoming, following President Theodore Roosevelt's decision that reclamation would be a priority in his administration. While Shafroth initially introduced his own reclamation legislation, he worked with these men on a congressional conference committee that eventually drafted the measure that became the national Reclamation Act; Shafroth was also the floor manager of the House when the Newlands bill came to a vote in Congress.[14]

To supplement the flow of the Uncompahgre River, the federal engineers used the original plan of diverting the Gunnison River by a tunnel six miles in length and a canal almost twelve miles long. The Reclamation Service started work almost immediately and over the next several months the government acquired the rights to the tunnel, although it took several years before the arrangements became final. Under the aegis of the Reclamation Service, contractors began digging the tunnel, but within a year, the builders went bankrupt and the federal engineers continued to direct the crews on the project, having to change the location of the tunnel. As a testament to the engineering efforts, a model of the Gunnison tunnel was prepared and shown at the Louisiana Purchase Exposition in St. Louis in 1904, and President William Howard Taft was the guest of honor at the grand opening ceremonies for the Gunnison-Uncompahgre Tunnel on September 23, 1909. During the ensuing decades, the Reclamation Service built additional diversion dams and either purchased private canals or constructed new ones, totaling approximately 470 miles, to bring water to the project lands. In 1932 the Uncompahgre Valley Water Users' Association accepted control of the project from the federal government.[15]

When the Uncompahgre Project was authorized in 1903, the reclamation engineers estimated that approximately 171,000 acres could be irrigated, with 116,000 acres being already in private ownership and most of the balance open for reclamation homestead entry. As construction continued on the irrigation works, water was delivered as soon as the Gunnison tunnel was completed. Although Charles Dana Wilber's epigram that "rain follows the plow" was part of the Myth of the Garden in the nineteenth century Great Plains, in the West "where there is water people will come" is a truism. The population of the Uncompahgre Valley grew as did the acres of cultivated lands. The population in the Uncompahgre Valley was 5,171 in 1912 with 3,464 living on the project farms, which increased to over 6,000 in 1923. In 1913, the Uncompahgre Project canals delivered water to 37,000 acres while the private irrigation structures transmitted water to 13,600 acres. While the major crops were alfalfa, potatoes, oats, wheat, sugar beets, and apples, the Project Engineer suggested the farmers diversify their products to include dairy stock. He also suggested settlers better prepare the soil, acquire better seed, and improve the methods of water delivery and use. Within the next decade, the acreage increased to 64,180 acres irrigated within the project.[16]

10.3. About 1914, "Slim" Pickins, an Uncompahgre Valley farmer, displayed produce from his farm at the county fair in Montrose, Colorado.

Milk River

As in most western territories, farming in the Montana region saw little activity until the 1860s, although limited agriculture occurred earlier near the fur trading posts. The gold miners rushing to stake and work their claims did not want or have the time to till the soil for vegetables and grains, requiring others to provide those commodities. Farmers soon came to cultivate the land and construct small water delivery systems. Although the Milk River Valley in northeastern Montana receives approximately 20 inches of rainfall, irrigation was a necessity. The communities of Chinook and Harlem developed canal systems with a communal diversion dam, as did the Bureau of Indian Affairs for the Assiniboine and Gros Ventre tribes on the Fort Belknap Indian Reservation. By the turn of the century farmers irrigated 35,000 acres, growing oats, vegetables, and pasturage for livestock. But without a stable water supply, the economic growth of the region could not be assured.[17]

Under the instructions of Frederick Newell, Geological Survey Engineer Gerard H. Matthews studied the feasibility of diverting water from the St. Mary River to the Milk River in 1900. The engineers determined that with the construction of a gravity canal between the two rivers, it was possible to transport water from one river to the other. Cyrus Babb continued the survey of the region, investigating various diversion points and identifying what lands needed to be withdrawn. Eventual plans depended, however, on an agreement between the governments of Canada and the United States, because the waters of the St. Mary River traveled through Canada before returning to the United States. Although a treaty would not be reached for almost a decade, the Reclamation Service suggested that the Milk River Project be among the first approved. The waters of the Milk River Project also created problems within the continental United States when, as requested by the Reclamation Service, a determination of water rights was set in motion in 1905. The U.S. Supreme Court, in deciding the case of *Winters v U.S.* in 1908, established the Indian and federal reserved rights doctrine, a precedent followed by today's judicial system.

Although it is not clear why the Milk River Project was among the first chosen, the United States government may have wanted to protect the water supply of the Milk River from overuse by Canadian farmers or possibly guarantee it as a stable source of water for the Indians on the Fort Belknap Reservation. In his autobiography, Newell noted that the Milk River Project had "international complications," and like the other first projects, he was instrumental in sending out the engineers to survey potential reservoir sites and alignments for canals.[18]

The Reclamation Service engineers designed a system of irrigation canals and dams which would deliver water to the farmers for the irrigation of 120,000 acres. Beginning with the construction of Lake Sherburne Dam, the stored water would be released into the St. Mary River before being diverted into the twenty-nine mile long St. Mary Canal and then discharged into the Milk River. The water continues to flow northward into Alberta, Canada, before re-entering the United States, traveling more than 200 miles where it is stored in the Fresno Reservoir until it is needed by the farmers, proceeding through a series of diversion dams having journeyed through 200 miles of canals, 219 miles of laterals, and 295 miles of drains.[19]

10.4. Freighting a portable engine to a sawmill on lower St. Mary Lake in June of 1906. The lumber was to be used in construction work on the Milk River Project.

As construction of the engineering features continued through several decades, settlement of the lands progressed slowly. Even though there was no formal opening of the Milk River Project by the Secretary of the Interior for many years, the Reclamation Service allowed World War I veterans to file entries on the public lands in 1920. During the next decade, landowners with large holdings, not eager to divide their land into the smaller units as required by the Reclamation Act, hindered development on the Project. New farmers also had a difficult time adjusting to the farming conditions and many left within the year after planting their first crop. Those that remained produced good yields of grains, hardy vegetables, and alfalfa, which supported the local livestock industry.[20]

Throughout the Montana drought of the late 1920s, and the Dust Bowl of the 1930s, the Milk River Project acted as a haven for those farmers who lost everything. The federal government assisted in relocating both the "dry land farmers" who had tried to make a living in other parts of Montana and Texas and Oklahoma settlers who saw their lands blown away. The Bureau of Reclamation's mission was still helping the small farmer make a living and settle the arid West.[21]

North Platte

When the early fur trappers and traders traveled through the North Platte Valley seeking beaver in the first decades of the nineteenth century, they were among the first Euro-Americans to visit the region west of the 100th meridian. The trails they helped blaze led later immigrants across the land to the northwest territories and established the first trading posts at Fort Laramie and Fort Casper in the Wyoming region. Following in the wake of the pioneers, who crossed the prairies to the green lands of Oregon and Washington, were the cattlemen who saw the open range as the space necessary for their livestock. But within the last two decades of the nineteenth century, homesteaders decided to stay in Wyoming and Nebraska, fighting the cowmen, the blizzards, and the droughts.

Although not initially receptive to the idea of irrigation as a means of watering the land, the farmers along the North Platte saw that increases in agricultural production were possible when they no longer relied solely on rainfall. They dug canals, used water wheels, and while envisioning the cultivation of 60,000 acres along the North Platte, they were lucky to irrigate between 5,000 and 8,000 acres with the limited water supply. As with most locations in the arid West, local capital or private investors could not raise the funds necessary to construct dams to store enough water for the irrigable lands. Surveys had been prepared at the turn of the century for the construction of irrigation works, but it was not until Wyoming Senator F. E. Warren helped with the passage of the national reclamation bill that there was hope for the lands along the North Platte.[22]

10.5. Pathfinder Dam on the North Platte (Sweetwater) Project.

As possible recognition for Warren's assistance as well as the Nebraska congressional delegation's efforts in enacting the national reclamation law, Secretary of the Interior Hitchcock authorized the Sweetwater Project, later known as the North Platte, as one of the first to be developed by the newly formed Reclamation Service. Within the space of ten years Reclamation completed the Pathfinder Dam, cornerstone of the project and named after the early explorer, John C. Frémont, who traversed the North Platte River and perchance thought one day that the river would be tamed and provide the necessary life-giving water to the land. Over the next two decades, federal engineers constructed a diversion dam and irrigation system, including the 130-mile long Fort Laramie Canal and the Interstate Canal. Reclamation delivered water to farmers as early as the 1908 irrigation season.[23]

There were immediate signs of success on the North Platte Project with the construction of the Pathfinder Dam. Agriculture expanded with over a thousand newly irrigated farms by 1912, and during the next two years, the farm population increased by fifty percent. Livestock, both cattle and sheep, were brought to the project lands to feed on the crops during the winter. By the mid-1920s, over two thousand miles of canals and laterals were constructed on the North Platte Project, bringing water to about 220,000 acres in both Wyoming and Nebraska. Reclamation engineers resurrected an earlier idea to construct a regulating reservoir with Guernsey Dam, at Goshen Hole, Wyoming, and built additional reservoirs at Lake Alice and Lake Minatare in Nebraska. With the assurance of a water supply, the farmers started growing "speciality crops," such as sugar beets and alfalfa while continuing to raise potatoes, oats, corn, wheat, and barley. Under Warren Act contracts, the waters from the North Platte Project's storage dams are delivered to an additional 100,000 acres.[24]

Although the early reclamation settlers on the North Platte Project now had a water supply, they still faced other hardships, especially if they were unfamiliar with irrigation farming. The strong winds often blew the topsoil away with the newly planted seed, and uneven application of water could send it all down the drainage ditch to the canal or river. Bounties were often placed on grasshoppers and gophers. Many of the new farmers could not produce enough crops to pay for all the costs of keeping a household and paying the reclamation charges too. Those who were successful were usually the farmers who came from neighboring states or regions and were familiar with agricultural techniques, such as soil preparation and crop rotation. After the First World War, the United States gave returning servicemen the opportunity to farm on the North Platte Project, but while these soldiers and sailors could survive on the battlefield, few would be productive in raising crops. Farming was not always an easy enterprise on a reclamation project.[25]

Salt River Project

The early travelers crossing southern Arizona on their way to California followed the Gila River, not usually proceeding up the Salt River. But when the miners discovered bodies of ore along the Hassayampa River and then the military came to keep the hostile Indians away, Jack Swilling found the remains of prehistoric canals in what became the Salt River Valley. By the 1870s other farmers and settlers found the land along the Salt River to be fertile and stayed to cultivate the soil, growing extensive fields of grain or alfalfa, or establishing commercial businesses, but within thirty years the flow of the river was over-appropriated and growth could not be maintained.

At least a half dozen companies constructed canals, and most were cooperative organizations of local farmers who worked together to build the irrigation channels to deliver water to their own land. In 1883 the Arizona Canal Company sold bonds to investors around the country in order to construct the Arizona Canal in the northern area of the Salt River Valley. This canal company expected to make a profit from the sale of land and water rights to new settlers and with its chief construction contractor, W. J. Murphy, and original incorporator, Clark Churchill, formed the Arizona Improvement Company. Sitting on the first Board of Directors were local businessmen, Murphy, Churchill, and William Christy, along with California and Nevada entrepreneurs, Frederick W. Sharon and Francis G. Newlands.[26]

W. J. Murphy and his family purchased several tracts of land under the Arizona Canal and started an experimental citrus orchard with over 1,800 young orange and other fruit trees from southern California. The trees proved so successful that other varieties were planted including olive and lemon. Because the Arizona fruit ripened prior to the orchards in Southern California, Arizona landowners could sell their produce to the eastern markets first. By the mid-1890s over 150,000 citrus trees were growing on 1,500 acres, and farmers learned they could grow the trees with less acreage and work than the traditional harvests of grain.[27]

10.6. The Granite Reef Diversion Dam diverting water into the Arizona Canal in 1908.

W. J. Murphy built the Ingleside Club, complete with a golf course, near the Arizona Canal to bring investors and potential landowners to the Salt River Valley. With the help of men like Murphy, the population of the Salt River Valley doubled between 1890 and 1900, reaching almost 20,000 residents, and irrigated acreage increased from 111,000 to 130,500 acres. By the turn of the century, however, the landowners realized that a storage dam was needed on the upper Salt River for growth to continue, but private enterprise could not provide the needed funding.[28]

Arizona's struggle for a permanent water supply moved to Washington, D.C., at the beginning of the new century. Benjamin Fowler, chairman of the Maricopa County Water Storage Committee, had been in the federal Capitol at various times since 1900, lobbying for passage of a bill to permit the county to issue bonds for construction of a dam, and he then stayed to fight for a federal reclamation act. Through the efforts of national reclamation lobbyist George Maxwell, Fowler, who later became the first president of the Salt River Valley Water Users' Association, became well acquainted with Frederick Newell and Gifford Pinchot, Chief Forester. Fowler offered the U.S. Geological Survey $1,500 in matching funds to continue its earlier investigation of the Salt River, including a survey of a damsite at the confluence of the Salt River and Tonto Creek. Maxwell moved to the nation's Capitol, leasing a house near Newell to aid Francis Newlands in his congressional fight for a reclamation act. At his Washington residence, Maxwell gathered Newell, Fowler, and Pinchot to discuss the national irrigation movement and a possible Salt River Valley reclamation project.[29]

Gifford Pinchot and George Maxwell were good friends with vice-president Theodore Roosevelt, a strong supporter of the reclamation and conservation movements. Following the ascendency of Roosevelt to the office of President, the reclamation measure passed Congress and received Roosevelt's signature. The Secretary of the Interior was authorized to choose the first projects from a list supplied by Newell. The influence of Newell, Pinchot, and Maxwell, with Fowler's organization in the Salt River Valley, made the Tonto Project an attractive enterprise to the federal government, although most of the land was in private ownership.

Within months of the passage of the Reclamation Act, engineers arrived in the Salt River Valley to survey the lands and possible location of irrigation works. Prior to the construction of what would become Theodore Roosevelt Dam, the engineers constructed a sixty-mile road through the rugged Superstition Mountains and the canyons of the Salt River to bring supplies from the railhead at Mesa to the dam site. Building the "Apache Trail" would be one of the most dangerous tasks of the dam construction process, and in its first month of operation, over a million and one half pounds of freight would be hauled over it. Louis C. Hill, the supervising reclamation engineer traveled the Apache Trail while overseeing construction of the Roosevelt Dam. Built between 1905 and 1911, crews laid stone quarried from the neighboring canyon walls for the rubble-masonry thick-arch structure which spanned the Salt River to an original height of 280 feet and crest length of 723 feet, holding back over 1,300,000 acre feet of water. Stonemasons cut the upstream and downstream faces of the six to ten-ton blocks which were laid in a stair step fashion, giving the dam its identifiable appearance. President Theodore Roosevelt attended the dam's dedication, traveling over the Apache Trail, on March 18, 1911.[30]

10.7. By 1907 the aerial tramway was delivering concrete from the batch plant to the Theodore Roosevelt Dam site. In order to reduce the cost of the project, Reclamation built a plant to manufacture cement at the dam site and even shipped cement down the Apache Trial to the construction at Granite Reef Diversion Dam.

Flooding would delay construction at the dam site, but would also lead to the present configuration of the Salt River Project. The Arizona Dam, just below the confluence of the Salt and Verde rivers, diverted water to the north side canals but was prone to damage by floods, and in 1905 a major flood swept down the Salt River. The Arizona Dam was washed away and the farmers north of the Salt River approached Louis C. Hill for assistance. To unify the lands in the Salt River Valley, the Reclamation Service constructed the 1,000 foot long Granite Reef Diversion Dam which diverts water to both the north and south side canals. The federal government purchased many of the existing canals within the Salt River Project boundaries and built additional ones to bring the waters of the Salt and Verde rivers to 170,000 acres.

After prolonged conferences on irrigable acreage and repayment costs of the project, Secretary of the Interior Franklin K. Lane signed over operational control of SRP to the Salt River Valley Water Users' Association in 1917. Significantly, the September 6, 1917, agreement permitted the Association to retain the power revenues generated at SRP facilities, thus allowing for its future growth. Conceived by the Reclamation engineers as a source of electricity for construction of Roosevelt Dam, power generation, developed at first through construction of a power canal and later as part of the dam, was in the drawings almost from the initial plans. During the 1920s, Salt River Project management expanded its hydropower installations with the construction of three additional dams on the Salt River, and more lands joined the Association, bringing its membership up to 242,000 acres.

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In 1902 the authors of the national Reclamation Act provided a way for the settlers to support their families and develop the West through farming. The first five reclamation projects encountered varying degrees of success, but all managed to transform the land, some as originally intended, others with certain limitations, and at least one changed a fertile agricultural valley into a major metropolitan center that sparked development of the whole state.

While the men of the Newlands Project envisioned irrigating 200,000 acres at its inception, only 62,000 acres received project water by 1970. Today claims by others to the waters of the Truckee and Carson rivers and Lake Tahoe, including land and water set aside for a wetlands project in Lahontan Valley and settlement of water rights with the Pyramid Lake Paiute Tribe, limit the amount available for farming. Despite these water woes, the population has increased from under 1,000 people when the Newlands Project was authorized to over 18,000 people living within the Project lands. The "businessman/farmer" has become a part-time entrepreneur and more than 4,000 part-time farms, averaging thirteen acres, contribute approximately 35% of the current economy in Churchill County with a total crop value of a little over $13 million in 1992. The waters of the Newlands Project also support the growing recreational activities of camping, boating, and fishing.[31]

Currently farmers irrigate approximately 70,000 acres on the Uncompahgre Project, more than double the amount prior to its selection as a reclamation project, but less than the 130,000 acres planners imagined could be cultivated. Following the transfer of the operation and maintenance of the project to the Uncompahgre Valley Water Users' Association in 1932, additional irrigation works were constructed, including the Taylor Park Dam to regulate the water for the Gunnison Tunnel. With the exception of sugar beets, crops grown today are principally the same as when the project started. In the 1960s project farmers started growing malt barley for the manufacture of beer by the Adolph Coors Company. Today the population is closer to 20,000, whereas a century ago, the region contained fewer than 5,000 residents.[32]

Farmers on the Milk River Project cultivate about 100,000 acres, more than three times the amount irrigated 100 years ago. Project lands, stretching 165 miles, are divided into the Dodson Pumping Unit, and the Chinook, Malta, and Glasgow Divisions with individual irrigation districts operating the transmission and distribution facilities and the Bureau of Reclamation retaining control over the storage works. Like the Newlands Project, many of the current farm sizes provide income for only a part-time living, while owners have jobs in nearby cities. The irrigated acreage has remained relatively stable in recent years, with ranching and farming the main industries on project lands.[33]

Urbanization has not been a factor on the Milk River Project, but other elements have influenced this reclamation project. Over the years, changes in crops grown have impacted the neighboring communities. Sugar beets, once a major crop that required a large labor force as well as producing feed for sheep, are no longer grown on the project lands. The elimination of this crop had a trickle down effect—without the sugar beets, the large numbers of migrant workers have not been needed and the sheep industry left the Milk River area. Extreme weather conditions, ranging from 100 degrees in the summer to minus 40 degrees in the winter, have aided in the reduction of population on the Milk River Project. Farmers also have to contend with endangered or threatened species issues in the future to keep their irrigation water. Recreation is a major growth industry in the West and the creation of the Fresno and Nelson reservoirs and Lake Sherburne, have provided a favorite venue for boaters and fishermen who can also enjoy the waters of this reclamation project.[34]

Since a handful of mountain men began trapping beaver, to the early immigrants looking for a better life, to the rancher seeking grazing lands, to the farmer searching for the fertile acreage and enough water, the North Platte Project transformed the prairies into a part of America's farmland. At the turn of the century, the population of Scotts Bluff County was less than 3,000 people, while in 2002, in the city of Scottsbluff alone, there are over 14,500 residents. With the North Platte Project, the irrigated acreage increased from 3,000 acres to over 300,000 acres and encouraged the development of the sugar beet industry worth over $47 million in 1991. Besides being a cash crop, sugar beets also provide feed for the traditional western occupation of ranching; nearly a half a million head of cattle, sheep and hogs are raised on the North Platte Project. Almost from its start, the waters of the North Platte have been a safe haven for wildlife because President William Howard Taft created the Pathfinder National Wildlife Refuge. Project lakes continue to provide a resting place for migratory fowl as well as a setting for recreational activities, including boating and fishing.[35]

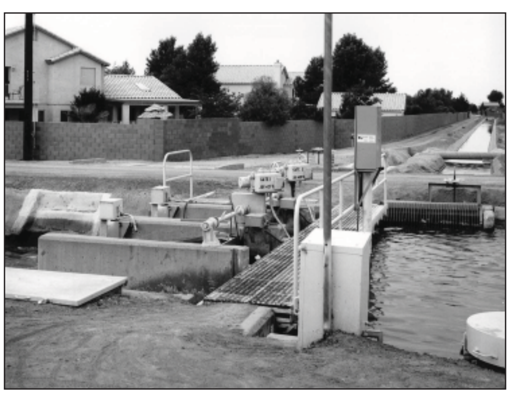
From its foundation, bringing water and power to its shareholders in the Salt River Valley, SRP has become the largest raw water supplier in the Phoenix metropolitan area and the nation's third-largest public power utility, delivering power to over 745,000 customers. Maricopa County is the major population center of Arizona, increasing from 20,450 people in 1900 to over 3 million in 2000. Phoenix, in the heart of the Salt River Valley, is the county seat, the state capitol of Arizona, and now the 6th largest city in the United States.

For almost one hundred years, the Association has continued to provide water to over 300,000 acre member and neighboring lands and has evolved into a multi-dimensional water service provider. Although only 44,000 acres are still being farmed in 2002 within the Project, SRP delivers water to urban irrigators and several municipalities which treat the water and distribute it to SRP's urban shareholders. To this end, ten water treatment plants operated by eight cities dot the SRP water system.

SRP's stewardship of central Arizona's water supply has made it a leader in the management of water resources, encompassing a wide range of activities. In partnership with several Valley cities, SRP jointly owns and operates the Granite Reef Underground Storage Project (GRUSP), one of the largest recharge projects in the United States. GRUSP stores Central Arizona Project water on behalf of the Arizona Water Banking authority and others for use in the future when dry conditions will prevail. To assist various Valley entities, SRP cooperated with the Bureau of Reclamation in the delivery of Central Arizona Project water with the construction of the CAP/SRP Interconnect Facility near Granite Reef Dam. Operated by SRP, the interconnect links the CAP canal with SRP's irrigation system, further allowing for the purchase of surplus Colorado River water to meet the demands of our shareholders during times of water shortage as well as to assist in water exchanges.

10.8. The Salt River Project's modern control room for its water system. Courtesy of the Salt River Project.

At the end of World War II, the Salt River Valley experienced a major explosion of growth which impacted SRP's traditional farming community. The returning veterans wanted homes, and farmers sold agricultural lands for thousands of houses in the newly developed subdivisions. With increased urbanization, the Association had to



10.9. The SCADA system on the Salt River Project controls this canal control structure. Courtesy of the Salt River Project.

find new ways to operate and maintain its canal system. Under the Bureau of Reclamation's Rehabilitation and Betterment Program, SRP started construction and implementation of the Supervisory Control System in the late 1960s. The advances in electronic equipment allowed for the design of a water distribution system covering 138 miles to be handled by a single operator. By the mid-1970s, computer equipment monitored telemetered data which displayed water levels and gate positions. The dispatcher could regulate 331 radial gates and almost one quarter of the deep-well pumps belonging to SRP. With this system, the water levels of the canals and laterals could be maintained at a constant level. Gone are the days when bells rang at the home of the gate operators to warn about pending trouble.

Keeping pace with new technology allowed SRP to utilize the new water Supervisory Control and Data Acquisition (SCADA) system developed between 1989 and 1991. SCADA is a complex computer-based system which allows remote control and monitoring of the entire water canal system, a major portion of the deep-well system, and numerous sites of interest to water accounting concerns. The system remotely scans and operates over 120 sites on the canals and controls over twenty off-project flow and special-delivery sites and an ever-expanding number of water quality monitoring stations throughout the system.

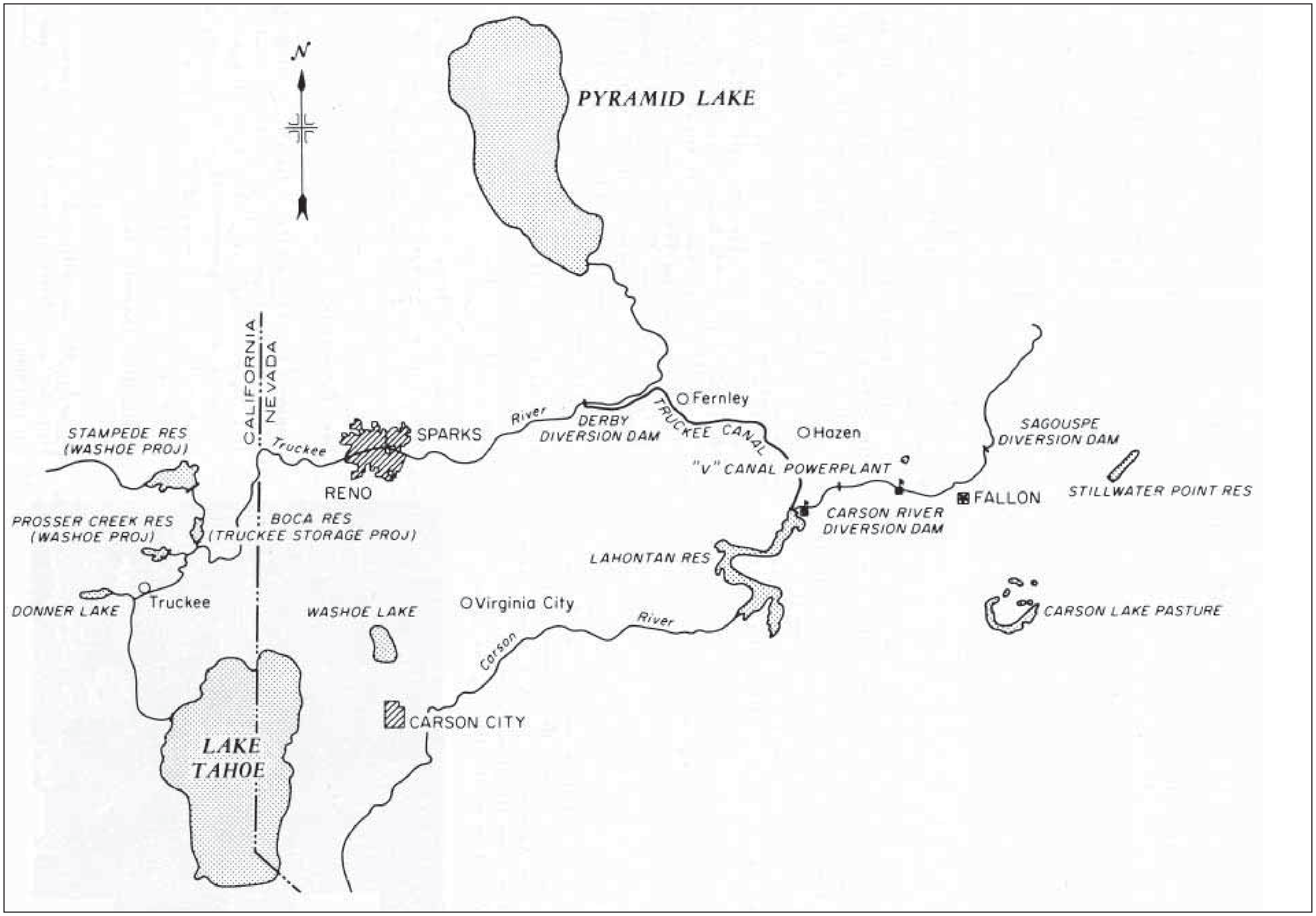
With thousands of homes adjacent to the canals, SRP continues to maintain the physical appearance of its irrigation facilities. No longer are sheep seen eating the grass along the canal banks or Yaqui laborers leading the horses in the ditches to eliminate aquatic moss and weeds. In 1989 SRP instituted a program of stocking its canals with white Amur, a sterile weed-eating fish that originally came from China and is considered an economically and environmentally safe alternative to chemical and mechanical weed control. SRP crews trim the trees and remove brush and other vegetation along the canal banks, not only for its own maintenance vehicles, but for the thousands of bicyclists, joggers, and horseback riders who use the paths for recreation. As part of a program completed in 1989, SRP installed safety steps and ladders providing a quick exit for stray animals and people who accidently enter the canal system.

From its earliest development providing electricity for the construction of Roosevelt Dam, power generation has been an integral part of the Salt River Project. The Association constructed its first hydropower plants on the Valley canals between 1911 and 1913, expanding its production with the construction of three additional dams, Mormon Flat, Horse Mesa, and Stewart Mountain, on the Salt River between 1923 and 1930. SRP had forty-nine power customers in the 1920s; by 1947 it delivered electricity to over 12,000 customers, and by 2003 it should transmit power to close to 800,000 people.

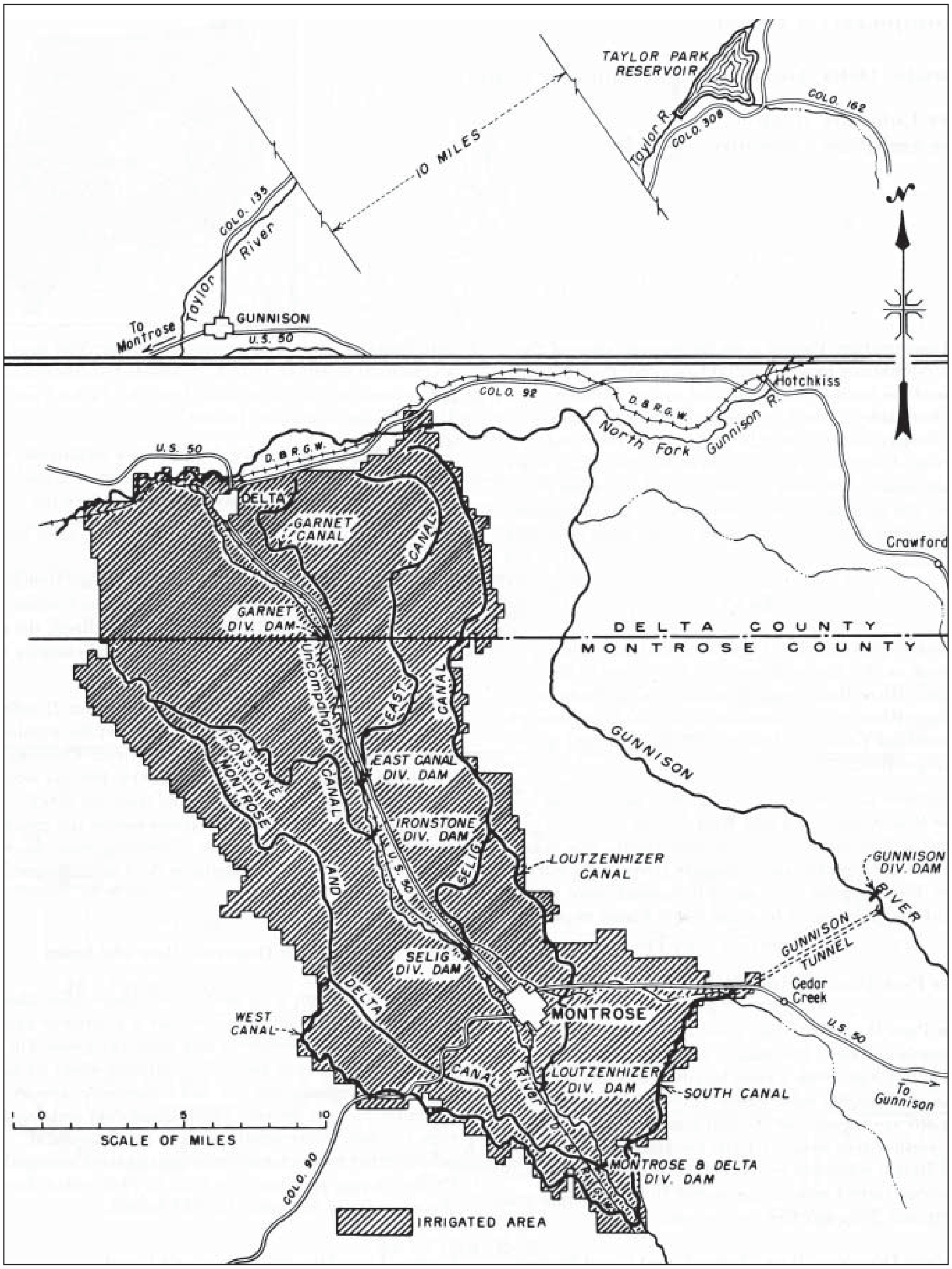
To meet this continually growing demand for electricity, SRP upgraded its transmission and distribution systems over the years, converting from 25 cycle power to 60 cycle after World War II and building non-hydropower plants. Within the Salt River Valley, SRP built several oil or natural gas generating stations and participated in several coal-fired power plants in the southwest region, including Mohave Generating Station and the Four Corners Power Plant. As part of the Central Arizona Project, SRP was chosen as the construction manager and plant operator of the Navajo Generating Station near Page, Arizona, participating with other utilities and the federal government. During the 1970s, SRP decided to construct the coal-fired Coronado Generating Station alone, while being a partner in the Palo Verde Nuclear Generating Station southwest of the Salt River Valley. In order to provide its customers with a reliable source of power in the future, SRP is expanding its Valley generating stations and finding new and environmentally compatible methods for the production of power, including landfill gasses and solar energy. From its inception to the present day, Salt River Project has supplied both water and energy that helped fuel the growth of the Association and central Arizona.

The passage of the national Reclamation Act heralded a new era in the development of the arid West. While some might argue that the rhetoric of its passage is mythic, nonetheless, the act President Theodore Roosevelt signed on June 17, 1902, transformed the West. Prior to selection by Secretary of the Interior Ethan A. Hitchcock as the first five reclamation projects, the lands in Nevada, Colorado, Montana, Wyoming-Nebraska, and Arizona, were being farmed, but without a stable water supply sustained growth could not be achieved. The federal government, in the name of the Reclamation Service and later the Bureau of Reclamation, provided the funding and the engineering expertise to construct the necessary storage works, to allow for that development, whether in actual increased irrigated acreage, population, or economic value. The success of the national Reclamation Act can be measured by the accomplishments of the Newlands, Uncompahgre, Milk River, North Platte, and Salt River reclamation projects.

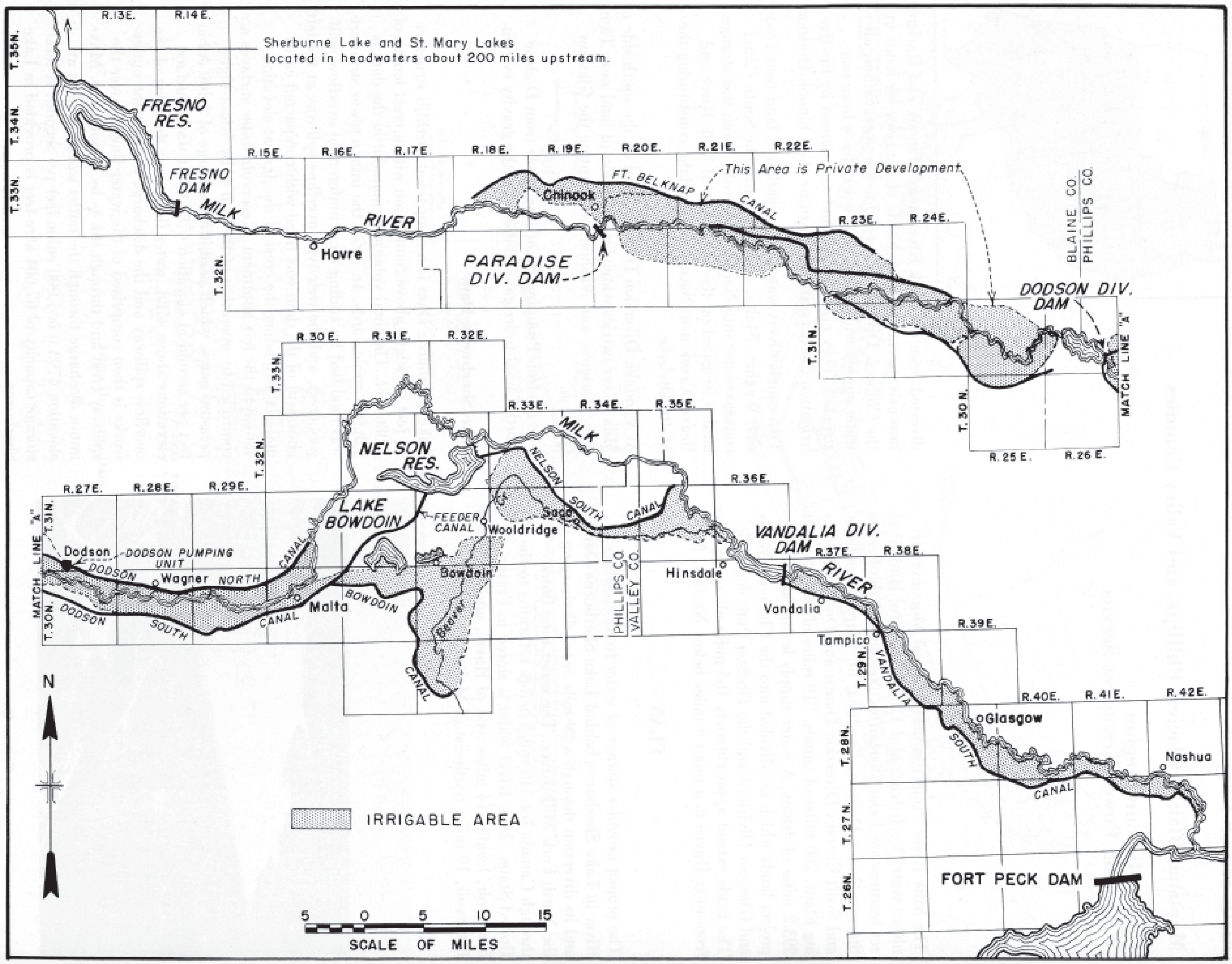
John Wesley Powell surveyed the American West more than one hundred years ago and saw thirty million acres that could be irrigated. Because of the vision of a few men and the Bureau of Reclamation, nine to ten million acres are productive, whether growing crops, homes, communities, or industries. Reclamation is the cornerstone of growth in the West: providing a stable water supply for crops, transforming the desert to farmlands, and now farmlands to cities, businesses, and communities; producing electricity to operate the irrigation pumps, light the homes, and now power our industries. Reclamation's objective hasn't ceased, but instead becomes more fully developed: the foundation of growth in the American West.



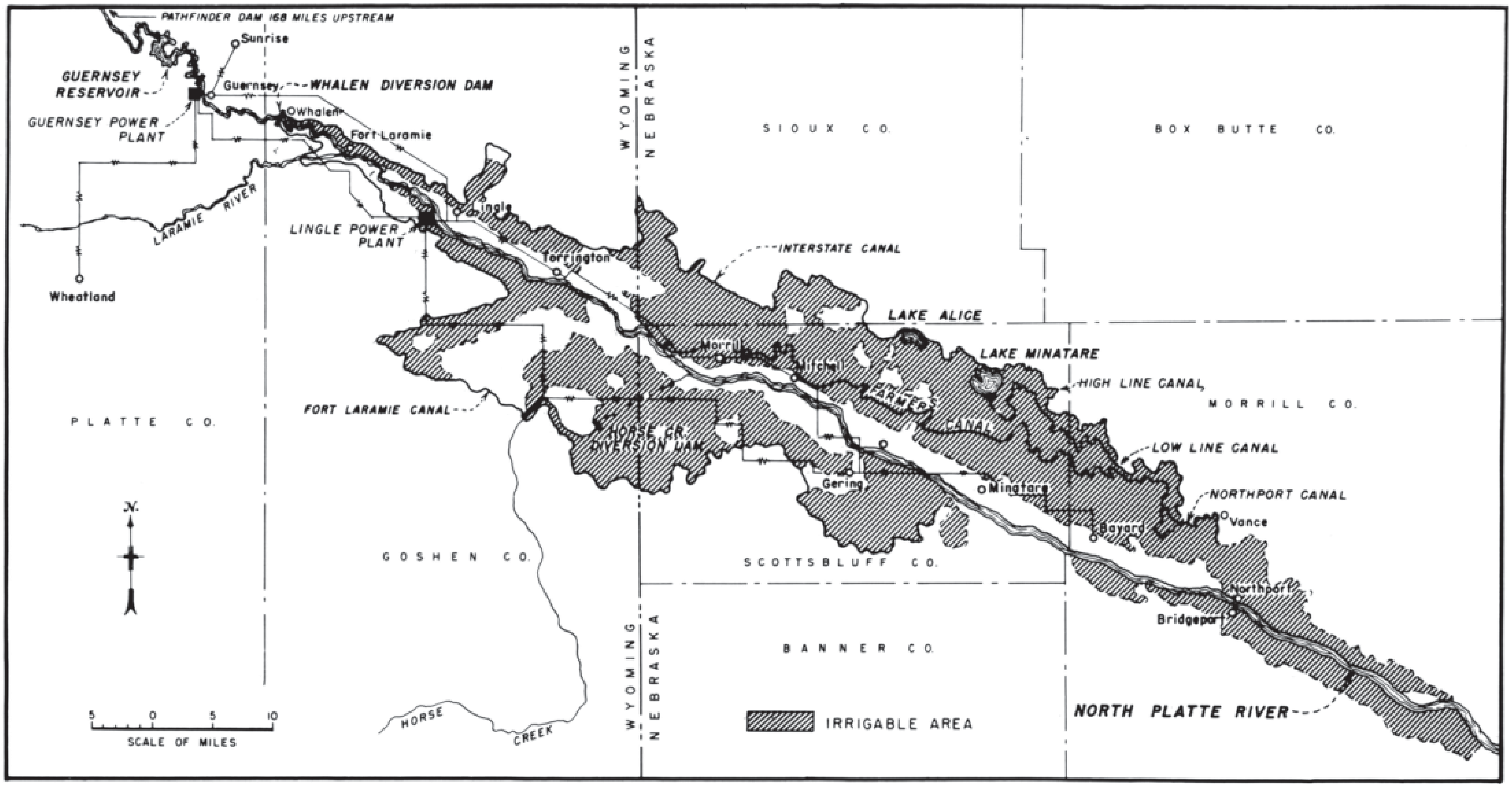
10.10. Newlands Project.



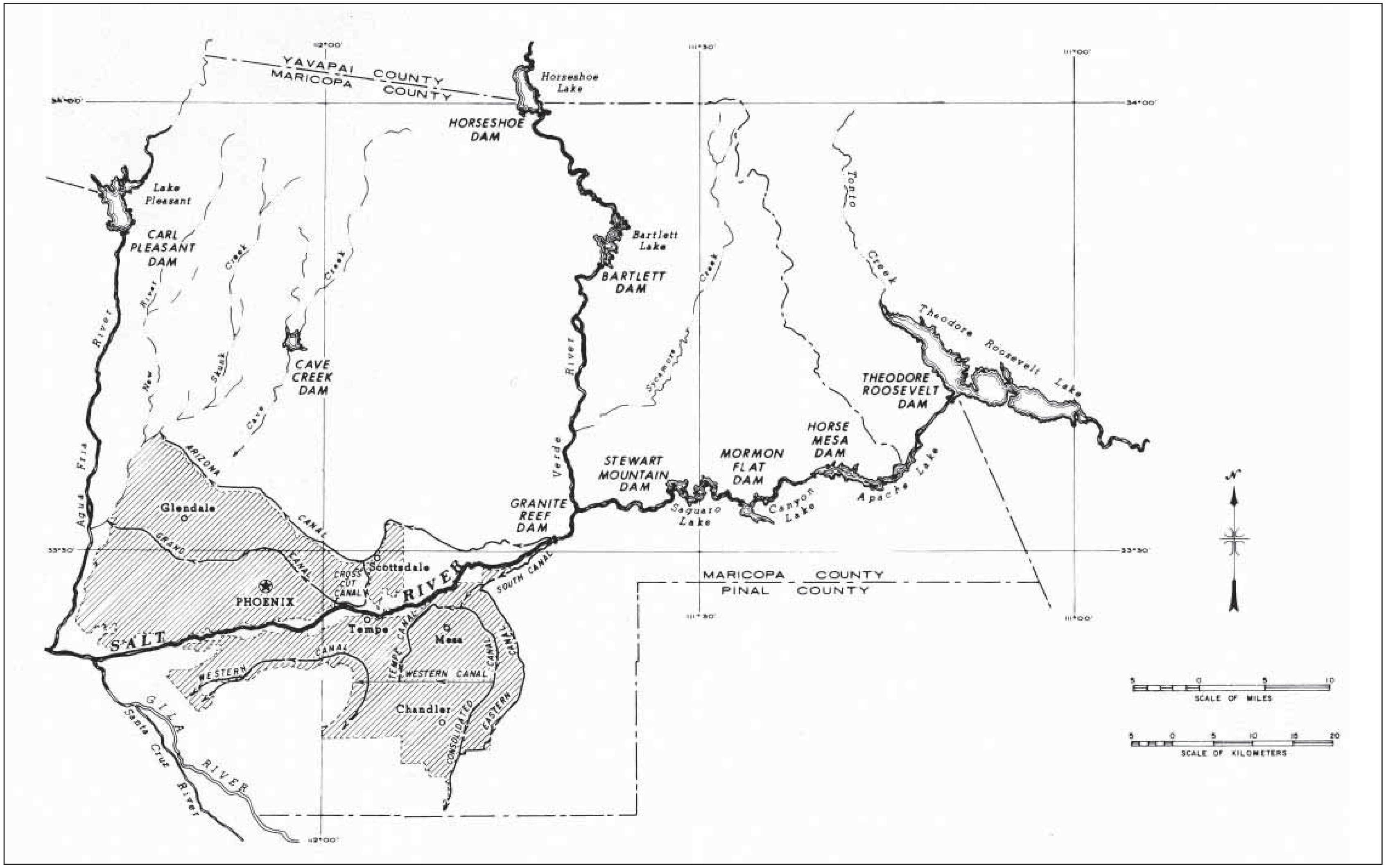
10.11. Uncompahgre Project.



10.12. Milk River Project.



10.13. North Platte Project.



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Creating an Irrigator's Reclamation Service: I. D. "Bud" O'Donnell, Civic Capitalism, and the U.S. Reclamation Service in the Yellowstone Valley, 1900-1930

By:
Carroll Van West

The capitalist transformation of rural America in the late nineteenth and early twentieth centuries is a central issue in American history. The economic development of the Yellowstone Valley of the northern plains between 1880 and 1920 mirrors the wider American experience in its intersection of governmental policy, the decisions of major corporate interests and international bankers, and the actions of local leaders. Throughout the Yellowstone, the passage of the Newlands Reclamation Act in 1902 and the creation of the United States Reclamation Service (USRS) encouraged local interests to think of their communities and their futures in new ways. Twenty years of agriculture in the valley was proof enough that farmers could not tame the region's demanding environment, but they could replace nature with massive engineering works that they could control. Although privately funded ventures had started the valley's irrigation, key civic capitalists in the Yellowstone were eager to exchange private development for federal funds and expertise to build a physical infrastructure for modern, market-driven farming. This exchange, however, was not a simple top-down reordering of the landscape and local economic priorities as dictated by federal policy. Rather, the goals and needs of local interests shaped the reclamation projects of the Yellowstone from the beginning, and the interaction between federal policy and local interests eventually led to basic change—a heightened regard for both irrigation and the individual farmer—in the United States Reclamation Service itself.

The central figure in the Yellowstone's search to build an irrigated empire, and a central figure in the history of the irrigation in the U.S. Reclamation Service, is I. D. O'Donnell of Billings, the service's first Supervisor of Irrigation. The USRS's *Thirteenth Annual Report* announced O'Donnell's appointment and praised his contributions. The report's authors noted:

> The underlying thought which prompted the creation of this office and the appointment of Mr. O'Donnell as the first incumbent was that there should be in the field, connected with the service, a practical business farmer, who could look at questions involved in the operation and management of the projects from the standpoint of the water user as well as from that of the service; who could advise the other officers of the service on all matters having to do with the efficient operation of the projects, and assist the water users on all matters coming under the general head of "better farming" methods.[1]

For the rest of the decade O'Donnell would push the interests of irrigators, and "practical" farmers before local, regional, and national forums, culminating in the 1918 publication of his treatise *Better Business, Better Farming, Better Living: Hints from a Practical Farmer to the Settlers on the Projects of the United States Reclamation Service* by the Reclamation Service. Although recognized today as "the father of irrigation in Montana," he is a neglected, largely forgotten figure within the history of the Reclamation Service and the later Reclamation Bureau, even though he continued to preach his vision of an irrigated West into the 1930s.

O'Donnell came to the west as a cowboy, not an irrigator. Ignatius Donnelly "Bud" O'Donnell was born in Ontario, Canada, on September 19, 1860; he was the second child of second-generation Irish immigrants, Daniel and Margaret McIntosh O'Donnell. His family moved in 1864 to Michigan where his father worked in the timber industry for several years before buying his own farm in Midland County, Michigan. Young Bud O'Donnell worked the farm and attended school in Saginaw, Michigan, until his early teen years, when he took up full-time work in the local timber business. He continued working in Michigan until he was twenty-one years old and he left with a friend for work in Chicago. Jobs were lacking there, however, and the lure of the west proved irresistible. O'Donnell took a Northern Pacific Railroad train to Dakota and Montana, where he looked for construction work.[2]

O'Donnell's first stop in Montana was at Miles City, where the Tongue River joins the Yellowstone River. A natural with an axe, he took a job cutting ties for the railroad, which was then streaking westward towards the Rockies. With that grubstake in hand, O'Donnell left for the gold and silver mines at Maiden, to the north of the Yellowstone. Quick riches proved beyond his reach, and once his grubstake was gone, O'Donnell was on the move again, and accepted his first cowboy job—putting up hay for a federal government contractor. He efficiently built corrals, stables, and fences and his experience qualified him for the next job—being a cowboy at the I J Ranch, a stock-raising enterprise owned and operated by a bunch of rich kids from back East—including Parmly Billings and Edward Bailey, the son and nephew, respectively, of railroad capitalist Frederick Billings, a former president of the Northern Pacific Railroad and the largest private landowner in the newly established Yellowstone County.[3]

O'Donnell proved to be the right man, in the right place, at the right time. Frederick Billings had long been interested in agricultural reform, and in making his sizeable interests along the Northern Pacific line, especially in Yellowstone County, highly profitable. While Northern Pacific president, he had encouraged the creation of the Cass-Cheney demonstration farm, which popularized the "bonanza farm" boom of the late 1870s and swelled land sales in Dakota Territory. He operated his own farm in Vermont as a demonstration farm, especially one that touted the value of hybrid seeds, purebred livestock, conservation, and diversification. But in Montana Territory his son and nephew soon tired of the hard work of ranch life, and Frederick Billings had a problem of his own in the city of Billings where his agent, Congregational minister Benjamin F. Shuart, had proven to be unreliable. In 1885 the elder Billings rearranged his business ventures in the Yellowstone Valley. He ordered his son and nephew to move to Billings, where they took over management of the family's land and development company, the Minnesota and Montana Land and Improvement Company, and established a private bank, the Bailey and Billings Bank. Frederick Billings then placed his various agricultural interests under the supervision of O'Donnell, who was placed in charge of the I J Ranch, along with other valley ranch land, and Reverend Shuart, who moved to his own ranch along Canyon Creek and the land company's "Big Ditch" irrigation system, east of Billings adjacent to large parcel of Billings family land, where he started the famed Hesper Farm. Shuart too followed the lead of his patron, Frederick Billings, and operated Hesper Farm as a model agricultural landscape, with irrigated fields, diverse crops, and modern soil conservation techniques.[4]

O'Donnell made the most of his opportunity to impress his patrons and after Parmly Billings's death in 1886, Edward Bailey sold O'Donnell the agricultural interests owned by Parmly Billings and they became partners. By 1890 Bailey and O'Donnell was a well established livestock firm; as O'Donnell later recalled, "we fed a number of bands of sheep, took up various land holdings, and kept a quantity of range. It was through these experiments that I caught a glimpse of a great future for farming in the Yellowstone Valley." Since the Billings family trusted his management instincts, and O'Donnell had already proved to be a quick study, the family named him as manager of the Minnesota and Montana Land and Improvement Company. By default, he became an irrigator since the land company had established and operated the "Big Ditch," the largest private irrigation effort in the region since 1883.[5]

For a cowboy, O'Donnell took to irrigation quickly, and by decade's end, he was considered one of the region's irrigation experts. He helped to establish the Montana Irrigation Society and served as its president. O'Donnell became an aggressive spokesman for northern plains irrigation. In the 1894 national publication, *The Irrigation Age*, O'Donnell bragged about the potential of the Yellowstone Valley's Clark Fork Bottom (where his Hesper Farm was located), predicting that due to irrigation the land was "destined to be the great feeding center of this section of the country." He improved and expanded the works of the "Big Ditch" and improved the land company's image and reputation among the farmers who relied on it. In 1892 he and Bailey purchased the Hesper Farm for $10,000 and O'Donnell began his own experiments with irrigation, with a special concern about what crops would grow most efficiently. The Billings *Gazette* Illustrated Edition of July 1894 approvingly commented that O'Donnell "enlists science to his aid in farming, irrigation and stock ranching, with the best results." Also in 1892, O'Donnell founded the Yellowstone Fair Association, where he began an annual ritual of promoting irrigation, scientific agriculture, and the cultivation of alfalfa and sugar beets, which he had successfully cultivated at Hesper Farm.[6]

O'Donnell is credited with producing the Yellowstone's first successful sugar beet crop and the first alfalfa crop in Montana. Both products, however, needed more water than other crops typically cultivated in the northern plains—a fact that also drove O'Donnell to support irrigation development. In 1893-1894 he began to serve as a lecturer for the Farmers' Institutes, sponsored by the Experiment Station of Montana State University, with alfalfa and irrigation being his favorite topics. O'Donnell also established new local irrigation ventures; the High Line Ditch Company, capitalized at $10,000, came in 1895 and five years later he joined with Preston Moss and others to create the Big Ditch Company, capitalized at $64,000. In 1898 he applied for a patent for his own improved headgate design. He served as a Montana delegate to various regional and national irrigation congresses; a meeting in Cheyenne, Wyoming, he recalled, was where "I gave my maiden address in the interest of an [federal] irrigation law" several years prior to the passage of the Newlands Reclamation Act.[7]

By the end of the nineteenth century, O'Donnell had proven sugar beets could withstand the harsh Montana climate—and that a Montana beet was higher in sugar content than those from other sections of the country. He had patched together a network of fellow irrigators across the region; and he had improved the efficiency of the Big Ditch as a water provider. He was ready to launch his holdings, and those of many other Yellowstone farmers, into a new agricultural age, one based on irrigation and the production of sugar beets. As horticultural expert S. M. Emery, the director of the Montana State Experiment Station, predicted to O'Donnell in April 1900: "The time is surely coming when Montana will produce its own sugar. You have all the conditions down there to make such a plant a success."[8]

To make that success, O'Donnell needed help from a variety of quarters. First, he needed new partners. The Billings family and Edward Bailey had bankrolled his ventures for over ten years, but with the new century on the horizon, the Billingses and Bailey had both tired of their western adventure. They were willing to sell the land company to O'Donnell, if he could find the partners. O'Donnell formed an alliance with the president of the First National Bank in Billings, Preston Moss, and together they bought out the Billings and Bailey interests. Moss and O'Donnell, soon joined by engineer Henry W. Rowley, became powerful business partners, and good friends. (In the early 1900s they all built architecturally distinctive homes next to each other in a new trendy neighborhood of Billings.) Moss was a native of Missouri, who moved to Billings in 1892 to be the vice-president of the First National Bank. Four years later he became the bank's president and invested in new Billings enterprises and agricultural projects in the Yellowstone Valley. He also owned a local telephone company, the Northern Hotel, the Gazette Printing Company, and the Billings Utility Company. Trained in civil engineering at the University of Minnesota, Rowley had been the original engineer of the Big Ditch and a Billings resident since 1882. He too brought money (gained from real estate investments and the Billings Water Power Company) to the partnership, along with experience with building large irrigation systems from scratch, something that O'Donnell had never done.[9]

The importance of the O'Donnell-Moss-Rowley alliance should not be underestimated; all three were classic examples of what historian John Cumbler has called "civic capitalists," who sought their "own profit, but each understood that his welfare was bound up with the welfare of others of his kind and the city that nourished them." The first major venture of these three civic capitalists was the Billings Land and Irrigation Company. They also jointly ventured into banking, commercial, and manufacturing enterprises while demonstrating their civic duty through support of such institutions as the new Parmly Billings Library. Due to his prior career within the Billings family's business circles, O'Donnell perhaps understood better than the others the need for reciprocal arrangements to nurture the fragile economy and settlements of the northern plains. As argued by an editorial in the Billings *Gazette*, after his appointment to the Reclamation Service in December 1913,

> In Billings, there are many men, who are really doing things, who have the right mental attitude. They make up the predominating influence of society, they lead, and the result is that the right mental attitude, the spirit, the loyalty of the Billings citizen has become proverbial throughout the land.

The "Doctor of Mental Attitude," concluded the editorial writer, was "I. D. O'Donnell." A later contemporary account of O'Donnell's career, published in 1919 after his years with the Reclamation Service, noted that O'Donnell "is the city's principal booster and has had more to do with organizing and getting new businesses started than almost any other man there." And a 1923 story praising O'Donnell in the Great Falls *Tribune* concluded that "in Billings whenever money is needed to build an addition to the public library or money is needed for something of historical importance [or] the help is needed of some public spirited citizen, the community instinctively turns to Mr. O'Donnell."[10]

To build a Yellowstone empire, O'Donnell needed more than strong local allies. He also needed, at least, federal recognition of the potential of an irrigated Yellowstone, if not federal support and money for Yellowstone irrigation. Through his office as president of the Montana Irrigation Society, and by attending various irrigation conferences, he had connected with various federal officials then exploring the possibility of new irrigation programs for the arid West. In particular, he assisted and supported the efforts of Elwood Mead to promote irrigation within the Department of Agriculture. He had met Mead at an 1897 irrigation conference, a key meeting that encouraged Congress to establish a division of Irrigation Investigations within the Agriculture department's Office of Experiment Stations in 1898. Under this program, Samuel Fortier and Elwood Mead came to the Yellowstone in 1900 and investigated the Big Ditch, while interviewing O'Donnell at Hesper Farm. In their follow-up report, Fortier and Mead acknowledged the assistance of O'Donnell, approvingly noted the 10,000 acres of alfalfa currently in the irrigated Yellowstone, and discussed how O'Donnell paid for Mead to install a weir at Hesper Farm in order to measure the water flow.[11]

Federal recognition, strong local allies, and a marketable crop were all important, but most importantly, O'Donnell needed more land than what the scattered holdings of the old Minnesota and Montana Land and Improvement Company provided. To acquire the needed land at the lowest possible cost, O'Donnell and Moss initially turned to the Carey Act of 1894, which granted free federal land to states for major irrigation projects. In 1903, a group of Washington state investors arrived in Billings to investigate the possibility of establishing an irrigation project on the Billings Bench northeast of the city. O'Donnell toured the capitalists around the city and county, convincing them that indeed the Yellowstone was the right place for such a project. In mid-October 1903 John Schram and W. T. Clark of Washington State, in partnership with Preston Moss, I. D. O'Donnell, and Henry Rowley, incorporated the Billings Land & Irrigation Company. The Washington investors put up $75,000, which was matched by a $50,000 loan from Moss and his First National Bank and $12,500 each from Rowley and M. A. Arnold, the cashier at Moss's bank. By 1905, the construction of the irrigation system was largely complete, cultivation was underway, and in April 1905 the company received its first land deeds from state officials who administered the Carey Land Act board. The project eventually irrigated over 24,000 acres.[12]

O'Donnell and Moss, however, did not plan to stop with Carey Act largesse—Bud O'Donnell had argued for a more comprehensive federal reclamation law for several years, and when the Newlands Reclamation Act became a reality in 1902, he immediately began to look for a suitable Yellowstone project. He located a perfect site: 35,000 acres of "open" land south of the Yellowstone River, bordered by the Big Horn River Valley, and serviced by the rails of the Northern Pacific Railway (NP) and the Chicago, Burlington, and Quincy (CBQ or Burlington Route). There was one hitch—and in the West of those days it was viewed as a hindrance more than an obstacle—the preferred land was on the Crow Indian Reservation.

CBQ officials had pushed their railroad through the Crow reservation in the mid-1890s, where the line linked with the Northern Pacific, and spurred growth in the Yellowstone Valley. That cession had proven easy enough to negotiate, but the railroad merely passed through the reservation and could do little to develop local traffic along the line. After railroad magnate James J. Hill, international financier J. P. Morgan, and others combined the interests of the Burlington Route with those of the Northern Pacific and the Great Northern Railway at the turn of the century, the new Hill-Morgan empire became even more interested in cracking open the Crow reservation to settlement. The railroads strongly supported the reclamation project, and for more reasons than mere traffic on the line. In 1900, a worried Montana Senator T. H. Carter warned James J. Hill: "This state will be dominated by a mob until the reclamation of the arid lands transfers the balance of power of the farmers." Hill, in particular, wished to boost agricultural production for both political and economic reasons, and his correspondents in 1902-1903 periodically informed him of developments in Montana.[13]

In April 1904 Congress approved a bill to amend current agreements with the Crow Indians to permit the withdrawal of land from the reservation to be used for the reclamation project in exchange for $1.15 million. The Crows already living in the ceded area had a choice: stay or accept compensation for their improvements and leave. Only three Crow settlers stayed. Engineers from the U.S. Reclamation Service soon surveyed the ceded land, and in May Assistant Chief Reclamation Engineer Arthur P. Davis came to Billings, where he met with X. H. Fitch, Supervising Engineer, and Robert Stockman, Engineer of Billings, to assess the engineers' findings. Davis ruled that the preliminary surveys were promising enough to justify the creation of a reclamation project and he ordered more intensive survey work under Stockton's supervision.[14]

Billings interests carefully monitored the work of the federal engineers; Moss and O'Donnell began their plans for creating a sugar beet refinery in earnest. On February 26, 1905, the USRS's Board of Engineers ratified the feasibility of the project—all that was needed now was an official authorization from the Secretary of the Interior. The approval of the engineering board was enough for Moss, O'Donnell, and Rowley. Less than three weeks later, on March 14, 1905, the three allies, together with M. A. Arnold and F. W. Shaw, incorporated the Billings Sugar Factory, with a capitalization of $750,000. Moss put up $650,000 while O'Donnell, Rowley, Arnold, and Shaw pitched in with $25,000 each. After Secretary of Interior E. A. Hitchcock signed off on the construction of the $900,000 Huntley Project (so named after an early settlement in the project area) on April 18, 1905, the creation of an expanded irrigated Yellowstone empire was formally underway. In May the Billings group signed a contract with the newly created Great Western Sugar Company (incorporated in New Jersey in January 1905) to provide sugar refined from Yellowstone-grown sugar beets. O'Donnell and his allies had used their own moxie, engineering expertise, boosterism, irrigation experience, federal land, and federal dollars to establish a potential powerful economic engine of change, where federal support made private enterprise possible. Billings now had its first truly large locally owned and operated industry, which depended totally on the success of irrigation and sugar beet cultivation.[15]

In 1906 the sugar company signed contracts with local farmers for seven thousand acres of beets. With the building of the Billings Sugar Factory—with a capacity of converting 55,000 tons of beets into 161,000 bags of sugar—a new age of reciprocal agricultural-industrial partnership was underway. The completion of the Huntley Project did not come as quickly as local interests had wished, although from the perspective of USRS engineers, the project had the sort of delays common to the service's initial projects. Local historian William Hancock observed:

> They all had problems common to construction today including wages, strikes, delays in the delivery of materials, adverse weather, flooding conditions and soil and drainage problems not contemplated. Horses and men were hard to find. One contractor shipped in two carloads of horses from Iowa and inexperienced Indian labor was often used.

On May 21, 1907, progress had proceeded to the point that President Theodore Roosevelt officially declared the Huntley Project acreage open for settlement, a total of 28,921 acres, enough for 585 farms between 40 and 160 acres in size. The remaining project acreage had too high of an alkali content, and the USRS only allowed settlement if prospective settlers knew they were claiming land of dubious value. To serve as trade centers for the Huntley settlers, the Reclamation Service also platted towns, such as Huntley, Ballantine, Worden, Osborn, and Pompeys Pillar, and opened lots for sale in August 1907.[16]

That most of the Huntley Project properties were small—40 or so acres in size—reflected a shared assumption by both O'Donnell and F. B. Linfield, director of the Montana Experiment Station and later dean of the College of Agriculture at Montana State University. Small acreage forced farmers to cultivate thoroughly and carefully as well as showing restraint in using the all-too-valuable supply of water. It also called for some diversification: small garden plots to provide food could exist adjacent to the sugar beet fields (indeed the small plots were a convenient way to force farmers to rely on sugar beets for their primary cash crop). Small lots also meant more settlers—and increasing the population was always a goal of O'Donnell and other like-mind investors in Yellowstone County.[17]

Forty-acre farms, however, did not please other Billings residents. The publisher of the Billings *Gazette*, E. H. Becker, pointedly referred to O'Donnell when he complained that the 40-acre tract reflected "a pet hobby of the reclamation service, backed by a very small minority of those who call themselves experienced farmers in irrigated districts." Becker insisted that there was "no demand in eastern Montana for 700 40-acre tract farmers at the very doors of this city." Admitting that the goal of the project was to produce sugar beets for the local factory, Becker pointed out that the "lands under the Huntley ditch alone, if intensely cultivated, would supply a sufficient number of beets to supply the demand of four factories," but there were no other factories on the horizon. To "protect the best interests of the settlers, but the best interests of the community commercially as well," he urged local residents to demand that the federal government grant larger farms.[18]

Becker's comments reflected the concerns of the region's large stockgrowing interests—some of whom had been grazing on Crow land for years—as well as the interests of real estate speculators who wanted to grab as much of the cheap irrigated land as possible when it became available. When the Huntley lands were made available to settlers, most registrants were merely interested in seeing how high a number they would draw in order to select the best available land. 5,491 individuals registered for the first 582 farms, but of the first 1,000 names drawn, a mere 76 completed filing and claimed a farm.[19]

Those who were serious about settling at Huntley soon discovered that while water had been diverted into the system, it was only for the priming and puddling of the canals, laterals, and structures. It would be months—April 6, 1908—before water was actually delivered to the farms. Then the Reclamation Service did little, in the farmers' eyes, to help the settlers. Since the irrigation system only delivered water to the high point of the farm unit, farmers had to build their own ditches, and most knew nothing about irrigation technology or even when and how to irrigate their fields to best advantage. Alex Kimonth, who lived near Ballantine, recalled his problems that first summer of water in July 1908:

> After a lot of hard work correcting mistakes made by ourselves and, also, by the government in placing ditches in the wrong place, we ordered water. Having never done any irrigating, we had a hard time to get the water in the places where it did any good. . . Our ditches were too small and we had to build them larger. By the time we had worn out two shovels, we got the ditches so that they could carry water.

The first year of cultivation at Huntley was generally a bust. While fields were planted by April, grains were largely produced, and yields were disappointing. Sugar beets would have to wait until the 1909 season.[20]

The delays and controversies of 1907-1908 troubled O'Donnell. The Reclamation Service had built the irrigation machine he always wanted for the Yellowstone, but now it seemed the machine did not immediately produce the garden that he and his allies envisioned. True to his personality, however, O'Donnell aggressively sought solutions. In 1907 he moved to shore up support for the project within the Billings business community by leading the transformation of the city's old Commercial Club into the Billings Chamber of Commerce, with himself as President. The chamber strongly supported the sugar factory and beet farming in its early publicity.[21]

O'Donnell also joined with others to establish a new educational institution to further the cultural process of turning cowboys into farmers. As early as 1904 Billings merchants John Losekamp and Christian Yegen had joined forces with educators Ernest T. Eaton and Lewis Eaton to establish a private high school, which operated out of various downtown buildings for its first four years. In late July 1908 the school was reorganized as the Billings Polytechnic Institute, with five individuals providing the vast majority of its capital: Losekamp and Yegen with $10,000 each, and O'Donnell, Preston B. Moss, and Henry W. Rowley with $5,000 each. The latter three also helped to provide the location for a new 60-acre campus, north of town along the Big Ditch. The announced educational goal of the Billings Polytechnic was

> industrial and technical education. It is now realized that hand training is mind training and that the young man or woman who is not trained to do something and to do that something well, has not been half educated.

The new school would have machine shops, home economics classes, and (not surprisingly) a demonstration farm where about 40 acres "will be put into crops under the direction of an expert in intensified farming."[22]

Another goal of the institute was to transform cowboys into farmers by replacing the region's early dependency on stockgrowing with industrial and agricultural ventures. This theme became predominant in 1911 as the institute's founders approached railroad magnate James J. Hill to donate 100 acres to the school. Hill's Great Northern Railway had operated a small dry land farming demonstration next to the school's 40 acres of irrigated land in 1909. School officials promised that with Hill's donation these efforts would be magnified into a "Model A" demonstration farm. "To bring about a solution to the agricultural problem here," a 1911 memorandum to Hill explained, "the Institute would conduct a series of model demonstration farms. These farms would be placed under average condition and on an entirely practical basis. It would have them so arranged that the farmers could come and study the methods for themselves. Not experiment but demonstration would be the work of these farms." This mailing to Hill included mock "before and after" photographs, with one showing three boys in cowboy hats and chaps, labeled as before, and the after photograph showed the same boys in farmer clothing and caps, with a big stack of sugar beets in front of them, as happy, healthy farmers.[23]

Also in 1908 O'Donnell directly helped the Huntley Project settlers by bankrolling its first experiment station, so the farmers could learn proper irrigation and cultivation techniques. In the summer of 1907 USRS engineers stationed at Huntley understood that many of the settlers who claimed units needed help. They contacted the Montana Agricultural Experiment Station and asked state officials to create a demonstration program for the project. When in 1908 the state refused to step forward—budgets were tight already and the experiment station was actively promoting dry land farming—USRS Supervising Engineer H. N. Savage asked O'Donnell to help immediately before the growing season was over. "I know it would profit the settlers very much to have this demonstration farm operated by you," claimed Savage, "in order that they might have the benefit of your experience and example, and also opportunity to consult with you about the crops growing under your management and their own within the project." Savage could offer O'Donnell little in return for his assistance. He promised to supply a "suitable" barn, a couple of small residences, four horses, a wagon, plow, disk harrow, tooth harrow, and plank smoother, and about 45 acres, of which the Reclamation Service only wanted five acres planted in sugar beets and a "few" acres in alfalfa. O'Donnell would be liable for everything else, including "all the running expenses and furnish the labor and seed."[24]

O'Donnell had too much tied to the future of the Huntley Project to say no; he accepted the arrangement and the Huntley Project Demonstration Farm became a reality. In 1910 O'Donnell's control passed to a partnership of the USRS, the U.S. Department of Agriculture, and the Montana State Experiment Station. The property was expanded to 300 acres and renamed the Huntley Project Experiment Station. Over the next decades, especially during the administration of Dan Hansen, who was superintendent between 1910 and 1949, the various programs at the demonstration farm proved of great benefit to the settlers. By 1910-1911 sugar beets had finally become a dominant crop, with approximately 4,000 acres planted, and even railroad promotional brochures were passing on the O'Donnell doctrine of intensive agriculture to prospective settlers. "After beets have been grown for three years," a Northern Pacific Railway pamphlet recommended, "some other crop should be planted, and a proper rotation of grain, alfalfa, and sugar beets will retain the fertility of the soil and make maximum yields possible."[25]

The early difficulties at Huntley opened O'Donnell's eyes, and purse strings, to the possibility of dry farming as a complementary method of cultivating the vast bench lands of eastern Montana. In 1909 Billings was the host city to the Fourth Dry Farming Congress and International Dry Farming Exposition. Preston W. Moss was the local chair, and I. D. O'Donnell was the treasurer. Dry farming was all the rage in Montana in the first two decades of the twentieth century, and incessant boosting of dry farming encouraged hundreds of thousands of settlers to come to the state and try their luck. O'Donnell and Moss were never vocal dry farming proponents, but they accepted that dry farming, in addition to the irrigated lands of the Yellowstone Valley, could open up a potential 2.5 million acres "directly tributary" to Billings. Moreover, supporting the congress would be good for local business, and their various other local ventures. For example, the conference was a perfect way to boost the Huntley Project (a tour was planned), the Billings Sugar Company (a photograph was included in the conference book), and Moss's Northern Hotel, where the important national and international delegates and officials would stay. Since the Great Northern's James J. Hill was going to give one of the congress's major addresses, Moss also would have an opportunity to discuss with Hill his development plans for "Mossmain," a planned community that never really developed, located near the new railroad yards at Laurel in Yellowstone County. Their involvement in the successful dry farming congress is an excellent example of the civic capitalism of Moss and O'Donnell in these crucial decades of expansion in Yellowstone County.[26]

The early years at Huntley showed O'Donnell both the potential and the problems inherent in the initial USRS irrigation projects. He was not alone in realizing that while the projects were impressive engineering feats, mere engineering alone would not transform the arid West into an agricultural garden. In fact, as more of the initial projects went into operation, criticism of the Reclamation Service grew among the settlers and adjacent local leaders who had hoped to substantially benefit from the federal largesse. The criticism had grown to a storm of protest by the time the administration of President Woodrow Wilson took office in March 1913. A series of conferences took place in Washington in 1913-1914, and Congress took action to amend the payment schedule for settlers while the USRS itself looked to internal reforms. In its *Thirteenth Annual Report*, the Reclamation service reminded readers (and quite likely its own staff) that "home making" was its primary goal: "increasing the number of farm homes and extending the area of productive lands in the United States are the objects of the work of the Reclamation Service." The USRS then admitted "that in order that the greatest possible good may be realized from the efforts of the Government and the irrigators, it is necessary that the irrigators appreciate the efforts of the United States to further their interests and that officials responsible for the administration of the irrigation projects fully understand the needs of the irrigators."[27]

In late 1913 Secretary of Interior Franklin K. Lane addressed the problem aggressively by appointing a Reclamation Commission, a five-member panel headed by USRS Director F. H. Newell and including I. D. O'Donnell in a new position, titled Supervisor of Irrigation. Bud O'Donnell now had an opportunity to do on a national stage what he had been doing in the Yellowstone Valley for twenty years—promote reciprocal partnerships between farmers, agricultural experts, and irrigation specialists; teach farmers the value of scientific agriculture; and demonstrate how to best use irrigation technology to cultivate individual crops.[28]

11.1. The Reclamation Commission, left to right, W.A. Ryan, Comptroller; I.D. O'Donnell, Supervisor of Irrigation; A.P. Davis, Chief Engineer; Will R. King, Chief Counsel; F.H. Newell, Director; Franklin K. Lane, Secretary of the Interior.

From all accounts, he entered his new career with missionary zeal.

> Numerous meetings have been held with the farmers and the officials of the water users' associations for the purpose of discussing on the ground questions of interest to the water users, stress being laid upon the improvement of farming methods,

reported the Reclamation Service. He became a regular contributor to the agency's official magazine, the *Reclamation Record*, where published versions of his favorite lecture topics appeared. His family kept news stories about his appointment and travels across the irrigation systems of the west in a large scrapbook. The local Montana press carefully reported his various trips and his frequent proclamations. In its 1914 anniversary edition, the Billings *Gazette* published O'Donnell's overview of his first months in office, ending with a message that he constantly repeated over the next four years:

> To view as a whole the magnificent constructive work of the government irrigation plan is to forget the small and relatively unimportant irksome details involved in the administration of this work. With a knowledge of the good that may be accomplished, I find unending pleasure in helping the farmers on all the projects with their difficulties. I find that these men and their families who have with confidence in the integrity of the

> representatives of their government settled on these government irrigation projects do not expect our Uncle Sam to demonstrate a paternal interest in their affairs—all they expect is opportunity to make good under the conditions in which they are placed.

O'Donnell saw his responsibility as providing them with that opportunity through instruction, demonstration, and preaching the virtues of being a "practical business farmer." He relished this role as a national farm advisor. By organizing and hosting a major national meeting on irrigation in Billings in March 1915, however, O'Donnell showed that he had not forgotten his role as a Yellowstone civic capitalist. The business generated by those who attended the meeting, and the positive national exposure of a rapidly booming Billings, brought added, and direct, benefits to the various business ventures of his local partners. The following year, 1916, he extended his help to the immediate region by creating the Midland Empire Fair, a huge celebration of the greater Yellowstone region, with particular emphasis on the areas included in the USRS projects at Huntley and at Shoshone, south of the Montana-Wyoming border, land that O'Donnell referred to as the Midland Empire with Billings as its urban commercial and industrial center. In the eyes of O'Donnell and his allies, the two Reclamation Service projects created the potential for an agricultural bonanza rarely equaled in the northern plains.[29]

The Reclamation Service at first provided O'Donnell with considerable praise. The *Thirteenth Annual Report*, published in 1915, observed

> It may be safely stated that the work of the Supervisor of Irrigation had aided materially in bringing out a feeling of confidence among the water users in the administration of the Reclamation Service and a desire on the part of the water users to cooperate to the fullest extent with the service in the interest of the projects.

But support within the agency waned over the next three years; by the time the Reclamation Service published O'Donnell's *Better Business, Better Farming, Better Living: Hints from a Practical Farmer* in the summer of 1918, O'Donnell resigned as Supervisor of Irrigation.[30]

Agriculture groups outside of the agency acknowledged the significance of O'Donnell's years in the Reclamation Service. In his 1919 article for *The Country Gentleman*, Philip S. Rose praised O'Donnell as the best farmer in Montana, but reserved his highest commendation for his USRS service: "the humanizing of the Reclamation Service has been Mr. O'Donnell's greatest public service." While he may have resigned from the Reclamation Service, he "had not resigned from doing what he can for the general public welfare."[31]

O'Donnell's work in the next decade showed his continued commitment to his early civic capitalist philosophy. While no longer a federal employee, O'Donnell continued as a voice for irrigation and diversified farming for the remainder of his career. He signed on as an agricultural specialist and spokesman for the Great

Northern Railway, and the extended Hill railroad interests, during the 1920s. He watched as an outsider as the Reclamation Service was reorganized and renamed the U.S. Bureau of Reclamation in 1923. He continued to write articles supporting reclamation and irrigation. In a 1925 article in the *New Reclamation Era* titled "Irrigation Hints from a Practical Irrigator," he once again sounded a favorite theme: "the better the farming the less irrigation required . . . Cultivation before and after irrigation should be your motto." O'Donnell approved when in 1928 a local group of farmers and settlers created the Huntley Project Irrigation District, ending the federal government's twenty years of administration. In the decade, he also became one of the Yellowstone's first serious collectors of the valley's early history. He paid for a stone obelisk to be placed at the first cemetery in the Billings area; he collected stories from other early settlers and published them as *Montana Monographs* in 1927. He began to enjoy a semi-retirement, taking a world tour with two of his daughters in 1931. When the New Deal came in the 1930s, some of his early friends in western agriculture, such as Elwood Mead and M. L. Wilson, held important national positions. O'Donnell, however, accepted only local responsibilities, with an appointment to the state's first Water Conservation Board in 1934.[32]

COMMON BIRDS AROUND THE FARM.

The Marsh Hawk.

By I. D. O'Donnell, Supervisor of Irrigation.

The general belief regarding hawks is that they are of no benefit to man and make their living by preying upon birds and poultry. This belief is not well grounded. As a matter of fact there are but about three kinds of hawks that are really detrimental to the interests of man. The other kinds of hawks, and particularly the marsh hawk, are the farmer's friends.

The marsh hawk's habit of eating its food on the ground and of building its nest on the ground marks it apart from other hawks. Its slow and graceful manner of flight also is distinctive, and there is no reason why the marsh hawk should be mistaken for other and destructive hawks and destroyed.

In searching for its food it flies near to the ground and goes back and forth across a field in a careful search for its food. Some writers accuse this bird of being cowardly in that it does not attack the more vigorous and larger birds and animals that some kinds of hawks prey upon.

WHAT THE MARSH HAWK EATS.

Field mice, ground squirrels, snakes, frogs, grasshoppers, crickets, etc., make up the food that the marsh hawk prefers. In cases of extreme hunger and when it can not secure the food it prefers the marsh hawk will capture and eat small birds of seed-eating type and an occasional chicken. Careful examination of the stomachs of these birds has proven, however, that the number of useful birds and poultry eaten is of no consequence when compared with the large number of insects, rodents, etc., taken.

The farmer should learn to recognize the friends he has among the several kinds of hawks and he should first get acquainted with the marsh hawk, which is now generally killed on sight, much to the damage of the farmer.

11.2. Pursuing his belief in education of Reclamation settlers, I. D. O'Donnell wrote this article "Common Birds Around the Farm," for the June 1915 issue of *Reclamation Record*.

By the Depression decade, his friend Elwood Mead was commissioner of the Reclamation Bureau and historians stressed that the future of the agency was to return to its original focus on home making as the true purpose of the Reclamation Bureau. But few now remembered O'Donnell's contribution to reclamation as a "home making" endeavor. O'Donnell himself, in interviews in his last years and in his stab at writing his memoirs, emphasized his cowboy days and the early settlement of Montana, going so far as to pose on the cover of the *Western Humane News* of December 1940 in full cowboy regalia, complete with chaps. After his death in 1948, his family continued Hesper Farm and today his grandson, Harley O'Donnell, still farms the land and maintains the homestead much as it was eighty years ago. But by the end of the century, his contributions had been mostly forgotten even in his home of Yellowstone County. Yet, when the Agriculture Committee of the Billings Area Chamber of Commerce recently planned a one-day guided tour of the now "historic" Huntley Project, "one of Montana's most productive agricultural areas," its schedule included a stop at one of Huntley's best farms, where "the careful rotation of corn, malt barley and sugar beets helps these producers maximize productivity, while combating disease and insect threats." Bud O'Donnell's legacy as the "practical farmer and irrigator" of the early twentieth century is not in the history books, but in the land itself.[33]

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"Did The Secretary Sell Us 'Blue Sky?'": Inclusion of Warren Act Contractors in the North Platte River Project

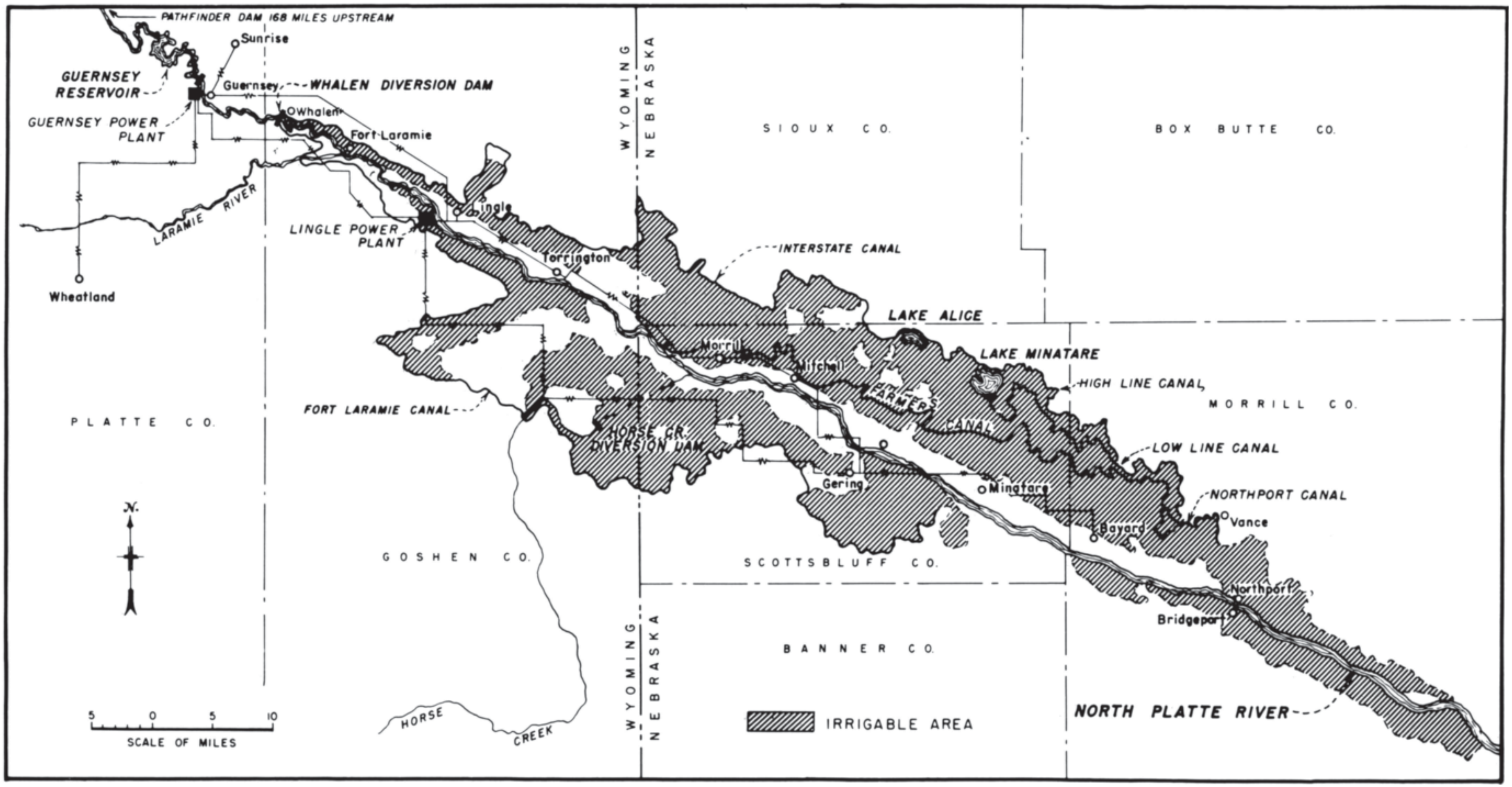
By
Alan S. Newell

Introduction

Construction of Pathfinder Dam on the North Platte River beginning in 1905 suggested the dawn of a new era of economic growth and prosperity for farmers in Wyoming and Nebraska. Since the early days of settlement in the North Platte River Valley in the 1880s, irrigators had contended with excess water during the spring and early summer months and with water shortages during the months of July through September. Pathfinder Dam and its one million acre foot reservoir offered the hope of a more regulated and predictable water flow, particularly in the critical late summer months.

The North Platte Project (authorized in 1903 as the Sweetwater Project) involved the construction of numerous dams and canals along a 111-mile stretch of the North Platte River between Guernsey, Wyoming, and Bridgeport, Nebraska. (See Figure 1) Reclamation Service engineers anticipated storing sufficient water behind Pathfinder to irrigate more than 300,000 acres of public land downstream from the project. However, as conceived, the North Platte Project offered little benefit to existing downstream irrigators; those who held water rights to the natural flow of the North Platte River. Established farms, some with water rights dating to the early 1880s, were not considered in the initial legislation. The benefits of Pathfinder and similar Reclamation Service projects were readily apparent to these North Platte farmers, who looked to the project to supplement their precarious supply of water. Congress responded to this interest by enacting the Warren Act in 1911 (34 Stat. 925). Legislators viewed the statute as a vehicle for incorporating existing private district irrigators into the new government sponsored units, thereby more efficiently utilizing the public project.

The Warren Act, similar to the Reclamation Act, received overwhelming support in both houses of Congress. Yet few supporters of the bill gave much thought to just how these existing irrigation districts would be integrated into the federal project. This task was left to Reclamation Service officials, who, during the first year following passage of the act, addressed three threshold administrative issues—all three of which fundamentally altered operation of the North Platte Project and eventually spawned protracted litigation. The first issue focused on the nature of "surplus water" as envisioned under the Warren Act. Was this to be a temporary disposal of water, contingent upon a determination of the yearly surplus prior to the sale? Or, would lands in private irrigation districts be able to acquire permanent rights to surplus water and be integrated into public district



12.1. North Platte Project map.

lands? Potential contractors overwhelmingly favored the later approach, and as the spokesmen for a private irrigation company remarked in 1931, without this guarantee of permanency, the United States would be selling farmers "blue sky."

The second issue followed closely on the heels of the secretary of the interior's decision in November 1911 to provide permanent surplus water to Warren Act contractors. At that time, the final design of the North Platte Project was not yet complete. But, it was clear to Reclamation engineers that providing permanent water to Warren Act contractors would necessitate a reduction in the size of future government units. The secretary made the decision to reconfigure the project and to reduce the size of prospective government districts during the first few months after passage of the Warren Act.

The disposal of permanent water and the reconfiguration of what became the Fort Laramie Unit structurally incorporated the Warren Act irrigators into the North Platte Project. The operational integration of them into the project, however, required an additional threshold decision. Facing pressure from its first potential contractor, Tri-State Land Company (later Farmers' Irrigation District), early in 1912 to allow for future as well as existing lands to be served by Pathfinder water, the Reclamation Service imposed a limit on the maximum amount of water that would be delivered to Tri-State by the government. As a practical matter, the imposition of this "cap" required the commingling of natural flow and storage water. The contract provision was readily agreed to by Tri-State and future Warren Act contractors. But, it had little significance until the drought years of the 1930s.

Faced with periodic water shortages, beginning in 1931, the Bureau of Reclamation allocated water to government and Warren Act districts on a prorated basis. In doing so, the Bureau was consistent with the decisions made in 1911 and 1912, that Warren Act contractors were equal partners in the North Platte Project. From the perspective of management, the Bureau of Reclamation believed that such an allocation was the only way practically to administer the North Platte system. Despite peripheral legal and other challenges to their interpretation of the Warren Act, Bureau engineers consistently followed this allocation system.

The Origins of the Warren Act

Historians have long recognized the importance of the National Reclamation Act of 1902. Some have argued that the act represented the expectations of a technical elite, focused on directing the efficient use of the nation's resources in a "progressive era." Others have seen the act as a triumph of established western interests seeking to utilize public money to encourage economic prosperity in the nation's arid region.[1] Given the difficulty in separating realistic economic goals from political decisions, it is no wonder that the legislative and administrative history of the 1902 act soon assumed an identity distinct from its legislative history.

One of the progeny of the Reclamation Act of 1902 was the "Warren Act", passed by Congress on February 21, 1911. This rather short statute provided for the distribution of surplus storage waters from reclamation projects to existing private irrigation districts within federal project areas. It authorized the secretary of the interior to contract for the storage and delivery of surplus waters conserved by any reclamation project in excess of the requirements of the project. Three of the nation's leading proponents of federal irrigation projects, Francis E. Warren of Wyoming, William Borah of Idaho, and Thomas Carter of Montana, were the principal figures behind passage of the Warren Act. All three men saw the advantage of incorporating private irrigation ventures into the federal projects then being constructed by the Reclamation Service.

Wyoming's Republican Senator Francis Warren was particularly interested in developing as much of the North Platte River Basin as possible. Warren, longtime Wyoming merchant, rancher, and the state's first elected governor, lobbied the federal government for construction of Pathfinder Dam, but also advocated funding other reclamation projects, such as the Shoshone Irrigation Project in the Big Horn River Basin of northern Wyoming. As Warren explained to one supporter from Wheatland, Wyoming, eventually all of the arable land in Wyoming would be occupied and developed either by dry-land or irrigated farms. The senior senator visualized:

12.2. Senator Francis E. Warren of Wyoming. Courtesy of the U.S. Senate Historical Office.

> The full development of the water in Wyoming … to have it as an adjunct to reinforce the rainfall and the conservation of rain and snow fall, so that, while certain crops may be raised without irrigation, there will be water on hand for other crops that demand partial irrigation, complete irrigation, or a little bit of help—say once in the course of the summer;[2]

Such an optimistic view of the state's agricultural potential led Warren to believe that Pathfinder Dam had "ample capacity to irrigate all of the lands under it in the North Platte Valley in Wyoming and Nebraska which can be reached by irrigation works of reasonable expenses."[3]

Warren was an early proponent of allowing existing private district lands to benefit from Pathfinder storage water. The Wyoming senator may have viewed the incorporation of these irrigators, many of whom resided in Nebraska, as a means to resolve downstream irrigators' claims to early direct flow water rights. Indeed, Warren expressed both concern and uncertainty as to the extent of these potential rights.[4] However, Warren's interest in expanding the North Platte Project was driven principally by his desire to see lands south of the river, in what was termed the "Goshen Park" area, benefit from the planned Fort Laramie Canal. It appears likely that Warren believed that by broadening the scope of the North Platte Project through such measures as incorporating private district lands into the project, he could ensure the greatest development possible at Goshen Park. Ironically, it would be the need to serve these "Warren Act" contractors that would later require the Reclamation Service to scale back the extent of lands that would be irrigated by water from the new canal.[5]

The salient feature of the various bills introduced by Warren beginning in December 1909 was the authority given to the secretary of the interior to (1) deliver surplus storage water to non-project entities and (2) to cooperate with individuals, districts and associations in enlarging existing project facilities to accommodate additional non-project lands. Opposing this effort were various western interests who either feared federal control over the distribution of water or who were concerned that the already ambitious plans of the Reclamation Service would be expanded to include new federal projects that served only private lands.

Both the title and the text of the original bill as introduced in mid-December 1909 (S. 4002), and later under new numbers in late February and March 1910 (S. 6723 and S. 6953 respectively), clearly stated the proponents' objectives. The proposed legislation authorized the secretary of the interior to contract for the delivery of "surplus water" from any reclamation project to private projects that had been established under the Carey Act of 1894 "or under the laws of any State or Territory."[6] The various bills as introduced also suggested that the sponsors envisioned expanding current federal projects to serve existing private district lands. This clause specifically authorized the secretary to enter into agreements "with persons, irrigation districts, associations, or corporations" to deliver water from enlarged federal facilities (dams, canals, etc.). As explained in the bill, these structures could be expanded because the government had secured a favorable site where a dam could be raised to store additional water, or canals widened to convey water to additional acreage.[7]

The purpose of S. 6953 and its predecessors may have been a bit too clear for members of the Committee on Irrigation and Reclamation of Arid Lands, who at the urging of the Interior Department amended the title of the bill to remove the term "surplus" water and to be less specific about the nature of a project site that might benefit from the legislation. Secretary of the Interior Richard Ballinger made clear his understanding of section 2 of the bill however, when he stated that:

> In some cases the Government has secured available sites whereon reservoirs may be erected of such dimensions as will irrigate a much larger area of land than it is deemed advisable to include within a government project. In the construction of a government reservoir the reclamation fund should only be used to construct it of such dimensions

> as will impound a quantity of water sufficient to supply the lands within the government project. Hence, unless the Secretary of the Interior can cooperate and contract with companies, associations, or districts to the end that reservoirs may be erected of such dimensions as to irrigate larger areas than the Government has included within its own project, great quantities of arid lands capable of irrigation will necessarily remain barren.[8]

Ballinger's concept was to allow federally-funded reclamation projects to expand by incorporating existing privately irrigated lands into the government project. The implication in this idea that public money might be used to finance private district irrigation or that, under state law, there could even be such a thing as "surplus water" fueled much of the congressional debate over the Warren Act.

Senator Weldon Heyburn of Idaho addressed the issue of "surplus water" in the spring of 1910. Heyburn was a resident of Wallace, Idaho, and represented industrial water users, such as mines and smelters, rather than irrigators. His Senate colleague, on the other hand, William Borah, lived in Boise in the Snake River Basin and had long been interested in irrigation ventures. Borah strongly supported Warren's bill. But Heyburn viewed it as an assault on state control of water, which he proudly claimed was sanctified by the Idaho constitution. Much of the lengthy and, at times, raucous debate, on S. 6953 centered on Heyburn's assertion that Congress was allowing the federal government to usurp a state right.[9] Heyburn was particularly intrigued by the Committee on Irrigation's amendments to the original bill and charged that "They took out the word 'surplus' in order to disarm those who are opposed to the bill."[10] Heyburn may have been correct about why the language of the bill was changed. However, the bill's supporters maintained that these changes clarified the purpose of the legislation, which remained consistent throughout the debates; i.e., to allow the Reclamation Service to derive revenues from existing excess storage capacity and to utilize fully prime reservoir sites that were under federal control.[11]

In the end, Senator Heyburn convinced few that his concern for federal infringement on state water law was a real threat. Indeed, this issue had been addressed earlier in passage of the Reclamation Act, and most congressmen seemed satisfied that supplementing that legislation would not pose additional problems. Given the senatorial sensitivity to this issue, however, Heyburn extracted a concession in the form of a proviso to section 2:

> That nothing contained in this Act shall be held or construed as enlarging or attempting to enlarge the right of the United States, under existing law, to control the waters of any stream in any State.

This did not mollify Heyburn who quipped, "The amendment is an apology, and only adds to the confusion as to what the statute will mean."[12]

Of more concern to proponents of the Warren Act and more illuminating as to the legislation's provisions is the skepticism of Nebraska Senator Elmer Burkett. Burkett distinguished between the purposes of sections 1 and 2 of the bill. While voicing support for section 1, he had reservations about the wisdom of section 2. Burkett was not concerned about Heyburn's charge that, by passing the bill, Congress was authorizing the secretary of the interior to sell surplus water. At the same time, the Nebraska senator was not misled by phraseology.

> The fact is we can call what we are selling the delivery and charging a price for it, or we can say we are selling water and charging a price for it. But the result is just the same. We are going to charge the people who get the water, call it whatever we may.[13]

What one called the process of "selling … excess water," as provided for in the bill did not bother Burkett. However, section 2 of the proposed bill, according to the senator, provided "for another and a distinct thing."[14]

Burkett believed that section 2 would allow the United States to invest in private irrigation projects, even if that investment involved no public domain lands. He explained:

> The first section [of the bill] provides that they [Reclamation Service] may use the water for private lands, but the second section provides that we will go into partnership with private concerns, and we will build these reservoirs, we will dig these canals, we will construct these ditches, for what? For private lands.[15]

While supporting the sale of truly "surplus" water, Burkett had grave concerns about the efficacy of promoting broader ventures between public and private entities. Burkett noted during the debate that the Reclamation Service was already strained by the cost of projects that it was presently involved in, and he saw little value in further expansion.[16]

Most senators did not share Burkett's concern for over-extending the reclamation fund. They understood section 2 to simply allow the secretary of the interior to enter into agreements to extend existing or planned federal projects. Indeed, given the requirement of the Reclamation Act that federal projects be designed to reclaim public domain land, they could not envision the scenario contemplated by Burkett.[17] Wyoming Representative Frank Mondell clearly articulated what he saw as the two prong benefits of S. 6953. In making his comments, Mondell was thinking specifically of the North Platte River Project.

> The first section of the bill relates primarily to those works which have been constructed. As I have said, it is an income to the service which otherwise the service could not acquire, and without this law, in the case of the North Platte Dam, the additional impounded water not needed for the irrigation of the lands under the project would simply be turned into

> the stream and the service would receive no benefit from it. This is the first section.
>
> Now, the second section contemplates two essentially different operations: First, that the settlers on a unit of a reclamation project who are anxious to have immediate construction and do not care to wait for the time when the service in the expenditure of its funds can build their canals may make contracts with the Reclamation Service under which they build their own works on the unit, and the contract with the service in fixing their water-right charges gives them credit for the work they have done at their own expense, and which otherwise would have to be done by the Government.[18]

Mondell considered this provision of section 2 to be the most important feature of the bill and he understood that it gave the secretary of the interior broad authority to maximize irrigable acreage.

Congress clearly expected private irrigation companies and the federal reclamation project to benefit from this new legislation. However, in only one instance during the entire debate on the Warren Act did Congress actually consider how the integration of a private system into a federal reclamation project might actually work. In the final House debate on S. 6953 on February 17, 1911, Illinois Representative James Mann queried Kansas Representative William Reeder, "Suppose there is a shortage of water in the end—who loses the water, the private parties, or the parties on the Government project?" This question would plague Bureau of Reclamation engineers for the next 50 years, and it immediately perplexed Reeder, who could only respond by hypothesizing that the first unit of the government project would be served first. However, if private existing lands were added to the project before completion of the federal portion, those earlier in time would be served before the public entity.[19]

Wyoming Congressman Frank Mondell again stepped in to clarify Reeder's response by explaining that the contracts entered into pursuant to the bill "can not affect the water right of any entryman under a reclamation project, for this reason, that when the reclamation project is inaugurated or initiated the water rights for the entire project and all units of it are filed, and the right dates from the time when the water-right application is made, provided due diligence is used in building works."[20] According to Mondell, all users of project water would have the same priority under state law and would be served equally by the United States.

Mondell's reference to the "relation back doctrine," as with Reeder's adherence to priority, underscored Congress' concern for ensuring that the Warren Act did not undermine state water law. However, the job of delivering water to the various government and "Warren Act contractors" was left to the discretion of the secretary of the interior. This task would require the Bureau of Reclamation to develop flexible procedures to ensure that all parties were dealt with equitably, particularly during periodic dry weather cycles on the Great Plains.

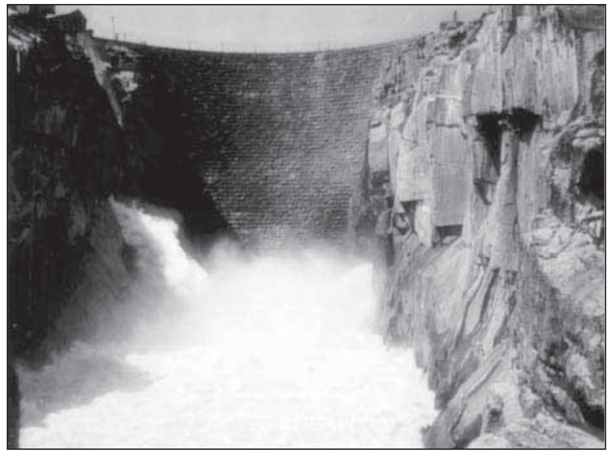
Creating and Administering Warren Act Contracts on the North Platte Project

Passage of the Warren Act in 1911 provided a statutory mechanism to incorporate lands within private irrigation districts into the publicly financed North Platte Project. Numerous questions remained, however, as to the number of potential irrigators who might elect to contract for surplus water. Moreover, since the only water that could be disposed of was "surplus water," the Reclamation Service had to determine the available supply from Pathfinder Reservoir, as well as the ultimate demand from future government project units that would be part of the North Platte Project. What indeed was "surplus water"? The answer that the Service found to this and other questions led to interpretations of the Warren Act that guided federal reclamation policy for much of the twentieth century.

The clamor to incorporate existing private irrigation district facilities into the North Platte River Project began even before passage of the Warren Act. A number of private irrigation companies and districts petitioned Secretary of the Interior Richard Ballinger during the winter of 1910-1911 to purchase water from Pathfinder Reservoir.[21] The secretary responded by explaining that legislation was pending to allow such a sale, but, at present, he was without authority to do so. Ballinger argued that, even with legislative authorization, he would need to be assured that there was sufficient water available in the reservoir to serve new irrigators on the government project before providing water to existing private lands. Unfortunately, Secretary Ballinger explained that the Board of Army Engineers had already prepared a report in 1910 indicating that there would be no surplus water available after meeting the needs of the North Platte Project as then contemplated.[22] Notwithstanding the secretary's finding, requests to purchase water from Pathfinder increased after passage of the Warren Act in late February 1911.[23] The Interior Department continued to base its response on the 1910 Board of Army Engineers report that had concluded that a surplus of storage water was unlikely, given current plans for the North Platte Project. Accordingly it would not agree to requests to sell storage water.[24]

The departure of Ballinger in March 1911 signaled a change in department policy. Beginning in June 1911 the secretary's office started forwarding applications for surplus storage water to the Reclamation Service.[25] That summer, Reclamation engineers began working on adjustments to the North Platte Project in order to free water for private use. The Board of Engineers determined in its July 24, 1911, report that Pathfinder Reservoir could provide 600,000 acre feet of water. Approximately 200,000 acre feet was committed to the Interstate Canal, 40,000 acre feet to a pending contract with North Platte Irrigation Company and 240,000 was to be reserved for the planned Fort Laramie Canal. The balance of surplus water was thus estimated to be 120,000 acre feet annually. The board recommended that the best use of this surplus was its "disposal" to existing canals on some equitable basis.[26]

The federal government's initial policy was to "rent" water to private district irrigators on a temporary, one-year basis until engineers could make a determination of what surplus water was available. As Reclamation Service Director Frederick Newell explained to Nebraska Senator Norris Brown in July 1911, "The system for utilization of the surplus stored water in the Pathfinder Reservoir will not be completed for several years and the Department feels that pending such completion it should not provide for any permanent rights for these canals."[27] Although most irrigators desired a more secure supplemental water supply, the Interior Department was soon inundated with petitions for temporary contracts.[28]


12.3. Pathfinder Dam on the North Platte Project.

Newly appointed Secretary of the Interior Walter L. Fisher and Reclamation Service Director Newell were well aware of the importance of the North Platte Project when they met with irrigators at Mitchell, Nebraska, on August 4, 1911. At that meeting, the secretary heard testimony concerning the development of the North Platte River Valley. He learned that the sugar beet processing industry had focused its interest on intensifying agriculture in the region through access to government and private irrigation projects. Secretary Fisher also was informed of the need for late season water. F. M. Sands of the Gering district explained that:


12.4. Walter L. Fisher while Secretary of the Interior.

> I believe we are all agreed as to the great benefit coming to this country when the Government came in and constructed the Pathfinder reservoir. But in the administration of the reservoir, there is a chance that the waters withdrawn from use by the early ditches during the flood season will not revert to them later in the season…. In other words, without any intention in the matter, there is a possibility that the Government will take waters from us in June and not give it to us in August. A gallon

> of water in August is worth two or three gallons in June. It is right and proper that the excessive June flow should be reduced—but I think we have a right to ask that the Government sell us at a fair price water that they have withheld from us in June.[29]

The secretary also heard from those who wanted the Reclamation Service to begin construction on a long-sought southside canal. The Fort Laramie or Goshen Hole Canal was considered by many to be part of the initial plan for the North Platte Project. Secretary Fisher noted a distinction between those mostly private district lands on the southside of the river from the largely public district lands on the northside. He questioned whether the participants in the Fort Laramie Canal would allow the federal government to place liens on their property to secure payment for the cost of construction and operation of the canal. The project's supporters assured the secretary that they would agree to such a condition.[30]

The interests of the Fort Laramie Project participants were potentially in conflict with the private district irrigators who sought permanent rights to surplus water from Pathfinder Reservoir. As noted above, consistent estimates placed the supply from Pathfinder at 600,000 acre feet annually. If those estimates were correct, there was potentially 160,000 acre feet available annually for private projects.[31] Estimates did not always prove correct, however, and Secretary Fisher wanted assurances from the private district irrigators that their right to surplus storage water under the Warren Act was second to that of the government project.

> One of the questions raised is what would be the situation of the present settlers or those coming in under the Government canal as compared with those holding land under the old ditches, if in the future there should be an actual shortage of water in the Pathfinder reservoir, and there would not be sufficient for all. Under those circumstances, you recognize you would probably have to concede the prior right of those under the Government canal. That seems to be the purpose of the law.[32]

The North Platte River Valley irrigators agreed with the secretary, but they also believed that the federal government would not sell them a water supply that was not dependable. Private district irrigators sought permanent rights to Pathfinder storage water and expressed a willingness to pay a fixed sum for the cost of construction and operation of the reservoir. They did so, as Fred Wright of Farmers' Irrigation District explained, "In view of the permanency that would be given us by the lump sum payment …"[33]

Secretary Fisher also had to insure the permanency of the government project, specifically, the Interstate Canal. He did so by 1) confirming a secure supply of water for the "Government [Interstate] canal" and 2) by suggesting that future configuration of the federal project be determined by the need to serve Warren Act contractors as well as government district irrigators. An exchange between Fred Wright, one of the first Warren Act contractors, and Secretary Fisher is illuminating. In responding to the secretary's concerns about a government district needs in water short years, Wright offered the following:

> MR. WRIGHT: In regard to that I take it that the Government knows better than any one else as to what the probabilities are and as to whether they were selling us anything of value or not. If the reservoir supply of water is taken up—that is a matter that the Government would be able to determine and regulate. I would assume that the position of the Department would be not to do anything intentionally that would bring hardship upon any one.
>
> THE SECRETARY: That is one of the serious questions on the south side [Fort Laramie Canal]. It would be a very serious thing if the Government should establish a project and invite settlers to take up the lands and build their homes, and there was a liability of being a shortage of water.
>
> I must say frankly that I concur in the general proposition stated—that the existing settler on the ground, even though he may not have come in under a Government canal, but coming under a private enterprise, if they are willing to do what is fair and reasonable, is entitled to a priority of right over an unknown settler who has not got here. …

Secretary Fisher's view was that Warren Act contractors would be sold a permanent water supply from Pathfinder, recognizing the preference to the existing government districts. He did not anticipate, however, the irrigation of any new government district lands so as to threaten the supply to Warren Act contractors. The secretary's views were welcomed by those potential contractors. According to the reporter, the secretary's statement was met with "unanimous and hearty applause."[34]

With this statement, Secretary Fisher initiated a policy that would govern the Bureau of Reclamation's future operation of the North Platte Project with respect to water delivery during years of shortage. Henceforth, Warren Act contractors would be considered part of the North Platte Project and would receive a guarantee of water delivery alongside the government district lands. The key to understanding of the government's position is the recognition that Secretary Fisher, adhering strictly to the terms of the Warren Act, protected the Interstate Canal, while providing for Warren Act contractors through a reconfiguration of the future North Platte River Project. The importance of this compromise was apparent soon after the August 4 meeting.

Early in October 1911 R. F. Walter, Reclamation Service supervising engineer in Denver, wrote to Chief Engineer A. P. Davis in Washington, D.C., acknowledging the latter's request for a recommendation on departmental policy with respect to the sale of surplus Pathfinder storage water. Walter claimed that it was premature to fix the amount of surplus water that would be available from the project. He acknowledged that there were senior water rights to the project held by downstream irrigators in Nebraska, and, until they were determined, he (Walter) would be unable to render an opinion. Walter recognized that "People under these Nebraska ditches as well as the people under the proposed Fort Laramie unit are clamoring for water and are very anxious to make a contract at this time." The Denver engineer thought that the Reclamation Service could use this anxiety "as a lever" to secure a final determination of senior water rights. To that end, Walter reported that his office had begun an investigation of Nebraska water rights, albeit without the cooperation of the State of Nebraska.[35]

A few days later, North Platte Project Engineer Andrew Weiss echoed Walter's concerns, but acknowledged that "It is probable that extremely strong pressure will be brought to bear on the Government to sell excess water rights from the Pathfinder, and it seems doubtful to me that if in the end this pressure can be successfully resisted." Weiss also noted that if the Reclamation Service did not prevail and continue to issue temporary, rather than permanent rights, then "it is exceedingly doubtful if the Fort Laramie unit can be undertaken at all."[36]

Neither Weiss nor Walter had to wait long for a response. Chief Engineer Davis reacted angrily to Walter's plea to allow more time to assess the volume of surplus water available in Pathfinder Reservoir. Davis charged that Walter was forgetting "that the Departmental policy in this matter was carefully considered and decided by Secretary Fisher last June." The secretary had determined that "preference should be given to lands already irrigated which require additional water supply, and that the irrigation of new lands should be secondary to their requirements."[37] Davis placed the future Fort Laramie canal in the same category as other new government or private district projects. He stated emphatically that "you … appear to assume that we must build the Fort Laramie project to its full size and then perhaps have a little water to sell to old ditches. This is the reverse of the present policy." Rather, surplus water should be offered as soon as possible so that the Reclamation Service could determine the size of the Fort Laramie unit.[38]

Walter's caution was not only unwarranted, but also politically ill timed. Davis informed Walter that the secretary had approved a letter drafted for Nebraska Representative Moses P. Kinkaid to be used at a public meeting in Bridgeport, Nebraska. That speech adhered to the policy of using surplus water for "old irrigated lands." By this, Davis meant that only existing privately irrigated lands would have a preference. Projected irrigable lands within the potential Warren Act contracts would not be considered comparably. Davis added that Walter would have to show a very good reason to reverse departmental policy on this issue.[39]

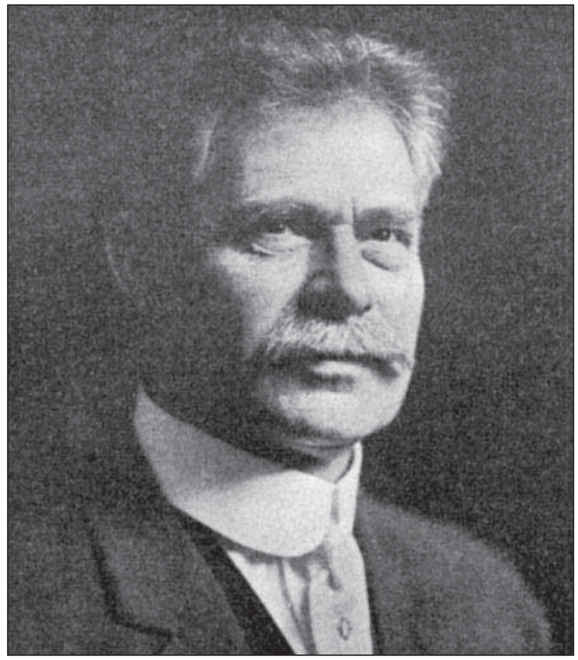
Both Walter and Weiss quickly responded to the chief engineer in a joint letter dated November 1, 1911. They claimed that they were in complete accord with departmental policy and had only raised this issue because they assumed "that the Fort Laramie Canal like the Third Lateral District under the Interstate Canal is part of the North Platte project." The engineers expressed concern about a possible conflict with the Warren Act. However, absent such conflict, they concurred in the plan to offer surplus water as soon as possible and "before the construction of the Fort Laramie extension is authorized."[40] With all project personnel in line, Secretary Fisher announced his policy on November 6, 1911, and, soon thereafter, the North Platte Project declared its intention to enter into contracts for the supply of permanent surplus water.[41]

The United States entered into its first Warren Act contract with existing water users on the North Platte River before the first major canal (the Interstate Canal) was completed on the north side of the river in 1915. That contract, executed in 1912, was with Tri-State Land Company, predecessor to Farmers' Irrigation District. By the end of 1912, "practically all the representatives of the older canal systems west of Bridgeport [had] expressed a desire to supplement their water rights to the direct flow from the river by Pathfinder storage."[42] In 1913 the United States signed five more Warren Act contracts with irrigation districts and companies that were using natural flow water from the North Platte River.[43] In 1914, 1915, and 1917 three more Warren Act contracts for North Platte Project water were signed with existing irrigators, bringing the total to nine contracts (see Figure 1).[44]

All nine of the contracts contain the proviso from section 1 of the Warren Act that the government projects shall be "prior to" the Warren Act contractors in the right to the use of storage water.[45] Of course, as noted above, the availability of surplus water through the reconfiguration of the project had already been decided through secretarial policy. Thus, all of the contracts confirmed that surplus storage water was available from Pathfinder Reservoir with the expectation that existing government district irrigators and Warren Act contractors could be satisfied with the available supply. The contracts provided for the government to deliver a supply of water to the Warren Act contractors in exchange for a fixed purchase price from the contractor plus the contractor's commitment to pay a set percentage of operation and maintenance costs connected with the storage facility providing the water. A delivery schedule with amounts and dates was included in each contract, together with the cumulative amount of water that each contracting district was to receive each year.[46]

Soon after execution of the first contract, private irrigation companies began raising issues that strained Secretary Fisher's accommodating policy. Fisher had initially approved the sale of surplus water under the Warren Act with the proviso that only currently irrigated lands would receive water.[47] Tri-State approached the Interior Department in 1912 with a proposal to include "lands which, although never irrigated, are under existing ditches or ditches existing at some particular time."[48] Responding to this request, the Reclamation Service established a new policy of setting a "maximum limit" on "the total water rights of the purchasing company after purchase shall have been completed."[49] This new policy allowed Tri-State and other potential Warren Act contractors greater flexibility in defining the lands that would receive surplus water, while providing a measure of certainty to the Service of the total demand for water.

The issue for Tri-State and other private companies was how much control the federal government would have over the total water supply (natural flow and storage) to their lands. Although the Interior Department consistently deferred to valid early rights to natural flow from the North Platte River, Reclamation Service engineers also recognized that, with construction of Pathfinder Dam, the North Platte no longer operated in a natural state. Reclamation's answer to the problem was to incorporate the "maximum" natural flow and storage water into the Warren Act contracts. This solution was apparent in the Tri-State contract. In reviewing a draft of that contract in July 1912 Reclamation Engineer Morris Bien informed the director that he had objected to Article 11 as initially drafted. That article stated that:



12.5. Morris Bien of the U.S. Reclamation Service.

> In order to enable the United States to deliver the supply of water herein specified on the basis of payments as herein provided it is agreed that the United States shall hold in trust for the benefit of the lands of the District all claims of the Company to the waters of the North Platte River and that the said Company shall assist the United States in the defense of said claims by the furnishing of all evidence and other like matters in its power or knowledge.[50]

Bien objected to this clause "because it places upon the United States the responsibility of acting as trustee in regard to these waters for the benefit of the lands of the District."[51] The Interior Department in Washington suggested a change in the language of Article 11 to provide for the company assigning its "rights, title and interest to the waters of the North Platte River" to the United States.[52] But this proposed change did not satisfy Bien. Rather, he suggested the following contract revision.

> The delivery of the water supply provided for in this contract will be accepted by the Company as in full satisfaction of all its rights to water of the Platte River, both natural flow and surplus storage from the Pathfinder reservoir and other reservoirs of the Reclamation Service constructed in connection with the North Platte Project.[53]

Although Bien's suggested language was used in the first Warren Act contract with Tri-State (August 20, 1912), subsequent contracts employed the substitute language originally proposed by the Interior lawyers in Washington.[54] The Reclamation Service's practical approach to providing storage and natural flow water apparently satisfied North Platte irrigators in 1912. However, the legal validity of assigning natural flow rights to the United States would be contested by those irrigators during the years of low water supply beginning in the 1930s.

Completion Of the North Platte River Project

Prior to passage of the Warren Act, the Reclamation Service had calculated the annual storage supply from Pathfinder Reservoir at a minimum of 600,000 acre feet.[55] In its July 1911 estimate of water supply requirements for anticipated projects, the Board of Army Engineers concluded that lands irrigated by the Interstate Canal system would require 200,000 acre feet and the proposed Fort Laramie Unit would use 240,000 acre feet.[56] Reclamation engineers also considered that, in the future, more surplus water might be available because of 1) more economical methods of water use; or 2) the Goshen Park unit of the project might not be constructed. One month later, Reclamation Service Director Newell stated that "no man is safe in prophesizing what will happen," but he reiterated that the Service would be "reasonably safe in disposing of 600,000 acre feet [from Pathfinder] as a minimum." Of this amount, he said, "250,000 [acre feet] goes to the Project, and under the terms of the law, this Project has a prior right."[57]

North Platte Project Engineer Andrew Weiss concluded in 1912 that 250,000 acre feet of Pathfinder water would eventually be sold to Warren Act contractors, including an anticipated 120,000 acre feet of storage water to the Tri-State Canal.[58] Estimates for the Interstate Unit remained at 200,000 acre feet of Pathfinder's storage water. The total of committed water was thus established at 450,000 acre feet. Engineer Weiss acknowledged that this amount could change if additional lands were to be irrigated, either by enlarging the North Platte Project or the private irrigation districts. However, based on current reports, Weiss expressed concern that all of Pathfinder's minimum flow of 600,000 annually would be utilized.[59]

The Board of Engineers reviewed the North Platte Project again in May 1912 and concluded that the Fort Laramie Canal would cover 125,000 acres.[60] The board added that selling storage rights to existing irrigators who had applied for storage water would not jeopardize the Pathfinder's water supply for the new unit under the anticipated scenario.[61] This optimistic view of the project's water supply changed quickly following the close of the January 1, 1913, deadline for Warren Act applications. By 1913 construction of two of the three canals making up the Interstate Canal system were completed. The Highline Canal diverted water from Lake Alice, which had a storage capacity of 11,015 acre feet, and the Reservoir Supply Canal carried water from Lake Alice to Lake Minitare (see Figure 1).[62] Also, by the end of 1913, six private irrigation districts had entered into Warren Act contracts for surplus storage water from Pathfinder.[63] The total amount of storage water sold to the Warren Act users was 143,465 acre feet.[64]

With these additions to the project, computations of available water and irrigation needs in 1914 showed that there was an inadequate supply of water for the proposed Fort Laramie Unit, which by then had been reduced from the 1912 estimate of 125,000 acres to 107,000 irrigable acres. According to the new calculations, the planned unit could now only accommodate 84,000 acres. Accordingly, consultants to the Reclamation Service recommended suspending further Warren Act contracts, except those in progress, until more water supply studies could be completed.[65] The consulting board also suggested that the Fort Laramie Unit be reduced to a smaller size and that the planned Goshen Park Unit be eliminated.[66]

Further analysis of the 1914 study, as well as additional studies, were completed in 1915 by three of the four members of the 1914 consulting board. This new board considered the storage water demand by Warren Act and project users to determine the total amount of required storage water. The board also reassessed the amount of storage water available. It's analysis involved use of a "more correct method of applying actual demand," assumption of a larger diversion into the Interstate Canal at the beginning of the irrigation season, and a slightly smaller amount of storage water per acre for any new project land to be irrigated.[67]

In their 1915 recalculation, engineers determined that there was an adequate water supply to irrigate 116,000 acres of new project land.[68] They recommended that the 116,000 acres of land be divided between a unit to be irrigated by the proposed Fort Laramie Canal and a new project district that would be irrigated by an anticipated extension of the Interstate Canal, via the Warren Act Tri-State Canal (Northport). Despite their higher estimate of available water supply, they affirmed the earlier recommendations that there be a moratorium on new Warren Act contracts and that the proposed Goshen Park High Line project be cancelled.[69]

Construction of the Fort Laramie Canal system started in 1915, after liens were placed on 90 percent of the deeded land to guarantee repayment of construction costs. The Reclamation Service estimated that the canal would irrigate 100,000 acres when finished.[70] Upon its completion in 1924, the canal actually was capable of delivering water to 107,000 acres.[71] By that time, the secretary had entered into agreements with the Gering and Fort Laramie District of the North Platte Project covering all of the Fort Laramie division in Nebraska and the Goshen Irrigation district covering all of the Fort Laramie division in Wyoming.[72] Also by the time of completion of the Fort Laramie Unit other project units were operating. In accordance with the 1915 Board of Engineers report, the secretary of the interior signed a contract with the Northport Irrigation District in 1919, agreeing to construct a canal that would provide water to

15,000 acres of land in the new project unit. Construction on the Northport Canal started that year and was completed in 1923 (see Figure 1).[73]

12.6. The Frank Vanchura homestead on the Fort Laramie Division of the North Platte Project.

The constant recalculations and revisions to the North Platte Project ultimately allowed the Bureau of Reclamation to meet most irrigator demands, at least partially. By 1924, the Bureau had completed construction of the principal components of the project, which included the four government units and the nine Warren Act contractors. To accommodate these interests, the Bureau had to redesign portions of the government units as originally conceived in the early 1900s.

The Bureau of Reclamation's Delivery of Water During Water-Short Years

The Bureau of Reclamation, delivered storage water to Warren Act contractors by following the delivery schedules in the specific contracts for the eighteen years following the first Warren Act contract—1912. Warren Act irrigators used their appropriated natural flow waters from the North Platte until that water ran out. Then they requested the delivery of their storage water according to the schedule in their respective contracts. Sometimes, when demand was particularly heavy, the Bureau implemented a rotation system. In 1912, for example, the rotation period was four days.[74]

Even though there was no shortage of project water during the 1920s, the Bureau faced questions as to whether or not government districts should have a "better right" than other users to project water, based on the Warren Act's acknowledgment of government contractors' "first right" to the use of storage water. In addressing this question in 1924, the Bureau suggested that water sold under the terms of the Warren Act were "permanent water rights." It noted, "It is argued by some that the water users under the projects proper [government units] should have a better right than the water users outside of the projects [the Warren Act users]." The Bureau acknowledged that Warren Act contracts "are now rather generally being made under section 2 of the [Warren] Act, and provide for rights having the same priority as those on the project from which the water is sold." In cases of existing Warren Act contracts, the Bureau dismissed the position that the government projects should have any better right than the Warren Act users. "There does not … seem to be any good reason to uphold this position," the Bureau concluded. "The Warren Act contractors outside of the projects pay in full for what they get in the same manner as do the water users under the projects."[75]

The drought that visited the high plains beginning in the early 1930s added poignancy to this academic discussion.

In 1931 lack of snow in the mountains and an absence of rain the previous summer, resulted in significant shortages of water in the North Platte River. Storage water from Pathfinder Reservoir was predicted to be exhausted before the end of August 1931, if withdrawals were to continue as in the past.[76] Anticipating drought, early in 1931, Farmers' Irrigation District filed a request with the Bureau of Reclamation to change its summer delivery schedule. Farmers sought to defer receiving early water in April and May and, instead, receive a greater allocation than its contract allowed between June and September.[77]

The Bureau's response to the predicted drouth was to initiate its allocation system. Bureau officials explained this plan at a June 17, 1931, meeting with irrigators in Mitchell, Nebraska. At that meeting, W. J. Burke, the Bureau's district counsel, advised the four North Platte Project irrigation districts that "the Warren Act contractors had purchased a water right and were entitled to their share of water." During the same meeting, the Bureau's Superintendent of Power C. F. Gleason advised the North Platte districts that he expected to "pro rate the water on an acreage basis, [and that] the acreage to be used would be the same as the acreage used in computing the O. & M. payments for the reserved works."[78]

Within days of stating this position, Bureau engineers began refining an allocation system to address the water shortage. They apportioned a prorated total supply to the various users, allowing the districts to determine when and at what rate to divert the apportioned amount. Under this system, the Bureau allotted approximately one-eighth of the total water supply to Warren Act contractors, after "carefully" studying the matter of how to apportion the available water among them and the government project districts. The Warren Act apportionment was "prorated upon their [the districts'] several contract schedules according to the percentage of a full reservoir supply" at Pathfinder on May 12, 1931." As a result of the proration, each Warren Act contractor received 62.5% of the water in its contract schedule. The Bureau notified the project users of the allocation system in late June.[79]

Later in the summer of 1931, Acting Chief Engineer S. O. Harper restated his intention to supply Warren Act irrigators in water short years. Harper responded to project users' arguments that Warren Act contractors should not receive any storage water until the project users received their full amounts. He stated that the uncertainties inherent in the contracts "leaves the way open for the adoption of a policy that would not result in direct conflict with the provisions of the contract and yet result in the most equitable use and distribution of the available water in a year like the present."[80]

While Bureau officials were implementing their allocation system, the Farmers' Irrigation District's earlier request to change its delivery date remained pending. In late December 1931 the Bureau's chief engineer addressed a letter to all North Platte Project water users (government projects and Warren Act contractors) seeking their views on the Farmers' request. Most of the districts responded by opposing Farmers' request and raising various interpretations of Warren Act contracts. Two government units—the Pathfinder and the Goshen districts—contended that language in the Warren Act "preserving a first right to lands and entrymen under the project" gave the government districts a prior right to project storage water over Warren Act contractors.[81] Gering Irrigation District, a Warren Act contractor, contested that position, arguing that such an interpretation amounted to saying that the Warren Act "authorized the secretary to sell blue sky."[82] The Bureau supported Gering's view and rejected the government projects' interpretation. Seeking an equitable distribution to all irrigators, Chief Engineer R. F. Walter eventually rejected Farmers' request for a contract modification.[83]

The Bureau continued to allot a partial schedule of storage water to Warren Act and government project users throughout the dry years of the 1930s.[84] Yet, government districts persisted with their position that they had rights to storage waters that were superior to Warren Act users' rights. Pathfinder Irrigation District objected to the Bureau's allocation system in 1934, continuing to insist that stored water could not be delivered under those Warren Act contracts unless there was "more than sufficient to supply the project lands."[85] Commissioner Elwood Mead concluded that the matter probably could be settled "only by a court decision in a case where all parties affected will have had an opportunity to be heard."[86] Nebraska officials weighed in on the side of the Warren Act contractors arguing that:

> No responsible person would enter into a contract if he knew that the rights obtained by him through such contract could be taken away from him at any future time. Neither would the Nebraska Warren Act contractors have contracted to pay one million dollars for storage capacity in the Pathfinder Reservoir if that storage capacity could be taken away from them for the use of any government canal that might be constructed in the future.[87]

In 1940 Bureau officials again debated how to treat Warren Act contractors in water shortage years, tying the debate to the issue of whether the Warren Act districts had rights to storage water that were junior to North Platte Project districts. They anticipated a water supply of about 45 percent for the 1940 irrigation season. District Counsel W. J. Burke initially signaled a reversal of the government's position when he suggested that Warren Act users had rights to storage waters that were junior to the government districts. On instruction from the commissioner, Burke, joined by other Bureau officials, drafted a new position paper more in line with Bureau policy. That paper confirmed the Bureau's earlier view, as reflected in a commissioner's decision in 1932, that Congress did not intend project lands to have a priority over Warren Act lands.[88] Burke and his co-authors proposed that Warren Act schedules for storage water be reduced to a percentage of the total contract amounts, as an administrative method of addressing water shortages. Warren Act contractors would receive their natural flow water as they saw fit, with storage water being used to supplement that natural flow up to the established percentage of the total amount as reflected in the individual contracts. The Bureau would apply the pre-determined percentage equally to Warren Act and government project contractors. This proposal was accepted on a temporary basis by the secretary of the interior.[89]

In accordance with this policy, storage water for the 1940 irrigation season was again allotted to Warren Act contractors on a prorated basis. Rather than basing the amount on the relative interest that contract holders had in Pathfinder Reservoir, however, the basis of the proration was now a percentage of the total contract schedule, which had been determined to be 41 percent of the amount in the contracts with the government.[90] Farmers' Irrigation District protested the method of allocation for 1940 claiming that it improperly deprived the district of storage water from Pathfinder.[91] In 1941 water again was allotted to Warren Act contractors based on a percentage of the total contract amount, which in 1941 was 68 percent of the schedule. There were no water shortages during the years 1942-1944 and Warren Act contractors had their full contract amounts available to them.

The protests of Farmers' Irrigation District and others to the Bureau of Reclamation's water allocation system did not end with verbal or written exchanges. Beginning in the mid-1930s, the Bureau of Reclamation, the Warren Act contractors, and the States of Nebraska, Wyoming, and Colorado were involved in legal action seeking answers to questions that were fundamental to the operation of the North Platte Project. Although neither of the two principal cases (*United States v. Tilley, et al.* and *Nebraska v. Wyoming*) specifically addressed the nature of Warren Act contracts, the courts' conclusions forced the Bureau to incorporate new factors in its water delivery method.

The issue of whether Warren Act contractors had transferred or assigned their natural flow rights to the United States in exchange for their Warren Act contract rights was before the court in the case of *United States v. Tilley, et al*. Establishment of the Northport Unit in 1915 required an agreement with Warren Act contractor Farmers' Irrigation District's predecessor, Tri-State Land Company to carry 250 cfs through its canal to the government project. The Bureau negotiated this agreement and Farmers' complied with it until the drouth year of 1936, when Farmers' failed to deliver sufficient flow downstream to Northport. The Bureau took the position that the Warren Act contractors had assigned their appropriative rights to the United States, and that this water was available to the United States for storage and delivery back to the contractors. The Bureau of Reclamation protested Farmers' action, but failed to deter the irrigation district. The State of Nebraska appealed the Bureau's interpretation of the Warren Act contract to the secretary of the interior, arguing that Nebraska's water rights could not be legally assigned to the United States or any other entity. In a June 1937 decision, the secretary found in favor of the Bureau and against Nebraska.[92]

The issue eventually ended up in federal court in Nebraska, when the United States sought injunctive relief against Nebraska and Farmers. The district court ruled in 1938 that a Warren Act contractor did not convey its natural flow rights to the United States under its Warren Act contract.[93] The case was appealed to the Eighth Circuit Court of Appeals, which, in 1941, also held that a Warren Act contractor's appropriative rights did not transfer to the United States. The circuit court reasoned that the language in Article XI of the Tri-State contract "does not on its face purport to transfer anything directly to the United States."[94]

The *Tilley* decision forced the Bureau to reconsider the validity of its allotment provisions for water short years. Specifically, the Bureau questioned the propriety of restricting natural flow diversions to the contract schedules and using a percentage of the contract amount as the basis for water allotments to Warren Act contractors in water short years. The Bureau interpreted the decision as requiring it to adopt a policy of supplementing natural flow water with storage water up to the amount of water provided for in the delivery schedule in the Warren Act contracts at any given time. From its reading of the *Tilley* case, the Bureau determined that the 1940 method of allocation for water-short years, based on contract schedules alone, could not be used as a basis for a water allotment.[95] Prior to the decision in *Tilley*, the Bureau apportioned natural flow and storage water. After *Tilley*, the agency revised its procedures to apportion only storage water in the North Platte River system.

The Supreme Court in its initial decision in *Nebraska v. Wyoming* (1945) also briefly addressed the Warren Act when it spoke about "surplus water."[96] In that litigation, the United States argued its long held position that a determination that there was surplus storage water available for use by Warren Act users was made prior to entering the Warren Act contracts. The United States contended that "surplus water" was "storage water in excess of that believed to be needed for the North Platte Project as then constructed and as proposed for extension.…"[97] The opinion and decree that resulted from the original *Nebraska v. Wyoming* litigation addressed only the interstate apportionment of the natural flow of the North Platte River.[98] Nonetheless, the court stated that storage water "should be left for distribution in accordance with the contracts which govern it," and generally acknowledged that the contracts were to be honored, including in times of low water supply.[99] The court also considered the management issues facing the Bureau and confirmed that a pro rata distribution among contractors was appropriate. In its opinion, the court recognized "the nature of the problem of apportionment and the delicate adjustment of interests which must be made."[100]

The Bureau's system for delivering water since 1945 has recognized the Supreme Court's pronouncements in the *Tilley* and the *Nebraska v. Wyoming* decisions.[101] In making adjustments to its allocations, the Bureau continued to maintain the same essential delivery system that it had established during the first year of water shortage, whereby it delivered pro rata shares of all contractors' water. During water short years, the Bureau designed and implemented an equitable method of ensuring that the four North Platte Project districts and the nine Warren Act districts all received a portion of their full amounts of water. But, following these decisions, Bureau officials also were more flexible with Warren Act and government unit contractors.

In 1954 the Bureau established a water allocation system when the storage water reached its maximum. The stated purpose of setting up the system of allotment was to "allow both the Warren Act contractors and the Project districts to participate in the storage with benefits to both groups." The advantage described for the Warren Act contractors was that it gave them "an opportunity to receive storage at a later date in lieu of natural flow." The advantage to the projects was that they would be able to "participate indirectly in the natural flows and thus supplement their storage during the entire season."[102] The formula used to compute allocations included documentation and averaging of previous years' storage water and diversions. After making adjustments for credits and improvements, Bureau officials determined the amounts for each of the thirteen districts.[103] The formula established for computing the water allotments for all of the districts was developed by Peter Anker, Chief of the North Platte Irrigation Operations, and has continued to be used since the 1950s.

Conclusion

Existing private irrigators within planned federal reclamation projects at the turn of the century recognized the value of partnering with the public projects in providing an adequate and dependable water supply from the North Platte River. Following passage of the Reclamation Act in 1902 and authorization for the North Platte Project less than one year later, irrigation companies along the river in Wyoming and Nebraska quickly moved to ensure their place in the reclamation plan. Passage of the Warren Act in 1911 confirmed the importance that Congress placed on responding to these needs and to garnering broad support for ambitious projects like the one planned for the North Platte River. It was left to the Bureau of Reclamation, however, to devise a mechanism to incorporate these private companies into the public project and, at the same time, not diminish the importance of reclaiming public lands for a new generation of farmers.

During the fall and summer of 1911, Interior officials faced the problem of reconciling the needs of potential Warren Act contractors for "surplus water" with expectations for the ultimate size of the North Platte Project. They reached an accommodation by 1) negotiating contracts for a permanent supply of storage water for Warren Act irrigators; 2) reconfiguring the remainder of the project to meet the needs of all irrigators; and 3) placing a "cap" on the total amount of water that would be delivered to Warren Act contractors. This approach satisfied the needs of all parties until the water short years of the 1930s. Faced with the prospect of diminished supplies throughout the system, the Bureau of Reclamation allocated water on an equitable basis both to government and Warren Act districts. Although both government and private irrigation districts complained about the system of allocation, and eventually filed lawsuits to stop or alter it, the Bureau continued to use the approach while refining the methods of calculation. To have done otherwise would have jeopardized the tripartite relationship between the Bureau of Reclamation, the government districts, and the Warren Act contractors. To not provide the Warren Act contractors with a permanent water supply would have been to admit that the United States had sold them "blue sky."

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Endnotes

1. A number of historians have written on the national Reclamation Act of 1902. These include, Roy M. Robbins, *Our Landed Heritage: The Public Domain, 1776-1936* (University of Nebraska Press: Lincoln, 1992); Samuel P. Hays, *Conservation and The Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Harvard University Press: Cambridge, 1959); Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (Oxford University Press: New York, 1985); and Donald Pisani, *To Reclaim A Divided West: Water Law and Public Policy, 1848-1902* (University of New Mexico Press: Albuquerque, 1992).
2. F. E. Warren to L. W. Moore, July 12, 1910, Francis E. Warren Papers, Political Papers, 1878-1945, General Correspondence, 1890-1929, "General Correspondence Letterbook, 29 May 1910- 13 September 1910. Box 10, Folder 2, Microfilm Reel No. 49, Accession Number 00013, American Heritage Center, University of Wyoming, Laramie, Wyoming.
3. F. E. Warren to J. M. Wilson, June 7, 1910, Ibid.
4. For example, see F. E. Warren to F. W. Mondell, August 20, 1910, Ibid. Warren's concern was expressed in his response to Mondell's letter of August 15 in which the Republican representative reported on his trip to the North Platte Project with the Board of Army Engineers. Mondell related that some of the Board's members viewed the unadjudicated water claims by Nebraska irrigators as a possible complication to the project's expansion. Mondell claimed that he was of the opinion that any such rights were well below the threshold that might jeopardize further development. See F. W. Mondell to F. E. Warren, August 15, 1910, Ibid.
5. F. E. Warren to L. W. Moore, July 12, 1910; F. E. Warren to Charles E. Perkins, August 18, 1910. Ibid. See also F. E. Warren to E. F. Hurdle, December 9, 1910; F. E. Warren to Hon. R. A. Ballinger, December 19, 1910, "General Correspondence Letterbook, 26 August 1910-28 January 1911", Box 10, folder 3, Microfilm Reel No. 50. For the relationship of the Warren Act to future expansion at Goshen Park, see Walter L. Fisher, Secretary of the Interior to F. E. Warren, May 2, 1911, "General Correspondence Letterbook, 5 April 1911-13 June 1911", Box 11, Folder 1, Microfilm Reel No. 52.
6. "Contracts For Disposition of Waters of Projects Under Reclamation Act," Sen. Rpt. No. 442, March 23, 1910, 61st Cong. 2d session (1910) p. 1; *Congressional Record*, April 6, 1910, vol. 45, pt. 4, p. 4315.
7. *Congressional Record*, April 6, 1910, p. 4315.
8. "Contracts for Disposition of Waters," Sen. Rpt. No. 442, p. 3.
9. For instance, during the Senate debate on April 14, 1910, Heyburn denounced the bill for allowing "the Government—not the Government, but one executive officer of the Government—to take possession of the waters of the streams of the State, and to sell them, not to all the people, but to a selected customer to the exclusion of the people." Heyburn also charged that giving the secretary of the interior the authority to deliver water to non-project entities was tantamount to selling water,

which was prohibited by state law. "This bill is to provide the water user with a master and make him pay the master's salary." *Congressional Record*, vol. 45, pt. 5, pp. 4666-4668.

10. Ibid., p. 4665.

11. The principal sponsor of the 1902 Reclamation Act, Nevada Senator Francis Newlands, articulated this later point in response to Heyburn. Newlands posited the scenario where:
"the Government has entered upon a reclamation project, and that project involves the construction of a dam on an excellent reservoir site, possibly the only practicable reservoir site within a large range of country; we will assume that the Government proposes to enter upon the reclamation of an area of land which will not require more than half of the storage capacity of the reservoir; we will assume that private parties, under the Carey Act, or outside of it, are entering upon another reclamation project within a convenient distance of the government project, and they have not a convenient reservoir. I understand it to be the purpose of this bill to enable the Secretary of the Interior in such a case to enter into a contract with the promoters of the second project. …"
Congressional Record, March 25, 1910, vol. 45, pt. 4, p. 3745.

12. *Congressional Record*, April 6, 1910, vol. 45, pt. 4, p. 4319.

13. *Congressional Record*, April 6, 1910, vol. 45, pt. 4, p. 4321.

14. Ibid., p. 4322.

15. Ibid., p. 4322.

16. Ibid., pp. 4322-4323.

17. See, for example, Thomas Carter's comments, *Congressional Record*, April 6, 1910, vol. 45, pt. 4, p. 4321.

18. *Congressional Record*, February 17, 1911, vol. 46, pt. 3, p. 2782.

19. *Congressional Record*, February 17, 1911, vol. 46, pt. 3, p. 2781.

20. Ibid., p. 2782.

21. Mitchell, Ramshorn, Gering, Winter's Creek, Central, Castle Rock, Minatare, Steamboat, Nine Mile, Alliance, Chimney Rock, Brown's Creek, Lucern, Farmer's Mutual, and Belmont companies and irrigation districts, to Secretary of Interior, Petition, December 30, 1910; Secretary of Winter's Creek Irrigation Company to Richard A. Ballinger, Secretary of Interior, Jan. 6, 1911, CCF, BOR North Platte Project, Box 1626, File 8-3. "Surplus Waters-Pathfinder Dam," Part 1 1-10-1911–8-31-1911, Record Group (RG) 48, National Archives, College Park, Maryland (NA).

22. This report is referenced in letters from the office of the Secretary of Interior to water applicants, e.g., R. A. Ballinger to Winter's Creek Irrigation Company, February 1, 1911; Acting Secretary of Interior to Sen. Norris Brown, May 16, 1911; Secretary of Interior to Norris Brown, May 23, 1911, p. 1, RG 48, all in CCF, BOR, North Platte Project, Box 1626, File 8-3, "Surplus Waters-Pathfinder Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

23. E.g., S. H. Osborne to Sen. Norris Brown, May 11, 1911, telegram; Sen. Norris Brown to Secretary of Interior, May 12, 1911; Sen. Norris Brown to Frank Pierce, May 20, 1911, all in CCF, BOR, North Platte Project, Box 1626, File 8-3, "Surplus Waters-Pathfinders Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

24. Frank Pierce, Acting Secretary of Interior, to Sen. Norris Brown, May 16, 1911; Secretary of Interior to Senator Norris Brown, May 23, 1911, CCF, BOR, North Platte Project, Box 1626, File 8-3, "Surplus Waters-Pathfinder Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

25. Samuel Adams, Acting Secretary of Interior, to Senator Norris Brown, June 5, 1911; Walter Fisher, Secretary of Interior, to Senator Norris Brown, June 27, 1911, RG 48, NA, all in CCF, BOR, North Platte Project, Box 1626, File 8-3, "Surplus Waters-Pathfinders Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

26. "Report On The Disposal of Pathfinder Water by Board of Engineers, July 24, 1911," p. 113 and D. C. Henny, "Report On The Irrigation Uses of Pathfinder Reservoir by D. C. Henny, Consulting Engineer," September 30, 1909, p. 81 both in vol. IX, *Drainage Hydrology, Interstate Unit*, *History of The Platte Project, Neb.-Wyo.* The 600,000 acre feet estimate was considered a minimum figure and was consistent with the report of Consulting Engineer Henny. The first such sale was contemplated with the North Platte Valley Irrigation Company, a Carey Land Act project in Douglas, Wyoming. A. P. Davis to First Assistant Secretary of Interior, July 13, 1911; Samuel Adams to Director of the Reclamation Service, July 22, 1911; CCF, BOR, North Platte, Box 1626, File 8-3, "Surplus Waters-Pathfinder Dam," Part 1, 1-10-1911–8-31-1912, RG 48, NA.

27. Frederick Newell to Norris Brown, July 24, 1911, CCF, BOR, North Platte Project, Box 1626, File 8-3 "Surplus Waters-Pathfinder Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

28. For example see Fred Wright and Others to the Secretary of the Interior, August 4, 1911, CCF , BOR, North Platte Project, Box 1626 File 8-3 "Surplus Waters-Pathfinder Dam," Part 1, 1-10-1911–8-31-1911, RG 48, NA.

29. "Report of a Public Meeting before Honorable W. L. Fisher. Secretary of the Interior at Mitchell, Nebraska, August 4, 1911," p. 22, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

30. Ibid., pp. 8-14.

31. This figure includes the 40,000 acre feet committed to the North Platte Irrigation Company.

32. "Report of a Public Meeting before Honorable W. L. Fisher. Secretary of the Interior at Mitchell, Nebraska, August 4, 1911," Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming, p. 25. As later events suggest, Secretary Fisher was probably only referring to the existing Interstate Canal and not to future canals.

33. Ibid. p. 24.

34. Ibid., pp. 25-6.

35. R. F. Walter to A. P. Davis, October 9, 1911, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

36. Andrew Weiss to R.F. Walter, October 12, 1911, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming. See also, A. P. Davis to Project Engineer, November 3, 1911, Warren Act Legislative History Documents, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

37. Davis probably exaggerated the longevity of the secretary's policy, which seems to have been first articulated at the August 4, 1911, meeting. A. P. Davis to R. F. Walter, October 24, 1911, Warren Act Legislative History Documents, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

38. Ibid.

39. Ibid.

40. R. F. Walter and Andrew Weiss to A. P. Davis, November 1, 1911, Warren Act Legislative History Documents, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

41. F. H. Newell to Supervising Engineer, December 12, 1911; and F. H. Newell to Secretary of the Interior, December 30, 1911, both in CCF, BOR, North Platte Project, Box 1626, File 8-3 "Surplus Waters-Pathfinder Dam" Part 2, 9-22-1911–3-18-1912, RG 48, NA.

42. Reclamation Service, *Eleventh Annual Report*, p. 127. See also, Local Board of Review, May 29, 1916, p. 17, noting the early petitions to the Secretary of Interior to purchase storage rights under the Warren Act. Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

43. A contract with the Gering Irrigation District was executed on January 17, 1913; with Chimney Rock Irrigation District, Beerline Irrigation District and Central Irrigation District on March 6, 1913; and with Browns Creek Irrigation District on July 14, 1913. The date of the 1912 contract with Tri-State was August 20. All of these contracts are found in contract files for the respective companies and irrigation districts in files of the Land and Water Division of BOR, Mills, Wyoming.

44. On November 27, 1914, a contract was signed with the Pleasant Valley Lateral Association, the predecessor to Hill Irrigation District. On July 1, 1915, a contract was signed with Goshen Land

Company, the predecessor to Lingle Irrigation District, and on April 17, 1917, a contract was signed with Lincoln Land Company, predecessor to the Rock Ranch Irrigation District.

45. All of the contracts were made under the authority of section 1 of the Warren Act, which provides for delivery of surplus waters from Reclamation projects to existing water users. Section 1 is specifically cited as authority for five of the contracts. Three of the contracts that fail to specify what section of the Warren Act authorizes the contract, simply refer to the Warren Act, without referring to any section. The other contract that fails to specify any particular section of the Warren Act—the Beerline contract—appears to have a typographical error, with a reference to "Section, of the Warren Act," but omitting any section number. All nine of the contracts, however, contain criteria for Section 1 of the Warren Act: determination that there is surplus water from the North Platte Project available in Pathfinder Reservoir, and a recitation of the "prior" right to the use of storage water by government contractors, "in accordance with Article 1 of the Warren Act." Specifically, all of the original versions of the Warren Act contracts contain the following provisions:

· The agreement is entered pursuant to the 1902 Reclamation Act and acts "supplementary thereto and amendatory thereof, and in particular ... the Warren Act."

· The Secretary of Interior considers it "advantageous upon the terms herein agreed upon to dispose of surplus storage capacity" in Reclamation-Act reservoirs "constructed or to be constructed" in the North Platte River basin; and surplus storage water is available for disposal under the Warren Act from the Pathfinder Reservoir.

· The respective companies or irrigation districts have a distribution system in place for irrigation from natural flow waters to which they had perfected a right on the North Platte River in specified areas.

· The United States will supply a definite amount of water to the districts, to be paid for in specified installments.

· The irrigation districts will make an additional payment of a specified portion of each year's operation and maintenance expenses.

· Government project rights to storage water are "prior" to the Warren Act users' rights.

46. The contract with Tri-State Company provides for the largest delivery of water, the highest purchase price and the largest portion of operation and maintenance costs. Tri-State purchased 180,000 acre feet of water for $500,000, plus payment of one-quarter of operation and maintenance costs for the storage works. The smallest purchase was made by the Rock Ranch District, which purchased 1,941 acre feet of water for $9,705 plus a commitment to pay one-two hundred and sixth of operation and maintenance costs.

47. Walter Fisher to Director, Reclamation Service, February 3, 1912, CCF, BOR, North Platte Project, Box 1626, File 8-3 "Surplus Water-Pathfinder Dam" Part 2, 9-22-1911–3-18-1912, RG 48, NA.

48. Acting Secretary of the Interior Samuel Adams to F. H. Newell, March 12, 1912, CCF, BOR, North Platte Project, Box 1626, File 8-3 "Surplus Water-Pathfinder Dam" Part 2, 9-22-1911–3-18-1912, RG 48, NA.

49. "Memorandum For Secretary Adams," March 18, 1912, CCF, BOR, North Platte Project, Box 1626, File 8-3 "Surplus Water-Pathfinder Dam" Part 2, 9-22-1911–3-18-1912, RG 48, NA.

50. "Draft of Contract—Tri-State Land Co," p. 8, n.d. attached to A. R. Howard to Director, Reclamation Service, July 12, 1912, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

51. Supervising Engineer Morris Bien to Director, Reclamation Service, July 15, 1912. Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming. The Reclamation Service frequently turned to Morris Bien for advice on state water law. Bien was responsible for preparing a model water law that the federal government tried, with varying success, to have states adopt. See Hays, *Gospel of Efficiency*, p. 16.

52. "Draft of Contract—Tri-State Land Co," p. 8.

53. Bien to Director, July 15, 1912.

54. See Agreement with Tri-State Land Company, August 20, 1912. The agreements that utilize the assignment language were with the Gering Irrigation District (January 17, 1913), the Chimney Rock Irrigation Canal and Water Power Company (March 6, 1913), the Beerline Irrigation Canal Company (March 6, 1913), the Central Irrigation District (March 6, 1913), and the Brown's Creek Irrigation District (July 14, 1913).
55. D. C. Henny, "Report on the Irrigation Uses of Pathfinder Reservoir," September 30, 1909, *History of the North Platte Project, Nebraska, Wyoming*, vol. IX, p. 81.
56. "Report on the Disposal of Pathfinder Water, by the Board of Engineers, July 24, 1911," in *History of the North Platte Project, Nebraska, Wyoming,* vol. IX, p. 112.
57. "Report of a Public Meeting before Honorable W. L. Fisher, Secretary of the Interior, at Mitchell, Nebraska, August 4, 1911," p. 32.
58. Andrew Weiss to Consulting Board, April 27, 1912, Memorandum on extent and condition of irrigable lands on the North Platte and Platte Rivers in Nebraska, *History of the North Platte Project, Nebraska, Wyoming,* vol. IX, pp. 128-9.
59. Ibid.
60. Board of Engineers, "Report on the Sale of Pathfinder Water, May 3, 1912," *History of the North Platte Project, Nebraska, Wyoming*, vol. IX, p. 141.
61. Ibid.
62. Bureau of Reclamation, Platte River Briefing Book: North Platte River Projects Tour, August 14-16, 1995, pp. 5-6.
63. Rock Ranch, Lingle, and Hill had not yet entered contracts.
64. *History of the North Platte Project, Nebraska-Wyoming,* vol. IX, Project History, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming, p. 41.
65. Consulting Board to Reclamation Commission, "Water Supply, North Platte Valley," December 8, 1914, *History of the North Platte Project, Nebraska-Wyoming, 1914*, pp. 236-7. In 1914, landowners on the south side of the river organized local support for construction of the Fort Laramie Canal, for irrigation of private lands. F. H. Newell to Lane, May 11, 1914, Report, Legislative History Documents, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.
66. Consulting Board to Reclamation Commission, "Water Supply, North Platte Valley," December 8, 1914, p. 237.
67. Walter Henny and Weiss, Board of Engineers, to Reclamation Commission, "Report on Water Supply — North Platte Project," March 10, 1915, *Project History*, 1915.
68. Ibid., p. 306.
69. Ibid. p. 307-8. The proposed extension of the Interstate Canal was discussed by the director of the Reclamation Service, F. H. Newell, in his report to the secretary of the interior in 1914. Newell recommended that project lands that would be served by such an extension enter into an agreement with the Farmers' Irrigation District to convey Pathfinder water through the Tri-State canal. Newell to Lane, May 11, 1914, Report, p. 8, Legislative History Documents, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.
70. Department of the Interior, *Fifteenth Annual Report of the Reclamation Service, 1915-1916*, pp. 257, 271. The principal portion of the unit was Goshen Hole or Goshen Park.
71. Department of the Interior, *Twenty-Fifth Annual Report*, p. 58.
72. This contract is discussed in correspondence to the Casper Chamber of Commerce from acting commissioner of the Reclamation Service, P. W. Dent, in Dent to Stafford, August 25, 1926, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20. Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming. The acting commissioner notes that the contract is a contract with government project users rather than with Warren Act users. He states, as his opinion, that Warren Act contractors receive storage water only after the water requirements of project users are met.
73. BOR, *Eighteenth Annual Report*, p. 208; Twenty-Second Annual Report, p. 81.
74. BOR, *Tenth Annual Report*, p. 157; Eleventh Annual Report, p. 126.
75. BOR, *Twenty-third Annual Report of the Bureau of Reclamation for the Fiscal Year Ended June 30, 1924*, p. 35.

76. Minutes of Meeting of District Boards, June 17, 1931, Folder 2-13-9: Hydrology, Misc. Correspondence, Box 49, BOR, RG 115, NA-Denver.

77. "Decision of the Chief Engineer, Bureau of Reclamation, May 27, 1932, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 1 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

78. Minutes of Meeting of District Boards, June 17, 1931, Folder 2-13-9: Hydrology, Misc. Correspondence, Box 49, BOR, RG 115, NA-Denver, p. 1. This position was consistent with the Bureau's position in 1924, that there didn't "seem to be any good reason" for government project contractors to have any better right to storage water than Warren Act users, discussed above. *Twenty-third Annual Report of the Reclamation Service, for the Fiscal Year Ended June 30, 1924*, p. 35.

79. Superintendent of Power to North Platte Project Districts, June 25, 1931, pp. 2-3, Folder: Storage Distribution 1931, Box 47, BOR, RG 115, NA-Denver. See, also, Superintendent of Power to Chief Engineer, June 26, 1931, Folder 2-13-9: Hydrography, Misc. Correspondence, Box 49, BOR, RG 115, NAFRC - Denver, pp. 2-3; "Decision of the Chief Engineer, Bureau of Reclamation, May 27, 1932, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

80. Acting Chief Engineer S. O. Harper to Superintendent of Power, July 3, 1931, Folder 2-3-6: Hydrology, Misc. Correspondence, Box 49, BOR, RG 115, NA-Denver.

81. Gering Irrigation District to Walters, January 30, 1932, p. 1; Gering Irrigation District to Walters, "Answer" to Goshen and Pathfinder Irrigation District claims, February 18, 1932, Third Party Interveners, Farmers' Irrigation, Goshen Irrigation District, Chimney Rock Irrigation, Exhibits in Opposition to Plaintiff's Second Interrogatories Motion for Summary Judgement 11-18-89, WTR-4.10, p. 1, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

82. Gering Irrigation District to Walters, February 18, 1932, "Answer" to Goshen and Pathfinder districts, p. 9.

83. R. Walter, "Decision of the Chief Engineer," May 27, 1932. The Bureau's conclusion about the meaning of "preserving a first right to lands and entrymen under the project" coincided with some of the basic arguments presented by the Gering District on this point. Gering District to Walter, "Answer" to Goshen and Pathfinder districts, p. 12.

84. C. F. Gleason to district counsel, April 28, 1936, p. 1, Folder 771: North Platte, Water Right Appropriations, Whalen Falls Enlargement #1398, 1931 thru 1940, Project Histories, Bureau of Reclamation, Mills, Wyoming; C. F. Gleason to Acting Commissioner, May 29, 1936, Folder: Willis Water Requests, etc.-1936, Box 48, RG 115, NAFRC-Denver, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming, p. 2. See, also, State of Nebraska, Supplemental Brief to the Department of the Interior, July 31, 1936, pp. 5-6. In 1932, 1933, 1937 and 1938, there was no water shortage. The Bureau's acting commissioner outlined the bureau's procedure for determining the allocations in July 1936. Superintendent of Power to acting commissioner, July 28, 1936, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

85. Pathfinder Irrigation District, "Resolution," August 7, 1934, p. 2, doc. File: 232, North Platte, Project Cost Repayment, Pathfinder Irrigation District, 1931-1948, Crop Reports, Box 43, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

86. Elwood Mead to Schroeder, September 17, 1934, File: 232.-North Platte, Project Cost Repayment, Pathfinder Irrigation District, 1931-1948, Crop Reports, Box #43, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

87. State of Nebraska, Supplemental Brief to the Department of the Interior, July 31, 1936, p. 4, Informal Production of Documents to Nebraska Based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 Letter to Richard A. Simms from John

Lawson, Box 2 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

88. W. J. Burke to Commissioner of BOR, May 20, 1940. Debler, Gleason, and Burke to Secretary of Interior, June 17, 1940; Acting commissioner to Burke, May 24, 1940; Commissioner, June 15, 1940, all cited documents in Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 1 of 20.

89. Acting Under Secretary to Superintendent of Power, June 25, 1940, Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 1 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

90. Warren Act Contract Summary, 1940; United States BOR, "North Platte Project, Final Water Supply for 1940," 1940; *North Platte Project History*, 1940, pp. 29-30 all in Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 4 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

91. Neighbors and Danielson, "Protest"; E. O. Daggert, Manager of Farmers Irrigation District, to BOR Commissioner, February 19, 1941, Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 4 of 20. Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

92. W. J. Burke, district counsel, Rebuttal Brief of the United States Bureau of Reclamation, before the Department of the Interior, November 3, 1936, pp. 41-2. See also United States Department of the Interior, Office of the Secretary, "Summary of Decision," June 4, 1937, copy available at Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming, p. 9.

93. *United States v. Tilley*, 124 F.2nd 859 (8th Cir. 1941).

94. Ibid. p.854.

95. C. F. Gleason to W. J. Burke, March 13, 1944; Burke to Gleason, March 4, 1944; Gleason to Regional director, September 24, 1945, Informal Production of Documents to Nebraska based on Wyoming's 6th Request of October 18, 1993, (Docket #576) Received in Conjunction with October 24, 1994 letter to Richard Simms from John Lawson, Box 1 of 20, Bureau of Reclamation, Great Plains Region, Wyoming Area Office, Mills, Wyoming.

96. The United States Supreme Court has maintained its jurisdiction over the original decree that it issued in the 1945 case of *Nebraska v. Wyoming*. The case has remained active and, indeed, the United States originally commissioned the research for this paper as part of that ongoing litigation. The parties have negotiated a settlement of the lawsuit, which is currently awaiting final approval by the court.

97. United States, Opening Brief, *Nebraska v. Wyoming*, June 4, 1942, volume 1, p. 53.

98. *Nebraska v. Wyoming*, 325 U.S. 589, 608, 610, 621 (1945). N.b.—that litigation goes on.

99. *Nebraska v. Wyoming*, 325 U.S. at 631. The court defined storage water in a way to give the Warren Act contracts "effectiveness," 325 U.S. at 631, 639-640.

100. *Nebraska v. Wyoming*, 325 U.S. at 618.

101. Gleason to Regional Director, September 24, 1945, Informal Production of Documents to Nebraska based on Wyoming's 6th Request of October 18, 1993 (Docket #576) Received in Conjunction with October 24, 1994 letter to Richard Simms from John Lawson, Box 1 of 20, paragraph 3.

102. BOR, "Method of Allocations — 1954 Irrigation Season," with cover page, Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 2 of 20. See also, "Meetings Between Water Users and Regional Director," Four States Irrigation Council Conference, n.d., Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 7 of 20.

103. The eight steps involved in this system are described, together with calculations for 1954, in "Allocation Method for 1954 (using current efficiency and average diversions)," Informal Production of Documents to Nebraska based on Wyoming's 6th Request of 10/18/1993 (Docket #576) Received in Conjunction with 10/24/1994 letter to Richard Simms from John Lawson, Box 2 of 20.

The Path Not Taken: The Development Company of America's Hudson Reservoir Project, Arizona Territory, 1898-1902

By:
Robert L. Spude

During the early summer of 1900, a group of businessmen held clandestine meetings over lunch or in private offices in New York City to discuss the building of the nation's highest dam and creation of a thirty-three square mile reservoir. Among them was Elton Hooker, the chief engineer of New York state's Public Works and a just returned member of the U.S. investigatory commission that studied the possibility of a canal across the Isthmus of Panama. Ex-Secretary of War Russell Alger, soon to be Senator from Michigan, was in attendance as was Henry M. Robinson, New York City corporate lawyer and player in the consolidation then underway to create U.S. Steel, the first billion dollar corporation. Two westerners, Governor Oakes Murphy of Arizona Territory and his brother Frank, a rising financier of the territory's mines and railroads, brought the group together to negotiate with Henry Man, of Man & Man, New York City lawyers, and possessors of the right to build a dam on the Salt River upstream from Phoenix.

The editor of the *Arizona Republican*, the Phoenix newspaper, shadowed the group in New York and leaked the story.[1] It appeared that the long-awaited storage dam and reservoir to ease all water shortages in the Salt River Valley were to be built, if, the editor asked, the citizens would agree to supply a $500,000 bonding subsidy. In the months following, two factions in the Salt River Valley soon coalesced, one supportive of the private project, another demanding that the federal government take charge of the site and build the dam.[2]

Instead of supporting the Murphy brothers, the other group in Phoenix accused the governor and his brother of trying to bilk taxpayers of $500,000 and defraud the Salt River Valley's residents. For the next two years the two factions clashed, one pro-Murphy and private enterprise, the other in opposition and pro-federal control. Today, the tale of the passage of the Newlands Act in 1902 and the federal construction of Roosevelt Dam at the site on the Salt River, 1903-1911, is well known. What is left out is the other group, the proponents of corporate dam building projects, of the path not taken.[3]

The leading promoters of the private project were the Murphy brothers, Frank and Nathan Oakes. Born in Maine, but raised in the lumber camps of Wisconsin, the two men followed separate paths West, sometimes together in Kansas or California, sometimes not. In December 1877 Frank moved to Prescott, Arizona Territory. After a period of varied jobs—stage driver, haberdashery clerk, scribe for the territorial legislature—Frank found his calling as a mine promoter. In 1883, his older brother Nathan Oakes Murphy, always known as Oakes, joined him in Prescott.[4]

Oakes had taught school, served in the military, then joined his brother in the firm of F. M. Murphy & Brother. One of the properties they acquired was the hydraulic gold mining operation along Lynx Creek, ten miles east of Prescott. Hydraulic mining used a stream of water to cut down stream banks, which then flowed into sluice boxes where the gold nuggets and flakes were washed out of the gravels. In the late 1880s, F. M. Murphy & Bro. operated their diversion dam, flume, and hydraulic nozzles during the high water of each spring.[5]

As others have pointed out, the basics of western water law came from the experience of hydraulic miners in the placer gold mining regions of Colorado and California. The experience at the Lynx Creek hydraulics would be used by Oakes, in training to be a mining lawyer and in his later irrigation views. He also understood the engineering basics as evidenced in his promotional pamphlet printed ca. 1889 in an effort to sell the mines. A British company, the Lynx Creek Gold & Land Co., Ltd., bought the property, built a sixty foot dam, cleared a storage reservoir site, and by 1891 began working the Arizona gold fields. By then Oakes had taken his profits and moved to Phoenix.[6]

Oakes had become active in Republican politics and rose through various appointed positions, first as personal secretary to the governor, then secretary of the territory, similar to a lieutenant governor today, and then, finally, governor in his own right in 1892. Forced to move to Phoenix with the removal of the territorial capital from Prescott, Oakes soon became a leader in the growing agricultural community in the Salt River Valley.[7]

Phoenix had risen upon the ruins of the prehistoric Hohokam peoples' homes and irrigation system. After 1867 a series of ever larger and longer ditches and canals supported the new farms and ranches along the Salt River. Phoenix became a territorial trade and political center, especially with the arrival of the capital in 1889. The 1890 census takers counted 3,152 residents.[8] When Oakes arrived in the small town, the city fathers had been working to build a railroad connecting the northern and southern parts of the territory via Phoenix. He organized a company, ushered through a twenty year tax exemption from the territorial legislature, and ceremoniously broke ground for the Santa Fe, Prescott, & Phoenix Railroad. Because of his gubernatorial duties, he passed the leadership of the project to his brother Frank, who completed the line to Phoenix between 1892 and February 1895. Wealthy investors from Chicago and Detroit, backing the Murphy brothers' railroad, also invested in Salt River Valley canal companies and land.[9]

During the 1890s the water diverted from the Salt River did not meet demands of boosters and land speculators, especially during drought years. Oakes Murphy became a leader in the political debate over water and irrigation, especially governmental support. At the 1892 National Republican Convention, Oakes was able to have included as part of that major party's platform the first call for federal support of private irrigation projects.[10]

In 1894 Oakes ran for and was elected to the U.S. Congress as Arizona Territory's delegate or non-voting member, and again pushed for support for irrigation projects in the territories. During his tenure as a member of the U.S. Congress, Phoenix hosted the National Irrigation Congress, one with many ideas but dominated by disputing factions and many resolutions. Murphy pushed for the cession of lands for irrigation projects, in line with the 1894 Carey Act.[11]

When Oakes left office in 1897, he turned to developing a resort and opening a land office in the Adams Hotel, Phoenix. Among the investors who had backed the Santa Fe, Prescott & Phoenix Railroad were some of the nation's most prominent businessmen, who now invested in his new projects. These investors included Dexter M. Ferry and C. C. Bowen of Detroit, the nation's largest seed producers. Through a field man, Dr. Alexander J. Chandler, they had bought Salt River Valley lands and built a major canal. Simon Murphy, a millionaire timber man from Detroit and "uncle" of Frank and Oakes, also invested in Salt River Valley lands, and supported the canal and land promotions of the Ferry and Bowen crowd through Simon's ranch manager A. C. McQueen.[12]

Included in the group of Detroit men was Russell Alger, another millionaire timber man. Alger had been a one-time candidate for U.S. President, but relinquished his bid to aid the Republicans and elect Benjamin Harrison. Eight years later, as payback, President William McKinley appointed Alger as his Secretary of War. Alger provided access to the White House for the Murphy brothers, and, in 1898, helped Oakes Murphy receive a second appointment as governor of Arizona.[13]

Upon his return to office Governor Murphy joined other residents in stating that the biggest need in the Salt River Valley was a means to store enough water to ensure that a steady stream could be provided for the expanding farmlands. He spoke at national arid lands meetings, raised awareness within the federal government, and sought incentives to assist private enterprise. By 1898 too, he, with his brother Frank, looked at ways to take over the company owning the best dam and reservoir site along the Salt River, the foundering Hudson Reservoir & Canal Company.[14]

Some sixty air miles east of Phoenix, the Salt River flows from a broad twenty-six mile wide valley into a narrow canyon barely two hundred feet across, an ideal water storage dam site. An 1889 visit by a Senatorial committee to Phoenix spurred the finding and description of the dam site, followed by a savvy New York lawyer who lay claim to it under the revised 1891 Federal land laws. In 1893 Wells Hendershott organized the Hudson Company Reservoir & Canal Company to build the dam and create a reservoir estimated, at first, at eighteen square miles. U.S. Senator John Martin of Kansas became president and secured the company's claim from the federal land office.[15]

However, 1893 was the worst time in the nineteenth century to promote new ventures. Across the nation railroads, banks, and canal companies went bankrupt as the country entered a depression that lasted from 1893 to 1897. Hendershott, a tall handsome promoter with personality, raised only $3,900. Sims Ely, secretary for Senator Martin, recalled that Hendershott had borrowed from the New York City law firm of Man & Man in order to keep an office open in Phoenix, take water measurements, and do minimal engineering assessments for the Hudson Company. The amount of capital needed—the Hudson Company had estimated $2.5 million—was beyond the reach of the Salt River Valley financial world at that time. Overextended, Hendershott transferred his control of the company to the Man brothers, particularly Henry Man. Sims Ely moved to Phoenix in 1895 as manager for the company.[16]

The company received a boost two years later when the U.S. Geological Survey published a report that confirmed that the site was the best along the river—indeed, was one of the best sites for a reservoir and storage dam in the West. That year Frank Murphy with Dr. Chandler visited the Hudson site. In addition, Sims Ely, Hudson Company manager, became part-time reporter for Frank Murphy's *Arizona Republican* newspaper. The following spring of 1898, Ely also became personal secretary to Governor Murphy.[17]

In his first report as governor, Oakes Murphy outlined in optimistic terms the products of the Salt River Valley, but added that without the Hudson Reservoir the limit of water for irrigation had been reached. His report also contains a lengthy description of the potential of the Hudson Company project, written as a promotional tract by secretary Ely. It stated "the further development of water supply is, therefore, one of the most absorbing problems with which the people of this Territory have to deal with."[18]

The Governor proposed several legislative initiatives to help build the dam, which was to remain a private enterprise. The territory should be given federal lands which it could then sell and use the revenues for irrigation projects. Also, the dam project should receive subsidies like railroad projects had, including tax breaks and county or territorial bonds. Frank Murphy had been in Washington asking Congress to allow the territory to issue gold bonds for public improvement projects, including water systems. He also boasted to a *New York Times* reporter that Arizona oranges could reach eastern markets two days ahead of those grown in California.[19]

Frank was the key to raising capital to build the dam. Ferry, Bowen, Simon Murphy, and Alger all helped back Frank Murphy's Santa Fe, Prescott & Phoenix Railroad. These men owned large tracts of land southeast of Phoenix.

They also pushed for a railroad extension to these undeveloped farmlands. The railroad could also support the dam building effort.[20]

In 1900 Frank Murphy and his partners owned the territory's richest gold mine, were consolidating its richest silver mining district, and held one of its most profitable railroads. They also owned newspapers, banks, mercantile, and other support business.[21] Imitating others, they began discussing the formation of a large holding company, ultimately called the Development Company of America (DCA), to transfer their operating companies to and then seek other opportunities for investment. The DCA would investigate new business proposals and, when one had promise, undertake its initial financial support by setting up an operating company. They would control the operating company by holding half its stock and bonds, but selling shares and mortgage bonds to the general investing public to raise funds. The Hudson dam project was an obvious choice for the group.[22]

The meeting in New York City in the summer of 1900 was followed by the drafting of the proposed company's documents. George W. Kretzinger, Chicago attorney and a director of Murphy's railroad and investor in Arizona mines, described the best way to organize the company. The Hudson Company was to be taken over by a new corporate entity, all the canals in the valley were to be acquired, the canals were to be improved and extended, all water franchises acquired, and the operation of an electric power system begun. This company would be controlled by a holding company, the Development Company of America (DCA).[23]

The DCA would be presided over by Frank Murphy. Engineer Elton Hooker would serve as vice president and general manager; he also represented his father-in-law Dexter Ferry. Making up the rest of the holding company directorate would be Senator Alger of Michigan; New York City lawyer Henry M. Robinson; N. K. Fairbank, Chicago grain and flour millionaire; Benjamin P. Cheney, representing the Santa Fe railroad and a Boston millionaire; Clement A. Griscom, Philadelphia shipping magnate; Eliphalet B. Gage, president of the Phoenix National Bank, Tempe Land Co., and the Tombstone Consolidated Mines Co., Ltd.; and seven other directors. Each had holdings in Arizona, were participants in earlier Murphy projects, and controlled wealth in their own fields.[24]

More importantly, while they were discussing possible projects in Arizona, they were ready to come into massive amounts of investment funds. Robinson was negotiating for steel and coal men in Michigan and Ohio with banker J. P. Morgan, who would buy them out to form U.S. Steel in 1901. At the same time, Frank Murphy was negotiating the sale of the Santa Fe, Prescott & Phoenix Railroad to the Santa Fe Railway for a reported three million, consummated in October 1901. These funds would be directed through the DCA to Arizona projects.[25]

The firm of Man & Man stood as ready and willing sellers of the Hudson project. Man & Man had continued to hold claim to the site and had funded Sims Ely, its Phoenix agent, to monitor water flow, collect statistics, and to work with local canal companies to ensure, if built, there would be water for all. In 1899 he had arranged an agreement with the canal companies that ensured certain water levels and levels of profit for the Hudson Company.[26]

The canals on the south side of the river, controlled by the Michigan group, would come into the new DCA operating company. Murphy was discussing cooperation with lawyer W. B. Cleary, manager of the New York controlled Arizona Water Company, owners of the Arizona, Grand, Maricopa, and Salt River canals, all the major canals north of the river. Also in support was Moses H. Sherman, now of Los Angeles, but major owner of the Phoenix municipal water and electric power system, trolley line, and an extensive land owner.[27]

Governor Oakes Murphy pushed the territorial legislature to pass a tax break of 15 years for new reservoir projects and then began pushing for a bond package of up to $2 million. During 1900-1901, various backers of the consolidation and holding company visited Phoenix. Senator Alger visited as did others including Chicagoan Marshall Field, backer of Murphy's railroad and one of the ten richest Americans of all time. Most importantly, in May 1901, President William McKinley visited Phoenix and the Congress gold mine, owned by Frank Murphy's group. McKinley made quips about Arizonans backing the gold standard, but, unstated, he supported his governor and his pro-business political attitude.[28]

During fall 1901 the finishing touches on organizing the Development Company of America were completed, and the initiation of construction of the Phoenix & Eastern Railroad began. The railroad would support valley communities and the dam construction. Papers were drawn to transfer the Hudson Company to the DCA. DCA vice president and engineer Elton Hooker readied himself to take charge of the DCA's many projects, including building the nation's largest dam. Construction engineer F. S. Washburn of Tennessee, expert in water control systems, joined DCA.[29]

As Oakes Murphy pushed for bonding legislation and Frank Murphy drafted papers for the organization of a strong operating company, advocates of federal irrigation continued to oppose private projects. Fate would be on their side. Outspoken leader of the group George Maxwell, a California lawyer specializing in water and irrigation law, was adamantly opposed to private sector involvement. The residents of Phoenix were of mixed minds; some, when meeting with Maxwell, followed his lead. Just as easily, when meeting with the Murphys, the same groups backed the Murphys' program of bonds and tax support for private projects. The name calling, begun in the summer of 1900 when the Murphys' newspaper first announced the plan, had died down—one can speculate that this abusive rhetoric was part of a political attack on Oakes Murphy, then the Republican candidate for Delegate to Congress (he lost). But the desire for public ownership and control continued to grow.[30]

In 1901 events took a decided turn. In September 1901 President McKinley was assassinated and Vice President Theodore Roosevelt took office. Unfortunate for the old guard, including Oakes Murphy, their access to the White House closed (Roosevelt had been a major critic of Secretary of War Alger during the Spanish-American War). In his first message to Congress, December 1901, Roosevelt also became a friend to federal irrigation project proponents by including a strong pro-federal reclamation statement and concluding that such projects were "too vast for private effort." The president's speech was followed by resolutions and outpourings of popular western support of a federal program.[31]

At that time, Frank Murphy wrote to a business partner,

> I have about made up my mind there is not much use trying to organize a local company on the lines we discussed, as I am inclined to believe we would find great difficulty in placing the securities of a reservoir company if controlled by local influences. I am about convinced that if the water consumers and tax payers are not willing to let a private enterprise take hold of the reservoir proposition on a fair basis, the next best thing for them to do is to get authority to issue their county bonds for enough money to construct the dam …[32]

As the Maxwell contingent gained access to the White House through Roosevelt's friend Gifford Pinchot, Governor Murphy was rapidly falling out of favor. Oakes met his new boss at the Grand Canyon April 6, 1902, and announced his resignation the next day. In a letter to a friend two weeks earlier, Governor Murphy had written that he would be relieved to quit the "very unprofitable and thankless office."[33]

The Murphys continued to push for support of the bond issue for the reservoir project. In May 1902 Frank met with some 300 business leaders in the Adams Hotel, Phoenix, asking their support for bonding their county for $1 million in order to get the reservoir built. At the same time, Governor Murphy, not officially out of office until July, was in Washington as part of a lobbying effort to influence reclamation legislation. The group worked with Senator Francis Warren of Wyoming for a reclamation bill friendly to the territory, especially its businessmen. Unfortunately, Senator Warren left suddenly because of his wife's death, and Oakes Murphy wired Phoenix that there would be no passage of the bond bill—it would not even make it to the floor of the House.[34]

As we know today, another group, led by George Maxwell, inserted instead the legislation introduced by Francis Newlands, Representative from Nevada, which passed June 17, 1902. At the last minute the initial proposal to provide support for only undeveloped federal lands was changed to allow for aiding private lands. As Karen Smith wrote, with this change, Salt River Valley land speculators "saw their land turn golden."[35]

13.1. This 1909 Phoenix orange grove is typical of the agriculture local farmers expected to be able to support with water from the Salt River Project.

With the passage of the Newlands Act, if not before, the Development Company of America halted the Hudson Dam project, a project later completed by the U. S. Reclamation Service as the Roosevelt Dam. Elton Hooker left in the fall of 1902 to become a leader in chemical manufacturing. The Murphy brothers continued to promote land deals in the valley, Oakes opening an office in the Adams Hotel. He profited from his speculations, sailed to Europe, and died in 1908 at the Coronado Hotel in San Diego.[36]

Frank Murphy and the DCA turned primarily to mining and operated some of the territory's largest mines. Unfortunately, the holding company's Tombstone Consolidated Mines, Ltd., hit an underground river equivalent to the flow of the Salt River and spent $8 million trying to pump the mines dry. The firm lost nearly as much as the Roosevelt dam would cost in the unsuccessful attempt and closed operations in 1911, the year Theodore Roosevelt dedicated his namesake dam.[37]

The different tracks followed by the Murphys from the well known triumphal story of the events leading to the passage of the Newlands Act and the construction of Roosevelt Dam brings up the question, could private industry have built and profited from the project? Were 90% of canal and irrigation companies in financial straits in the 1890s, as proponents of the federal act claimed? Evidence suggests that proponents of federal reclamation over-stated the crisis of the time. They claimed that not enough capital existed to build such works. Obviously, the Development Company of America had the funds.

The muckraking critics of the era pointed to the government's Roosevelt Dam project as being a scandal, called Uncle Sam a lawbreaker. The government by its lax regulation of land laws, one muckraker wrote, had encouraged fraudulent irrigation of thousands of acres of the public domain held by Dr. Chandler and his backers, when the water was to aid small farmers and owners of 160 acres or less. Further accusations were aimed at giveaway electricity. The Reclamation Service's contracts with Pacific Gas & Electric, heir of Moses Sherman, Murphy and other investors' Phoenix Light & Water Company, the muckraking critic pointed out, were scandalously low priced.[38]

Finally, Man & Man, through Sims Ely and ex-Governor Murphy, gained less than they hoped but their rights were bought out for a profitable $40,000. The New York, Michigan, and Chicago investors also made money in selling their canal companies to the government. In short, the Murphys and their friends were not hurt by the passage of the Newlands Act.[39]

The Development Company of America's Hudson Reservoir project fit well into the politics-as-handmaiden-of-business outlook of the William McKinley era of the 1890s. But, like many such projects, it was never undertaken by private enterprise. Instead, Teddy Roosevelt and the progressives brought new ideas and legislation, and for the West, irrigation projects beyond the imagination of any nineteenth century empire builder.

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Irrigation and Early Hydropower Development in the Salt River Valley

By:
Stephen Sloan

Abstract

Water and power have always had an intricate relationship throughout the modern history of the American West. The limited availability of reliable sources for irrigation and accessible traditional means of energy production led residents of Arizona's Salt River Valley to take extreme measures to guarantee water and power. Without the development of these two resources in the early decades of the twentieth century, the post World War II boom in central Arizona would have remained an impossibility.

Experiments with hydropower development in western U.S. reclamation projects at the turn of the century provided a glimpse of the dividends water storage could offer in energy production and revenues. In the Salt River Valley, the success of early power generating plants on the canal system and at Roosevelt Dam led developers to seek an expansion of reservoir capacity and hydropower generation. As a result, the Salt River Project constructed three dams below Roosevelt and above the canal diversion dam at Granite Reef. Through the operation of generating stations at these sites, the Salt River Valley Water Users' Association sought a rapid and significant increase in power revenues to fuel further project expansion and ease governmental debt.

In the case of the Salt River Valley, however, the goals of hydropower generation and efficient irrigation were divergent during periods of the 1920s and 1930s. In times of drought, farmers often demanded additional water to be released from dams on the upper Salt to water their fields. When requests went unheeded, many of the farmers claimed that SRP was holding water to be used for power generation, which provided much higher revenues than irrigation. Farmers' organizations argued that the project was catering to power buyers rather than focusing on their primary mission, providing a reliable and sufficient water supply for irrigation. Until the development of additional reservoirs and the implementation of pump storage technology, times of drought renewed the underlying tensions between hydropower and irrigation.

Although much has been written on water in the West, the relationship between western irrigation and hydropower is a topic often neglected. Focusing on the decades of the 1920s and 1930s, the paper reveals how the character of a project changes when irrigation and generation not only coexist, but compete. Such a study offers needed insight into not only the history of the Bureau of Reclamation, but reveals much about the nature of the twentieth-century arid West.

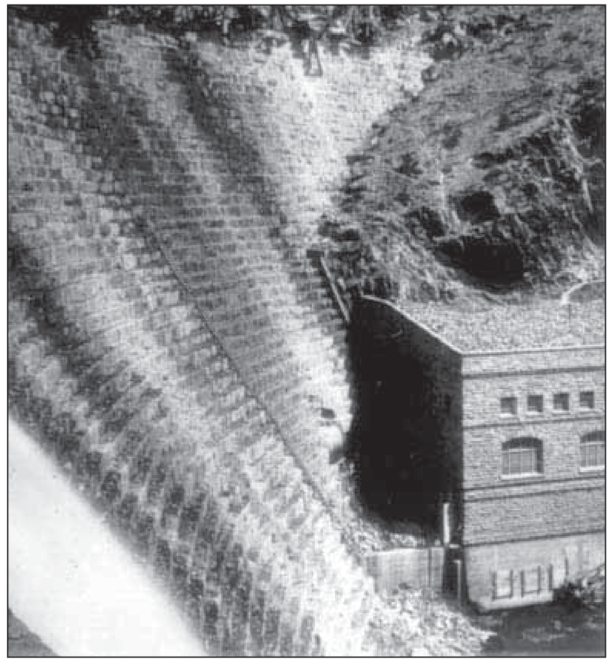
Water and power have always had an intricate relationship in the history of the American West. These two elements were the cornerstone for the creation of modern Arizona and the Salt River Valley. Without the development of each of these resources in the early twentieth century, the reality of the post World War II Valley boom would have remained an impossibility.

Aridity, according to many western scholars, is the defining characteristic of the American West. For early residents of the Valley in the late nineteenth century, aridity represented a primary obstacle to permanent settlement. The Salt River, the major water source for central Arizona, varied in flow from raging torrent to a small stream. Early settlers, such as the Swilling party, based the first recorded attempts to irrigate the flatlands along the Salt River upon a system of irrigation ditches constructed by prehistoric Valley residents. The Hohokam left a legacy of 600 to 700 miles of primary irrigation canals and laterals. Many of these ditches became the foundation for the modern network of Valley waterways.[1] Like the Hohokam, modern settlers began damming, diverting, and ditching the Salt to make the most efficient use of limited water resources.

As the population grew and more irrigation enterprises depended on the erratic flow of the Salt, better control over the water supply became a necessity. Farmers along the river witnessed cycles of flood and drought that compromised their ability to prosper. Flood meant not only damage to crops, but, more importantly, was seen as a waste of valuable river water. Drought brought conflict over water rights and dramatic drops in farm production. A solution to the problems of flood and drought required a comprehensive irrigation plan for reducing loss and increasing supply. An answer to the question of how to develop the irrigation resources of the Valley came with the passage of the federal Reclamation Act of 1902. The act allowed funding for the construction of Roosevelt Dam at the confluence of the Salt River and Tonto Creek, seventy-seven miles east of Phoenix. The dam impounded floodwaters for agricultural use during dry years and served as the keystone of the new irrigation system. With creation of the Salt River Project, local farmers had hope that triumph over the obstacle of aridity was close at hand.

Along with the challenge aridity presented in much of the West, western power generation development was an equally formidable task. In the Salt River Valley, the inaccessibility of traditional power sources, such as timber and coal deposits, caused developers to look for alternatives for energy. Steam plants that used fuel oil to operate boilers provided an early, yet expensive, alternative. The development of western U.S. reclamation projects provided glimpses of the dividends that water storage could provide in energy production and revenues. The first reclamation projects, including the Salt River Project, used hydroelectric power in the construction of irrigation features. As Bureau of Reclamation Director Elwood Mead would later note, the earlier government effort made "extensive use of the opportunities which existed on many mountain streams, to cheapen the cost of excavating canals by employing hydroelectric power to displace coal and gasoline, horses and mules."[2]

Soon after planning began for Roosevelt Dam construction, reclamation engineers realized that hydropower could provide the most reliable and efficient source of energy for construction. Developers noted that the energy produced at Roosevelt could not only be used for construction, but also wholesaled to the nearby Globe area mines, sent to the Valley as power for pumping, or transmitted to Phoenix as a municipal energy source.[3] The hydroelectric units installed at Roosevelt started the Salt River Project in the power business and created the first multipurpose project under the Reclamation Act.

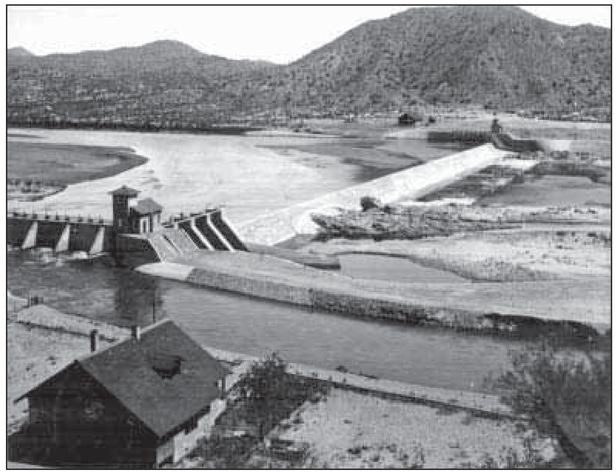

14.1. Roosevelt Dam and Powerhouse in August of 1909.

As the Bureau of Reclamation continued to develop irrigation features throughout the Valley, the work at Granite Reef Diversion Dam and along the canal system required a new network of transmission lines to power construction and excavation equipment. The lines erected during this period would later form the main distribution system reaching out to all corners of the Valley.[4] The water distribution network thus determined the structure of the early power grid for the valley. As work continued, additional hydropower plants were created along the canal system to supplement the primary generation at Roosevelt.

In 1917, U.S. Secretary of the Interior Franklin Lane insisted that the project cease to be federally operated and that control be turned over to the landowners. He argued that government paternalism had no place in such a local concern. Although many local representatives were hesitant about the change, Karen Smith argues that one of the factors that led them to agreement was a recent "reinterpretation of reclamation policy which allowed profits from the sale of power to be used in any way the water users wanted."[5]

The prospect of future hydropower development was an important factor in rallying local support for the Salt River Valley Water Users' Association's assumption of project control. The revenues created by hydropower sales could be used by the Association to pay off government debt and subsidize the cost of water storage and transmission. Although plans for expanded power production were not yet widely considered, the revenues being generated by the power production system in place indicated the profit potential that might be available from an expanded system.

In 1917, the generation system included the Roosevelt units and four small hydro plants in the canal system. The principal power development of the project remained at Roosevelt, where the Association operated a generating station with an installed capacity of 16,000-horsepower. The Association, in accordance with a 1910 contract with the government, created the four smaller plants, Crosscut, South Con, Arizona Falls, and Chandler. Built in 1914 at the junction of the New Arizona Crosscut and the extension of the Grand Canal, the Crosscut hydro-plant was the closest generating station to metropolitan Phoenix. The South Con, built in 1910, served as a generating station at the junction of the Eastern and Consolidated Canals, a few miles below Granite Reef diversion dam. Arizona Falls, an older facility on the Arizona Canal, was fitted with two hydroelectric units in 1912. Originally a steam plant, the Chandler Power Plant was converted to hydropower around the beginning of the decade at the existing site on the Tempe Canal.[6] All four generating stations operated on the existing canal network and did not involve any significant retention or diversion of water that was to be used for irrigation. Together with Roosevelt, the five generating stations had a total capacity of 27,000-horsepower.[7] The small network of power producing hydro-plants would soon prove inadequate to satisfy the growing demand for industrial and residential power.



14.2. Granite Reef Diversion Dam in 1910.

Soon after taking control of the project, the leadership of the Association began to realize the unique positioning of the project in relationship to power for Arizona. T. A. Hayden, an Association engineer, noted that, in 1920, 80% of the total annual power load for the state of Arizona was "used within a radius of less than 100 miles of the Association's plants; half of this load being already in touch with the Association's existing transmission lines."[8] Project leadership recognized that a ready and accessible market needed new power sources and the unused hydropower potential of the Salt could provide the answer.

One of the leading proponents for the expansion of hydropower generation on the Salt River Project was C. C. Cragin, the general superintendent and chief engineer of the Association in the 1920s. Cragin, who was recently named one of Energy Markets Most Influential People in Electricity and Gas, had a bold vision of what the Association generation system could become with new developments. In a proposal for additional hydropower development submitted to the Association board in 1922, Cragin provided a detailed analysis of the power situation for the Association board. His Report on "Proposed Additional Hydro-Electric Power

Development in the Salt River" included a brief analysis of the early relationship between hydropower and irrigation. In the report, the engineer acknowledged that the superior right to the waters of the Salt had been and should always be for irrigation. Cragin argued, however, that the centrality of irrigation did not preclude the development of power resources. For Cragin, the Association could no longer ignore the unused power potential of the Salt. He noted that it had become "quite evident that large quantities of power are now going to waste while the water drawn from Roosevelt Reservoir, for irrigation use, drops to the lower level of the Valley."[9]

Early proponents of energy development such as Cragin recognized the difficulties of matching the goals of an irrigation project and a hydropower generation venture. The water movement patterns for irrigation were by no means ideal for power generation. Water releases through Roosevelt and the canal system vary greatly throughout the year. In summer, when the agricultural demand for water was high, generation capacity could exceed demand, while in winter electricity available plummeted with the drop in irrigation. Any future development of hydropower had to deal with a heavy water flow for seven months of the year and a very light flow for five months. Cragin argued that the relationship between irrigation demand and hydropower production forced the Association to choose between three alternatives: contract for a variable power supply depending on irrigation demand, waste water for power, or build additional storage to regulate water releases for power purposes.[10] In considering a course of action, the Association's concern regarding competing power suppliers made contracting for variable power an unattractive alternative and wasting water went against the fundamental nature of the project.

Although proponents of hydropower expansion spoke of the usefulness of the new power for residential and agricultural purposes, a large consideration in pursuing additional energy development was the potential industrial load. Some of the larger enterprises in the market for additional hydropower at the time included the Inspiration Consolidated Copper Company, Ray Consolidated Copper Company, Magma Copper Company, and Southwest Cotton Company. These firms represented potential markets for power as well as partners that could be used to help finance new developments. As H. J. Lawson, president of the Association in the 1930s, would note, "the Project was most fortunately situated as regards to power development, being far from any other source of power or fuel supply and in a fast developing country with a very considerable and industrial mine load."[11]

It became evident by the early 1920s, that a new source of energy was required to supply the growing needs of the developing Valley. Many members of the Association were of the opinion that if the Project did not provide the desired energy, outside interests would take advantage of the opportunity. The introduction of new competitors in power production could not only have resulted in a loss of revenue due to lower rates and less customers, but could have caused an interference with the existing irrigation system.[12] Additional hydropower development was necessary both to reach new markets and protect established ones.

Additional reservoir construction along the Salt seemed to be the only acceptable solution for the power generation situation encountered by the Association. More storage could ease the complications presented by attempting to generate hydropower on a system with a single dam. With additional water storage, irrigation water passed through Roosevelt Dam could not only generate power and be captured by lower dams until needed, but also generate additional hydropower when passed through the lower dams. The additional water storage would bring power production to an underutilized 45-mile long, 604-foot drop from Roosevelt Dam to Granite Reef Diversion Dam. Once water left Roosevelt, it could be used for power several times before entering the canal system. Just as waste had been an overriding concern in developing the irrigation system, it became a central theme in developing the Valley's power resources.

The first dam constructed on the new system was built approximately seventeen miles below Roosevelt in a box canyon near Mormon Flat. The construction of Mormon Flat Dam, 1923 to 1925, began the fundamental shift of the project from one devoted exclusively to irrigation to an irrigation/hydropower development. According to Cragin, the value of the Mormon Flat Dam would be that it "permits the generation of hydro-power during times when there is no irrigation draft on Roosevelt."[13] Of secondary importance, the new dam could stabilize the daily and weekly fluctuations in power development at Roosevelt by offering additional irrigation storage downstream.

Along with the Mormon Flat Dam, the Association constructed two additional storage reservoirs on the lower Salt and gated the Roosevelt spillways in the 1920s. Horse Mesa, located between Mormon Flat and Roosevelt, 1924 to 1927, and Stewart Mountain, constructed 1928 to 1930, completed a seven-year period of construction, and Stewart Mountain, built below Mormon Flat above the Granite Reef Diversion Dam, contributed both additional water storage and hydropower generation to the Project. Manipulating the water levels at the four generating dams on the Salt, the Association could better maximize energy production.

Power, which in the early days of reclamation was viewed as primarily for construction and pumping, was now supplied to towns, homes, cotton gins and mines. As a result of the additional development, the Project increased the generating capacity of the hydroelectric system from 23,000-horsepower to 103,000-horsepower. The gross annual power revenues escalated from approximately $500,000 annually to yearly revenue of nearly $2,500,000.[14] The additional revenue proved important in many ways: to subsidize water delivery costs, to pay portions of the expansion costs, and to repay government debt. As Association President H. J. Lawson would later note, "the only reason why the Salt River Project has been able to meet its obligations to the government can be given in one word—power."[15]

The expansion of the power system increased the electricity available to both the urban and rural areas of the Salt River Valley. For the Salt River Valley farmer, the benefits provided by the new development were many. By 1930 2,000 farms had electricity with approximately fifty new connections per week. Power was used not only for pumping, but for "cooking ranges, water heaters, ensilage cutters, milking machines, cream separators, feed grinders, incubators, brooders and a host of other farm appliances."[16] Advertisements for the latest in home electrical appliances were prevalent in local newspapers as retailers claimed the ways in which new products, such as the vacuum cleaner and the washing machine, could lessen manual work and improve the quality of life in the Valley.

Despite the gains in rural electrification realized through the expansion of the hydropower system, some argued that the irrigation/hydropower relationship remained strained. The dual objectives of maximizing hydropower generation and efficiently providing irrigation were often at cross-purposes. Although the development of additional storage below Roosevelt Dam was proposed as a way to reconcile the variant goals of irrigation and hydropower, the expansion served to increase the tension within the relationship by raising the importance of hydropower to the Project.

In a 1932 journal article in the *American Society of Civil Engineers Papers*, C. C. Cragin reflected on the dynamics of developing hydropower on an irrigation project. He noted three fundamental restrictions that must be honored when embarking upon combined development: power development is justified only when there is little or no interference with the irrigation system, generation expansion is only warranted when the profit margin assured is significantly greater than that required in an independent power concern, and an irrigation project is justified to enter the general power business only in the most unusual of circumstances.[17] Although he argues that the Salt River Project's hydropower expansion considered these three restrictions, Cragin was conscious of the many tensions inherent in the creation of a dual-purpose project.

In the early 1930s some Salt River Valley farmers' groups argued that the Project had forgotten its true purpose and lost its way. Critics protested that the pursuit of hydropower distracted the Association leadership from the heart and soul of the Project, water storage and irrigation. In times of drought, unmet demands for water releases from Valley farms caused some to accuse the Association of catering to power buyers over irrigation interests. By holding water, critics argued, the Project was timing releases for the generation and sale of power, which provided much higher revenues than irrigation.

In some cases, the Association offered to sell power to Valley farms for the pumping of irrigation water rather than release reservoir storage. Farmers often objected to this new policy based on claims that the land was legally entitled to river flow, which they argued was of a much higher quality than pump water. In a 1936 court case, *E. C. Adams vs. Salt River Water Users' Association*, the plaintiff sued maintaining that "crop yields have for a number of years been gradually going down, down, down and that these things are a direct result of what the Association had done."[18]

Critics of the changing character of the Project contended that the relationship between hydropower and irrigation was irreconcilable. Some argued that a farmers' organization had no place in such a highly competitive business as energy; an endeavor that required a great deal of long term planning and management as well as the development of new sources of capital for expansion.[19] The local division of opinion regarding the future role of the Association in hydropower was so prevalent that it eventually reached Washington. In a 1937 memo, Bureau of Reclamation Commissioner John C. Page noted that in light of the dispute, Association directors "might well consider the basis on which they would be willing to release all power facilities to the United States."[20]

The Association hydropower development of the 1920s became a heated political issue in Valley political debates during the 1930s. The argument over the irrigation/hydropower relationship created warring factions vying for control. Critics attempting to gain control of the organization contended that the leadership of the previous decade guided the Association down the incorrect path of hydropower expansion. Defenders of hydropower countered that their reactionary opposition preferred to eschew progress for a return to the horse-and-buggy age. They argued that, for whatever flaws may exist in the hydropower system, "it is a utopian condition too good to be lost, just because some petty conspirators are trying to paint the picture far blacker than it really is."[21]

Tensions in the relationship between hydropower and irrigation remained high until several new developments in the Valley in the late 1930s. Three changes that quieted the controversy were the creation of additional water storage on the Verde River, the implementation of pump storage technology, and the development of alternative power sources. Bartlett Dam, completed in 1939, had no hydropower generation and offered water storage exclusively for irrigation. The new dam on the Verde was also situated below Salt River generation and could release water directly to Granite Reef and into the canal system. Pump storage technology made it possible for the Project to use inexpensive, off-peak power to pump from the tailwaters below dams back up into the reservoir at night. Pump storage allowed the Project to replenish reservoir capacity with waters that had already been released for power generation. The development of additional steam plants in the late 1930s and the completion of transmission lines for Colorado River power in 1940 eased the reliance on Salt River generation by providing a variable load not dependent on irrigation demands. The Association now had alternative answers to the often challenging problem of supplying a reliable source of energy.

With the transformation of the Valley following World War II, the relationship between hydropower and irrigation changed dramatically. In the context of the new rapid residential and industrial growth the earlier hydropower expansion was seen as a critical development for the future success of central Arizona. Upon reflecting on the changes of the 1920s and 1930s, the period was not just one of the evolution of the Salt River Project, but the beginnings of a Valley metamorphosis from an agricultural/rural area with a priority of irrigation to a non-agricultural-urban region with a need for energy.

In 1998, only 22 percent of the water deliveries from the Salt River Project went to agricultural customers. Although agricultural production still exists in the Valley, the urbanization of the Valley has changed the basic function of the Project. In the 1930s, critics argued against attempts to build hydropower on a project devoted to irrigation. By the end of the twentieth century, irrigation now exists as somewhat of an adjunct on a project much of the population perceives as devoted to power generation.

Only through knowledge of the early relationship between hydropower and irrigation can one realize the dramatic changes that have taken place in the Salt River Valley. Such awareness provides a new angle on the well told story of the West and its water. Understanding the dynamics of the relationship between hydropower and irrigation offers needed insight into not only the history of central Arizona, but much of the twentieth century arid West.

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Water, Culture, and Boosterism: Albin and Elizabeth DeMary and the Minidoka Reclamation Project, 1905-1920

By:
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In July 1904 thirty-three year-old Albin C. DeMary traveled from his home in Boise, Idaho, to the Reclamation Service's newly opened Minidoka tract.[1] DeMary's duties as clerk of the U.S. Assay Office alerted him to the Reclamation Service's first Idaho irrigation project. Proposed in 1903, the project would provide water to the arid sagebrush plains of southern Idaho's Snake River desert. DeMary returned with an enthusiastic vision for Minidoka's commercial future and with a steadfast commitment to reclamation. "The character of the soil is such that the establishment of a beet sugar factory upon the tract would prove an unbounded success," DeMary told a Boise newspaper reporter. He and his companions had been "struck" by "the absence of lava rock…upon the entire 60,000 acres."[2] Less than a year later, DeMary moved his parents and his wife of four years, Elizabeth Layton DeMary, to Minidoka, where he established a homestead three miles northeast of present-day Rupert.

15.1. The buildings on the east side of the square in Rupert, Idaho, on the Minidoka Project in July of 1906.

DeMary's optimism, characteristic of a generation of early irrigation entrepreneurs in the arid West, stemmed from the notion that government aid could do what individual investors could not—turn Idaho's windswept, lava-rock-strewn desert into an agrarian oasis. Federally-funded irrigation projects, DeMary and other boosters reasoned, would provide small farmers an unprecedented opportunity for economic independence. DeMary's Commercial Club and Water Users Association, along with his wife's Culture Club, represented the political and cultural influence that young, educated settlers exercised in newly established irrigation communities during the settlement period (1870-1920). The efforts of the DeMarys and their like-minded associates—a self-styled Protestant "elite"—influenced the formation of city government, shaped community policy, and challenged gendered divisions of work. The activities of the Commercial, Culture, and Water Users associations reflected the political and social values of Progressive reform; their methods married coercive and positive environmentalist approaches to social change.[3] While their methods and their technology represented the future, their vision of agrarian utopia was grounded in the Jeffersonian past. Dusty and desperate, reclamation towns offered middle-class reformers a unique opportunity to shape business and social environments.[4]

After arriving on the Minidoka tract in 1905, Albin DeMary quickly built a modest house on his claim, where he and Elizabeth began raising their four-year-old daughter, Dorothy. A photograph from this period shows Elizabeth and Dorothy DeMary standing on the packed dirt outside of their one-room house, dressed in their finest clothes and hats, seemingly oblivious to the blowing dust and sagebrush surrounding them. Their ability to look beyond the dust to an agrarian paradise transcended economic development. The future held more than accessible water–it also possessed a Progressive culture. Reclamation promised to turn the desert into an "irrigated Eden," but new irrigation towns offered the promise of cultural, as well as land, reclamation.[5] Irrigated settlement harkened back to a past of small farms in rural America, but irrigation's entrepreneurial settlers challenged the social landscapes of the rural West. The creative work produced by Elizabeth DeMary's Culture Club resided at the center of cultural construction on the Minidoka Project. The creative expressions of Rupert clubwomen reflected the unique circumstances of settling an arid land, and provided a contrast to the progress narrative articulated in booster literature. Through their literary practices, Culture Club members redefined and shaped cultural perceptions of the irrigated landscape.[6]

15.2. Harvesting potatoes in 1909 on the Henschied Ranch near Rupert, Idaho.

Albin DeMary had been a reporter for the *Idaho Statesman* and a clerk in the U.S. Assay Office in Boise before coming to the project. DeMary's background, coupled with his degree from Illinois College, distinguished him as one of the Minidoka Project's elite settlers. When suspicions of fraud and embezzlement forced the U.S. Land Commissioner for the newly platted town of Rupert to resign in April 1906, DeMary received the appointment to succeed him. DeMary held the office until 1924, and throughout his tenure served as an informal liaison between the Minidoka settlers and the Reclamation Service. His various roles as land commissioner, charter member of the Rupert Commercial Club (became the Rupert Chamber of Commerce in 1917), and founding member of the Minidoka Settlers' Association (later the Minidoka Water Users Association, and one of the earliest water users' organizations in Idaho and the Intermountain West), gave DeMary the authority to influence Rupert's business environment. At the same time, he negotiated with federal officials to achieve control of reclamation water for Minidoka settlers. Like many Progressive reformers, DeMary believed in the scientific management of resources, and he remained committed to the ideal of federal reclamation. He also believed that once the service completed a project, local control of water became essential for business development. Reclamation could provide both agricultural and commercial opportunities, but only if local settlers and businessmen exercised authority over the project.[7]

While Albin DeMary worked to achieve local control of the Minidoka reclamation project, his wife, Elizabeth DeMary, labored to provide the project's fastest-growing community–Rupert–with an urban, Progressive culture. DeMary seemed intent on proving that an early twentieth century reclamation town did not have to exhibit the abhorrent cultural characteristics of many frontier outposts. Elizabeth DeMary was salutatorian of her class at MacMurry College, Jacksonville, Illinois, in 1893, and she had further literary training at the University of California and the University of Chicago. Throughout her life she published poetry, essays, and travel articles. Her work appeared in many local and national publications and anthologies, including *Times Magazine*, *The Reclamation Era*, *Seeing Idaho*, *Sunlit Peaks*, *Poems of the Northwest*, *Homespun*, and *The Book of American Verse*. Before coming to Rupert, DeMary organized the South Boise Improvement Society, which applied Progressive "city beautiful" principles to a section of the state's capital city. Reclamation towns, however, offered the kind of aesthetic and social control that could never exist in an established community. Rupert possessed none of the problems "city beautiful" adherents associated with older, "decaying" environments.[8]

15.3. The office of the Minidoka Irrigation District in Rupert in 1927.

The land that the DeMarys chose to homestead occupied a tiny portion of the Minidoka Project, designed to encourage agricultural settlement in the arid regions of the Snake River Plain in southern Idaho. The sagebrush desert and lava fields of the south-central Snake had long intimidated potential homesteaders. Oregon Trail diarists told of the dust and heat of southern Idaho—for overlanders the trail through what would become Idaho's "Magic Valley" signified only hardship, an obstacle to bypass on the way to the Willamette Valley. Because of its lack of appeal to homesteaders, the area did not experience large-scale agricultural settlement until late in the nineteenth century. Much of this late-arriving settlement, moreover, came from the West, not the East. Homesteaders who reached Oregon and California too late to procure land in those regions turned back to try their luck in the arid interior regions. The first non-Indian settlement in the Minidoka area began in the 1880s and 1890s, when small numbers of farmers and ranchers came to the region and settled near the Snake River. Farmers like Henry Shodde constructed private irrigation systems, some under the homestead provisions of the Desert Land Act of 1877, using water wheels in the river's flow to irrigate up to about two-hundred acres. With its vast elevation variation, hot summers, and a yearly rainfall of between nine and twelve inches, the Snake River Plain defeated most individual and private irrigation enterprises.[9]

The failure of private and state irrigation projects provided federal reclamation adherents with the ammunition to lobby for a federal reclamation act. The national bill came in 1902 with congressional approval of the Newlands Act, a bold measure which created the United States Reclamation Service and authorized the federal government to finance and construct large-scale irrigation projects in the arid West.[10] After passage of the Reclamation Act, the Interior Department withdrew 130,000 acres of land from homestead filings north and south of the lower Snake River to create the Minidoka tract. Crews, including an all-female survey group, arrived to survey the Minidoka Dam site in March 1903. In April 1904 the Interior Secretary appropriated $2,600,000 for the construction of a dam, spillway, canal system, power house, and pumping mechanism at Minidoka, making it the seventh project funded under the Newlands Act. The Reclamation Service entered into a contract with Bates-Rogers Construction Company, Chicago, in August 1904 and within the year work on the dam commenced. Bates-Rogers completed the dam and its supporting structures in 1909; at that time the project's irrigation water impacted approximately 45,000 acres. It was during this initial phase of construction that Albin DeMary, along with his father and two other interested businessmen, visited the Minidoka Project and became enthusiastic about the economic prospects of the region north of the Snake River—the territory that, through DeMary's influence, became Minidoka County in 1912.[11]

15.4. Minidoka Dam in 1911.

Homesteaders appeared in the Minidoka area almost immediately after the Reclamation Service chose the site. Most of the early inhabitants of the project associated themselves with the Rupert town site, though the Reclamation Service also created the towns of Heyburn and Paul as part of the project. The *Rupert Pioneer* announced in November 1905 that "Rupert is on the map, and is out for business, all she can get in a legitimate way." The boosters had their eye not only on the land north of the Snake River, at that time part of Lincoln County, but also on development opportunities south of the river, in Cassia County. "… No ordinary stream will be permitted to become a barrier in extending Rupert's commercialism," the Rupert paper warned the neighboring community of Burley in 1905. "Eight months ago a sagebrush plain, inhabited only by coyotes and long-eared jacks," the *Pioneer* continued,

> now, at the close of eight months, a city of 400 inhabitants, a school of a hundred scholars, a business aggregation of 64 concerns, an opera house,

> two secret orders, a Methodist Church, a Sunday school, a lawyer to get people out of trouble … a doctor to cure people of their ills, and a glorious future that no man can doubt.[12]

Albin and Elizabeth DeMary committed themselves to securing that "glorious future." Elizabeth DeMary influenced the cultural climate of Rupert primarily through her founding of the Culture Club. Rupert's unformed social structure held great promise for DeMary and her associates, for they could engage in municipal *building* rather than in mere "Municipal Housekeeping," the term then applied to women's club reform.[13] Instead of battling existing institutions, they *were* the institution. Considered "the first rural community woman's club in Idaho," the Culture Club heralded Rupert's entrance into the Idaho Federated Women's Club movement. The General Federation of Women's Clubs, founded in 1890, served as a national umbrella for women's organizations. Though wide-ranging in size, location, and membership, the federated clubs shared a commitment to education, literacy, political activism, and environmental beautification. The clubs enjoyed their greatest membership in urban environments, but may have had their greatest relative influence in rural environments. Isolation, blowing dust, unrelenting sun, and scarce water led many women on the reclamation frontier to seek female companionship through the club movement. Throughout the irrigated West, these groups supported public libraries, city parks, and restrictions on certain behaviors, including sidewalk spitting and alcohol consumption. The Culture Club and other federated clubs advocated a conservative political role for women, based on the moral exceptionality of women, rather than a more radical equal rights position. They also took the majority of their membership from the ranks of white, Protestant, and well-educated women. The General Federation motto "Unity in Diversity" referred not to the diversity of the women but to the variety of clubs—few immigrant, African-American, American Indian, or Hispanic American women were invited to join the ranks.[14]

Women's clubs in the reclamation West were particularly lacking in diversity. In places like Rupert, where everyone started out in the same dusty shack, "keeping up appearances" placed additional emphasis on associating with the "right people." By the early twentieth century, a certain level of consumption was required to maintain middle- or upper-class status, consumption that was often unattainable on the sagebrush flats. The household manual *Our Home, Or Influences Emanating from the Hearthstone*, published in 1899, warned housewives that appropriate furnishings were essential for the proper rearing of children: "It is as much the duty of parents, then, to adorn and beautify their home as it is to keep the moral atmosphere of that home pure."[15] Nineteenth-century sentimental novels portrayed the degraded and "uncivilized" conditions of frontier life. Women in irrigated settlement areas attempted Victorian and Progressive domesticity without gas lighting, indoor plumbing, or household help, at a time when their urban peers experienced a revolution in home convenience. To avoid the grim demise of female protagonists in Victorian sentimentality—to lose status, refined taste, and thus authority—middle-class women in irrigated settlement communities founded literary societies.[16] If their living conditions placed them among the laboring masses, their creative endeavors set them apart from both the irrigated landscape and from association with the working class. The societies also formed the basis for a political voice that influenced living conditions for all residents on the sagebrush plains.

Elizabeth DeMary and six other women inaugurated Rupert's Culture Club at the home of Anna LaRue, the wife of another of Rupert's first homestead filees and businessmen, in October 1905.[17] The club chose to limit its membership to eighteen, ostensibly because it planned to meet exclusively in private homes, and committed itself to the cultural and artistic advancement of Rupert. The club did not welcome immigrants or Catholics. The group held its second meeting in the DeMary home, but by the spring of 1906 moved some of its meetings to the (relatively) prestigious dining room of the Rupert Hotel, located on the town square. At the first meeting, club members signed a petition requesting that the State Traveling Library include Rupert on its schedule. The traveling library, founded by the Columbian Club of Boise in 1893, had become the primary source of literary material for over two hundred Idaho communities by 1905. Hosted by women's clubs throughout the state, the traveling library illustrated the connection between literacy, education, class and culture that infused rural women's groups. The Culture Club claimed the traveling library, which first visited Rupert in 1906, as an early victory in its perceived struggle against frontier illiteracy and degradation.[18]

The Culture Club engaged in a variety of other civic programs, and actively encouraged the literary and artistic pursuits of its own members. The group funded a lyceum lecture series, sponsored an art exhibit, lobbied for women's public restrooms, and spawned a plethora of other women's clubs, including the Clionian Club, Fortnightly Club, Rupert Civic Club, and Merry Go Round Club.[19] In advocating the institution of public restrooms, the club supported more than a place for a lady to use private facilities. Public restrooms for women corresponded to a value system of domestic consumption–in order for women to shop in town, they needed to have access to a private place. Women's lounges offered an escape from street grime, and a place in which to gather, where literature and reading could be placed for the pleasure of the cultured woman. Restrooms also enabled farm women to come to town with the knowledge that there would be somewhere to rest and, perhaps, to read.[20] To further expand the minds of Rupert's populace, Culture Club women also leant their support to Rupert's Opera House and Dramatic Association, which hosted its first production in November 1905. The only such venue south of Boise, the opera house reflected the cultural idealism of Rupert's clubwomen. When it first opened the town newspaper declared that the theater was "designed in such a manner that between acts out of town people can gaze upon it and be convinced that their wants can be supplied in our city."[21]

The ladies of the club did not, however, want *all* needs to be met in Rupert. The club discouraged alcohol consumption and participated in the elimination of Rupert's "Red Light District." Village trustees and "a large number of citizens," the

Rupert Pioneer reported in September 1906, met to discuss the town's "social evil." The group informed red light district occupants that they had twenty-four hours to leave town or face arrest and fines; the "social evil" responded by leaving on the night train.[22] Saloons also became a target of the Progressive spirit in early Rupert. In November 1909 three Minidoka project reclamation towns—Rupert, Heyburn, and Acequia—passed legislation illegalizing the sale of alcoholic beverages.[23]

Elizabeth DeMary's club drew upon the irrigated landscape to portray Rupert as a uniquely progressive urban center. Yearly "moonlit excursions" to Minidoka Dam married the ideals of the Culture Club to the optimism of reclamation.[24] A photograph housed at the DeMary Memorial Library in Rupert indicates that the Culture Club held meetings in the verdant, irrigated backyard of the DeMary home. Eight well-dressed women in hats sit near an arbor while Elizabeth DeMary serves tea and cookies from a white-clothed table.[25] In giving her 1907 presidential address to the Culture Club, Elizabeth DeMary declared that the club, like reclamation water, was responsible for breaking "the unspeakable quiet of the desert." Reclamation water turned the desert green; Progressive women's clubs provided the appropriate social and cultural landscape. The club had grown in membership "until a name upon our roll is a coveted possession," DeMary explained in her 1907 presidential speech, because "our aim is one of mutual helpfulness and a reaching out for those things which broaden and enrich life." "Our vision is not bounded by the endless sage brush and the encircling hills," DeMary continued; "We have penetrated beyond." The 1907 banquet ended with a series of lecture presentations by Rupert's elite settlers. Topics included "A Little Journey in the World: A Contrast of Naples, Italy, and Minidoka, Idaho," "Reminiscences on Roast Turkey," and "Art in a Shack." The latter speech emphasized the need for culture even in a "humble shack" in a "bleak desert."[26] DeMary later described her cultural contribution in the *Reclamation Record*. Every reclamation woman, she emphasized, "had made a great sacrifice to come to this new land in order that she might help to create in the desert a new garden."[27]

The literary practices—the reading, writing, and poetry—maintained by the Culture Club, and other irrigated settlement women's clubs, reflected and defined cultural perceptions of the irrigated landscape. DeMary's poem "Irrigation" appeared in *Reclamation Era* magazine, and illustrates the connection between women's literary work and the "reclaiming" of the desert:

> Oh, Mesa, with those wise clear eyes of old
> Could you have dreamed this vision to behold?
> Long aeons you have gazed across the plain
> And Man's control have held in high disdain
> But now where gone are deer and antelope
> The stubborn sage that clung to every slope
> The caravan that wound its weary way,
> The lurching stage that would not brook delay?
> Again where vanished tribes of warriors bold
> Who bravely fought these native trails to hold?

Gone to oblivion, and through the land
A magic wand is Irrigation's hand.
From distant ports skilled birdmen
wing their flights
While desert dark gives way to myriad lights;
Where once the drifting dunes of sand held sway
The children gather flowers as they may,
And tapestries are spread o'er all the fields
Where yellow ripening grain abundance yields
Oh, Mesa, with those wise clear eyes of old
Could you have dreamed this vision to behold?[28]

Like DeMary, Irene Welch Grissom, a clubwoman appointed Idaho's Poet-Laureate in 1923 "in response to the request of the State Federation of Women's Clubs," portrayed a gendered irrigated landscape in her work. DeMary's desert is transformed by "Man's control"; Grissom's desert yields to masculine engineering:

A dreamer comes–as dreamers will–
To watch the swirling torrents spill
Between the steep, black lava walls,
And on the foaming, crashing falls.
He sees the desert, vast and grand,
Give way before a man-made land,
The sparkling streams flash here and there,
And life is springing everywhere.[29]

With the desert's greening comes feminine influence; DeMary's "children gather flowers as they may," while Grissom's irrigated landscape is dotted "with houses set in misty green, And church spires lifted high."[30] These gendered portrayals defined the position of women's clubs on the irrigated frontier. First, men tamed the desert with engineering marvels. Then, women "settled" the new "garden" by introducing the elements of civilization—children, homes, and churches.[31]

In providing a forum for women's views, supporting women's literacy and education, and by sponsoring women's creative practices, the Culture Club indirectly supported other Progressive reforms, including suffrage. No evidence exists that the club openly endorsed national suffrage. Indeed, many Minidoka settlers viewed the group as narrow and elitist. But, as the first women's organization on the Minidoka Project, the club inspired a host of other organizations that supported more radical reforms. The Federation of Women's Clubs, of which the Culture Club was a member, endorsed suffrage at its 1910 national convention.[32] A photograph of the Rupert square, taken during the early 1910s, reveals that the reclamation community hosted a suffragette parade. Finely dressed women march down the dusty street, carrying signs with slogans such as "Rupert for Suffrage" and "Votes for Women." The parade appears to be well-attended; rows of men and women line the streets of the square. Minidoka Project suffragettes already possessed the right to vote, because Idaho became the fourth state to grant that right in1896. Rupert's suffrage parade suggests that women in states and communities that already had the vote were essential in procuring the Nineteenth Amendment in 1920. They actively lobbied for a right that they already possessed, so that women who could not safely fight for that right would eventually possess it as well. Many of the women who already had the vote lived in the arid West, the area served by the Reclamation Act. Wyoming (1869), Utah (1870), Colorado (1893), Washington (1910), California (1911), Oregon (1912), Arizona (1912), Montana (1914), and Nevada (1914) all granted full suffrage to women before 1920. Women in reclamation communities used their unique relationship with the federal government to support national suffrage. Reclamation communities received unprecedented federal attention; suffrage advocates used this attention to lobby for women's voting rights.[33]

Elizabeth DeMary's influence extended beyond the cultural landscape to the built environment. Rupert's central green, the only town square in the state of Idaho, recalled the city squares of Midwestern towns, where both DeMarys spent their childhoods. The Reclamation Service platted Rupert in 1904; by 1905 businesses had sprung up on four streets facing a square, where Reclamation officials planned to dig the first well on the Minidoka tract. Settlers called the town Wellfirst, or Wetfirst, until the service officially changed the name to Rupert.[34] The earliest businesses to locate on the town square did so illegally, as the lots were not appraised and sold until 1907 and 1908. Pressure from concerned citizens, like the DeMarys, helped to maintain the integrity of the square throughout 1905 and 1906, despite problems with squatters and a lack of water. When, during the spring of 1906, an enterprising businessman attempted to erect a building in the center of the square, a group of concerned citizens formed a committee to halt the construction. Albin DeMary participated in the group, which convinced Cal Masterson to move his building and collected six dollars in donations to help defray the cost of relocation.[35]

In June 1907, with the first irrigation water in sight, Rupert surveyed, cleared and graded its streets and planted poplar trees throughout the central green. "In the center will be a circle of 75 feet in diameter surrounded by trees," the paper explained, "in which seats will be placed for summer lounging, and to which walks will lead diagonally from each corner, and one from each side of the four side centers." To further enhance the irrigated landscape of the town square, town trustees forbade carriage traffic on the immediate side streets, so that women would not have to step over steaming clumps of manure, and instituted an ordinance requiring teams to be "properly tied either to a hitching post or suitable weight." In 1910, Rupert's trustees issued contracts to build sidewalks around the square; the town voted to pave its streets in 1919. By 1947, the *Minidoka County News* declared, "no city of comparable size in Idaho has as many hard-surfaced streets as the City of Rupert, and every one of them oiled since 1919!" The Rupert town square remains a testament to the Edenic idealism of reclamation settlers. An elite corps of Rupert founders managed to make the city green a priority, even when water was scarce and intended for crop irrigation, not aesthetic use. In January 2001 the National Park Service listed the Rupert town square and its surrounding historic district on the National Register of Historic Places.[36]

Albin DeMary's influential civic organizations overlapped and complemented the efforts of the Culture Club, blurring the lines between the political and domestic spheres of men's and women's activity. In February 1906 DeMary and twenty-three other men, many fledgling Rupert business owners, gathered at the Benton building on the square to form the Commercial Club. The group committed itself to procuring a water works, electric power plant, flour mill, sugar factory, and graded city streets. Throughout the 1910s and early 1920s DeMary and his colleagues never missed an opportunity to further Rupert's business environment. The establishment of the Amalgamated Sugar Factory between the towns of Rupert and Paul in 1917 provides an example of the Commercial Club's accomplishments. The Minidoka Project's vast acreages of irrigated land and small family farms attracted the Amalgamated Company; the Commercial Club provided the push to bring the plant to Rupert. The Commercial Club helped convince Minidoka farmers to appropriate over 5,000 acres for sugar beet production. DeMary's organization also secured the right-of-way for a road leading directly from Rupert to the processing plant. Throughout 1917 the Commercial Club collected donations to compensate farmers for the land they surrendered for the road.[37]

15.5. Irrigating sugar beets on the Minidoka Project.

In spite of victories like the traveling library, Rupert town square, and sugar factory, organized optimism and boosterism did not create the kind of cultural agrarian paradise that the DeMarys envisioned. The Minidoka Project remains one of the most successful in reclamation history—Rupert and the other project settlement communities are still viable communities with economies based on irrigated agriculture. But the DeMarys were not successful in fending off the "frontier image," or in preventing dangerous settler squabbles. Elizabeth DeMary's club activities could not, in the end, produce a permanent Protestant-controlled culture. In many ways, the idealism of Progressive settlers like the DeMarys stemmed not from actual successes, but from the desire to *appear to be succeeding* in their efforts to turn irrigation projects into Progressive garden oases. Observations by visitors to the project during the first decade illustrate the difficulty of this endeavor. Henry A. Wallace, who toured the Minidoka project in 1909 as part of his investigation of irrigated farmland for the family journal *Wallaces' Farmer*, found little to praise in Rupert and its surrounding farmland. Wallace attributed the slow development of irrigation and urban culture in the Minidoka area to the very fact that it was a federal project—as opposed to the more developed, private Carey Act project in Twin Falls. "Rupert is a government townsite [sic], and shows the effects of it," Wallace wrote, "for it is one of the most dilapidated little towns which I have ever seen." His description must have horrified Rupert's boosters:

> All the buildings are little square frame affairs with just enough ambition to be painted. The ramshackle buildings are arranged on four sides of a square which has a fine stand of blue grass and white clover which the town hasn't had energy enough to mow. There are a few poplar and locust trees which may make some shade some day.

After observing the Rupert square, Wallace toured the countryside and interviewed individual homesteaders, many of whom expressed frustration with the landscape and with reclamation. "At first we didn't get water when the government promised it to us," a woman from Iowa told Wallace, "then when we did get water the wind was so strong that we could hardly get anything seeded down before the wind would come along and blow it out or cut it down." The owner of a three-year old claim, a man from Montana, explained that Minidoka farms had a ramshackle appearance because "these people around here are not a very high class of irrigators." Most of the homesteaders came to the country without capital, and "for the first two years they had an awful hard time hanging on, for the water wasn't ready yet and on their own places there wasn't anything but sage brush … then when the water did come they didn't have enough money to fix their land right, and they just stuck in their crops haphazard." Another settler complained of the wind, and to illustrate told Wallace the already mythic story of the Minidoka project. A man on one side of the project, the tale went, planted a garden. The wind came up and blew it fifteen miles, across the river, to another settler's claim, who then raised the garden himself.[38]

Despite Wallace's grim observations and disgruntled interviewees, he looked beyond the poverty of the present to a prosperous, well-watered future. Wallace saw potential in the Minidoka soil, even as he wrote that "it is a backward country, the people are without money, and there is no booming whatever." The country "should grow steadily," he predicted, "and a thickly populated little farming community should develop here." He also shared Albin C. DeMary's Progressive commitment to scientific solutions. While the town and homesteads disappointed Wallace, the Minidoka dam did not. The structure "is a tremendous affair," Wallace proclaimed, with "3,200 feet of spillway" on the south of the main dam which makes up "the prettiest part of the whole thing." Wallace's description of the concrete spillway as creating a "beautiful parabola in going over" mixed natural imagery with scientific accomplishment, an integral characteristic of the reclamation vision. Terms like "tremendous," "prettiest," and "beautiful" presented Wallace's Midwestern readers with an image of the Minidoka Dam as a natural wonder.[39]

Wallace's research uncovered the contradictions inherent in the reclamation vision.[40] Homesteaders desired government-supplied water, but they wanted to control it; claimants took advantage of accessible land, but they didn't possess the capital to develop it; settlers envisioned an agrarian Eden but lived in one-room houses on plots of blowing dirt; Progressive ideals competed with the needs of immigrant farmers; and a growing schism between middle-class irrigation professionals and impoverished farmers threatened the cooperation necessary to make reclamation work. These problems reached a fever pitch during the early 1910s, creating the need for settlers' and water users' associations to negotiate directly with the Reclamation Service. DeMary served as the settlers' representative throughout this period. As reclamation settlers and government officials institutionalized the patterns of irrigation on the Minidoka tract, Progressive ideals began to take a back seat to water allocation, control, and development.

From the project's inception, the conflict between vision and reality contributed to the disillusionment of settlers and deteriorating relations between the Reclamation Service and water users. The geographic characteristics of the Minidoka project created difficulties for water users. Most of the land suitable for a gravity-flow canal system lay on the north side, or Rupert side, of the Snake. Terrain on the south side of the river necessitated construction of a pumping system to lift the water to farmland. Construction of both the gravity canals and the south side lifts proceeded slowly, while reclamation officials struggled to work out the complex allocation and payment schedules of both sides of the river. Settlers who filed and moved onto their claims waited for several years before they received irrigation water. The dam at Minidoka reached partial completion in the fall of 1906, but a scarcity of available labor forced delays in the construction of the north side canals, which did not deliver water until July 1907. Many north side settlers planted seed in anticipation of water that year, but did not receive it in time to save their crops. North side settlers complained, but they were fortunate; on the south side, settlers waited until 1912 and 1913, when reclamation officials completed the lift stations.[41]

Dam and lift completion inaugurated new problems. In November 1906, only two months after Minidoka Dam began service, the Snake River shrank to a trickle. The *Rupert Pioneer* declared that "for many miles below the Minidoka dam, there was hardly enough water flowing to float a toothpick." Dam gates were closed and ferry service was interrupted until reclamation officials released water from the Minidoka reservoir, Lake Walcott. Canal erosion and seepage wasted irrigation water, which bled the Snake dry. By 1906 the Reclamation Service employed one water master and eleven "ditch tenders" or "ditch riders" to monitor canal banks for bank erosion. During the early years of the project, before the canal banks were packed solid and sodded, waves created by southern Idaho winds constantly threatened to wash out their banks. Ditch riders patrolled about six miles each of the main canals. If they encountered a wash or bank erosion, they notified the service and made the necessary repairs. Seepage, or water leakage through soil infiltration, represented a more insidious, and invisible, threat to water control. Nearly 100,000 acre-feet of water seeped out of canals on the Minidoka Project's north side in 1912. Even after the early settlement years, seepage and erosion continued to haunt Minidoka settlers, necessitating the eventual lining of main canals with stone and mortar or concrete.[42]

Other unexpected environmental consequences accompanied the Minidoka construction. Canal digging and field plowing stirred up enormous clouds of dust, which combined with strong southern Idaho winds to make the project nearly uninhabitable. Dust settled in homes, destroyed machinery, and blocked out the sun, requiring the use of oil lamps during the middle of the day. "When we looked toward the west," Minidoka settler Gerhard A. Riedesel recalled of a 1914 dust storm, "we saw a dark, threatening wall of dust advancing with a vertical front perhaps 1,000 feet high, extending from the southwest to the northwest as far as we could see." Riedesel's family sought cover in the house, but the "dust sifted through the cracks around the door and windows and soon the entire floor and all the furniture were covered with a dusty, dry, gritty layer of yellow silt." Respiratory problems plagued Minidoka homesteaders. Dry winds and dust often forced farmers to reseed, as they did across the project in 1908 and 1909. Since most settlers lived in one- or two-room houses, often without adequate windows or door frames, homesteaders could not escape the fine silt that invaded their private oases.[43]

Frustrated by delays and dust storms, settlers eager for water found that once they had it, they couldn't get rid of it. Water seeped out of the canals only to cause saturated fields to flood. Drainage on the north side of the Snake presented as great an engineering challenge as construction of the original gravity canals, forcing water users to pay additional funds to the Reclamation Service in order to finance the construction of miles of drainage ditches. "Funny, how we hurried to get water on the land and then had to spend a lot of money in drainage to get it off again," Albin DeMary recalled in a 1944 letter to a former reclamation official. "Just now," DeMary added, "we have the promise of another drain a mile south of Rupert to take care of some wet land." By 1909 more than 10,000 acres of Minidoka soil were no longer arable because they were *too wet*. In August 1909 the Reclamation Service began construction of a $400,000 surface drainage system in order to regulate the elevation of the sub-water. Surface drainage ditches did not provide adequate relief, so the service added drain wells and pumping stations to remove excess water. More than seventy miles of drainage ditches had been dug on the project by 1912.[44]

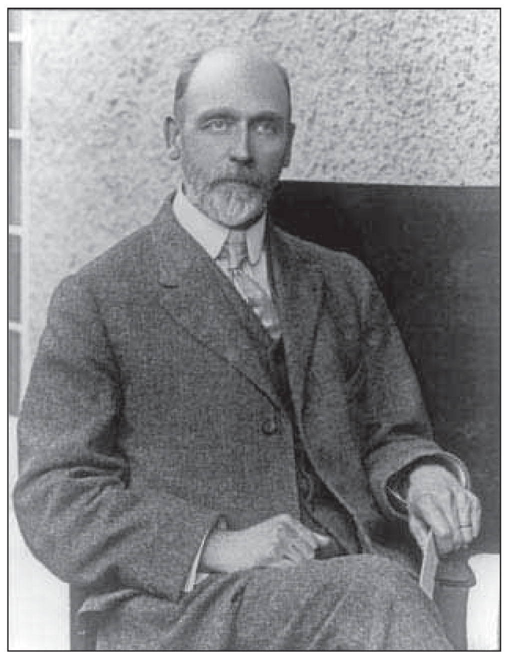
Settlers on the north side battled drainage problems, while on the south side pump division settlers found that they had to construct their own lateral canals when the service diverted part of the Minidoka Project's funds to the Boise-Payette Project. Beginning in 1906 the service envisioned a cooperative effort between water users, who were supposed to dig the lateral, or sublateral, irrigation ditches connecting individual farms to the main canals. The service organized more than four hundred local districts to complete the work, but did not always get the cooperation it sought. Farmers competed with each other for completion of their section of the lateral ditches. Homesteaders hired someone else to build their section of the lateral canal, leaving their neighbors to complete the task on their own. Disagreements between neighbors over lateral water distribution, in some cases, turned violent. In July 1908 a settler referred to only as Mr. Landford and his neighbor, John Fleming, had a heated argument over who would have the use of the lateral water on that day. Landford prevailed; Fleming went home to plan his revenge. The following morning, Fleming hid himself in a field of alfalfa and waited for his neighbor, the father of three, to arrive to check his ditches. When Landford approached, Fleming shot and killed him. Fleming received the sentence of death by hanging, but it was later reduced to life. The guilty Minidoka settler served twelve years in the state penitentiary.[45]

Dust storms, water shortages, settler rivalries, and reclamation policy combined to create near rebellion on the Minidoka Project in 1911. Some discouraged water users relinquished their improved claims for sums ranging from $400 to $4000 (for eighty acres), while others worked through the settler association to achieve control of reclamation water. Settlers openly questioned the authority of the Reclamation Service, despite the fact that their very existence on the desert tract depended on the service. In March, one settler lamented in the *Pioneer-Record* that the Reclamation Service's "charges for operation and maintenance are assessed against the settler without his consent and expenditured [sic] without his knowledge." "No function of this United States government is self-contained enough, or big enough," J. D. Akins continued, "that it can trample with impunity the rights of its humblest citizens." Settler anger increased in April when the service revealed that it intended to issue a new contract replacing the original water charge of $22.00 per acre with a charge of $26.00 per acre. Albin DeMary's Commercial Club rushed to form a committee to draft a statement to send to Idaho Senator William Borah, decrying the new policy and demanding graduated water payments "without any strings." Ignoring the fact that Minidoka businesses and farms had been the beneficiaries of the government's construction projects, the club issued a public statement declaring that if the service had overspent on construction, then it "should stand the loss the same as any individual would have to stand it . . ." The Minidoka Water Users Association, which replaced the first settlers' organization, joined with the Commercial Club in rejecting the new contract. DeMary, acting on behalf of both the Commercial Club and the Minidoka Water Users Board of Directors, prepared a series of resolutions to unite the settlers in their opposition. DeMary recommended that the settlers agree to the new contract, provided that the service publish an itemized schedule of its operation and maintenance expenses; offer the settlers a graduated scale for water right payments; give the settlers fair representation in the management of the project; and pledge itself to help secure passage of legislation giving settlers patents to their lands (as it stood, patents could only be issued after water users had paid for their water right in full).[46]

15.6. 1920 portrait of Morris Bien who was sent to deal with settlers over charges on the Minidoka Project.

The water users succeeded in prompting the Interior Department to send "legal representatives" to Rupert in May 1911 to meet with Albin DeMary and other members of the board. On May 23 Morris Bien and Philip H. Wells met privately with DeMary and several other men from the water users' executive committee; later in the evening they held a public hearing. The executive meeting lasted several hours and threatened to erupt when one board member accused local reclamation officials of making false statements. DeMary outlined the settlers' position, emphasizing that "a good many of the settlers when they filed on this project … believed that the government would take it and operate it at its expense." Now, DeMary explained, the settlers resented what they viewed as "improper use of money in the operation and maintenance of the project." Reclamation officials made no apologies for the policies of the service, noting instead that "it is easy to say that this should have been done better. … Everybody knows if they look back, they could have done differently." Still, the federal officers concluded that they intended to "work up a public notice … that will settle everything."[47]

Albin DeMary's proposals and his representation of the settlers at the users' meeting did not meet with the satisfaction of all of the project's farmers. Some settlers refused to participate in the association, which they viewed as a self-interested, elitist institution. "We are sick and tired of the antics of the men who style themselves the Minidoka Water Users Association …," P. O. O'Rourke bellowed in an editorial in the *Pioneer-Record*: "There will be no treaty making [sic] with the truce breakers, there will be no surrender." Despite the opposition of settlers like O'Rourke, DeMary and the water users could claim at least some of the credit when Interior Secretary Walter L. Fisher and Reclamation Director Frederick Newell visited the project in September 1911. Fisher and Newell met with the water users and listened to their grievances; by October, the water users had a new contract which addressed some of the settlers' concerns. The new contract allowed for graduated payments and divided water and drainage payments equally throughout the project. It also grandfathered any settler who had an original contract at the $22.00 per acre rate. Interior Secretary Fisher refused to reconsider the loathsome $26.00 per acre amount, however, and he further maintained that the authority of the Reclamation Service could not be divided by providing for official representation of the water users in the governing body of the agency.[48]

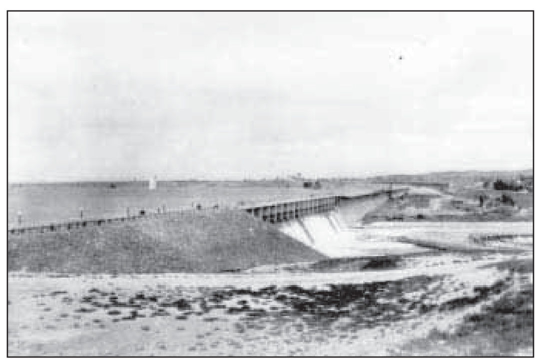


15.7. Frederick H. Newell visited the Minidoka Project in 1911 with Secretary of the Interior Walter L. Fisher.

The new contract and visit by reclamation officials met with criticism in the *Pioneer-Record*; one editorialist declared that "this city was inflicted last Tuesday with the presence of a bunch of high reclamation officials, whose visit amounted to about as much as ___(fill in the blanks for yourself)." Nonetheless, the new contract heralded a better relationship between the water users and the Reclamation

Service. The years following 1911 were good ones for Minidoka farmers. By 1913 DeMary estimated that 8,700 people lived on the project, which also boasted 1,684 farms at an estimated average value of $6,454. DeMary's boosterism paid off when, in November 1914, voters on the Minidoka Project voted to make Rupert the seat of Minidoka County. DeMary's 1913 history of the project credited the Interior Department with giving settlers "more latitude," extending the time for water payments, and limiting the number of cancellations made on homestead entries. DeMary also recognized his wife's efforts at shaping the culture of the reclamation community. Several women's clubs engaged in "serious literary work," DeMary noted, and exerted "a large influence in moulding the character of the citizenship."[49]

DeMary's efforts at forming an influential water users' association laid the groundwork for future organizations, including the Minidoka Irrigation District, founded in 1917, and the Burley Irrigation District, formed in 1918. The power these groups wielded, however, declined by the late 1910s. As more watered acreage was added to reclamation projects along the Snake River, competition for water from homesteaders outside of the Minidoka tract increased. Scientific engineering complicated the river's flow, and made water allocation for all Snake River users more complex. Throughout the 1910s, water users upriver, in Rigby and Idaho Falls, decried what they viewed as unfair allocation of the water to "Magic Valley" (Minidoka and Twin Falls) users. Reclamation officials attempted to preserve the Minidoka Project's water in the Jackson Lake reservoir (completed in 1907 and expanded in 1910 and 1916), but this allocation had to travel downstream, *past* Idaho Falls and Rigby farms, to reach Rupert farms. The service could not specifically identify, of course, what part of the living river was Minidoka water. Conflicts up and down the Snake resulted in the creation of intra-cooperative water users' associations. Groups like the Snake River Committee of Nine utilized attorneys, water engineers, and relations with the Bureau of Reclamation (the Reclamation Service became the Bureau of Reclamation in 1923) to negotiate water allocation between projects on the upper and lower Snake. At the same time, the bureau increasingly relied on technical experts to manage its projects, particularly after creation of American Falls reservoir in 1927. These trends limited the ability of small, project-oriented settlers' groups to negotiate, like the Minidoka Water Users did in 1911, directly with the government agency.[50]



15.8. American Falls Dam in 1927, soon after completion.

Changes in the political environment also affected the Culture Club. Like many federated women's clubs, the group disbanded during World War I. Competition from other women's organizations, the transfer of club goals from cultural advancement to the support of the war effort, the debate over women's suffrage and pacifism, and a perceived linkage between socialist groups and organized women's clubs hurt attendance nationwide.[51] The demise of the Culture Club may also have been reflective of a population shift on the project. Despite Albin DeMary's best efforts to expand reclamation on the north side of the river and to attract businesses to the city, by 1920 it became clear that Burley, the community on the southern side of the Snake River, would outstrip Rupert in population and become the premier commercial center on the Minidoka tract. Burley's proximity to Twin Falls, Paul, and Heyburn gave it a strategic geographic advantage. Between 1920 and 1930, the town of Rupert lost population, dropping from 2,372 to 2,250 inhabitants.

Some of DeMary's commercial projects conflicted with the values of his wife's Culture Club. The Amalgamated Sugar Factory stimulated the production of sugar beets; sugar beet farmers employed children to do the monotonous hoeing that beets required, at a time when federated clubs worked to limit child labor. Snake River farmers hired immigrant workers, changing the original demographic structure of reclamation towns like Rupert. German and Russian Catholic immigrants came in large numbers to take advantage of homestead claims, particularly on the "North Side" of Rupert, where it was found that a natural aquifer made dryland farming possible. These immigrants found the kind of opportunity advocated by Progressive women's clubs, but, at the same time, their presence diluted the influence of Rupert's elite Protestant settlers. Moreover, these new immigrants failed to adhere to the domestic and cultural standards maintained and supported by clubwomen. By the 1920s, the Idaho State Federation of Women's Clubs was advocating a firm stance on the issue of immigration and Idaho communities. "Throughout the Federation this term emphasis was on Americanization," the Federation's historian explained, "for war had shown the need for assimilating into American life the foreign born upon her shores."[52] It may have seemed to Elizabeth DeMary that the urban evils she had tried to escape–child labor, corporate influence, Eastern European immigration, poverty–had followed her to the desert.[53]

The efforts of Elizabeth and Albin DeMary to create a locally-controlled irrigated oasis with a Progressive culture on the Minidoka Project revealed the complex ideology underlying reclamation settlement. Albin DeMary's careful negotiations between water users and the Reclamation Service, his relentless support of commercial enterprises, and his involvement in southern Idaho's earliest water users association made Rupert the business center of the Minidoka Project until the 1920s. In founding the Culture Club, Elizabeth DeMary created one of rural Idaho's first women's organizations. Her support of Progressive aesthetic values helped to preserve Idaho's only town square. Rupert's opera house staged the only live musical performances south of Boise; its streets played host to suffrage parades; its elite Protestant founders outlawed houses of prostitution and saloons; and its paved streets offered shaded, manure-free walking. Through their literary practices, clubwomen shaped and defined cultural perceptions of the irrigated landscape.

The reality of life on the sagebrush flats often interfered with the Progressive vision. Rupert's position as the lead Minidoka city faded as the relationship between local water users and the Bureau of Reclamation became more complex. By the mid-1920s, large, multi-project water users' organizations had overshadowed their smaller, project-based antecedents. New reclamation dams and reservoirs, population growth, and greater demand for power generation limited the relative power of small users' associations in reclamation settlement towns. The demise of the DeMary vision for Rupert paralleled a decline in the relative authority of small farmers on the projects. During the brief settlement period, however, the DeMarys demonstrated that water users and reclamation homesteaders possessed a considerable amount of authority in determining the shape of their projects and the cultures of their towns.

Laura Woodworth-Ney prepared the original of this paper for the history of Reclamation symposium on June 18-19, 2002, at the University of Nevada–Las Vegas. In September of that year she revised the paper. A different version of this paper, one based on Elizabeth DeMary, was published as "Elizabeth Layton DeMary and the Rupert Culture Club: New Womanhood in a Reclamation Settlement Community," in Dee Garceau-Hagan, editor, *Portraits of Women in the American West* (New York: Routledge, 2005). Dr. Woodworth-Ney is chair of the Department of History at Idaho State University in Pocatello. She is the author of *Mapping Identity: Creation of the Coeur d'Alene Indian Reservation, 1805-1902* which was published by the University Press of Colorado in 2004.

Endnotes

1. This paper is based on research conducted for a larger manuscript using the Albin C. DeMary Manuscript Collection at the DeMary Memorial Library in Rupert, Idaho. DeMary collected government documents, personal photographs and letters, newspaper articles, and publications on Idaho and the Rocky Mountain West until his death in 1977. He donated the funds for the construction of Rupert's city library, built in 1958, which houses the manuscript collection and the library that he compiled and also donated. Elizabeth DeMary's papers are also held at the city library, as well as her personal book collection. Elizabeth died in 1942; after her death, Rupert's history became Albin DeMary's focus and passion. Madelyn Player was extremely generous in allowing me access to her private library and manuscript collection, which also aided in the research for this paper. Albin C. DeMary Manuscript Collection [DMC], DeMary Memorial Library, Rupert, Idaho.
2. As quoted in Susan E. Williams, "An Urban Study of Rupert, Idaho" (Unpublished Master's Thesis, Kent State University, March 1963), 54-7. See also "Minidoka County Grew Fast After 'Late Start' in Idaho," in *The Minidoka Story: The Land and the People* (Rupert, Idaho: *Minidoka County News*, 1963; Reprint, 2001), 1-2. *The Minidoka Story* is comprised of reprinted newspaper articles from the *Rupert Pioneer* and other early papers. I will give page citations for the reprint, rather than citations for the individual articles.
3. Paul Boyer, *Urban Masses and Moral Order in America, 1820-1920* (Cambridge: Harvard University Press, 1978), 189-190.
4. Minidoka County Historical Society, *A History of Minidoka County and Its People* (Dallas, Texas: Taylor Publishing Company, 1985), 185-6. For a general treatment of Progressive politics and ideals, see Alan Dawley, *Struggles for Justice: Social Responsibility and the Liberal State* (Cambridge, Massachusetts: Belknap Press of Harvard University Press, 1991).
5. "Photograph of Elizabeth and Dorothy DeMary," circa 1906, DeMary Photograph Collection, DMC.
6. Anne Rugles Gere, *Intimate Practices: Literacy and Cultural Work in U.S. Women's Clubs, 1880-1920* (Urbana: University of Illinois Press, 1997), 1-16.

7. Minidoka County Historical Society, *A History of Minidoka County and Its People, 185-86; Albin C. DeMary, History of Rupert, 1905-1922*, March 29, 1906, April 5, 1906, Unpublished Typed Manuscript, DMC, DeMary Memorial Library, Rupert, Idaho. DeMary's *History of Rupert* is comprised mostly of typed transcripts from the area's earliest newspaper, *The Rupert Pioneer*. My citations give the dates that DeMary assigned his manuscript entries.

8. For a brief biography of Elizabeth DeMary, see Minidoka County Historical Society, *A History of Minidoka County and Its People*, 185. For a discussion of the ideology of Progressive urban planning, or "positive environmentalism," and its relationship to social control, see Paul Boyer, *Urban Masses and Moral Order in America, 1820-1920* (Cambridge, Massachusetts: Harvard University Press, 1978), especially 220-32.

9. There were, of course, exceptions to this pattern of failure. The Carey Act, passed by Congress in 1894, provided that each state containing "desert land" as defined by the Desert Land Act (1877) could select up to one million acres for reclamation. The land would be held by states "in trust" for homesteaders; the land was available as long as the states found a way to irrigate it. States could either construct their own irrigation projects or hire private companies to do the work, for a price per acre set by the state. One of the Carey Act's greatest successes occurred in Twin Falls, Idaho, located approximately forty-five miles west of Rupert. There, Ira B. Perrine headed the largest private irrigation project in the United States. Indeed, Idaho eventually contained three-fifths of all land irrigated under the provisions of the Carey Act. For an overview of the Desert Land and Carey acts, see Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy 1848-1902*; *Histories of the American Frontier*, Ray Allen Billington, ed. (Albuquerque, New Mexico: University of New Mexico Press, 1992), 88-9, 251-72; and Tim Palmer, *The Snake River: Window to the West* (Washington, D.C.: Island Press, 1991), 53-111. For a brief examination of pre-1902 irrigation projects in Idaho, see Carlos A. Schwantes, *In Mountain Shadows: A History of Idaho* (Lincoln: University of Nebraska Press, 1991), 163-6. For a contemporary observer's comparison of the Minidoka Reclamation Project with the Twin Falls Project, see Richard Lowitt and Judith Fabry, eds., *Henry A. Wallace's Irrigation Frontier: On the Trail of the Corn Belt Farmer, 1909* (Norman: University of Oklahoma Press, 1991), 158-66. Minidoka County News, *The Minidoka Story*, 1; Congress, Senate, "National Irrigation Policy–Its Development and Significance," 76th Cong., 1st Sess., *Senate Document No. 36*, 2, DMC; Department of Interior, *Twenty-first Annual Report of the Reclamation Service* (Washington, D.C.: Government Printing Office, 1922), 63, DMC.

10. For a detailed examination of the politics surrounding passage of the Newlands Act, see Pisani, *To Reclaim a Divided West*, 273-325. The full text of the Reclamation Act can be accessed through the Center for Columbia River History website, located at http://www.ccrh.org/content.htm.

11. Burley Irrigation District Home Page, *Burley Irrigation District History*, http://www.cyberhighway.net/~bid/history.htm; Eric A. Stene, "The Minidoka Project," Fifth Draft, Bureau of Reclamation History Program, Research on Historic Reclamation Projects, 1997, Bureau of Reclamation DataWeb, http://dataweb.usbr.gov/html/minidoka1.html; DeMary, *History of Rupert, 1905-1922*, February 22, 1912, March 14, 1912, April 4, 1912; Minidoka County News, *The Minidoka Story*, 1.

12. DeMary, *History of Rupert 1905-1922*, November 9, 1905, December 28, 1905, October 19, 1905, February 15, 1906.

13. Karen J. Blair, *The Clubwoman as Feminist: True Womanhood Redefined, 1868-1914* (New York: Holmes and Meier, 1980), 73-5.

14. Vernetta Hogsett, *The Golden Years* (Caldwell, Idaho: Caxton Printers, 1955), 1-7; 98; Sandra Haarsager, *Organized Womanhood: Cultural Politics in the Pacific Northwest, 1840-1920* (Norman: University of Oklahoma Press, 1997), 179-82.

15. Charles E. Sargent, *Our Home, Or Influences Emanating from the Hearthstone* (Springfield, Massachusetts: The King-Richardson Company, 1899), 367.

16. See Lori Merish, *Sentimental Materialism: Gender, Commodity Culture, and Nineteenth-Century American Literature* (Durham, North Carolina: Duke University Press, 2000), 1-27.

17. Frank LaRue was elected City Treasurer of Rupert in 1909. See Minidoka County Historical Society, *A History of Minidoka County and Its People*, 11.

18. DeMary, *History of Rupert, 1905-1922*, October 19, 1905; The Minidoka County News, *The Minidoka Story*, 2; Vernetta Murchison Hogsett, *The Golden Years: A History of the Idaho Federation*

of Women's Clubs (Caldwell, Idaho: Caxton Printers, 1955), 365; Haarsager, *Organized Womanhood*, 161-165.
19. DeMary, *History of Rupert, 1905-1922*, December 23, 1915; Minidoka County News, *The Minidoka Story*, 2.
20. Gail McDonald, "The Mind a Department Store: Reconfiguring Space in the Gilded Age," *Modern Language Quarterly* Volume 63 (June 2002): 227-50.
21. "'Joe Ruggles' Was First Play at New Opera House in Rupert," *The Rupert Pioneer*, November 23, 1905, reprinted in Minidoka County News, *The Minidoka Story*, 31.
22. DeMary, *History of Rupert, 1905-1922*, September 20, 1906.
23. The measure passed by a vote of 274 to 107 in Rupert. See Minidoka County Historical Society, *A History of Minidoka County and Its People*, 12.
24. Another example of the cultural interpretations of irrigation can be found in the art and writings of Mary Hallock Foote, perhaps Idaho's best-known nineteenth-century female writer. Foote accompanied her engineer husband to the Boise Valley, where he worked for a number of years on a failed irrigation project. Some of her manuscripts and letters are housed at the Huntington Library, California.
25. This unlabeled photograph is displayed in the reading room at the DeMary Memorial Library, Rupert, Idaho.
26. Haarsager, *Organized Womanhood*, 148, 332-6. Details of the Culture Club's first annual banquet can be found in DeMary, *History of Rupert, 1905-1922*, January 3, 1907.
27. Elizabeth DeMary as quoted in U.S. Bureau of Reclamation, *Reclamation Record* 7 (February 1916): 60-1; also quoted in Mark Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West*, Foreword by William Cronon (Seattle: University of Washington Press, 1999), 222*n1*.
28. *Irrigation* was published in the Service's journal, *Reclamation Era*. I found it taped to the inside cover of Elizabeth DeMary's book *Sunlit Peaks*, housed in the DeMary Manuscript Collection at DeMary Memorial Library in Rupert, Idaho.
29. From *The Passing of the Desert*, in Irene Welch Grissom, *The Passing of the Desert* (Garden City, New York: Country Life Press, 1924), 2.
30. From *The Mirage*, in Grissom, *The Passing of the Desert*, 3.
31. Mark Fiege discusses the various cultural myths associated with irrigation in *Irrigated Eden*, 171-202.
32. Hogsett, *The Golden Years*, 41.
33. The photograph of the suffrage parade is the private property of the James Goodman family, Rupert, Idaho. The photograph is reproduced in Minidoka County News, *The Minidoka Story*, 8. For more about the founding of Rupert's Methodist Church, see A. M. Lambert, "Church History on Project," in DeMary, *History of Rupert, 1905-1922*. For information about another of Rupert's social clubs, the Pansy Club, see Mrs. C. B. Burgher, "Flowers Nurtured in Sheltered Spot Gave Pansy Club Its Name," in *The Minidoka Story*, 10. The Pansy Club supported the Boise Children's Home and the American Red Cross.
34. The source of Rupert's name has been cause for much speculation by regional historians. The Reclamation Service did not keep a record of the sources for all of its place names. Contemporary historians suggested that it was named for a prominent writer of the time period, Rupert Hughes, though Hughes later denied the assertion. Another theory suggested that it was named for Prince Rupert of the Hudson Bay Company. Albin C. DeMary unsuccessfully attempted to uncover the origins of the town's name during the 1940s, by writing to retired reclamation officials. See Minidoka County News, *The Minidoka Story*, 2; J. T. Burke to A. C. DeMary, October 25, 1944, "*Letter Scrapbook*," DMC, DeMary Memorial Library, Rupert, Idaho.
35. A 1906 photograph of the Rupert square shows four rows of framed wood buildings surrounding a completely treeless, grassless plot of dirt. See "Early Rupert Scenes," in Minidoka County News, *The Minidoka Story*, 39; Minidoka County Historical Society, "Scrapbook of Rupert, Idaho: Articles and Pictures," 5, Minidoka County Museum, Rupert, Idaho.
36. DeMary, *History of Rupert, 1905-1922*, June 6, 1907, June 13, 1907; Minidoka County Historical Society, "Scrapbook of Rupert, Idaho," 5; "Rupert Square Had Sidewalks Built in 1910," in Minidoka County News, *The Minidoka Story*, 14; U.S., Department of the Interior, National Park

Service, *National Register of Historic Places Listings*, January 26, 2001, http://www.cr.nps.gov/NR/listings/20010126.htm.

37. Many of Rupert's current residents are not as pleased with the sugar refinery as its earliest residents were. Some current residents blame the plant for Rupert's large number of unskilled, low-paying agricultural jobs. Others complain about the stench and air pollution caused by the plant. Minidoka County Historical Society, *A History of Minidoka County and Its People*, 11; DeMary, *History of Rupert, 1905-1922*, May 23, 1917.

38. Lowitt and Fabry, *Henry A. Wallace's Irrigation Frontier*, 144-52.

39. *Ibid*., 154-7. Mark Fiege examines the interplay of "myth, metaphor and the irrigated landscape" in *Irrigated Eden*, 171-202.

40. For an examination of the patterns of modern state control of resources, and the inherent difficulties in their "organization of nature," see James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1999).

41. Department of Interior, *Fifteenth Annual Report of the Reclamation Service* (Washington, D.C.: Government Printing Office, 1916), 157; Ralph W. Maughan, *Historical Highlights of Cassia and Minidoka Counties* (Rupert, Idaho: Privately Printed, 1990), 5-9.

42. DeMary, *History of Rupert, 1905-1922*, November 8, 1906; Minidoka County Historical Society, *A History of Minidoka County and Its People*, 10; Fiege, *Irrigated Eden*, 28.

43. Riedesel as quoted in Maughan, *Historical Highlights of Cassia and Minidoka Counties*, 19-20; Minidoka County Historical Society, *A History of Minidoka County and Its People*, 14.

44. As stated by Ralph Maughan, "wet and swampy areas where no crops will grow" remain to the present on the Minidoka Project. Burley Irrigation District Home Page, *Burley Irrigation District History*, 5, 7; Department of Interior, *Fifteenth Annual Report of the Reclamation Service*, 157; Albin C. DeMary to J. T. Burke, October 17, 1944, "Letter Scrapbook," DMC; Maughan, *Historical Highlights of Cassia and Minidoka Counties*, 10.

45. Charles Coates, "Federal-Local Relationships on the Boise and Minidoka Projects, 1904-1926," *Idaho Yesterdays* 25 (Summer 1981): 2-9; Maughan, *Historical Highlights of Cassia and Minidoka Counties*, 9; Fiege, *Irrigated Eden*, 127-128; Minidoka County Historical Society, *A History of Minidoka County and Its People*, 10-11.

46. DeMary, *History of Rupert, 1905-1922*, March 9, 1911, April 6, 1911, May 18, 1911.

47. "Stenographic Report of Meeting of Board of Directors of the Minidoka Water Users Association with Bien and Wells," May 23, 1911, in DeMary, *History of Rupert, 1905-1922*.

48. *Ibid,* August 31, 1911, October 5, 1911.

49. *Ibid*, August 31, 1911, January 1, 1914, November 5, 1914.

50. For an extensive discussion of the Snake River Committee of Nine and other cooperative organizations, see Fiege, *Irrigated Eden*, 25-7; 81-116.

51. Hogsett, *The Golden Years*, 98.

52. Hogsett, *The Golden Years*, 90.

53. Williams, "An Urban Study of Rupert, Idaho," 59. Leonard J. Arrington addressed the population growth of Idaho's twentieth-century agricultural communities in *History of Idaho*, Volume I (Moscow: University of Idaho Press, 1994), 471-532. Population of some of Idaho's communities, particularly Twin Falls and Rexburg, have exploded since this paper was first written in 2002.

"LAW OR NO LAW!"—Elwood Mead and The Struggle Over Power Plant Revenues, Shoshone Project, 1926-1953

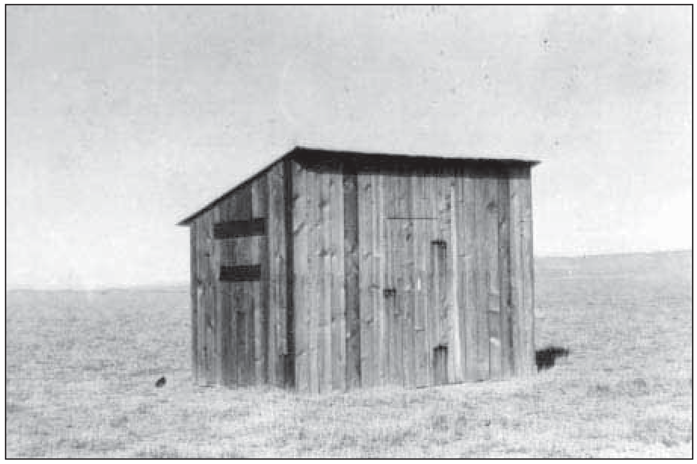
By:
Robert E. Bonner

On January 11, 1912, the fledgling Water Users Association on the Shoshone Reclamation Project held its third annual meeting. Following an animated discussion and the passage of resolutions in support of such things as an extension of the repayment period and public accounting for operation and maintenance expenses, they offered their final resolution of the evening. Their outgoing president referred to the matter as their "birthright," and urged them to look well to it. They resolved

> To the end that all waterpower rights, privileges and possibilities may be conserved to the people of this project we ask that no step in relation to same be taken which may have within it the possibility, however remote, of either loss or deterioration in respect to such property rights. That absolute ownership and control of all power sites, perquisites and privileges, within the limits of this Project, must ultimately repose in the aggregate body of land owners or water users. Our heritage in this connection must not in any wise or at any time be placed in jeopardy.[1]

Much of the discussion among historians of the waterpower developed by the Bureau of Reclamation at its damsites throughout the West has centered upon the big question of the relation of this publicly-produced power to the private power industry.[2] Indeed, the issue of public vs. private power was of concern to Reclamation leaders from the passing of the Waterpower Act of 1920. Settlers on Reclamation projects, however, had a quite different view of the power question. The prospect of hydroelectric power development on a project meant a significant increase in the standard of living of the local farmers, and as such was advertised heavily in publications like Reclamation Record. But the Shoshone water users in January of 1912 were not thinking of electric lights in their houses. Since April of 1906 every person who bought a water right on a Reclamation project purchased at the same time a future interest in the profits of any power development on the project. Tacked on (section 5) to the act governing the withdrawal of townsites on Reclamation Projects was a provision directing that the money derived from the lease of power on a project be "placed to the credit of the project" in the Reclamation Fund.[3]

From 1906 to 1939, according to the official historian of the Bureau, Reclamation policy with respect to the distribution of profits from power plants was governed by that provision.[4] Power revenues on many projects were handled in this way. And it is true that the only general legislation on power revenues between 1906 and 1939 merely confirmed the 1906 law.[5] However, the policy was frequently a subject of controversy and required authoritative redetermination more than once.[6] Moreover, the official account ignores the facts that there were legislative interventions for a decade before 1939 designed to direct power revenues away from projects, in contravention of the Act of 1906, and a serious sustained effort to rewrite Reclamation law to separate water and power income in the early 1930s.



16.1. The "Claim shanty of Roderick Seaton, Garland Flat," Shoshone Project, Wyoming, April 13, 1906.

As it happened, the legal storm over power plant revenues broke on the Shoshone Project in northwestern Wyoming. The Project consists of four divisions. The first to open, in 1908, was the Garland Division, approximately 35,000 acres divided into roughly 650 farms on the flat bench land around the town of Powell. A decade later the Frannie Division, north and east of the Powell flat and less than half the size of Garland, was opened to homesteading. Settlers in both of these areas took land in full knowledge of the 1906 act. They were paying the costs of the dam in the canyon west of Cody, and they expected to benefit someday from the development of a power plant there. The Reclamation Service put off building the power plant until they needed a source of power to operate construction machinery on the third unit of the project, Willwood. The power plant was completed in 1922, as construction began on the Willwood Diversion Dam and canal system.[7]

16.2. School children on the Willwood Division of the Shoshone Project in September of 1930.

The twenties were a difficult period for American agriculture, especially on Reclamation projects saddled with rising construction costs. The major effort of the Reclamation Service in the early 20s was the so-called Fact-Finders' Commission, a kind of Domesday inquest into every facet of every project to find solid ground of agreement on costs and procedures between farmers and administrators. This was Interior Secretary Hubert Work's great effort to refound Reclamation. Out of it came a new name, the Bureau of Reclamation, a new leader (Elwood Mead, who had been prominent on the Commission), and comprehensive legislation known as the Fact Finders' Act, passed December 5, 1924. Many changes were embodied in the Act, but power policy remained unchanged. Subsection I of the Act provided that whenever water users take over the operation of a project, the profits "as determined by the Secretary" of any power plant on the project will be credited annually to the construction charges of the water users, confirming thereby the Act of 1906.[8]

The same Act provided for a new and more generous method of repaying construction charges, limiting the payment per acre to five per cent of the average gross annual income over the past ten years. However, in order for settlers to take advantage of the provisions of this act they needed to form an irrigation district under state law. The farmers of the Garland Division had generally resisted forming such a district, but the enticement of the 5% provision plus the confirmation of the power plant rights convinced them that it was time to take on the responsibility. They formed the Shoshone Irrigation District November 28, 1925, and then entered upon lengthy negotiations with the Bureau for a contract. Almost a year later they completed those negotiations, and the Irrigation District took over the operation of the works for the Garland Division. Paragraph 31 of their contract, in language that directly repeated Subsection I of the Fact Finders' Act, guaranteed that any net profits realized by the power plant would be credited to the construction charges owed by the district.[9]

The Frannie Division of the Project also organized itself into an irrigation district, the Deaver Irrigation District (so-named for the major town in that part of the project) and worked out a contract with the Bureau in the fall of 1926. The contract with Deaver contained a significant new provision with respect to the power plant, whereby the Deaver district obligated itself to pay a proportionate share of the costs of the Shoshone power plant, "in order to receive its share of net profits of said plant." This provision was to be effective only if the Shoshone Irrigation District similarly agreed to accept a share of the power plant costs, which they had not done in their contract.[10] Commissioner Mead stated that the idea to include this provision arose from the district negotiators, although since similar provisions had been showing up in contracts with other districts, it seems likely that the government negotiators had some role in it.[11]

The Deaver contract caused some consternation among Shoshone unit-holders. Some felt their own contract language protected their rights in the power plant, believing that they were already being charged those costs as the plant was an integral part of the project, while others thought it best to amend the contract to accept specific obligation for the costs of the power plant. At the same time, officials of the Bureau were trying to sort out their own position. E. E. Roddis, District Counsel, offered his opinion that the law gave the Secretary no power to build a power plant without a repayment contract, and therefore the water users were implicitly understood to have contracted for it and could expect profits from it to be applied to their construction charges. This was not how Elwood Mead saw it. Whatever the legal theory of Reclamation might be, it was the policy of the Commissioner from December 1927, that districts had to accept a specific obligation to repay the additional construction expenses of building a power plant before they could expect to benefit from power revenues.[12]

Among other developments, the impending construction of Boulder Dam made it imperative, in Mead's mind, to separate power revenues from irrigation repayments; power was no longer simply incidental to irrigation construction. The power plant on the Salt River Project had shown for years the potential for commercial power sales.[13] Although the Shoshone power plant was smaller than, say, Minidoka, none of the power was required for pumping for irrigation, and the potential commercial development was consequently larger. The Bureau was pursuing plans for expansion of the Shoshone power system, but found itself ensnarled in legislation from an earlier time.

The news about power plant repayment was unwelcome to the Shoshone farmers, but they quickly overcame their disappointment and began to negotiate a new contract to assure their rights. Everyone knew that their power plant was now a profitable venture and was likely to become a cash cow very soon. Bureau officials in Powell, Billings, Denver, and Washington continued to grapple with the meaning of Subsection I of the Fact-Finders' Act. Some wanted to hold off payment to Deaver and Shoshone until all power project costs had been repaid. Since there were still three units of the project to be constructed, each of which presumably would incur a share in the power system expenses and profits, that position would mean the first two districts would have to wait decades to receive any benefits. Others said that the 1924 legislation clearly directed that surplus revenues be applied as soon as they became available, which would be very soon. This was the position of the Denver office, stated forcefully in a letter accompanying a draft contract dated March 5, 1928. Powell, Billings, and Washington officials were, however, increasingly uncomfortable with the prospect of so much money going to the credit of these unit-holders. They began to search for a means to hold it back.[14]

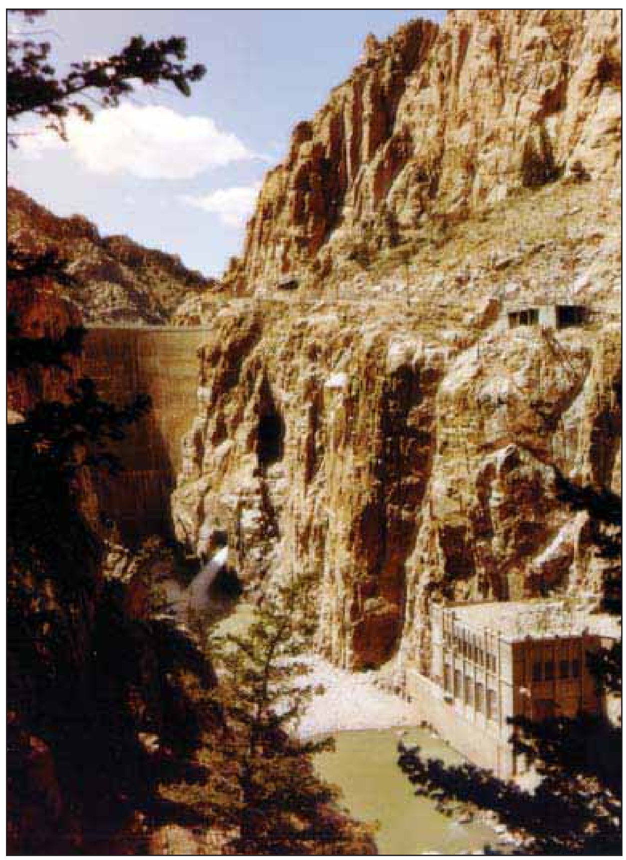
The District Counsel in Billings initially proposed that a repayment contract be made for 20 years or less, presumably to prevent it from being too generous a deal for the farmers. He based his position on the theory that power plant repayment was an entirely separate contract rather than an amendment to the 1926 contract, and therefore the repayment could not be made on the 5% of crop-return basis embedded in that contract. Congress had repealed the 5% crop-return repayment method in the Omnibus Adjustment Act of 1926. The Commissioner, in seeking clarification from the Interior Department, pointed out that if their current contract were applied to the power plant the unit holders would pay nothing for the power plant until 1986, when the plant would probably be obsolete, but they would collect at least five cents per acre immediately based on present prices. The Department solicitor ruled that while a contract could not be made on the basis of the 1924 repayment method, a new contract might go forward on the basis of a 40-year repayment period, according to the provisions of the 1926 act.[15]

Knowing the water-users' antipathy to increased assessments, the Bureau believed no contract would be acceptable to the Shoshone District that did not simply extend their 5% crop-return payment schedule to cover the new indebtedness. Moreover, when the Commissioner instructed the Denver office how to proceed with the contract he stipulated that any new contract include a provision for paying depreciation on the plant, estimated at five to seven per cent, as a matter of operation and maintenance. He also interpreted the forty-year repayment provision as having begun when the first water-right contracts were taken out, in 1908 (more than a decade before the plant was even designed!), leaving a twenty-year period for the district to accomplish the repayment of power system costs. Acting Commissioner Dent suggested to the Chief Engineer in Denver that he remind the water users that the plant is not presently showing a profit if depreciation is figured in, as that "may make the district disinclined to go on with the purchase of an interest in the power plant."[16]

R. F. Walter, the Chief Engineer, seems to have been uncomfortable with his colleagues' strategy of discouraging negotiation. He proposed terms more attractive to the water users and continued to deal with them in apparent good faith.[17] The Bureau sustained an appearance of serious negotiation throughout the spring and summer. In August Elwood Mead himself met with the Shoshone District board at the Burlington Inn in Cody, and in September Secretary Ray O. West visited the Project with Mead and discussed the contract. District negotiators worked to secure a 40-year repayment schedule that would begin in 1929, but the Bureau resisted. It seems clear that as the negotiations began both District and Bureau negotiators assumed that not only Shoshone and Deaver but the yet-to-be-built divisions of the project would share in the costs and benefits of operation of the power system. But as contract negotiations stretched out, Elwood Mead developed other ideas. In the negotiations he was driving a hard bargain, apparently hoping to discourage the District. At the Cody conference, for instance, Mead took the position that the District must agree in 1928 to pay as much as it would have had to pay if they had agreed in 1926, meaning they would have to make up two years' payments when a new contract was signed and cover any operating losses during that same period of time.[18]

On November 16, 1928, Mead made public his new view, in his introductory message to the Subcommittee of the House Committee on Appropriations in charge of Interior Department appropriations for fiscal year 1930. He had previously circulated it within the department, particularly to those engaged in the Shoshone negotiations, as a confidential memo, in search of responses. The core of the matter, as Mead presented it, was that projects with power plants were deriving a subsidy from their power sales that gave them a striking advantage in repayment over water users on projects without power plants, and this problem could only be expected to grow worse as power revenues increased. He cited situations on the Newlands and Minidoka projects, and dwelt on the Shoshone negotiations at some length. He noted that expansion of the Shoshone power system was under consideration, the money for which would come from the Reclamation Fund, but that under current law the eventual profits would all go to the farmers, "and the revenue promises to be large." He proposed a legislative remedy, in which power revenues would be applied first to power system expenses, then to construction debts of the project on which it is located, and finally back into the Fund to recover losses incurred in Reclamation development.[19]

It seems unlikely that Mead was as concerned with disparities among project repayment situations as he was horrified at the possibility of power revenue leaking away into the hands of so many farmers. Experience seemed to be showing him on every side that control of falling water was more important to the future of his Bureau than control of spreading water. The Chief Engineer and he had already initiated specific studies for doubling or tripling of the power to be generated from Shoshone Dam, all of which was to be sold commercially.[20] If he was to build a mighty Bureau, as indeed seems to have been his determination, he would need to seize control of power profits wherever they were not already contracted away. It was in this environment that the end-game of the Shoshone power plant negotiations was played out.



16.3. Buffalo Bill (Shoshone) Dam and the Shoshone Powerplant, Shoshone Project, Wyoming.

Mead's was truly a move to cut the Gordian knot. Power policy was ensnarled in old laws, arcane theories, and complicated interpretations of precedent. Reclamation officials were uncertain how to proceed. The superintendent in Powell, who had argued from the beginning for delaying power revenues until all construction costs had been repaid, nevertheless reminded Mead that power generation on the Shoshone project would have been impossible without the dam and reservoir, the cost of which the farmers were already repaying. That common sense consideration was brushed aside at higher levels. Chief Engineer Walter recognized the importance of capturing the power revenues, but wrote of it as something to be considered when entering into further investments in power.[21] On the other hand, District Counsel Roddis encouraged Mead by referring to the law of trusts. The power plant had been built by the Reclamation Fund, which was a trust. Putting revenues from power directly into the Fund would result in faster repayment than would result from repayment contracts with the farmers, and as trustees of the Fund they were obligated "to use the trust estate to the best possible advantage."[22]

The Shoshone water users, however, surprised Washington by their determination to contract for power plant construction expenses. They were receiving active encouragement from the farmers on the Deaver District, whose own interest in the power plant depended upon a satisfactory contract being reached with the Shoshone people. The District submitted a contract proposal abandoning their stand on repayment on a crop-return basis, accepting the Bureau's insistence on a new, 40-year contract. As they in effect called the Bureau's bluff, Mead's solution seemed the only way out for a Bureau desperate to retain power revenues.

Late in November Assistant Secretary of the Interior E. C. Finney wrote to the District's attorney, Ernest Goppert of Cody, who had written him to try to move negotiations ahead,

> It is believed that at the next session of Congress legislation will be proposed which would affect the disposal of the unsold interest in the Shoshone power plant. Under the circumstances it is considered advisable to await the possible action of Congress at the next session before definite reply is made to your letter.[23]

In this manner Mead's sword descended upon the knot. He showed the House subcommittee overseeing Interior Department appropriations how power revenues could be redirected and they accepted his formulation before the end of 1928. The change in policy, while not general, affected other projects besides the Shoshone.[24]

The official Bureau history of these events crystallized within the year 1929. Ignoring the genuine attempts of the District to negotiate a contract, Bureau apologists—notably Elwood Mead himself—put the onus on the water users, claiming that they had never been willing to repay construction costs on the power system. He never mentioned the terms under which negotiations were terminated. The Bureau then treated the Interior Department Appropriation Bill passed March 4, 1929, as if it were a Congressional intervention rather than a clear result of Bureau policy. It is true that Congressman Cramton had a record of watching carefully over the Bureau's handling of the Fund, and there can be little doubt that he genuinely supported the change, but it was obvious then and it is obvious now that the Bureau did not negotiate in good faith.

Mead's candor in the Interior Department appropriation hearing makes this perfectly clear. In his introductory presentation he expressed his dismay that the Newlands project received $16,000 a year from power while they only paid $8000 a year in assessments for the power plant. More shocking still, the South Side of the Minidoka project received an excess of more than $100,000 a year to apply to extension of their system, with no obligation to repay. Later in the hearing, when Representative Cramton argued that the Bureau should never have entered into the contract they did with Deaver, Mead blurted out, "I am clear that, law or no law, we do not want to make any more contracts of that kind."[25] He went on to argue forcefully that the increased demand for power due to oil development near Powell made it likely that power would bring in more money than irrigation soon, and if it were developed in a business-like way it would be very large indeed, which he believed ought properly to belong to the Government.[26] In light of such statements, the letters water users received from Washington during the year after the Mead coup were arrogant as well as insulting to those who knew how things had gone.[27] Nevertheless, agents of the Shoshone Irrigation District continued to pursue the matter with the Department of the Interior.

During 1930 and 1931 the District sent members to Washington to talk with Interior Department personnel, and set about preparing an elaborate legal appeal to the Solicitor. The success of water users on the North Platte Project in securing their own rights to the power plants there, which Mead had also attempted to terminate, gave them courage for this effort. Briefs from the District and the Bureau were presented and a hearing held before the Solicitor in the spring of 1931, and on July 29, 1931, Solicitor E. C. Finney handed down a decision supporting the Bureau, denying the District any share in the power revenues. The District's appeal argued that the Act of March 4, 1929, was unconstitutional, in that it deprived them of rights guaranteed by the Fact-Finders' Act and their contract, but since neither of those instruments specifically mentioned payment for the costs of power system construction the Bureau's defense was successful. Apparently the District realized they could not get any farther by claiming treachery on the part of the Commissioner, so they fell back upon this much shakier ground of constitutional argument.[28]

While pursuing administrative relief, the water users also turned to their Congressional delegation for help. Senator Robert Carey introduced a bill December 11, 1930, that would have provided a legislative remedy to the situation created by the Act of March 4, 1929, compelling the Department of the Interior to follow the provisions of the Fact-Finders' Act insofar as the Shoshone Project was concerned. The Bureau believed that the process of appeal to the Solicitor had in fact been undertaken primarily to obtain the Bureau's brief so they could attempt to get favorable legislation passed. Mead's response to this legislation was swift and powerful. He drafted an 8-page memo for Secretary Wilbur to employ in response to the House Committee, detailing the write-offs and adjustments that had benefited the Shoshone settlers already amounting (in the always-suspect Bureau calculations) to over $2½ million, and underlining the extent of the subsidy they would receive if they got power revenues in addition. He developed, in December 1930, the strongest argument yet for separating power and irrigation, embracing fully the potential of commercial power development. This was the first blast of the full-scale legislative initiative that was to occupy the Bureau for the next three Congresses.[29]

Senator Carey tried to mediate some resolution between Mead and the water users toward the end of 1931 but found Mead inflexible.[30] Ernest Goppert, the District's attorney, in consultation with a Washington law firm, determined to file a writ of mandamus against the Secretary of the Interior, now Ray Lyman Wilbur, hoping to compel him to perform his duty to pay out proportionate power revenues to the District annually under the 1924 act. To make this case they had to argue that the 1929 act was unconstitutional, a violation of the Fifth Amendment provision against taking property without due process. The property in question, they alleged, was their right to power plant revenues guaranteed them by the 1924 act and the 1926 contract. This was a far stretch, since the Bureau could argue in response, ironically, that the very efforts to negotiate for a share of the power plant costs that Mead had interrupted showed that the District knew it had no vested interest without agreeing to pay for the construction costs. Blandly brushing aside the complicated negotiations discussed above, the Bureau simply noted that the Congressional intervention of March 4, 1929, made it impossible for them to comply with the 1924 act. They did not need to argue that the 1929 legislation was constitutional.

The District tried to show, what District Counsel Roddis had seen at the outset, that there was no authority for the Bureau to build power plants except as part of irrigation projects: the construction charges, therefore, that they had been paying for two decades gave them those rights implicitly. They also produced considerable evidence that all conversations regarding power plant revenues held between the District and the Bureau until late in 1927 had regarded the power plant as part of the Shoshone Project upon which they were paying construction charges and to which they had clear legal rights. This should have been a strong argument, and might have been in another legal process, but not in this one. The attempt to enforce a writ of mandamus was a difficult legal strategy.[31]

The Bureau, perhaps stung by having lost the North Platte case, pulled out all stops to defend its position in this suit. Their position here was stronger, of course, because of the Act of March 4, 1929, and a slightly different contractual history. They bombarded Judge Graves, the solicitor defending the Secretary of the Interior, with advice and documents, even offering to send office employees who were present at the 1926 contract negotiations to testify that the District had not then been interested in purchasing an interest in the plant. The most useful of these communications was probably the suggestion by Acting Commissioner Porter W. Dent that mandamus cannot be used to enforce a contract right, but only a duty imposed by law. The Shoshone case, he suggested, is a contract case, by their insistence that Article 31 of their 1926 contract is the ground for their property right in the power plant. Dent also reminded Graves that the District would not be without remedy if their petition were denied, since the Court of Claims exists to adjudicate contract disputes. After noting that Congress was well within its constitutional rights when they passed the 1929 act, Justice Atkins appropriated Dent's legal argument and rejected the District's petition for a writ of mandamus on June 13, 1933.[32]

The District and their lawyers immediately appealed to the Court of Appeals for the District of Columbia. They ignored the suggestion of contract adjudication in the Court of Claims and persisted in their pursuit of a mandamus ruling. This was clearly not a good idea. Justice Atkins had made it clear that he thought the merits of their case were worth considering, but not in this way, and they chose to ignore him completely. The result should have been predictable. The appeal was argued February 5, 1934, and decided April 9, 1934. Associate Justice Van Orsdel reaffirmed every point of the Supreme Court's decision. He dwelt emphatically upon the fact that the Secretary of the Interior has discretion to determine the matters at issue, that mandamus does not extend to discretionary matters, and he reminded the District that the federal government cannot be sued without its own consent.[33] Even then the District did not give up the legal fight. In June they filed a petition in the Supreme Court of the U.S. for a writ of certiorari, but it was quickly denied and they turned instead to Congress.[34]

Congress was at that very moment engaged in the final stage of deciding the fate of Commissioner Mead's attempt to achieve a statutory basis for his new power policy. When the first attempt by the Wyoming delegation to overturn the Act of March 4, 1929, failed, Congressman Cramton introduced a bill, written in concert with Mead, to provide that power plant revenues on reclamation projects everywhere should be handled as they were after 1929 on the Shoshone Project. H.R. 16976 was introduced February 9, 1931. It was sent to the Committee on Irrigation and Reclamation, from whence it returned two weeks later with a favorable report. Mead had drafted not only the bill but also Secretary Wilbur's letter in support of the bill. He argued that changing circumstances required this bill's adoption, noting in passing that the policy developed with respect to the Shoshone Project had also been adopted on the Black Canyon Power Plant on the Boise Project and the Kennewick Highlands unit in Washington. Mead was walking a fine line, trying to convince the Congress that power on the projects should be developed in a business-like manner while at the same time attempting to pacify critics of government entry into the development of commercial power. He also needed to reassure his audience that contracts presently in force would be honored. Still, his goal was clear; as he told the committee, it was of "the utmost importance that a uniform law be adopted."[35]

The effects of the Depression and the continuing problems of Reclamation finances had combined to drive Mead to search for a solution through power income. There was an obvious financial crisis within Reclamation. They had been operating on loans from the general fund which stipulated returns to the

Treasury of $1,000,000 per year, they faced demands from Western interests for maintaining and even extending construction, and crop values, the basis of returns to the Reclamation Fund, had fallen by $3,000,000 in the last year. Power revenue offered the possibility of meeting the loan obligations and funding continued development as nothing else could do. In fact, it was almost certainly the desire to expand power production and sales at the Shoshone plant that forced his hand in 1928; he needed to increase revenue but could not do it while the disposition of power revenues was uncertain.[36] Mead campaigned aggressively with members of Congress for his new law, showing them the amounts of money now being generated by Reclamation power plants, detailing the losses of ordinary Reclamation revenue, and painting Reclamation settlers on projects with power plants as undeserving government debtors about to collect unearned dividends in perpetuity. It was a good case, and he made it outside Congress to such people as the editor of the *Saturday Evening Post* as well. It failed, however, to overcome political opposition in the Congress.[37]

The House, as will be seen below, carried a grudge against the Bureau for the manner in which earlier legislative maneuvers had been carried out. The Senate, it seems, was more circumspect. Senators seem to have been much less concerned with the details of Reclamation finance than Congressmen. Senator Thomas Walsh of Montana, for instance, expressed surprise, in a letter to Mead in April 1932 that the Bureau was building power plants to subsidize irrigation on some projects. When the Casper-Alcova project was authorized that month, Senators removed from the bill a provision that would have enacted Mead's policy of returning power revenues to the Reclamation Fund after construction charges had been met. They substituted an article stipulating that future profits "shall be disposed of as Congress may direct." Senator C. C. Dill of Washington, the author of that amendment, maintained that the Congress was not ready to decide Federal policy on this question.[38]

When the Roosevelt administration was fully settled in Mead tried again, this time in 1934. Administratively, the landscape had changed dramatically, with Harold Ickes now running the Department of the Interior. The bill that went to the 73rd Congress was a much more forthright assertion of a new order than the first bill had been, and Ickes clearly had a large role in preparing it. The core of the Secretary's position may be found in his letter to the Senate committee hearing the bill:

> Now that power development has become a more important feature of irrigation and community development, provision should be made for the full utilization of the latent and possible power developments created by the construction of irrigation projects. The Government should be the agency to determine the economic and social benefits that may result from the full utilization of these power possibilities, and to use these latent and possible power developments in the upbuilding of the project and surrounding communities. Operations of the past and present enable the Government to estimate the economic benefits and financial returns.

> Absence of some uniform legislation of the kind proposed by this bill has prevented the full utilization of possible power development at several large reservoirs. Under existing general legislation the repayment of this development must be underwritten or guaranteed. Repayment requirements of irrigation costs are such that agriculture will not carry the added burden of power development.[39]

This bill put power first in a wholly new way. Not only was he proposing to separate the power and irrigation functions of the Bureau of Reclamation, he was proposing to do it in the pursuit of an aggressive development of public power resources that subordinated the traditional irrigation mission of the Bureau. In retrospect, Ickes made Mead's 1931 bill look rather timid, more of a bureaucratic defensive ploy than a major policy initiative.

Not surprisingly, Ickes's bill met with virtually no resistance from the Senate. S. 3375 was introduced April 13. Ickes's letter to Senator Alva Adams, Chairman of the Committee on Irrigation and Reclamation, was sent May 10. On June 6, S. 3375 was read for the third time and passed by the Senate without a nay vote.[40] It was a different story entirely in the House. Introduced the same day, H.R. 9124 was sent to the House Committee on Irrigation and Reclamation, chaired by Representative Dennis Chavez of New Mexico. Where the Senate Committee had seen no need for hearings, the House Committee scheduled full committee hearings starting in early June. Determined opponents of Elwood Mead like Representatives Vincent Carter of Wyoming and Terry Carpenter of Nebraska led the charge against the bill, supported frequently by other western congressmen. Taking away the actual and potential assistance power revenues offered to struggling farmers on Reclamation projects did not set well with them. Others were opposed to the idea of the Department of the Interior setting itself up in the power business. The spectre of large power companies taking cheap power from these projects and selling it back at exorbitant rates haunted the hearings. Things went so badly that Marshall Dana, president of the National Reclamation Association, a hand-picked mouthpiece of Mead's, offered the suggestion that the committee not proceed to a vote on the bill until they had had a chance to talk it over with their constituents. When the committee adjourned on June 14 H.R. 9124 was clearly dead.[41]

It could be that the House was more hostile than the Senate because it was more closely tied to local interests. It could also be because there was a palpable current of hostility to the Bureau of Reclamation among the members of the House Committee on Irrigation and Reclamation. At several points in the hearings on H.R. 9124, Representative Carter referred with a nasty edge to the proceedings by which Mead had got his way on the Shoshone Project power plant. Within the first hour he had drawn the Committee's attention to the actions of Representative Cramton back in 1928, slipping the Shoshone provision into the Interior Department appropriation bill "the night before Congress adjourned… with no committee having had a chance to have a hearing on it."[42] On the fifth day of hearings he interrupted the testimony of the Bureau's chief accountant to remind everyone that "the Cramton amendment" had never come before the Reclamation Committee, and that if a point of order had been raised against it when it was attached to the Appropriations bill the point of order would have been sustained. He concluded, "I know that if the question of that policy had come before the Reclamation Committee it would never have been adopted."[43] Among the many reasons the bill died, this resentment surely bulked large.

As the Bureau effort ground to a halt, the District resumed its attempt to get the 1929 act overturned in Congress. In fact, they had never really abandoned this course. Senator John Kendrick took up the cause in 1932, when the Senate Committee on Irrigation and Reclamation held hearings on a bill to relieve the Shoshone District. In these hearings an alternative vision to that of the Bureau regarding the events of 1928-1929 was developed, with Mead and Cramton as the villains. J. T. Whitehead, spokesman for the Shoshone Irrigation District, testified that Cramton and Mead worked together to produce the language for the 1930 appropriations bill. "Those hearings under Mr. Cramton were never open hearings. Judge Winter was the Congressman from Wyoming at the time. He did not know that that provision was in the appropriation bill."[44] The bill went through the House in four days and only ten days in the Senate. The provision for the Shoshone Project was not germane to the appropriation bill, i.e. there was no money being appropriated for power. Mead attempted the same thing with the North Platte Project power revenues, but the Nebraska congressman saw it and insisted on having it removed. Senator Kendrick learned of it just before it passed and notified the Shoshone people, but by the time they got back to him the bill had passed the Senate. In testifying to this view of the facts Whitehead was careful not to challenge the wisdom of the new policy with respect to power revenues, but to focus on the sanctity of contract and the deviousness of Mead and Cramton in pursuing the overthrow of valid contracts.[45]

These early efforts did not succeed, but they established the ground of a continuing attempt to get justice for the Shoshone District. In 1933 Representative Carter introduced H.R. 17, identical to the Kendrick bill of the previous year. The following year was spent defeating the Interior Department bill, but 1935 saw a renewed offensive from Wyoming. Representative Paul Greever introduced H.R. 6875 in March, and Senator Joseph O'Mahoney introduced S. 2286. These bills tried to meet the Bureau half way by providing that the power revenues on the project that were properly allocable to the unconstructed divisions be handled according to the terms of the 1929 act, but that the revenues allocable to the divisions that had contracted with the Bureau be handled according to the terms of the contracts. The House committee gave Greever's bill a full hearing in May. The Department of the Interior, in opposing the bill, denied that existing contracts in fact gave any rights to the districts. They also insisted that it was bad policy, contrary to the principles set forth in H.R. 9124. Since that bill had failed to pass, it seems strange that the secretary would be relying upon it in this way, but it is surely revealing of the mindset of the administration. They had, after all, been following the principles of Mead's Shoshone policy without legislative approval on other projects since 1930.[46]

The argument for the Shoshone District was carried by Ernest Goppert again. Their strategy this time was to insist that the 1926 contract was valid even without specific language regarding the power plant, and the 1929 act was an abuse of Congressional procedure and administrative power. Goppert repeated arguments developed in the court cases. The water users had actually been charged enough to cover the power plant costs in addition to the irrigation system, but Bureau accounting procedures had kept the money in a separate account. The Bureau had no authority to set up a separate power account. All features constructed on the project were covered by the public notices of original and supplementary construction costs, and that was the only way the Bureau could legally proceed. The District could find no remedy in court only because they were prevented from suing the government without its permission. In fact, Goppert testified that Justice Atkins stated from the bench "that if this was a suit against a private individual, he would have no difficulty in entering a decree in our favor."[47] Since the Department of the Interior had relied upon the 1929 act to rule against Shoshone while they ruled in favor of North Platte water users on a similar case, Goppert appeared confident that removing the 1929 act would result in a decision favorable to the District.

On the second day of these hearings Goppert had the opportunity to question R. M. Patrick, of the Bureau legal division. It was a very hard-nosed examination, in which Goppert pursued the way the Bureau handled its accounts, hoping to show that the 1929 act was part of a change in procedure that was unauthorized by Congress and kept secret from the water users. Patrick admitted that original construction charges on the Shoshone Project did contemplate repaying the cost of the dam and reservoir, but since 1929 they were no longer charged against the irrigation districts. More significantly, he stated that the Bureau had had no objection to the provision in the Shoshone District contract (Section 31) for distribution of surplus power revenues, "because the amount was to be determined by the Secretary, and we felt perfectly safe that if a net profit came to the district from the operation of the power plant, no portion of the profit would be allowed to go to the Garland Division."[48] He tried to place all the responsibility for the midnight legislation of the 1930 Appropriation bill on Representative Cramton, exonerating Mead in particular. And he attempted to dodge Goppert's contention that the District had paid enough to cover expenses for the plant by saying that it was only money; if they were not charged for the power plant they could not have paid for it. This straightforward exposure of the way the Bureau did business did not help their case.[49]

The issues on both sides had by this time been finely distilled, and the questioning brought them out very clearly. The committee, particularly Representative Robinson, seemed determined to find the equity of the matter, inquiring into just what the water users themselves had been led to believe about power revenues. Both the Bureau's goal of using power for development when irrigation repayment could not manage it and the District's goal of re-establishing a right they felt was theirs by custom and contract got a full hearing. The testimony from both sides showed quite clearly how the Bureau had pursued its policy by manipulation of its own cost accounting procedures, and Goppert was much more persuasive than Patrick on the matter of the District's legal rights. The simple, eloquent letter from Herman Krueger of Deaver, detailing the 1928 negotiations and Mead's public promises in Powell and Deaver that their interests would be taken care of carried considerable weight.[50] The committee unanimously agreed to provide the Shoshone District the relief they sought. In spite of that, and in spite of its having passed the Senate in June, the bill never came to a final vote in the House in that Congress. In the 75th Congress, however, Representative Greever and Sen. O'Mahoney brought it back. The Bureau seemed resigned to its passage and put up little resistance, and without much ado in the way of hearings or debate the bill received President Roosevelt's signature on April 8, 1938.[51] After nearly a decade of combat in a variety of theaters, it seemed that the water users of the Shoshone Project had won their war.

Although there was great celebration in Powell in the spring of 1938, it soon dissipated. One-fourth of the unit-holders on the Shoshone Irrigation District held back the first installment of their 1937 construction payment in expectation of some help from the legislation. But the Bureau informed the District by telegram only a week after the bill was signed that they would do nothing without an opinion from the Interior Department solicitor, and concluded, "Believed very doubtful that it will result in any credits to water users at this time." They then passed the matter to the Interior Department.[52]

The Bureau asked for a solicitor's opinion, but Secretary Harold Ickes took the matter upon himself to pronounce as a matter of policy, rather than simply a legal interpretation. He took a great deal of time to prepare it, while the Shoshone District wrote and cabled Commissioner John Page and Ickes repeatedly to learn where they stood. Page tried to be polite and helpful, but Ickes was not cut from the cloth of those early Interior Secretaries who had nurtured government settlements all over the west. He resisted the farmers and their political representatives, and it was not until September 1940, more than two years after the relief legislation had passed, that he communicated his determination to the Bureau and the District.[53]

The legislation of 1938 had in effect done away with the infamous appropriation bill rider of 1929, authorizing and directing the Secretary to apportion power revenues according to the contract of 1926. Commissioner Page had warned the Committee on Irrigation and Reclamation that this was not likely to produce any result: "the bill in effect merely proposes to grant something, providing the contracts grant it. But according to the Department the contracts do not do so, while the districts contend that they do."[54] Ickes emphatically closed the door. No stranger to high-handed administrative action, he endorsed completely the Mead history of the contract negotiations. Ignoring the fact that the water users had understood themselves to be paying for the dam and reservoir for twenty years, he denied that they had paid anything for the power system and therefore they were not entitled to any of the profits. Power was a separate element of the Project, he said, conveniently overlooking the fact that there was no legislative authority to do that in 1929; the Government alone had taken the risk and to them belonged the profits. Point by point he rejected the District case, and brushed aside the clear intent of Congress.[55]

The door so emphatically slammed did not stay shut, but the details of negotiations over the next 14 years need not weigh us down here. In the end, by Act of Congress dated July 14, 1954, the Shoshone District was awarded a credit of $426,000 on their construction charges, an approximation of what they might have earned had the 1938 legislation been honored in spirit. Deaver also received their proportionate share. For their part, the Bureau cleared their claim on Shoshone power revenues and strengthened the fence around them where the other districts of the Project were concerned. The Bureau resisted only feebly in the end, but the damage had been done long since.[56]

What are we left with, then, at the end of what one Interior staffer called "this long, bitter controversy?" Looking at the history from the local viewpoint, the settlement may be viewed as a testimony to the determination of the Shoshone settlers. Certainly, from start to finish, they never abandoned their conviction that the dam and its attendant power revenues were part of what they had bargained for when they took out water rights in that valley. It is interesting to note that one of the principal spokesmen in the 1954 hearings was one C. W. Fowler, then an attorney in Washington but also the owner of a farm near Powell that he homesteaded in 1910; he had been secretary of the water-users association at that January 1912 meeting when power revenues were first formally discussed.[57] These farmers were more than ordinarily stubborn in defense of right as they saw it. They convinced three generations of Senators and Congressmen to carry their case in Washington, and ultimately achieved a good part of what they set out for. Perhaps we could say they won.

If they won, however, it was at a terrible cost. Twenty-six years of settled hostilities between the settlers and the Bureau left a residue of virulent anti-federal sentiment in the Shoshone Valley that is a feature of life there to this day. The Shoshone Irrigation District paid off its construction charges to the federal government in 1978. The water-users knew they were paying off sooner than they would have done without the settlement, but they could not forget that they would have paid off even sooner and still be enjoying income from the plant if the original contract as they understood it had been honored. There are people on the Project today who talk of legal action to restore those rights. It is perhaps no surprise that the Shoshone Irrigation District built its own low-head power plant on its main canal and subsidizes its irrigation operations today with power plant revenues.[58]

Looked at as a piece of the history of the Bureau of Reclamation, this story should be chastening. The staff of the Bureau seems to have groped their way through the matter of power plant revenues in general and certainly fumbled the Shoshone case. They had to work out the law and policy of power revenues more or less by the seat of their pants; theirs was not the arrogance of power but the desperate bluff of people who know they are on shaky ground. Elwood Mead grasped an essential point about Reclamation finance but pursued it with such devious arrogance and defended it with such blind passion that he alienated not only project settlers but a generation of powerful men in Congress. In terms of his drive to bureaucratic dominance, Mead would give nothing away to Floyd Dominy.[59] There were real obstacles to shifting the basis of Reclamation finance, but violating law and contract and exposing the underside of Reclamation bureaucratic methods in Congress surely made things worse. It is quite possible that if he had acted in good faith with the people of the Shoshone Project, and with their elected representatives, Mead would have got his power revenue bill passed in 1935 or even earlier. The merits of the policy change, after all, were recognized by Congress with the passage of the Reclamation Projects Act of 1939, after they had dealt with the equities of the Shoshone matter.[60]

Because Mead and Ickes were in the business of building powerful bureaucratic entities to compete in the modern world, and because the issues at the center of this story were key to that growth, this story also reveals in passing the processes and consequences of developing big government. In 1928 Mead and Secretary West went to Powell and Deaver to meet with the people, as Secretaries and Commissioners had been doing for two decades. By 1940 no one would have thought of such a thing. Mead had been a very popular choice for Commissioner in 1925, but there was open enmity between him and Shoshone Project leaders from 1929 on. In 1933 S. A. Nelson, President of the First National Bank in Powell and a pioneer homesteader, published his own account of the negotiations; he had been present at every conversation affecting the Shoshone water users since 1909. It is perhaps enough to note the title, "The High-Water Mark of Bureaucratic Racketeering," to catch the flavor of this pamphlet.[61] Both the pamphlet and this larger story seem to show that people were moved out of the center of Reclamation during the New Deal; power, under a variety of descriptions, moved in.

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Endnotes:

1. Powell, Wyoming, *Tribune*, January 19, 1912.
2. See for instance, Donald C. Swain, *Federal Conservation Policy*, 1921-1933 (Berkeley: University of California Press, 1963), or Donald Pisani, *Water and American Government: The Bureau of Reclamation and the American West*, 1902-1935 (Berkeley: University of California Press, 2002).
3. Act of April 16, 1906, chap. 1631, 34 Stat. 116, cited in *Federal Reclamation Laws Annotated,* Vol. I, (Washington, D.C.: U.S. Government Printing Office, 1943), 94-6.
4. William E. Warne, *The Bureau of Reclamation* (New York: Praeger Publishers, 1973), 89.
5. The Fact-Finders' Act of 1924, Subsection I. See below.
6. *Hearing before the House Committee on Irrigation of Arid Lands*, 64th Cong., 2nd sess.; Subsection I of the Second Deficiency Act FY 1924 (Fact Finders' Act) and notes, *Federal Reclamation Laws Annotated*, Vol. I, 277-9.
7. Shoshone Project History, 1922, Shoshone Irrigation District Archives, Powell, Wyoming, cited hereafter as SID Archives. Homesteading on Willwood, the third division of the Project, began in 1926, but operated from the beginning on a water rental basis. The farmers there, not having formally undertaken to repay construction costs at that time, did not nurse the same expectations from the power plant. As they did not have a repayment contract until 1949, they remained on the sidelines throughout the controversy with which this paper is concerned.
8. *Federal Reclamation Laws Annotated*, Vol. I, 272-83. Brian Cannon has recently published a thorough study of the Fact Finders' Act, "'We Are Now Entering a New Era': Federal Reclamation and the Fact Finding Commission of 1923-1924," *Pacific Historical Review* 66 (May 1997): 185-211.
9. Department of the Interior, Bureau of Reclamation, "Contract with the Shoshone Irrigation District… ," November 4, 1926, in SID archives.
10. Shoshone Project History, 1926, SID archives.
11. Mead to Project Superintendent, November 17, 1926, SID archives. Water users on the Yuma and Minidoka Projects had contracted to pay for power plants before this negotiation. See *Federal Reclamation Laws Annotated*, Vol. I, 268, 277-9.
12. Shoshone ID to E. E. Roddis, November 30, 1927; Roddis to Commissioner Elwood Mead, December 2, 1927; Mead to Senator Francis E. Warren, December 17, 1927; all in SID Archives. It should perhaps be noted here that a reader will search in vain through our only biography of Elwood Mead, James Kluger's *Turning on Water with a Shovel* (Albuquerque: University of New Mexico Press, 1992), for any mention of hydroelectric power income apart from Boulder Dam.
13. Pisani, *Water and the American Government,* chapter 8.
14. Records of power plant revenues are printed in the annual project histories. R. F. Walter, Chief Engineer (Denver), to Commissioner, March 5, 1928; District Counsel E. E. Roddis to Commissioner, March 12, 1928, in SID Archives.
15. Acting Commissioner P. W. Dent to Secretary of Interior, March 13, 1928, and Solicitor E. O. Patterson to Secretary, March 24, 1928, in National Archives, RG 48, Department of the Interior, Office of the Secretary, Central Correspondence File (CCF) 1907-1936, 8-3 Shoshone; Federal Reclamation Laws Annotated, 318.
16. Commissioner Dent to Chief Engineer, April 2, 1928, SID Archives.
17. Chief Engineer to Superintendent, April 26, 1928, SID Archives.
18. District Counsel to Superintendent, August 21, 1928; Acting Commissioner to Superintendent, October 1, 1928; District Counsel to Chief Engineer, October 20, 1928; in SID Archives. According to later testimony at a Congressional hearing, Mead assured the water users of the Deaver District on this trip who were concerned about their rights to the power plant, "you need have no fears in regard to that. Your rights will be fully protected;" *Hearings before the Committee on Irrigation and Reclamation, House of Representatives*, 74th Cong., 1st Sess., on H.R. 6875, May 2 and 6, 1935 (Washington, D.C.: U.S. Government Printing Office, 1935), 26.
19. *Hearing before the Subcommittee of the House Committee on Appropriations for FY 1930* (Washington, D.C.: U. S. Government Printing Office, 1929), November 16, 1928, 387.

See also memo from Project superintendent to Commissioner commenting on the confidential memorandum, October 30, 1928, SID Archives.

20. Chief Engineer to Commissioner, October 27, 1928, marked Confidential, SID Archives.

21. Superintendent Mitchell to Commissioner, October 30, 1928, SID archives; Chief Engineer to Commissioner, October 30, 1928, National Archives, Denver Regional Branch, Bureau of Reclamation, RG 115, E. 7, Central Administrative Records, 1919-1929, Box 106, folder 140.1.

22. District Counsel Roddis to Commissioner, November 5, 1928 (confidential), SID Archives.

23. Finney to Goppert, November 21, 1928, RG 48, Office of the Secretary, CCF 1907-1936, 8-3, Shoshone; Goppert to Mead, December 20, 1930, RG 115, E. 7, Project Correspondence File 1930-1945, Box 1028, folder 201.1.

24. District counsel Roddis to Superintendent Mitchell, December 31, 1928 (confidential), SID archives. Roddis reported to Mitchell the language that would be included in the Act of March 4, 1929.

25. *Hearing before the Subcommittee of the House Committee on Appropriations*, November 16, 1928, 401.

26. Ibid., 402.

27. See, e.g., Mead to George Hendricks, secretary of the irrigation district, January 15, 1930, or Assistant Secretary Joseph Dixon to George Atkins, March 11, 1930, SID archives. Dixon's letter was particularly long and patronizing, frequently (as Atkins pointed out in an angry reply March 31) taking isolated statements out of context to make them mean something other than they had meant at the time.

28. *Federal Reclamation Laws Annotated*, Vol. I, 277-278. Full text copies of the Interior Department Solicitor's decisions in favor of the North Platte water users, no. M. 25908, dated October 17, 1930, and against the Shoshone water users, no. M. 26630, are filed in the SID archives.

29. Elwood Mead, Memorandum for the Secretary of the Interior, December 29, 1930; Ray Lyman Wilbur to Addison Smith, Chairman of the House Committee on Irrigation and Reclamation, December 30, 1930; RG 115, E. 7, Central Administrative Correspondence 1930-1945, Box 239, folder 140.1. Mead felt supremely confident in late 1930 that the House of Representatives would not budge from the position he and Cramton had crafted; Mead to Superintendent Mitchell in Powell,
December 17, 1930, RG 115, E. 7, Project Correspondence File 1930-1945, Box 1028, folder 201.1.

30. *Congressional Record*, 71st Cong., 3rd Sess., 549; Acting Commissioner M. A. Schnurr to Chief Engineer, April 14, 1931, SID archives; Carey to Mead, December 22, 1931, and Mead to Carey, December 24, 1931, RG 115, E. 7, Project Correspondence File 1930-45, Box 1037, Folder 225.07.

31. Petition of Shoshone Irrigation District vs. Ray Lyman Wilbur, in the Supreme Court of the District of Columbia, June 24, 1932; Answer and Response of the Department of the Interior to the Rule to show cause, July 14, 1932; both in SID archives.

32. Acting Commissioner Dent memorandum to Judge Graves, July 5, 8 and 11, 1932; Commissioner to District Counsel, June 30, 1932; District Counsel to Commissioner, July 5, 1932; Acting Superintendent to Commissioner, July 7, 1932; Document and Transcripts of court proceedings in Shoshone Irrigation District vs. Harold L. Ickes, in the Supreme Court of the District of Columbia, no. 81460, filed June 24, 1932; all in SID archives. In fact, the Court of Claims was not a practical remedy, since the District would have had to apply to the Court each year to have its share of the revenues determined.

33. *United States ex rel. Shoshone Irrigation District. V. Ickes, Secretary of the Interior*, no. 6061, Court of Appeals of the District of Columbia, in Federal Reporter, 2nd series, vol. 70 (St. Paul: West Publishing Co., 1934), 771-773. Although Ray Lyman Wilbur was named as defendant when the case began, Harold Ickes was substituted as defendant before the initial judgment was handed down.

34. Secretary of the Interior to Attorney General, July 2, 1934, SID archives; Hearings before the Committee on Irrigation and Reclamation, House of Representatives, 74th Congress, 1st Session, on H.R. 6875, 2.
35. House of Representatives Report no. 2865, to accompany H.R. 16976, 71st Congress, 3rd Session; Congressional Record, 71st Cong., 3rd Sess., 549, 5805.
36. Chief Engineer to Commissioner, August 21, 1928, and October 27, 1928, RG 115, E.7, Project Correspondence Files, 1919-1929, Box 1011, folder 320.
37. Commissioner to Chief Engineer, January 14, 1931, Mead to Addison Smith, Chair of House Committee on Irrigation and Reclamation, February 24, 1931, Commissioner to Chief Engineer, March 21, 1931, (with circular on Reclamation finances), Mead to Senator Charles McNary, March 21, 1931, and Mead to Senator Hiram Johnson, March 21, 1931, also enclosing circular on finances; RG 115, E. 7, Central Administrative Correspondence 1930-1945, Box 239, folder 140.1.
38. Walsh to Mead, April 9, 1932; Mead to Walsh, April 14, 1932; Extract from the *United States Daily*, April 11, 1932; RG 115, E. 7, Central Administrative Files 1930-1945, Box 239, folder 140.1. Mead had apparently convinced Casper-Alcova's chief sponsor, Senator John Kendrick of Wyoming, that his new policy should be written into the bill; see Mead to Kendrick, March 15, 1932, ibid. Donald Pisani suggests that Congress was wary of Reclamation establishing with power revenues a second, independent Reclamation fund; see *Water and the American Government*, chap. 8.
39. Senate Report no. 1057, to accompany S. 3375, 73rd Congress, 2nd Session.
40. *Congressional Record,* 73rd Cong., 2nd Sess., 6532, 10576.
41. *Hearings before the Committee on Irrigation and Reclamation, House of Representatives*, 73rd Congress, 2nd Session, on H.R. 9124, A Bill to Provide for the Distribution of Power Revenues on Federal Reclamation Projects (Washington, D.C.: U.S. Government Printing Office, 1934).
42. Ibid., 5.
43. Ibid., 60. Of course there were hearings on Mead's new policy, as noted above. Carter seems to have meant that there were no hearings on the specific plan to deny power profits to the Shoshone water users.
44. Library of Congress, Unpublished transcript of hearing of the Senate Committee on Irrigation and Reclamation, March 8, 1932, on S. 3390, a bill to provide for the distribution of power plant revenues on the Shoshone Project, Wyoming, 28.
45. Ibid.
46. Internal memo (Kubach) for Dr. Mead, August 22, 1932, RG 115, E. 7, Central Administrative Correspondence 1930-1945, Box 239, Folder 140.1. Mead actually admitted in his 1932 annual report that the Bureau was following this policy without specific legislative authority; Annual Report of the Commissioner of Reclamation… for the fiscal year ended June 30, 1932 (Washington: U.S. Govt. Printing Office, 1932), 14.
47. *Hearings before the Committee on Irrigation and Reclamation, House of Representatives*, 74th Cong., 1st Sess., on H.R. 6875, A Bill providing for the allocation of net revenues of the Shoshone Power Plant, May 2 and 6, 1935 (Washington, D.C., U.S. Government Printing Office, 1935), 7.
48. Ibid., 22.
49. Ibid., 15-24. Mead's own arrogant estimate of the committee proceedings may be found in a letter he wrote to Representative Marion Zionscheck, a member of the committee, in which he characterized the repayments by the District as "driblets." He ended that letter saying, "The picture which the attorney for the irrigation district paints of this community of Government debtors insisting upon paying a charge to the government although Congress has declared the charge not payable [in the 1929 act] is artistically appealing, but wholly lacking in verisimilitude." This is the man who earned a reputation in the twenties as a friend of the Reclamation settlers! Mead to Zionscheck, July 29, 1935, SID archives.
50. *Hearings before the Committee on Irrigation and Reclamation, House of Representatives*, 74th Cong., First Sess., on H.R. 6875, May 6, 1935, 25-27.

51.	*Congressional Record*, 75th Cong., 1st Sess., 503, 8348, 9003; 75th Cong., 3rd Sess., 1574, 1620, 3990, 4138, 5227. The Bureau, headed now by John C. Page, had made a serious effort to lobby against the bill in 1937, to no avail; Memorandum from Page to Representative Greever, July 28, 1937, RG 48, Office of the Secretary CCF, 1937-1953, 8-3, Shoshone. Their 1938 state of mind is contained in a memo from Page to Ickes, March 7, 1938, RG 115, E. 7, Project Correspondence File 1930-1945, Box 1028, folder 201.1.

52.	Acting Commissioner Williams to Secretary of the Interior, April 18, 1938, RG 48, Office of the Secretary CCF 1937-1953, 8-3, Shoshone.

53.	Shoshone Irrigation District to Page, July 20, 1938; same to Ickes, October 20, 1938; Page to Harry Barrows, Shoshone Irrigation District, November 1, 1938; Barrows to Page, December 5, 1938; Sen. O'Mahoney to Page, February 7, 1939; Congressman Frank Horton to Page, February 9, 1939; Barrows to Page, June 7, 1939; Page to Shoshone Irrigation District, July 8, 1939; all in RG 115, E. 7, Project Correspondence File 1930-1945, Box 1028, folder 201.1.

54.	Memorandum from the Secretary to the Commissioner, Bureau of Reclamation, September 16, 1940, RG 48, Office of the Secretary CCF, 1937-1953, 8-3, Shoshone.

55.	Ibid.

56.	Richard Pelz, ed., *Federal Reclamation and Related Laws Annotated*, (Washington, D.C.: U. S. Government Printing Office, 1972), vol. II, 985; Congressional Record, 83rd Cong., 2nd Sess., 20 (H.R. 6893) and 197 (S. 2683); Library of Congress, Unpublished U.S. House of Representatives Committee Hearings, 1953-54, January 29, May 17, May 18, 1954; Unpublished U. S. Senate Committee Hearings, June 25, June 29, 1954; Congressional Record, 83rd Cong., 2nd Sess. 12023.

57.	See above, p. 1. Fowler testified at the January 27, 1954, meeting of the House Subcommittee on Irrigation and Reclamation; unpublished U. S. House of Representatives Committee Hearings, 1953-54, H.R. 6893, 2-17.

58.	Tudor Engineering Co., Facts on the Construction of the Shoshone Irrigation District's Garland Canal Power Project, n.p., n.d. [1983], in SID Archives.

59.	For estimates of Dominy's conduct as Commissioner of Reclamation in the 1960s and 70s, see Marc Reisner, *Cadillac Desert; The American West and its Disappearing Water* (New York: Penguin Books, 1986) and Donald Worster, *Rivers of Empire; Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985).

60.	*Federal Reclamation Laws Annotated*, Vol. I, 588-603.

61.	First published in the Powell *Tribune*, March 2, 1933; subsequently printed and circulated separately.

From Self Sufficiency to Colony: The Bureau of Reclamation and Wasatch County, Utah

By:
Jessie L. Embry

Abstract

Wasatch County, Utah is the home of three Bureau of Reclamation projects, Strawberry, Deer Creek, and Jordanelle reservoirs. All three transfer water from the county to Utah's more populated areas. The dams provide essential water for Utah and Salt Lake counties, but they have a negative impact on Wasatch County. Residents lost grazing lands and the use of water. Farmers adjusted their businesses. Land was buried. Once self-sufficient farming and ranching towns are now bedroom communities for the Wasatch Front. The reservoirs are Utah's playgrounds, increasing the population with day visitors who require services but spend little or no money in the county.

Welcome to Wasatch County, Utah, a series of mountain valleys with changing reputations. First, they were the impossible to settle. Then, they were the sheepmen's paradise. According to some records, ranchers shipped more sheep from the railroad depot in Heber City than anywhere else in the United States in the late nineteenth century. Recreation was always important with fishing in the Strawberry and Provo rivers. But dairy farms and creameries were also important industries.

All that has changed, and the Bureau of Reclamation played an important part in that transformation. Heber City, Midway, and Charleston, once known for their sheep, horses, and cows, are now bedroom communities for the Wasatch Front.

Settlement of Wasatch County[1]

When the Mormons arrived in the Great Basin in 1847, they settled on the easily accessible lands. But areas such as the Salt Lake and Utah valleys filled quickly, and newcomers and a second generation looked elsewhere for land. In 1857, Provo (Utah Valley) residents working at sawmills in Big Cottonwood Canyon, southeast of Salt Lake City, crossed over the mountains to the south and examined a valley formed by the Provo River. They were impressed. When they announced their findings in Provo, other residents rejoiced and some hoped to move.

The sawyers were not the first to see the valley. Others had considered settlement, but there were two major obstacles. First was climate. There were rumors of frost every month of the year. Despite these fears, cattlemen took their animals to the south side of the valley and started harvesting meadow grasses for winter feed. During the spring and summer of 1857 other Utah Valley residents also explored the area and considered permanent settlements in the valley.

An even more pressing concern was the difficult mountain pass. Provo Canyon, formed by the Provo River, was steep and narrow. The first attempt to build a road failed in 1852. In 1855 the Utah Territorial Legislature passed a bill allowing the Provo men to construct a road. The "Utah War" in 1857, a confrontation between the United States army and the Mormon pioneers over the attempt to replace Brigham Young as territorial governor, halted all road work. But before the "war" was over, a group of Utah County residents proposed the road again to Brigham Young. Young met with Provo citizens on June 6, 1858, and the next day the group formed the "Provo Kanyon Company."

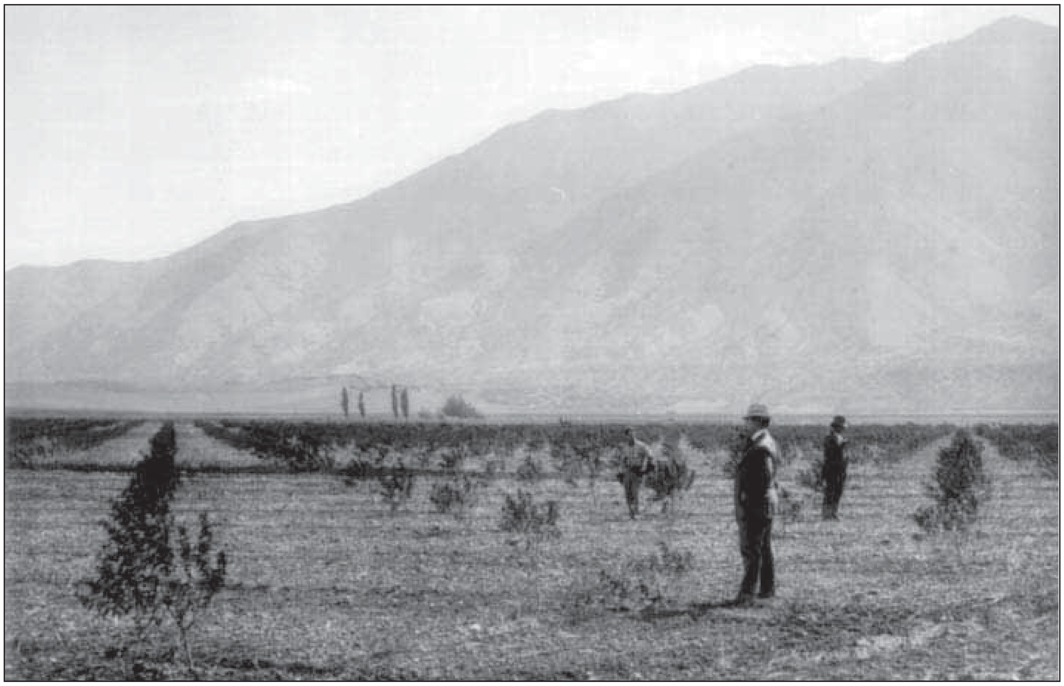
When the road was completed, Provo residents made plans to settle at the head of the canyon. They held planning meetings during the winter of 1858-59, and in that spring eleven adventurers moved. Of the nine men there is information on, eight were born in England and one was born in Canada. They were between twenty-three and sixty-two years of age. By the end of 1859 eighteen families lived in the fort that the settlers built to protect themselves from the Ute Indians. The next spring there were sixty-two homes in the fort.

The first settlers named their valley Provo after the river, but then changed it to Heber, after a Mormon Church leader Heber C. Kimball, to avoid confusion with Provo City in the lower valley. They established communities where they could find irrigation water along Center, Daniels, and Snake creeks. Later, others established communities such as Lake Creek, Center Creek, Buysville, Daniel, and Hailstone, near available water, but even those farmers had to transport water to their farmland. Those not close to a stream had to move the water farther. Lacking capital, farmers banded together in cooperative efforts to dig irrigation canals. The limited water was then shared by all.

Strawberry River and Reservoir

The settlers were always looking for additional water sources, and more were found in the mid-1860s. Then some Utes, led by Black Hawk, responded to a smallpox epidemic and a cold winter and started stealing Mormon cattle. While most of the raids occurred in central Utah in Sanpete and Sevier counties, there were some in Wasatch County. To control the attackers, some residents followed the Utes east into the Uinta Basin. There they also saw water and grazing opportunities. They started working on a canal in 1872, using territorial and federal laws for financial assistance and land ownership. Then in the late 1880s farmers engineered and constructed a 1,000 foot tunnel through the crest of the Wasatch Mountains, thereby diverting water from the Strawberry River to their farms. At the turn of the century, they also converted lakes into reservoirs despite concerns from those in the lower valleys that their water supplies would be cut off.[2]

Water was limited throughout the state, and other farmers were also looking for more water sources. At the turn of the century, desperate Utah Valley farmers turned their attention to the Strawberry River for water, made possible after the federal government removed the Ute Indians further east to the Uintah Indian Reservation. Seeing the earlier success of the Heber Valley farmers, Henry Gardner of Spanish Fork in Utah County envisioned a similar effort to transfer the water from the Strawberry River only on a much grander scale.



17.1. This August 1910 photograph of a peach orchard on the Strawberry Valley Project south and east of Utah Lake. The picture is looking toward the Wasatch Mountains.

Gardner's project proved to be too expensive and too complex for the farmers of Utah Valley. But the passage of the 1902 Newlands Act which established a revolving fund as well as the predecessor of the Bureau of Reclamation made the project possible. In 1903 the Utah County farmers presented their plans to the federal government, and within a year work began on the Strawberry Valley Reservoir.

For the farmers of Utah Valley, the Strawberry Reservoir was a savior; they developed new farm land, older farms received additional water, and residents returned to the community of Payson which had been withering from lack of water. As a result, historian Thomas G. Alexander concluded, "It is difficult to conclude that the Strawberry Valley Project has been anything but successful."[3]

The project, however, cost the people of Wasatch County. Besides the loss of water, they also lost grazing rights. For nearly a quarter of a century, ranchers and farmers from the valley had leased summer grazing land in Strawberry Valley from the Utes. The development of the Strawberry Reservoir limited summer grazing opportunities for the livestock of the ranchers and farmers of Wasatch County. While the reservoir was under construction, the federal government leased the surrounding lands to sheepmen. John C. Cummings from Wasatch County held the lease from 1905 to 1907. During this time Utah County sheepmen tried to obtain permission to run sheep on the project, but the government told them that there were too many sheep and cattle already on the land.

In 1907 Heber City residents acquired a lease from the Reclamation Service which allowed them to be on the land from June 1 to December 31, 1907. The Heber men were able to hold on to their leases by outbidding sheepmen from Utah and Salt Lake counties as well as other sheep owners from Wasatch County. When the group did not exercise its option to renew in 1909, the property came open for bid again, and although the same group got the land, the cost went from $10,408 to $10,600. In 1911 the highest bid was only $6,126. The project engineer claimed that the sheepmen had kept the bids down, and he refused to accept any of them. A group from American Fork and Lehi in Utah County finally bid $9,126, and Wasatch County residents lost the use of the Strawberry lands to Utah County ranchers.[4]

A further limitation developed when Utah's U.S. senators, George Sutherland and Reed Smoot, pushed through a bill in 1910 to protect the Strawberry watershed from overgrazing and to raise additional money to help repay the construction costs of the reservoir. Wasatch County stockmen opposed the withdrawal of additional acres from grazing. In a pamphlet, "Some Facts You People of Wasatch County Should Know," some county residents claimed that Smoot was not being honest. The pamphlet authors encouraged residents to vote for men who "by their deeds have demonstrated that they are for you good people" and not the "kind that sit idly by while big interests grab up your birthrights."[5]

The pamphlet authors' efforts were unsuccessful. Smoot continued to be a senator, and the Strawberry Water Users continued to control the lands surrounding the reservoir. The conflict between the Strawberry Water Users and the Wasatch County livestock men, represented by the Heber Horse and Cattle Growers Association and the Wallsburg Grazing Association, came to a head in 1919. The water users from Utah County and the Wasatch County residents both appealed to national organizations to resolve their differences.

Wasatch County people felt that they had rights to the lands based on their leases with the Native Americans for the past forty years. They questioned whether the government had purchased the lands properly from the Utes. They contended that they could not survive financially without grazing rights in the area. In a passionate appeal to the director of the Reclamation Service, the Wasatch County residents explained, "A grave injustice would be done the people of Wasatch County if these lands were again thrown open for competitive bids and they were refused these grazing rights which they have so long enjoyed and which are essential to the welfare of these entire communities." The letter continued that the Utah County water users were mainly farmers, and "these grazing lands are not now and never were essential to the prosperity of these farmers and water users."[6]

The U.S. Forest Service agreed with the Wasatch County residents. The acting forester wrote to the Reclamation Service that the watershed around the Strawberry Reservoir was "one of the most important in the State of Utah" and needed to be protected. He described the cooperation that he had always received from the Wasatch County stockmen, adding that the Forest Service policy was to "give preference to small nearby stockmen who are so situated that they are dependent upon the use of the range for their livelihood."

The Strawberry project manager, however, favored the water users, telling the chief engineer, "I cannot see any good reason for considering the desires of the Heber people who have no interest in the project." He complained that Wasatch County residents had not bid the highest for the use of the land, resulting in "material loss to the water users." He insisted that the water users were as interested in the watershed as the Wasatch County stockmen and would work with the Forest Service. The disputes continued, and the Secretary of the Interior, F. K. Lane, attempted to resolve them by asking the water users to lease land to the small livestock operators from Heber, arguing that there ought to be enough range for small operations from both counties.[7]

The Utah County water users and the Wasatch County livestock organizations held a face-to-face meeting on October 24, 1919. The livestock group wanted to see the land divided so that each group had control of an area. The water users were willing to lease some property but not to divide the land. The debate continued, and in November the two groups met again and finally came to an agreement. At the end of the current lease, the Bureau of Reclamation would give the Strawberry Water Users a five-year lease on the land, and the water users would sublease part of the area to Wasatch County residents. Water users would be treated as other lessees until the reclamation project was completed and turned over to them. Wasatch County residents complained because as sublessees, they had to work through the water users. The Reclamation Service refused to answer direct questions.[8]

The battle continued. Wasatch County residents asked Utah congressman Don B. Colton to introduce a bill to put the grazing lands back into the Unita Forest jurisdiction. In 1922 the Strawberry Water Users sent representatives to Washington, D.C., to prevent passage of the bill which they felt violated their contract with the Reclamation Service. At the meeting George Fisher spoke on behalf of the Wasatch County residents. After explaining that the Strawberry Reservoir took valuable lands away from stockmen, Fisher concluded, "The whole record of the people of Wasatch County is one of infinite patience and forbearance as step by step their public lands were either disposed of or their use abridged." Senator William H. King of Utah countered that the water users had the right to the private land and it should not be transferred to the federal government. With the support of leaders like King, the Wasatch County plan to transfer the lands to the Forest Service did not make it out of committee.[9]

By 1926 when the sublease with Wasatch County grazers expired, the water users wanted to cancel any association with the Wasatch stockmen. Pointing out that the Wasatch County people were to have adjusted their grazing needs so they didn't need the land and that the people had "no interest or right whatever in the lands," the water users complained to the project engineer that they had suffered because of the sublease. The lease was not renewed, and the Wasatch County stockmen lost all use of the land.[10]

17.2. Rainbow trout caught in Strawberry Reservoir in 1918.

Wasatch County residents not only used Strawberry Valley for grazing; they also went there for recreation, mainly hunting and fishing. The filling of Strawberry Reservoir provided additional opportunities for county residents and people from the Wasatch Front to fish and boat. Within a few years, Strawberry became a prime fishing hole in the state, attracting anglers by the thousands. In 1926 the Strawberry Water Users Association took over the management of the reservoir and began developing its recreational possibilities. With no established guidelines, the first fishing villages sprang up at random along the reservoir's shores. By the late 1970s old house trailers, buses, cabins, and boats dotted the landscape in an unsightly clutter. Uncontrolled development along the shores threatened to pollute the reservoir. For nearly a decade there was a debate between Wasatch County officials, the Strawberry Water Users, the state board of health, and the Bureau of Reclamation on who was responsible for establishing and maintaining cabin regulations.[11]

In 1978 an expanded Strawberry Reservoir threatened to flood out some cabins. Cabin owners had three years to move their homes, but some simply abandoned them. The county and water users argued over who should remove the buildings. The water users said the county should because it had collected taxes. The county officials contended that the water users had collected the fees for the cabins. In the end, the water users moved them under the direction of the Bureau of Reclamation. Because of continued disputes with the water users, the National Forest Service now manages the recreational uses at Strawberry.[12]

What has been the recreational impact of Strawberry Reservoir on Wasatch County? It has brought visitors. In the late 1970s the Bureau of Reclamation called it "Utah's finest fishing hole." Visitation increased from 168,629 in 1973 to 248,338 in 1975. A study showed that it was the sole destination for most of the visitors. At first glance it might appear that Strawberry added to the economy of Wasatch County, but that was not the case. A Utah State University study found that these visitors spent very little money in the county. About 80 percent spent fewer than five dollars while they were at the reservoir; 44 percent spent nothing at all. Most people came with their own supplies; they did not stop in other parts of Wasatch County to buy them. While Wasatch County received very little revenue from Strawberry, its expenses were high. The county officials were responsible for public health and safety, fire protection, and law enforcement.[13]

While the overall effects of the Strawberry Reservoir were negative for Wasatch County, Strawberry Valley was not where most county residents lived. The reservoir took away water and grazing rights and brought in additional tourists, but it did not affect residents' homes. However, the second Bureau of Reclamation project, Deer Creek, had a greater negative impact because it was in the Heber Valley.

Deer Creek Reservoir

Plans for a reservoir on the Provo River developed slowly. After World War I, water users from northern Utah and Salt Lake valleys turned their attention to Wasatch County in search of additional water for their growing cities and expanding farms. One important source they saw was the unused high volume spring runoff in the Provo River watershed. If this runoff could be stored, it would help solve a water crisis. In 1922 water users from Utah and Salt Lake counties looked for a place to build a reservoir. The site they selected was in Wasatch County, a short distance downstream from Charleston where Main Creek from Round Valley and Deer Creek joined the Provo River. There were, however, problems with this site. Much of the community of Charleston would be flooded, and the Denver and Rio Grande railroad line and the highway from Heber City to Provo ran through the center of the proposed reservoir. Wasatch County farmers also feared that with the construction of the reservoir they would lose precious water rights.

The Utah Water Storage Commission and the Bureau of Reclamation did not consider the Deer Creek project a top priority and delayed plans. However, between 1931 and 1935 there was a severe water shortage in Salt Lake and Utah valleys. Utah Lake dropped from 850,000 acre feet to 20,000 acre feet. Residents again appealed to the federal government for assistance, and in 1933 the Federal Emergency Administration of Public Works gave the Provo River Project $2,700,000 to build the reservoir and other facilities.[14]

In surveying the site, the Provo River Water Users Association, a committee formed to represent the newly formed municipal water users, found that the dam would cover much of Charleston. Though the committee reported that Charleston had some of the most valuable ranching land in the state, it determined that the people along the Wasatch Front needed the water and that was more important than preserving the ranch lands.[15]

Allen M. Winterton recalled that the state was purchasing the land for the reservoir about the time he got married. "Our farm was one of those affected by the backed up water." When the water users offered to purchase his farm, he saw no other option. Max North recalled that the Provo River Water Users purchased his father's farm. His parents "got as much out of it as it was worth." Others were not as happy. The local newspaper, the *Wasatch Wave*, reported that 60 percent of the Charleston residents wanted more money for their land. Most settled though, and by the end of 1938 the Provo Water Users Association had purchased seventy-two tracts of land totaling 4,117.31 acres. The association paid $364,462.66 for this land. When the sale was completed, the association sold the land to the Bureau of Reclamation.[16]

Still some people refused to sell their property unless they received more money. The Provo Water Users Association condemned the property and took the owners to court. At the end of 1938, the water users' legal counsel, with the help of the Bureau of Reclamation's attorney, filed eight cases. During the next three years, the Wasatch County District Court recorded thirty-eight cases, some dealing with the same people, filed against the Provo River Water Users Association.

The first case was heard in the Wasatch County District Court in 1938. The Arvil Scott trial lasted twelve days, and the jury awarded the defendant $24,417 for 102.2 acres and $4,961 for the damages to the remaining 600 acres. The Bureau of Reclamation complained, "This was greatly in excess of the appraised value… and grossly unjust." The water users appealed eventually to the state supreme court, but then settled out of court for 14 percent more than the appraised value. Although this was the first case to go to court, it was one of the last resolved and was not completed until 1941.

All the cases tried in Wasatch County resulted in awards higher than the appraised value. Because the Bureau and the Provo Water Users Association felt that they could not receive a fair trial with Wasatch County juries, they requested a change of venue. Their motion was successful in only one case; the courts moved that case to the Cache County District Court. There the jury awarded $2,000 instead of the $800 appraised value. Because it was less than the Wasatch County courts awarded, the Bureau called the settlement "satisfactory."

Eventually the Provo River Water Users Association agreed to settle most cases out of court. The association, for example, offered John and James Ritchie 14 percent more than the appraised amount for their property. They justified the increase since they could not win a change of venue and court costs were high.[17]

17.3. This 1940 photograph by Ellis Armstrong, later a Commissioner of Reclamation, shows CCC forces dismantling the Atwood house in the Deer Creek Reservoir area near Charleston on the Provo River Project.

Some Wasatch County residents were bitter about Deer Creek. In 1946 when the Forest Service asked local residents to stop overgrazing to protect the Deer Creek watershed, L. C. Montgomery remembered what the construction of Deer Creek meant to his family, arguing that "not one drop of water of the entire Provo River watershed is entitled to be stored in the Deer Creek Reservoir." He continued that his family owned "one-fourth of the water of the Daniel Creek project and it was necessary to confiscate my property to protect it." As a result, he concluded, "The hundreds of thousands of people [who] would get the benefits of that confiscation ought to pay me for it." Moroni Besendorfer's family lived above the dam in Charleston, but he knew all the families whose property was taken. He recalled, "Some people just died because they were affected so much. It took everything they had. Some of the ranchers had beautiful homes down there.… It took big barns. It took livelihoods and wiped them out."[18]

Deer Creek Reservoir changed Wasatch County in many ways. Its immediate effect was to cover hundreds of acres of rangeland and inundate two-thirds of Charleston. That town's population dropped from 342 in 1930 to 323 in 1940, a 5.5 percent drop. Overall the rest of the county grew, partly because construction workers moved into the area. As the government continued to purchase land, Charleston's population dropped to 175 in 1943, a decrease of 50 percent.[19]

The Wasatch Front population continued to expand and demanded more water. Even though the Wasatch County area already provided 95 percent of the water for 84 percent of Utah's population, the Bureau of Reclamation suggested taking more in 1959 with an expansion of the Deer Creek Reservoir. According to the *Wasatch Wave*, while the reservoir had "become a beautiful and permanent part of our valley," the plan to raise the water level had "opened old wounds and recalled bitter memories of farms and yards and roads and familiar landmarks which went reluctantly under water. It could happen again." The planned enlargement would destroy homes, displace ninety families, and require the railroad, the Charleston bridge, two highways, the Charleston community center, and the Midway fish hatchery to move. The Church of Jesus Christ of Latter-day Saint meetinghouse in Charleston would be "accessible by rowboat." The editorial concluded, "Wasatch County, wake up and fight for your land." Later the newspaper complained, "Deer Creek was just completed a few years ago. The people did not have the foresight at that time for the enlargement. Why is it feasible now at additional costs?"[20]

17.4. Construction at Deer Creek Dam.

The expansion was not made, but Deer Creek Reservoir continued to impact Wasatch County. All valley residents lost water rights. One resident, Calvin Giles, recalled that before Deer Creek Dam the residents had free use of the water, then "they started to put weirs to measure water.… We were used to taking all [the water] we wanted. But as time went on, they regulated the water and cut us down severely in the valley."[21]

In addition, the reservoir raised the water table, and since its water went directly into the culinary systems in Salt Lake and Utah counties, governments along the Wasatch Front encouraged Wasatch County communities to upgrade their sewage treatment facilities. In 1953 Salt Lake City threatened to sue if Heber did not clean up its sewage system. Heber City residents passed a bond in 1953, and the system was completed in 1955. The *Wasatch Wave* boasted that it was one of the best in the nation. Within fifteen years the system was outdated. In 1970 the *Wave* reported that sometimes "manholes. . . [spewed] raw sewage out of open ditches and on into canals and then into Deer Creek."[22] Midway also needed a sewer system. In 1965 the county commission formed a sewer district for Midway, and the town passed a bond in 1966. Alvin Kohler, the mayor of Midway at the time, explained, "We had Deer Creek Dam to the south of us and that water was being diverted into culinary use. We felt that we weren't contributing to the water quality for people downstream."[23]

Communities also had to improve their water systems. Charleston had unique problems because it was so close to Deer Creek Reservoir. Residents there had used thirty shallow wells since 1875 to supply culinary water. In 1948 the state board of health condemned the wells, claiming "hazardous surface contamination." The Salt Lake City Board of Health threatened not to use the milk from the town's sixty-five farms if the water supply was not improved. Charleston received grants from the Utah Water and Power Board and developed springs east of town. The new pipeline served 270 people and 450 cows.[24]

Eventually all of Heber Valley's cow population disappeared as technology changed and small farmers could not afford to upgrade their systems. Although the reasons were complex, protecting the water supply in Deer Creek Reservoir was one argument. Elmer Kohler remembered that in the early 1930s many Midway residents started producing milk for the Salt Lake market. For example, Kohler had 25 head. However, in 1970 he explained,

> I was crowded out. We were on Salt Lake City's drinking watershed. More of Deer Creek's water was used for culinary. Salt Lake was quite concerned about the drainage from corrals and farms going… into Deer Creek. It would pollute their drinking water. They just made the requirements tougher until we had to quit.

Kohler continued that the Salt Lake City Board of Health gave him a year to upgrade his facilities and recommended he visit a milking parlor in southern Utah. He complained, "I was only making about $4,000 a year profit on the milk. You can imagine how many years it would have taken to pay off a $100,000 place just to milk the cows."[25]

Unlike Strawberry, initially Deer Creek was not used for recreation. According to county planner Robert Mathis, "For the first thirty years or so of its existence, Deer Creek Reservoir was ruled off limits. Commissioner [Moroni] Besendorfer always says that he wasn't allowed to go swimming in Deer Creek Reservoir because he'd pollute the water." That policy changed, and as a result, tourists came. In 1989 314,532 visitors came. Those numbers dropped with the development of other state parks. In 1999 197,547 visitors went to Deer Creek State Park, and 73,325 visited between January and July 2000.

There were some cabin and camping facilities near Deer Creek Reservoir, but they were never the problems that they were around Strawberry. Even then the Utah Division of Parks and Recreation eventually removed any cabins and only allowed camping at Snow's boat camp.

However, many visiting Deer Creek are day users, coming up Provo Canyon with all their supplies and not going into Heber City or Midway. As Robert Mathis explained, "The type of recreation that we've had in the county has largely been people packing picnic baskets and driving to the county." He compared recreation in Park City and Wasatch County, pointing out, "They are milking the tourist business. Wasatch County is not. Despite some businessmen that would like to encourage it, I still see skepticism." Then referring to the study about the expenses at Strawberry, he continued,

> But I think the point that was made in that study is real. In our county we get a few dollars from the people that come through. In Salt Lake City, they get $75 or $80 from the people who come through. In Park City, they get more than $100 from each one. We have an opportunity that we have not exploited to this point.[26]

Jordanelle Dam and Reservoir

As the communities along the Wasatch Front continued to grow, residents demanded more water. The Bureau of Reclamation considered several proposals including the Deer Creek Dam enlargement, but none were developed. In 1963 a dam was proposed for Jordanelle, six miles north of Heber. The idea was not new; an engineer had suggested diverting Colorado River water from the south side of the Unita Mountains to the Wasatch Front as early as 1905. The Colorado River Compact of 1922 and the Upper Basin Compact of 1948 guaranteed Utah a share of Colorado River water. To transport this water to the populated area, Utah officials and Bureau of Reclamation engineers began planning the large and complex Central Utah Project in 1956 which included the Bonneville Unit, the largest section. The Jordanelle Dam was to be "crown jewel" of the Central Utah Project. It would help maintain a full Deer Creek Reservoir and store approximately 320,000 acre feet of exchange water which had been stored in Utah Lake for the Salt Lake Valley.[27]

The Bureau of Reclamation planned to build the Jordanelle Dam near the border of Wasatch and Summit counties on land belonging to the Jordan family. John Jordan came to Heber in 1859. He bought a ranch east of Heber and moved there in 1875. John's son George and his sons ran cattle and sheep there until George retired in 1931. George also built a small resort with a store and cabins. The family brand was Jordan L, so they named the resort Jordanelle.[28]

Before the dam could be completed, the U.S. Congress needed to approve the Central Utah Project and seven counties—Juab, Utah, Summit, Wasatch, Salt Lake, Duchesne, and Uintah—had to approve a water conservation district. In 1962 five of these counties—all except Duchesne and Uintah counties—approved the water district. Walter Montgomery, Wasatch County commissioner, told the Midway Boosters that the county needed the conservation district to save its water interests. "Wasatch County's area is the birthplace of most of the water for the northern part of the state of Utah, and we can't get a drink," he lamented. Residents could not even drill wells because in 1921 the Provo Water Users Association filed on the underground water and claimed wells in Heber Valley affected their water use.[29]

By 1964 all seven counties approved the conservation district, but for the next ten years the Bonneville Unit of the Central Utah Project was a political football in the U.S. Congress. In 1975 Clyde Ritchie, Wasatch County's representative on the conservation district, supported plans for a dam at Jordanelle because it would increase Heber Valley's water supply by 20 percent and bring recreation to the area.[30]

Other residents were not as supportive. In 1978 the Bureau of Reclamation conducted a telephone survey of Wasatch County residents. Many residents agreed with Ritchie that the dam would help the county: 30 percent felt it would bring tourism, 25 percent saw more employment opportunities, and 21 percent said improved water. On the negative side, 42 percent opposed the growth the dam would bring, 15 percent were concerned about safety, and 11 percent expected an increase in crime.

The Bureau of Reclamation study that year pointed out other benefits. Irrigation companies would receive 26 percent more water, which could boost farm income by a million dollars a year. It would also bring 100 jobs and seasonal housing during construction. Eventually the study pointed out that the reservoir would create 1,300 jobs but acknowledged most of the employees would probably commute from the Wasatch Front. On the negative side, the study explained the reservoir would bury 3,060 acres and required use of another 3,000 acres.[31]

Jordanelle threatened the lifestyles of thirty-eight families, approximately 100 people. The dam's water covered three businesses, farms, and a family cemetery, and also destroyed wildlife and river habitat. County Commissioner Tom Baum complained, "Private land is continually being used here for public uses and we are losing out. We have two reservoirs, fish and game land, mitigating land and with the possibility of the reservoir our private lands are slowly diminishing." Residents of Keetley protested that the relocated Highway 40 would split their farms. While the environmental impact statement talked about the recreational advantages for Wasatch County, some residents complained that the focus was all on leisure activities and ignored those who made their homes in the area.[32]

The citizens had an even greater concern. What would happen if the dam did not hold and the stored water dumped on Midway and Heber City? Just before construction began, the Teton Dam, a large federally constructed project in eastern Idaho broke, flooding much of the downstream area. Could the same thing happen in Wasatch County? County commissioners were especially concerned when some geologists pointed out that a fault line ran through the proposed dam site. One geologist, Leon Hansen declared the dam site was unsafe and said that if it broke "a minimum of 50,000 lives would be lost." Four geologists from Brigham Young University questioned the safety of the dam because of the geological conditions in the area. The Bureau of Reclamation geologists agreed there was a fault line in the area but argued "lay observers… and even experienced geologists are not qualified to comment on whether or not engineering can compensate for site problems."[33]

As the groundbreaking date neared, many Wasatch County residents saw the disadvantages outweighing the advantages. As Robert Mathis explained, "People were really unhappy. They were unhappy about water rights, unhappy that the dam was here, and unhappy about the loss of tax base. I thought most importantly they were unhappy about being left out of the basic planning." In 1975, by a vote of 1,090 to 853, county residents voted against a request by the Central Utah Water Conservancy District to enter a supplemental repayment agreement. Along the Wasatch Front voters had agreed to the proposal by a 73 percent margin.[34]

Changes in the Central Utah Project continued, and Wasatch County residents became more upset. While the original bill gave $20 million to provide pressurized irrigation systems for Heber Valley, in 1990 that was cut to a $500,000 feasibility study. Other water projects would transfer water from Daniels Creek. In March 1990 the *Wave* protested:

> First Wasatch people lost rights to Strawberry water. Then almost an entire community was uprooted from their family farms and homes to make room for Deer Creek Reservoir to store downstream water. Then the bureau took more homes and farms to store upstream Provo River water, and now their eyes are on Daniels water. We'll share our water—reluctantly, yes, but we will share. However, we expect a fair deal, including a place in the front of the line for our own water and a sprinkling system, free of charge without having to grovel for it.[35]

County commissioners Moroni Besendorfer and LeRen Provost went to Washington, D.C., to protest the loss of water rights in Wasatch County. They claimed, "It would take twenty percent of the county's irrigation water and dry up Daniels Creek in order to increase flows in the Upper Strawberry River tributaries." The county officials formed an unlikely partnership with state environmentalists and presented the argument that adapting the project to meet the needs of Wasatch County residents would also preserve the wetlands. Congress modified the legislation. In 1996 the county had two representatives on the Central Utah Water Conservancy District Board, but "people were still somewhat distrustful. They felt that by getting the [Central Utah Project] Completion Act through that a deal had been struck which allowed us to receive some benefits from the project and prevented further changes in lifestyle."[36]

In 1994 Besendorfer thought people still worried about the location of the dam. He said he tried to watch the construction, and "a couple of times they kind of ushered me away from the areas because they did not want me to see what was there. Hopefully nothing ever happens because if it does, it's not just going to affect our county."[37]

17.5. Jordanelle Dam and Reservoir

The construction of Jordanelle prompted the Bureau of Reclamation to look at recreational possibilities not only on that reservoir but also on the Provo River between Jordanelle and Deer Creek. The bureau first asked for a fifty-foot access right-of-way. Property owners protested that they did not want to deal with the trespassers and garbage that would come with the public access and that they did not want the area fenced off because they wanted their animals to be able to get to the river. According to Tom Baum, "We are tired of giving up our land in Wasatch County so that others can come in here.… We have already given up hundreds of acres of land here for recreational use and it's our economic loss." Later the government condemned the fifty-foot access area.[38]

The river continued to be an issue. In 1996 the Utah Reclamation and Mitigation Conservation Commission made plans to return the Provo River to a "meandering, blue-ribbon trout stream." The environmental impact statement talked about the benefits to those fishing along the river and not the effects it would have on Wasatch County. According to a Salt Lake newspaper article, "The county's population is subject to dramatic seasonal surges. Counting day visitors, the population could grow from 12,000 to over 100,000." When asked what could be done to deal with the impact, locals responded, "Pay an honest price for condemned land.… and then cough up a few million to help finance law enforcement, garbage collection, road maintenance and the other services visitors now get for nothing." The problems only got worse. In 1998 the "series of meanders" were enlarged from ten to twelve miles. Wasatch County residents again protested. As Bill McNaughtan, who would lose 34 acres explained, "It's an emotional impact, knowing your father and grandfather worked the land."[39]

The Jordanelle Dam was completed in 1993 and the reservoir was filled by 1996, a year ahead of schedule. Tourists immediately started arriving, filling the 180-reservation campground each weekend and meeting the 300-boat limit by 11:00 a.m., with hundreds being turned away.[40] In 1999 338,200 people visited the park; for the first six months of 2000, the state park recorded 58,938 tourists. Boating continued to be popular, so in 2000 the State Parks cut the boats allowed on at any one time. But Jordanelle, like the other reservoirs, provides day trips for Wasatch Front residents and does not bring a lot of money to the county.

There is one difference though between Deer Creek and Jordanelle. Jordanelle is in an undeveloped area on the edge of Summit and Wasatch County. Park City is only a few miles down the road and has grown rapidly with seasonal homes. Developers see great potential for similar subdivisions around Jordanelle. Wasatch County approved construction that would create a city larger than any other in Wasatch County and double the homes in the county. Wasatch residents were concerned about who would provide the services such as building a fire station at Jordanelle and handling sewage. While the county issued bonds to cover these expenses, officials insisted that those receiving the services would pay off the debt. Some Wasatch residents questioned that and were afraid they would pay as well.[41]

Summary

During the summer of 2000, Deer Creek and Jordanelle were both down, and the water users' association explained that if there is not an above average snow fall, water use will have to be restricted along the Wasatch Front. Residents of Salt Lake and Utah valleys may no longer have green lawns and all the water they want. They dread the loss of water resources.[42] They have come to depend on the water from these two reservoirs just as residents of southern Utah Valley depend on Strawberry Reservoir. Yet, Wasatch County residents have experienced the same losses throughout the twentieth century so that the more populated Wasatch Front could have water. Over the years the communities in Wasatch County have changed from self sufficient ranching and farming communities to bedroom communities and playgrounds for Utah.

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Endnotes

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Private Power at Boulder Dam: Utilities, Government Power, and Political Realism

By:
Sarah S. Elkind

Several years ago, I toured Hoover Dam.[1] I was unprepared for its scale and was struck by the bare logistics posed by its construction. The thing that stayed with me most, however, was the fact that Southern California Edison and several other private firms operated turbines in the dam. Indeed, I am not the only one who has been surprised by this. The Water Power Act of 1920 specifies that all hydroelectric power developed in association with federal flood control and irrigation go first to publicly-owned power distributors. Many early supporters of the dam assumed it would contribute to the growth of public power in the United States. So how did this dam come to symbolize the triumph of public-private cooperation instead of public enterprise?

Boulder Dam, as Hoover Dam was known throughout the 1920s, was conceived in the height of the Progressive Era's public power campaign. The most important proponents of the dam did not, however, emphasize the dam as a boon to public electrical systems. Boulder Dam forced southwestern leaders into heated discussions of water rights and the relations between the states and Washington. They conceded use of the dam to private utilities, rather than waging two political battles: one for the dam and a second for public hydroelectric power development at the dam. Indeed, by itself the battle for the dam raised the specters of interstate and international rivalry, and an ever more imperial Los Angeles.[2] It is this compromise that I wish to examine here.

In 1928 Congress finally passed the Boulder Canyon Project Act. Ostensibly to control flooding in Yuma, Arizona, and in the Imperial Valley, the dam promised to improve irrigation and urban water supply, curb Mexican claims to the Colorado River, and increase hydroelectric power available to local mines and, once the problems of long-distance power transmission were solved, to distant cities.[3] Because the Water Power Act of 1920 stipulated that all power from federal dams go first to public utilities, early backers assumed that federal development of the Colorado would bring public power to the Southwest. As the largest single water project undertaken in the 1920s, this was an important test case for federal dam construction and the politics of public ownership.

By 1928 proponents of the Boulder Canyon Project Act no longer insisted on public hydropower on the Colorado because the private utility industry's opposition threatened to defeat the project altogether. For its part, the utility industry regarded a federal dam as direct competition, but also opposed federal construction on principle. Any expansion of public enterprise, they argued, posed a general threat to private enterprise. The utility industry had some special claims on the Colorado River because Southern California Edison had applied for hydropower permits on the river long before Congressmember Philip Swing introduced the first Colorado River bill. In political terms, these private claims were most important when they stimulated Arizona's and Nevada's protests that a federal dam would help Southern California in trying to steal their water, power, and revenues. In the end, private utilities won at Boulder Dam, gaining an important foothold in their efforts to forestall the wholesale substitution of public for private utilities in the United States.

Boulder Dam stands as a compromise between the Progressives' desire for comprehensive, public development of natural resources, and conservative fears of excessive federal power. Federal funds paid for the dam, and the Bureau of Reclamation operates it, but private as well as public utilities use its hydropower. This arrangement evolved for three reasons: proponents compromised on the public power because they viewed other aspects of the dam as more important; rhetoric about the dangers of expanding federal authority threatened to scuttle the dam; and, finally, the need—again political—to limit the outlay of federal funds for construction of Boulder Dam made finding buyers of hydropower more important than protecting public utilities. Boulder Dam, the first cash-register dam and a strange amalgam of public and private enterprise, sprouted from the intersection of the Progressive Era and the Red Scare.

A River in Great Demand

A number of overlapping natural resource desires inspired Boulder Dam. Farmers in Mexico and California's Imperial Valley wanted water for irrigation. Residents of Yuma, Arizona, and the Imperial Valley also needed protection from the Colorado River floods and silt that threatened their fields, waterworks, and homes, but found that development in one part of the valley increased problems elsewhere. Mining companies in Arizona and Nevada wanted cheap electricity from the river, as did the many Arizona farmers who used electricity to pump ground water onto their fields. Los Angeles hoped for Colorado River water and power. Meanwhile, Colorado, New Mexico, Utah, and Wyoming eyed developments along the southern section of the river with deep suspicion. They feared that these more rapidly growing communities would claim all the water rights first, and thus preclude their own development.

American irrigation along the lower Colorado River began in 1901 when Charles R. Rockwood's California Development Company brought water through Mexico into the Imperial Valley.[4] In February 1905 floods breached Rockwood's levees, swamping fields under silt and mud, tearing up railroad track, and surging into Salton Sink. Two years later, the Southern Pacific Railroad repaired its broken track and some levees, but tensions between the California Development Company and officials in Mexico impeded efforts to fix other problems left by the flood.[5] By the 1910s political unrest in Mexico complicated repairs, and, naturally, Mexican irrigators resisted any changes that might reduce the water reaching their fields. By the 1910s these problems inspired proposals for an All-American Canal.

An All-American Canal would carry Colorado water directly to Imperial Valley fields, without crossing the Mexico border. This would eliminate many of the logistical complications of trying to build and maintain waterworks that crossed an international border. Supporters expected the All-American Canal to increase the amount of water available to Imperial Valley farms by bypassing leaking canal sections south of the Border, and the Mexican farmers who had come to rely on the old waterworks.[6] Proponents of the All-American Canal also lobbied for their project on purely emotional grounds. In the years after Rockwood built the original Imperial County canals, American investors developed and leased thousands of acres of irrigated farmland in northern Baja California. Wealthy Los Angeles businessmen, including Harry Chandler of the *Los Angeles Times*, routinely rented land to Chinese and Japanese farmers, even though Chandler decried the Asian presence in California. Many southern Californians loathed Chandler for giving American water to Asians, and for supporting what they saw as an incipient, dangerous Asian colony so close to Los Angeles.[7] That these wealthy Americans then also used the cloak of America's international responsibilities to ensure their own profits reeked of political influence, profiteering, and cut-throat economics. The legacy of these early conflicts over Mexican water rights, race, and the shape of the American economy continued to shape Colorado River policy for many years.

The Colorado also attracted attention from federal reclamation engineers and hydroelectric utility corporations. In 1902 Joseph B. Lippincott surveyed the lower Colorado River and identified Boulder Canyon as one of the most promising sites for federal development.[8] Representatives from Southern California Edison joined federal surveys of the river in 1902 and 1921, but because of the costs of damming a powerful river like the Colorado, and because the Mojave mining district had only limited power needs, Southern California Edison concluded that it could not expect to make an immediate profit from power sales. Only with efficient long-distance power transmission technology developed in the early 1920s could Southern California Edison, or the Bureau of Reclamation for that matter, expect to sell power to a market large enough to recoup construction costs.[9]

Once long distance transmission was possible, Southern California Edison applied to the Federal Power Commission for permits to develop hydropower dams at Boulder, Glen, and Pyramid Canyons.[10] By 1924 Southern California Edison had additional incentives for these permits. A drought reduced their hydropower generating capacity in California. Meanwhile, growing resistance to Los Angeles' expanding demand for water and hydropower in California promised to make future development for Southern California consumers ever more difficult. This crisis environment allowed Southern California Edison to emphasize the public services it provided both in developing new irrigation resources and by meeting consumers' power needs during the crisis.[11]

Los Angeles began its own Colorado campaign about the same time as Southern California Edison. The Los Angeles city council declared its interest "in the building of the dam at Boulder Canyon and allocation of the power privileges at that dam."[12] At a public hearing in 1922, Los Angeles representatives called for federal dam construction and municipal distribution of hydropower consistent with the 1920 Federal Power Act.[13] Many other Angelenos, however, considered electricity from the Colorado so important, that they were not so picky. They agreed that power revenue should subsidize dam construction even if this increased the cost of electricity. They claimed to have no opinion about who should manage Colorado River flood control even though flood control could affect hydropower operations. Most importantly, they professed not to care who else received electricity from the dam even though this, too, could increase power prices or reduce available supplies.[14] In their ostensible indifference on these questions, Angelenos distanced themselves from some of the most contentious issues surrounding the Colorado River. They also left open a door for the intermingling of public and private development that eventually evolved here.

Power supplies outweighed other considerations because Los Angeles quickly outgrew the Department of Water and Power's generating capacity. In 1914 Los Angeles voters approved bonds for a public power system.[15] By 1919, and over the objections of the *Los Angeles Times* and utility firms, the city of Los Angeles had arranged to purchase Southern California Edison's grid inside the city. The Department of Water and Power planned to buy electricity from Southern California Edison until it completed the ill-fated hydroelectric plant and reservoir in San Francisquito Canyon.[16] But even before the Saint Francis Dam was finished, growing power consumption strained supplies so much that even the combined electric capacity of the municipal and private systems could not meet the city' needs. The Department of Water and Power could not guarantee power supplies to new "factories, smelters, or refineries."[17] The projected power shortages under public management and the failure of the Saint Francis Dam allowed private utilities to paint public power as unsafe and badly managed throughout the Colorado River debates.[18]

Los Angeles did not turn immediately to the Colorado River for additional electricity. First, the Department of Water and Power went "prospecting for other power sites." Because Southern California Edison, Southern Sierras Power, and other utilities had long since claimed or developed the best power reservoir sites in the region, the city had few options. At one point Los Angeles even tried to take a Southern Sierras Power Company facility in the Owens River Gorge by eminent domain.[19] Detractors criticized Los Angeles for pursuing the Colorado River, frequently citing the Owens Valley conflict as evidence of the city's imperial heartlessness. In fact, its plans for the Colorado did make Los Angeles look aggressive and over-confident. Few cities, after all, challenged state governments other than their own. The decision to pursue the Colorado, however, decreased political conflict in the arenas most important to Los Angeles' future. By the 1920s Los Angeles could not expand its water or power networks in southern California without creating even greater opposition than they had in the Owens Valley. Had the city turned instead to northern California's streams, Los Angeles would likely have created determined enemies in state politics.[20] Boulder Canyon represented a reasonable alternative because it solved Los Angeles's problems without increasing political conflict in California.

Of course, Los Angeles wanted more than electricity from the Colorado River. The 1923-1924 drought that threatened the city with power shortages also raised the specter of future water famine. In this context, William Mulholland informed the House Committee on Irrigation and Reclamation in 1924 that Los Angeles wanted 1000 acre-feet a year of Colorado water to supplement its other supplies. The drought prompted Los Angeles voters to approve both the aqueduct from the Colorado and the Metropolitan Water District. Other cities in southern California also saw the Colorado as a solution to their water and power problems. Riverside advocated construction of a dam "in response to the necessities of the cities and the people in these southwest states, with Government development and Government construction and Government sale, providing the waters cheaply at cost and the power to the people."[21] The City of Long Beach hoped Colorado River power would reduce electricity costs enough to help it compete with Riverside, Los Angeles, and other Southern California communities.[22] This interest in the Colorado changed the whole question of Colorado River development. Los Angeles, Riverside, and Long Beach would buy enough electricity to make the dam economically feasible. They had enough congressional representation and political pull to get the project built. The city's designs on the river confirmed Arizona's and Nevada's worst suspicions about Los Angeles and the real purpose of the dam.[23]

Interest in the Colorado, of course, was not limited to Imperial County and Los Angeles, but no major development could take place until all the seven states along the river reached an agreement on water rights. The federal government had jurisdiction over the Colorado River as a navigable river, and as a hydroelectric power resource in the public domain. So any community, state or private corporation that wished to develop the river needed federal approval. In addition, any project would establish water rights on the river by prior appropriation that could interfere with subsequent development. Federal jurisdiction gave state officials the opportunity to lobby against projects in other states, but thus blocking development was the <u>only</u> means by which state officials could protect their constituents' interests in the Colorado. So no project could get through Congress until state officials felt reasonably assured that their constituents would have access to Colorado River water when they needed it. The Colorado River Compact, signed by all the Colorado basin states except Arizona, and ratified by Congress in 1928, finally resolved this deadlock, by allocating half of the water in the river to the so called Upper Basin States of Colorado, New

Mexico, Utah, and Wyoming, and half to the Lower Basin states of Arizona, California, and Nevada.[24]

The Colorado River Compact did not entirely resolve interstate disputes. Because the Compact did not allocate water within each half of the basin, the states still had to agree on how to develop their half of the river. Of the lower basin communities interested in the Colorado, only Los Angeles was actually poised to use waters impounded by a dam in Boulder Canyon. Thus, only California had the means and need to establish rights to the lower basin's portion of the river. Arizona's state officials had refused to sign the Colorado Compact because they feared that California, and specifically Los Angeles, would appropriate all of the lower basin's water, and thus leave Arizona dry. To protect its future access to the Colorado, Arizona therefore consistently disputed federal jurisdiction over the Colorado and dismissed California's plans as Los Angeles' illegitimate scheming.

By the mid-1920s the fate of a dam at Black or Boulder Canyon rested on the resolution of several entrenched conflicts. Los Angeles and Imperial County hoped for federal construction of a reservoir for hydropower, flood control, irrigation, and urban water supply. Southern California Edison expected to build private hydroelectric facilities on the Colorado. Arizona wanted to block any development that might establish water rights in California. Colorado, New Mexico, Utah, and Wyoming, secure in the belief that the Colorado River Compact protected their futures, still had to decide whether to side with California or with Arizona in the dispute over Boulder Dam. The upper basin states hoped federal construction at Boulder Dam would ease the passage of upper basin projects, but they had no assurance that California would support funding for these projects or that California would refrain from campaigning to limit upper basin use in violation of the Colorado Compact.[25] Eastern voters and some residents of the upper Colorado Basin dismissed Boulder Dam as a lavish federal expenditure that served special interests in California rather than the national good.[26] Meanwhile, the United States' resolution of Mexico's claims to the Colorado, the Rio Grande, and other border rivers in 1944 added to the demands for Colorado River water by guaranteeing Mexico 1,500,000 acre feet of water from the Colorado each year without specifying who had to give up their water to meet this obligation.

18.1. Black Canyon during early preparations for construction of Boulder Dam.

The Limits of Federal Authority: The Hydropower Debate

Clearly these conflicts complicated Colorado River politics. A closer look at just one of the conflicts, hydroelectric power development, demonstrates that Boulder Dam was a product of a national debate over political philosophy, not a localized dispute over water rights. Even so, the water resource conflicts were important. Indeed, the very intractability of inter- and intrastate disputes over water made it possible, indeed necessary, for supporters of the dam to marginalize the power question. Arizona's unbending opposition to the Colorado River Compact magnified the threat of utility corporation opposition to the dam and made the staunchest supporters of the dam all the more eager to compromise the Water Power Act of 1920 for the sake of the Colorado River project. But public power development was not ancillary, and the evolution of debate over hydropower demonstrates how participants in that debate used contemporary political philosophy and rhetoric to shape public policy for the twentieth century.

Although Arizonans' objections to Boulder Dam emphasized the threat that outsiders—including California, federal officials and the private utility corporations—posed to their state, the hydropower development question must be considered in a broader context. Philip Swing proposed a federal dam at a crucial moment in the negotiation between federal and local governments and between public and private enterprise in America. Public utility advocates nationwide sought to strike a balance between the business-centered "normalcy" of Coolidge and Harding on the one hand, and public demand for public services on the other. This debate revealed deeply-rooted anxieties about federal authority. In nearly every commentary on Boulder Dam, this fear of public authority appears in warnings of federal intrusion on local autonomy, and of government displacement of private enterprise. So, when private utilities mobilized the rhetoric of limited federal authority, they bound their interests and the principles of private enterprise firmly to Americans' desire to use federal monies to meet local priorities, without losing local autonomy. The utilities' ability to navigate these conflicting impulses about public services and private enterprise, and about federal assistance within local control ultimately left proponents of federal dam-building with little room to maneuver on hydropower development at the great dams.

Even though westerners focus on the Colorado, debate over power development there echoed national discussions of the fate of Wilson Dam at Muscle Shoals, Alabama.[27] Approved as part of the National Defense Act of 1916, Wilson Dam was intended to power a cyanamid plant producing nitrate-based explosives. After the war, private companies sought control of the dam, even though the authorizing bill prohibited the federal government from privatizing the facility after the war.[28] Alabama utility corporations sought to add Wilson Dam to their own power networks. Henry Ford, meanwhile, promised to produce 40,000 tons of nitrate fertilizer for sale at only an eight percent profit, if the federal government completed and maintained the dam, and gave him a hundred-year lease on the property.[29] At the same time, public power advocates suggested that the Secretary of War complete the dam, build distribution lines, sell electricity to public utilities, and use the proceeds to fund research on fertilizers.[30] The senate debate on Muscle Shoals turned on two issues: should public agencies or private companies operate the dam; and, should the dam power the fertilizer production at the cyanamid plant or provide electricity to domestic and industrial consumers throughout the region?

Presidents Coolidge and Hoover vetoed bills for public operation of Muscle Shoals in 1928 and 1930, despite the fact that both the Water Power Act of 1920 and the National Defense Act of 1916 seemed to mandate public operation of the hydropower plant at Muscle Shoals.[31] These vetoes, like the debate over public power at Boulder Dam, reflected deep divisions over private enterprise in America. Americans wanted inexpensive power, but could not agree whether private or public power would yield the lowest rates. They also responded to political statements about the benefits of small government, even as they looked to public officials to control the political, economic and social influence of major corporations.

In Arizona this ambivalence appeared throughout the debate over the Colorado River Compact and the Boulder Canyon Project Act, even though Arizonans were more preoccupied with California. California appeared frequently in the correspondence that Arizona congressional representative Carl Hayden received expressing alarm that the Bureau of Reclamation's dam would only feed Los Angeles' insatiable demand for water and electricity. Many of these letters urged Hayden to push for a federal dam at Glen Canyon to better irrigate Arizona farms.[32] Senator Henry F. Ashurst also complained that the Colorado River Compact and the Boulder Canyon Project disproportionately benefited California. He complained that California had negotiated in bad faith during the conferences that yielded the Compact, and he cited the creation of the Metropolitan Water District of Southern California in 1926, three years before the Boulder Canyon Project Act passed, as proof.[33]

Some Arizonans favored the Colorado River Compact because they saw in federal development a means to counter California's considerable political influence. Arizona's delegation to the American Association of Engineers, for example, projected that the Compact would promote growth for Arizona agriculture, mining, and industry by increasing energy supplies.[34] Others expected the Compact to bring more federal flood control, irrigation, and hydropower to Arizona.[35] More pessimistic Arizonans resigned themselves to California's use of Colorado River resources for which Arizona had no immediate need, but proposed that California at least pay Arizona for the use of Boulder Dam electricity.[36]

In keeping with the national debate in the late 1920s on the expansion of federal authority, the fate of Arizona's autonomy featured prominently in the Colorado River debate. The Phoenix Real Estate Board suggested that the dam might bolster local control because the federal government could turn the dam over to an independent irrigation or power district.[37] Other observers cautioned that private development would transfer even more resources to California than would the federal plan. In this light, Southern California Edison's application for a permit to develop Glen Canyon Dam represented an "attempt to acquire control of the Colorado River,"[38] because Southern California Edison had already declared and justified its intention to sell Colorado River electricity to Los Angeles consumers.[39] Although Arizona's relationship with California, not private utilities or the growth of federal authority, dominated these discussions, the public power debate permeated the way Arizonans defined the threats to their own autonomy.

In the national arena, the public power question figured more prominently and more directly in debates over Boulder Dam. Given their defeat at Muscle Shoals, many public power advocates saw Boulder Dam as the last opportunity to reverse the policies that had led to enough "larceny of public assets to last a century or two."[40] The Los Angeles business community found itself caught between desire for Boulder Dam's water and power, and their commitment to private enterprise.[41] Meanwhile, the utility industry remained a significant force, by funding the publicity campaigns in defense of private enterprise undertaken by such groups as the Better American Foundation and the Greater California League, and by successfully lobbying against both large federal projects like Boulder Dam and the local bond measures that cities needed to purchase or build distribution grids.[42] Despite this considerable political influence, the utilities did not block Boulder Dam completely; it is not clear that they wanted to, whatever their rhetorical position in defense of private development on the Colorado.

In 1928 Congress approved the Colorado River Compact and Boulder Dam over Arizona's continuing objections. The Boulder Canyon Project Act did not settle the question of hydroelectric power development, however, because it did not specify whether the Bureau of Reclamation would wholesale power from federally-operated turbines, lease machinery in a federally-constructed power plant, or lease the <u>right</u> to generate power in a power plant built and operated by lease-holders.[43] Congress left this ambiguity in the bill in order to pass it. The bill also required the Bureau of Reclamation to get power contracts signed to guarantee enough power revenue to underwrite construction before any construction began.[44] So, regardless of the political expedients behind the ambiguities in the Boulder Canyon Project Act, the question of who would develop and distribute power from Boulder Dam had to be settled quickly. Los Angeles offered the only ready market for Boulder Dam electricity. In fact, this market was so important that the Bureau of Reclamation based its contracts on the cost of steam-generated electricity in Los Angeles.[45] This merely confirmed Arizona's worst fears, but for the rest of the country the Boulder Canyon Project Act provided an opportunity to continue the debate over public versus private enterprise.

In the late 1920s the notion of the public interest figured prominently in the public discourse. Periodicals like *The Nation* and *The New Republic* insisted upon federal involvement because state regulation provided inadequate public protection.[46] During the presidential campaign of 1928 Al Smith insisted that private control of hydropower sites reduced public control of power rates, weakened regulatory authority over electric utilities, and exposed the public to unnamed future hazards. Given these dangers, he argued, there was "nothing socialistic or revolutionary" about regulating utilities or developing public power.[47] Franklin D. Roosevelt, unsurprisingly, praised Smith's vision of public power.[48] Hugo Black, then a senator from Alabama, accused the "power trust" of reaping excessive profits from the sale of a necessity.[49] Gifford Pinchot maintained that public generation of power at Boulder Dam would curb the growth of the utility monopoly, and vilified the opposition for playing into the hands of the utility corporations.[50] Even years later, critics raged that private corporations "still claim[ed] the right to install their own generators in public dams, build transmission lines and retail the power."[51] These arguments all relied on Progressive faith in public enterprise as an antidote to the excesses of private capital, and a well-established tradition of portraying utilities as greedy, willful monopolies that refused to accept public ownership in spite of public opinion.

Whatever Pinchot thought of them, private utility advocates used the rhetoric of the public interest just as readily as did Smith, Roosevelt, and *The Nation*, but their definition of the public interest differed. A pamphlet by the Ohio Chamber of Commerce exemplified the private power advocates' use of "public good" rhetoric. The Chamber objected to Boulder Dam because it opened "this wide crack in the door for the entry of state socialism," and because it allowed federal officials arbitrary authority. The Chamber warned that the Boulder Canyon Project Act gave the Secretary of the Interior authority "at his own discretion, to engage the government of the United States in the manufacture and sale of electrical power." They called this a radical concentration of power in the hands of one man, and a "typical instance of the increasing centralization of authority and expenditures in federal bureaus." The Chamber went on to protest the Boulder Canyon Project Act as a threat to democracy and local control: "This is a far cry from the ideas of the founders of this government. If the present tendency to center power and administration in Washington for all sorts of power is not checked, the states of the Union will be reduced to the position of mere counties within the next two or three generations."[52] The implication, of course, was that the state governments were far more capable of serving voters than a remote Congress or Cabinet officer.

The utility industry likewise warned that public ownership threatened democracy. In 1927 American power corporations denounced public development at Muscle Shoals and Boulder Dam as "'socialistic' and 'dangerous.'"[53] Southern Sierras Power Company called federal dam-building defective and costly, concluding that "Political engineering, political banking, political railroading, and general public utility operating is usually unsound and dangerous.[54] The utility insisted that private enterprise retain a role in Boulder Dam.[55] Because they paid taxes and could complete dam or hydropower plants without the "delays and excessive costs that are usually incident to the construction and operation of public owned works," [56] Southern Sierras claimed private enterprise participation would reduce the overall burden on the national treasury, and thus would benefit the public.

Public officials issued similar warnings. In a 1921 memo to President Harding, for example, Secretary of the Interior Albert Fall called the City of Los Angeles "socialistic" for pursuing a public power system.[57] A few years later, New Jersey Congressional Representative Charles A. Eaton characterized Boulder Dam as "the adoption of a socialistic Russian Scheme of having the Federal Government go into the power business in competition with its own citizens in private fields."[58] Eaton reportedly endorsed only those river development policies that kept the federal government out of "the field of private business."[59] Likewise, Elmer O. Leatherwood, a member of the House Committee on Irrigation, called the Boulder Dam project "inimical to the best interests of the United States and the people of the whole country" because it violated the "principle of private industry in the country," and might eventually allow groups to "practically federalize the entire development" of western streams.[60]

Advocates of public power had a response to the implication that only the cooperation of business and government preserved American democracy. Drawing parallels to the Teapot Dome scandal, public power advocates alerted Americans to the "powerful interests" that exerted pressure on public officials. *The Nation* blamed campaign contributions by the nation's private utilities for Secretary of the Interior Ray Lyman Wilbur's and President Hoover's willingness to undermine the Water Power Act of 1920 by permitting private utilities too much access to and control over hydropower facilities at federal dams.[61] *The New Republic* cited as evidence a proposed amendment to the Swing-Johnson Bill that would have compelled the federal government to lease all power rights at Boulder Canyon. Bad enough that this would have turned "over to private profit without adequate compensation, not millions of dollars' worth of government oil, but millions of dollars' worth of government water power."[62] The real danger, however, lay in power of the utilities to create a "system of depriving the people… from sharing equally in the public domain resources."[63]

The utilities also wielded influence outside the halls of government. The United States Chamber of Commerce, a bitter opponent of public power, had many ties to power companies. In fact, the president of the Chamber from 1927 to 1928, Lewis E. Pierson, served on the board of directors of several power companies and worked with executives from several powerful utility firms on the governing board of *Nation's Business*.[64] The utilities used media and public relations campaigns to promote their positions. These efforts were so pervasive that *The Nation* raged, "There is no other field of public interest in which there is so complete, effective, and continuously operating machinery for the dissemination of misinformation and silencing of opposition as in the domain of the public utilities."[65] In 1929 the Federal Trade Commission investigated the political activities of the utility industry to see if a power trust truly threatened American democracy and public interests.[66]

By 1929 it was clear that the Bureau of Reclamation was going to build Boulder Dam. Opponents of federal dam-building had lost, the public interest had been defined to include an increased federal role in the development and distribution of western resources, and the still unresolved matter of power development was about to set important precedents for private and public enterprise. The utilities adjusted their strategy accordingly. Southern California Edison now argued for federal construction because the region would benefit, not "in the emancipation of an oppressed people from the tentacles of an imaginary power trust octopus, but in the impetus that will be given the Lower Colorado Basin by flood protection, irrigation, and the disbursement of hundreds of millions of new money for material, labor and supplies in that territory." [67] In other words, Boulder Dam would serve the public by promoting growth; private power development was consistent with this program of economic development.[68]

The utilities' political flexibility in the face of shifting policies frustrated their opponents. Many public power advocates cited the utilities' changing strategy as a sign that the companies had always intended to profit from dams built with the taxpayers' dollar. The utilities and their allies did not defeat the dam, but only because Congress left the public power question out of the final Boulder Canyon Project Act. The fact that many American's suspected that the federal government had exceeded its authority by infringing on states' rights as well as private enterprise clearly increased the influence of private enterprise in Colorado River policy.[69] As Al Smith found, Boulder Dam, Muscle Shoals, and projects like them, went against too many currents in American politics. Interstate disputes over power rights, and regional conflicts over the distribution of federal largess, forced advocates of both public utilities and federal dams to compromise. The justifications for this compromise were explicit. Philip Swing recognized that California interests had to remain united throughout the final authorization of the dam because intramural conflict would likely reduce the water available for Imperial County and the power available to Los Angeles.[70]

18.2. The interior of Nevada Powerplant at Hoover Dam.

John R. Haynes saw private operation of Boulder's generators as an acceptable way to protect Los Angeles and other public agencies from taking on too much financial responsibility for the dam.[71] Although Boulder Canyon had presented an obvious opportunity to implement the Water Power Act of 1920 and to set a precedent for publicly-generated and publicly-distributed electricity, the difficulties of so extending federal authority and of implementing the Reclamation Act and the Water Power Act made this politically impossible.

Anti-Federalism and Political Realism at Black Canyon

When Southern California Edison and the Bureau of Reclamation signed contracts for Boulder Dam power, they all but settled the debate over public power in the United States. Public ownership proceeded in the Tennessee Valley and parts of the Columbia River, but Boulder Dam did not herald a new age of public ownership. Boulder Dam's hybrid of public and private enterprise came to be portrayed as the acme of effective government, subject to far less criticism even than the participation of industry leaders in designing industrial regulations. Yet this arrangement was at once an accident of politics, and the product of a very specific campaign by the utility industry to protect their interests in the nation's hydropower resources.

Philip Swing's vision of the dam included public power development, but he considered the dam itself and the All-American Canal far more important. Others grafted their vision onto his, adding water supply for Los Angeles, hydroelectric power for Arizona mines and, ultimately, for Los Angeles' industries. In order to justify the dam, early advocates emphasized the need for electricity in general, as much as they did the need for public sales of that power. This was, perhaps, a crucial mistake for the public power movement because it divorced the dam from the question of who should generate power at the dam. But given the early participation of Southern California Edison in river surveys, and given national resistance to a project of this magnitude in a region of the United States that contributed so little to the national economy, this may also have been very astute politics.

So many groups opposed the dam for so many reasons that this compromise may have been the only way to get the dam built. The utility industry astutely exploited the rifts in American politics. They championed private enterprise against creeping socialism. They offered themselves as mediators between federal and state authority, and perhaps even more importantly, between California and the other states of the Colorado River Basin. National ambivalence about federal authority worked for the utility industry in a second way. Many Americans feared government growth as much because increased federal activity would increase taxes as for any other reason. So, Congress insisted that power revenues cover the costs of construction and so reduced the amount of tax funds spent on the dam. This, too, made secure hydropower development far more important than publicly-owned generation or distribution of that power.

In the end, interstate rivalry, competitive envy of Los Angeles' commercial expansion, and a generalized desire to limit federal authority permitted private utilities to retain major claims on natural resources—in spite of the Water Power Act and in spite of the fact that no private corporation had the resources to take on the Colorado River. But the ambiguities in the Boulder Canyon Project Act and the resolution of those ambiguities in favor of the private power corporations reveal deeper patterns in American political thought. News coverage of the utilities' lobbying efforts against the Water Power Act, Muscle Shoals, and Boulder Dam portrayed the utilities as heavy-handed, greedy, and self-interested. Although a consensus had emerged against expanded federal authority, something of the Populist and Progressive concern about the tyranny of private enterprise remained. This is why the "cooperation" between public and private entities met with such approval. At Boulder Dam, the public sector checked the private sector, and the private sector checked the public, even as they both supplied the Southwest with extremely important public services. This then, would be the model for development for many decades to come.

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Endnotes

1. I have no wish to engage the partisan dispute over the name of this dam. Because most documents from the 1920s and 1930s refer to "Boulder Dam," I have used that name throughout this paper.
2. Many documents of this time use ambiguous or confusing terms to refer to utility corporations. For example, an editor emphasizing the public services provided by a publicly-traded, for-profit power supplier, might refer to Southern California Edison as a "public utility." Although I retain original usage in direct quotes, I designate as "public" or "municipal" those utilities or power systems funded primarily by taxpayers. I call stockholder-funded utilities such as Southern California Edison "private utilities," "utility corporations," or occasionally, simply "the utilities."
3. Most histories of the Colorado River emphasize the water rights disputes that pitted California against Arizona, and the states of the upper basin against those of the lower basin. To a more limited extent, they explore the conflicts between urban and rural water use and development, or the relationships between Anglos, Native Americans, and Mexicans. It is hardly necessary for me to replicate that work.
4. Norris Hundley, Jr., *Water and the West: The Colorado River Compact and the Politics of Water in the American West*. Berkeley and Los Angeles: University of California Press, 1975, 20-2. In less than ten years, the Imperial Valley boasted 400 miles of canals, 160,000 acres of cultivated farmland, and a population of 15,000.
5. Hundley, *Water in the West*, 20-9.
6. For descriptions of the bureaucratic problems, of the increase in costs due to import duties levied on materials carried into Mexico for canal maintenance, and the difficulties of maintaining water quality in the canal, see Beverley Bowen Moeller, *Phil Swing and Boulder Dam*. Berkeley, Los Angeles, London: University of California Press, 1971, 12-4; and Hundley, *Water in the West*, 30-3.
7. The question of water deliveries to Mexico was used by both sides of the Boulder Dam debate. In one congressional hearing, for example, Senator Fred T. Coulter protested that the

Boulder Canyon Project would deliver water to two million acres of land in Mexico "belonging to a few powerful and rich Americans" who "are selling these cheap lands to… millions of Japanese in Japan" and thus "establishing a Japanese military and industrial base, endangering our peace.…" (Senator Fred T. Coulter, "Definition of Colorado Compact—Its Defeat a Dawn of a New Year," in "Protection and Development of the Lower Colorado River Basin: Information Presented to the Committee on Irrigation and Reclamation, in Connection with H.R. 2903," *Colorado River Hearings and Miscellaneous Documents* vol. 1, 68 Cong., 1 sess. [1924] Committee on Irrigation and Reclamation.) On the other hand, proponents of the bill cited the same rich American landlords and Japanese farmers to justify building the dam because the dam and the All American Canal would reduce the amount of water flowing into Mexico. (Burdett Moody, "The Colorado River Boulder Canyon Project and the All-American Canal," Boulder Dam Association, November 1926, Los Angeles Area Chamber of Commerce Collection, Carton 102, Regional History Center, University of Southern California, Los Angeles.) Chandler's interest in Mexican lands was widely reported. See for example, Robert L. Dufus, "The Drama of the Colorado," *The New Republic*, 42 (1 April 1925), 147-9. For more on this subject, see also, Hundley, *Water in the West*, 33-4.

8. Hundley, *Water in the West*, 12-4. Lippincott was in charge of southwestern Reclamation Service activities.

9. William A. Myers, "River of Controversy: A Review of the Involvement of the Southern California Edison Co. and Its Predecessors in the Development of the Colorado River, 1902-1942" (SoCal Edison, 1982), 4-6.

10. William A. Myers, "River of Controversy: A Review of the Involvement of the Southern California Edison Co. and Its Predecessors in the Development of the Colorado river, 1902-1942" (SoCal Edison, 1982), 12.

11. *Annual Report to the Stockholders of Southern California Edison for the Year 1924* (Los Angeles: Southern California Edison, 1924), 5, from Corporate Communications Department, Edison International.

12. Statement of Mr. Ralph L. Criswell, President of the City Council, Los Angeles, California, U.S. Congress. House Committee on Irrigation of Arid Lands, "Hearings on H. R. 11449," Part III, 22-24 June 1922, 67 cong., 2 sess., 1922, 100-101, in "Development of the Colorado River Basin," Huntington Library pamphlet volume.

13. Testimony of W. T. Matthews, "Problems of the Imperial Valley and Vicinity," letter from the Secretary of the Interior… together with the proceedings of the conference on the construction of the Boulder Canyon Dam held at San Diego, Calif.", Senate Document 142, 67th cong., 2 sess. (Washington: 1922), 282-3.

14. Statement of Mr. Ralph L. Criswell, representing the City of Los Angeles, "Protection and Development of the Lower Colorado River Basin," Hearings before the Federal Power Commission and other matters relating to the Development of the Colorado River, Committee on Irrigation and Reclamation, House of Representatives, 68 cong., 1 sess. (Washington: 1924), 78-79, 100-101. Not all Angelenos accepted these priorities. John Haynes and his fellow Progressives, for example, insisted on public distribution of power from Boulder Dam. See Tom Sitton, "The Haynes Foundation and Urban Reform Philanthropy in Los Angeles: A History of the John Randolph Haynes and Dora Haynes Foundation," unpublished manuscript, December 1997, p. 18 (Since published as Tom Sitton, *The Haynes Foundation and Urban Reform Philanthropy in Los Angeles: A History of the John Randolph Haynes and Dora Haynes Foundation* (Los Angeles: Historical Society of Southern California, 1999.)

15. "Power Bonds Carry by Three Thousands," *Los Angeles Times* 9 May 1914.

16. "Annual Report to the Shareholders of Southern California Edison for the year 1919," (Los Angeles: 1919), 10-1, Corporate Communications Department, Edison International. Southern California Edison even offered to purchase power from the aqueduct to allow the city to offset its water system costs without competing with the private utilities. See "Offer to buy Power Officially Recorded," *Los Angeles Times* 6 May 1914. The power bonds paid for construction of the Saint Francis Dam, which collapsed in 1928 killing some four hundred people in the Santa Clara Valley of Ventura County. For more on the Saint Francis Dam disaster and its implications for Los Angeles water and power development and flood control, see Donald C. Jackson and

Norris Hundley, Jr., “Privilege and Responsibility: William Mulholland and the St. Francis Dam Disaster,” *California History* 82:3 (2004), 8-47, 72-78.

17. Statement of Mr. Ralph L. Criswell, President of the City Council, Los Angeles, California, U.S. Congress. House Committee on Irrigation of Arid Lands, “Hearings on H. R. 11449,” Part III, 22 -24 June 1922, 67 cong., 2 sess., 1922, 100-101, in “Development of the Colorado River Basin,” Huntington Library pamphlet volume.

18. George L. Hoxie, “The Fictitious ‘Surplus’ of the Los Angeles Municipal Electric Power Department” November 1930, Los Angeles Area Chamber of Commerce Collection, ; “Dam Break Reveals New Tactics of Power Trust” *Seattle Post-Intelligencer*, 26 Mar 1928 (editorial), Philip Swing Papers, Special Collections, University of California–Los Angeles.

19. Los Angeles tried to condemn the power plant in order to increase municipal power supply. In 1922, the U.S. Court of Appeals reversed a lower court’s decision to permit Los Angeles to condemn the Southern Sierras’ Owens Gorge plant on the grounds that the decision would have allowed California’s major cities to “demolish, piece meal, the great hydro-electric systems of the state” and to steal water and power away from the communities that relied upon private water and power services. “Owens Gorge Case Decision Is Reversed,” *Sierras Service Bulletin*, 2:5 (November 1922), 4; E. B. Criddle, “What the L. A. Litigation Means,” *Sierras Service Bulletin*, 1:5 (June-July 1921), 1, Corporate Communications Department, Edison International.

20. Statement of Mr. Ralph L. Criswell, President of the City Council, Los Angeles, California, U.S. Congress. House Committee on Irrigation of Arid Lands, “Hearings on H. R. 11449,” Part III, 22 -4 June 1922, 67 cong., 2 sess., 1922, 100-1, in “Development of the Colorado River Basin,” Huntington Library pamphlet volume.

21. Testimony of Horace Porter, Mayor of Riverside, “Problems of the Imperial Valley and Vicinity,” letter from the Secretary of the Interior… together with the proceedings of the conference on the construction of the Boulder Canyon Dam held at San Diego, Calif., Senate Document 142, 67th cong., 2 sess. (Washington: 1922), 284.

22. Testimony of George L. Hoodentyl, “Problems of the Imperial Valley and Vicinity,” letter from the Secretary of the Interior… together with the proceedings of the conference on the construction of the Boulder Canyon Dam held at San Diego, Calif., Senate Document 142, 67th cong., 2 sess. (Washington: 1922), 286-7.

23. “Judge Borwon Notes of Interview with Don J. Kinsey,” 2 July 1963, p. 8, Fletcher Bowron Papers, “Metropolitan LA History Project: Research Materials,” Box 65, Huntington Library.

24. For a complete discussion of the Colorado River Compact, its genesis, results and sources of dispute among the states involved, see Norris Hundley’s classic *Water in the West*. Additional information on the Colorado River Compact may be found in Moeller, *Phil Swing and Boulder Dam*, 42-7.

25. Hundley, *Water in the West*, 171-4..

26. Hundley, *Water in the West*, xvii,

27. In the northeast, an important conflict over public power emerged in the early 1920s when a utility linked to Secretary of the Treasury Andrew W. Mellon proposed to build power plants at the Saint Lawrence Seaway and Niagara Falls, resources that the New York Water Power Commission was charged with protecting and developing in the public interest. Opponents argued that the New York Water Power Commission, charged with overseeing these resources, was intended to foster public utilities in the state. “Public Power First” *New Republic* vol 45 (17 February 1926), 346.

28. Preston J. Hubbard, *Origins of the TVA: The Muscle Shoals Controversy, 1920-1932* (New York: W W Norton, 1961), 1-2.

29. Ford offered Washington $5 million and an annual rent of $55,000 for this power complex. George Norris, “Shall We Give Muscle Shoals to Henry Ford?” *Saturday Evening Post* 24 May 1924, 30-1 and passim.

30. On the Muscle Shoals debates, see Preston J. Hubbard, *Origins of the TVA*.

31. American Public Works Association, *History of Public Works in the United States, 1776-1976*, ed. by Ellis L. Armstrong, (Chicago: American Public Works Association., 1976), 249.

Coolidge was sharply criticized for his defense of private enterprise. In 1926, Nebraska Democrat Edgar Howard denounced Coolidge for "murdering every piece of legislation which does not have advanced approval of the Morgan Mellon group." (Edgar Howard to *Los Angeles Examiner*, 4 June 1926, Philip Swing Papers..

32. R. B. Hovland to Carl Hayden, "Colorado River Development," 31 March 1924, in "Statements by Citizens of Arizona relative to the Colorado River Problem.…," Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 59. See also Ralph L. Criswell's testimony for Los Angeles, "Protection and Development of Lower Colorado River Basin… Hearings before the Federal Power Commission and Other Matters Relating to the Development of the Colorado River," (Washington, 1924), 78-9.

33. U.S. Congress, Senate, Committee on Irrigation and Reclamation, "Report on Boulder Canyon Reclamation Project, 69 Cong., 1 sess., Report 654, pt. 1, in *Colorado River Hearings and Miscellaneous Documents*, 13; Speech of Phil D. Swing of California in the House of Representatives," 11 Mar 1926, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 14.

34. "Report of the Colorado River Committee of Arizona State Assembly of the American Association of Engineers," in "Statements by Citizens of Arizona relative to the Colorado River Problem…," Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 21.

35. Kiwanis Club of Phoenix, "History of the Ownership of the Power Sites on the Colorado River," 19 January 1923, in "Statements by Citizens of Arizona relative to the Colorado River Problem…," Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 39-41.

36. See for example, American Legion of Prescott, Arizona, "The Power Royalty Issue and the Colorado River Compact," 2 August 1923, or Dwight B. Heard, "Statements of Candidates for Governor of Arizona regarding the Colorado River Compact," both in "Statements by Citizens of Arizona relative to the Colorado River Problem.…," Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 49-50, 58.

37. Phoenix Real Estate Board, "Ultimate Control of Water and Power Resources of the Lower Basin of the Colorado River by a Tri-State Irrigation and Power District," 2 July 1923, in Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 43. The Board envisioned an interstate district, including parts of Arizona, Nevada and California.

38. "Speech of Honorable Charles H. Rutherford on the Colorado River Compact," delivered in the Arizona State Senate, 20 February 1923, in "Statements by Citizens of Arizona relative to the Colorado River Problem… ," Protection and Development of the Lower Colorado River Basin: Information presented to the Committee on Irrigation and Reclamation, in Connection with H. R. 2903, *Colorado River Hearings and Miscellaneous Documents*, vol. 1, 68 Cong., 1 sess. (1924), Committee on Irrigation and Reclamation, (Washington, 1924), 73-84.

39. In testimony before Congress, Edison's general manager declared the utility ready to build a hydropower dam on the Colorado independent of federal efforts. Southern California's need for power, and the dearth of undeveloped power sites closer to Los Angeles not only justified the expense of developing the Colorado, but made the project quite necessary. See R. H. Ballard, in "Boulder Canyon Project: Excerpts from the Hearings before the Committees on Irrigation and

Reclamation… of the 68th, 69th, and 70th Congresses on the Swing-Johnson Bill…," *Colorado River Hearings and Miscellaneous Documents*, vol. 1, (Washington, 1924), 16.

40. William Kent to Committee on Irrigation of Arid Lands, telegram, 16 February 1924, Philip Swing Papers, 144.

41. "Using the Chamber of Commerce for Hocus Pocus Game," *Los Angeles Examiner*, editorial, 10 February 1924, Philip Swing Papers, Box 157, Scrapbook 1A, p. 20.

42. Franklin Hitchborn, "Union Men Forced to Contribute to Better American Federation" unlabeled news clipping, Philip Swing Papers, Box 144. See also "Power Fights Boulder Dam Says Swing," *Los Angeles Herald*, 18 February 1924, Philip Swing Papers, Box 157, Scrapbook 1A, p. 20; Franklin Hitchborn to Committee on Irrigation of Arid Lands, telegram, 16 February 1924, Philip Swing Papers, Box 144. One newspaper reported that Southern California Edison ordered its employees to send telegrams urging local officials and chambers of commerce to oppose the Swing-Johnson Bill. See "Furious Charge of the Edison Brigade of Six Hundred Agents," unidentified newspaper, 10 April 1924, Philip Swing Papers, Box 157, Scrapbook 1A, p.45.

43. California. Colorado River Commission. *Colorado River and the Boulder Canyon Project*, (Sacramento: 1930), 116.

44. California. Colorado River Commission. *Colorado River and the Boulder Canyon Project*, 160.

45. California. Colorado River Commission. *Colorado River and the Boulder Canyon Project*, 159.

46. *The Nation* condemned state utility regulations because "all those whose purpose it is to defeat genuine efforts and adequate regulation" supported oversight by the states rather than the federal government. According to *The Nation*, these interests wanted the states to regulate utilities "precisely because they recognize the demonstrated inability of the individual States to cope with the problem" of utility power. See Guido H. Marx, "How to Control Public Utilities," *The Nation* 132:3430 (1 April 1931), 348; "The Utilities as an Issue," *New Republic* 62 (7 May 1930), 311-2.

47. Alfred E. Smith, "Water Power and Its Social Uses," *The Survey*, 57:7 (1 Jan 1927), 424.

48. "The Utilities as an Issue," *New Republic* 62 (7 May 1930), 311-2.

49. "Black Raps 'Power Trust' over Radio," *Washington (DC) Evening Star*, 28 February 1930, Philip D. Swing Collection, Box 136, UCLA Special Collections

50. Gifford Pinchot, "Who Owns Our Rivers," *The Nation* 126:3262 (18 January 1928), 64-6.

51. Judson King, "Uncle Sam and His Water Supply: Some Notes on the Report of the President's Water Resources Policy Commission" National Popular Government League, *Bulletin*, No. 241, 27 January 1951, 5, SBM P F 164.

52. Frank B. McMillin, George B. Chandler, Ohio Chamber of Commerce, "Why Ohio is Interested" n.d., Swing Papers, Box 144.

53. "Utility Companies United to Oppose U.S. Projects," transcribed from *Washington News*, 17 October 1927, Philip Swing Papers, Box 144. For use of red scare rhetoric in the Muscle Shoals debate, see also Preston J. Hubbard, *Origins of the TVA: The Muscle Shoals Controversy, 1920-1932* (New York: W. W. Norton, 1961), 288.

54. "Political Engineering," *Sierras Service Bulletin* 6:1 (February 1931), 2, in Edison International Public Relations Office Collection, Edison International, Rosemead, California.

55. "Southern Sierras Power Company Presents Its Position on Power and Canal Development Plans," *Brawley News* 21 March 1924, Philip Swing Papers, Box 144. Southern Sierras Power endorsed Southern California Edison's proposal for federal control of Colorado development, combined with private construction of power facilities, if not entire dam structures.

56. "Southern Sierras Power Company Presents Its Position on Power and Canal Development Plans," *Brawley News* 21 March 1924, Philip Swing Papers, Box 144.

57. Albert Fall to Warren G. Harding, 24 September 1921, "3rd Enclosure. Subject: Colorado River Power Project and Appointment of Commissioner." Albert Fall Papers, Box 47, Huntington Library.

58. "Congress advised to Leave Power Development to Private Interests," retyped from *Sunday Dispatch*, 4 December 1927, attachment to Harry A. Slattery to Philip D. Swing, 13 December 1927, Swing Papers, Box 134. Slattery was careful to point out that Eaton had worked for General Electric and edited that company's newsletter, *The Lamp*, before running for Congress.

59. “Congress advised to Leave Power Development to Private Interests,” retyped from *Sunday Dispatch*, 4 December 1927, attachment to Harry A. Slattery to Philip D. Swing, 13 December 1927, Swing Papers, Box 134.
60. Elmer O. Leatherwood, “A National Legislator’s Views on Colorado River Development” *The Tax Digest* 3:6 (December 1926), 203-6, Swing Papers, Box 17.
61. E. M. Scofield to *The Nation*, 10 March 1930, Swing Papers, Box 136; untitled editorial, *The Nation* 132:342 (28 January 1931), 94.
62. “Shall We Have A Power Scandal?” *The New Republic*, 49 (26 January 1927), 264-65. See also “Would Lease Muscle Shoals; Hint of Another Oil Scandal,” *Labor News* 14 May 1926, Urban Archives, CSU Northridge.
63. William J. Schaefle, “The People of the United States Do Not Want Another Tea Pot Dome Scandal,” *American Globe* 25:7 (April 1928) 5-6, Philip D. Swing Collection, Box 43, UCLA Special Collections.
64. Judson King, “Who’s Who in the Super-Power Lobby,” National Popular Government League *Bulletin* 115:2, 15, Philip Swing Collection, Box 145, UCLA Special Collections.
65. Guido H. Marx, “How to Control Public Utilities,” *The Nation* 132:3430 (1 April 1931), 348. The utilities’ public relations campaign included the dissemination of pamphlets, books, and other materials to schools, “for the purpose of influencing public opinion in favor of private ownership” of power facilities, and attempts to rally other business organizations to oppose the Boulder Canyon Bill. See Bruce Gustin, “Bannister Scores Power Trust for Secret Work in Schools,” unidentified clipping, 8 June 1928, Swing Papers, Box 145; “Insurance Interests Help Defeat Boulder Canyon Dam Legislation,” *Western Progressive*, 1:3 (Mar 1927), 1-2, Swing Papers, Box 17. The effort to rally business organizations apparently included a campaign in the *American Agency Bulletin*, an insurance industry publication, that urged agents to “line up” with the power industry. The *Western Progressive* carried reprints of articles from the *American Agency Bulletin* provided to them by one insurance agent “who could not be bamboozled by these greedy interests.”
66. Norris Hundley, *Water and the West*, 273. The Commission found that the private utility industry spent over $1 million per year to promote private ownership and to defeat Muscle Shoals and Boulder Dams, but concluded that there was no “power trust” per se. The utility companies themselves cited this last point to defend themselves against the public power movement. They also complained about the “organized propaganda being carried on through a great syndicate of newspapers and prominent radicals to make it appear that the power industry is in the tentacles of a powerful octopus, which will strangle the people.” See “Power in the Public Eye” *Sierras Service Bulletin* 4:8 (September 1929) 2, in Edison International Public Relations Office Collection, Edison International, Rosemead, California.
67. “Boulder Dam Power,” *Sierras Service Bulletin*, 4:7 (August 1929) 2, from Corporate Communications Department, Edison International.
68. Norris Hundley observed in 1975 that the “desire to tap the federal largess without incurring federal control” was one of the prominent themes of western development. This applies as much to Boulder Dam as it did elsewhere on the Colorado River as well as the Central Valley Project and numerous other sites throughout the West. As multipurpose dams built by the Army Corps of Engineers tended to have fewer restrictions on power development and irrigation acreage, this desire for federal funds without federal regulation gave the Army Corps a boost during its longstanding competition with the Bureau of Reclamation for budget, project authorization, and institutional status. See Norris Hundley, *Water in the West*; Lawrence B. Lee, “California Water Politics: Depression Genesis of the Central Valley Project, 1933-1944,” *Journal of the West* 24: 4 (1985), 63-81, discusses competition between the Bureau of Reclamation and the Army Corps of Engineers in the context of acreage limitations.
69. See Norris Hundley, *Water in the West*, 271-7. See also Elmer O. Leatherwood, “A National Legislator’s Views on Colorado River Development” *The Tax Digest* 3:6 (December 1926), 203-6.
70. P. D. Swing to Chas. L. Childers 21 Feb 1930, Swing Papers, Box 136.
71. J. R. Haynes, 25 Mar 1930, “While it is a logical deduction from the text of the Swing-Johnson Bill…” John R. Haynes Papers, Box 11, Special Collections, University of California, Los Angeles.

Boulder Dam Recreation Area: The Bureau of Reclamation, the National Park Service, and the Origins of the National Recreation Area Concept at Lake Mead, 1929-1936*

By:
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The struggle to keep dams out of the national parks that pitted conservationists against the West's water and power interests has constituted a major recurring theme in American environmental history. From the early fight over the fate of Yosemite's Hetch Hetchy Valley, to the campaigns to keep dams out of Dinosaur National Monument and Grand Canyon National Park, historians have recounted the continuing effort to keep the National Park System free of dams. But what would happen if things were the other way around? What if, instead of trying to keep a dam out of a national park, the National Park Service (NPS) invented a new type of area—a national recreation area—that would have at its center the world's largest dam, reservoir, and hydroelectric generating plant? Between 1929 and 1936 that is exactly what happened, as the U.S. Department of the Interior made plans for the lands that would surround Boulder Dam and its reservoir, Lake Mead.

In October 1936 Secretary of the Interior Harold L. Ickes approved an agreement between the National Park Service and the U.S. Bureau of Reclamation (USBR) to create Boulder Dam Recreation Area—America's first national recreation area. The Boulder Dam Recreation Area agreement concluded seven years of work begun during the Hoover administration, and it marked the beginning of a decades-long cooperative partnership between the NPS and USBR to plan for and develop outdoor recreation at federal reservoirs in the West. The mutually beneficial partnership allowed each of the two agencies to further its own interests. For the National Park Service, it meant gaining new areas to manage while expanding its role in outdoor recreation. For the Bureau of Reclamation, it meant the ability to promote recreation as a benefit of its projects, while avoiding the distraction of managing recreation itself. This achievement was all the more remarkable in that it was accomplished without significant opposition from private local interests or conservationists.

The development of the Boulder Dam Recreation Area has not received full treatment in the historical literature of environmental history or the national parks.[1] Yet it is a story that is as significant as it has been obscure. First, the effort to create the Boulder Dam Recreation Area challenged the National Park Service to find a way to reconcile its own ideal of preservation and public

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enjoyment with an enormous utilitarian project, a dam belonging to another federal agency. The resulting compromise established the precedent for a new type of National Park Service area—a national recreation area—that emphasized outdoor recreation while seeking to balance preservation and education with other uses—dams, grazing, and mining, for example—that were traditionally not allowed in national parks. This compromise would become the central principle behind the forty national recreation areas that would follow. Second, the NPS-USBR partnership produced important, if unintended, consequences. The increasingly cozy relationship between the two agencies that began at Lake Mead resulted in the National Park Service's acquiescence to the Bureau of Reclamation's later proposals to build the Echo Park Dam in Dinosaur National Monument and the Bridge Canyon Dam in the lower Grand Canyon—setting the stage for two of the pivotal conservation battles of the 1950s and 1960s.

The development of America's first national recreation area—conceived during the Hoover administration—was a consequence of the Boulder Canyon Project Act of 1928. In the act, Congress directed the Bureau of Reclamation to construct a major water-resources-development project on the lower Colorado River for the purposes of controlling floods, storing water for both irrigation and domestic use, and generating hydroelectric power.[2] Boulder Dam would impound the waters of a mammoth reservoir reaching 115 miles upstream—as far as the little community of St. Thomas, Nevada, on the lower Virgin River, and Pierce's Ferry, Arizona, in the Colorado River's lower Grand Canyon. Although recreation was not a purpose specified in the Boulder Canyon Project Act, Bureau of Reclamation officials understood that public recreation would be a significant use of the new Boulder Dam Reservoir. Indeed, the bureau had first noticed the recreational potential of its reservoirs shortly after the 1906 construction of Theodore Roosevelt Dam on the Salt River Project in Arizona. Swimming and boating became popular at the reservoir, and a hotel to accommodate visitors soon followed.[3] In 1914 Arizonans even tried—unsuccessfully—to have the area surrounding Roosevelt Reservoir designated a national park.[4] By the 1920s, throughout the arid West, the recreational importance of its reservoirs to local residents and to their tourist economy was becoming clear to the bureau. As a 1928 Bureau of Reclamation pamphlet noted, "They are entering increasingly into the life of the people as pleasure resorts and playgrounds, as bird sanctuaries, and as excellent fishing grounds…"[5] The federal government provided little in the way of services or facilities at the reservoirs, however, despite their growing recreational appeal, other than the issuing of permits for private-sector developments and the stocking of fish by the Bureau of Fisheries.[6]

But the Boulder Canyon Project's enormous dam and reservoir would be the world's largest—attractions destined to become, in the words of Reclamation Commissioner Elwood Mead, "a tourist mecca," that would draw visitors, not just from the Southwest, but from "every part of the world."[7] Many of these tourists would be coming simply to gaze passively upon the dam and reservoir—much as tourists gaze upon Niagara Falls or the Grand Canyon—and then move on.

But tourism and outdoor recreation were changing in the 1920s and 1930s, and a growing number of visitors would not be content with such passivity. The interwar years saw a revolution in the nature of outdoor recreation. Those tourists whom John Muir had once derided as "tender, pulpy people," who traveled in "smooth comfort" to gaze upon scenic spectacles, were now being joined by legions of Americans who shared Muir's love of a more strenuous outdoor experience.[8] The outdoor recreation boom was partly the result of increasing leisure time, particularly for middle-class Americans. But more importantly, as Paul Sutter has argued, it was improved transportation—private automobiles and modern highways—that put outdoor recreation venues within the reach of city dwellers seeking a weekend outing or a week's vacation and brought "remote natural areas into the recreational orbits of modern Americans."[9] As a result, participation in auto-camping, hunting, fishing, and recreational boating increased rapidly.[10]

Looking to the future of the Boulder Canyon Project, the U.S. Department of the Interior recognized that these new patterns in recreational demand would necessitate building not only roads, overlooks, and lodgings but also campgrounds, trails, swimming areas, and boating facilities. Furthermore, visitors would require interpretive and educational services to provide them with "information about the dam and lake, as well as the natural glories of the region."[11] But the Bureau of Reclamation, although it acknowledged the importance of the reservoir's recreational potential, had no interest in assuming the responsibility of developing and operating recreational programs and facilities. Providing high-quality outdoor recreation opportunities, along with the other benefits associated with its projects, would undoubtedly generate public-relations dividends for the bureau. But the agency possessed, its leaders readily conceded, "neither the necessary experience [n]or personnel to administer the area" for recreational use.[12] The bureau saw itself strictly as an organization that constructed and operated water-resources- development projects, not parks, and it did not want to assume additional functions not directly related to its mission.

While the Bureau of Reclamation lacked the expertise and interest to develop the Boulder Canyon Reservoir for recreational purposes, the National Park Service abounded in both. Since its creation in 1916, the NPS had administered and promoted recreation in its national parks and national monuments. It knew how to plan, design, and construct the necessary facilities and developments; it provided educational and interpretive services; and it had policies and procedures in place for managing and regulating visitor use. The Park Service considered itself the nation's foremost recreation agency and was proud to claim "years of experience and experimentation in handling visitors in such manner as to lift them from the place of mere tourist to that of the enthusiastic seeker after the fascinating facts of natural history."[13] Management of the recreational aspects of the Boulder Canyon Project would fall to the National Park Service.

National Park Service involvement in developing a recreation area at Boulder Dam began during the Hoover administration. In June 1929, Secretary of the Interior Ray Lyman Wilbur made a trip to inspect the Boulder Canyon Project area and recognized the scenic and recreational value of the public lands surrounding it. Secretary Wilbur grew up in southern California and as an undergraduate at Stanford University had participated in a botanical collecting expedition to southern Arizona, which had instilled in him, he later recalled, "a real love of the desert and also some understanding of its significance."[14] His visit to the dam site seemed to reawaken his fascination with the desert landscape. Upon his return to Washington, Wilbur ordered a report on the "national park possibilities in connection with the Boulder Canyon Reclamation Project" and directed the Bureau of Reclamation and the National Park Service to consult with one another about the future management of the area.[15] Between 1929 and 1932 National Park Service staff and consultants made a series of studies and investigations of the area surrounding the planned reservoir.[16]

19.1. During a tour of Hoover Dam construction on November 12, 1932, Ray Lyman Wilbur (third from right) accompanied President Herbert Hoover (between Mrs. Hoover and Mrs. Wilbur).

One of the first proposals, advanced in 1929 by Ernest Walker Sawyer, Wilbur's assistant secretary of the Interior, sought to preserve the area from "depredation" through the establishment of an enormous "national park, recreation area, or outdoor nature shrine" between the Colorado River and Zion National Park. Tentatively labeled the "Proposed Virgin National Park," the project would span the lower Virgin River and the Colorado River country upstream of the Boulder Dam site. The area would comprise nearly 8,000 square miles surrounding the dam's projected reservoir and would be accessed through highway entrances at Boulder Dam, Moapa Valley, and Zion, and by airplane from Grand Canyon National Park. Sawyer intended the expansive boundaries to include numerous outstanding features: the Boulder Dam reservoir; archaeological sites such as Salt Cave, Gypsum Cave, and the "Lost City of Nevada" pueblo ruins; historic Mormon settlements like Fort Callville and Pipe Spring; and numerous scenic natural features such as the Kolob Canyons (near Zion), the Valley of Fire, and areas in the western Grand Canyon such as Toroweap, Shivwits Plateau, Lava Falls, and Vulcan's Throne.[17] The idea found a champion in Secretary Wilbur.

At Wilbur's prompting, NPS Director Horace M. Albright reported that the proposed Virgin National Park region had much to recommend it: The canyon of the Colorado below Grand Canyon National Park was of "great scientific importance"; the prehistoric Indian ruins along the lower Virgin were of interest to archaeologists; and the Kanab and Shivwits Plateaus were excellent examples of wild tablelands. The region possessed, in short, "many natural features demanded of any area under consideration for national park status." But the area fell short of fully meeting NPS standards of suitability and feasibility. Suitability was impaired in two ways. First, although the area was highly scenic, many of its best features duplicated those already better represented in Grand Canyon National Park, and NPS policy held that duplication was to be avoided within the park system. Second, and more significantly, the presence of Boulder Dam and its artificial reservoir would be "contrary to the well established policy of maintaining natural landscape conditions…" With regard to feasibility, Albright noted the problems presented by a considerable acreage of private and state land intermingled with federal holdings, a longstanding pattern of extensive livestock grazing that would be "difficult to extinguish," and the presence of Indian reservation and national forest lands within the boundaries of the area, all of which would "operate against the administration of the area within the principles of national park protection." As a consequence, Albright concluded that the area should not become a national park, although he recommended further study to identify "certain smaller areas" that appeared "worthy of preservation" as national monuments.[18]

19.2. In 1927 or 1928 Stephen Mather and his ranking staff sat for this portrait in Washington, D.C. From left to right: Arno B. Cammerer, Arthur E. Demaray, Stephen T. Mather, George A. Moskey and Horace M. Albright. Photo courtesy of the National Park Service.

Despite Albright's negative report, Wilbur remained interested in the scenic and recreational potential of the region. Perhaps an expansive Virgin National Park was not the best way to proceed, but he still believed that some action should be taken to protect the area. He told Albright:

> Since it is unique in character, the land is largely public land, and the lake will provide a new feature both of beauty and for transportation, I think that we should devise some method by which it can be held in the public interest. Whether it should be classified as a recreation area, a national monument, or in some other way, I do not know. I would like though to have you seriously consider not letting it leave the National Park Service and of originating legislation which will give us a chance to retain it in its original beauty. Even if it is not of National Park standard, it is of sufficient national significance to warrant most careful study by us as to its ultimate disposition.[19]

Committed to his goal of protecting the scenic desert landscapes surrounding the Boulder Dam reservoir, Wilbur urged President Hoover to withdraw the lands from entry, guaranteeing that they would remain in public ownership until the matter could be resolved.

In April 1930 President Hoover signed an executive order withdrawing from settlement 4,212 square miles of public land upstream from the Boulder Dam site, based on Wilbur's determination that the lands would be "of greater public value from a scenic and scientific standpoint than for economic development" and that the new reservoir would offer "unusual recreation opportunities."[20] In particular, the reservoir would improve public access via scenic boat tours, according to the Interior Department, that would allow visitors to "enjoy a stupendous view of the great gorge of the Colorado River that hitherto could be seen only by the most hardy and experienced boatmen, and that even for them was fraught with serious danger." The reservoir at Boulder Dam would open new vistas to the touring public "second in significance only to that portion of the Grand Canyon within the Grand Canyon National Park."[21] Based on the recreational potential identified in NPS studies, Secretary of the Interior Wilbur recommended that "at least part" of the area be established as a "national monument or some other special preserve to be developed and administered by the National Park Service."[22]

Yet the question of National Park Service involvement with the Boulder Canyon Project would be problematic. The National Park Service had been created in 1916 in the aftermath of the titanic battle to stop the city of San Francisco from damming the Tuolumne River in Yosemite National Park's scenic Hetch Hetchy Valley. The fight had helped to define what kinds of development would be appropriate in a national park. Although San Francisco won the battle, the dam at Hetch Hetchy would prove the exception rather than the rule. Indeed, park advocates, such as the Sierra Club and the American Civic Association, pointed to the loss of Hetch Hetchy—and the urgent need to prevent another park from suffering the same fate—as a prime example of the urgent need for Congress to establish a national park agency with a strong preservation mandate.[23] During the 1920s the young National Park Service fought to prevent the Bureau of Reclamation and its supporters from building more dams in the national parks. In particular, NPS Director Stephen T. Mather and his assistant, Horace M. Albright, worked to protect Yellowstone National Park and Glacier National Park from dam proposals that would have benefited irrigators in Idaho and Montana.[24] But now Secretary Wilbur was suggesting that the NPS add to its holdings a new area with the world's largest manmade dam at its center. How could such a thing be reconciled with the national park idea? As historian Richard Sellars has noted, "Philosophical contradictions" were bound to emerge when "the main feature was itself a gigantic impairment to natural conditions."[25] How the agency resolved this contradiction would set an important precedent.

Whether the Boulder Canyon Project area met the exacting criteria of national park quality and national significance, and whether a dam could be allowed in an area under NPS management were questions that demanded answers. The National Park Service exerted powerful influence over decisions to create new parks and monuments, and although the agency was eager to expand into new areas, it frequently rejected "inferior" park proposals that fell short of its rigorous standards.[26] As a result, scrutiny of the project launched a round of vigorous and searching discussions within the national park leadership. M. R. Tillotson, superintendent of Grand Canyon National Park, advocated for NPS management of the dam and reservoir area due to its superlative size. As the world's largest, Tillotson believed that it would make "an attraction of considerable tourist interest." In order to assure its proper development, he said, the withdrawn lands around the proposed reservoir "should become a National Park or Monument, either as a distinct unit or as an addition to Grand Canyon National Park."[27] Assistant Director Conrad Wirth was eager for the NPS to begin helping the Bureau of Reclamation to administer the recreational facilities of the project, but he had reservations over how the area should be designated due to the presence of the dam. "I do not see how this area could be considered for a national park, on account of its artificial make-up," he wrote. Although national monument status might be warranted because of the dam's "scientific qualifications" as a "tremendous engineering accomplishment," as well as the area's potential for "national recreation," he maintained that the area should be "placed in some other classification than a national park or monument."[28] Others within the agency concurred with Wirth. Wallace R. Atwood believed that the project area would "prove to be a very valuable recreation section," but he was not convinced that it should be part of the national park system. "Maybe we can look forward to a classification which will include areas of this nature," he wrote.[29] Education and Research Director Harold C. Bryant concurred, writing Director Albright that he was "not convinced of the value of the Hoover Dam Site as a national monument." He regarded it as "one of those third class areas needing another name."[30] A consensus emerged: First, the area required further and more intensive study to determine its suitability. Second, the National Park Service needed to devise a new category for areas that were primarily valuable for recreation, rather than for their superlative natural or historical significance. Such a new category—distinct from parks or monuments—was needed in order to ensure that allowing a dam in a recreational area would not become precedent for allowing one in a national park. In the absence of such a categorical distinction, the NPS could expect opposition to the plan by groups—such as the National Parks Association, the American Civic Association, and the Sierra Club—whose mission it was to safeguard the parks from despoliation.

Establishing a primarily recreational area would be a new departure for the National Park Service. To be sure, recreation was a key element of the agency's mission. The 1916 Organic Act directed it to "provide for the enjoyment" of park resources and make arrangements for the "accommodation of park visitors."[31] A

1918 letter, known as the "Lane Letter," from Secretary of the Interior Franklin Lane to Stephen Mather, spelled out how the agency should implement the Organic Act; it specified that outdoor recreation activities would be allowed in the parks, so long as they were consistent with the policies intended to safeguard the parks and preserve them unimpaired.[32] Moreover, during the 1910s and 1920s, Mather emphasized tourism and recreational development in the parks as a means of developing a national constituency that would provide the NPS with the political support it needed. As Mather's successor, Albright was also a "dedicated proponent" of outdoor recreation and tourism.[33] Yet recreation was secondary to the purposes for which the parks had been established: to preserve unimpaired for future generations the superlative and nationally significant natural and cultural resources they contained. What the NPS now contemplated creating at Boulder Dam was something new, something that risked the appearance that it was compromising its mission of preservation.

The National Park Service's internal concern over whether the Boulder Canyon Project area met national park standards was not the only obstacle standing in the way of protecting the area. The ranching and mining interests of Arizona and Nevada, wary of any further federal encroachment or regulation upon their activities, were hostile to the idea of a new national park or monument surrounding the reservoir. Rather than calling for preservation, for example, the State of Nevada hoped the electrical power and roads associated with the dam project would accelerate the development of the area's mineral resources, and the governor called for a thorough survey of the "mining potentialities in the vicinity of Boulder Dam."[34] Similarly, the State of Arizona opposed the large executive withdrawal of public lands around the project area.[35] There was strong sentiment in the state against "any more land being included in Federal Reservations," one NPS official noted.[36] Even Utah entered the fray. Because the rural ranching economy of southern Utah was closely tied to the "Arizona Strip" lying north of the Colorado River, the Utah State Legislature memorialized Congress in opposition to the monument withdrawal, arguing that the establishment of a monument would "retard the development" of the region by banning 75,000 sheep and 15,000 cattle from their accustomed range and by preventing homesteaders from acquiring property in the area. Any move to make a park or monument designation could expect stiff resistance from the affected states.[37]

Facing these challenges, in 1932, Secretary Wilbur assigned Louis C. Cramton to investigate the withdrawn lands and to make recommendations on how best to resolve the knotty problems of recreation and conservation that the Boulder Canyon Project posed. Cramton, a former congressman from Michigan and a strong advocate of the national parks, had helped the NPS in the fight to prevent irrigators from tapping the waters of Yellowstone National Park.[38] Following Cramton's re-election defeat in 1930, Wilbur appointed him "Special Attorney to the Secretary" and entrusted him with special projects. One of his first tasks had been to devise a system of commercial permits for Boulder City to ensure orderly development rather than the "boomtown" atmosphere typically associated with construction camps.[39] Cramton's commitment to the national park idea and his practical familiarity with the Boulder Canyon Project made him a good choice to lead the recreation investigation. In May 1932 Cramton led a study team into the field to assess the withdrawn lands, gauge their scenic and recreational potential, and determine how best the area could be protected and developed. The study team included Roger W. Toll, superintendent of Yellowstone National Park, Minor R. Tillotson, superintendent of Grand Canyon National Park, Preston P. Patraw, superintendent of Zion National Park, and W. R. F. Wallace, an engineer from the Bureau of Public Roads.[40]

Cramton reported that the withdrawn lands upstream of the dam site were recreationally valuable, highly scenic, and worth protecting. Yet no single solution could be successfully applied to the entire area. Accordingly, he divided the withdrawal into two separate sections and proposed different treatment for each. The eastern section, encompassing the lower Grand Canyon and bordering Grand Canyon National Park, appeared to be of national park quality and deserved to be added to the National Park System. Cramton recommended that the president establish a Grand Canyon National Monument to protect the area until Congress could enact legislation expanding the park's boundaries to include it.[41]

But the western section of the withdrawal, including the dam and reservoir, required a different approach. The scenery here was attractive but not to a superlative degree. More importantly, the presence of the dam, and other land uses like mining and grazing, would conflict with the National Park Service mission of preserving its lands unimpaired. In spite of these problems, however, the area did present outstanding recreational opportunities. The area ought not to become a national park or national monument, yet it should not simply be returned to the public domain, undifferentiated from the millions of other acres of Nevada and Arizona desert. To resolve the problem, Cramton innovated and proposed a new category, one flexible and expansive enough to accommodate the philosophical contradictions the area posed. He recommended that the Boulder Dam area be designated a recreational area in which recreation and scenery would coexist with regulated utilitarian development.

In a memo to Secretary Wilbur, Cramton attested to the national significance of the area's recreational potential. The Boulder Canyon Project's spectacular dam and enormous reservoir would stimulate such interest among tourists, Cramton wrote, that "every transcontinental traveler" would want to see it. Moreover, apart from its appeal as a visual spectacle and engineering marvel, Cramton said, the

> recreational use of this area is an important byproduct… which should not be neglected. It will meet the desires and confer direct benefits upon the many thousands of visitors who will annually come here from the majority of the states of the Union who

have no direct interest in the flood control, irrigation, and power possibilities of the project.

For these reasons, the reservoir area was of national importance and deserved federal protection and management.[42]

Despite its recreational value, however, Cramton recommended that the area "not be given a national park or national monument status." First, although it was remarkable and interesting, the area's scenery was not "outstanding" enough to meet the exacting standards of national park quality. Second, the mission of the National Park Service was to protect scenery, natural features, historical objects, and wildlife from impairment by development. But the dam would be a "recent man-made work" that would be "changed as the necessities of man may from time to time require" and thus did not belong in a national park. Third, allowing the presence of a dam and reservoir as the "central feature" in a national park or monument would undermine the Park Service's efforts to keep dams out of the other parks. "Conservationists have for two generations fought to protect our national parks from becoming incidental or subordinate to irrigation and water supply uses," Cramton wrote. "To deliberately bring into the national park chain and give national park status to such a dam and reservoir," he warned, "would greatly strengthen the hands of those who seek to establish more or less similar reservoirs in existing national parks." Finally, livestock grazing and mining were important established uses of the area, and neither would be appropriate in a national park or monument. Cramton concluded that the reservoir area should be added to the national park system, but with a name—a "recreation reservation," he called it—that reflected its primarily recreational purpose.[43]

Cramton proposed the creation of a "Boulder Canyon National Reservation" that would place the area's "recreational administration in the National Park Service while the primary jurisdiction is left with the Bureau of Reclamation." Although the NPS internally referred to the area as a "recreation area," Cramton's decision to use the term "reservation" was deliberate. Cramton argued that such a designation fit the NPS mission, which—according to the National Park Service Organic Act of 1916—was to "promote and regulate the use of Federal areas known as national parks, monuments, and reservations hereinafter specified." He also pointed out that Section 2 of the act referred to "such national parks and reservations of like character as may be hereafter created by Congress." Thus, he argued, it would be "entirely consistent with history and with principle, as well as with efficiency, for the National Park Service to administer the recreational use of a reservation even though another organization might have a primary interest in such an area."[44]

The Hoover administration acted on Cramton's recommendations. On December 22, 1932, President Hoover signed a proclamation creating the 273,000-acre Grand Canyon National Monument, which provided protection for the spectacular Toroweap section of the western Grand Canyon.[45] With the monument established, action was now needed on the recreation area. Cramton believed that the project could proceed under Secretary Wilbur's authority without an immediate need for authorizing legislation. At the secretary's direction, the Park Service could advise the Bureau of Reclamation on developing recreation policies and drawing up model agreements for concessionaires. Still, Cramton recommended that the project be placed on a firmer foundation for the long term by seeking legislation to formally grant the NPS jurisdiction over the recreation area.[46] To that end, Cramton provided Secretary Wilbur with a draft bill that defined the roles and responsibilities of each agency. Within the nearly 1.2-million-acre proposed reservation, the Bureau of Reclamation would administer the dam and its appurtenant works, while the Park Service would manage the recreational use of the reservoir and its surrounding lands. The purposes of flood control, irrigation, and hydropower, defined in the Boulder Canyon Project Act, would remain the primary uses of the area under Bureau of Reclamation jurisdiction. The Secretary of the Interior would have the power to make necessary regulations within the reservation to protect the project's utilitarian values. While these values would be primary, the legislation would establish recreation and conservation as secondary uses under National Park Service authority. Because they were politically important industries in Arizona and Nevada—and because the Interior Department did not want to unnecessarily provoke resistance to its plans—livestock grazing and mining would be allowed to continue within the reservation, subject to Park Service regulation to make certain that such activities did not interfere with the recreational development of the area. Finally, about 1.25 million acres of previously withdrawn land, not needed for recreation purposes, would be restored to entry under the public land laws, which would also help quiet resistance by the mining and livestock industries in the affected states.[47]

19.3. Commissioner Elwood Mead at his desk in the Interior office building.

In early 1933, National Park Service Director Horace Albright and Reclamation Commissioner Elwood Mead wrote to Secretary Wilbur, concurring with Cramton's recommendations.[48] Mead and Albright identified several recreational activities that the new reservoir would accommodate, including boating, scenic boat tours, wildlife observation, and visiting special points of scenic, archaeological, or historical interest. Fishing, too, would be a new recreational opportunity, as the reservoir would settle out the Colorado's thick and murky silts, making the reservoir a suitable habitat for the trout and bass that sportsmen desired.[49] In general, the development of the reservoir's recreational potential would "increase the tourist business" in Nevada and Arizona.[50] Such benefits would help build support for the project and would certainly generate good public relations for the NPS, USBR, and the Department of the Interior. Secretary Wilbur accepted the recommendations and forwarded the draft legislation to Congress. In February 1933, Representative Samuel Arentz of Nevada and Senator Carl Hayden of Arizona introduced the Interior Department's Boulder Canyon National Reservation bill in the House and Senate.[51]

Although Secretary Wilbur's days in office were numbered—Franklin Roosevelt's inauguration was only a month away—he lobbied on behalf of the legislation. "This largest artificial reservoir in the world," he wrote Congress, "possesses great recreational and educational possibilities which should be conserved." Rather than assigning new responsibilities in the field of recreation to the Bureau of Reclamation, he argued that the Park Service was the proper agency to carry out that conservation. The legislation would avoid the "building up of duplicating organizations." It would also make permanent the areas needed for "reclamation, power, and park purposes" while restoring excess withdrawn lands to entry. Passage of the bills, Wilbur told the chairmen, was "urgently desirable" because it would "replace uncertainty with certainty" regarding NPS authority to manage the reservoir.[52] The American Civic Association, an organization that considered itself a guardian of the parks, approved of the recreation plan and submitted a statement to Congress in support of it.[53] But the legislation was cause for concern among other conservation groups. Walter Huber and William Colby, members of the Sierra Club board of directors, wrote to Horace Albright that they were "a little fearful" about the area's potential to "lower the bars" of park standards and "endanger the areas of strictly National Park caliber" by involving the NPS in "administering considerable areas devoted in part to commercial uses" such as mining, grazing, and water resources development. While the Sierra Club would not "take any part in opposing" the bills, Huber and Colby told Albright that they did not "look with much favor" upon the recreation proposal. Likewise, the National Parks Association expressed misgivings about the creation of what it called "national recreation reservations without standards," but weakened by the Great Depression, the association found itself too "enfeebled" to offer serious opposition.[54] Yet it was not these groups but the strong opposition of Nevada Senator Tasker Oddie—incensed that the federal government had violated Nevada's sovereignty in its administration of Boulder City—that blocked action on the reservation bills over issues unrelated to the concerns of conservation groups.[55] With the bills stalled in committee, the NPS still had no formal role at the Boulder Canyon Project, leaving the Bureau of Reclamation to respond—grudgingly—to the public's recreational demands. The issue would remain for the incoming Roosevelt administration to resolve.

The second phase in the development of NPS-USBR cooperation began during the New Deal era and resulted in the formalization of their recreation partnership through an interagency memorandum of agreement. Taking office in 1933, Franklin Roosevelt and his New Deal administration brought renewed energy and purpose to the National Park Service. Because the national parks and monuments were "places for renewing national confidence," they became "focal points" for New Deal activity.[56] FDR and his Secretary of the Interior, Harold L. Ickes, strongly supported the expansion of the National Park Service. In 1933 Roosevelt transferred to the NPS all the national monuments previously administered by the Department of Agriculture and the Department of War. The administration declared 1934 "A National Park Year," seeking to stimulate the tourist economy by aggressively promoting the park system.[57] FDR also backed the creation of new national parks, including Olympic and Kings Canyon.

The New Deal brought not only the territorial expansion of the National Park Service but an expansion of its functions as well. In particular, the administration responded to the national boom in outdoor recreation demand by supporting the expansion of the agency as the nation's leader in outdoor recreation. In 1933 Albright retired, making Arno B. Cammerer the new director. Cammerer, who served from 1933 to 1940, moved the agency "further along in the direction set by Mather and Albright," fully embracing the new emphasis on recreation and tourism.[58] Under Cammerer—and Conrad Wirth, his energetic assistant director—the National Park Service increasingly provided planning and development assistance to state and local governments. The NPS operated a state parks division, which directed the work of several Civilian Conservation Corps camps in developing state and municipal parks. The 1936 Park, Parkway, and Recreation Area Study Act authorized the NPS to make a survey of the nation's outdoor recreation needs and to partner with state and local governments to plan for meeting those needs. The agency's recreation mission also expanded through the creation of new types of National Park System units, which emphasized recreation rather than significant natural or cultural resources. These new areas included the national seashores, parkways, recreation demonstration areas, and—beginning with Boulder Dam—national recreation areas.[59]

19.4. Arno B. Cammerer, Director of the National Park Service.

In 1935, the Roosevelt administration reintroduced the Boulder Canyon National Reservation bill. The new NPS Director, Arno B. Cammerer, and Reclamation Commissioner Mead prepared the legislation, and Secretary of the Interior Harold L. Ickes forwarded it to Congress. The new bill contained the same division of powers and provisions as the 1933 version. But now, going beyond the earlier bill, it authorized the National Park Service and the Bureau of Reclamation to cooperate in planning and managing recreation at other federal reservoirs associated with future reclamation projects to be built around the West.[60]

Meanwhile, the USBR and its contractor, The Six Companies, Inc., made rapid progress on the dam. In February 1935 the diversion tunnels closed, and the Colorado River—once derided as "too thick to drink and too thin to plow"—began pooling behind the dam, forming a reservoir of sparkling, clear water that "for a distance of 25 miles or more" was "a dark emerald green in the canyons and a deep blue in more open country."[61] In September President Roosevelt visited Boulder Dam and dedicated it to the American people. In his dedication speech, he celebrated the area's recreational potential, describing it as "an immense new park" for "the enjoyment of all the people."[62]

Completion of the dam and the filling of the reservoir put pressure on the Roosevelt administration to resolve the recreation issue. As the number of tourists and recreation seekers visiting the dam continued to grow, it may have seemed that "all the people" were descending *en masse* upon their "immense new park." The Union Pacific Railroad, now dubbing its route through southern Nevada "the Boulder Dam Route," promoted the dam—"the most thrilling sight in America"—as a weekend destination for western tourists and as a side-trip for cross-country passengers.[63] Even airlines enticed passengers with the promise that their plane would circle for a close-up aerial view of the "gigantic dam and lake."[64] Most visitors, however, arrived by automobile. In 1935 Commissioner Mead noted that tourist travel to Boulder Dam and its reservoir was "greater now than ever before," with 365,000 visitors making the trip that year.[65]

Roosevelt had described the area as a "park." If so, it was one without adequate facilities or clearly defined administration. The Bureau of Reclamation reluctantly found itself having to grapple with managing recreation and tourism. Much of the early tourism had simply involved watching the dam's construction from cliff-side overlooks. But with the dam completed and the reservoir rising, visitors now expected boat tours offering an opportunity to see the dam and upstream canyons from water level. The bureau responded by issuing temporary permits to "several boat owners of known responsibility," including those who now plied the reservoir in motorboats and sailboats, as well as commercial boat operators—such as the Murl Emery Company and Boulder-Grand Canyon Navigation Company—which were allowed to operate forty- and fifty-passenger tour boats on the reservoir.[66] "Scores" of swimmers also flocked to the shoreline near Boulder City and at Las Vegas Wash. Walker Young, the bureau's construction engineer in charge of the Boulder Canyon Project, reported, "the reservoir has become a very popular attraction for those interested in boating and swimming." "Every afternoon and evening," he said, "the reservoir is used by a large number of swimmers, with a generous portion made up of children."[67]

The USBR struggled to manage the influx of recreation seekers. In addition to managing the tour boat concessions, the agency now needed to provide boating facilities, including docks, marinas, and launching ramps, and beach and swimming facilities, such as restrooms, changing rooms, food vendors, and lifeguards. The bureau fully expected the National Park Service—

eventually—to assume these responsibilities, constructing needed developments, administering necessary concessions, and regulating visitor use and safety on the reservoir. But until Congress authorized the Park Service to do so, the Bureau of Reclamation had to manage the problem itself. In the meantime, Secretary Ickes approved the bureau's request for NPS guidance in developing its interim recreation policies. Administration fell to the city manager of Boulder City, Sims Ely. Ely already had charge of issuing business permits there, and so the bureau simply added the responsibility for recreation-related permits at the reservoir to his portfolio. Granting concessions and constructing improvements at the reservoir would take time, but action on safety issues could not be delayed. "The conditions at Boulder Dam require immediate attention or loss of life may result from lack of proper safeguards for boating and swimming," Commissioner Mead wrote Secretary Ickes. In August 1935 Secretary Ickes approved an emergency request from the bureau to hire lifeguards and patrolmen to protect recreationists.[68]

19.5. An excursion boat on Lake Mead before the lake rose above the upstream diversion dam.

Although it could not yet step in to manage recreation at the reservoir, the National Park Service was eager to begin developing recreational facilities at the reservoir site. It was able to do so by establishing Civilian Conservation Corps (CCC) camps through its state parks division. NPS Assistant Director Conrad Wirth worked with the USBR to bring camps to the Boulder Canyon Project Area.[69] The first was State Park Camp 1 (SP-1), set up in November 1933 at Overton, Nevada, on the Virgin River arm of the reservoir. CCC enrollees from Camp SP-1 helped develop Nevada's Valley of Fire State Park, building roads, trails, campsites, picnic shelters, and tourist cabins. Enrollees helped archaeologists excavate the "Lost City" pueblo ruins and other archaeological sites that would be flooded when the reservoir filled to capacity. They also built the park's Lost City museum, which housed some of the recovered artifacts.[70]

Although no state park was projected for the lower end of the reservoir, the NPS state parks division established two CCC camps there. In November 1935 and January 1936 the NPS set up Camp SP-4 and Camp SP-6 at Boulder City. The mission of the two camps, known as the "Twin Camps," was to construct "facilities for caring for the tourist travel as well as for local residents" and the "eradication of scars, pits, rubbish, etc.," that were the result of the dam's construction. The camps were needed, the NPS argued, because the USBR and its contractors had "done nothing in the way of accommodations for visitors."[71] Twin Camps enrollees made impressive contributions to the development at the reservoir. They worked to build a swimming beach at Hemenway Wash by clearing and grading the rocky shoreline and spreading truckloads of sand. They built dressing rooms, restrooms, picnic shelters, and floating platforms at the beaches. They built docks and launching facilities for the lake's tour boat operators. Enrollees also rebuilt and landscaped the rustic stone observation point overlooking the dam, and made improvements to the Boulder City Airport, readying it for use by Grand Canyon-Boulder Dam Tours, Inc., which operated sightseeing flights. Finally, they cleared the lakeshore of brush and driftwood logs and also removed logjams and submerged logs—hazardous to boaters—from the reservoir itself.[72]

Through the CCC, the National Park Service built recreational facilities it could not yet operate, while the Bureau of Reclamation, which was responsible for managing them, did not want the job. The situation demanded a resolution. Again, however, Congress failed to enact the needed legislation. As recreational demands mounted, and as the recreation problem became more difficult for the bureau, the agencies and Secretary Ickes finally decided to move ahead, finding the necessary authority in existing legislation. Citing provisions of the Economy Act of 1932, which authorized "interdepartmental procurement by contract," as their basis for authority, the agencies began negotiating an inter-bureau cooperative agreement that would grant the NPS control over recreation at the reservoir.[73]

During the summer of 1936, NPS and USBR officials negotiated a division of administrative responsibilities at Lake Mead—the new official name of the Boulder Canyon Reservoir, which had been renamed in honor of the recently deceased commissioner of reclamation. A special committee, consisting of representatives from the Interior Department Solicitor's Office, the Bureau of Reclamation, and the National Park Service, met to develop a joint memorandum of agreement. They recommended that the management authority at Lake Mead be divided "territorially rather than functionally," in order to avoid conflicts. The bureau would retain jurisdiction over the administrative and employee community of Boulder City, as well as Boulder Dam and its associated engineering works. The Park Service would gain control over both the remainder of the reserved lands within the Boulder Canyon Project Area and the surface waters of Lake Mead.[74]

The two agencies would be territorially separate, but the Bureau of Reclamation would retain certain rights within the National Park Service area. While most roads and highways within the area were assigned to the NPS, the bureau would retain control of the Lower Portal road, which it needed for access to construct and operate the dam's powerhouse. The USBR would likewise retain other utilitarian facilities running through the NPS area, including telephone lines, water lines, and the railroad line. In the future, the USBR would have the authority to construct power transmission lines through the area. The NPS, for its part, would gain control of the Boulder City Airport, which would be "an important link in the chain of accommodations to travelers desiring to visit Boulder Dam and Grand Canyon National Park."[75]

The committee also made recommendations to guide the Bureau of Reclamation's administration, particularly with regard to visitor services at Boulder City. The USBR, the committee suggested, should issue permits for construction of additional privately owned accommodations, such as "auto court" cabins and a campground or "tourist camp." At the dam itself, the committee recommended that the bureau continue to allow visitors to enter the dam. Although a private firm had requested a permit to operate a guide service at the dam, the committee believed that such applications should be denied and that the bureau should operate its own tours. The bureau, they believed, should have "close control" over public contact at the dam in order to coordinate visitation with dam operations. A concessionaire, however, should be allowed to operate a souvenir shop at the dam.[76]

The committee had few similarly specific recommendations for the National Park Service. "The National Park Service for years has been engaged in the planning, development, and operation of recreational areas," the report declared. "For this committee to make detailed suggestions would not only be presumptuous, but… unwise." But they did propose that the National Park Service request a budget appropriation to purchase the surface rights to a group of patented mining claims located near the main highway through the recreation area. They also recommended that the NPS provide fishing and sightseeing access to the river and canyon below the dam.[77]

The cooperative agreement also embraced the key ideas of the Cramton Report. First, the agencies agreed that mining and prospecting could continue in the recreation area—subject to reasonable NPS regulations—"except where they will interfere physically and directly with a legitimate recreational development." Unsurprisingly, given the economic importance of mining in Arizona and Nevada, the Bureau of Reclamation had been inundated with protests from residents and members of Congress from both states, urging that mining not be banned from the area surrounding the reservoir. The committee determined that allowing prospecting and mining to continue—which, it believed, would "not result in injury to the recreational use of the area"— would not only help deflect opposition to National Park Service management but would also "do much to create good will."[78] Second, livestock-grazing received similar treatment. Although the National Park Service banned grazing in the parks (or sought to eliminate it where it existed as a prior use), the committee recommended that the agency authorize grazing in the new national recreation area. "Grazing should be permitted as a gesture of good will toward the project on the part of residents of Nevada and Arizona," they concluded, noting that there was not much actual risk to the area's environment, since "the project area is largely arid and affords little opportunity for grazing of stock."[79] The Lake Mead grazing and mining policies, responses to local environmental and political conditions, would prove to be far-reaching and significant, for they established a precedent of recreation-centered multiple-use management—rather than strict preservation—for future national recreation areas.

On October 13, 1936, Secretary Ickes signed the memorandum of agreement. Recognizing that "a large number of visitors use the lands and waters of the Boulder Canyon Project Area for purposes of recreation," and further noting that the National Park Service had substantial experience in "administering areas devoted to recreational uses," the memorandum established Boulder Dam Recreation Area—the nation's first national recreation area.[80]

In the newly created Boulder Dam Recreation Area, the National Park Service was charged with planning and building recreational facilities, including scenic roads and hiking trails. It also had responsibility for negotiating contracts with the concessionaires who would operate boating marinas, lodgings, visitor services at swimming beaches, and sightseeing tours. The NPS would also regulate mining or grazing in the recreation area.[81] Meanwhile, the Bureau of Reclamation would operate the dam and its related facilities for the purposes specified in the Boulder Canyon Project Act: flood control, water storage, and hydropower generation. The bureau would continue to manage Boulder City and provide space for NPS administrative offices there. It would also establish regulations governing public access to Boulder Dam and its related works and provide for a "skilled guide and lecture service" at the dam.[82]

With the cooperative agreement finally in place, both agencies set about promoting the new Boulder Dam Recreation Area. The Department of the Interior issued press releases promoting tourism in the region. The Bureau of Reclamation used its publication, *The Reclamation Era*, to spread the news as well. Several articles in the magazine touted Lake Mead's proximity to other national parks in the Colorado Plateau region, including Grand Canyon, Bryce Canyon, and Zion, as well as its suitability as a winter resort.[83] The magazine also ran an article by NPS Director Arno Cammerer that highlighted the recreational improvements constructed by the Civilian Conservation Corps and described the various boat tours and lodging opportunities that were available. He wrote, "The great Boulder Dam…, planned originally to provide power, irrigation, and flood control, has now added recreation as a fine bonus for traveling America."[84]

In 1936 Congress appropriated $10,000 for the National Park Service to prepare a master plan to guide development of the recreation area. Developed by Assistant Director Conrad Wirth, the plan laid out proposed roads, trails, overlooks, overnight accommodations, and day-use recreation areas.[85] To carry out the plan, Congress began making large appropriations to finance development, and funding soon reached $100,000 per year. The Civilian Conservation Corps carried out much of the work.[86] The work of the Twin Camps—now designated NP-4 and NP-6—accelerated with the influx of money, and enrollees set about developing new facilities.[87] They built a hiking trail from Hemenway Wash to the summit of Red Mountain, erected and staffed entrance stations to collect statistics on visitation, and converted the vacant Six Companies hospital building for use as the National Park Service's Boulder Dam Recreation Area administrative headquarters. The new headquarters also included a museum featuring natural history and archeological exhibits.[88] In 1937 the National Park Service also entered into an agreement with the Bureau of Biological Survey, to coordinate wildlife management projects (especially to protect bighorn sheep and waterfowl) in the recreation area, parts of which had previously been designated the Boulder Canyon Wildlife Refuge.[89]

In developing the agreement, the National Park Service had sought to tailor the recreation project in such as way as to avoid or minimize local political opposition. But they soon encountered a powerful challenge, despite their best efforts. In 1939 U.S. Senator Key Pittman of Nevada threatened to reduce the size of the Boulder Dam Recreation Area. Pittman represented Las Vegas interests that had opposed continued federal control over the reservoir. They disliked the NPS policy of strictly regulating the business practices—and numbers—of concessionaires. The *Las Vegas Evening Review-Journal*, for example, called for a wide-open approach to development at Lake Mead, including allowing gambling and liquor sales within recreation area boundaries. The paper editorialized that the government should "allow as many resorts to be built as there are people to build them" and denounced the recreation area plan as a federal "take over."[90] The paper and its allies no doubt approved when Pittman introduced legislation to grant 8,000 acres of federal land near Lake Mead to the State of Nevada for development as a state park. Eighty percent of the land at issue was located within the Boulder Dam Recreation Area boundaries, in the vicinity of Las Vegas Wash.

Secretary Ickes strongly opposed the bill. Ickes detested Nevada's famous vices and did not want to see them extended to Lake Mead. On a 1939 trip to Boulder Dam, he briefly visited Las Vegas, which he described as "an ugly little town where gambling dens and saloons and prostitution run wide open day and night." "Three quarters of an hour was all we needed to get the savor of this rotten little town," he wrote. Ickes was glad to return to Boulder City, which, in contrast, he called, "the neatest and most attractive-looking place in Nevada," owing to the federal government's policy of prohibiting gambling, prostitution, and the sale of hard liquor. Boulder City, rather than Las Vegas, was the model for what Ickes had in mind for development at the recreation area. Despite Pittman's assurances to the contrary, Ickes believed that the state park proposal was a ruse, backed by "gamblers and saloonkeepers" in order to build lakeside casinos that would lure Boulder Dam and Lake Mead tourists. When Pittman's bill passed both houses of Congress, Ickes interceded with President Roosevelt, who vetoed the bill on August 10, 1939.[91]

In his veto message, FDR affirmed the "national interest and value" of the Boulder Dam Recreation Area. "All of the people of the United States," he stated, "have a paramount interest in Boulder Dam and its related facilities for water conservation and utilization" as well as "a paramount interest in the outstanding recreational and scenic attractions of Lake Mead and the surrounding territory." Because the area was "worthy of consideration as a possible national park or monument" and had "attracted thousands of visitors from all parts of the Union," it therefore constituted a recreational area "truly national in character." Pittman's bill would have opened the door "to uses which might be at variance with the national interest in the Boulder Dam–Lake Mead region." Moreover, to transfer federal lands from the Boulder Dam Recreation Area to the state would set an "undesirable precedent" for national parks and national forests, FDR declared.[92]

Following the veto, the NPS again proved adept at public relations by accelerating the development of recreation facilities at Las Vegas Wash, the location nearest to the city of Las Vegas—and the area that Pittman had targeted. Although the NPS had initially planned to place priority on other areas, such as Hemenway Wash, Overton, and Pierce's Ferry, it now hoped to win goodwill from the city by channeling funding and CCC manpower to build a swimming beach and campground at Las Vegas Wash.[93] By 1941 the National Park Service had made considerable progress throughout the Boulder Dam Recreation Area. The area now featured swimming beaches, campgrounds, and boating facilities at Las Vegas Wash and Hemenway Wash and a new administrative and visitor-orientation center in Boulder City. The lakeshore was cleared of debris, and trails, scenic roads, and overlooks were completed or under construction.

Although World War II slowed the pace of construction at the recreation area, the postwar period brought the promise of both expansion and development. In 1947 the National Park Service renamed Boulder Dam Recreation Area. It became Lake Mead National Recreation Area after Congress changed the name of the dam from Boulder to Hoover.[94] Also that year, a new inter-bureau cooperative agreement renewed NPS management of the recreation area and extended the area's boundaries southward to encompass the lands withdrawn for the new Davis Dam, then under construction downstream. Deeming it to be "in the best interests of the Government to provide for unified administration of and jurisdiction over this entire area," Secretary Ickes added the Davis Dam's Lake Mohave reservoir and thousands of acres of surrounding land to Lake Mead National Recreation Area.[95]

Building upon the success of the 1936 Lake Mead agreement, the two agencies coordinated recreational planning for other new reservoirs the bureau expected to build in the West.[96] Their partnership was cemented in 1941, when the bureau agreed to fund a major NPS planning study, which resulted in the publication of *A Survey of the Recreational Resources of the Colorado River Basin*, a key document that guided development of the National Park System in the region. In return, the NPS agreed "in principle" to the future possibility of converting Grand Canyon National Monument and Dinosaur National Monument into "multiple-use national recreation areas"—modeled after Lake Mead—should the bureau decide to proceed with building its proposed Bridge Canyon Dam and Echo Park Dam.[97] While the National Parks Association and Sierra Club had been wary but deferential with regard to the Lake Mead issue, both were roused into full-blown opposition by these plans that threatened to impair existing national parks and monuments. Joined by the Wilderness Society, conservationists ultimately blocked both dams in two of the most bruising preservation battles of the 1950s and 1960s.[98] Defeated in its attempt to build the Echo Park Dam, Reclamation succeeded in building a dam at Glen Canyon, an area outside the National Park System. But the USBR-NPS recreation partnership again proved useful: its reservoir—Lake Powell—became the centerpiece of the Glen Canyon National Recreation Area, established by interagency agreement in 1958.[99]

Between 1945 and 1965 the National Park Service and the Bureau of Reclamation entered into agreements establishing nine new national recreation areas: Millerton Lake (1945) and Shasta Lake (1945) in California; Coulee Dam (later renamed Lake Roosevelt) in Washington (1946); Shadow Mountain Lake (1952) and Curecanti (1965) in Colorado; Glen Canyon in Utah and Arizona (1958); Flaming Gorge in Utah and Wyoming (1963); Arbuckle (later renamed Chickasaw) in Oklahoma (1965); and Sanford (later renamed Lake Meredith) in Texas (1965).[100] When an area's scenic and recreational opportunities were deemed to be of national significance, the National Park Service retained management.[101] In other cases, however, the NPS later agreed to transfer management to another agency. For example, Millerton Lake Recreation Area, at the Central Valley Project's Friant Dam, near Fresno, California, became a state park. In other cases, such as Shasta Lake, Flaming Gorge, and Shadow Mountain Lake, national recreation area reservoirs adjacent to national forest land were eventually transferred to the U.S. Forest Service to promote management efficiency and to avoid duplication of administration. The NPS also cooperated with the Bureau of Reclamation at smaller reservoirs that were valuable for outdoor recreation but that lacked sufficient national significance to warrant federal management. In these cases, the NPS did not manage the recreation facilities but instead provided design and planning assistance to state and local agencies. The National Park Service and the CCC developed Lake Guernsey, on the Bureau of Reclamation's North Platte Project, as a Wyoming state park. Cachuma Lake on Reclamation's Cachuma Project in California, developed with NPS guidance, became a Santa Barbara County park in 1953.[102]

The Kennedy administration brought about another shift in federal recreation policy that marked the third—and culminating—phase in the development of USBR-NPS cooperation at Lake Mead, which resulted in the permanent legislative establishment of Lake Mead National Recreation Area. In

1963 President Kennedy's Recreation Advisory Council confirmed the success of the national recreation area experiment. Formed to help guide federal outdoor-recreation policy, the council proposed a "system of National Recreation Areas" to help solve the problem of meeting the "steeply mounting outdoor recreation demands of the American people." To shape the development of this system, the council issued a set of criteria. According to the council, new national recreation areas were to be large areas—more than 20,000 acres—and within a day's drive of major population centers. They were to possess "natural endowments" that were "well above the ordinary" but still "of lesser significance than the unique scenic and historic elements of the National Park System." The new policy echoed the 1932 Cramton Report in its endorsement of multiple-use management, directing the federal agencies that administered national recreation areas to recognize outdoor recreation as the "dominant or primary resource management purpose," while permitting and regulating uses such as grazing, mining, logging, water-resources development, and hunting, so long as they were compatible with—and not detrimental to—recreational use. Finally, the council called for future national recreation areas to be established legislatively by congressional statute rather than administratively through interagency cooperative agreements.[103] In honor of its role as a model for the national recreation area concept and in recognition of its significance as the first area of the national park system set aside for primarily recreational purposes, on October 8, 1964, Lake Mead National Recreation Area became the first national recreation area established by an act of Congress.[104] Comprising nearly 1.5 million acres, Lake Mead National Recreation Area is the nation's largest. It is also the one of the most popular, attracting about eight million visitors per year—mostly from Southern California and the Southwest.[105]

Lake Mead National Recreation Area, created by interagency agreement in 1936 as Boulder Dam Recreation Area, plays an important if unacknowledged role in American environmental history. The first of its kind, it pioneered a new type of National Park System area. It arose out of conflicting impulses. The starkly beautiful desert country surrounding what was then the world's tallest dam and largest reservoir needed resource protection, visitor education services, and recreational planning best provided by the National Park Service. Yet because of the dam, the area could not be a national park or national monument in the traditional sense, where nature was to be preserved without impairment. Instead, it would have to be a new type of area, one that could reconcile mass recreational development and preservation of outstanding natural and cultural resources with mining, grazing, and federal water projects—uses typically considered inappropriate in the National Park System. It also represented a marriage of convenience, which allowed both federal agencies to serve their own bureaucratic interests while garnering wide public support. For the National Park Service, the goal was expansion. The agreement at Lake Mead gave the NPS additional territory to manage, larger development appropriations from Congress, and an expanded role in outdoor recreation. For the Bureau of Reclamation, the goal was to delegate recreation management to another agency so that it could focus on its water engineering mission without being distracted by other responsibilities that fell outside its area of expertise. Both goals depended on winning the blessings of private interests, conservationists, and the general public. This marriage of convenience yielded offspring, too. The first was an eventual system of some forty national recreation areas, inspired by the compromises between recreation, preservation, and development embodied in the Cramton Report. The second, and most significant for American environmental history, was the recreation-planning partnership between the NPS and USBR in the Colorado River Basin, which resulted in the Echo Park Dam and Bridge Canyon Dam proposals. The roots of those pivotal conflicts—which shaped the course of the environmental movement—are embedded in the interagency agreement that established Boulder Dam Recreation Area.

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Endnotes

1. The major standard works on the history of the National Park Service have given little attention to the emergence of the national recreation areas. Richard Sellars' *Preserving Nature in the National Parks: A History* (New Haven, Connecticut: Yale University Press, 1997) and John Ise, *Our National Park Policy: A Critical History* (Baltimore: The Johns Hopkins University Press, 1961) offer brief accounts of the national recreation area concept and its origins. Alfred Runte's *National Parks: The American Experience*, 3rd ed. (Lincoln: University of Nebraska Press, 1997) largely ignores the origins of the national recreation areas, focusing instead on the development of the urban national recreation areas of the 1970s. Even briefer treatment is offered in Ronald A. Foresta's *The National Parks and Their Keepers* (Washington, D.C.: Resources for the Future, 1984) and Robert Shankland's *Steve Mather of the National Parks*, 3rd rev. ed. (New York: Alfred A. Knopf, 1970). The issue is completely missing from the biography of Horace Albright, the National Park Service director most directly responsible for the national recreation area at Boulder Dam; see Donald C. Swain, *Wilderness Defender: Horace M. Albright and Conservation* (Chicago: University of Chicago Press, 1970). Furthermore, since these authors write from the perspective (and records) of the National Park Service, the equally important role of the U.S. Bureau of Reclamation in developing the first national recreation area has been overlooked.

2. The Boulder Canyon Project would deliver irrigation water to the Imperial and Coachella Valleys via the All-American Canal and the Coachella Canal and would supply Southern California's Metropolitan Water District via the Colorado Aqueduct. Southern California claimed 64 percent of the project's hydroelectric power, while Nevada and Arizona each received 18 percent. The name of the Boulder Canyon Project's dam has been the source of much confusion. Although the dam was actually constructed in Black Canyon, after geological studies revealed it to be a superior location, the project retained the Boulder Dam name. In 1930, Secretary of the Interior Ray Lyman Wilbur changed the name to "Hoover Dam" in honor of President Herbert Hoover. Following the election of President Franklin Roosevelt, Interior Secretary Harold Ickes insisted that the government revert to the original name, "Boulder Dam." In 1947, Congress legislatively restored the name Hoover Dam, finally putting the name controversy to rest. Joseph E. Stevens, *Hoover Dam: An American Adventure* (Norman: University of Oklahoma Press, 1988), 18-9, 26-7, 32; U.S. Department of the Interior, Bureau of Reclamation, *The Story of Hoover Dam* (Washington, D.C.: U.S. Government Printing Office, 1971), 15.

3. Charles I. Zinser, *Outdoor Recreation: United States National Parks, Forests, and Public Lands* (New York: John Wiley and Sons, 1995), 598.

4. John P. Orme to the Secretary of the Interior, April 3, 1914, "Proposed National Parks, Arizona," File 0-32, Proposed National Parks, box 635, Entry 7, Central Classified Files,

1907-1932, Record Group 79, Records of the National Park Service, National Archives and Records Administration, National Archives at College Park, Maryland.

5. U.S. Bureau of Reclamation, *Federal Irrigation Reservoirs as Pleasure Resorts* (Washington, D.C.: U.S. Government Printing Office, 1928), II.

6. National Park Service, *Recreational Use of Land in the United States: Part XI of the Report on Land Planning* (Washington, D.C.: U.S. Government Printing Office, 1938), http://www.cr.nps.gov/history/online_books/recreation_use/chap3-1c.htm.

7. "Mead Portrays Dam's Benefits," *Los Angeles Times*, January 28 1931, 11.

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21. "Great Lake Would Open New Scenes," *Los Angeles Times*, May 18, 1930, E5.

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31. "An Act to Establish a National Park Service, and for Other Purposes," August 25, 1916, 39 Stat. 535, in Lary M. Dilsaver, ed., *America's National Park System: The Critical Documents* (Lanham, Maryland.: Rowman and Littlefield, 1994), 46-7.
32. Franklin K. Lane to Stephen T. Mather, May 13, 1918, in Dilsaver, 48.
33. Sellars, 94.
34. "Balzar Charts Nevada's Path," *Los Angeles Times*, January 21, 1931, 6.
35. M. R. Tillotson to the Director, December 10, 1931; Virgin National Park (Proposed) File, box 628, NRA-LM, Entry 7, CCF 1907-1932, RG 79, NACP.
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37. Legislature of the State of Utah, H.J.M. 1, "Memorial to the Congress of the United States Protesting Against the Withdrawal from Entry and Against Preventing Grazing on Public Lands in Northwestern Arizona," March 9, 1931, Virgin National Park (Proposed) File, box 628, NRA-LM, Entry 7, CCF 1907-1932, RG 79, NACP.
38. Horace M. Albright and Robert Cahn, *The Birth of the National Park Service: The Founding Years, 1913-1933* (Salt Lake City, Utah: Howe Brothers, 1985), 117. NPS Director Conrad Wirth described Cramton as "perhaps as much a Park Service man as he was a member of Congress." Conrad Wirth, *Parks, Politics, and the People* (Norman: University of Oklahoma Press, 1980), 30.
39. Stevens, 146.
40. Louis C. Cramton, Memorandum for the Secretary, "Park and Recreational Treatment of the Colorado River Area from the Grand Canyon to the Hoover Dam, including the Hoover Reservoir Area," June 28, 1932, File 0-35, Proposed Parks, Boulder Canyon National Reservation, 1932, box 628, NRA-LM, Entry 7, CCF 1907-1932, RG 79, NACP.
41. Ibid.
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43. Ibid.
44. Ibid.
45. In 1975, Congress expanded Grand Canyon National Park to incorporate the 1932 Grand Canyon National Monument. National Park Service, *The National Parks: Index 2005-2007* (Washington, D.C.: U.S. Government Printing Office, 2005), 21; David Harmon, Francis P. McManamon, and Dwight T. Pitcaithley, eds., *The Antiquities Act: A Century of American Archaeology, Historic Preservation, and Nature Conservation* (Tucson: University of Arizona Press, 2006), 292.
46. Louis C. Cramton, Memorandum for the Secretary, "Park and Recreational Treatment of the Colorado River from the Grand Canyon National Park to Hoover Dam, including the Hoover Reservoir Area," November 21, 1932, File 0-35, Proposed Parks, Boulder Canyon National Reservation, 1932, box 628, NRA-LM, Entry 7, CCF 1907-1932, RG 79, NACP.

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48. Elwood Mead and Horace M. Albright, Memorandum to the Secretary, February 7, 1933, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR.

49. Ibid.

50. Louis C. Cramton, Memorandum for the Secretary, December 22, 1932. File: "H.R. 14662 (S. 5637) Boulder Dam, 72nd Congress, 2nd Session, 1932," box 628, NRA-LM, Entry 7, CCF 1907-1932, RG 79, NACP.

51. "Vast Play Area Sought In Bills," *Los Angeles Times*, February 15, 1933, 6; U.S. Congress, House of Representatives, 72nd Cong., 2nd sess., H.R. 14662, "A Bill for the establishment, development, and administration of the Boulder Canyon National Reservation, and the development and administration of the Boulder Canyon Project Federal Reservation, and for other purposes," February 14, 1933. S. 5637 was the Senate companion bill.

52. Ray Lyman Wilbur to Gerald Nye, February 15, 1933, Colorado River, File 400.11, "Reservation of Lands, 1930-June 1940," box 340, Entry 7, WO-PCF, RG 115, NARA-RMR.

53. U.S. Congress, Senate, *Boulder Canyon National Reservation: Hearing Before a Subcommittee of the Committee on Public Lands and Surveys on S. 5637*, 72nd Cong., 2nd sess., February 24, 1933, 42-3.

54. Walter L. Huber to Horace M. Albright, March 8, 1933, File: 0-35, Proposed Parks: Boulder Canyon National Reservation, Part 3, box 2856, NRA-LM, General, Entry 7, CCF 1933-1949, RG 79, NACP; John C. Miles, *Guardians of the Parks: A History of the National Parks and Conservation Association* (Washington, D.C.: Taylor and Francis in cooperation with the National Parks and Conservation Association, 1995), 135-6.

55. The Boulder Canyon National Reservation legislation also contained some administrative housekeeping language regarding the Bureau of Reclamation's federal reservation at Boulder City and the construction site. Oddie's opposition stemmed from an ongoing dispute between the Department of the Interior and the State of Nevada over the power to tax property and enforce state laws in the area under the bureau's control. He did not make any particular argument against the recreation reservation itself, other than to say the proposed legislation "assembles a number of problems, the solutions of which should be made entirely separate and the subjects of separate bills." U.S. Congress, Senate, *Boulder Canyon National Reservation: Hearing Before a Subcommittee of the Committee on Public Lands and Surveys on S. 5637*, 72d Cong., 2nd sess., February 24, 1933, 13.

56. Sutter, 136.

57. Ibid.

58. Sellars, 94.

59. Harlan D. Unrau and G. Frank Williss, *Administrative History: Expansion of the National Park Service in the 1930s* (Denver: National Park Service, 1983), 129-60.

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61. Wesley R. Nelson, "Boulder Canyon Reservoir," *The Reclamation Era* 25 (September 1935): 180.

62. "Important Dates in the History of Boulder Dam," *The Reclamation Era* 26 (April 1936): 84; Franklin D. Roosevelt, *The Public Papers and Addresses of Franklin D. Roosevelt*, vol. 4, *The Court Disapproves, 1935* (New York: Russell and Russell, 1969), 399.

63. The UPRR offered excursion fares from Los Angeles to Boulder Dam for $11.62. Passengers traveling between Los Angeles and Chicago could add a Boulder Dam side-trip to their ticket for 55 cents. *Los Angeles Times*, November 18, 1935, 10.

64. Western Air Express-United Air Lines advertisements, *Los Angeles Times*, June 28, 1935, A14; *Los Angeles Times*, September 3, 1936, 12.

65. Elwood Mead to Harold L. Ickes, May 6, 1935, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, Washington Office, Project Correspondence File, 1930-1945, Colorado River, RG 115, NARA-RMR; "Park Service to Assist at Lake Mead," *The Reclamation Era* 26 (March 1936): 65.

66. Ibid.; Harold L. Ickes to Sen. Alva B. Adams, March 6, 1939, File 0-35, Boulder Dam, History & Legislation, Part 1, box 2856, National Recreation Areas, Lake Mead, General, Entry 7, CCF 1933-1939, RG 79, NACP; Nelson, 180.

67. Nelson, 180; Construction Engineer to Chief Engineer, June 28, 1935, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR. For a description of the tough-minded Ely, see Stevens, 142-58.

68. Elwood Mead to Harold L. Ickes, July 13, 1935, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR.

69. John C. Page to Elwood Mead, July 12, 1935, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR.

70. Thomas W. Miller, "Narrative Report for the Month of March, 1934," Boulder Dam State Park Camp #1, Overton, Nevada, April 1, 1934, Folder "SP2 Cathedral Gorge Camp, Nevada," box 94, Nebraska SP-5 to Nevada SP-4, Entry 41, Reports on CCC Projects in State and Local Parks, 1933-37, RG 79, NACP; Thomas W. Miller, "Narrative Report for the Months of June & July 1935," Folder "SP1 Boulder Dam—Overton, Nevada," box 94, Entry 41, RG 79, NACP.

71. C. M. Bailey, "Narrative Report of CCC Accomplishments, Sixth Period," n.d., Folder "SP-6 Nevada—Boulder City Camp," box 95, Nevada SP-5 to New Jersey SP-4, Entry 41, RG 79, NACP.

72. Dennis McBride, *Hard Work and Far From Home: The Civilian Conservation Corps at Lake Mead, Nevada* (Boulder City, Nevada: Boulder Images, 1995), 20, 21, 25.

73. Unrau and Williss, 154.

74. Frederic L. Kirgis, George A. Moskey, and Mae A. Schnurr, Memorandum for Under-Secretary West, September 1, 1936, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR.

75. Ibid.

76. Ibid.

77. Ibid.

78. Ibid.

79. Ibid.

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81. Ibid.

82. Ibid.

83. "Boulder Dam a Tourist Mecca," *The Reclamation Era* 26 (August 1936): 184-5; "Park Service to Assist at Lake Mead," *The Reclamation Era* 26 (March 1936): 65.

84. Arno B. Cammerer, "Building a Playground at Boulder Dam," *The Reclamation Era* 28 (November 1938): 222-4.

85. Conrad L. Wirth, "Report on the Proposed Boulder Dam Project Area, Nevada and Arizona, Master Planning Principles and Objectives," May 1, 1936, Colorado River, File 131.24, "Cooperation with National Park Service, through August 1936," box 229, Entry 7, WO-PCF, RG 115, NARA-RMR.

86. Ise, 369.

87. John C. Paige, *The Civilian Conservation Corps and the National Park Service, 1933-1942: An Administrative History* (Denver: National Park Service, 1985), Appendix C.

88. McBride, 30-3.

89. "Memorandum of Agreement between the National Park Service and the Bureau of Biological Survey Relating to the Development and Administration of the Boulder Canyon Wildlife Refuge," March 31, 1937, box 2855 National Recreation Areas, Lake Mead, General, Entry 7, CCF 1933-1939, RG 79, NACP.

90. "Just What is the Plan?" *Las Vegas Evening Review-Journal*, January 30, 1936; "Vegas Group on Record Against New Proposal," *Las Vegas Evening Review-Journal*, April 18, 1939.

91. Harold L. Ickes, *The Secret Diary of Harold L. Ickes. Volume II: The Inside Struggle, 1936-1939* (New York: Simon and Schuster, 1954), 580-1, 588, 693.

92. Franklin D. Roosevelt, "Veto Message of August 10, 1939," File 120–Legislation, "Correspondence relating to national parks, national monuments, and national recreation areas, 1927-1953," box 81, Southwest Regional Office Subject Files, RG 79, NARA-RMR.

93. Arthur E. Demaray to Guy D. Edwards, March 22, 1939, Colorado River, File 400.11, "Reservation of Lands, 1930-June 1940," box 340, Entry 7, WO-PCF, RG 115, NARA-RMR.

94. National Park Service, *The National Parks: Index 2005-2007*, 61.

95. "Modification of Memorandum of Agreement Between the National Park Service and the Bureau of Reclamation Relating to the Development and Administration of the Boulder Canyon Project Area," July 18, 1947, file 201-15, "Recreation Area Policy," Lake Mead National Recreation Area Subject Files, 1936-1969, box 4, RG 79, NARA-Pacific Southwest Region, Laguna Niguel, California (hereafter RG 79, NARA-PSWR); National Park Service, *The National Parks: Index 2005-2007*, 61.

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98. For the Echo Park/Dinosaur National Monument controversy, see Susan Rhoades Neel, "Irreconcilable Differences: Reclamation, Preservation, and the Origins of the Echo Park Dam Controversy," Ph.D. dissertation, (Los Angeles: University of California, 1990) and Mark W. T. Harvey, *Symbol of Wilderness: Echo Park and the American Conservation Movement* (Albuquerque: University of New Mexico Press, 1994). For the battle over Grand Canyon and the Bridge Canyon and Marble Canyon dams, see Byron E. Pearson, *Still the Wild River Runs: Congress, the Sierra Club, and the Fight to Save Grand Canyon* (Tucson: University of Arizona Press, 2002).

99. National Park Service, *The National Parks: Index 2005-2007*, 83.

100. Based on the success of its partnership with the Bureau of Reclamation, the National Park Service also entered into partnerships with other federal water resources agencies. An agreement with the U.S. Army Corps of Engineers created Lake Texoma Recreation Area (1946-49) on the Texas-Oklahoma border. An agreement with the International Boundary and Water Commission created Amistad National Recreation Area (1965) on the Rio Grande, in Texas. Barry Mackintosh, "Former National Park System Units: An Analysis," 1995, http://www.cr.nps.gov/history/hisnps/NPSHistory/formerparks.htm; National Park Service, *The National Parks: Index 2005-2007*, 32, 81, 83, 90.

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102. Ise, 468; Barry Mackintosh, "Former National Park System Units: An Analysis," 1995, http://www.cr.nps.gov/history/hisnps/NPSHistory/formerparks.htm; U.S. Bureau of Reclamation, Cultural Resources, Wyoming, Lake Guernsey, http://www.usbr.gov/cultural/wyoming.html; File 0-41, "Agreement Re: Cachuma Reservoir," and "Friant and Shasta Dams," Lake Mead National Recreation Area Subject Files, 1936-1969, box 1, RG 79, NARA-PSWR.

103. Recreation Advisory Council, "Federal Executive Branch Policy Governing the Selection, Establishment, and Administration of National Recreation Areas," Circular No. 1, March 26, 1963, in Dilsaver, ed., 263-7.

104. National Park Service, *The National Parks: Index 2005-2007*, 61.

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Hydroelectric Power From Eklutna: Reclamation Efforts to Develop Southcentral Alaska During the Cold War Era

By:
John W. Heaton
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Congress charged the Bureau of Reclamation in the Newlands Act,[1] of 1902 with administering a perpetual fund designed to reclaim arid lands for western farmers to keep the Jeffersonian dream of an agrarian society alive in the twentieth century. By all accounts, the efforts of the Bureau have been largely responsible for the development of much of the West's water resources during the twentieth century to provide the foundation not only for agriculture in the region but also the infrastructure for a diversified modern economy. Historians have examined the role of this government agency in providing irrigation water, hydroelectric power, flood control, navigation, and recreation for the benefit of the public. More recently, scholars have emphasized either the environmental impact of dams or the role the Bureau played in expanding the influence of the federal government in the West over the last century. The Eklutna Project, thirty-four miles north of Anchorage, Alaska, offers an interesting case study in Bureau of Reclamation history because it was not implemented as part of a water resource management plan, and the federal government never intended to maintain permanent control of the facilities. Indeed, there was never a need to reclaim arid Alaska lands, and reclamation laws were not extended into the territory. Alaskan territorial officials, at the height of the Cold War, succeeded in convincing the federal government of the need for a cheap and dependable supply of electric power to facilitate the development of a remote, but strategically important, region of the nation. The Bureau of Reclamation planned and funded this technically challenging project and eventually turned it over to local public utilities.

Hydroelectric power is not new in Alaska. In the 1930s, although the state was still thinly populated and little changed in some respects since the days of the gold rush, larger Alaskan settlements nevertheless enjoyed many of the amenities of modern living. They had phone service, water systems, and electricity. Most communities generated power from coal or oil, but occasionally small hydroelectric power plants were used. One such installation was built by private interests in 1929 at the mouth of Eklutna Lake, some 24 miles northeast of Anchorage. The seven-mile-long and one-mile-wide Eklutna Lake, (elevation 868 feet) lies in a steep-sided, trough-like valley some 23 miles long. It is headed by a glacier and a snowfield. The lake overflowed into Eklutna Creek below the rock dam, which had been built to provide a water supply for the small power plant near Eklutna Village, about 8 miles downstream from the dam.

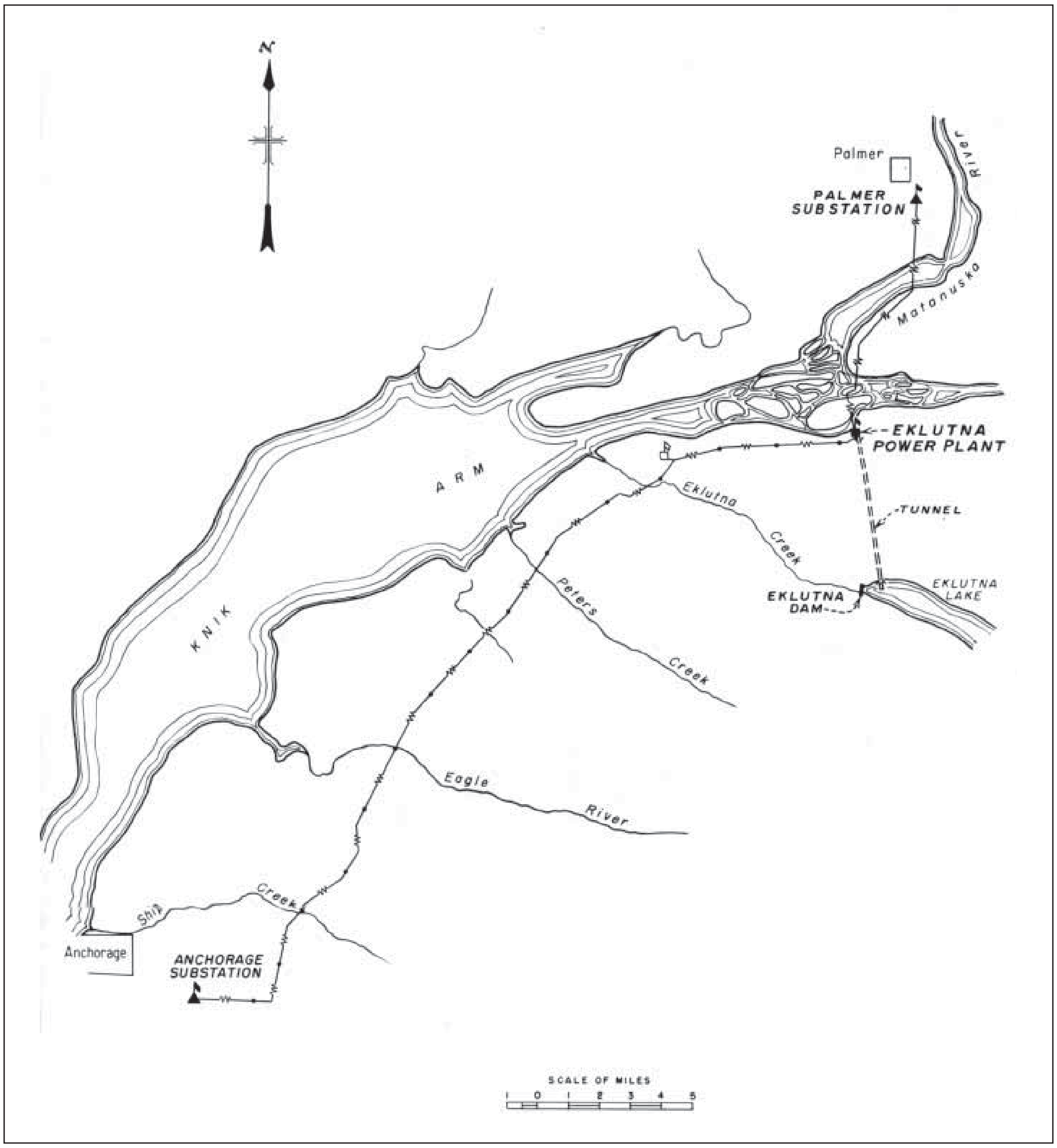
The initial structure was not overly successful because when the water level rose four to five feet above its natural barrier, the slightest leak allowed the water to escape. To remedy the situation, wood pilings were driven across the mouth of the overflow channel, permitting the storage of water to a depth of three to four feet above the natural lake level. In the fall of 1934 contractors built an earth-and rock-fill structure which incorporated portions of the original dam. It provided a more stable water supply which ensured more dependable generation of electricity. In 1943 the city of Anchorage purchased the dam from the private owner, but it grew increasingly clear that the project could not meet the demands of a growing region.[2]

The crisis in the availability of electric power hampered attempts to develop southcentral Alaska and increased in proportion to rising populations beginning in the 1930s. World War II, of course, brought an influx of people to Alaska, particularly to Fairbanks and Anchorage where military construction activities offered employment. But even before the outbreak of war, the population of southcentral Alaska had been rising mainly due to a federal railroad project in the region. Anchorage became the headquarters for these operations in 1914. With completion of the railroad in the early 1920s, which included numerous maintenance facilities and offices in Anchorage, many of the workers chose to remain in Alaska. In the 1930s, the widespread economic fallout of the Great Depression in "the states" helped to develop the agricultural potential of lands north of Anchorage. A government program brought 200 families, displaced by drought conditions in the Midwest, to the Matanuska Valley. With the outbreak of World War II, as the government increasingly recognized the strategic importance of Alaska, men and government resources poured into the territory in unprecedented amounts which helped to boost the population of Anchorage by 500 percent between 1939 and 1945. Housing, never abundant, became extremely difficult to find. Moreover, services could not keep up with increasing demands during these years of initial growth and development. By 1945 the demand for power exceeded supply.[3]

Anchorage Power and Light urgently searched for additional sources of electricity which led it to use diesel generators and even the boiler and generating equipment of a wrecked ship (the *Sacket's Harbor*). Alaska's man in Washington, territorial delegate E. L. Bartlett, attempted to respond to calls for help from many Alaskan towns.[4] The River and Harbor Act of March 2, 1945, had provided for preliminary examination and surveys of Cook Inlet to improve navigation, develop hydroelectric power, and provide harbor facilities. A spokesman for the Corps of Engineers advised Bartlett to introduce legislation which would authorize the construction of a hydroelectric plant at Eklutna.[5]

Representative Ben F. Jensen (R, Iowa), chairman of the House Interior Department Appropriation Subcommittee, became interested in Alaskan development and was largely responsible for making $150,000 available for an investigation of the territory's power resources. An Alaska Investigations

Office was established and under the able leadership of Joseph M. Morgan and his colleagues, an exhaustive investigation of Eklutna and other potential hydroelectric sites was made. The investigation determined that, as of 1949, the utility system serving the Anchorage area and the Matanuska Valley had a production capacity of only 8,625 kilowatts—far short of actual needs. Total Alaskan generating capacity from private plants amounted to 35,931 kilowatts and from public plants amounted to 19,440 kilowatts, for a grand territorial total of 55,371 kilowatts, woefully inadequate for Alaskan needs. Delegate Bartlett asserted in Congress that federal policy had actively and long supported the development of water resources in the West, while not "a thin dime" had been put into Alaskan water power development. He argued that a "start should be made now" because plentiful power was a prime necessity for "a self-sufficient economy," which, in turn, "was essential for national defense."[6]



20.1. Map of Eklutna Project. Map from the 1961 *Reclamation Project Data* book.

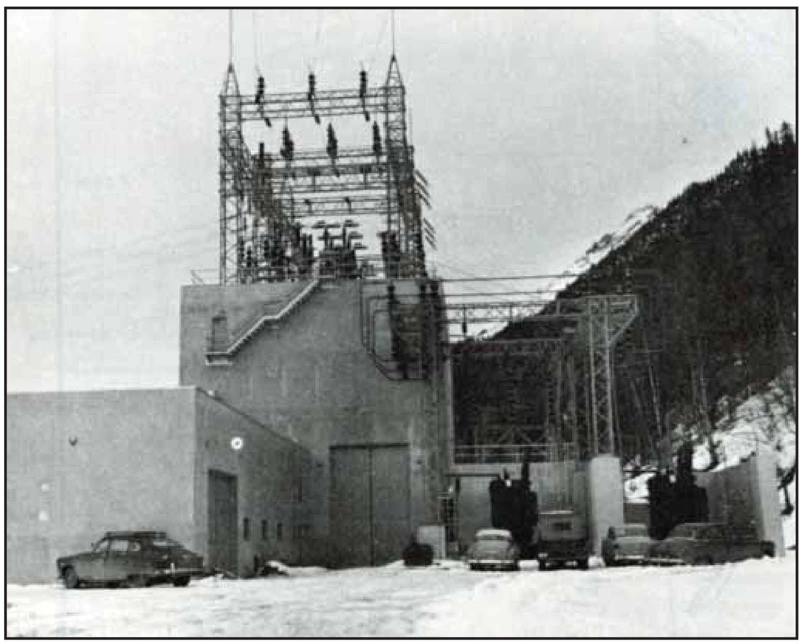
In 1949, the House Public Lands Committee favorably reported a bill which called for the immediate construction of the Eklutna project at a cost of $21,500,000. The Bureau of the Budget gave its approval with the reservation that Federal Reclamation laws were not to be extended to the territory, nor were recreational facilities to be developed along with the project.[7]

The proposed Eklutna facility would replace the old earthen log structure and consist of a low dam raising the level of the lake by two feet, a four-and-one-half-mile tunnel leading from the lake through a mountain to the north, a penstock of 1,250 feet and, at the base of the mountain, a power plant of 30,000 kilowatt capacity. Transmission lines would carry the electricity to the Matanuska Valley and to Anchorage. Not until September 22, 1950, did the Bureau of Reclamation officially announce that initial plans and specifications were being expedited along with a $1.1 million appropriation to enable construction bids to be received as soon as possible.[8]

By February of 1951 the drilling contractor was employing shifts of workers, seven days a week. In the planning stage were 12 permanent homes for employees at the power plant as well as two 10-car garages, a warehouse and water works, roads, general utilities and a 115,000 volt transmission line to Palmer. Palmer Constructor of Omaha, Nebraska, a three-firm organization including Peter Kiewit Sons, Coker Construction Co., and Morrison-Knudsen Co. had won the bid for building the four-mile long, nine-foot diameter, transmountain water diversion tunnel and other facilities at Eklutna for $17,348,865. The bid called for completion of the project within 1,050 days. It was soon apparent, however, that the cost of the project had been underestimated. Bartlett was naturally perturbed when several House Committee members advocated the project's abandonment and he pressed for money to complete Eklutna. Certainly, abandonment would have been an extremely effective demonstration of Congressional displeasure at the cost overrun, but would have meant that the $11,729,000 already expended would have been wasted, as Goodrich W. Lineweaver, Acting Commissioner of the Bureau of Reclamation, pointed out.[9]

On April 2, 1953, after a year's delay and much political maneuvering, the Territories Subcommittee of the House Interior and Insular Affairs Committee debated the Bartlett bill and made a number of recommendations. These were that the cost increase be limited to $30,000,000; that the annual operation and maintenance expenditures be restricted to $120,000; that electricity be sold at no less that 11.5 mills; and that the Department of the Interior negotiate with the city of Anchorage for the purchase of existing hydroelectric facilities and water rights at no more than the original costs minus a reasonable depreciation. Until these stipulations were met, and the Department of the Interior had negotiated with Anchorage, the full House Committee on Interior and Insular Affairs would not take up the matter. After still more debate and the adoption of a number of amendments, among them a cost ceiling of $33,000,000 plus "such sums as may be necessary for the operation and maintenance of the project," the full House finally passed the Bartlett measure on July 30, 1953.[10]

At the Alaskan general election of October 6, 1953, Anchorage voters approved an agreement between the city and the Department of the Interior that stated that as soon as power went on line at Eklutna, Anchorage was to transfer the site of its original hydroplant, together with its water rights at Eklutna, to the Department. In return, Anchorage was to receive some 16,000,000 kilowatts of firm power from Eklutna with monthly credits on the city's electric bill to be given until October 12, 1978, the date on which the license from the Federal Power Commission expired. Eklutna power for Anchorage became a reality when the first 15,000 kilowatt unit went on line in January 1955, and the second in March of the same year. The total project had cost $30,521,183, approximately $2,500,000 less than the amount Congress had finally authorized.[11]



20.2. Eklutna Powerplant. Photo from the 1961 *Reclamation Project Data* book.

Alaska officially entered the union as the 49th state on January 3, 1959, and by then it had become clear that with the rapid growth of the Anchorage metropolitan area, power demand again far outstripped available generating capacity. Bartlett, now the senior U.S. Senator from Alaska, introduced a bill which enabled the Bureau of Reclamation to accept from Anchorage whatever monies were necessary to raise the dam at Eklutna to convert 20,000,000 kWh annual dump power to firm power. At hearings held in May 1960 the small rural electric cooperative associations in southcentral Alaska opposed the Bartlett measure because it allowed Anchorage to purchase extra power at a discount rate at the expense of other consumers of Eklutna power. The Bartlett bill subsequently died.[12]

On March 27, 1964, at 5:36 p.m., an earthquake, registering 8.5 on the Richter scale, shook southcentral Alaska and devastated several communities. Eklutna suffered much damage to its power plant. As soon as possible after the earthquake, the Bureau of Reclamation performed temporary repairs to restore the power plant and pressure tunnel to normal operation and ensure an adequate supply of water. On September 16, 1964, Senator Bartlett submitted a measure on behalf of Senator Ernest Gruening (D, Alaska) and himself which provided that any repair money spent on Eklutna would not be reimbursable from its revenues. The Senator reintroduced the measure in 1965, and the Department of the Interior reported on it favorably in April 1966. But the Bureau of Reclamation had since been forced to construct a new dam—for $121,000 more than the estimated repair costs of the old one. Bartlett asked that the $121,000 be reimbursable while the estimated repair costs be absorbed by the federal government. His measure was signed into law on September 26, 1968, saving Eklutna's power customers $2,805,437.[13]

The new dam, an earth and rockfill structure 815 feet long and 51 feet high constructed downstream from the damaged complex, was finished well ahead of schedule on November 15, 1965. Beginning in 1967 the Alaska Power Administration (APA), a federal agency the Department of the Interior had created, took over operation and maintenance of the facility, a responsibility it maintained until 1995.[14]

During these decades APA operated and marketed the power from two federal hydro projects in Alaska, including Eklutna and Snettisham (U.S. Army Corps of Engineers), a project in southeast Alaska which served the Juneau region. The APA was one of five Power Marketing Administrations through which the federal government marketed power from over one hundred hydro projects developed by the Bureau of Reclamation and the U.S. Army Corps of Engineers throughout the United States. The government built these structures for flood control, navigation, irrigation, and recreation. However, the projects administered by the APA were different in that they were not designed originally as water resource management facilities, nor, according to a recent Department of Energy report, were they conceived as projects that the federal government would permanently control. Instead, the government built Eklutna (and Snettisham) to "encourage and promote economic development and to foster the establishment of essential Industries in Alaska."[15]

By the 1980s Alaska's congressional delegation considered this mission fulfilled and raised the question of divestiture, and the DOE concurred. The APA-run Eklutna project by this time provided only about 5 percent—47 megawatts—of the power for its market area. The proposal garnered widespread support, and in 1997 three local public utilities, Anchorage Municipal Light and Power, Matanuska Electric Association, and Chugach Electric Association assumed ownership and control of 53%, 17%, and 30% respectively of the Eklutna project. The sale of APA assets in Alaska transferred about $80 million to the U.S. Treasury, about 95% of the value in interest and payments the government would have received in lieu of the transfer. Although, as critics of the agreement charged, the government could have received more in an open-market deal, it did remove administrative costs of management, operation, and repair at the facilities, as well as responsibility for damage by potential earthquakes in the future. Moreover, it preserved the original mission of Eklutna by preserving low rates to the region's power users because consumers would have borne the costs of a market-based divestiture.[16]

At the beginning of a new century the Eklutna Project, once held out as a Bureau of Reclamation effort to help power the development of an emerging territorial economy and key component of the nation's strategic defense, now serves as a small cog in a much larger regional energy system. With the Eklutna Project, the Bureau of Reclamation played a key role—one unique in the Bureau's history—in providing the power for the emergence of a modern Alaska. Once the local southcentral population and economy reached critical mass, it was able to generate funds locally to build on the foundation provided by the federal government and to eventually assume control of this source of power.

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Endnotes

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12. E. L. B. Papers, 86th Congress, Legislative Bill File, Box 9, S 3222, Eklutna Power Project, 1959-60.
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The Central Valley Project: Controversies Surrounding Reclamation's Largest Project

By:
Eric A. Stene

Abstract

The Central Valley Project differed from many Bureau of Reclamation projects because it began as a state project in an already agriculturally developed region of California. The Central Valley Project (CVP) was a multipurpose project intended to provide irrigation water to farmland, electrical power for large populations, and flood control protection for the Sacramento-San Joaquin Delta and low-lying areas near the Sacramento River. It was intended for the CVP to accomplish these tasks with a combination of dams, pumping and pumping-generating plants, off-stream reservoirs, and canals. The successes of the CVP came at a cost of controversy about the acreage limitations declared in the Reclamation Act of 1902, environmental concerns, and incomplete structures. This paper will look at the debates surrounding the acreage limitations and the environmental disasters which occurred as a result of CVP construction.

The history of the Central Valley Project is the story of evolution from a state water project to a Reclamation project. Politics and competition for the project stirred between the Bureau of Reclamation and the Army Corps of Engineers. Information about the battle over acreage restrictions will be gathered from interviews conducted in the late 1940s, at the request of the Bureau of Reclamation; Reclamation's project histories about the Central Valley Project; the laws enacted to confront the issue of acreage limitations; and books concerning the Central Valley Project. Proponents and opponents of acreage limitations argued for and against the policy as Reclamation attempted to resolve the controversy surrounding the issue which continued for decades.

A more recent, but often more emotional issue surrounding the CVP, was the project's effect on the environment. Environmental advocates frequently castigated the CVP facilities' effect on the environment. The environmentalist view conflicted with those whose views tended toward the improvement of agriculture, flood control, and electrical power for the human population. As perceptions and priorities changed, so did Reclamation's policies and operations as the Bureau worked to halt damage to the environment while continuing operation of the CVP.

The Central Valley Project was hardly an unqualified success. However, the CVP accomplished many of Reclamation's goals regarding flood control and agriculture. In the process, the natural environment was severely damaged, possibly irreparably so. Politics tended to dictate Reclamation's activities and responses. This had a direct impact on Reclamation's success or lack thereof in its efforts.

The Central Valley Project began as the crown jewel for the Bureau of Reclamation. It became a complex Gargantua of technology and controversy. As the project grew in size and scope, the debate expanded as perspectives and priorities changed. The Central Valley Project became a complex of water projects as Reclamation and the state of California assumed the posture of campaign managers and attempted to make the project all things to all people. The Project accomplished many of the goals set forth by Reclamation and California, but fell short of others as expectations exceeded abilities. Arguments ranging from acreage limitations to environmental damage plagued the project from its beginning. Many of those arguments still have not been resolved, and, depending on each person's perspective, the project is everything from a savior of the arid agricultural lands of the Central Valley and a flood control success to corporate welfare and environmental Armageddon for California.

The Central Valley Project encompasses a large section of California. It is approximately 450 miles long and from forty to seventy miles wide. The warm climate encourages agriculture, but runoff comes in uneven quantities.[1] The Sacramento River watershed receives two-thirds to three-quarters of northern California's precipitation though it only has one-third to one-quarter of the land. The San Joaquin River watershed occupies two-thirds to three-quarters of northern California's land, but only collects one-third to one-quarter of the precipitation. The Sacramento Valley suffers from floods, and floods and droughts alternately afflict the San Joaquin Valley.[2]

As early as the 1870s plans appeared to transfer excess water from the Sacramento River to the often parched tracts in the San Joaquin Valley, but most early efforts concentrated on flood control along the Sacramento River. After years of planning and debate about the proposed project led nowhere, California appealed to the Federal government for assistance. The Bureau of Reclamation and the U.S. Army Corps of Engineers (COE) vied for the opportunity to construct the facilities on the colossal project, which came to be called the Central Valley Project.[3]

History and Construction

California's history encompasses several hundred years of habitation by various groups of Native Americans. European settlement of the state began with the Spanish in the seventeenth century. The Spanish established Roman Catholic missions and other settlements along the California coast, but they rarely ventured to the interior of the territory. Citizens of the United States began immigrating into California in the 1840s. Increasing migratory pressure by settlers on many north Mexican provinces and political machinations by the United States sparked the Mexican-American War in 1846. The United States defeated Mexico in 1848, and the resulting Treaty of Guadalupe-Hidalgo gave Mexico's northern states, including California, to the United States for $10 million. The acquisition of California alone brought the United States riches the country did not know existed, and more problems to go along with them.[4]

The discovery of gold at Sutter's Mill in 1848 brought a flood of Americans into the area, and in 1850 California became a state. The first California Legislature in 1850, immediately enacted laws to deal with the state's most precious resource, not gold, but water. The California Legislature adopted English Common Law's riparian water rights. According to that law, owners of land bordering streams or bodies of water had a right to a reasonable amount of that water. Owners, whose land did not border bodies of water, had no rights to any of the water.[5] The laws severely restricted the number of landholders who had access to California's water supply.

The 1850 California Legislature gave the State Surveyor General responsibility for water development. In 1878 the California government created the office of the State Engineer, which then became responsible for state water planning. William Hamilton Hall, the first State Engineer, conducted a broad study of California's water problems, on a $100,000 budget. Hall planned to appropriate more money and conduct a more detailed study, but for unspecified reasons the legislature abolished the State Engineer position in 1889.[6]

The California Legislature passed the Wright Act in 1887, forming irrigation districts. One Reclamation official considered the Wright Act a model for irrigation legislation in the West.[7] Others claimed it was a good idea, but badly implemented. The districts encountered problems in selling their bonds, filling their reservoirs, and allocating water in a fair manner. Wyoming State Engineer, and future Reclamation Commissioner, Elwood Mead declared the Wright Act, "a disgrace to any self-governing people."[8] California amended the Wright Act in 1897, stopping the establishment of irrigation districts until the formation of the Irrigation Districts Bond Certification Commission.[9]

21.1. B. S. Alexander, U.S. Army Corps of Engineers. Courtesy of the U.S. Army Corps of Engineers.

The Federal government also became interested in California water during the nineteenth century. Lt. Colonel B. S. Alexander studied the Sacramento and San Joaquin Rivers in 1873. In a report to President Ulysses S. Grant, Alexander visualized a system of canals to complete an exchange of water from the Sacramento to the San Joaquin Valley. A report on the "Sacramento Project" in 1904, first connected the U.S. Reclamation Service to water problems in the Central Valley, but that connection remained limited. California created the State Reclamation

Board in 1911 and authorized it to spend $33 million on a flood control project in the Central Valley. The Reclamation Service reported on the possibility of storing Sacramento River water at Iron Canyon near Red Bluff in the Sacramento Valley. In 1920 Homer J. Gault, a Reclamation engineer, and W. F. McClure, the California State Engineer, wrote another report on Sacramento River storage in Iron Canyon, but Reclamation involvement remained nonexistent.[10]

In a 1919 letter to California Governor William Stephens, Colonel Robert Bradford Marshal, Chief Geographer for the U.S. Geological Survey (USGS), proposed a plan to build storage reservoirs along the Sacramento River system, and transfer water from the Sacramento Valley to the San Joaquin Valley via two large canals lying on both sides of the Sacramento River. The plan earned Marshal the nickname, "The Father of the Central Valley Project."[11]

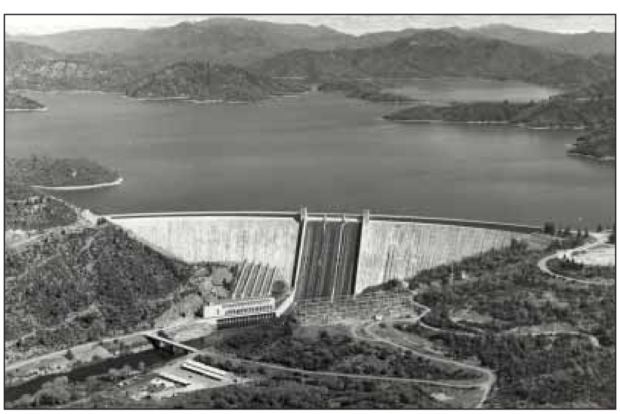
California's government became interested in a comprehensive water plan for the state in 1921. The state legislature directed the State Engineer to come up with such a plan. They wanted it to accomplish conservation, flood control, storage, distribution, and uses for all California water. The legislature directed the State Engineer to estimate total costs for the reservoirs, dams, and any other facilities needed to institute the state water plan. The legislature then appropriated $200,000 to investigate this state water plan and received the report in 1923. Further legislation and appropriations raised the bill to one million dollars. Between 1920 and 1932, approximately fourteen more reports detailed water flow, drought conditions, flood control, and irrigation issues in California. State Engineer Edward Hyatt used the reports to create the California State Water Plan.[12]

Salinity control, especially in the Sacramento-San Joaquin River Delta, became a major concern for northern California water users, and a major component of the California State Water Project. The Delta frequently experienced salinity intrusion, which caused problems for Antioch and Pittsburg. Unless water flowed past Antioch at a minimum of 3,300 second-feet, salt water from San Francisco Bay moved into Suisun Bay and the Delta during high tide, making the water unusable for crops and industry. Between 1919 and 1924 the salt water in Suisun Bay allowed sufficient growth of teredo, a woodboring worm, to destroy wharves and pilings in the Bay valued at $25 million. In 1924, the water reached its lowest recorded stream flow. The maximum salt water content at Pittsburg reached 65 percent. In 1926 Pittsburg and Antioch stopped using water from Suisun Bay for crops and industry. Both communities had used the bay water since the middle of the nineteenth century. In 1930 the state water plan called for construction of a 420 foot dam at Kennett to maintain a regular flow to Antioch, keeping salt water out of Suisun Bay. The California Legislature authorized the future Central Valley Project as a state project in 1933. The act authorized the sale of "revenue" bonds not to exceed $170 million.[13]

Even with the authorized revenue bonds, California found itself unable to finance the project. Further hampering revenue collection was the inability of the state to get the project approved for loans and grants under the National Recovery Act. Reporting to Reclamation on the upper San Joaquin Relief Project, Harry W. Bashore said that the State Engineer considered Kennett Reservoir the cornerstone for the entire Central Valley Project. California applied to the Federal Emergency Administration of Public Works (FEA) for grants and loans, and created the Water Project Authority. The Committee on Rivers and Harbors of the House of Representatives recommended $12 million of Federal money for construction of Kennett (later Shasta) Dam because of the national benefits to navigation and flood control on the Sacramento River. After reviewing the investigations, the California Joint Federal-State Water Resources Commission, the United States Senate Committee on Irrigation and Reclamation, the Bureau of Reclamation, and the Army Corps of Engineers approved and recommended the plan.[14]

California amended its application to the FEA in 1934, and the Water Project Authority became effective. On September 10, 1935, President Franklin D. Roosevelt issued an executive allocation of $20 million under the Emergency Relief Appropriation Act, later reduced to $4.2 million, for construction of the Central Valley Project. Apparently officials assumed the approval was valid under the Emergency Relief Appropriation Act of 1935, but the Supreme Court case of the *United States vs. Arizona* (295 U.S. 174) briefly threatened that assumption. Before 1935 the government sometimes started irrigation projects using relief funds without conforming to the Reclamation Act, but the court's decision said the Secretary of the Interior and the Federal Emergency Administrator of Public Works did not have the authority to construct Parker Dam, on the Colorado River, without the consent of Congress. The Supreme court ruled that such an approach violated reclamation laws.[15]

Technically, authorization of the Central Valley Project could not take place at the time because there were no executive branch findings and approval of feasibility. The technical problems, however, did not stop authorization of the project. Active participation by Reclamation, in matters relating to the Central Valley started in September 1935 at meetings in Sacramento and Berkeley. Reclamation Commissioner Elwood Mead, Chief Engineer Ray Walter, Construction Engineer Walker R. Young, and State Engineer Edward Hyatt attended the meetings. Secretary of the Interior Harold Ickes sent the



21.2. Shasta Dam, Powerplant, and Lake at the location originally proposed for Kennett Dam.

feasibility report to the President on November 26, 1935. Roosevelt approved the Central Valley Project, including Kennett (later Shasta), Friant, and Delta Divisions, on December 2, 1935.[16]

The Rivers and Harbors Act of 1937 reauthorized the Central Valley Project, and authorized $12 million for construction. The Rivers and Harbors act listed improvement of navigation, regulation, and flood control of the Sacramento and San Joaquin Rivers as the first priorities of the Central Valley Project. Reclamation's primary purpose, supplying water for irrigation and domestic use, followed these priorities and power generation ended up the last priority on the list.[17]

The Central Valley Project continued largely unscathed through the late 1940s and 1950s. The government authorized new divisions of the project, with economic feasibility the only necessary criteria. The project became a conglomeration of various Federal and state government agencies by the end of the 1960s. The Army Corps of Engineers built several dams in California under the Flood Control Act of 1944, several of which became integrated into CVP. Meanwhile, California continued with its State Water Project.

The Corps of Engineers (COE) completed Folsom Dam in 1956, turning over operation and maintenance to the Bureau of Reclamation after completion. Congress integrated more COE projects into CVP during the 1960s and 1970s. The Corps of Engineers continued to operate and maintain several dams in the Central Valley and the Corps often found itself holding surplus water at the dams. As a result, Reclamation drew up contracts for releasing the surplus water for irrigation because COE specialized in flood control, not irrigation water supply.

The California State Water Plan, published in 1957, proposed immediate construction of a project on the Feather River. Development on the Feather River marked the inauguration of the California State Water Project, strongly supported by California Governor Edmund G. "Pat" Brown who realized the seriousness of California's water situation. Unlike the CVP, which only compelled repayment for its irrigation projects, the State Water Project required water users to pay all project costs for the $1.75 billion in bonds. According to the Water Education Foundation, although a little more than 50 percent complete in 1994, the State Water Project then consisted of twenty-two dams and reservoirs and the North Bay, South Bay, and California Aqueducts. Approximately 30 percent of the water supplied by the State Water Project irrigated the San Joaquin Valley, while the other 70 percent supplied water for residential, municipal, and industrial use, most of it in southern California.[18]

The Acreage Limitation Battle

One major stumbling block for Reclamation Service involvement in a water project in the Central Valley was the 160 acre limitation imposed by the

Reclamation Act of 1902. According to Norris Hundley, Congress intended for the Act to promote family farms, reclaim arid land, and prevent speculators and large landowners from profiting at government expense. Because of California's history, much of the land was already held in farms the acreage of which greatly exceeded the 160 acre maximum. In 1920, 60% of the land in the Central Valley was held in farms of 1,000 or more acres. This increased to 70% of the land by 1935. Furthermore, much of the land was owned by absentee landlords. Early on, the large landowners in the Valley feared imposition of the acreage limitation, encouraging them to rebuff Reclamation's assistance and look for alternative solutions to their irrigation woes.[19] The acreage limitation controversy only provided the first seeds of dissension, soon followed by the debate over public versus private power and environmental concerns.

Construction on the Central Valley Project started in the late 1930s, and controversy bloomed toward the end of World War II. The first blow to the large landowners came in 1943, when Reclamation ceased its policy of not enforcing the acreage limitation. Following the war, advocates of small farmers formed the Central Valley Project Conference (CVPC) to counter the influence of the Central Valley Project Association (CVPA). George Sehlmeyer, Master of the California Grange, led the CVPC, which extolled the virtues of acreage limitations and public power. The CVPA viewed the two policies as anathema. One of the CVPC's biggest victories came on September 8, 1945, as 200 delegates gathered to attend the Conference's California Water Conference.[20]

The California Water Conference of 1945, with Governor Earl Warren presiding, revealed a large amount of support for the CVP among small, working farmers; though the year's *Project History* reported,

> Paid mouthpieces of the vested interests, such as the Pacific Gas and Electric Company, the Irrigation Districts Association, the California Farm Bureau Association, the State Water Project Authority, and others, without exception, opposed the Bureau's program of wide distribution of benefits resulting from the expenditure of public funds.[21]

Several issues arose at the conference, including: state vs. federal operation and control; public vs. private distribution of power; and COE vs. Reclamation construction of multipurpose projects; and controversy over the 160 acre limitation in the Reclamation Act of 1902. In "Water, Power, and Politics in the Central Valley Project," Charles E. Coate said, "The Army faced a decidedly hostile audience, and the bureau [sic] won the meeting's endorsement"—apparently in spite of the "paid mouthpieces."[22]

Not everyone felt the same fondness for the CVP. Robert Franklin Schmeiser, elected president of the Associated Farmers of California, Inc., in 1947, adamantly opposed Reclamation involvement in the Central Valley. Mainly he opposed Secretary of the Interior Harold Ickes but aimed his wrath at Reclamation. Schmeiser railed against the 160 acre limitation expressed in the Reclamation Act of 1902. He supported COE construction of the Project, believing the Corps would supply irrigation water at a lower rate than the Bureau. Schmeiser did not like Reclamation's "propaganda organization," and argued against "the dictatorial powers they possess over the public."[23] Using the popular vernacular of the time to deal with opposition, Schmeiser called Reclamation officials "Communists" because of the acreage limitations and public power policy, always combustible topics in the CVP.[24]

Others supported the 160 acre limitation. Joseph Claude Lewis strongly supported Reclamation's policy. Lewis, a pro-labor member of a farmers' cooperative in the 1940s, expressed his support for the acreage limitation and low cost public power. He dismissed accusations that Secretary of the Interior Julius A. Krug and Reclamation Commissioner Michael Straus were Communists, a label often placed on himself.[25]

During the mid-1940s, several attempts were made to exempt the CVP from the acreage limitation requirements, but these failed. Even irrigation water released from dams built by the Corps of Engineers became subject to the limitation, but the pendulum soon swung in favor of the large landholders. The death of Franklin Delano Roosevelt in 1945, was followed by the resignation of Secretary of the Interior Harold Ickes. Shortly thereafter Straus curtailed enforcement of the acreage limitation when he ran into opposition in Congress as farms came to be viewed as businesses. One of the strongest opponents was Sheridan Downey of California, who had been Upton Sinclair's running mate for Lieutenant Governor in 1934. Straus remedied the situation politically by defending acreage limitations while creating loopholes for the large landowners—methodologies of bypassing the limitations collectively labeled "technical compliance."[26]

One method open to corporate farms aimed at circumventing the acreage limitation was for each stockholder to obtain water for 160 acres of the land. Often large growers deeded land to children and other relatives while continuing to work the acreage and profit from it. Large landowners also deeded land to employees and then leased back the acreage. In still another scheme, wealthy landowners made accelerated payments. In this process, they paid back the Bureau of Reclamation in a lump sum before the ten-year deadline. This theory operated under the premise that Reclamation could not force the landowners to sell the land once the Bureau had received repayment.[27]

The strategies devised to bypass the acreage limitations placed the issue on the back burner where it silently festered until the 1980s. The Reclamation Reform Act of 1982 recognized the large landholdings of many California farmers. Even though two-thirds of California farms consisted of less than 100 acres, 80 percent of the farmland existed in holdings of over 1,000 acres. Furthermore, 75 percent of California's agricultural production came from 10 percent of the farms. The Reform Act increased the limitation to 960 acres and eliminated the residency requirement for farmers, which Reclamation never really enforced in the Central Valley because most contracts were with water districts, not individual farmers.[28]

Even with Congress' concession on the acreage limitation, those in possession of more than 960 acres pressed to resume circumvention of the law. The pressure paid off as the Westlands Water District received a waiver from the Bureau of Reclamation to continue receiving a subsidized water rate until 2007. This meant payments of $17 per acre-foot rather than $42 per acre-foot. Reclamation went further in 1987, by declaring that farms in excess of 960 acres could continue receiving subsidized water as long as they were part of a farm management system.[29]

Environmental Crises

The 1960s marked the end of the era of large dam building, and caught the CVP in a political and economic whirlpool with no apparent end. All divisions of the Central Valley Project and the features of the State Water Project supply water to the Central Valley, and they all contribute to the environmental problems. One high profile problem which grew out of the CVP was the declining population of Chinook salmon in the Sacramento River. Most attention focused on the winter-run Chinook salmon, listed as threatened species by the Federal government and an endangered species by California. The estimated population of the winter-run Chinook in 1969, reached 117,000. In 1991, only 191 adults returned to the Sacramento River to spawn.[30]

The environmental movement entered the mainstream in the early 1970s. Soon, along with the Endangered Species Act of 1973, signed by President Richard Nixon; the movement created more controversy for the Central Valley Project. The Act established criteria for listing endangered species and protecting them from harm by federal agencies or private concerns. The Central Valley Project felt the consequences of the Endangered Species Act because of project features' impacts on migratory fish species. The Shasta Division dams primarily affected Chinook salmon and steelhead trout.[31] Shasta and Keswick Dams blocked a large number of streams, tributary to the Sacramento River, that were formerly used for spawning by the migratory fish. To solve the problems, managers used fish traps and hatcheries to move the migrating fish upstream or artificially breed them, but they could not keep pace with the decreasing populations. Shasta Dam not only blocked migration upstream, but it blocked the flow of cool water downstream, keeping water temperature above the maximum fifty-six degrees Fahrenheit necessary for the spawning salmon. Beginning in 1992, Reclamation bypassed the turbines in Shasta Powerplant, and released water directly into the Sacramento River to improve conditions for endangered, winter-run Chinook salmon.[32]

The population of winter-run Chinook salmon peaked in 1969, numbering about 118,000 at Red Bluff Diversion Dam. After 1969, populations of salmon and steelhead trout at the dam steadily declined. By 1990 the salmon population dropped to less than 5 percent of their 1969 total. The situation elicited outcries against the Project from environmentalists and commercial fishermen. Reclamation instituted policies to alleviate the impact on the declining salmon population.[33]

Fish ladders and subsurface openings in the dam alleviated the migration problem, but led to another—predatory fish. Environmentalists equated salmon traveling through the subsurface openings, downstream through the dam, to putting the fish in a washing machine, disorienting the salmon when they get clear into the river. The disoriented fingerling salmon became easy prey for squawfish, which often lined up on the downstream side of Red Bluff Dam to feast on the small fish.[34]

In 1987 Reclamation began opening Red Bluff Dam's gates yearly, from December 1 until April 1, for the winter-run salmon returning to spawn at Shasta Dam. Inclusion of the winter-run Chinooks on the listing of threatened species by the National Marine Fisheries Service (NMFS), prompted Reclamation to take further action. Reclamation completed a $17 million renovation of the dam in March 1990. The improvements included a temporary fish ladder in the center of the dam for passage when the gates remained closed. Renovations did not immediately boost the Chinook population. In 1991 the adult, winter-run Chinook count reached a record low of only 191 at Red Bluff Diversion Dam. The population gained in 1992 and 1993 with counts of 1,180 and 341 respectively. The NMFS designated the winter-run Chinook as endangered in December 1993.[35]

Red Bluff Diversion Dam diverted irrigation water into Tehama-Colusa and Corning Canals. The diversion capacity of the first sections of the two canals totaled 3,030 cubic feet per second. A drum and fish screen structure, constructed in the period 1969-1971, prevented fish passing through the headworks from entering the canals. A bypass system returned the fish to the river. In accordance with an agreement with the U.S. Fish and Wildlife Service, Reclamation placed gravel beds along the upper 3.2 miles of the Tehama-Colusa Canal to simulate natural spawning beds. The artificial spawning beds failed to work as planned, and the canal headworks still trapped young fish.[36]

Reclamation developed several alternatives to protect salmon at Red Bluff Diversion Dam. Alternative 4A (Large Pump) would essentially end usage of the dam. The plan called for utilization of a pumping plant to make water diversions, and leave the dam's gates open, to make the river free flowing again. Alternative 4B (Small Pump) would close the gates during the peak summer months, mid-May to mid-July, keeping them open the rest of the year, and using a small pump to assist in diverting water to the canals. Alternative 3A4 (Small Ladder) planned to increase the flow capacity of the left and right fish ladders and add a permanent fish ladder to the center of the dam. Alternative 3C4 (Large Ladder) called for modification of the right fish ladder for greater flow capacity and addition of a permanent center fish ladder. The plan would replace the left fish ladder with a "state-of-the-art fish ladder."[37] By the end of 1994, Reclamation had not decided on which plan to use. Residents of Red Bluff became concerned that some of the proposed alternatives for protecting the salmon, would alter the recreation potential of Lake Red Bluff, behind Red Bluff Diversion Dam, and discourage travelers along I-5 from stopping at the city of Red Bluff, thereby affecting the community's recreational revenue.[38]

The powerful pumping plants in the Delta Division had a major, and often detrimental effect, on stream flow in the Delta and the San Joaquin River Basin. During periods of low water flow and high quantities of exports, the Delta pumps actually reversed the flow of the San Joaquin River, taking it back upstream. Through the Delta's transport system, water normally traveling to the west, toward San Pablo Bay, instead moves back toward the east and south. The "reverse flows" disorient migratory fish, often luring them to the pumps, and draw salty ocean water into the San Joaquin River and other waterways.[39]

In 1944 Reclamation officials realized the salinity problem in the Delta was more pronounced than they previously thought. Charles E. Carey, the Region Two Director in 1944, believed Shasta Dam could not entirely control the salinity problem, precluding use of the Delta as a reservoir as planned at one time. Carey announced some possible alternatives to alleviate the salinity problem: build a closed conduit through or around the Delta to carry Sacramento River water directly to the other side without letting it mix with Delta water; change the Water Exchange Contract to make the water quality requirement less extreme (Carey believed this unlikely, but others claimed it was possible); control the Sacramento River tributaries to control salinity and assure water quality; build Folsom Dam.[40] The proposed closed conduit foreshadowed later plans for the Peripheral Canal.

In the course of Delta Division development, though not built, the Peripheral Canal became one of the most controversial elements of Division planning. Reclamation proposed the Peripheral Canal to the Interagency Delta Committee (IDC) in early 1963, as an alternative water transfer system. By early 1965 the proposed canal had almost universal acceptance in the Delta region. California wanted Reclamation to design and construct the Peripheral Canal, then the state would assume control of the feature. Reclamation did not want state control of the canal, but did not have the authority to build it. California's Department of Water Resources (DWR), on the other hand, did have the authority to construct the canal.[41]

The IDC pointed out that much of the Peripheral Canal route would parallel Interstate 5, and material excavated from the canal could be used as highway fill. In January 1968 the California Departments of Water Resources and Public Works executed an agreement under which Public Works advanced $2 million to purchase rights of way in San Joaquin County for the canal. DWR agreed to repay the money when canal construction began, or no later than January 1, 1976.[42]

Changing attitudes in the United States, toward the environment and a myriad of other issues, soon infected perceptions of the Peripheral Canal. Contra Costa County opposed the canal because residents viewed it as another way to transport fresh water, out of their locale, to southern California. About the same time, questions arose about the environmental impact of the Peripheral Canal on fish populations in the Delta and the Central Valley. Environmentalists believed the canal's outlets would draw fish to them. They also believed the nitrogen-rich water from agricultural drainage could foster algae growth, stagnating waters and suffocating the fish.[43]

In a December 4, 1969, speech to the Irrigation Districts Association, William Gianelli, Director of DWR, responded to the environmental arguments, contending, "Californians must not 'fall into the quagmire trap of Chicken Little emotionalists."[44] The draft environmental impact report of 1974 received such a negative response, DWR decided to take some extra time to prepare an acceptable final report. Early in 1975, with construction of the Peripheral Canal scheduled to commence that summer, Director of DWR John Teerink announced a one year delay.[45]

The Department of Water Resources "proposed an amalgam of joint state-federal programs and facilities," including the forty-two mile Peripheral Canal, in 1977.[46] DWR contended the canal would circumvent the Delta channels and carry water more efficiently from the Sacramento River to the pumping plants of the CVP and the State Water Project. The canal could release fresh water into the Delta at certain points along its reaches to support irrigation, to benefit fish and wildlife, and to combat salt water intrusion. Supporters, including the Metropolitan Water District of southern California and various agribusinesses, argued the canal would help end the reverse flows caused by the south Delta pumps. Opponents continued arguing against on the basis of the environmental impact of the canal and further exports to southern California. A referendum on the entire project went before California voters as Proposition 9 in 1982. Proposition 9 failed because of cost (an estimated $3.1 billion) and environmental concerns. Other alternatives surfaced after the defeat of Proposition 9, but none went forward.[47]

Studies link several factors to the decline of the Chinook population including predation by two species introduced into the Delta, striped bass and Colorado River squawfish; lack of water flow in the rivers because of upstream dams; and disorientation and destruction by the Delta Division pumping plants. The striped bass population also experienced large declines. Another species facing declines and possible extinction was the three inch long delta smelt. A fish found only in the Sacramento-San Joaquin Delta, the smelt faced destruction by the same forces as the Chinook salmon. The California Fish and Game Commission rejected the smelt for a state listing as a threatened or endangered species, but in March 1993 the U.S. Fish and Wildlife Service listed the smelt as a threatened species under the Federal Endangered Species Act.[48]

Reclamation developed the Delta Division in an area ripe for controversy, before and after construction of the Central Valley Project. Special interest groups competed to use the Delta and its water for their own special interests. Some groups argued for land use zoning areas strictly for municipal purposes, recreational development, fish and wildlife enhancement, or maintaining the Delta in its "natural" state. Returning the Delta to its natural state seems the least likely, and indeed the most farfetched, idea. The Delta's true natural state began disappearing over a century ago as river diversions, hydraulic mining, industrial development, agricultural development, and the building of state and Federal water projects transformed the region.[49]

The Central Valley Project Improvement Act of 1992 (CVPIA) started the CVP in a new direction. President George H. W. Bush signed the bill as part of the Reclamation Projects Authorization and Adjustment Act of 1992, over the objections of California Governor Pete Wilson and Central Valley legislators. Environmentalists considered the act a victory, while California agricultural leaders considered it a disaster. The CVPIA reallocated 800,000 acre-feet of CVP water (600,000 in dry years) from Valley farmers toward the restoration of Central Valley fisheries. CVPIA limited renewed agricultural water contracts to twenty-five years with no long-term renewals. The Central Valley Project Improvement Act opened a new political pandora's box in California.[50]

In another area of the Central Valley Project, Friant Dam was blamed for the extinction of a large run of Chinook Salmon on the San Joaquin River. The Bureau of Reclamation is also faulted for not exercising its responsibility to wildlife concerns. In *Overtapped Oasis*, Marc Reisner argued that several amendments were passed concerning fish and wildlife, but Reclamation supplied less than 100,000 acre-feet of fresh water for state and federal refuges.[51]

The most traumatic environmental consequence of the Central Valley Project proved to be the Kesterson Reservoir disaster. Reclamation began construction of the San Luis Drain in 1968, to transport wastewater to the west Delta. The Drain terminated at a series of twelve manmade ponds collectively called Kesterson Reservoir. Kesterson was planned as a regulating reservoir to hold drainage from lands irrigated by San Luis Dam until the water could be flushed into the Delta during winter.[52]

Kesterson was designated a national wildlife refuge, and in the early 1980s Californians learned the price wildlife paid for using it. Pollution entering Kesterson Reservoir in drainage from the San Luis Unit via the San Luis Drain was discovered to have caused deaths and deformities in waterfowl in the refuge. The pollutants included salts, pesticides, and trace minerals, most notably selenium. Reclamation responded by closing the refuge. This action brought protests, forcing Reclamation to change its stance. The Bureau then announced it would end irrigation supplies to the farmers Reclamation deemed most responsible for the runoff. It was then the farmers' turn to protest. They successfully forced Reclamation to rescind its order.[53]

In the mid-1980s, California officials warned pregnant women and children not to eat waterfowl from Kesterson. By the end of the 1980s, sirens warned the birds away and fences kept others at bay. Reclamation filled the reservoir in with dirt in 1988, and the ground was kept level to prevent the accumulation of standing water. Later studies showed that the amount of selenium present still exceeded safe levels. The pollutants' effects were not limited to the wildlife at Kesterson Reservoir. Farmers affected by the runoff sued Reclamation for alleged damages to fields that the farmers claimed resulted from Kesterson leakage. After closure of the San Luis Drain, the Westlands Water District received 38 damage claims from farmers and landowners claiming the action diminished property values and resulted in lost crops.[54]

The internal battle over water in California evolved with the onset of the environmental crises. Early in the twentieth century, battle lines formed between northern California (extending north from the borders of Ventura and Los Angeles Counties) and southern California. By 1990 the opposing forces realigned into agricultural, urban, and environmental interests. Gaining the upper hand came through various alliances between the conflicting groups.[55]

Overview

The Central Valley Project is a complex operation of interrelated divisions. Shasta Dam, at one time considered the key to the Central Valley Project, acts as a flood control dam for the Sacramento River. Shasta stores water for controlled releases downstream. The Trinity River Division diverts surplus water from the Trinity River, in the Klamath River Basin, into the Sacramento River. Water from the Trinity River Division enters the Sacramento at Keswick Reservoir in the Shasta Division. Downstream from Shasta Division, the Sacramento River Division supplies Sacramento River water to Tehama, Glenn, Colusa, and Yolo Counties for irrigation. Releases from Shasta Division help control salinity in the Delta Division

The American River Division provides flood control on the American and the Sacramento Rivers. The division supplies irrigation water along the Folsom South Canal. The American River Division's Sly Park Unit, essentially operates independently from the rest of the Division, irrigating parts of Placer County. The Friant Division impounds or diverts the entire flow of the San Joaquin River, except for flood control and irrigation releases. Friant Dam sends irrigation water south through the Friant-Kern Canal, and north through the Madera Canal. The Army Corps of Engineers built New Melones Dam and Powerplant on the Stanislaus River from 1966 to 1979. The COE turned the dam over to Reclamation in 1979. The dam primarily operates as a flood control and power facility, but Reclamation has contracts to supply water to two water districts in the area.

The Delta Division is the hub around which the Central Valley Project rotates. This Division contains the facilities for transporting water from the Sacramento River to the San Joaquin Valley and for controlling salinity in the Delta Division. The Delta Cross Channel diverts water from the Sacramento River to the Tracy Pumping Plant, the Contra Costa Pumping Plants, and the intakes of the Contra Costa and Delta-Mendota Canals, sending the much needed water south into the San Joaquin Valley.

The San Luis Unit provides storage for the Central Valley Project for dry seasons. The Unit is a joint venture between Reclamation and the California Department of Water Resources. The Gianelli Pumping-Generating Plant, one of the joint facilities, pumps surplus water from runoff and melting snow from the Delta-Mendota Canal and the California Aqueduct into San Luis Reservoir, the largest offstream storage reservoir in the United States. When water flow through the Delta Division becomes too low, water is released from San Luis into the Delta Mendota Canal and the California Aqueduct. The San Felipe Division diverts water from San Luis Reservoir into lands west of the Coastal Mountain Range, south of the San Francisco Bay.

Congress authorized the Allen Camp Unit of the Pit River Division on September 28, 1976. The Allen Camp Unit in Lassen and Modoc Counties of northeastern California, was to consist of Allen Camp Dam on the Pit River, Hillside Canal stretching 25 miles to the east, and Pilot Canal branching off Hillside to the southeast. The Concluding Report of 1981 determined the Unit was infeasible and the project was canceled.

The Central Valley Project plans encompassed thirty-five counties in an area about 500 miles long and 60 to 100 miles wide, making it the largest Reclamation project.[56] The CVP contained some of the country's largest dams, Shasta and San Luis among them. Reclamation intended Auburn Dam, on the American River, to be the largest on the Central Valley Project, but political turmoil left the dam incomplete and in limbo.

In spite of the social, environmental, and political controversy surrounding the Central Valley Project, it remains an impressive accomplishment. The Central Valley contains three-quarters of the irrigated land in California, and one-sixth of the irrigated land in the United States. The Central Valley's annual farm production exceeds the total value of all the gold mined in California since 1848.

The Central Valley Project ranks first among Reclamation projects in value of flood damage prevented between 1950 and 1991. During that time period the Central Valley Project prevented more than $5 billion in flood damage.[57]

Conclusion

The Bureau of Reclamation received a large amount of criticism over the Central Valley Project and indeed the application of the Reclamation Act to the Central Valley proved inconsistent with most other Reclamation projects. The later environmental impact of the project also created a storm of controversy. So much so that in recent years the Central Valley Project became a political and environmental bombshell, and a victim of changing times. California politicians soon avoided dealing with the CVP and the State water projects, viewing both as machines of political suicide. With these thoughts in mind it is important to understand the Bureau of Reclamation's role and position in order to understand the Bureau's actions.

The Bureau of Reclamation is a Federal Government agency, subject to the whims of a parade of politicians who make their way in and out of government office. The Bureau depends on the good graces of these politicians for funding and for it's very existence. The Central Valley Project placed the Bureau in a position in which, in a highly politicized environment, it struggled to balance the wants of politicians with the requirements of the Reclamation Act and the environment.

The initial controversy involved acreage limitations. The Reclamation Act required that farms receiving water could not be larger than 160 acres. The Central Valley had been settled and the acreages established long before Reclamation entered the scene, unlike most other Reclamation projects. The large landholders also held considerable political clout in northern California. Furthermore, the acreage limitation was viewed by many in the mid to late 1940s as un-American and possibly Communist, a grave label to deal with at the time. Finally changes in the country's leadership affected how the Interior Department's leadership viewed the acreage limitation, from the time of Franklin Delano Roosevelt to George H. W. Bush.

The other controversy involved the impact of the CVP on the environment. In the early decades of the project, the environment was not an overriding concern in the country, so it was not a factor in the initial design and construction of the CVP. The environmental movement gained momentum with the Endangered Species Act. From then on, politicization of the environment impacted operation of the CVP and pressed the need for modification of the Project's facilities.

Like the acreage limitation controversy, the amount of concern about the environment depended on the political concerns in Washington and the political necessities of the Interior Department and the Bureau of Reclamation. When environmental concerns became apparent and paramount, Reclamation moved to deal with them, although not as quickly as many would have liked. Whether it was Kesterson or Chinook salmon, much of the damage had been done before most people became concerned.

The Bureau of Reclamation is run in accordance with the wishes of Congress and the President, and much of its efforts are geared toward remaining a viable entity and surviving in a political arena. These variables dictate Reclamation's activities. The Central Valley Project certainly had its drawbacks. There is no argument against that. It is also important to realize that the CVP achieved many of the goals set for it. Irrigation, electrical power, and flood control all serve mankind, as was important at the time construction began. Contemporary values aside, the Project was a success in those terms. Success of the Central Valley Project also exacted a terrible price.

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Bumpy Road For Glen Canyon Dam

By:
W. L. Rusho

Basic Concept and Purpose

Probably no dam built in America has been so controversial as Glen Canyon Dam. Built in the late 1950s and early 1960s, the dam was planned and designed to be a contributor in a long dream to subdue and conquer the earth, or as was often heard in pioneer days, “to make the desert blossom as the rose.” Its basic purpose was to allow increased irrigation and other water development in the entire Upper Basin of the Colorado River, including Colorado, Utah, Wyoming, and New Mexico.

My experience with the dam is intensely personal, as I had been employed during its construction as Public Affairs Officer for the Bureau of Reclamation (BR). For over five years I rode the monkeyslides, conducted tours for reporters and dignitaries, wrote articles and news releases, drafted speeches, conducted ceremonies, produced motion pictures, and directed the guide service and all photography. In late 1963, when the dam was virtually finished, I was transferred to the Salt Lake City BR Regional Office, which had jurisdiction over Glen Canyon Dam. From that time on I continued to be regularly involved in developments at the dam, both by many personal visits and by reports from others. Even after my retirement in 1988, I worked as a contractor producing motion pictures concerning operation of the dam.

Considered as a lineal descendant of the many dams constructed by the Bureau of Reclamation, Glen Canyon Dam was not unusual. Designed to be a storage dam—rather than a flood control structure—its purposes were to hold as much water as possible, release only what was necessary, and fluctuate releases as drastically as required to maximize revenues from hydropower production. After the last of eight generators came on the line in 1966, virtually the only restrictions on its operation derived from the 1922 Colorado River Compact, the 1944 Treaty with Mexico, as well as a number of related laws, all of which comprised what was loosely termed “The Law of the River.”

Early History of the Glen Canyon Dam Concept

Actually, lower Glen Canyon, near where the dam was built from 1956 to 1964, had been eyed many decades earlier by hydrologists and engineers, not for a water storage dam, but for a flood control dam.

In 1906 and 1907 a tributary flood on the Salt River caused the Colorado River to break through an irrigation gate south of Yuma, Arizona, and to flow unchecked for two years into the Salton Sink of California, thus greatly enlarging the Salton Sea. After the gap was finally closed by dumping huge amounts of rock into the breach, the river returned to its original course toward the Gulf of California. But the need for a flood control dam and reservoir was made apparent to all.

In 1921, U.S. Geological Survey engineer Eugene C. LaRue proposed, to an obsession that Glen Canyon should be the logical site for the needed flood control dam. A reservoir there would hold a vast amount of water, and, even more important, its upstream location would allow all locations downstream to be free of floods, allowing river flows to be available for irrigation and municipal developments.

While the engineers were looking at possible dam sites, politicians, water managers, and lawyers were scheduling meetings with representatives of all the states within the Colorado River Basin to divide up the obviously limited (except during rare floods), flows of the river. Agreed upon and signed in 1922, the Colorado River Compact substantially divided the flows of the river between what was termed the Upper and the Lower Basins of the river, to be measured at Lee Ferry, Arizona, (a point one mile below the river gauge at Lee's Ferry). Furthermore, as a concession, the Upper Basin agreed to guarantee 75 million acre feet delivery to the Lower Basin in any ten year period, amounting to an average flow of 7.5 million acre feet (m.a.f.) annually.

E. C. LaRue was frustrated in his campaign to have Glen Canyon made the site of the flood control dam. During the 1920s, the focus for a flood control dam shifted instead, first to Boulder Canyon, and then to Black Canyon, both within a few dozen miles of the then small town of Las Vegas, Nevada. A dam at Black Canyon would be much closer to the major hydropower markets of southern California. It would require less concrete for its V-shaped canyon, compared to Glen Canyon's U-shape. Also, a dam in Glen Canyon would be in the Upper Basin, which might be administratively difficult for Lower Basin officials to handle. The Boulder Canyon Project Act, passed in 1928, authorized the construction of what we now know as Hoover Dam.

Although the Bureau of Reclamation had officially reserved Glen Canyon as a possible dam and reservoir site soon after World War I, construction of Hoover Dam in the early 1930s seemed to obviate the need for another main stem dam. In 1936, therefore, the National Park Service, encouraged by Interior Secretary Harold Ickes, proposed an Escalante National Monument, to cover 6,968 square miles of southeastern Utah—twice the size of Yellowstone National Park.[1] The proposed monument would have included all of Glen Canyon as well as considerable public land then used for grazing.

In 1938 combined opposition from ranchers forced the Park Service to reduce the size of the proposed monument to 2,450 square miles, eliminating most of the grazing areas, but leaving Glen Canyon. Then the State of Utah weighed in, undoubtedly with Bureau of Reclamation's covert urging—favoring continued reservation of Glen Canyon as a possible reservoir site rather than part of a National Monument. Stalemated, the Escalante National Monument proposal slowly died of inaction as the Nation turned its attention to World War II.

For many years after the 1922 Compact was signed, water use in the Upper Basin was so small that there was no problem delivering the required average of 7.5 m.a.f. yearly to the Lower Basin. In 1944 when the United States agreed, by treaty, to deliver 1.5 m.a.f. of Colorado River water annually to Mexico, plenty of water still flowed by Lee's Ferry for that purpose. But water demands were continually growing, not only in the rapidly expanding economy of California, but also in the Upper Basin, where farmers and water managers envisioned a number of possible projects that would consume available water.

The Colorado River Storage Project Plan (CRSP)

Soon after World War II, Bureau of Reclamation officials printed a report entitled *The Colorado River—A Natural Menace Becomes a National Resource*,[2] in which a large number of potential projects were outlined for both the Upper and Lower Basins. Key to enabling several water projects in the Upper Basin was to be large storage capacity reservoirs that would help meet the Compact commitments to the Lower Basin. For this role, a large dam at Glen Canyon would be vitally important, as its potentially huge pool of water would insure that, in case of a severe drought, such as occurred in 1933 and 1934, irrigation and municipal projects upstream would not be denied their regular allotment of water. Other, much smaller, storage reservoirs were also envisioned on tributary rivers upstream from Glen Canyon Dam. In 1946, however, this "wish list" of projects was not yet a fully developed plan.

Eight years later, the Bureau of Reclamation published a report, actually a proposal for legislation, for what was to be termed the Colorado River Storage Project.[3] Essentially, this was a refinement of the 1946 list of potential projects, all integrated into a comprehensive plan incorporating storage dams and reservoirs to meet downstream commitments and to produce hydroelectric power. "Participating Projects" would then be built to develop water for irrigation and for municipal and industrial uses, while revenue from the sale of hydropower would fully repay the costs of the storage projects. Although it was not called a subsidy, the hydropower revenue would also materially assist the repayment of Participating Project costs. Altogether, it appeared to be a neat package—except for one particular feature—the proposed Echo Park Unit.

Congressional Authorization

Along with the Glen Canyon Unit (dam, reservoir, and powerplant), the Echo Park Unit was designed as a storage unit. Compared to Glen Canyon's potential storage of 26 million acre feet of water, Echo Park would hold only about one-fourth as much, but Echo Park received the major portion of attention during Congressional hearings for one reason—the dam and reservoir were to be located in Dinosaur National Monument, a segment of the National Park System.

Leading the campaign against Echo Park Dam was David Brower, Executive Director of the Sierra Club. By his ability to locate arithmetic errors in the Bureau of Reclamation's estimate of reservoir evaporation and through his public interviews, speeches, writings, and advertisements, the dam fell into disfavor with Congressmen, and it was eliminated from the CRSP bill. In his campaign, however, Brower linked Echo Park Dam with Glen Canyon Dam, stating that Echo Park Dam would not be necessary if the height of Glen Canyon Dam was built higher to allow more water storage. In the early 1950s, therefore, Brower raised no objection to construction of Glen Canyon Dam.

Many years later, during 1999 and until his death in 2000, Brower maintained that if, in the 1950s, he had known how beautiful Glen Canyon was, he could have eliminated Glen Canyon Dam from the CRSP proposal by using the Congressional backing that he then possessed. Considering the political power in Congress then available to Upper Basin interests, figures such as Congressman Wayne Aspinall of Colorado and Senator Arthur Watkins of Utah, it is doubtful that Brower was correct in his half-century latter-day second-guessing. Even Lower Basin legislators, such as Representative Stewart Udall and Senator Barry Goldwater, both of Arizona, and to their later regret, supported the CRSP.[4]

Brower's verbal association of proposed dams in Echo Park and Glen Canyon has led many newspaper reporters, writers, and other casual observers to conclude that a dam in the latter was a substitute for the former. Actually, nothing could be further from the truth. The Bureau of Reclamation had estimated that something over 30 million acre feet of storage would be necessary to meet downstream needs should a drought such as that of 1933-1934 recur. Since a reservoir at Echo Park would have held only 6.4 m.a.f., compared to Glen Canyon's 26 m.a.f., obviously, a dam in Glen Canyon was the key to the feasibility of the entire CRSP plan. Had Brower actually tried to and succeeded in eliminating Glen Canyon Dam, the entire CRSP would have been killed.

Furthermore, Brower's late-in-life contention that the defeat of Echo Park Dam forced the Bureau of Reclamation to raise the height of Glen Canyon Dam is incorrect—the 1954 Bureau design shows the dam crest at elevation 3,711 feet above sea level—the level of the dam as it was actually built.

This is not to say that there was no opposition to the building of Glen Canyon Dam. Contrary to the later contention of Brower and the Sierra Club, Glen Canyon was not the "place no one knew." While it was not nationally famous, it had been visited often, particularly in the 1950s, by Utah Boy Scout groups and others who simply enjoyed boating down the calm, scenic river. According to the late historian C. Gregory Crampton, Glen Canyon was the most accessible, and therefore the most visited—at least by boat—of all the canyons of the Colorado River.[5] Although most people who had boated through the canyon were opposed to the dam, they were generally unorganized and their opposition was no match for the steam roller of proponents pushing for water development.

Construction of the Dam

Many observers, both within and outside the Bureau of Reclamation, have marveled at the speed with which construction began on the CRSP. At the time there was no need for any detailed economic or environmental studies. Following the authorization of the CRSP (Public Law 485–84th Congress; P.L. 84-485) on April 11, 1956, engineers and surveyors were rushed to the site by July, and on October 15, of that year, the first ceremonial blast was set off on the canyon wall.

22.1. Glen Canyon Dam. Photograph by the the author in 1969.

During 1956 and on into 1957 design engineers in the Denver Office were still hard at work producing specifications for the dam. One might wonder then why the Bureau was already doing site work when the design for the dam was not yet finished. The answer is two-fold. Some work on site could be done, such as road building and planning the city of Page. Perhaps the main reason for the haste, however, was a desire to follow a well-known, time honored—and usually successful—construction strategy, which states that when an agency starts a job that depends on appropriations from a legislative body, funding is much more assured if it seeks to *continue*, rather than *start*, a project.

According to Glen Canyon Project Construction Engineer, Lemuel F. Wylie, the principal dilemma confronting him in 1956 had nothing to do with the dam, but rather with the questionable location for the construction town, later to be named Page. Since the dam site was in a remote area, in a yet unbridged canyon, completely in Arizona, but quite near the Utah-Arizona state line, political interests of both states considered it desirable to have the town established on their side of the canyon, since economic and transportation ties would probably develop early with adjoining cities. Delegations from both states repeatedly visited Wylie at his temporary Kanab, Utah, office, all requesting favorable consideration.

Years later, in 1969, former Senator Carl Hayden of Arizona publicly stated that Page had been so located because of his request to place it on the Arizona side.[6] Considering that in 1956 Hayden was Chairman of the Senate Appropriations Committee, it was a foregone conclusion that the Bureau would agree. A large spring of good water had been located on the Utah side, leading some engineers to recommend that location,[7] and a perfunctory examination was made there. But considering Senator Hayden's expressed preference, the only real question was precisely where on the sandy Arizona side the town would be placed. Wylie reported in an interview that he and Louie Puls, Chief of the Concrete Dams Section of the Chief Engineer's Office, hiked along the sandy Arizona side in July 1956, found nothing suitable, then decided to examine a low plateau about a mile to the east. After hiking to the top, the two looked around, and then Puls said, "Lem. What's the matter with this?" Wylie replied, "Not a thing—not a thing."[8]

So the town of Page was situated on the Arizona side, on Manson Mesa. But the selected town site had another difficulty—it was located on the Navajo Indian Reservation. To resolve this, Wylie and Department of the Interior lawyers met with tribal officials several times without conclusion, until one of the lawyers suggested a land trade. This idea met with favorable response, resulting in the Government's obtaining 55,000 acres of land for Page and for the Navajo side of the future reservoir in exchange for a like amount of land on McCracken Mesa in southeast Utah.[9]

When asked about problems encountered while building the dam, Wylie could think of nothing major. "It was mostly mechanical", he said. "The contractor knew what to do, I knew how to handle day to day problems, and I had a competent staff to insure quality construction."

A labor strike shut down construction of the dam for six months, from July to December 1959. The dispute arose when the prime contractor, Merritt-Chapman and Scott, curtailed making extra housing payments, up till then paid to employees for the remote location of the job, after determining that housing was available in Page and in company dormitories. The strike was finally settled near Christmas 1959, and by January 1960 the work was again well underway. No event delayed construction from that point on, and the dam and powerplant were finished on schedule.

Archaeology and History Investigations

Today, with the National Environmental Policy Act of 1969 in effect, no project can be undertaken on Federally-owned land without preliminary and thorough archaeological and historical investigations (as well as many other studies), of the area to be impacted. In 1956, however, no NEPA rules were in effect, so Glen Canyon received no studies prior to inundation that would be considered as counter to authorization of the dam. What it did receive was what was called simply the Glen Canyon Archaeological Salvage Project. In compliance with the Historic Sites Act of 1935, the National Park Service obtained funding and let two contracts for the work. The largest was awarded to the University of Utah to investigate the right bank of the Colorado, the triangular area between the Colorado and the San Juan, and the left bank of the Colorado above the confluence with the San Juan. The Museum of Northern Arizona was authorized to examine the south side of the Colorado and the San Juan.

Even before 1956, Glen Canyon and the San Juan River Canyon were known to have substantial numbers of archaeologically significant sites, including dwelling areas, granaries, trails, petroglyphs, and pictographs. Several private or institution-sponsored research expeditions had ventured into the region, particularly in the 1930s. Prominent among these was the Rainbow Bridge–Monument Valley Expedition, (RBMVE), a cooperative effort by the National Park Service and several universities, which operated from 1933 to 1938.[10] Although the RBMVE only touched on Glen and the San Juan River Canyons, its crews found numerous archaeological sites, although few were excavated at that time.

Initiating the Salvage Project in 1957, with the dam already under construction, both the University of Utah and the Museum of Northern Arizona sent qualified crews, consisting of archaeologists, helpers, students, horse wranglers, boatmen, and cooks, into the canyons and onto the surrounding areas. To obtain base data for regional comparison, they also surveyed archaeological sites on highland areas, such as the Kaiparowits Plateau and Cummings Mesa.

Dr. Jesse D. Jennings, director of the University of Utah effort, devised special techniques to help speed the project. For instance, he enjoined crew chiefs to "use the coarsest tool that will do the work" i.e., recover the data. A shovel can be as useful as a trowel, a road patrol or scraper as useful as a shovel, or a dragline as useful as a pick, in the hands of an excavator who is free of ritual compulsiveness.[11] Of course, there was no way to get a road patrol, scraper, or dragline into most of the canyons, but his philosophical approach had the merit of accomplishing as much as possible in the time available.

Every form of transportation was tried as a means to get crews into the main and side canyons, from airplanes, to four wheel drive vehicles, to horses and mules. But the areas were so rugged and remote that the rivers themselves became the main travel and communication lines. Small, outboard powered aluminum boats were extensively used, with occasional recourse to rubber rafts.

According to Jennings, the Survey found and recorded over 2,000 archaeological sites, of which about 80 or 85 were fully or partially excavated.[12] In confirmation, Don Fowler, one of Jennings' crew chiefs during the 1957-1963 survey, estimated that due to lack of time, less than 10 percent of the sites were examined in any detail. But both Jennings and Fowler agreed that the survey was adequate to determine the population densities at various stages of pre-historic cultures. Dispelling earlier rumor, no large ruin, such as at Mesa Verde or Chaco Canyon, was found. They did determine that Ancient Puebloans (Anasazi) had occupied the canyons during three periods, the earliest starting about 500 A.D.

During the last period, about 1250 A.D. the occupants were probably starving and fighting among themselves.

Writing as a professional archaeologist, Jennings could not praise the Glen Canyon Salvage Project highly enough, for it finally provided adequate funding for substantive research, as opposed to the piddling, poorly-funded studies in previous years. He wrote that over thirty previous explorations of Glen Canyon by problem oriented or pot hunting men resulted in no scientific account.[13] He wrote:

> I suggest that in virtually any detail, and certainly in overall results, emergency salvage archaeology is superior to most other work done in America.[14]

Jennings, now deceased, therefore did not lament the drowning of over 2,000 archaeological sites. He proudly pointed to the many volumes of useful and accurate scientific data that were recorded in monographs and books. And besides the data, he and his researchers had accumulated a museum full of small artifacts available to future archaeologists.

On the personal side, Jennings wrote that

> … learning the Glen and working in and near it for six or seven summers was a rich, emotionally charged period of my life. The vastness, the isolation, the stillness, the overwhelming beauty of the land, even (especially) the heat, the still starlit nights, the blue or brassy midday sky, all combined to make me constantly aware of my good fortune. . . . millions of vacationers each year fish, swim, water ski, windsurf, and camp in the tributaries and some spots on the lake itself see and enjoy much of the same natural beauty as I once did. But the intimacy of the river and the side streams is gone, and all my hard won knowledge of the sandbars, the shoals, and the camping sites is now obsolete, but remain bright in memory.[15]

In the original Glen Canyon Salvage Project plan, no separate provision had been made for historical research, as it was assumed that archaeologists could record any rare historic site while in the course of their regular tasks. Dr. C. Gregory Crampton, historian at the University of Utah took it upon himself to address the lack of historical research as a separate dedicated project by writing to the National Park Service and convincing them of the omission. Consequently, Crampton himself was given $25,000, expected to be enough to do the job. With such limited funds, Crampton could hire no one, but had to do all the research himself, using only unpaid graduate students (loosely termed ‘slaves’), as assistants.

During the years 1957 to 1963 Crampton tediously filed through old mining records, courthouse documents, diaries and manuscripts, and newspaper accounts. Following written leads, he then made eight float trips, each with one or two graduate students, to stop at specific sites mentioned in the written records. With his funds nearly exhausted, Crampton, with my urging, persuaded Frank Clinton, Regional Director of the Bureau of Reclamation, to authorize and fund boat trips down the San Juan River in 1962 and down Cataract Canyon in 1963. On these last two trips, I traveled along, acting as official photographer, as we stopped and recorded numerous historic sites.

From 1959 to 1963 Crampton wrote seven detailed monographs, complete with maps, photographs and documentation, each published as an "Anthropological Paper" by the University of Utah. Following these works, he published *Standing Up Country: The Canyonlands of Utah and Arizona*,[16] in which he brought Glen, Cataract, and San Juan Canyon histories into a regional perspective. He followed this with *Ghosts of Glen Canyon*,[17] a series of Glen Canyon historical vignettes and photographs arranged by river mile. In these books he repeatedly emphasized the point that Glen Canyon, containing hundreds of historic sites, was the most historic of all the canyons of the Colorado.

The Rainbow Bridge Problem

In Public Law 84-485 authorizing the Colorado River Storage Project are the words: "That as part of the Glen Canyon Unit, the Secretary of the Interior shall take adequate protective measures to preclude impairment of the Rainbow Bridge National Monument." These words were inserted at the insistence of environmental groups, including the Sierra Club, the Wilderness Society, and the National Parks Association, with the intention of preserving Rainbow Bridge and its surrounding 160-acre enclave set aside as a National Monument in 1909, in its natural state.

Congress also included the following clause:

> It is the intention of Congress that no dam or reservoir constructed under the authorization of this Act shall be within any National Park or Monument.

This clause was inserted as an affirmation of Congressional opposition to a dam in Dinosaur National Monument (Echo Park), as well as a desire to keep Glen Canyon reservoir water out of Rainbow Bridge National Monument.

In regard to Rainbow Bridge, the Bureau of Reclamation faced a delicate situation, namely, how to keep reservoir water out of the monument without tearing up the surrounding landscape to build a barrier dam quickly enough so that the reservoir could be allowed to fill without untimely delay.

By the terms of P.L. 84-485, the Bureau had no choice but to keep water from the future Glen Canyon reservoir from entering the boundary of the Rainbow Bridge National Monument. Created by Executive Proclamation in 1909, the 160-acre monument lay about 5.5 winding stream miles southeast of the Colorado

River. As the reservoir rose, it would enter the monument area at elevation 3,606 feet above mean sea level. and at its planned maximum elevation of 3,700 feet it would be 45 feet deep in the channel beneath the bridge, but still 21 feet below the lowest abutment of the bridge itself.[18] Therefore, to keep reservoir water out of the National Monument, as required by law, would necessitate some kind of downstream barrier dam.

It was obvious to those of us who worked for the agency at the time that top officials of the Bureau would build a barrier dam only after considerable loud protesting. And the most effective way to ward off building such a dam was to postpone specific Congressional appropriations for the endeavor—perhaps indefinitely. One Bureau publication stated:

> Much of the earth materials required for construction of any possible restraining dams would have to be obtained from the top of the high mesa [1,200 vertical feet above the stream channel]. Heavy equipment to work the high mesa borrow area would have to be lifted to the mesa top by cableways or carried in by helicopters it would be impossible to build a road on to the high mesa.… borrow operations would necessarily leave certain unavoidable and irremovable construction scars.[19]

One might question why the Bureau would resist building a barrier dam, since, after all, the agency was in the business of building dams. At least one author, Hank Hassell, in his book *Rainbow Bridge—An Illustrated History*, felt that it was simply pay back to the Sierra Club for having embarrassed the Bureau in the Echo Park Congressional hearings.

> With the benefit of hindsight it now seems clear that the motive of both Congress and the Bureau was simple one-upmanship. Western states congressmen had been stung and stung badly by Dave Brower's success in stopping Echo Park Dam. The Bureau, too, felt that it had been publicly humiliated on its own turf, and now both bodies saw a way to strike back.[20]

Three possible sites were examined for a barrier dam in the deep, narrow canyons leading from Rainbow Bridge down to the Colorado River. The middle site, Site B, preferred by the Bureau, would have required a small dam upstream from the bridge and a tunnel to divert natural runoff to an adjacent canyon.

Dam site C, further downstream, would not have required the diversion structures, but would have required a large dam, 365 feet high, with a crest length of 800 feet. It could have been constructed by building a haul road from the north, with a bridge over the Colorado River, and much of the construction scars would have been inundated by the future reservoir, yet it was never seriously considered by the Bureau. The reason was simple,

> it would have taken too long to build, and was at too low an elevation. The site C dam would have had to be in place before the gates at Glen Canyon Dam were closed. Such a situation would have set back the filling schedule for Lake Powell and was considered unacceptable.

The Bureau, through the Interior Secretary, in 1960, dutifully asked for $3.5 million in appropriations (of the projected $25 million final price), to begin construction of the structures to protect Rainbow Bridge. But heavy lobbying by Senator Frank Moss of Utah, Congressman Wayne Aspinall of Colorado, and Floyd Dominy, Commissioner of the Bureau of Reclamation, convinced the House Appropriations Committee to delete the line item from the budget with the words, "No part of the fund herein appropriated shall be available for construction or operation of facilities to prevent waters of Lake Powell from entering any National Monument."

In 1961 Interior Secretary Stewart L. Udall, recognizing that building a dam at site B would leave disastrous construction scars on the landscape, sought a way out by proposing a new National Park that would encompass, not only Rainbow Bridge, but also much of the fantastically eroded landscape—all Navajo land—in surrounding areas. On April 9 he organized a mass visit to the bridge by environmental representatives, news reporters, and governmental officials to promote what he called Navajo Rainbow National Park, with helicopter transportation furnished by the U.S. Air Force and by private air services. Although his concept had merit, it would have been a magnificent National Park, one key provision of his proposal was to put the boundary of such a park at the normal high water line of Lake Powell, thus eliminating the need for a barrier dam. But Dave Brower and others would not accept it. Also, Udall had failed to consult with Navajo Tribal leaders, who were miffed at the slight and also refused to go along, thus killing the proposal.

During the 1960s, Congress each year expressly denied funds for a barrier dam, inserting the same prohibitive clause in the Appropriations Bill. In August 1962 the National Parks Association, the Sierra Club and other conservation organizations filed suit, asking for an injunction to prevent the closing of the gates at Glen Canyon Dam until protective works for Rainbow Bridge were at least under construction. The judge, however, dismissed the suit, ruling that the organizations had no standing in law as they would not suffer harm by the filling of Lake Powell. Upon that note, the Bureau closed most of the diversion tunnel gates on March 13, 1963, and Lake Powell began a rapid rise.

As lake waters crept up the narrow canyons toward Rainbow Bridge, Dave Brower, now head of a new organization called Friends of the Earth, enlisted the Wasatch Mountain Club and Ken Sleight, owner of a river running company, to join him in a suit to keep Lake Powell away from the bridge. In November 1970 the suit was filed, asking only that Lake Powell be limited to elevation 3,606, thus keeping it out of the National Monument, in accordance with Section 3 of

Public Law 84-485. On February 27, 1973, Judge Willis Ritter, in Salt Lake City, granted the plaintiff's motion and ordered the Bureau to lower Lake Powell to the 3,606 level. To the Bureau and to Upper Basin water users, this was a disastrous decision, for the top 94 feet, from elevation 3,606 to 3,700, contained almost half of the storage volume of the reservoir. Furthermore, the lowered reservoir would substantially reduce the hydraulic "head" on the turbines, thereby cutting power production and revenue.

Of course the government appealed and on May 1, 1973, a three-judge panel of the Tenth Circuit Court of Appeals voted 2 to 1 to allow Lake Powell to enter Rainbow Bridge National Monument while the case was reviewed. Then, just three months later, the Appeals Court issued its decision. Voting 5 to 2, the Court held that Congress had indeed repealed Section 3 of Public Law 84-485 by repeated acts of denying funds for protective works. Chief Justice David T. Lewis strongly dissented, commenting that the decision "was a deep trespass upon the prerogatives of Congress and a clear and dangerous violation of the doctrine of separation of powers. … [and] an equally dangerous judicial aggression."

Brower and his lawyers appealed to the Supreme Court, where the conservation case was joined *amicus curiae* by Attorneys General of 16 states, all of which disagreed with the Appeals Court decision. Out of four required, however, only three Supreme Court justices agreed to hear the case. Therefore on January 21, 1974, the Court announced that it had denied the appeal and that it would not review the case. Thus a new legal precedent, repeal of a law by implication, and denial of appropriations, had been set. So Lake Powell would continue to rise. And it rose, faster than almost anyone had predicted.

The Spillway Crisis, 1983-1984

Of course, the lake level fluctuated up and down in accordance with seasonal runoffs, and in some years it declined more than it rose. Generally, however, the level was higher each year until the lake actually filled, to elevation 3,700 on June 22, 1980, an event that was marked by a public celebration on the crest of the dam. As a demonstration, both spillways were slightly opened for a short time. Lem Wylie, who had supervised the construction and who was invited as a guest for the celebration, expressed amazement at the rapid filling. "I never expected to see this in my lifetime," he stated.

Yet the filling in 1980 was only prelude to a much more dramatic event. While runoff prediction is an inexact science, predictions are vital for reservoir regulation. Any storage reservoir, such as Lake Powell, should be kept as full as possible, with accidental spills kept to a minimum. Therefore, runoff predictions are necessary early each spring so that sufficient space—but not too much—can be provided in the reservoir.

In 1983 nature dealt predictors a bad hand. Accumulated snowfall in the mountains on April 1 was only a bit above average, but the snow kept falling, in increasing amounts. By early May it appeared that Lake Powell had insufficient space for the runoff, so the Bureau opened the wicket gates of the powerplant so as to operate at full capacity, night and day. Still the water rose steadily toward the full mark of elevation 3,700 feet. The four outlet tubes, capable of a combined 11,000 cubic feet per second release were also opened.

Early in June one spillway radial gate (a heavy steel gate that is raised to admit flow from the bottom), was opened to allow water into the left spillway. When this operation is performed, water roars into the spillway, drops precipitously through several hundred feet, until it reaches the elbow section, then flows through the lower end, at that point horizontal, of what had been the diversion tunnel. Upon exiting, it strikes a "flip bucket" designed to dissipate the tremendous energy by throwing the water high into the air, allowing it to fall into the Colorado River. In 1983, the operation worked well—except for the insidious phenomenon known as cavitation.

All civil and mechanical engineers are familiar with cavitation, a process where a fast moving liquid is thrown upward by some small obstruction, thus creating vapor cavities, or small vacuum pockets. These cavities then collapse with destructive force, digging holes into the surface on which the liquid is flowing. The holes are rapidly enlarged and deepened. After one hole is formed a leapfrog action is initiated, causing further cavitation holes to form on down the surface. One might ask why designers specified spillway tunnels that were almost certain to suffer cavitation damage when used. The only answer is that a well-managed reservoir should almost *never* spill, and then only for very short periods, after which the cavitation damage could be repaired.

A spillway tunnel had been provided on each side of the canyon, but the right, or west, spillway was not used initially at Glen Canyon so as to confine the cavitation damage to the left one. As the inflow into Lake Powell topped 100,000 c.f.s., the gates were gradually opened until 32,000 c.f.s. were roaring through the left tunnel. I was one of the witnesses who saw the outflow turn orange, hurling chucks of concrete and sandstone into the Colorado River. Most of the engineers were somewhat worried, although they knew that most of the damage would be downward—not laterally into the lake. Yet obviously an inspection was in order.

With the gates temporarily closed, two intrepid engineers, clad in foul weather gear, rode a tugger-lowered cart into the dark left spillway. Almost 600 feet down the 60 degree slope they encountered massive holes cut clear through the three-foot thick concrete lining, and into the sandstone, with reinforcing bars twisted and broken. Just beyond they could see a series of large holes further down. At this point they could go no further and were hoisted back to the daylight.

By the end of June, when the inflow into the lake rose to around 120,000 c.f.s. the gates of both spillways had to be opened. The biggest worry was not that the lake would top the dam, elevation 3,715, but that the water would rise above elevation 3700, at which point the water would flow over the top of the gates, even if they were in closed position. Work crews hurriedly placed temporary 4'x 8' plywood panels upright across the top of the gates so as to increase storage. To a non-engineer, it sounds fantastic to hold back a 186 mile long lake with plywood panels, but it worked.

For a more permanent and effective fix, heavy steel 8-foot high flashboards were fabricated and trucked to the dam. Even as a large flow of water was roaring under the gates, workmen on top of the gates starting installing these flashboards on July 4th, working around the clock, and within two days they were in place.

On July 14, the lake level reached 3,708.4, held at that elevation for almost a day, then began a slow, but measurable, decline. The flood of 1983 was over. By early August all spillway flows were curtailed.

But the measure of the massive job of spillway repair had yet to be determined. I was one of a team who, in late July, waded into cold, standing water of the left tunnel and proceeded up the dark cavern toward the elbow section. It was an eerie spelunking experience to be entering that awesome dark underground chamber, not quite sure of what we would find. Pulling a raft laden with battery powered floodlights, we scrambled and climbed around and over an amazing array of rock rubble, at least one piece as large as a good sized automobile. In many places the concrete lining was entirely gone, with rebar broken off by metal fatigue. Apprehensive of the expected large hole at the elbow section, we stopped wading short of having to swim, but from our vantage point we could easily see the series of large cavitation holes just above the elbow section. Having recorded the damage on film and videotape, we retraced our route to the sunshine.

With the powerplant operating at full tilt, and with all four outlet tubes shooting eight-foot wide jets into the Colorado River, emergency repairs began on the spillways. Drained of water, adit tunnels were gouged into the lower sides of each tunnel, near the outlet portals, to allow access to heavy equipment and trucks. A contractor hired hundreds of men and women to remove broken concrete, loose sandstone, and to prepare the tunnels for new rebar-filled concrete lining. When the huge hole at the elbow section of the left tunnel—the most severely damaged—was drained, it was measured to be 32 feet deep, 40 feet wide, and 150 feet long. It took twenty-five hundred cubic yards of concrete to fill the hole.

Meanwhile, in the Denver Engineering Laboratories, engineers were giving final touches to the design for air slots to be incorporated in the upper portion of the Glen Canyon spillways. Their design called for a four-foot wide, four-foot deep, circular trench to be cut and lined about 110 feet down from the upper portal of each spillway. Tests had shown that when high velocity water crossed these air slots, a cushion of air bubbles would be introduced, on which the water would ride through the remainder of the spillway. Cavitation would therefore be virtually eliminated.

The general principle of using air slots on tunnel type spillways had been conceived by design engineers during the 1970s, had been tested, and had actually been retrofitted into the spillways at Yellowtail Dam in Montana. Whenever funds permitted, air slots were planned for all Bureau of Reclamation dams with tunnel type spillways. Had the 1983 damage not occurred, the spillways at Glen Canyon Dam would probably have been retrofitted with air slots sometime during the 1980s. But with a large contractor on site, it was logical to build in the air slots as part of the ongoing spillway repair.

Also, so as to prevent surprise incidents like the 1983 runoff, it was apparent that runoff forecasting had to be improved. Bureau officials in Salt Lake City, in cooperation with the National Weather Service and the Soil Conservation Service, devised an improved forecasting model, and ways to quickly refine that model as snowfall in the mountains accumulated. It was not accomplished too soon.

As work on the spillways progressed through the fall of 1983 and into the new year, large amounts of snow continued to fall in the high country, and the 1984 forecast showed that the runoff could be even greater than in 1983. With the spillways temporarily out of commission, it was obvious that releases of water through the dam and powerplant had to be kept at a maximum. Through May and June Lake Powell inched upward until it was only a few inches from the top of the new flashboards on the spillway gates. Then in early July the lake level began to recede. The crisis point had been passed.

On August 12, 1984, the left spillway, completely repaired and incorporating an air slot, was tested with a release of 50,000 c.f.s. The event was astounding to watch, as huge jets of water arced gracefully from the flip buckets over 100 feet before plunging violently into the river. Spray filled the downstream canyon, refracting rainbows from the bright summer sunlight. After a few days of testing, the flow was curtailed and the spillway pumped dry for an inspection. I was fortunate to accompany the team of engineers that went in to examine the concrete surface. We could see no damage whatsoever. The air slots had been a complete success in preventing cavitation.

Altogether, the repair of the two spillways had cost around $30 million, but the steady full operation of the powerplant to release more water had netted around $34 million in extra revenue. Furthermore, as most of the power was sold to energy companies in California, it enabled them to save great quantities of oil that would have been burned in oil-fired generating plants.

Glen Canyon Power and the Grand Canyon Ecosystem

Almost simultaneous with the spillway crisis, Glen Canyon Dam hit another bump in the road. For many years, even before the dam was completed, biologists, geologists, archaeologists, and river runners had been concerned with the altered character of the Colorado River flowing from the dam and through the Grand Canyon. What enters Lake Powell as a warm, silt filled river emerges through the dam cold and clear, similar to a mountain stream. It also fluctuated high and low in accordance with power demands at the Glen Canyon Powerplant, sometimes very rapidly. No studies had yet been made, but most scientists predicted damage to the Grand Canyon ecosystem.

What caught the attention of the public, however, was a Bureau of Reclamation proposal to increase the power producing capacity by adding generators to the outlet tubes. Since peaking power earns considerably more revenue than off-peak power, the idea had been to convert the entire powerplant into a peaking power operation. Outflows during off peak would be practically curtailed, while during peak power demand, all eight generators, increased to twelve by addition of the four on outlet tubes, would be operated at full capacity. And to maintain steady flows through the Grand Canyon, a re-regulating dam, about 30 feet high, built to contain a fluctuating reservoir, was planned for the canyon a few miles below the dam. To Bureau officials intent on finding ways to increase revenue the plan was a good one, but it struck a very large obstacle—public opinion.

In 1981 during public hearings in Page, Flagstaff, and Salt Lake City, the proposal aroused the ire of many who simply did not want another dam, even a small one, built in Glen Canyon. To them, the hated concrete dam was bad enough; they were not going to let the Bureau flood the last 15 miles of Glen Canyon below the dam. Fishers, in particular, who reveled in those 15 miles of good fishing, cried foul. Even river runners, who might have been expected to embrace the idea of a non-fluctuating river below Lee's Ferry, were vocal in opposition. Many of these opponents wrote newspaper articles, appeared on national television, and urged people to write protest letters to their Congressmen.

Within a few months, the Bureau surrendered, giving up the proposal, but opting instead to rewind each of the eight generators at the dam so as to increase the power output, which would not change river flow patterns. The public protests, however, had called attention to possible damage the clear, cold, fluctuating river was doing to the Grand Canyon ecosystem. Responding to this pressure, Under Secretary of Interior Robert Broadbent ordered a thorough study of several scientific aspects of the riverine environment below the dam. Although it was officially called the Glen Canyon Dam Environmental Studies, (because it concerned flow releases from the dam), the studies were to be made in the fifteen miles remaining of Glen Canyon, and in the 275 miles of the Grand Canyon.

With the Bureau of Reclamation as prime agency, cooperation and assistance was needed and obtained, under contract, from the National Park Service, the U.S. Geological Survey, the U.S. Fish and Wildlife Service, the Arizona Game and Fish Department, several universities, and many Indian tribes. Researchers from all of these agencies and institutions spent over ten years investigating every possible change brought about by the flow regimen over the previous 20 years. For two years, from 1983 to 1985, they were hampered by the continual high releases, and virtually no fluctuations, required by the spillway crisis, thus creating an abnormal flow pattern. Most substantive investigations therefore began after the spillways had been repaired.

Researchers knew, even before they ventured into the Grand Canyon, that the clear water and fluctuations would be having some effect; the only question was how much. All of the sand, silt, and many of the minerals that used to flow though the canyon, nourishing the beaches and riverine life zones are now continually captured by Lake Powell. Furthermore, clear water accelerates degradation of the stream bed and shorelines, causing much of the existing sand to disappear into the river. High flows and rapid and wide fluctuations in river flow due to changes in power demand at the Glen Canyon Powerplant add substantially to the degradation.

Before 1963 the temperature of the river in Grand Canyon was synchronized with the seasons, warm enough to support a warm water fishery that included pike minnow, formerly known as squawfish, razor backed suckers, bony tailed chub, and hump backed chub. Researchers suspected that these four species, having been impacted by cold water flows for over two decades, and all now listed as endangered, would have all vanished from the canyon.

After ten years of research, at a cost of about $100 million, almost all of the predicted results were confirmed; however huge amounts of additional data were obtained concerning the downstream ecosystem. Voluminous reports and books have been written on the findings.

Here are a few examples of what was learned. A viable humpback chub population was discovered in a relatively small estuary where the warm Little Colorado River flows into the Colorado River. But all the other endangered fish species had vanished from the canyon. Rainbow trout, however now live in the cold river, in reduced numbers as the distance from the dam increases. Surprisingly, bald eagles have begun to frequent the canyon to fish in the lower mile of Nankoweap Creek, flowing into the Colorado River, where trout spawning occurs.

Tamarisk, *tamarix, ramosissima,* a water devouring phreatophyte, was found to have greatly spread along the river banks, largely due to the lack of high, sand-laden spring runoff flows to uproot them and wash them away. Several bird species, however, such a Bell's vireo, summer tanager, hooded oriole, and great-tailed grackle, have greatly expanded their nesting range throughout the dense foliage of the tamarisk and other bushes that now line parts of the river.[21]

So that left only the question of how the operation of the dam could be altered so as to minimize deleterious effects on the Grand Canyon ecosystem. In November 1989 the Secretary directed an Environmental Impact Statement (EIS) be prepared on the operation of the dam, with Reclamation again as the lead agency. Expressly ruled out was the option of removing the dam. So also was drilling a prohibitively expensive tunnel to convey sediment from an upper part of Lake Powell around the dam to the canyon. As for the cold water releases from the depths of the lake, the Bureau agreed to study ways to raise the temperature by modifying the intake structures.

In early 1991 the Bureau changed the flow regime by raising the minimum flow, by cutting the peak off maximum flows, and by slowing down the "ramping," speed where flows are altered either up or down. The final EIS, completed in March 1995, and the Record of Decision (October 1996) essentially recommended perpetual maintenance of this pattern, except in emergencies.

Congress passed the Grand Canyon Protection Act of 1992, requiring some type of continual monitoring of effects on the downstream ecosystem, now complied with by formation of a Glen Canyon Adaptive Management Work Group.

Ironically, what began in 1981 as the Bureau's desire to produce more peaking power has resulted in turning the dam and powerplant into a near steady-state power producer, with very little peaking power, and certainly less revenue.

In a separate, but similar incident, Regional Director David Crandall of the Bureau once told me that, in the early 1970s, he and his staff had tried to obtain agreement from the Navajo and Ute Tribes to construct another backbone transmission line through their reservations, parallel to the one built in the early 1960s. To this leaders of both tribes replied firmly, "Absolutely not, but we would like you to remove the line that is already there!" No second line was ever built.

Changing Perceptions about Pre-dam Glen Canyon

From the early 1950s onward, opposition to having a dam in Glen Canyon has been a factor to consider. During the Congressional hearings of 1954-1956, opponents were vocal but unorganized, and numbered comparatively few. River running at that time was not widely popular. Boating parties venturing into Glen Canyon were occasional private parties and often Boy Scout groups. And of those that did see the main canyon, very few ventured far into the varied and fantastically eroded side canyons. As late as 1955, the private party of Katie Lee, Tad Nichols, and Frank Wright bestowed names on several previously unnamed side canyons.[22]

Glen Canyon suffered also by the attention given to the Grand Canyon. Whereas Grand Canyon was magnificently huge, astoundingly deep, and almost incomprehensible, "one of the great sights, which every American, if he can travel at all, should see . . . ," (Theodore Roosevelt) Glen Canyon was colorful, intimate, and comfortable. The Colorado River in Grand Canyon was lined with threatening river rapids; the same river in Glen Canyon had none. A spur rail line reached the South Rim in 1901 and the first automobile arrived at that point in 1902, but no decent road reached Glen Canyon until 1957. Quite probably, had Glen Canyon not been overshadowed by the public attention given to the Grand Canyon, it would have been much better known when engineers and water managers started talking about a dam.

How indeed is a geological curiosity transformed into a cultural icon? It is not a simple process of "being there." As author Stephen J. Pyne points out, Grand Canyon itself was once just a geological curiosity. Explorer Joseph C. Ives, writing in 1858, called it a "profitless locality"—but the image of the canyon was gradually transformed by a cadre of scientists, writers, painters, and photographers, including John Wesley Powell, Clarence Dutton, William Henry Holmes, Thomas Moran, and publicity men and women of the Santa Fe Railroad.

In his book *How the Grand Canyon Became Grand* Stephen Pyne writes:

> Among the last of America's landscapes to be formally explored, the Grand Canyon had become among the first of its natural marvels and, for a nation that tended to substitute natural monuments for cultural ones, entered the pantheon of its sacred places. Its valorization offered as much a cross section through American history as of earth history. The evolution of that interpretation had, with eerie symmetry, mimicked the evolution of the Canyon's features. The spasmodic tectonism of geographic exploration, the varied tributaries that flowed from the main currents of American thought—with breathtaking brevity the two processes had merged, and not merely laid down a course of history but entrenched it so deeply the Canyon became a permanent feature of America'cultural lanscape.[23]

Before the dam, Glen Canyon missed similar scrutiny by scientists as well as by lyric poets and painters. It had been visited by perhaps hundreds of miners and prospectors in the 1890s and again in the 1930s.[24] Yet to most of those who had heard the name at all, Glen Canyon was simply another in a long series of gorges cut by the Colorado River through the Colorado Plateau, probably a good place for a dam.

All of this began to change after construction began on Glen Canyon Dam. Realizing that time was running out to see the canyon, private river boating parties floated through Glen Canyon in increasing numbers from 1956 to 1963, when water storage was initiated in Lake Powell.

One of the most influential members of these boating groups was David Brower, Executive Director of the Sierra Club. Brower, who had not objected to Glen Canyon Dam so long as Echo Park Dam was eliminated from the Colorado River Storage Project in 1956, was astonished by the beauty and variety of Glen Canyon. He soon contracted with photographer Eliot Porter to take color photographs in the canyon, for eventual publication in a Sierra Club book, entitled *The Place No One Knew—Glen Canyon of the Colorado*.[25] The title of the book, which came out in 1963, was of course, a misnomer, since Glen Canyon was historically the most visited by boat of all the Colorado River canyons. What the title meant, rather, was that writers, painters, and photographers had never enshrined Glen Canyon sufficiently to make it a cultural icon. Understated in the title was the belief that had the canyon been a cultural icon, such as the Grand Canyon, Glen Canyon Dam would never have been authorized.

After Lake Powell began to form, most of the publicity centered on the beauties of the lake and the novelties of boating into narrow side canyons barely wide enough for passage. During the 1960s very little was said about the loss of pre-dam Glen Canyon. Gradually, however, more voices were heard decrying the loss, particularly among young people. Certainly, the loss of confidence in the Federal government due to the Vietnam War and Watergate had a pronounced effect, for it caused many of college age to question what else the government had done wrong. Also, with new equipment and money, this younger generation was more adventurous than those earlier. Although it would be a mistake to categorize an entire generation, many of them wanted to climb mountains, hike trails, camp out, surf in the waves, and boat down wilderness rivers. To them it was frustrating to learn through books such as Eliot Porter's and several magazine articles, what Glen Canyon used to be. At least some of them felt that older generations had denied to them a moving river and much of the scenery in Glen Canyon, as well as a great adventure—even perhaps, a soul inspiring mystical journey. A slow houseboat trip on Lake Powell—or even on a speedy personal water craft—could hardly compensate. By the early 1980s these discontented young people were ready to organize against the dam. The vanished Glen Canyon was indeed becoming a cultural icon—even posthumously.

The Drain Lake Powell Movement

A strong and influential voice was added in 1968, when Edward Abbey burst upon the scene with his book *Desert Solitaire—A Season in the Wilderness,*[26] a robust, well-written collection of Abbey's stories from southeastern Utah. *New Yorker Magazine* called Abbey "a good hater."[27] In describing Lake Powell Abbey wrote:

> [Where Major John Wesley Powell] and his brave men once lined the rapids and glided through silent canyons, two thousand feet deep the motorboats now smoke and whine, scumming the water with cigarette butts, beer cans and oil, dragging the water skiers on their endless rounds, clockwise.[28]

Abbey also quipped, "I'm a humanist: I'd rather kill a man than a snake!" And one of his visions, supposedly written while Glen Canyon Dam was still under construction, was that

> some hero will carry a rucksack full of dynamite into the dam, hide it carefully, then attach blasting caps to the official dam wiring system so that when the dam is dedicated by the President and Secretary of the Interior and Governors from the Four Corner states, a button will be pushed, igniting the loveliest explosion ever seen, and the new rapids formed will be named 'Floyd E. Dominy Falls' in honor of the chief of the Reclamation Bureau.

Desert Solitaire was an immediate best seller and has gone through several editions and reprinting, and is even today, four decades later, still in print. In 1975 Abbey followed this up with *The Monkey Wrench Gang*,[29] a novel about a small band of self-righteous, do-gooder eco-terrorists who have the dream of destroying Glen Canyon Dam, but who, in the meantime, whet their destructive impulses on power lines, road building equipment, and on the train carrying coal from Black Mesa to the Navajo Powerplant near Page. Again Abbey displayed his writing talent, as well as his iconoclastic view of economic development and what he called "industrial tourism"

These two books by Abbey contributed greatly to the anti-dam movement, both by enhancing the status of the pre-dam Glen Canyon as a cultural icon and by fanning the flames of discontent with the dam and with Lake Powell which some referred to as "Lake Foul", or, at best, "Reservoir Powell." This said, one could hardly dispute the fact that around three million people visit Lake Powell each year, spending millions of dollars on boats, lodging, food, and supplies. What it does mean rather, is that public perceptions of the lake (or reservoir), were becoming more polarized. Undoubtedly the boating portion of the public loves the lake—it is, of course, one of the most scenic lakes in the world—while a vocal minority now calls for removal of the dam as soon as possible.

On a warm spring day in 1981 Ed Abbey showed up at the dam, ostensibly to act as high priest for a recently organized group calling themselves Earth First! A few of its members climbed over a gate leading to the crest of the dam, then walked to the center point where they unfurled a tapered sheet of black plastic sheeting 300 feet down the downstream face, meant to represent a terrible crack in the dam. On the bridge, 350 feet away, Abbey shouted "Earth First! Free the Colorado!" and the seventy or so people that had accompanied him joined in.[30]

The Earth First! Mission Statement originally boasted of engaging in violent tactics, such as 'cracking' dams with banners, blockading bulldozers, sitting in trees, and disabling Earth-destroying equipment ("monkeywrenching"—as one word) was introduced to the vocabulary of the modern environmental movement.[31]

Soon after this 1981 incident, the Bureau tightened security at the dam. First workmen installed closed-circuit TV cameras at practically all access points. Casual visitors, could no longer roam freely on a self-guided basis down the elevators and onto the west end of the generator floor, the transformer deck and the governor gallery. They would now have to first obtain a ticket, have all tote bags inspected, and then proceed in small groups accompanied by a Bureau guide. Furthermore, accessible areas were reduced by cutting out the sensitive governor gallery.

Near Moab, Utah, a few rebellious men and women actually tried their hand at eco-terrorism, monkeywrench style, by chain-sawing down a wooden transmission tower, thereby disrupting power service. The loud public reaction against this act seemed to alert the perpetrators that it was self-destructive behavior, calculated to win no allies. At least three times, studios in Hollywood have seriously considered turning *The Monkey Wrench Gang* into an action filled movie, but each time they have backed away for fear of inspiring copy-cat acts of destruction.

During the 1980s until 1996, protests against the dam seemed to subside, perhaps because of the environmental studies and the preparation of an Environmental Impact Study then underway. The National Environmental Policy Act of 1969, had, however, significantly altered the equation by requiring extensive studies and producing an Environmental Impact Statement prior to authorization. Congressman Wayne Aspinall, who had played such a pivotal role in the campaign for CRSP in 1956, was heard to say, in 1981, "We got the CRSP approved just in time. Today we could never get it authorized—particularly if it included Glen Canyon Dam."

Barry Goldwater, set to retire from the Senate in 1986, said that if he could recast one vote in his entire Senate career, it would have been his vote to authorize Glen Canyon Dam.[32]

In 1996 a new group advocating removal of the dam was formed. The Glen Canyon Institute was led by two men: David Wegner, a biologist who had served as director of the environmental studies for the Bureau of Reclamation, and Richard Ingebretsen, a physician in Salt Lake City. In the GCI mission statement is the following:

> Although in 1996 the Bureau of Reclamation completed an EIS on operations of the dam, decommissioning the dam was not offered as an alternative to the public. Public comments, which suggested decommissioning of the dam, were simply rejected as falling outside the scope of that EIS process. Glen Canyon Institute believes that the American public should decide whether or not the long term environmental costs of maintaining Glen Canyon Dam outweigh the short term benefits provided by Powell reservoir.[33]

Goal of the GCI is to produce a Citizens' Environmental Impact Statement that would clearly show the benefits of removing, or at least decommissioning, the dam. Now based in Salt Lake City, the organization has reported a membership of 1,400 individuals spread throughout the United States. Richard Ingebretsen readily admits that draining Lake Powell is a long term objective, probably not achievable for at least twenty years, yet he is optimistic that their effort will meet with success. While Ingebretsen and his group mention the economic costs of lake surface evaporation, what they are really striving for is to raise pre-dam Glen Canyon to the status of a cultural icon, just as David Brower had been trying to do since 1963.

Brower, probably the most influential environmentalist in the country, the man who had almost single-handedly defeated Echo Park Dam, was also a member of GCI, and spoke at several of the GCI meetings. On his own initiative in 1997 Brower convinced the National Board of the Sierra Club to unanimously declare its support for draining Lake Powell, thus making it national policy. Subsequently Brower wrote even more articles, gave more speeches, always advocating decommissioning of the dam, while admitting apologetically that he had tacitly supported the dam during the 1950s. Brower died in 2000, but many of his followers in the Sierra Club and elsewhere have vowed to carry on his campaign.

Congressman James Hansen of Utah responded to the movement by calling for a hearing before his House Interior Committee in September 1997. His primary purpose was obviously to squash the drain Lake Powell initiative in the bud. At that hearing, Sierra Club president Adam Werbach and GCI's Dave Wegner reportedly "took a beating from politicians and experts who dismissed the plan as loony," "impractical," and "certifiably nutty,"[34] The hearing somewhat backfired in that it only helped to publicize the concept of draining the lake by giving it Congressional and media attention.

To counter the threat from the GCI and the Sierra Club, a group of Page residents, in July 1997, organized what they named Friends of Lake Powell. Its avowed purpose was and is to discount negative claims against the dam and reservoir and to promulgate the recognized benefits.

Some people considered that the methods employed by the Glen Canyon Institute and the Sierra Club were too slow to take effect. A new group was therefore organized in January 2000 with more radical tactics in mind. Living Rivers, headquartered in Moab, espouses public demonstrations and media attention, but not eco-terrorism at the dam or anywhere else. When Living Rivers announced that its first rally would be held at the dam on March 14, 2000, the Friends of Lake Powell countered that they would hold a demonstration at the same time and place—the Bureau feared a possible riot. When the day arrived local police were on hand to separate the groups by the width of the canyon, one on one side, one on the other. Separate demonstrations and speeches were then forthcoming, one group promoting draining the lake and one against it. Visitors standing on the bridge separating the two demonstrations were watched closely by the police. No trouble, other than loud public address systems, was reported.

In the future we can look forward to sustained opposition to continued operation of Glen Canyon Dam, restricted though it has been. And Lake Powell will continue to provide a Mecca for fishers, boaters, and water oriented sports. Considering the economic investment in the dam and powerplant, in the city of Page, in recreation facilities around Lake Powell, and in the Navajo Generating Station, which draws clean cooling water from the lake, it is not likely that the drain Lake Powell movement will have success, at least not for several decades. Emphasizing the need for continued operation of both Glen Canyon Powerplant and the Navajo Generating Station is the current, and probably long term, demand for additional electrical energy in the western United States.

Sedimentation

Sediment, of course, continues to settle in the upper parts of the lake, diminishing its storage capacity and its ability to meet downstream commitments during times of drought. Although never mentioned in promotional literature, sediment storage is a vital function of Lake Powell, since it greatly increases the useful life of Lake Mead, about 300 miles downstream.

The San Juan River arm of Lake Powell, which receives a majority of the sediment input, is already heavily clogged. The San Juan Marina on that arm had to be closed in 1988 due to heavy sedimentation. In the early 1990s a sediment bar built up so firmly on the San Juan arm that it blocked the inflow from the river, forcing the water to rise up, flow across a section of nearby flat sandstone, then drop by a 20-foot waterfall into Lake Powell. Although this silt dam later washed out, it was an indication of things to come.

No one knows when sediment will reach the dam, but it will not be soon. Anticipating that eventual day, Bureau engineers are considering using the outlet tubes to flush some of that sediment around the powerplant.[35] A study of sedimentation rates by the Bureau showed that it would be 700 years before sediment would reach the penstock level, elevation 3,490, where water is drawn into the turbines. Although the powerplant could, and probably will, generate power up till that time, no official prediction has been made as to when the reservoir will be too small to meet downstream commitments—or when Lake Powell is so diminished in size that water oriented recreation is no longer practical. Perhaps by then the drain Lake Powell movement will have finally achieved success and the stored sediment will be draining around or through the dam, through the Grand Canyon, and filling up any remaining capacity in Lake Mead.

Drought

Drought is a problem not only to Colorado River water users, but also to the entire western U.S. The prime stated reason for building Glen Canyon Dam was to sustain required flows to the Lower Basin and Mexico during drought periods.

Yet when a severe drought period actually occurred, as in the years 1999 to 2005, both Lake Powell and Lake Mead were drawn down extensively. In fact, releases from Glen Canyon Dam in 2004 were the first in the dam's 40-year history in which extra Lake Powell water was released to meet Compact commitments. As a Bureau spokesman stated, "Lake Powell releases kept Lake Mead from going dry."

Several meteorologists and climatologists are now saying that drought should be considered usual, and that it may last for long periods. Therefore, water users and Bureau of Reclamation officials have undertaken discussions on ways to tacitly circumvent the Upper Basin downstream commitment of the 1922 Compact, and to replace it with criteria to keep Lake Powell and Lake Mead at equal levels, percentage wise and to equalize the shortage of water between the two basins.

Because of the new criteria essentially considering Lake Powell and Lake Mead as one storage unit, combined with expected drought years and continuing increasing withdrawals from Upper Basin users, Lake Powell may never fill again.

Conclusions

The bumpy road that Glen Canyon Dam history has taken in the past 55 years represents a long encounter with scenic values, with cultural antiquity, with natural processes of flood and sedimentation, and with preservation of two national icons, the Grand Canyon and Rainbow Bridge. The very rust-red sandstone landscape that backdrops Lake Powell, making it one of the most scenic bodies of water in the world, is the same scenery that causes environmental groups to demand that the lake be drained so that the heart of the scenery—the canyon floor and the river can be seen and accessed. Those opposed to the dam will continue to promote pre-dam Glen Canyon as a national and cultural icon that should be returned from the depths—the sooner the better. But they will have little success so long as investments in the dam and lake remain both widespread and profitable. When the day arrives that maintenance of the dam no longer makes economic sense—no matter how far in the future that may be—Glen Canyon Dam will strike the biggest bump of all. We can only guess what future generations will do with the dam at that time.

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The Indian Camp Dam Controversy: The Real Beanfield War

By:
Marilyn J. Koch

Abstract

This essay explores the controversial history of Indian Camp Dam, a Bureau of Reclamation project authorized under the Colorado River Storage Project and the San Juan-Chama Diversion Project. The dam was proposed, but never built, for predominantly Hispanic farmers in the Taos Valley of northern New Mexico. Using interviews with participants in the controversy as the basis for her study, the author argues for more complete and complex histories of intra- and interethnic cooperation and resistance, histories that embrace "untidy ambiguities."

"When [we] talk about history we don't mean what actually happened, do we? The cosmic chaos of everywhere, all time? We mean the tidying up… into books. History unravels; circumstances, following their natural inclination, prefer to remain raveled."

Penelope Lively, *Moon Tiger*

As we gather in 2002 for the centennial of the Bureau of Reclamation, we have set time aside for many events: for the special tour of Hoover Dam; for our host's celebratory events; and to meet with friends and fellow historians. But most importantly, we have *set time aside* in the most literal meaning of that phrase, for we will spend most of our time in the Past, recognizing the history of the past 100 years of the Bureau of Reclamation. As we gather to recognize the Bureau of Reclamation, we should perhaps ponder that verb: *recognize*—to look over again, literally, "to re-know."

To *set time aside* and to *recognize* are also most appropriate definitions for what we do as historians. We are also, though, in the broadest sense, storytellers. I do not mean that historians create fictions nor fantasies, though some do, but that we place very raveled events and circumstances into a narrative framework. We unravel and we tidy up. We have to in order to satisfy the necessity for a coherent work.

My contribution to this Symposium, my 'looking over again' a piece of the history of the Bureau of Reclamation, explores the controversial history of Indian Camp Dam, a project that Reclamation never built. Because it offers us insight into the oppositional strategies at work against the Bureau of Reclamation, this never-built project provides an additional dimension to our re-knowing, perhaps one that histories of completed projects cannot give. Because historians tend to emphasize what *did* happen, rather than what did not, they risk overlooking or missing opportunities to examine the meanings that an event had as it unfolded; they risk holding the past "hostage to an as yet undefined future."[1]

Indian Camp Dam, a relatively small dam, was to have been built near Taos, New Mexico, in the valley about three miles south of Talpa, New Mexico, as part of the Colorado River Storage Project (CRSP). The Bureau of Reclamation designed Indian Camp Dam to benefit predominantly Hispanic farmers and ranchers who needed an additional and reliable source of water for irrigating their lands, many of which were located on Spanish colonial land grants. Because my essay is not the first to look at the Indian Camp Dam controversy,[2] and because events surrounding the controversy have also been satirized in the popular novel by John Nichols, *The Milagro Beanfield War*, I am 'looking over again' the story of Indian Camp Dam in a literal, revisionist, sense as well. Beneath any tidied up narrative of the Indian Camp Dam controversy lie layers of complex human interactions that comprise the very raveled and very untidy historical, political, and cultural past of northern New Mexico. I do not presume that my history will do more than add another dimension, but I hope it adds a more raveled one.

Toward that goal, I have incorporated interviews conducted with principal participants in the controversy, in particular Andres Martinez and Rudy Pacheco, two Hispanic water leaders who ultimately found themselves on opposite sides, and John Nichols and Paul Bloom, two Anglos who also opposed each other. I have also incorporated the contemporary perspective of Eluid Martinez (no relation to Andres Martinez), Commissioner of the Bureau of Reclamation during the Clinton Administration. Eluid Martinez became involved in the Indian Camp Dam controversy in 1971 when he was a young hydrographic engineer working for the Office of the New Mexico State Engineer. As a native of northern New Mexico, an observer of the controversy, and as former Commissioner of Reclamation, Eluid Martinez commands a unique vantage point from which to comment upon the Indian Camp Dam project. I believe the oral histories of these participants reveal that previous versions of the Indian Camp Dam history have omitted facts critical to a complete and fair understanding of the controversy.

23.1. Eluid L. Martinez, Commissioner of Reclamation from 1995-2001, previously worked in the State Engineer's office in New Mexico, where he served as State Engineer at the end of his career.

This essay also examines the legal framework proposed for the ownership and maintenance of the dam, and how this project was influenced but ultimately hobbled by the tangled institutional structures, cultures, and organizational ideologies of the federal and state agencies involved in the controversy, including the Bureau of Reclamation. Ultimately, this essay questions stereotypical assumptions of how ethnic boundaries were set, maintained, and crossed during the controversy–assumptions that have since been further distorted by the success of *The Milagro Beanfield War*. This novel, and to some extent the subsequent movie, have garnered huge popular appeal. To a surprising degree, the novel encompasses the general public's entire awareness of northern New Mexico's environmental politics. The term "beanfield war" has become synonymous with any Anglo/Hispanic environmental dispute in New Mexico. The book continues to be displayed prominently in hotel and airport gift shops, alongside the iconic red chili *ristra* lights and howling coyotes, as if to announce "This is New Mexico." But "to recognize" the history of Indian Camp Dam is to recognize that a stereotypical and romantic description of a cliche struggle—Anglo developers and reclamationists versus earth-loving Hispanic farmers, a struggle that has taken on the power of legend—can be not only deceptive and unfair, but can also have long-lasting effects on how we choose to use and conserve natural resources.

Finally, by examining the history of this controversial and never-built reclamation project using the oral histories of these participants, I hope to show the validity of Donald Pisani's statement in *To Reclaim a Divided West*, that "The story of the West must begin from the ground up, rather than from the top down. The parts must be understood before sense can be made of the whole."[3] If we are to use this centennial to recognize the Bureau of Reclamation, it seems fitting to: "look over again" one of these parts.

Indian Camp Dam was designed to have been built in the forested canyon of Rio Grande de los Ranchos, a tributary of the Rio Grande, three miles south of Talpa, New Mexico. Talpa is one of over a dozen small settlements within Taos valley lying along eight mountain streams, all making competing demands on the valley's watershed. In addition to the competing demands of these predominantly Hispanic settlements, Taos Pueblo Indians claim *Winters* rights,[4] prior and paramount rights, to the headwaters of the valley's tributaries at Blue Lake.

While it is beyond the scope of this essay to detail the complexities of Indian water rights in New Mexico, an awareness of *Winters* rights is important to a theoretical understanding of the context, and perhaps even more importantly, the subtext, of the Indian Camp Dam controversy. Although Taos Pueblo was not involved in the controversy in an overt or active fashion, because its *Winters* rights were still not fully appropriated, nor yet fully put to beneficial use, and still theoretically held in trust by the United States, they remained unquantified. In 1970, just as the Indian Camp Dam controversy intensified, Taos Pueblo won its long battle with the U.S. government for return of Blue Lake. Against this backdrop the increasing demands for the water, and at least two years of drought, served to heighten awareness and competition for water throughout the Taos valley. In many important ways these tensions were not new. As John Baxter demonstrates in *Dividing New Mexico's Waters, 1700-1912*, conflicts over water had tangled the web of human interaction, resistance, and compromise in the Taos valley for the past 300 years.[5]

Indian Camp Dam was originally conceived as one of the hundreds of projects comprising the Colorado River Storage Project, or CRSP. When Congress finally passed and President Eisenhower signed the CRSP into law in 1956, the legislation enabled the Bureau of Reclamation to build the network of dams necessary to divide up and store Colorado River water among the seven western states, including New Mexico, that claim it. The ideological framework for the CRSP grew not only out of the federalism of the Reclamation Era, but also out of New Deal federalism and its social welfare programs. The CRSP was not only a project of environmental engineering, but in social engineering as well.[6] Beneath this framework lay the powerful symbolism of the Jeffersonian agrarian ideal of the yeoman farmer, which infiltrated and informed everyone's approach to Indian Camp Dam.

As originally conceived, the CRSP was one of this country's largest water reclamation projects. Its scope was astounding.[7] It encompassed scores of small and medium sized reclamation projects–the dams and reservoirs that fill the modern Western landscape. It included large and very controversial projects, such as the infamous and never-built Echo Park Dam, and Glen Canyon Dam, which created Lake Powell and stores the equivalent of two years' flow of the Colorado. The Bureau of Reclamation called Glen Canyon Dam its "cash register." Money that Glen Canyon Dam generated from electrical power subsidized the construction of other CRSP projects. The CRSP was the first reclamation project to link the receipt of power revenues from one location to payment for irrigation projects in others. This enabled politicians and reclamationists to rationalize the construction of irrigation projects in places where, until then, the economics of large scale irrigated farming had been considered impossible or, at best, marginal—places like Taos, New Mexico.

The CRSP called for water to be transported from the San Juan River, New Mexico's only source of Colorado River water, into the Azotea Tunnels underneath the Continental Divide, and finally into the Rio Grande Basin via the Chama River. This transfer, initially a part of the CRSP, is called the San Juan-Chama Diversion Project (SJCDP). Throughout the 1950s New Mexico's Senator Clinton B. Anderson, himself a strong advocate of reclamation and New Deal ideologies, fought for New Mexico's share of Colorado River water and for the SJCDP. As head of the powerful Senate Interior and Insular Affairs Committee, he helped direct the course of legislation required to enact the SJCDP pursuant to the terms of the Colorado River Compact. Anderson and most reclamation advocates believed that in order for New Mexico to use Colorado River water most effectively, the water had to end up in the Rio Grande, where it could then reach and serve the most populated and agriculturally productive portions of the state. This transfer subjected the imported waters to further complicated political compromises and to the terms of the Rio Grande Compact.

In 1962 Congress finally approved and President Kennedy signed into law the SJCDP and construction of the tunnels began. Senator Anderson had seen to it that most of the water would go to his constituency in central and south-central New Mexico, primarily for municipal and industrial use by the city of Albuquerque.[8] New Mexico's other U.S. Senator, Democrat and Hispanic Dennis Chavez, supported Anderson's long battle for the CRSP and the SJCDP. In return, Chavez won Anderson's promise that over one-fourth of the water (30,000 acre feet per year) would go to Chavez's constituency, the predominantly Hispanic farmers and ranchers in northern New Mexico.

Taos was too far north and east of the Chama River to receive the imported waters directly. Instead, by constructing dams, Taos and three other northern New Mexico communities were to impound waters from their respective Rio Grande tributaries in the total designated amount. This same amount would then be substituted with San Juan water flowing into the Rio Grande in order to replenish the Rio Grande and meet the downstream requirements called for under the Rio Grande Compact.

Under the terms of the Rio Grande Compact, New Mexico had to meet certain downstream delivery obligations, both intrastate and interstate. The Rio Grande Compact divided the New Mexico portion of the Rio Grande above the Elephant Butte Reservoir and designated the amounts that had to be delivered into the Reservoir from the upstream section of the river. Similarly, New Mexico also had delivery requirements and obligations to Texas. The most serious opposition to the SJCDP had come from Texas and from the Elephant Butte Irrigation District (EBID) in southern New Mexico. Texas and the EBID jointly questioned how their rights would be protected, especially in times of drought when they feared that the additional upstream projects proposed by SJCDP would consume too much water at the expense of those below Elephant Butte Dam. In return for dropping their opposition to the diversion, EBID and Texas demanded and were guaranteed strict compliance with the Rio Grande Compact.

The state of California, through the Colorado River Board of California, had also mounted vigorous opposition to SJCDP by attacking the feasibility of the New Mexico projects and questioning how they conformed to the Colorado River Compact and the pattern of protecting the Colorado River Basin as a whole. California wanted assurance that none of the Colorado River water would be made available for consumptive use, "whether by exchange or substitution or use of return flow, to any state not a party of the Colorado River Compact,"[9] that is, Texas. Thus, under the Rio Grande Compact New Mexico was left to assume responsibility to the EBID and Texas to limit the use of the water upstream to the amounts imported and simultaneously, under the provisions of the Colorado

River Compact, New Mexico was to keep Colorado River water out of Texas by consumptively using the total diverted volume.

It is critical to an understanding of the Indian Camp Dam controversy to appreciate the complexity of the Colorado and Rio Grande Rivers' water regimes and their requirements and demands upon the state and federal regulatory agencies. It is also critical to appreciate the significance of the Hispanic water users' role in fighting for northern New Mexico's portion of Colorado River water. Of the 30,000 acre feet per year allocated to northern New Mexico, almost half (12,000 acre feet per year) was to benefit a few hundred farmers living on a few thousand acres of marginal lands high in the Sangre de Cristo mountains around Taos. These farmers were not passive or unwilling recipients. Indeed, it is doubtful that this water would have been allocated to Taos, sought as it was by so many competitors both within and outside of New Mexico, without strong and collective support of the Taos farmers. Initially, they played not only an active role in fighting for the water, but in justifying its use as a way of preserving, perpetuating, and enhancing their pastoral lifestyles.[10]

In 1954 and again in 1958 Taos water users sent their spokesperson, dairy farmer Andres Martinez, to Washington to testify before Senator Anderson's Interior Committee. He spoke in favor of the CRSP and funding for the San Juan-Chama Diversion. Martinez delivered a lengthy statement advocating passage of the CRSP.[11] He and the other eight signatories, six of whom were Hispanics, outlined the history of their county and its people. Martinez testified that 50 percent of the heads of household in Taos left their homes and families each year to find work ". . . in the beet fields and mining camps of Colorado or running the sheep camps of Colorado, Wyoming and Montana. There [were] no jobs in Taos County."[12]

Martinez told the senators that 100 years earlier Taos had been a prosperous farming community, "called the granary of that part of the world," with "great flocks of sheep and great herds of cattle." But that was before the Rio Grande Compact required them to send "many thousands of acre-feet of water per year to Texas."[13] It was also before the creation of the Forest Service, which the farmers claimed had sharply curtailed or denied grazing permits on what had been their ancestral and communal lands, and before the Taos Pueblo Indians had come to have more water rights, including the rights to the best streams in Taos.

In her seminal essay on the history of patterns of ethnic stratification in Taos, anthropologist and Taos native, Sylvia Rodriguez, shows that "appropriation of community common lands was probably the single most devastating blow dealt the native agro-pastoral subsistence economy,"[14] and that "around the time of statehood [1912], Taos seems to have gone from a valley of golden promise to an economically stagnant backwater, awaiting touristic discovery."[15] While the touristic discovery of Taos is beyond the scope of this essay, its pervasive economic influence, as well as that of the luxury home real estate market (nascent in Hispanic villages near the Taos Ski Valley at the time of the Indian Camp Dam controversy), cannot be overlooked as factors contributing to tensions in the valley and conflicts over land and water use.

Andres Martinez's 1954 Congressional statement advocated a dam to impound excess runoff waters. The farmers argued that a dam would allow a more stable water source and prevent the injudicious over-use of the spring season's waters, a practice that had grown out of the farmers' desire to capture as much water as possible, when possible, from Taos's highly ephemeral streams. The extra water would also make possible the irrigation of new lands and local market gardening would increase, increasing the saleable output from their farms. In their final plea, the farmers proclaimed that the San Juan River waters and a dam in Taos "would change an area of potential tragedy into one of great productivity and prosperity."[16] This plea meshed perfectly with the social goals of reclamation and was exactly the kind that the altruistic rationalizations of the CRSP were designed to address.

After passage of the CRSP and the SJCDP, the Bureau of Reclamation determined that two of the four water storage projects planned for the Taos area could not be built due to geological obstacles. Then, in 1969, Indian Camp Dam itself appeared endangered as well. Even though Taos was eligible for the huge power revenues that would pay 96.6 percent of the construction costs of the dam, Reclamation questioned whether the dam, even with the heavy subsidies, could meet the government's cost-benefit ratios. Because the lands to be benefitted were so marginally productive, Reclamation announced that the project was not feasible "as a purely agricultural irrigation unit."[17] Farmers mounted a campaign to fight for the dam. They organized a full scale "Save the Water" effort to lobby for the water, to endorse the dam, and to "recommend that the ground rules for water use or even design be changed to make [the dam] feasible."[18] By November 1969 Hispanic ditch commissioners and *mayordomos*[19] from thirty-five ditch systems and other members of ditch associations from Arroyo Hondo to Llano Quemado united to fight for the dam.[20]

Needing to put the water to beneficial use and fearing political repercussions if three of the four projects proposed for northern New Mexico failed to be built, the Bureau of Reclamation did change the ground rules. It added on a "recreational use" provision, which allowed the Forest Service to step in to maintain and operate the small lake created by the dam. This use required the Forest Service to contribute significantly to the costs of the dam. But ironically, this plan, tacked on to help pay for the dam, later became one of the opponents' most forceful arguments against it. Hispanics long resented the Forest Service as the agency that held and controlled much of what had been land grant common lands during the Spanish and Mexican colonial periods, and they linked Forest Service development projects to debt and dispossession.[21] The Forest Service had become a powerful symbol of their "stolen" homeland.[22]

Another such powerful symbol was the quiet title suit. Such suits were seen as the means by which Hispanics had lost over 80 percent of their grant lands by the turn of the twentieth century.[23] Because both the Rio Grande and Colorado River Compacts required stringent accounting of existing Rio Grande waters, the New Mexico State Engineer believed that these waters had to be measured prior to the addition of the imported Colorado River waters. The only legal mechanism for this accounting was stream adjudication, or quieting title to the water. In 1969 New Mexico State Engineer Steve Reynolds, through his Special Attorney General, Paul Bloom, filed stream adjudication suits along the entire northern stretch of the Rio Grande, including the Taos tributaries, to determine the nature, amount, location, and priority of all existing water rights.[24]

At the initiation of the stream adjudication suits, at least two interpretations of the *Winters* reserved rights for Indians prevailed. Water law historian Ira G. Clark provides a helpful discussion that serves to distill these two interpretations, one propounded by William Veeder and the other by Paul Bloom. These two views, both supported by the *Winters* decision, illustrate the ambiguity in the law and the conflicted position of the federal government's reclamation policies viś à viś Indian reserved rights. Veeder, a veteran official in the Department of Justice during the Nixon administration, voiced a tenacious defense of Indian water rights pursuant to *Winters*, holding that

> . . . in signing treaties with the United States the Indians… retained everything they did not cede including their water rights… Their rights were therefore 'immemorial' in origin and prior in time to all counterclaims. Development by the Bureau of Reclamation and other interior department agencies of "surplus" waters originating on or flowing through Indian reservations was limited in time to the period during which Indians were unable to use them. Nor could any appropriator assert rights based on state law because the federal government had exclusive control over Indian resources.[25]

Furthermore, Veeder placed Indian reservations in a position "to assert superior claims to all additional waters as the needs develop."[26] As Clark states, this interpretation imposed "drastic limitations on the power of state water control agencies" and threatened non-Indian water users in the vicinity of reservations, especially Hispanic water users in places like Taos, since their lands and *acequias* usually have the oldest appropriated rights in these vicinities. The Indians' claim of prior and paramount rights could conceivably not only halt further development within the state, but these claims would "jeopardize the rights of junior appropriators who were already using the water beneficially."[27]

Clark describes Paul Bloom as "a most vocal exponent" of the counter-position to Veeder's. Bloom interpreted *Winters* as holding that

> …the United States impliedly reserved waters for Indian use at the time the reservations were created, based on the constitutional power

> of Congress to dispose of and make all needful rules and regulations respecting property belonging to the United States. It did not therefore, differ materially from the implied reservation of water at other federal enclaves.[28]

Clark charges that of the federal agencies, the Bureau of Reclamation was "the worst offender" in its "purposeful 'reclaiming' of Indian waters for use on federal projects"[29] since it and other federal agencies were supposed to protect Indian water rights rather than preempt and develop them.

The stream adjudication suits exposed the uncertainty of the extent of the Indians' *Winters* claims to Taos valley's water and thus opened a Pandora's box of distrust, competition, and greed, and exacerbated centuries' old tensions and ambiguities over unresolved water claims within the communities. Although he believed it was New Mexico's duty to initiate the adjudication suits, the State Engineer underestimated the effect the suits would have on the communities, and on Taos valley's response to the dam.[30] The State Engineer may have also miscalculated the extent to which mistrust of the state's motives in initiating the suits led to a deeper apprehension and questioning of other legally required components of the dam.

Both New Mexico law and reclamation law required the water users to form an entity capable of issuing bonds to contract with the government to construct the dam, but New Mexico law limited the proponents' choices for such an entity to either a conservancy district or an irrigation district.[31] Initially Andres Martinez, as head of the Taos Unit Coordinating Council's executive committee, recommended the water users form a conservancy district. The Council argued that under irrigation district laws, irrigators would bear the full burden of the dam's remaining costs, even though others in Taos would benefit indirectly from the added water. By sharing costs of the dam with non-irrigators under a conservancy district, the cost per farmer, in the form of ad valorem taxes, would be halved.[32] Yet as tension and misapprehension grew, irrigators began to suspect that while conservancy district laws favored irrigators in this respect, in other, more important, respects they did not. Under conservancy district statutes, members of the conservancy district's board of commissioners, at that time a three-person appointed board, did not have to be farmers or irrigators. Hispanic ditch commissioners and *mayordomos*, the leaders who oversaw operation of the traditional existing irrigation system, began to realize they would lose immediate control over water allocation and management.[33] In the summer of 1971 sixteen *mayordomos*, led by Andres Martinez, very publicly resigned from the local water users' association that had formed to promote the dam, basing their change of heart on opposition to formation of the conservancy district.[34]

Conservancy district case law in New Mexico reflects that users in the Middle Rio Grande Conservancy District, New Mexico's first and largest conservancy district, litigated over most of the very issues that Taos users feared, citing many of the same reasons. Yet a look at the first case deciding the constitutionality of New Mexico's first conservancy act shows that mistrust and antipathy toward conservancy districts were not unique to New Mexico. In citing precedents for its decisions, the New Mexico Supreme Court quoted the Ohio court: "Rarely has a law been found which has been assailed with such frequency or from so many angles."[35]

Conservancy district laws in New Mexico have evolved into an odd hybrid that reflect simultaneously the goals of flood control—the original ostensible purpose of the act—as well as reclamation, drainage, and irrigation. There is no doubt that promoters of the original act sought protection from floods. In fact, the original act forbade the creation of conservancy districts north of Santa Fe County, since that section of the River with its deep gorges was not flood prone. When the act was challenged on the grounds that it was unconstitutional by reason of being special or class legislation, the court ruled that the differences in natural conditions along the northern portion of the river justified the special classification that forbade flood control districts where they were not needed.[36]

Proponents of the first act also convinced the legislature that drainage of the middle Rio Grande valley was imperative, as aggradation of the river had waterlogged the entire middle valley and the City of Albuquerque was "hemmed in by unhealthy marshes and swamps."[37] But in addition to flood control and drainage, boosters of a conservancy district for the middle Rio Grande valley also clearly wanted the economic development that reclamation promised to bring. An Albuquerque editorial on June 4, 1922, proclaimed:

> It is difficult to imagine an investment of effort that would yield such enormous and such certain returns. Nor is it difficult to bring this development about.… There is not a business in Albuquerque that can fail of doubled volume from reclamation of the Middle Rio Grande Valley, because that reclamation will double the tributary population not once but several times over and add enormously to the flow of wealth to and through this city.… Why not get up and hustle—while the hustling is good?[38]

Most importantly, conservancy district proponents needed the ability to increase the tax base by bringing municipalities, principally the City of Albuquerque, and railroads into the district to share in the costs. Conservancy district laws allowed lands to be classed and assessed according to benefits received and, unlike irrigation districts that were limited to agricultural lands, conservancy district laws allowed the inclusion of non-agricultural lands.

In 1923 New Mexico modeled its first conservancy act on both the Ohio act, passed in 1914, and the Colorado act, passed in 1922. Those states designed their laws solely for purposes of flood control, in response to disastrous floods in Dayton and Pueblo, respectively. In its opening remarks determining the constitutionality of this first New Mexico conservancy act, the court *In Re*

Proposed Middle Rio Grande Conservancy District "made a careful comparison" of the New Mexico conservancy act with those of Ohio and Colorado and found that

> . . . in the main the provisions of all three acts are the same. The Colorado act followed the Ohio act, making such changes as seemed suitable for the conditions prevailing in the Western states, and the New Mexico act closely followed the Colorado act, occasionally including a provision which was in the Ohio act and omitted from Colorado law.[39]

Yet the appellants questioned the title of the act, arguing that it indicated that the New Mexico legislature had in mind different purposes from those declared in the Ohio and Colorado conservancy acts, namely irrigation. They argued that because the title of the New Mexico act included the subject of cooperation with the federal government in its reclamation policy, "the indications are that the purposes of our Conservancy Act look to the improvement of the agricultural conditions of the Rio Grande Valley, and that alone."[40] Appellants argued that the Ohio and Colorado acts were adopted "solely and exclusively for the protection of life and property, and not in any sense calculated to interfere with the industrial pursuits of their people."[41]

The New Mexico Supreme Court appeared oblivious to the appellants' suggestion that the Middle Rio Grande Conservancy District would interfere with agricultural pursuits or engage in reclamation. Replying that "it did not appear" that the legislature, in passing the conservancy act, "had in mind alone or principally the reclamation of lands," the court noted there were already statutes existing authorizing the formation of irrigation and drainage districts, and these had been approved on the same day as the conservancy act.[42] In closing, the court noted that if "an attempt should hereafter fraudulently be made to accomplish a purpose not within the purview of this act, the courts would doubtless give protection to the complaining parties."[43]

But backers of the Middle Rio Grande Conservancy District appear to have intentionally "recast and enlarged" their proposed language for the original act, specifically to add a provision for reclamation. Notes kept by the membership committee of the Middle Rio Grande Association, the booster organization formed to work with the legislature for passage of the conservancy district law, reflect that "changing from drainage to reclamation ha[d] been more or less confusing," but "when the people [were] correctly informed,… [the] committee… met with hearty response from people… ready and anxious for reclamation, some of whom were opposed to drainage."[44]

In 1927, apparently anticipating that the Supreme Court would hold that under the original act reclamation alone was insufficient to warrant the organization of a conservancy district, the legislature amended and broadened the act to allow unambiguously "for irrigation of lands, though they are not menaced by floods."[45] This amendment led to another challenge to the act's constitutionality in 1929 when plaintiffs in *Gutierrez et al. v. Middle Rio Grande Conservancy District* argued that as petitioners for the conservancy district they had been "moved by a desire only for flood control but that a corporation resulted with power to make irrigation its principal object."[46] The Supreme Court ruled that the new conservancy act did not change the character of the Middle Rio Grande Conservancy District as a district organized for "the main purpose of flood control with irrigation and drainage incident thereto.[47] By 1940 the Supreme Court, again noting that New Mexico conservancy district laws closely followed the Colorado and Ohio statutes, acknowledged finally that "The provision for the irrigation system, included with flood control and reclamation, is, however, peculiar to the New Mexico Act."[48]

More importantly though to the discussion and context of the Indian Camp Dam controversy, the Supreme Court in 1940 for the first time examined the management and control of existing community *acequias* by the conservancy district. Noting that the old community ditch laws were not repealed by the conservancy act, and that water rights were not affected by the act, the court nevertheless dodged the question of what duties, if any, remained to ditch commissioners who continued to be elected and operate under the old regime, independently of the conservancy district. The court termed this question "intriguing."[49] Ultimately, the court ruled against dual control of the ditches, stating that "the administration of these [water] rights, so far as the impounding, diversion, carrying and delivering of… water for irrigation… has now been placed in the hands of this new and superior authority, plaintiff [conservancy] District."[50]

Taos water users questioned virtually all of the same provisions that water users in the Middle Rio Grande Conservancy District did in appealing the constitutionality of that district, including their inability to appeal assessments made by the county treasurer; the appointment rather than election of the conservancy board; the impingement upon their power to manage and control their own affairs; and the lack of a requirement that a majority of the landowners in the district sign the petition for organization of the district.[51] All of these provisions seemed "undemocratic" and "un-American" to opponents of the district in Taos.[52] But most of all, the Hispanics who turned against the conservancy district feared "this new and superior authority."

Originally, the proposed conservancy district in Taos included 774 acres of land lying within the San Cristobal de la Serna Grant. Granted by the King of Spain in 1710, the La Serna Grant was the oldest non-Indian Spanish land grant in Taos County (and one of the oldest in New Mexico).[53] Having held onto most of these ancestral lands through the intervening decades of rapid Anglo land expropriation after New Mexico became a territory, the Hispanic residents of La Serna were deeply suspicious of the taxes that the conservancy district could impose.[54] To irrigators who owned small plots it "seemed 'wrong' to have to start paying $5.75 an acre for the same water" they had been using for generations.[55]

Land tenure patterns in La Serna further compounded the problem for the La Serna farmers.[56] Because of the Hispanic tradition of dividing land equally among multiple heirs, each tract with access to the river, or *acequia*, acreage in the La Serna Grant included many long, extremely narrow plots (in some cases only a few feet wide and several miles long). Many farmers owned several narrow but non-contiguous plots, often with rights to different *acequias*. The Bureau of Reclamation recognized that farms under ten acres were not considered economically feasible and recommended that owners of such narrow tracts consolidate their lands by forming land pools or co-ops. The Bureau of Reclamation also recommended a change in cropping patterns, away from forage crops to more cash intensive crops. Not only did the La Serna landowners fear the loss of their lands if conservancy district taxes for the dam could not be repaid, they also resented and resisted the pressure to change their traditional ownership and cropping patterns.[57] In the fall of 1971 the La Serna irrigators petitioned for the removal of their lands from the conservancy district.

State statute required the district court to approve the petition for the conservancy district, an approval now complicated by the petition for removal of the La Serna lands. After months of delays (including the self-excusal of an Anglo judge), District Court Judge Santiago Campos ruled in October 1972 that the La Serna land grantees' opposition to the conservancy district constituted an "insurmountable obstacle to any reasonable finding of benefit from irrigation to all the lands within the proposed district."[58] Moreover, he ruled that the exclusion of La Serna left the costs of the project higher than the resulting benefit, and thus the necessary statutory justification for the formation of the conservancy district was absent. However, Judge Campos noted the "intense and pressing interest in the Taos community,"[59] as well as the obvious need for the water. He warned that opposition to the conservancy district could well mean loss of the water that everyone needed and he warned the opponents of the character in Othello whose hand threw away a pearl richer than all his tribe. The judge told the remaining proponents that he would not totally dismiss the petition if they could alter their plans and substitute other lands for the La Serna lands.[60]

Judge Campos's decision proved fatal for the conservancy district, though that was not his apparent intent. The petitioners, not wanting to lose the fabled pearl, took Campos's suggestion and redefined the conservancy district boundaries. If anything, this move only increased the controversy, since the newly incorporated lands included large tracts belonging to several prominent Anglos, including an Anglo developer and his sister, owners of the largest land holdings in Taos valley. Unlike the neighboring La Serna lands, much of the newly added lands had not been irrigated previously. This fueled rumors that the water would not be used for irrigation, but would be converted to commercial uses and development purposes.[61]

In April 1973 Judge Campos granted the formation of the revised conservancy district. The dam's opponents, now allied under Andres Martinez as the "Tres Rios Association," appealed Judge Campos's decision. On May 14, 1975, the New Mexico Supreme Court ruled that Campos's compromise decision to allow a reformed district was illegal. The Supreme Court agreed that Judge Campos had properly excluded the La Serna lands from the district because such lands would not benefit from the conservancy district. But the higher court ruled that Campos had exceeded his authority in allowing the petitioners to "amend the petition so as to create a new and different district, since signers of the original petition contemplated and intended a different district from the one resulting, and where the ultimate tax burden upon those remaining in the district would be definitely affected."[62]

After the 1975 New Mexico Supreme Court decision nullified the Rancho del Rio Grande Conservancy District, no one in Taos pursued the project further; Indian Camp Dam never got off the drawing board. That same year John Nichols published *The Milagro Beanfield War*, and the story of the dam's demise took on the aura of legend: local *nativos* and a few concerned, earth-loving Anglos versus the callous government in cahoots with land-grabbing, usually Anglo, capitalist developers.

By the time he left New York for New Mexico in 1969, John Nichols described himself as "strung out, on edge, going down fast."[63] The son of privilege and wealth, a graduate of private prep schools and Hamilton College (the setting of his first successful novel, *The Sterile Cuckoo*), he became active in the anti-war movement in New York City in the late 1960s. But he found New York relentless and wanted out. Because he found himself "looking at the world from a much more Marxist or even socialist perspective," he wanted to come to New Mexico, which he saw as fertile ground for his political activism.[64] Because New Mexico "approximated a colonial country," Nichols believed it would be like "moving to the third world," and that interested him.[65] He also sought "an environment where [he] could be startled constantly by natural phenomen[a]… having roots in a special landscape not yet destroyed by progressive human endeavors."[66] Instead, what confronted Nichols in Taos valley was a community on the brink of building Indian Camp Dam, a project many would have proudly labeled a "progressive human endeavor."

Like other refuge seekers, Nichols saw life in northern New Mexico as "an antidote to modern mechanization, and land of exotic primitivism and simple truths."[67] In his memoir, *If Mountains Die*, Nichols wrote that he was "destined" to "wind up in northern New Mexico as the semi-Marxist-Leninist propaganda arm for a group of quixotic Spanish-speaking septuagenarians locked in mortal combat with the U. S. government over preservation of their water rights, their land, their culture, their very historical roots."[68]

During our interview, Nichols downplayed his own role in the controversy, calling it a "minor but vocal one."[69] He recalled "speaking out" at meetings and holding heated exchanges with Paul Bloom, the attorney from the State

Engineer's office. And although Nichols wrote many articles opposing the dam in the local weekly independent newspaper, *The New Mexico Review*, he denied that he played a significant role in changing public opinion.[70] This denial is probably more accurate than his more romanticized written memoirs. The articles Nichols wrote in 1971 in *The New Mexico Review* did not receive wide distribution among Hispanics and, having arrived in Taos only recently, he was not well known within the community then.

There is also evidence to support attorney Paul Bloom's observation that Nichols' overtly politicized speeches at public meetings offended many Hispanics "who identified him either with the Hippies or the crazy environmentalists… they didn't like… being told they were barefoot, serape-wearing peasants… [who needed] to be protected by this political agitator who view[ed] Hispanic culture as being on a museum shelf for 300 years…"[71]

Since the publication of *Milagro Beanfield War* it has become difficult for even the participants to unravel how much influence Nichols had on actual events at the time of the Indian Camp Dam controversy, and how much he has been credited with, or blamed for, because of the book. In everyone's attempt to give coherence, and perhaps meaning, to these events, Nichols's fictional and satirical version has somehow become the standard that other versions must meet.

Nichols described to me one heated public meeting about the conservancy district that he attended, saying it was "just like a film set." He said that the room was "split in two," with "100 percent Chicano farmers on one side, and bankers, lawyers, real estate people, Anglo business people from town and the developers in the valley on the other side."[72] Nichols claimed that the controversy "seemed to pretty much break up into what most battles around here do, between essentially smaller farmers, impoverished people, and the developers of the valley, which is a cliché struggle all over the world."[73]

But neither the historical record of Indian Camp Dam nor the recollections of the other interviewees reveals a simple two-sided dichotomy, nor do they reveal a "cliché struggle." Nichols's description *did* seem like something off a movie set—indeed, it seemed to be right out of the movie version of *The Milagro Beanfield War*. A far more intriguing, more ambiguous, more complicated, but less coherent scenario emerges not only from the legal and political web of the dam's history, but from other participants' memories.

Born in 1898, Andres Martinez grew up poor but relatively well educated at a Presbyterian mission school in Taos. He lived his entire life in Taos, except for the many months each year during his youth when he traveled the circuit as a shearer on the sheep ranching circuit throughout the West. Martinez's father had been a shepherd who never owned irrigated land, just a small vegetable plot and house in Ranchos de Taos. As a child, Martinez supplemented the family's income by picking onions from his mother's garden, loading them onto burros, hiking to Elizabeth Town, and selling the onions to the miners who paid him with little bottles of gold dust.[74] Martinez's depiction of his childhood and early adulthood mirrors that of the majority of Hispanics in northern New Mexican villages during the first quarter of the twentieth century, as described by Sarah Deutsch in *No Separate Refuge*:

> Faced with an increasingly intrusive conquering economy and culture, the Hispanics could not retreat. They had to formulate new strategies in order to maintain the viability of their villages… among the options, seasonal labor proved the most attractive…through the strategy of work and migration patterns, they retained their control over their own enclaves, retained for themselves a homeland—both a refuge and a base for expansion without loss of cultural identity.… The migrants [were] 'living links' to the goods, services, and cash of the Anglo economy.[75]

Martinez managed to save enough money to leave the seasonal labor system, though it appears he never forgot the lessons of that strategy. In 1950, he and his wife bought eight cows and a forty-acre dairy farm in Taos. By the time he sold his dairy and retired, he was on the board of directors of the local savings and loan and one of its largest shareholders. He was not an "impoverished farmer"; arguably, he had become a "rico." Rumors had it that he had also become a Mormon and had sought appointment to the Interstate Stream Commission.

Even though he ultimately opposed construction of the dam, Martinez remained, at age 92 when I interviewed him, fiercely proud of the role he and other Hispanics played in getting New Mexico its share of Colorado water. Fighting for the water remained a core and defining memory. He described himself as "fighting for twenty years to get it."[76] Martinez admitted that in the beginning he and the other Hispanic water users "were all for the dam."[77] That is, until they learned more about the conservancy district. Martinez claimed that the conservancy district would have resulted in loss of lands due to its power to impose property liens and, if necessary, foreclose and sell the property to pay back taxes.[78]

Perhaps because of the varied experiences of his youth as a migratory worker, Martinez became adept at crossing ethnic boundaries. While maintaining his strong ties and identification within the Hispanic community as a respected leader, he also negotiated and cooperated with Anglo power brokers when he believed it would benefit Hispanics. His status within the Hispanic community enabled him to travel out of this ethnic enclave while simultaneously strengthening it by establishing his own presence and identity within the predominantly Anglo arena of reclamation politics and interstate water management.

The most ambiguously positioned participant in this controversy may have been Paul Bloom, who was, in 1969, a 30-year-old Special Attorney General working for State Engineer Reynolds and the Interstate Stream Commission. In this position, Bloom came to be the point man and spokesperson not only for the state in its efforts to explain Indian Camp Dam but also for the Interstate Stream Commission in its efforts to promote the dam—sometimes the latter role was at odds with his private opinions about the dam.

Bloom denies he ever tried to "sell" the dam, but as the state attorney who initiated the stream adjudication suits, he was assigned to hold town meetings to explain why the dam triggered the adjudication suits. Bloom was keenly aware that the Interstate Stream Commission was "clearly a booster of record [for the dam]."[79] He also understood the "complicated calculus of log-rolling," and "jealous intrastate and interstate jurisdictions, communities, and political power bases… that had constantly traded off and fought each other to get their key interests taken care of…" and he realized when he was assigned to go to Taos that "all of these compromises were expressed in years of impatience to get [the dam] going."[80]

Because Bloom was the voice of government, he became heavily involved in the controversy and was often the focal point of the community's re-ignited distrust of the government. While this distrust was historical for the Hispanics, for Anglos like Nichols who opposed the dam, this distrust was contemporary, tied to the emerging environmental activism of the late 1960s, and perhaps even more significantly, to anti-Viet Nam War sentiments. John Nichols often conflated his opposition to the dam with militarized rhetoric directed personally against Bloom. In July 1972 Nichols described Bloom in *The New Mexico Review*:

> Bloom… has been a pivotal figure in the attempt to erect Indian Camp Dam over the dead bodies of the poor people in Taos for whom the Dam is allegedly being built.… And perhaps Bloom, petulant, frowning, doomsayer here and culture savior there, is wondering why nobody believes anymore in the magic of his Indian Camp baubles, bangles, and bright shiny promises.
>
> Well: maybe it's because some grizzled old brujo was staring through the smoke of his pinon fire one day, gazing up towards the soft green hills at the eastern edge of the Little Grande Valley, and on the crest of one little mountain he saw a strange figure from the State Engineer's office with his left hand thrust Napoleonically between the breast button in his Brooks Brothers tunic, standing proudly beside his Indian Camp howitzer, grandiosely proclaiming—as it has been the habit of certain other United States Government landscapers et al. to proclaim: "It was necessary to destroy the people of Little Rio Grande Valley in order to save them…"[81]

Like others, Bloom believed that the issue of the conservancy district was "the kiss of death" for the dam, not because of the dangers of conservancy districts but because "it allowed it to be demagogued to death."[82] Bloom claimed he never saw "a more effective case of demagoguery, of romantic nostalgia, of playing on all the nineteenth century fears and agendas."[83] Yet Bloom maintained that in 1971 he privately believed the dam came 100 years too late. He thought it was a "somewhat utopian… rather touching… unreal political thing to do."[84] But by the mid-twentieth century the lands the project was intended to benefit had been divided up into such small tracts that land pooling would have been a daunting if not impossible task. This, combined with the short growing season, flood risks, high elevation, and distance from markets, seemed to Bloom to be problems the Bureau of Reclamation's optimistic forecasts could not overcome. But he did not see it as his place to make this judgment because, he said, the local water users wanted this project. "It had been negotiated by them and for [them] by their elected representatives, over many years, justified by their federal government on certain assumptions, including the benefits from irrigation."[85] He believed that "[people] couldn't simply let comparative economics dominate what [they] do with natural resources or the rich and the big cities would have everything."[86]

Bloom also saw clearly that once Andres Martinez and his group went into open opposition, the dam "was doomed… at least doomed to an endlessly long and painful and divisive dispute."[87] Bloom warned State Engineer Reynolds and the Interstate Stream Commissioners that even if all the hurdles could be overcome, it would be done at a great price in community discord and division. Bloom recalled that the Stream Commissioners looked at him "as if they'd heard Santa Claus had been shot." [88]

In 1971 Rudy Pacheco was a 41-year old cattle rancher and school administrator and owner of one of the larger tracts of lands in the proposed conservancy district. Pacheco wanted the conservancy district and the dam. After Andres Martinez's resignation as leader of the water users' organization, Pacheco led the proponents. Pacheco never wavered in his support of the dam and remained bitter that it was never built, believing that its loss forced him to move his ranching operation to Colorado. He believes that now, without the dam, it is virtually inevitable that each of the eight Taos streams' flow will have to be commercialized and domesticated because "they killed agriculture in Taos County."[89]

Pacheco recalled that before the opposition to the dam became overt, Hispanic farmers discussed the possibility of producing grain for Coors Brewing Company and raising beans for the Campbell Soup Company because bean crops had been very cost effective in the Taos area. Campbell's ultimately located its operation in Bayfield, Colorado, using irrigated lands from another CRSP project. "Campbell's had guaranteed a contract for 6,000 acres of beans for a twenty-year period. That was a cash crop that La Serna people could have used," Pacheco claimed.[90] Interestingly, Pacheco blamed John Nichols, rather than Andres Martinez and the other Hispanics who withdrew their support, for loss of the water. "Through his ignorance [Nichols] did the valley an injustice by sacrificing that amount of water that could have been used forever in the future… and that's something you lose culturally and historically and it will never come back."[91]

Perhaps because of his relative wealth, but more likely because of his relative youth, Pacheco was unable to maintain a coalition of water users in 1971 with the same strength as the coalition Andres Martinez previously formed. Martinez and the other elder *mayordomos* who defected symbolized Hispanic tradition melded to American agrarian ideals. Ultimately, this symbol proved too powerful for younger Hispanic farmers to overcome.

In 1971 one year out of college, Eluid Martinez joined the office of the State Engineer as the first Hispanic engineer in the history of that office. In conjunction with the stream adjudication suits, he began learning to conduct the hydrographic studies that the suits required. While he did not witness the confrontations between Bloom and Nichols, Eluid Martinez did attend meetings of local water users as part of his duties to explain the stream adjudication suits. He perceived that the attention, but not the controversy, had shifted to the adjudication suits. At his first such meeting at a local elementary school, he was told not to enter the room unless he spoke Spanish. He did not perceive this as an attempt on the part of the Hispanics to keep Anglos away, but rather a concern that any explanations of the adjudications be given in Spanish, since many of the older participants did not speak English.[92]

Yet Eluid Martinez acknowledged that at the time of the controversy there was an increased animosity in Taos valley against "outsiders," primarily the Hippies, who had flocked to the area in what Rodriguez terms "The Great Hippie Invasion."[93] As Rodriguez points out, this influx of thousands of people into Taos between 1968 and 1971 also placed increased pressures on the valley's resources since the Hippies, although seeking the "same romantic utopia their bohemian predecessors had sought," also came with dreams of "going back to the land."[94] According to Rodriguez, Hippies were:

> able to buy up parcels of irrigated land rather cheaply from Hispanos, who needed the cash and had little inkling of the transformation about to occur.… within another decade the average price of an irrigated acre had increased by as much as forty times.[95]

Significantly though, Eluid Martinez did not perceive that there "was much controversy" in Taos at the time over the matter of the stream adjudications themselves. "Most of the surveys were completed and brought to closure fairly quickly in terms of water right offers that were signed and accepted… except for those lands that had been offered no water rights because of non-use."[96] Here again the water and land use patterns of Hispanics in northern New Mexico came into play and worked against them under New Mexico law. According to Eluid Martinez, "in the traditional way of managing *acequias* in northern New Mexico, the land owners would consider that their water rights would be protected as long as they paid their ditch dues and ditch assessments."[97] Because so many Hispanics left northern New Mexico in the decades following World War II, primarily for economic reasons and in a continuing pattern of out-migration similar to that described by Deutsch above, their lands went fallow and unirrigated although they continued to pay their ditch dues. When the hydrographic surveys picked up lands as being non-irrigated, the lands were deemed to be without water rights. However, by the time of Indian Camp Dam, New Mexico's water rights forfeiture laws had been amended to allow for notice by the State Engineer and a four-year opportunity for the user to cure the non-use and place the lands back under irrigation. While this change in the law rectified the situation somewhat, it could not ultimately alleviate the problem many absentee Hispanic landowners confronted: how to put their lands back into production from afar. Similarly, many older Hispanics who stayed on their lands were unable to irrigate them without the assistance from younger family members who no longer lived nearby.

Upon the death of State Engineer Steve Reynolds, who had held that office for thirty-five years and become one of the most powerful men in the state's history, Eluid Martinez stepped into the position in November 1990. He went on to serve as Commissioner of the Bureau of Reclamation under President Clinton. With the perspective he gained throughout those years of state and federal water administration, Eluid Martinez now believes that opponents of Indian Camp Dam "might have made a mistake, in terms of water supply." Because of the still unresolved *Winters* claims of the Indians, "[holders of] the existing irrigated lands that would have been supplemented by the San Juan-Chama replacement waters are today fighting for their very existence in the adjudication that's taking place.… In hindsight, if that project would have been constructed, in my opinion it would have provided the water supply necessary to address all these concerns."[98]
Yet despite this opinion Eluid Martinez, like Bloom, also conceded that as an irrigation project Indian Camp "even if proposed today, would probably not be economically feasible," primarily due to the obstacles of the land tenure system.[99]

According to Eluid Martinez, the Bureau of Reclamation was accustomed to building projects for farms of 160-960 acres. Moreover, Indian Camp Dam was not a project that Reclamation could build, as it usually did, from the ground up on lands to be newly irrigated, at least not primarily. The project was hobbled by ineffective attempts, from all sides, to make it fit into an existing and foreign irrigation framework. "It was something new to them," Eluid Martinez said, referring to the existing *acequia* irrigation system in Taos and the Bureau of Reclamation.[100] But this "foreign-ness" was not one-sided. The complicated history of Indian Camp Dam illustrates profoundly the collisions that can occur at cultural intersections, where indeed, in hindsight, it can be said of the actions of almost all the resisting participants, "it was something new to them."

Other researchers tend to rely on Nichols's nonfictional accounts of the Indian Camp Dam controversy as the basis for their findings that Indian Camp

Dam and the related SJCDP projects exemplify "top down planning," and they conclude this reveals that "Hispanic participation, at least at the grass roots level, was not effective."[101] These interpretations overlook or downplay the importance of the Hispanic water users' very active and effective participation in obtaining the allocation of the SJCDP water. In *Water and Poverty in the Southwest*, Brown and Ingram outline the complex problems facing rural Hispanics in northern New Mexico and examine Hispanics' attitudes about water rights and their preferences for water use and economic alternatives. But ultimately, and ironically, Brown and Ingram see the "lack of water storage as a continuing problem,"[102] and they end up recommending some of the same changes that were proposed by the Bureau of Reclamation for the Indian Camp Dam project, namely a change in cropping patterns, land pooling (in the form of cooperative grazing programs), reservoirs ("water storage capacity"), and permanent diversion structures.[103] In *Acequia Culture: Water, Land, and Community in the Southwest*, Rivera extols traditional *acequia* culture and examines the stream adjudication suits, but he fails to place the suits in the context of the Hispanics' fight for SJCDP, in fact he never mentions SJCDP. By consistently stressing the *acequias*' "traditional" culture, he misses the opportunity to view *acequia* users as dynamic agents of change themselves.

Sylvia Rodriguez argues that in Taos the "ongoing process of expropriation [of Hispanic land and water bases] and the recent acceleration [of this process] has… intensified Hispano resistance to further usurpation and displacement…"[104] These resistant reactions represent, she says, "strategies of ethnic boundary maintenance."[105] Rodriguez believes that whereas specific ethnic cultural content can change more or less continuously, "boundary maintenance through time is the essential feature of ethnic persistence."[106]

While I agree with Rodriguez that boundary maintenance through time is an essential, if not *the* essential feature of ethnic persistence, I believe that the entire history of Indian Camp Dam controversy reveals that the boundaries themselves are not constant or predictable. In northern New Mexico, I see a kind of ever-changing shoreline where ethnic boundaries shift with the tides of certain events. Cultures selectively borrow from one another, in complex processes of cooperation, negotiation, accommodation, assimilation, and acceptance, even amidst processes of resistance and rejection.

Perhaps the most intriguing aspect of the Indian Camp Dam history is the extent to which it exposes not only obvious inter-ethnic strategies for boundary maintenance and accompanying tensions and conflicts, but also the intra-ethnic contradictions and conflicts, such as those between Anglos John Nichols and Paul Bloom and between Hispanics Andres Martinez and Rudy Pacheco. The controversy blurred ethnic boundaries even as it revealed and defined them.[107] Beneath these blurred boundaries lies the deep irony that everyone involved—from the politicians, to the Bureau of Reclamation, to Anglos John Nichols and Paul Bloom, to Hispanics Andres Martinez and Rudy Pacheco—everyone claimed to be fighting to save, each in his own way, the dying Hispanic agro-pastoral lifestyle in Taos.

We all struggle to define ourselves in the world and to give our lives, our stories, meaning and emotional satisfaction. In telling our stories and our histories we too often resist or omit the confusion of untidy ambiguities, even though experientially we find them commonplace. In an attempt to order and explain the past, too often we simplify it. I would argue that our histories should be layered, multifaceted, and multi-voiced. They need complexity, perhaps even confusion and cacophony. They should embrace rather than shun the untidy ambiguities.

The more we learn of Indian Camp Dam "from the ground up," these "parts before the whole," the more we grasp the incredible inclination of these events to remain untidy and *raveled*. Yet we also recognize the incredible obligation we have to respect the right of these events to be properly represented, especially when the past, raveled though it may be, can give us not only meaningful insights into how we interact and negotiate with one another for the use of our natural resources, but also give us informed ways to choose our own local futures.

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Endnotes

1. Paul A. Cohen, *History in Three Keys: The Boxers as Event, Experience, and Myth* (New York, 1997), 62.
2. F. Lee Brown and Helen M. Ingram, *Water and Poverty in the Southwest* (Tucson, 1987), 58-62; John Nichols, *If Mountains Die, A New Mexico Memoir* (New York, 1987) and "Land and Water Problems in Northern New Mexico: New Mexico Conservancy Districts," Speech given October 16, 1975, University of New Mexico School of Law; C. Lynn Reynolds, "Decision Making and Cultural Change: The Status of Spanish American Small Farms in Northern New Mexico," Ph.D. diss. Southern Methodist University, 1975, and "Economic Decision-Making: The Influence of Traditional Hispanic Land Use Attitudes on Acceptance of Innovation," *The Social Science Journal*, Volume 13, No. 3, October, 1976; Jose A. Rivera, *Acequia Culture: Water, Land and Community in the Southwest* (Albuquerque, 1998),155-158; Sylvia Rodriguez, "Land, Water and Ethnic Identity in Taos," *Land, Water, and Culture: New Perspectives of Hispanic Land Grants*, ed. Charles L. Briggs and John R. Van Ness (Albuquerque, 1987), 353-354.
3. Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy 1848-1902* (Albuquerque, 1992), 332.
4. *Winters v. United States*, 207 U.S. 564 (1908).
5. John O. Baxter, *Dividing New Mexico's Waters, 1700-1912* (Albuquerque, 1997). Baxter gives a comprehensive history and analysis of water conflicts in the colonial period, including numerous references to conflicts in Taos valley. See also Rodriguez, "Land, Water, and Ethnic Identity in Taos."

6. Paul L. Bloom, "Law of the River: A Critique of an Extraordinary Legal System," *New Courses for the Colorado River: Major Issues for the Next Century*," Ed. Gary D. Weatherford and Lee Brown (Albuquerque, 1986); Norris Hundley, Jr., *Water and the West: The Colorado River Compact and the Politics of Water in the American West* (Berkeley, 1975); John Uptown Terrell, *Water for the Colorado River* (Glendale: 1965); and Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York, 1985). Bloom states that the laws governing the Colorado "cannot be found in any single set of statutes, codes or compilations… [They are] an odd composite of state, federal, and international laws and decisions." (p. 139)

7. See Worster, *Rivers of Empire.*

8. Ira G. Clark, *Water in New Mexico, A History of Its Management and Use*. (Albuquerque, 1971), 509.

9. Ibid, 511.

10. United States Congress, Senate, Andres A. Martinez and Senator Clinton P. Anderson's testimony regarding S. 3648, 85th Congress, Second Session, July 9-10, 1958, Congressional Record.

11. Middle Rio Grande Flood Control Association and J. Benito Vigil, Vigillio Trujillo, Andres A. Martinez, O. G. Martinez, Gil B. Gallegos, Emett Ellis, E. C. Cabot, Joe D. Austin, Abad Martinez, *Statements on Colorado River Storage Project and Participating Projects and Particularly the San Juan-Chama Project in New Mexico* (Albuquerque: Middle Rio Grande Flood Control Association, 1954), cover letter.

12. Ibid.

13. Ibid.

14. Rodriguez, "Land, Water and Ethnic Identity in Taos," 338. This essay gives the fullest and most nuanced analysis of these issues.

15. Ibid, 339.

16. Middle Rio Grande Flood Control Association, et al., *Statements*, 13.

17. *Taos News*, January 23, 1969.

18. Ibid.

19 In New Mexico, community *acequia* systems or associations are recognized as political subdivisions of the state. Each community *acequia* association is under the general control and supervision of three commissioners and a *mayordomo*, who are elected for a one-year term by those persons who have rights on the *acequia*. The commissioners organize and elect from among themselves a chairman, secretary, and treasurer. The *mayordomo*, under the direction of the commissioners, is the chief executive officer of the *acequia*, and is usually an elder and highly respected member of the community. Phil Lovato, *Las Acequias del Norte, Technical Report Number 1* (Taos: Four Corners Regional Commission, New Mexico State Planning Office, Kit Carson Memorial Foundation, Inc., 1974) 15, 24-28.

20. Rudy Pacheco, "Indian Camp Dam: The Positive View," *Taos News*, August 11, 1971.

21. Sarah Deutsch, *No Separate Refuge: Culture, Class and Gender on an Anglo-Hispanic Frontier in the American Southwest, 1880-1940* (New York, 1987) 184.

22. C. Lynn Reynolds, "Decision Making and Cultural Change: The Status of Spanish American Small Farms in Northern New Mexico," Ph.D. dissertation Southern Methodist University, 1975, p. 251.

23. Rodriguez, "Land, Water and Ethnic Identity," 338.

24.. Interview of Paul Bloom by Marilyn Koch, April 3, 1989, audiotape (in Marilyn Koch's possession), side 2, tape 2. See also Lovato, *Las Acequias del Norte*, 51-53. The Taos tributaries' adjudication is *State of New Mexico ex rel. State Engineer, et al. v. Eduardo Abeyta and Celso Arellano, et al.*, U.S. District Court Nos. 69CV7896 BB and 69CV7939 BB (Consolidated) (the Abeyta adjudication). The still-pending northern Rio Grande stream adjudication suits filed by Paul Bloom as special attorney general under State Engineer Steve Reynolds were stayed until the judicial resolution of issues central and common to all, namely the amount and extent of the Indian water rights, in *State of New Mexico ex rel. Reynolds v. Aamodt, et al.,* U.S. District Court No. 6639 (filed April 20, 1966) (the Aamodt adjudication). The Aamodt adjudication covers Rio Grande tributaries south of Taos (the Nambé, Pojoaque, and Tesuque valley tributaries) and involves non-Indian claimants (including the City and County of Santa Fe) and Indian claimants of those three pueblos, as well as the Pueblo of San Ildefonso. Settlement negotiations began in 1989 in the *Abeyta* adjudication between Taos Pueblo and the Taos Valley Acequia Association, a group of 55 community ditch associations.

[Author's note: In 2003, after presentation of this paper at the Reclamation centennial symposium, the parties negotiating settlement, which then included Taos Pueblo and the Taos Valley Acequia Association as well as the State of New Mexico, the Town of Taos, El Prado Water and Sanitation District, and twelve Taos area mutual domestic water consumer associations, began working closely with a mediator. On March 31, 2006, these parties released their Draft Settlement Agreement (DSA). However, the United States was not a party to this phase of the negotiations, nor to the DSA, although it did participate in the local phase of the negotiations. Thereafter the federal phase of negotiations began, whereby the local parties, who collectively represent the vast majority of the surface and ground water appropriators in the Taos Valley, and the United States have sought to resolve the related federal issues and develop congressional legislation with the goal of approval and funding for a final agreement. A major impediment to final resolution of the adjudication suits is the procurement of substantial federal funding at a time when current federal budgets cannot accommodate the settlements.

On June 18, 2007, New Mexico's senior Republican senator, Peter Domenici, the ranking member of the Senate Energy and Natural Resources Committee, introduced U.S. Senate Bill 1643, the "Reclamation Water Settlements Fund Act of 2007" authorizing a settlement fund to fulfill New Mexico's Indian Water rights settlements, including the *Abeyta* and *Aamodt* suits. The bill would raise $1.37 billion for implementation, specifically the construction of the infrastructure contemplated under the terms of the DSA, with approximately 30 percent of the monies to be generated over the next ten years by the State of New Mexico from its federal oil and gas royalty payments. (See "Bill Would Shore Up the Funds for Settlement," *Taos News*, June 21, 2007.) In June 2007, Taos Pueblo also signed an agreement with the *Aamodt* pueblos (Pojoaque, Tesuque, Nambé, and San Ildefonso) to share a portion of its originally allocated San Juan-Chama Diversion Project water in an effort to move the *Abeyta* and Aamodt adjudication settlements to Congress. (See "Taos Pueblo to Share Water Rights," *Taos News*, June 21, 2007.) Under the terms of the DSA, the total water right for Taos Pueblo is 12,152.51 acre feet per year (depletion)(DSA, Article 5.1.1.1) of which its San Juan-Chama Diversion Project surface water right is 2,440 acre feet per year (DSA, Article 5.4). The DSA contemplates that several non-Pueblo parties will acquire water rights through the San Juan-Chama Diversion Project and also provides for the Town of Taos to convert its San Juan-Chama Diversion Project service contract for 400 acre feet per year to a repayment contract allocating the Town 500 acre feet per year (DSA, Articles 6.2.10,11). The DSA, an overview of the DSA, and the press release issued by the parties to the DSA, can be found, respectively, at: http://www.ose.state.nm.us/PDF/Settlements/Taos/AbeytaSettlementAgreement-2006-03-31.pdf; http://www.ose.state.nm.us/PDF/Settlements/Taos/TaosOverview-2006-04-11.pdf; and http://www.ose.state.nm.us/PDF/2006/pr.2006-03-31-TaosSettlement.pdf]

25. Clark, *Water in New Mexico*, 625.

26. Ibid.

27. Ibid, 626.

28. Ibid, 625.

29. Ibid, 624.

30. Bloom Interview, side 2, tape 1.

31. New Mexico Statutes Annotated, Chapter 73, Article 9, Sections 73-9-1 through 73-13-47, Pamphlet 117, Irrigation Districts, NMSA 1978 (1978 Supp.) and Chapter 73, Article 14, Sections 73-14-1 through 73-19-5, Pamphlet 118, Conservancy Districts, NMSA 2000 (1996 Supp.)

32. Ibid. Clark, *Water in New Mexico*, 204-212; "Indian Camp Taxes, Costs Explained," *Taos News*, September 1, 1971.

33. Interview of Andres A. Martinez by Marilyn Koch, 7 April, 1990, audiotape (in Marilyn Koch's possession), side 1, tape 1; Bloom Interview, side 1, tape 1. See also C. Lynn Reynolds "Economic Decision Making and the Influence of Traditional Hispanic Land Use Attitudes on Acceptance of Innovation," *The Social Science Journal*, Volume 13, No. 3, October 1976, 29-30;

and Lovato, *Las Acequias del Norte*, 36-38. New Mexico law recognized *acequias* as public and political subdivisions of the state beginning in 1965. Additionally, *acequias* have managed their affairs with a great deal of autonomy by local customs and traditions.

34. *Taos News*, "Unfair and Malicious Representation Cited," August 4, 1971.

35. *In re Proposed Middle Rio Grande Conservancy District*, 31 N.M. 188, 196 (1925).

36. Clark, *Water in New Mexico*, 212. See also *Cater v. Sunshine Valley Conservancy District*, 33 N.M. 583 (1928). At the time of the Indian Camp Dam controversy, this conservancy district law was amended to allow for formation of a conservancy district north of Santa Fe County.

37. C. T. DuMars and S. C. Nunn, Eds., *Middle Rio Grande Conservancy District Water Policies Plan, Working Document* (Albuquerque: Middle Rio Grande Conservancy District, 1993), 5.

38. "Certainties of Growth Before Albuquerque—If Albuquerque Wills To Be a City," Editorial [clipped from unknown newspaper but probably *The Albuquerque Journal*], June 4, 1922. Middle Rio Grande Association Manuscripts, No. MSS 62 SC, Center for Southwest Research, Zimmerman Library, University of New Mexico, Albuquerque.

39. *In re Proposed Middle Rio Grande Conservancy District*, 31 N.M. 188, 195 (1925).

40. Ibid, 217.

41. Ibid.

42. Ibid, 218.

43. Ibid, 220.

44. Report of the Membership Committee, Middle Rio Grande Association, undated. Middle Rio Grande Association Manuscripts, No. MSS 62 SC, Center for Southwest Research, Zimmerman Library, University of New Mexico, Albuquerque.

45. *Cater v. Sunshine Valley Conservancy District*, 33 N.M. 583 (1928).

46. *Gutierrez et al v. Middle Rio Grande Conservancy District*, et al, 34 N.M. 346, 363 (1929).

47. Ibid, 364. But, for an example of the maxim 'the law is made for the times, and will be made or modified by them,' see *In re Sandia Conservancy District; City of Albuquerque, et al v. Middle Rio Grande Conservancy District, et al.*, 57 N.M. 413, 259 P.2d 577 (S. Ct. 1953), 416-417, wherein the Supreme Court, in 1953, appeared to have re-ordered what it saw as the Middle Rio Grande Conservancy District's functions. It wrote that the district was "organized, primarily, for irrigation, reclamation and to afford protection from floods…."

48. *Middle Rio Grande Conservancy District v. Chavez*, 44 N.M. 240, 245 (1940).

49. Ibid, 247.

50. Ibid.

51. *In re Proposed Middle Rio Grande Conservancy District*, 31 N.M. 188, 198 (1925).

52. Interview of Eugene Weisfeld by Marilyn Koch, April 6, 1990, audiotape (in Marilyn Koch's possession), side 1, tape 1. At the time of the Indian Camp Dam controversy Eugene Weisfeld was a VISTA volunteer and Rural Legal Aid attorney who represented the Tres Rios Association in its appeal of the formation of the Rancho del Rio Grande Conservancy District. In 1990, he was Taos Town Attorney.

53. Rodriguez, "Land, Water and Ethnic Identity," 334. Jerry L. Williams, editor, *New Mexico in Maps* (Albuquerque, 1986) 105-107.

54. Bloom, side 2, tape 1; Interview of Rudy Pacheco by Marilyn Koch, 7 April 1990, audiotape (in Marilyn Koch's possession), side 2, tape 1; Reynolds, "Economic Decision Making…," 22.

55. *Taos News*, June 2, 1971.

56. John R. Van Ness, "Spanish American vs. Anglo American Land Tenure and the Study of Economic Change in New Mexico," *The Social Science Journal*, Volume 13, No. 3, October 1976.

57. Reynolds, "Economic Decision Making…," 24.

58. *Taos News*, October 4, 1972.

59. Ibid.

60. Ibid.

61. John Nichols (without byline), "Indian Camp Dam: The Mystery Welded to Reality," *New Mexico Review*, Vol. 4, No. 4-5 (April-May, 1972), 5-7.

62. *Rancho del Rio Grande Conservancy District v. Tres Rios Association*, 87 N.M. 482, 353P.2d 1333 (1975).

63. John Nichols, *If Mountains Die*, back cover.

64. Interview of John Nichols by Marilyn J. Koch, April 8, 1990, audiotape (in Marilyn Koch's possession), side 2, tape 1.

65. Ibid.

66. Nichols, *If Mountains Die*, 60.

67. Sarah Deutsch, *No Separate Refuge*, 191. See also David Whisnant, *All That is Native and Fine, The Politics of Culture in an American Region* (Chapel Hill, 1983), and James Byrkit, "Land, Sky, and People: The Southwest Defined," *Journal of the Southwest*.

68. Nichols, *If Mountains Die*, 13.

69. Nichols Interview, side 1, tape 1.

70. Ibid.

71. Bloom Interview, side 2, tape 2. Interview of Rudy Pacheco by Marilyn Koch, April 7, 1990, audiotape (in Marilyn Koch's possession), side 1, tape 1.

72. Nichols Interview, side 2, tape 2.

73. Ibid.

74. Interview of Andres Martinez by Marilyn J. Koch, April 7, 1990, audiotape (in possession of Marilyn Koch), side 1, tape 1.

75. Deutsch, *No Separate Refuge*, 23, 30, 39.

76. Andres Martinez Interview, side 2, tape 1.

77. Ibid.

78. Ibid. See also Reynolds, "Economic Decision Making…" 22-3.

79. Bloom Interview, side 1, tape 2.

80. Ibid.

81. John Nichols, "No Comment from Bloom," *The New Mexico Review*, Vol. 4, No. 6-7 (July 1972), 10-11.

82. Bloom Interview, side 2, tape 2.

83. Ibid.

84. Ibid.

85. Ibid.

86. Ibid.

87. Ibid.

88. Ibid.

89. Pacheco Interview, side 2, tape 1.

90. Ibid.

91. Ibid.

92. Interview of Eluid Martinez by Marilyn J. Koch, June 16, 2001, audiotape (in Marilyn Koch's possession), side 1, tape 1.

93. Rodriguez, "Land, Water and Ethnic Identity in Taos," 350.

94. Ibid.

95. Ibid.

96. Eluid Martinez Interview, side 1, tape 1.

97. Ibid.

98. Eluid Martinez Interview, side 2, tape 1.

99. Ibid.

100. Ibid.

101. Brown and Ingram, *Water and Poverty in the Southwest*, 61-62; Rivera, *Acequia Culture*, 156, footnote 31; 157, the quoted section is attributed to the Tres Rios Association, but was, according to John Nichols [Nichols Interview, side 2, tape 2], written by him for the Tres Rios Association; 158.

102. Brown and Ingram, *Water and Poverty in the Southwest*, 87.

103. Ibid, 89-93, 101.

104. Rodriguez, “Land, Water and Ethnic Identity in Taos,” 314.
105. Ibid.
106. Ibid, 315.
107. This is an on-going and evolving process. Another ironic example of the cooperation between opponents and proponents of the Indian Camp Dam, and perhaps the meshing of ethnic boundaries as well, can be found in the cooperation between Las Acequias del Norte, a coalition of community ditch systems of northern New Mexico, and Paul Bloom. In 1974, Bloom helped Las Acequias del Norte compile information on New Mexico’s water laws for use in public education literature that Las Acequias del Norte distributed to its members. One such member was the Tres Rios Association, the alliance of *acequias* formed by Andres Martinez to fight the conservancy district, having itself evolved into an activist organization. See Lovato, *Las Acequias del Norte*, Technical Report Number 1, acknowledgment page.

Hydropolitics in the Far Southwest: Carl Hayden, Arizona, and the Fight for the Central Arizona Project

By:
Jack L. August, Jr.

According to former U.S. Secretary of Interior Bruce Babbitt, we are now approaching the last phase of a productive century of federally sponsored reclamation in the American West. With the development of a few remaining authorized dams and delivery systems, the era of the construction of the great reclamation projects will come to an end. A major contributor to the process of water resource development in the American West was longtime senator Carl Hayden of Arizona (1877-1972). A native of Arizona's Salt River Valley, Hayden, in his earliest years, experienced the often-cruel vicissitudes of flood and drought in the arid Southwest. He saw Arizona grow from a raw territory of a few thousand hardy pioneers to a desert oasis of millions. Central to his efforts in the service of his Arizona constituents was the development and use of the Colorado River, the controversial interstate stream that serves the needs of the seven basin states (Wyoming, Colorado, Utah, New Mexico, Nevada, California, and Arizona). And, while he devoted his public career to the residents of his state, the man who became known as the "Silent Senator" had an impact and significance far beyond the borders of the Grand Canyon state.[1]

The most striking feature of Hayden's political career was its longevity. He spent sixty-seven of his ninety-four years of life in public office. Between 1900 and 1912 he learned the art of politics by serving in a variety of local and county offices; Tempe town councilman, Maricopa County treasurer; and Maricopa County sheriff. When statehood was achieved in the latter year, voters elected their native son to the House of Representatives, kept him there for seven terms, and in 1926 promoted him to the U.S. Senate where he remained until his retirement in 1969. During his fifty-seven years in the federal government, he served with ten presidents, beginning with William Howard Taft and ending with Lyndon Baines Johnson.

As Secretary Babbitt, a former Arizona governor, and other elected officials from the Grand Canyon State quickly learned upon the outset of their government service, Hayden's lengthy tenure in office benefited Arizona in a multitude of ways, and to catalogue his accomplishments would require volumes. In 1912, when he first stepped into the House of Representatives, Arizona was one of the most sparsely settled states in the union. When he retired from the Senate in 1969, Hayden returned to one of the fastest growing states in the country. Today, dams and reservoirs, thousands of acres of reclaimed farmland, power-transmission lines, highways that helped create Arizona's important tourist trade, a healthy commercial and industrial economy, Indian and veterans' hospitals, and aircraft and military bases stand as testaments to the public career of Carl Hayden.

Fellow lawmakers who spent time with and around Hayden commented on his kindness, humility, and modesty. Indeed, in what became a biennial ritual for senate newcomers, Hayden evinced amazement among newly elected senators for never sitting in the front row of the Democratic side of the Senate, as he was entitled. Instead, he maintained the seat he took in March 1927, on the aisle, one row removed from the back. Another well-known Hayden quality that cut against the grain of conventional political wisdom was the Arizonan's propensity for silence. Especially in the Senate, a political body notable for its oratory, Hayden stood out as the soul of brevity. His remarks in the Congressional Record consumed less space, perhaps, than any other senator in recent history. Yet, as any careful observer of western politics knows, the absence of Hayden verbiage gave no hint of his power, knowledge, or effectiveness. Upon his fiftieth anniversary in Congress, the New York Times declared, "few individuals in the history of Congress have done so much with so little talk." Furthermore, when Hayden chose to appear before a committee with a project or a request, most members were certain it was justifiable. If Hayden wanted something, it needed little persuasion or rhetorical advancement. In a great political incongruity, Hayden fashioned silence into a form of legislative power.[2]

At the same time, Senator Hayden, arguably, was one of the most powerful senators in U.S. history. As Marc Reisner suggested in his critical volume, *Cadillac Desert: The American West and its Disappearing Water*, "Senator Carl Hayden of Arizona [was] the most powerful man in legislative government" in the 1960s. Besides emerging as a ranking member of the Senate Appropriations Committee in the late 1920s and early 1930s and chairing this powerful committee from 1954 to 1969, he served as president pro tempore of the Senate and was third in line for the presidency. Although he held vast political power, one of the Arizonan's most useful attributes, according to President Johnson, was the high degree of affection in which his colleagues held him. Moreover, Hayden chose most often to use his influence behind the doors of committee rooms or in persuasive conversations in the cloakrooms of Congress. At the same time he did his homework with consummate care until he knew, as one of his Republican senate colleagues recalled, "the front, back, and middle of everything." Perhaps fellow Arizona senator Barry Goldwater said it best shortly after his return to the Senate after his run for the presidency: "Let me put it this simple way, whenever my service in the Senate is terminated I hope that my service to my country and my state equals a small fraction of what Carl Hayden has provided in both areas."[3]

While Hayden developed a renowned legislative expertise in the area of federal reclamation, he could also boast of several other areas of proficiency that added to the growth and development as well as the conservation and preservation of the American West. Hayden, for example, was one of the great leaders in federal highway legislation, coauthoring the New Deal measure, the Hayden-Cartwright Act of 1934, which established the formula for distribution of federal aid for highways to the states on the basis of area rather than population. This legislation helped tremendously in providing transportation links between the

West's far flung cities. Hayden introduced and supported measures that advanced mining operations throughout the country. His efforts provided for fair prices, protection against unfair imports, and subsidies for strategic metals.

Notably, he was the sponsor, in 1919 of the Nineteenth Amendment to the Constitution, extending the right of suffrage, and he sponsored and managed the House bill to establish Grand Canyon National Park. He worked for social security legislation and in 1950 fostered an amendment to that law that allowed American Indians to be included within its framework. Other broad areas of federal legislation attracted his attention: forest conservation, national parks, labor, public lands, agriculture, and veterans' affairs, to name a few.

Water, however, and its use and distribution, more than any other issue, lay at the heart of Hayden's public career. He became most famous as a statesman who helped bring water and life to a vast region of the country. Unquestionably, the fortunes of his Arizona pioneer family were tied to water, or more specifically, to its diversion onto land. As a local politician he lobbied for one of the first, and most successful, federal reclamation projects, the Salt River Project. During his first term in the House he further displayed his understanding of the importance of water to his home state by obtaining authorization of an engineering study that led to the construction of Coolidge Dam on the Gila River and the San Carlos Reclamation Project. He also helped shape federal reclamation policy in its early years by writing and securing passage of the provision that allows local water-user associations throughout the country to take over the care, maintenance, and operation of federal reclamation projects. In nearly six decades in Congress, reclamation issues occupied more of his attention than any other legislative subject, and Colorado River development took up a significant portion of that time.

On February 14, 1962, the fiftieth anniversary of statehood, Hayden, in an exceedingly rare instance of public self-evaluation, commented on his most important contribution to Arizona—bringing federal reclamation to the Grand Canyon State. "The basic factor in making Arizona's spectacular agricultural and industrial development was the Reclamation Act of 1902 sponsored by that great and energetic president, Theodore Roosevelt," he told the *Arizona Republic*. That law made possible the use of federal funds to develop water for irrigation and hydroelectric power, both of which were essential to the state's prosperity. "Needless to say," Hayden added, "I have helped that basic program move forward." The then-eighty-four year-old senator concluded his comments, not dwelling on the past but rather by urging Arizonans to look toward their future. "I hope to see the day when central Arizona and other important areas of the state have the water required to continue the pattern of growth and progress attained in the first half-century," he challenged his constituents.

Hayden alluded to Arizona's decades-old obsession, the Central Arizona Project (CAP), which today channels Arizona's hard-won share of Colorado

River water to the central portions of the state, including the rapidly growing metropolitan areas of Phoenix and Tucson. The recently completed project not only will shape the nature of federal reclamation in the American Southwest in the twenty-first century, but also will impact the delicate desert environment in countless ways. Today Arizonans take for granted CAP, yet know little of its historical and legislative origins, many of which reach deep into the early history of the far Southwest. Indeed, Hayden, who had tried unsuccessfully to fashion some sort of central Arizona diversion project since the 1920s, persisted in his efforts through years of jousting with California and the other basin states and won his final and most gratifying legislative battle between 1963 and 1968 when CAP was authorized through passage of the Colorado River Basin Project Act. Significantly, this last, successful phase of the process began in the U.S. Supreme Court, where it took nearly eleven years to resolve a host of complex issues surrounding the use and distribution of Colorado River system water.[4]

At 1:30 P.M. on August 13, 1952, Senator Carl Hayden welcomed a small group of somber-faced Arizonans to his office on Capitol Hill. After a brief exchange of pleasantries he stuck a battered white straw hat on his bald head, strode to the door and beckoned, "Come on boys, let's get this done." Together the group walked to the U.S. Supreme Court building. Among them was J. H. "Hub" Moeur, chief counsel for the Arizona Interstate Stream Commission (AISC), who filed a bill of complaint against California, asking for a judicial apportionment of the waters of the lower Colorado River basin. After witnessing the filing the seventy-four-year-old senator issued a short statement to the press. "I believe this action," he told those gathered on the steps of the Supreme Court, "will make possible the settlement of a most serious controversy which is delaying the development of the Colorado River basin." "If the Californians are sincere in their oft-repeated demands for court action," he added, "then they will welcome the opportunity to present their side of the case." With that, Arizona launched the monumental *Arizona v. California* Supreme Court case.[5]

As several students of the case have noted, it was one of the most complex and fiercely contested in the history of the Court. Before its completion, 340 witnesses and fifty lawyers had produced 25,000 pages of testimony before a special master. The case took nearly eleven years and cost nearly $5 million. And, when a sharply divided Court announced its opinion on June 3, 1963, followed by the decree on March 9, 1964, the river possessed a greatly modified legal framework governing its apportionment and use among the lower basin states.[6]

Arizona's contentions had changed little since the late teens and early twenties, when the basin states focused their attentions on Colorado River development. She asserted that California had made contracts for delivery of over 5.3 million acre feet of water annually in spite of laws limiting it to 4.4 million acre feet. The limitation notwithstanding, Arizona's attorneys argued that California had constructed reclamation works capable of diverting 8 million acre feet of water annually thereby posing a threat to Arizona and other basin states. According to Arizona's attorneys, for the state to sustain its existing economy it required 3.8 million acre feet of Colorado system water per year. Furthermore Arizona relied on and asserted its rights to water under a variety of federal and state actions including the Colorado River Compact; the Boulder Canyon Project Act, the California Limitation Act of 1929, and, additionally, the state had entered into a water delivery contract with the federal government.[7]

California registered no objection to Arizona's motion. Her substantial team of attorneys, led by the brilliant and indefatigable Northcutt "Mike" Ely, agreed with the U.S. Solicitor General, who advised the Supreme Court that the federal government had an interest in the case and would move to intervene if Arizona's motions were granted. On January 19, 1953, the Court granted Arizona's original motion and the bill of complaint was filed. Hayden hoped for prompt action because he knew that no further progress could be made on CAP, or any other lower-basin project, until the Court reached its decision.[8]

On May 20, 1953, California responded to Arizona's bill of complaint. In nearly 500 pages of narrative and supporting documentation, California's attorneys contended that it had a right to the beneficial and consumptive use of 5,362,000 acre feet of Colorado River system water per year under the terms of the Boulder Canyon Project Act and her contracts with the Secretary of Interior. Moreover, she claimed prior appropriative rights to the use of that amount of water and that these rights were senior to Arizona's and therefore superior. Finally, California argued that Arizona, by failing to ratify the Colorado River Compact within the specified six months when the other six states had done so in 1923, as well as her subsequent attempts to have the agreement declared invalid and the Boulder Canyon Act declared unconstitutional, precluded her right from interpreting this statute.[9]

For the next four years California conducted a campaign of judicial delay. A blizzard of motions and filings delayed the start of proceedings, while the number and complexity of issues raised prompted the Court to appoint a special master to hear arguments. On January 1, 1954, George I. Haight assumed the position. After ruling on several preliminary motions, Haight died suddenly before formal hearings began. Judge Simon Rifkind, a sharp-witted federal jurist from the southern district of New York, replaced him. Finally, on January 14, 1956, hearings on *Arizona v. California* began.[10]

In the meantime, Hayden, on September 14, 1955, and nearing the end of his fifth term in the Senate, announced at a Phoenix Press Club forum that he intended to seek reelection in 1956. The election, however, posed new challenges for the seventy-eight-year-old senior solon. Besides the election taking place against the backdrop of the Supreme Court case, Arizona, during the 1950s, was undergoing an unprecedented spurt of population growth, industrial development, and overall economic expansion. Indeed Arizona boomed during the post-war years, attracting people, industry, and capital. Much of this new money financed urban and agricultural expansion in the state's heartland embracing fast growing Phoenix and Tucson. Moreover, the distinctive technological, commercial, and urban dimension of this growth brought forth heightened expectations from an increasingly affluent electorate. Longtime politicians like Hayden took careful notice when the youthful conservative Republican upstart, Barry Goldwater, won a stunning upset victory over the well-entrenched Democratic incumbent Ernest McFarland in the race for the U.S. Senate in 1952. The conservative victory not only shattered the Democratic party's domination of state politics-which dated from the territorial period-but also signaled the onset of a new era of conservative hegemony in Arizona. Furthermore, Arizonans old and new expected the economic boom to continue and the key to sustaining this growth was the continued expansion of water supplies and affordable power.[11]

By the mid-1950's, however, the rivers of Arizona were fully developed and irrigators had turned increasingly to groundwater supplies. In their efforts to keep pace with the boom, they pumped with such intensity that water tables dropped and aquifers were exhausted. Thus the stakes were high in 1956, with *Arizona v. California* and the apparent pressing need for expanded water and power supplies. Much like his election campaigns for the U.S. Senate in 1926, Hayden's efforts at reelection in 1956 centered on water resource development generally, and the use and distribution of waters of the Colorado River system specifically.[12]

Hayden's 1956 election campaign was noteworthy for other reasons as well. His advancing age, questions about his health, and rumors of incipient senility emerged during the course of the primary campaign and carried over in the general election. His Democratic primary opponent, Robert "Doc" Miller, a forty-eight-year-old Phoenix-area druggist, suggested that "youth must be served and age must be retired," adding that Hayden, at age seventy-nine and with fifty-two years on the public payroll was desperately seeking another six years in office. To these charges, Hayden and his staff responded to the anticipated criticism with resolve and innovation. Hayden's administrative aide, Roy Elson, assessed the claims: "A lot of people, particularly as he got older and his hearing got bad, thought he was senile. There was nothing senile about Carl Hayden. You'd think he was up there asleep, and then he'd ask the most penetrating questions. He'd cut all the shit out and get to the heart of the matter. He was superb at doing that. I mean people would marvel."[13]

After careful deliberation, Hayden agreed to make his first television film for use in a political campaign. His appearance on "Personalities in Government" featured the veteran senator's views of various presidents and congressional leaders with whom he had served during his forty-four years in Congress. The show, and subsequent radio and television appearances, not only helped Hayden dispel rumors about his poor health and failing mental abilities, but also raised public awareness of his considerable accomplishments. Moreover, during the course of the campaign Hayden convinced voters that McCarthy-era Vice-President Richard Nixon's charges that he was a dangerous left-leaning ideologue out of touch with modern American values were ridiculous and unfounded. Additionally, the new technology reached the growing numbers of new Arizona voters who were made aware that Hayden, in December 1955, had advanced to head the powerful Senate Appropriations Committee thereby giving the Grand Canyon State unprecedented influence in federal affairs.[14]

Hayden's influence and stature in Congress were emphasized in the 1956 campaign as well as in his final campaign for the U.S. Senate in 1962. An especially flattering portrayal by former U.S. Senator and Assistant Secretary of State William Benton, published in the *New York Times Magazine* on July 24, 1955, was adapted and utilized by Hayden campaign strategists in a variety of ways. Benton sought to praise the unsung or unappreciated heroes on Capitol Hill who rarely received "a stick of news type for their pains." Chief among them were those senators and representatives who were committee specialists. They mastered the detailed and complex problems of legislation, worked long hours in solitary study, and attended faithfully often-tedious committee sessions that lay behind the construction of appropriation bills, tax measures, and major substantive legislation in all fields. This was the non-glamorous drudgery, which was the heart of effective work in Congress and without injustice to anyone, Benton, ventured, Senator Carl Hayden of Arizona was the person who symbolized those in Congress who had "performed magnificent services for years on end while remaining virtually unknown to the general public."[15]

Benton continued that, although Hayden spoke seldom and never with a tinge of rhetoric or passion, his influence within the Senate was enormous. He marveled also that his advice was sought and heeded by members of both parties and was trusted by everyone. Indeed Hayden's handlers used this and other laudatory pieces to full advantage, effectively countering political attacks from the right and questions about Hayden's age and mental acuity. On election night, November 6, 1956, Hayden, as usual, won every county in the state, defeating his Republican opponent, Ross F. Jones, 170,816 to 107,447.[16]

The central issue of Hayden's final election campaign-the election of 1962-remained CAP and the Colorado River. Despite the senator's age, state leaders convinced him to run for a seventh term. A *Phoenix Gazette* editorial of September 21, 1962, put Hayden's reelection in perspective for its readers: "The U.S. Supreme Court's impending decision on a master's report favorable to Arizona in the Colorado River controversy puts CAP just around the corner. Every ounce of California's political clout will be brought into play. It will take a unique combination of power to beat the project's enemies. Such a combination rests in the hands of Carl Hayden." On the same day, the *Arizona Republic* elaborated upon these themes: "Arizona's congressional delegation is vastly outnumbered by California which wants the Colorado River for itself. Only the parliamentary skill of Senator Hayden supported by the universal esteem in which he is held in Congress will secure passage of CAP.… Senator Hayden stands above party politics. He should be reelected by overwhelming non-partisan support.… Senator Hayden deserves the vote of every citizen who wants Arizona to prosper." Clearly, Arizonans saw their hopes tied to Hayden and his seniority in the Senate.[17]

In spite of his distinguished record, his acknowledged leadership in Arizona's water struggle, and support from newspaper editors throughout the state—including conservative publishing mogul Eugene Pulliam—Hayden faced several serious challenges in his 1962 campaign for reelection. His bright, aggressive, thirty-two-year-old assistant Roy Elson, who managed the campaign, acknowledged that the Arizona electorate had grown and changed since 1956, adding that "there must have been a fifty percent increase in voting population" during the six-year period. Moreover, Hayden's aide later recalled that in 1962 "forty percent of the people in Arizona didn't even know who Carl Hayden was because he didn't put out press releases." Elson, described by Capitol Hill colleagues and newspapermen as Hayden's "Rasputin or Machiavelli," knew that most of these newcomers had never heard of Hayden and still others questioned the wisdom of voting for an eighty-four-year-old man. Moreover, in the fall of 1961 his wife of fifty-three years, Nan, passed away, leaving many wondering whether the elderly senator would not have the strength, emotionally or physically, to conduct his public responsibilities effectively. Meanwhile, the Republican Party continued its unremitting growth in the state, building a powerful and well-financed organization. Indeed, Hayden's staff knew the senator was politically vulnerable in 1962.[18]

Elson took decisive action in early 1961, preparing a fifteen-page confidential memorandum for Hayden that detailed the difficulty ahead if the senator chose to run for reelection. As the administrative aide put it, "I wrote to the senator on what we had to do if he was going to win, because this whole change in the demographics of the population.… We couldn't rely anymore on his old organization, we had to do more press, get things into the can, do television spots." Throughout the year Elson, who for the first time in Hayden's electoral career hired a press secretary, executed a well-organized and effective campaign strategy.[19]

He convinced the new Democratic administration to visit Arizona to honor Carl Hayden. Indeed, one of the highlights of the campaign occurred on November 17, 1961, when President John Kennedy and Vice President Lyndon Johnson attended a $100-per-plate fundraising dinner in Phoenix. Billed as a bipartisan tribute to the aging senator, it garnered intensive media coverage. Newspaper, radio, and television reporters competed aggressively for the best photo or an interview with visiting political luminaries. President Kennedy told the dinner audience at the Hotel Westward Ho, "Every federal program which has contributed to the development of the West, irrigation, power, reclamation, bears his mark. And the great federal highway program which binds this country together, which permits this state to be competitive east and west, north and south, this in large measure is his creation. In one well-orchestrated stroke of political handiwork, Elson had accomplished his goal of reintroducing and redefining Senator Hayden, under the most favorable of circumstances, to a rapidly growing electorate.[20]

In addition to the November gala, during the fall of that year the Hayden campaign traveled throughout Arizona shooting newsreel footage of the senator at Glen Canyon Dam and at various military bases—film that proved crucial to the success of the campaign.[21]

Beginning in early 1962, however, Hayden experienced a series of nagging bouts with flu, and infections which threatened to derail the reelection effort. First the senator contracted a stubborn flu, and then a urinary tract infection struck. Elson recalled that Hayden convalesced in his apartment at the Methodist building across from the capital, and "for a long time we had some people sitting in our office, some John Birchers, demanding to see the senator." As a result of these pesky ailments, during the fall of 1962 rumor spread that the senator had actually died; prompting a somewhat feeble Hayden to assert publicly that news of his death was simply not true.[22]

It was during this critical period that Elson's earlier campaign strategy came into play. The newsreel footage shot the previous year, along with help from local television station executives willing to air the footage, aided the faltering campaign. Also on the Saturday before the 1962 general election, Elson orchestrated a media event that put to rest rumors surrounding Hayden's mortality. Vice-President Lyndon Johnson and Senator Richard Russell of Georgia arrived at Bethesda Naval Hospital—where Hayden spent the final thirteen days of the campaign—to brief the ailing senator on the Cuban Missile Crisis. While photographers shot pictures, Hayden got out of his bed and three veteran Democrats held a press conference. The newsmen quickly drafted stories that although Hayden was not well, he was nevertheless alive and alert.[23]

On the night of the election, Hayden, still at Bethesda, asked Elson what he thought was going to happen. The senator expressed concern that the Republicans nominated the mercurial and oddly charismatic Glendale car dealer and prominent conservative, Evan Mecham, to run against him. Elson told his mentor that although the future governor of Arizona had run a vigorous campaign, "I think you're going to win by twenty-six or twenty-seven thousand votes." Elson's prediction was on the mark as Hayden won the election by a count of 199,217 to 163,388—a small margin for him. Then that night, before the polls closed, Hayden phoned all his key campaign workers in Arizona and personally thanked them for their help. Many were in tears over the emotional victory as Hayden had been elected for an unprecedented seventh term to the U.S. Senate.[24]

Senator Hayden took little time to celebrate as he quickly refocused his energies on the Supreme Court decision in *Arizona v. California*. When the opinion was finally announced on June 3, 1963, Hayden considered it a tremendous victory for Arizona while local newspapers considered it "a personal triumph for Carl Hayden." The Court, Hayden was pleased to note, centered its opinion on the Boulder Canyon Project Act rather than the Colorado River Compact. Moreover Congress, the justices reasoned, in passing the legislation "intended to and did create its own comprehensive scheme for… apportionment." In addition Congress had authorized the Secretary of Interior to utilize his contract power to implement a lower-basin agreement. Importantly for Arizona, each state retained exclusive rights to its tributaries, which meant exclusive rights to the Gila. Concerning mainstream apportionment, the Court gave Arizona what it and Hayden had argued for since the 1922 negotiations over the compact: "4,400,000 acre feet to California, 2,800,000 acre feet to Arizona, and 300,000 to Nevada." "That formula," wrote Ben Cole of the *Arizona Republic's* Washington Bureau, was "a personal triumph for Carl Hayden because the decision referred back twenty-five years to the December 12, 1928, debate in which Hayden pointed out that the Boulder Canyon bill and its allocation formula settled the dispute over lower basin waters." After reading the ninety-five pages of opinion and dissent, Hayden informed newsman Cole,

> naturally I am pleased that the Supreme Court has in general followed the Special Master's recommendations with reference to the division of the waters of the Colorado River. This is especially gratifying because it makes possible at last for us to put our rightful share of our waters to use in the Colorado River Basin.[25]

Underlying the decision favorable to Arizona was a deeply divided Supreme Court. The five justices upholding the recommendation of Special Master Simon Rifkind were Hugo Black, author of the opinion, Byron R. White, Arthur J. Goldberg, Tom C. Clark, and William Brennan, Jr., Justice William 0. Douglas wrote a tart dissent, and Justice John Harlan drafted a separate dissent which had the concurrence of Justice Potter Stewart. Chief Justice Earl Warren, who was governor of California at the time the suit was filed, did not participate in the decision. Douglas, whose dissent was extremely sharp, wrote in part:

> Much is written these days about judicial lawmaking, and every scholar knows that judges who construe statutes must of necessity legislate interstitially… the present case is different. It will, I think, be marked as the baldest attempt by judges in modern times to spin their own philosophy into the fabric of law in derogation to the will of the legislature. The present decision, as Mr. Justice Harlan shows, grants the federal bureaucracy a power and command over water rights in the seventeen western states that it has never had, that it always wanted, that it could never persuade Congress to grant, and that this court up to now has consistently refused to recognize.[26]

Understandably, Californians reacted with anger and apprehension to the decision. They charged the Court with misreading the intent of Congress, eroding the rights of the states, and argued that the ruling represented the first time that the Court had interpreted an act of Congress as apportioning water rights to interstate streams. Previously, rights had been determined only by interstate compact or by the Supreme Court itself. Thus this untoward judicial innovation threatened California, and Hayden and his senate staff quickly concluded that Golden State leaders would try to regain in the political arena what they had lost in the judicial decision. Elson described the situation on the heels of the ruling, "We knew that California and Northcutt Ely would try some way to stop this through the legislative process, even though they had lost… What they couldn't accomplish in court they would try to do in the field of politics."[27]

Other aspects of the decision reflected a departure from previous judicial renderings. The Secretary of the Interior would allocate future surpluses and shortages among and within states. The later feature marked, as one expert on the Colorado has written, "an especially sharp break with tradition." Moreover, the Court ruled that Congress could invoke the navigation clause of the U.S. Constitution as well as the "general welfare" clause to divide the waters of non-navigable and navigable streams. This dimension of the ruling, as Justice Douglas wrote in his scathing dissent, increased drastically federal control over the nation's rivers. For Hayden and Arizona, nevertheless, the ruling appeared to clear the way for legislative action on CAP.[28]

Besides the positive implications for CAP, *Arizona v. California* proved a victory for American Indians as well. As noted earlier, when Arizona filed suit in 1952, the federal government intervened not only to protect its interests on the river, but also to defend the rights of the Native Americans living on the twenty-five reservations within the lower basin. U.S. attorneys petitioned for adequate water for all irrigable lands on Indian reservations as well as national parks, forests, recreation areas, and other federal lands. In their decision the justices ruled in favor of the government although limiting their decision to five reservations abutting the mainstream of the river—Fort Mohave, Chemehuevi, Cocopah, Yuma, and Colorado River. Basing its reasoning on *Winters v. United States* (1908) the Court held that the five reservations were limited not just to their land but their rights also extended to water. The justices concluded that "It is impossible to believe that when Congress created the… Colorado Indian Reservation and the Executive Department of this Nation created the other reservations they were unaware that most of the lands were desert… and that water from the river would be essential to the life of the Indian people."[29]

Especially noteworthy was the fact that in determining the amount of water the Indians were to receive, the Court adopted the government's position. Thus the Indians were awarded water based upon irrigable acreage. And in a supplemental decree, the Court added that the Indians were not restricted in the uses to which they could put their water. As one scholar wryly observed, "Reason, rather than agriculture, seemed to emerge as the ultimate test." Although he agreed in principle with the Court's ruling pertaining to the affected tribes, Hayden expressed concern that Indian uses were to be charged against the state in which the reservation was located. Arizona, where most of the Indian land under the ruling was located, therefore, bore the majority of the burden of this "Indian water." Moreover, the justices ruled that these rights dated from the establishment of the reservation and were superior to later non-Indian rights, including those rights based on uses initiated before the Indians had begun diverting water from the Colorado or its tributaries. The Court thus reaffirmed *Winters* asserting that American Indian rights existed whether or not they were actually using the water and continued unimpaired even if they should cease their uses. Some of the lands along the lower reaches of the Colorado had been set aside as early as 1865 and none later than 1917. Clearly, *Arizona v. California* left the tribes in a much stronger legal position than they previously maintained.[30]

Upon the announcement of the Supreme Court decision Hayden phoned Don Smith, a reporter for *U.S. News and World Report*, to issue a rare public statement. "The decision of the U.S. Supreme Court on the division of Colorado River water," he told Smith, "is the most significant federal action in history affecting the state of Arizona. This adjudication must now be followed by the construction of the long-awaited CAP." During his recent reelection effort, Hayden made authorization of CAP the centerpiece of his campaign, promising to work for the project's prompt authorization after the Supreme Court's decision. Toward this end, the aging dean of the Senate sought and won a seat on the Senate Interior and Insular Affairs Committee as a very "junior" member. In addition to this parliamentary positioning, Hayden, in April 1963, prepared and sent a draft bill and strategy memo to the Arizona delegation in order to foster unity in the state's approach to Congress. He wrote: "I feel that our bill should be as simple as possible, and as similar as practicable to the bill considered by Congress in the late 1940s and early 1950s and twice passed by the Senate." And on June 4, 1963, one day after the Court's ruling, Arizona senators Hayden and Goldwater and the three House members of Arizona's delegation introduced legislation (S. 1658; H.R. 6796, H.R. 6797, and H.R. 6798) to authorize CAP, one of the largest water project proposals ever to come before Congress.[31]

Hayden's bill authorized a diversion of 1.2 million acre feet of water annually out of the Colorado River to provide supplemental irrigation and municipal water to central and southern Arizona. To do this, it provided for the construction of five dams and reservoirs, two power plants, and transmission and distribution facilities on the Colorado and its tributaries in Arizona and western New Mexico. A key feature of this first bill was a 740-foot-high-dam at Bridge Canyon on the Colorado River at the headwaters of Lake Mead. If built, Bridge Canyon Dam promised to be the highest dam in the western hemisphere. The Bridge Canyon power plant would have an installed capacity of 1.5 million kilowatts, and one-third of its capacity would be transmitted south to pump water over a canal and aqueduct system from the existing Parker Dam on the Colorado 219 miles to the Phoenix area and 341 miles to Tucson.[32]

Shortly before introduction of S. 1658, the Bureau of Reclamation completed a supplemental feasibility report on CAP in January 1962. It estimated that CAP would provide additional water to irrigate 880,000 acres of land in Arizona and would provide 303,000 acre feet of municipal and industrial use water for 1.1 million people, primarily in the Phoenix-Tucson areas. In the fifteen-year period that elapsed between the two bureau reports on CAP, Arizona's population had grown from 700,000 to approximately 1.4 million, and lands under irrigation in central Arizona from 566,000 to about 1 million acres. In addition, U.S. Geological Survey data indicated that Arizona had "mined its groundwater basins in the state at an alarming rate. According to the survey, the groundwater level was dropping at a rate of ten feet per year in the Phoenix area and twenty feet per year in Pinal County, south of Phoenix. In some areas wells were going dry or saline water was seeping into them, making them unusable, and the ground was subsiding from over-pumping. C. A. Pugh, area engineer for the Bureau of Reclamation at Phoenix, estimated that the overdraft of groundwater basins in the state totaled 2.2 million acre feet annually. The net delivery of water from CAP would amount to only 1,070,000 per year, so it could not possibly replenish more than half the water deficit in the state at that rate of use. If these statistics were accurate, Hayden reasoned that Arizona appeared to be heading into a water crisis that could be only partly addressed by CAP.[33]

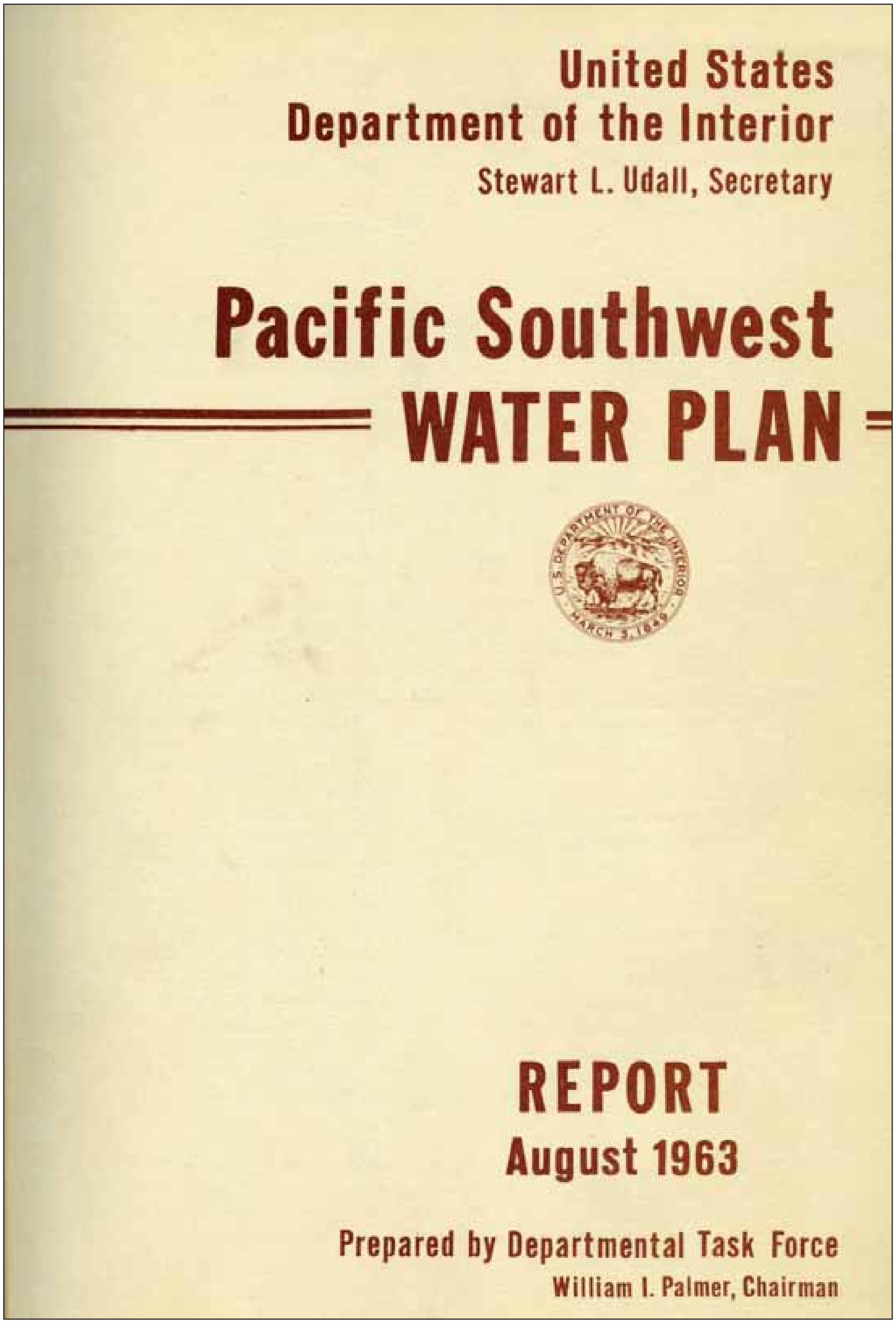
Hayden knew well that in spite of Arizona's obvious need for additional water, Congress historically delayed final action on reclamation projects until leaders and all sections of the state and region were unified or had arrived at a general consensus. Thus looking for the broad support necessary for his bill he made known past support for several big packages of upper-basin projects including the Colorado River Storage Project Act of 1956, which led to the construction of Glen Canyon Dam. He also played a prominent role in backing numerous individual state proposals such as New Mexico's San Juan-Chama Project, which passed Congress in 1962. In light of these and other previous efforts in support of regional water resource development, Senator Hayden believed he deserved the same kind of consideration for CAP within his state and throughout the region. Beyond these arguments, the extent of Arizona's legislative effort for CAP was commensurate with the perceptions within the state of the benefits to be gained from the proposed project. This was based partly on the felt need for additional water in some parts of Arizona, but in large part, the belief in CAP was, as political scientist Helen Ingram aptly put it, "emotional and symbolic."[34]

Yet between 1960 and 1963 the anticipation of a Supreme Court decision favorable to Arizona prompted federal administrators and representatives in the basin states to begin formulating a regional plan acceptable to the entire basin—not just Arizona. In January 1962, for example, Secretary of the Interior Stewart

Udall, an Arizonan and former congressman, encouraged Congressman Wayne Aspinall (D -Colorado), Chairman of the influential House Interior and Insular affairs committee, to request the Interior Department to conduct a comprehensive study on water development in the Colorado River in preparation for the expected pressure for authorization of individual state projects—including CAP—as soon as the decision in *Arizona v. California* was handed down.[35]

Indeed several studies were already underway and in November 1962 Aspinall asked Udall for an outline of the Interior Department's plans for a regional approach to water development in the basin. In an effort to practice "constructive water statesmanship," Secretary Udall, and his undersecretary James Carr of California, adopted this regional approach and by January 1963 he revealed a huge $8 billion plan which included projects in five western states. In announcing his regional program—the *Pacific Southwest Water Plan* (PSWP)—Udall hoped to "erase the outmoded concept limited by state lines, and concentrate on meeting the total water needs of a region." In addition to this lofty goal, he also sought to reconcile diverse interests and several multiple use water projects into one harmonious and comprehensive plan. In August 1963, after Hayden had introduced his CAP bill, the PSWP was sent to the seven basin states and to five federal departments for review and comment. No state with water entitlements below Lee's Ferry was left out of the scheme and seven of the proposed seventeen projects benefited Arizona, California, Nevada, New Mexico, and Utah. PSWP, moreover, sought to unify the interests of Arizona and southern California, with several programs aimed at easing California's concern over mainstream withdrawals by CAP. Water transfer from northern to southern California, water salvage projects, and several new reclamation programs were included in the plan to mitigate other California concerns. Beyond this, Udall tried to exploit common interests in PSWP by proposing two huge hydroelectric dams, Bridge Canyon and Marble Canyon, to be located near the Grand Canyon National Park. Revenues derived from these cash register dams would underwrite the cost of the entire plan, and guarantee the future growth and development of the Southwest.[36]

To Hayden PSWP and the comparatively simple CAP bill were competing legislative initiatives, and the senator and Arizona's political leadership were particularly incensed with the Kennedy administration in general and Secretary Udall in particular. During 1963 and 1964, in several exchanges of letters and memos between Hayden's office and Interior, an agitated Hayden let it be known in vivid and uncompromising language that he considered the overdrawn PSWP a method for delaying consideration of CAP that played into the hands of California and upper basin opponents of CAP, particularly Colorado. Then-governor of Arizona Paul Fannin added that he considered PSWP "a plot against Arizona born in California and formalized in the Interior Department by California's undersecretary." Fannin advocated the Senator's approach: "We must and will go it alone with the CAP as proposed by Hayden in S. 1658." In numerous correspondences through the next two years, Udall suggested to Hayden and other



24.1. August 1963 Pacific Southwest Water Plan Report cover.

state leaders that the CAP fit into his broader regional program. To one of these missives, dated December 19, 1963, in which Udall alerted the senator that he could not file a favorable report on a separate CAP bill, Hayden shot back,

> I vigorously protest your failure to keep your commitment to me and to other officials of this state. I insist that language be included in the PSWP which will be a clear endorsement of the CAP as embodied in S. 1658 and/or as a separate first segment in any regional program.

According to Elson, "it irritated the hell out of Carl Hayden because there was nothing incompatible with a simple CAP to any regional plan."[37]

Several CAP supporters offered other, more politically-sinister explanations, for the legislative standoff in 1963-1964. Although not discussed openly, several Capitol Hill insiders suspected that an understanding had been struck with President John F. Kennedy and Secretary Udall. As Hayden aide Elson described the unwritten agreement: "Let's not rock the boat with anything that's going to cause a big problem with California, particularly southern California, at least until after the 1964 elections." The *Yuma Daily Sun* of June 16, 1963, seconded Elson's musings concerning the politics of PSWP. "There is also the task of getting the approval of the Kennedy administration. Which will be ardently courting California's 40 electoral votes in 1964, an election year." California was now the largest state in the nation; it counted thirty-seven more electoral votes than increasingly Republican Arizona and was doubtlessly a prize in the 1964 presidential sweepstakes. Many CAP proponents realized that Kennedy, as leader of the entire nation—and a practical and politically savvy person as well—would not simply brush aside the arguments of Democratic Governor Edmund G. "Pat" Brown or the forty-member congressional delegation. Whether valid or not, the notion that Kennedy did not want Udall appearing to take sides with his state of Arizona and its small electoral vote as opposed to California and its substantial electoral vote was a topic of discussion during the early phase of CAP's legislative journey.[38]

Not surprisingly, Stewart Udall took a great deal of editorial abuse within Arizona over his "federalized regional project" that "placed all water and power of the Colorado under control of his department." One highly charged and exaggerated editorial in the *Arizona Republic* of August 18, 1963, asked "Udall, Where Are You?" suggesting that the grandiose plan (PSWP) meant that he had written off Arizona for his political future and that he had come under the influence of the California water lobby headed by Undersecretary of the Interior James Carr. Younger brother and Arizona congressman Morris Udall was the focus of similar harsh and unfair criticism. Observers questioned whether he supported CAP or the "empire-building plan" unveiled by his brother. As the influential *Arizona Republic* editorialized,

> Voters know where Stewart Udall stands-he's against the Central Arizona Project.… Will Morris Udall align himself with the rest of the Arizona delegation, which unanimously supports the project? Or, will he, in deference to his brother, sit on the sidelines and refuse to help Arizona?[39]

To an unsympathetic Hayden, Secretary Udall confided that "he had taken his daily horsewhipping from the Phoenix newspapers," but he resented what he termed a personal attack by Senator Goldwater and the unwarranted attacks on his younger brother by powerful publisher Eugene Pulliam. He explained:

> From this point on I intend to give Goldwater and Pulliam blow for blow if that is what they want. I may be 1000% wrong but on the basis of my knowledge of the art of the possible in the House and my conversations with Chairman Aspinall and others, it has been my best judgment that some kind of regional approach will be absolutely essential if a Central Arizona Project is to pass in the House.

Furthermore, the Secretary told Hayden,

> Governor Fannin and the Arizona water people have made a grievous mistake in failing to have any consultation whatsoever with the members of the House concerning basic strategy. The Pulliam-Goldwater tactics of attempting to bludgeon my brother and Representative [George] Senner (D-Arizona) into line with their strategy is outrageous and indefensible.

Clearly, the administration's preference for a regional approach to Colorado River development in the form of PSWP posed unforeseen challenges to Hayden and his staff. In spite of the uncharacteristically harsh rhetoric between the two distinguished Arizonans and among state interests, Hayden agreed with Udall's notion that "It is largely up to the two of us to hold the whole thing together." As a result of the need to make progress on CAP both camps made a frosty pledge to confer at any time on strategy matters.[40]

Nevertheless, as Arizona's quest for CAP shifted to Congress, and as several proposals and counterproposals made their way through the maze of subcommittee and committee hearings, Hayden knew that his accumulated power and influence in the Senate bode well for the legislation. In 1966, moreover, an Arizona "Task Force" arrived in Washington to lend support to the legislative effort, drawing staff and expertise from the state's water establishment: Arizona Interstate Stream Commission, Arizona Public Service, the Central Arizona Project Association, and the Salt River Project. Additionally, Hayden chaired the Senate Appropriations Committee, and he could, if he wanted, hold up every other water project in the country.[41]

As usual he appeared before a variety of congressional committees adding to his already considerable record of testimony in behalf of the project. Typical of his statements between 1963 and 1968 was his testimony in support of his bill, S. 1658, before the Senate Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs on August 27, 1963. "Arizona's efforts to obtain her full share of Colorado River water have been frustrated by the deliberate delaying tactics of California," he told the subcommittee, and "after fifteen years of separate consideration by Congress, the effort is being made to absorb the simple and readily understood Central Arizona Project into one of the most controversial, complex, and confusing water resource development plans ever presented to Congress." Hayden told this and other groups of legislators in subsequent testimony that he believed in a regional concept of water resource development, that he could support any features of a regional plan which were sound, but that he was opposed to anything that would complicate and delay authorization of CAP. The senator expressed serious concern for Secretary Udall's PSWP because if the plan was never constructed, the benefits to California would be greater than if the plan were constructed. Hayden posited that in the end it would be cheaper for California to use Arizona's water than it would be to participate in any comprehensive plan.[42]

The Arizona senator did not want the urgently needed and completely feasible CAP to be stalled because of controversy over a master plan. Nor did he want other worthy projects, like Utah's Dixie Project or California's Auburn-Folsom South Project, hindered because they would have to be included in the collection of separate projects, which Secretary Udall called PSWP. Hayden correctly predicted that senators and representatives would hear testimony that there would be insufficient water in the Colorado River to sustain CAP. In anticipating these arguments he pointed to previous statements by Commissioner of the Bureau of Reclamation Floyd Dominy, who stated that despite rumors to the contrary "there is certainly enough water in the river for the CAP of 1.2 million acre feet" under the *Arizona v. California* ruling.

Hayden also criticized the portion of the PSWP proposal to import 1.2 million acre feet of water from northern California to southern California at a cost of billions of dollars while ignoring an equal amount of water that could be developed at a minimum cost through adequate conservation practices within the area. "This committee," he inveighed, "is being requested to provide funds for the import of water from northern California at a great cost to protect the right of southern California to waste water."

What especially irked Hayden about PSWP or other "regional" initiatives that emerged over the four-and-one-half years of legislative wrangling in what became the Colorado River Basin Project Act of 1968, was the obvious efforts of certain interests within California to delay CAP or nullify *Arizona v. California*. Later he recalled that "it appeared a lifetime of labor was approaching fruition." The Court decision, combined with solemn assurances of California's former governor Earl Warren who in 1948 told Hayden, "whenever it is finally determined that water belongs to Arizona, it should be permitted to use that water in any manner or by any method considered best by Arizona," seemed to clear the way for authorization of CAP. Moreover, shortly after the opinion, Governor Edmund G. "Pat" Brown announced that California, having lost the Supreme Court case, would not try to accomplish by obstructionism what she had failed to accomplish by litigation. As Hayden stated on August 4, 1963, and reiterated on several occasions thereafter: "For forty years I have witnessed the thwarting of Arizona's effort to put to use its share of Colorado River water. At every turn Arizona has encountered the deliberate delaying tactics of California and there is every reason to believe that his plan of obstructionism will continue." To his dismay, he found that "a small group of Californians, notwithstanding previous commitments, continued to nullify, by delay, the Supreme Court's decision." Although California employed the politics of delay throughout the process of legislative consideration of the bill, Hayden firmly believed that the concept of equity would prevail in the end. Indeed, California had its water, Nevada had its water, the upper basin was developing its water, and Arizona had nothing. Thus as he told lawmakers at the outset of legislative consideration of CAP, "I think all of you know that I have always attempted to help in any way possible with every project of our western resources—even when I was being fought on my own project—but quite frankly my patience has been exhausted."[43]

In spite of California's continued opposition, Hayden had powerful allies in the Senate. His close and respected friend, Senator Henry Jackson (D-Washington), chaired the Senate Interior Committee. Jackson, whose state owed much of its post-war prosperity to Hayden-supported federal reclamation programs, monitored carefully natural resource development and federal reclamation. Moreover, Jackson's valued relationship with Senator Hayden and firm alliance with President Kennedy served Arizona well throughout CAP'S various journeys through the Senate between 1963 and 1968. During the course of arriving at a measure suitable to all contending and conflicting interests, however, California and the upper basin looked to the Northwest and the Columbia River system to import and augment Colorado River water supplies in an effort to avoid water shortages made worse by CAP. At one point during the process, several senators and congressmen contemplated the importation of 8 million acre feet of water per year from the Columbia River Basin and even as far north as Canada. Naturally, Jackson saw fit to protect the interests of his region and took actions to eliminate transbasin transfers of water during final consideration of the CAP bill. In its final form the legislation contained a provision that provided for a ten-year ban on interbasin feasibility studies.[44]

Hayden also counted on support from Senator Clinton Anderson (D-New Mexico) who served as chairman of the Power and Reclamation Subcommittee of the Interior Committee. Anderson held considerable stature in the Senate as well as with groups concerned with water resource development and, besides, he had a stake in the bill as it pertained to protecting and extending water entitlements for his state. Moreover, his especially close relationship with Senator Jackson made Anderson an important ally in the CAP fight. Indeed, throughout his last term in office, Hayden relied on these two powerful senators to counter the opposition arguments of California's two senators, Thomas Kuchel (R-California), the ranking Republican member of the Senate Interior Committee, and Claire Engle (R-California), who helped engineer the 1951 defeat of CAP in the House of Representatives.[45]

Thankful for the support he maintained in the Senate, Hayden and his staff nevertheless knew the real fight for passage remained in the House of Representatives. Between 1963 and 1968 Arizona, fortunately, had capable and bipartisan representation in the House. John Rhodes, a Republican, was a respected and influential leader among House Republicans who served on the House appropriations subcommittee which would ultimately provide money to build the project. George Senner, a northern Arizona Democrat from Arizona's then-newly created third district, was untested and soon lost his seat to the inimitable Sam Steiger of Prescott, a Republican. And Morris Udall, a member of the key Committee on Interior and Insular Affairs, maintained special responsibilities over the bill. Importantly for Arizona, her three-man team in the House worked well together during the final four and one-half year legislative history of the bill.

Although Arizona's House delegation introduced CAP bills identical to Hayden's the day after the Supreme Court's decision, passage was another issue. Indeed nine out of ten bills introduced and referred to committee never saw a floor vote. The power of congressional committees in the House, moreover, could not be overstated and of special importance were the committee chairmen. Bills opposed by the chairman rarely emerged from committee for a floor vote. The chairman controlled the schedule of hearings on legislation, and undecided members often followed the chairman's lead. Since the principal obstacle to passage of CAP was in the House, the House Interior Committee-and its Irrigation and Reclamation Subcommittee where the CAP bill was referred-held vital importance for CAP proponents.[46]

For Hayden this meant CAP passing through the gauntlet of the House Interior Committee, chaired by Wayne N. Aspinall. According to most observers of Colorado River Basin affairs, Aspinall, the former schoolteacher with a testy disposition who had climbed from a small western Colorado town to chairman of this all-important committee, distrusted expansionist California and felt similarly about Arizona. In fact, the river ran under the window of his home on Aspinall Drive in Palisade, Colorado, and he sought to conserve every acre foot of water before the lower basin states would take it and never give it back. Mo Udall considered the sixty-seven-year-old chairman who had served in Congress since 1948 "a superb legislative tactician." Of utmost concern to Aspinall was the obvious fact that although entitled to 2.8 million acre feet of water, Arizona's use of this amount through CAP might cut sharply into water destined for upper-basin use but not yet developed. During one crucial phase of CAP's consideration in the House Interior Committee in 1967, Hayden, in an uncharacteristic display of power, threatened to eliminate funding for construction of the Frying Pan-Arkansas Project in Colorado and allowed that he would hold up other projects important to the House Interior chairman if Aspinall did not move the bill forward. Therefore, as Hayden knew from the outset of legislative consideration of his bill, if CAP was going to get past Aspinall and his committee, Colorado must be satisfied.[47]

In addition to Aspinall, John Saylor of Pennsylvania, ranking Republican on the House Interior Committee, continued to frustrate Arizona as he had in the 1950s. Described by one colleague as a "dynamic, hard- hitting protagonist," who had earned respect in the House, Saylor was an ardent conservationist who supported the growth and expansion of the National Park system and advocated programs for outdoor recreation. Saylor, moreover, backed a strong wilderness bill, the "integrity of the national parks," and complained vigorously about the Bridge Canyon Dam provision of CAP because it threatened to back water into Grand Canyon National Park. While not opposed to sound reclamation projects he opposed increasing public power development and spotty financing and poor planning in "marginal reclamation projects." He voted against the upper Colorado project in 1956 thereby gaining recognition and support among environmentalists for his efforts.[48]

Indeed in 1966 and 1967 environmentalists' opposition to the construction of dams in and around Grand Canyon brought nationwide attention to CAP and threatened to derail the entire project. Environmentalists waged a spirited campaign against the dams reminiscent of the great battle over Echo Park. By 1966 virtually everyone involved in the legislation—through hearings, meetings, and "confidential" parlays—knew that the river was over-allocated and most wanted to see augmentation from the Northwest, so they generally favored the Grand Canyon dams. As expressed in his first Supreme Court CAP bill, Hayden still advocated construction of Bridge Canyon Dam, as he had since 1947, and indicated that he also supported Marble Gorge Dam if indeed revenues were needed to finance augmentation and other development. Yet the previously fragmented environmentalist movement, representing diverse interests and a wide array of organizations, brought significant pressure to bear on Congress and the Johnson administration. They contended that the dams would flood scenic areas and inundate portions of Grand Canyon National Park and Grand Canyon National Monument. A few groups, including the Sierra Club, the National Parks Association, and the Arboretum, saw a great deal to lose with the inclusion of hydroelectric power dams in the bill.

The California-based Sierra Club, with a national membership of about 40,000 at the time of the battle, was the most prominent and well organized of the anti-dam environmental groups. Led by its energetic and controversial director, David Brower, the Sierra Club spearheaded a broadly gauged effort to fight construction of dams in the vicinity of the Grand Canyon. An impressive letter writing campaign and an effective public-relations program, underscored by the strong emotional and symbolic appeal of "saving" the Grand Canyon from profit-mongering developers, accomplished much for their cause. Brower wrote President Johnson, Secretary Udall, and other members of the administration directly, protesting the dams. Soon Johnson administration officials, members of congress, and Arizona's leaders began receiving thousands of letters daily from individuals and groups as diverse as the social science faculty at Dartmouth

College in Hanover, New Hampshire, to first grade public school classes in Sandusky, Ohio.[49]

In the course of the advocacy campaign, a series of highly publicized well-attended addresses brought further attention to the issue. In Denver, for example, Brower, speaking before an anti-Grand Canyon dams audience, quipped that he did not oppose dams in the Grand Canyon as long as the Bureau of Reclamation built a comparable canyon somewhere else. As one chronicler put it, "Never before had conservationists challenged the collective will of seven states."[50]

By early 1966 the public was suitably convinced that the most controversial aspect of the legislation involved the two proposed dams. And in the spring of that year, after *Reader's Digest*, *Life*, and even *My Weekly Reader* ran stories attacking the Grand Canyon dams, Hayden realized they posed insurmountable political obstacles. By early 1967 Hayden, as he met with senate leaders in efforts to further revise CAP, knew that an alternative source of energy would be required to pump CAP water to central Arizona. In a July 1967 memorandum to President Johnson advising him that the Senate Committee on Interior and Insular Affairs had overwhelmingly recommended passage of S. 1004, the CAP bill-for the fourth time-he added that this legislation contained "no new Colorado River dams." As Elson interpreted the outcome of the anti-dam fight: "Most people in the East and other places were for CAP, but they were against the dams because they had been informed by Brower and his operatives that within the region there existed adequate amounts of alternative energy sources, notably low-grade coal." As a result Hayden and Arizona were forced to accept an alternative to hydroelectric power. Yet, as historian Donald Worster explained in his analysis of this environmentalist victory, they lost something as well. In exchange for Grand Canyon dams, energy required for CAP was derived instead from coal strip-mined on Hopi lands at Black Mesa and burned in the Navajo Generating Station near Page "polluting crystalline desert air with ash and poison gas." As one Reclamation official explained the paradox, "it didn't solve a damn thing except it gave us power to pump water to central Arizona."[51]

If acquiescing on the dam issue, incorporating aspects of Secretary Udall's regional plan, and jousting with Congressman Aspinall's upper basin demands in the House proved difficult but tolerable, Hayden had great difficulty with another necessary compromise. From the start of congressional negotiations California's senators made it clear that its central demand for dropping opposition to CAP would be a first priority of 4.4 million acre feet awarded it in the CAP legislative battle, Roy Elson recalled: "For California...it all became an argument about what to do about the shortages in the river… we got into these early difficulties mainly over that issue." Hayden knew immediately the implications of the demand; California wanted Arizona to regulate their mainstream diversions so that California would never receive less than 4.4 million acre feet out of the 7.5 million acre feet lower-basin allocation. At first an intransigent Hayden refused to negotiate the issue with California senator Kuchel. By 1965, however, as time seemed to get shorter and the issue more complex, the bill in the Eighty-eighth and Eighty-ninth congresses carried provisions for twenty-five-and twenty-seven- year guarantees for California's 4.4 priority. In the final version of the bill, however, Arizona promised California that CAP diversions "shall be so limited as to assure the availability" of 4.4 million acre feet annually in perpetuity.[52]

As Hayden neared the last year of his final term in office and CAP remained stalled in the House Interior Committee in spite of the numerous concessions already made, a frustrated and impatient state leadership triggered another minor complication for the senator. Rumor of an Arizona "Go-It-Alone" CAP, promoted by the state conservatives and elements within the Arizona Power Authority (APA) first surfaced in 1963. A prominent feature of the state-financed and operated plan included the successful application of the Arizona Power Authority to the Federal Power Commission to finance, construct, and manage a hydroelectric power dam on the Colorado River. Hayden quickly thwarted this untimely effort by shepherding through Congress a bill (S. 502) that preserved the jurisdiction of Congress over the construction of hydroelectric power works below Glen Canyon Dam on the Colorado River. With the passage of S. 502 on June 23, 1964, those Arizonans calling for a state-owned and operated CAP were effectively prohibited from taking action though they lobbied the senator and threatened continuously to take action as late as 1967. While the state "Go-It-Alone" plan reflected the lack of consensus within Arizona over CAP strategy, it was more accurately an illustration of the high degree of frustration over repeated legislative delays in the CAP bill.[53]

By the end of 1967, after seemingly endless negotiations among and within states, implementing selected provisions from over thirty Department of Interior studies and discarding others, crafting suitable and appropriate legal language, and including the time-honored pork barrel benefits for those politicians who needed to "bring home the bacon," CAP was finally ready to move. Key in breaking the political logjam in California was newly-elected Republican governor Ronald Reagan, who began direct and productive negotiations with Arizona's Republican governor Jack Williams. Reagan informed his administrators that he had "become increasingly concerned over the serious impasse… relative to the Colorado River legislation and with the adverse impact this stalemate is having on other programs in California and on reclamation throughout the West." Another crucial element in prompting final action was Hayden's pressure on House Interior chairman Aspinall, who in the fall returned from a "vacation" in Colorado and was virtually forced to hold final hearings on the bill and report it out of committee. The legislation, depending on one's perspective, was either light enough or heavy enough to move. During the spring of 1968, as Hayden and his staff participated in fashioning the final compromises and details in conference committee, most of the key players who participated in creating the measure that emerged from Congress—even opponents of CAP like California's Thomas Kuchel—could not disguise their profound pleasure that Senator Hayden came away from the momentous struggle with one last political victory. On September 12, 1968, when the Senate agreed to the House version of the Colorado River Basin Project Act, the ninety year-old Hayden received glowing tributes for his persistent efforts. The senator quietly acknowledged the accolades with nods of appreciation. On September 30, 1968, President Johnson, at a ceremony attended by Senator Hayden and other Arizona dignitaries, signed CAP into law.[54]

Besides CAP, the legislation included authorization of several other controversial reclamation projects as well, including Hooker Dam in New Mexico, an aqueduct from Lake Mead to Las Vegas, the Dixie Project in Utah, and the Uintah Unit of the Central Utah Project. The Act also authorized the San Miguel, Dallas Creek, West Divide, Dolores, and Animas La-Plata projects in Aspinall's state of Colorado. Additionally, it authorized the establishment of a Lower Colorado River Development Fund to build a still-yet-to-be-defined augmentation project. Finally, the bill made delivery of Mexico's 1.5 million acre

24.2. President Lyndon Baines Johnson hands the pen with which he signed the Colorado River Basin Projects Act on September 30, 1968, to Senator Carl Hayden.

feet of water a national, not regional, responsibility. This legislation, signed into law two days before Hayden's ninety-first birthday, was—at the time—the most expensive single congressional authorization in history, containing $1.3 billion for implementation of the program.[55]

On May 6, 1968, shortly before the final touches were being completed on CAP, Hayden was led into the Appropriations Committee chamber jammed with senators, friends from Arizona, and a few representatives from the media. President Johnson arrived bearing a pair of walnut bookends and issued a short, grandiloquent tribute. Senator Richard Russell of Georgia, Hayden's best friend in the Senate, then chaired a brief ceremony and introduced Hayden. The Arizona senator walked slowly to the dais and announced,

> Among other things that fifty-six years in Congress have taught me is that contemporary events need contemporary men. Time actually makes specialists of us all. When a house is built there is a moment for the foundation, another for the roof, the walls, and so on. Arizona's foundation includes fast highways, adequate electric power, and abundant water, and these foundations have been laid. It is time for a new building crew to report, so I have decided to retire from office at the close of my term this year.

Then, as cameras clicked, Hayden burst into tears, as did nearly everyone else in the crowded room. With the typically brief announcement, Hayden signaled the end of his congressional service.[56]

Most accounts of the political and legal history of CAP dutifully acknowledge Hayden's preeminent role in bringing water to central Arizona. Yet the veteran senator's influence has been obscured by the length of the process, the legendary *Arizona v California* Supreme Court case, and the thousands of pages of mind-numbing technical and fiscal testimony in the Congressional Record. Hayden, more than any other CAP proponent, fashioned the legislative strategies that shaped CAP's configuration in the public mind. His actions and statements before innumerable congressional committees not only provide an important perspective for assessing CAP's broader economic, social, and environmental significance, but also reveal Arizona's profound role in fashioning solutions to vexing regional and national issues. Indeed, the hundreds of miles of canals, pumping stations, and water-delivery systems that today wind their way through miles of desert stand as a testament, for better or worse, to Hayden's towering public career.[57]

The realization of Carl Hayden's dream—the CAP—at the end of the twentieth century raises some fundamental questions. Will the desert bloom in the twenty-first century with renewed agricultural activity and urban expansion? Or, is this water-based civilization in a fragile ecosystem doomed to flourish briefly—then disappear? Will Las Vegas and southern California, both pressing against their environmental limits and desperately seeking a greater share of lower-basin water, succeed in forcing Arizona back to the federal bargaining table? Certainly Hayden foresaw these questions and sensed their implications even as he fought mightily for the beneficial implementation of federal reclamation in the arid West.

Put another way, Hayden focused much of his considerable energy on the single, most important factor confronting his arid constituents—the search for large quantities of fresh water. Throughout his congressional career he represented the "heart of the West," which was to historian Walter Prescott Webb "a desert unqualified and absolute… a gigantic fire" that defied human settlement and economic development, yet vividly defined the region as a unique place on the American landscape. From Hayden's perspective, Arizona and the Southwest were deficient in comparison with other parts of the country, and the most notable deficiency was water. Much of his public career, as exemplified in the legislative fight for CAP, was devoted to rectifying that deficiency.

Underlying the mad scramble for Colorado River water was the peculiarly western obsession with economic growth and development. This almost myopic quest in the environmentally sensitive central Arizona desert has come under close scrutiny in recent years. Scholars from a variety of disciplines have revisited the era of the western water wars and orgy of dam building, and have come away with profound questions regarding the long-term effects of environmental manipulation and the ultimate fate of the Colorado River, which one interpreter describes as "A River No More." As scholars and politicians reassess and revise their economic and environmental interpretations of federal reclamation, Carl Hayden will stand out as one public figure that in many ways symbolized this critical movement in the American West. Without question water has been among the region's most critical concerns in the nineteenth and twentieth centuries. No doubt the environment will continue to influence the direction of public policy in the region in the twenty-first century as well.[58]

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Endnotes

1. Bruce Babbitt, "The Future of the Colorado River," in Gary D. Weatherford and F. Lee Brown, eds., *New Courses for the Colorado River* (Albuquerque: University of New Mexico Press, 1986), x-xvi; Bruce Babbitt, "Introduction," in Jack L. August, Jr., *Vision in the Desert: Carl Hayden and Hydropolitics in the American Southwest* (Fort Worth: Texas Christian University Press, 1999) 1-8.
2. *Sen. Doc.* 76, 87 Cong. 2 Sess., 29-33; Jack L. August, Jr., "Carl Hayden: Born a Politician," *Journal of Arizona History* 26 (Summer 1985), 117-24; Jack L. August, Jr., "A Sterling Young Democrat: Carl Hayden's Road to Congress, 1900-1912," *Journal of Arizona History* 28 (Autumn 1987), 217-42; Jack L. August, Jr., "Carl Hayden's Indian Card: Environmental Politics and the San Carlos Reclamation Project," *Journal of Arizona History* 33 (Winter 1992), 397-442; Jack L. August, Jr., "A Vision in the Desert: Charles Trumbull Hayden: Salt River Pioneer," *Journal of Arizona History* 36 (Summer 1995), 109-134; Jack L. August, Jr., "Carl Hayden, Arizona, and the Politics of Water Development in the Southwest, 1923-1928," *Pacific Historical Review* 58 (May 1989), 195-216.
3. According to Marc Reisner, a critic of Bureau of Reclamation activities in the American West, Hayden exercised "near-despotic rule" over the Bureau's authorizing committees by World War II. Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water* (New York: Viking Press, 1993), 256.
4. See August, *Vision in the Desert,* passim.
5. *Arizona Daily Star,* August 14, 1952; *Arizona Republic,* August 14, 1952; Wayne Aiken interview with Jack L. August, Jr., September 18, 1982, Oral History Collection, Department of Archives and Manuscripts (DAM), Arizona State University (ASU); Norris Hundley, Jr., "The

West Against Itself," in Weatherford and Brown, eds. *New Courses for the Colorado River,* 30; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon, 1985).

6. The Supreme Court voted 5-3 in favor of Arizona in *Arizona v. California* et al. 373 U.S. 564,565 (1963); Hundley, "The West Against Itself" *New Courses for the Colorado River,* 275; *Washington Post,* June 4, 1963; *Arizona Republic,* June 4, 1963.

7. Arizona's 3.8 million acre feet included the 1 million acre feet of Gila River water put to beneficial use under the San Carlos Irrigation Project. T. Richmond Johnson, *The Central Arizona Project* (Tucson: University of Arizona Press, 1968), 84, 94-5. See also the Boulder Canyon Project Act [45 Stat. 1057] and the California Limitation Act [Laws of California, 1929, ch. 16], 38-39; John G. Will, "Law and Water," *Project Rescue: A Seminar on the Central Arizona Project* (Tempe, Arizona State University, 1964), 19-23.

8. The solicitor general advised the Court on October 17, 1952, that the federal government would move to intervene in the case. T. Richmond Johnson interview with Jack L. August, Jr., March 20, 1985, Phoenix, Arizona, OHC, ASU, *New York Times,* June 4, 1963, Hundley, "The West Against Itself," 32.

9. *Arizona v. California et al.* 373 U.S. 564,565 (1 963); Johnson, *Central Arizona Project,* 88-97.

10. Simon Rifkind interview with Jack L. August, Jr., October 12, 1986, Ruidoso, New Mexico, author's files.

11. See Norris Hundley, Jr., *The Great Thirst: California and Water, 1770-1990* (Berkeley: University of California Press, 1992) 300-1; *Arizona Republic,* August 15, 1955.

12. Hundley, *The Great Thirst,* 30 1; August, *Vision in the Desert,* 178.

13. Roy L. Elson, Administrative Assistant to Senator Carl Hayden and Candidate for the United States Senate, 1955- 1969, "Oral History Interviews April 27 to August 21, 1990," Senate Historical Office, Washington, D.C., 103; Paul M. Butler to Carl Hayden, May 30, 1955, Box 716, Folder 9; Paul Eaton to Renz Jennings, February 14, 1956; Paul Eaton to Steven Shadegg, February 24, 1956, Carl Hayden Papers Collection (CHPC), DAM, ASU.

l4. *Arizona Daily Star* (Tucson), October 27, 1956; *Phoenix Gazette,* October 3, 1956, January 11, 1956; *Arizona Republic,* November 22, 1956; *Newsweek,* November 12, 1956, 68; Stephen Shadegg to Paul Eaton, April 19, 1956, Box 716, Folder 11 ;Lyndon Johnson to Hayden, January 15,1955, Box 716, Folder 3; Democratic Policy Committee, "News Release," January 16, 1955, Box 716, Folder 2, CHPC, DAM, ASU.

15. William Benton, "For Distinguished Service in Congress," *New York Times Magazine,* July 24, 1955.

l6. Secretary of State, "Official Canvass: General Election, November 6, 1956," Department of Library and Archives, Phoenix, Arizona; Benton, *New York Times Magazine,* July 24, 1955; Lewis Douglas, "Statement by Lewis Douglas, Sr.," October 1, 1956; Hayden, "Election Night Speech," n.d., Box 716, Folder 8, CHPC, DAM, ASU.

17. "*Arizona Republic,* "Arizona Days and Ways Fiftieth Anniversary Issue," February 14, 1962, 536; Sen. Doc. 76, 87 Cong. 2 Sess., "Tributes to Honorable Carl Hayden, Senator from Arizona, To Commemorate the Occasion of his Fiftieth Anniversary of Congressional Service," February 19, 1962 (Washington, D.C.: Government Printing Office, 1962), 29, 42-3; *Phoenix Gazette,* September 21, 1962; *Arizona Republic,* September 21, 1962.

18. For an analysis of Hayden's last U.S. Senate campaign see Jack L. August, Jr., "Old Arizona and the New Conservative Agenda: The Hayden versus Mecham U.S. Senate Campaign of 1962," *Journal of Arizona History* 41 (Winter 2000), 385-412; Elson asserted that during his service to Hayden (1952-1969) "there wasn't a thing I did… that wasn't with the approval of the senator, or he didn't know about. I was the hatchet man, I was the negotiator, and caught a lot of hell for it because they didn't think [my actions] were what the senator wanted." Elson, "Oral History Interviews, April 27 to August 21, 1990," 122-3, 198; *Cervi's Rocky Mountain Journal* (Denver), July 27, 1967.

l9. Elson, "Oral History Interviews," 124. Hayden initialed the memorandum and Elson took it as permission to do "everything that was in there, whether he agreed to it or not."

Meanwhile, Elson had commissioned a poll that showed the senator in serious trouble throughout the state.

20. August, "Old Arizona and the New Conservative Agenda," *Journal of American History (JAH)*, 389-90; *Arizona Republic,* November 3, 15, 16, 17, 18, 19, 1961.

21. Elson, "Oral History Interviews," 125-6.

22. *Los Angeles Times,* January 5, 1969; Elson "Oral History Interviews," 125-7; James Minotto interview with Barbara Van Norman, July 5, 1973, Tempe, Arizona, Carl Hayden Oral History Project, DAM, ASU. 7

23. Ross Rice interview with James Minotto, July 5, 1973; Ross Rice interview with Morris Udall, December 30, 1972; Jack L. August, Jr., interview with William S. Gookin, July 20, 1985; Jack L. August, Jr., interview with Barry Goldwater, September 15, 1985, Oral History Collection, DAM, ASU; *Los Angeles Times,* January 5, 1969; *Arizona Republic,* November 4, 1962. Three years after the 1962 election, a political science textbook witten by Marvin H. Bernstein and Wallace Murphy of Princeton University, in a footnote on page 312, reported that Hayden had died. Hayden took time to write the Princeton professors, informing them that their textbook, *American Democracy in Theory and Practice,* was not in accord with the latest edition of the *Congressional Directory,* which indicated that "I had been reelected in 1962 for a term of six years." Hayden included a wry postscript to the letter: "I have not determined whether I will be a candidate for reelection to the United States Senate for a term beginning in 1969." See also, *Washington Post,* May 6, 1965.

24. August, "Old Arizona and the New Conservative Agenda," *Journal of American History,* 406; Elson, "Oral History Interviews," 128; *Arizona Republic,* November 8, 1962; *Los Angeles Times,* January 5, 1969; *Official Canvass, General Election, November 6, 1962,* compiled and issued by Wesley Bolin, Secretary of State, November 26, 1962, Office of the Secretary of State, Phoenix, Arizona.

25. August, *Vision in the Desert,* 259; Jack L. August, Jr., interview with Wesley Steiner, February 18, 1985, Phoenix, Arizona; Jack L. August, Jr., interview with Wayne Akin, Phoenix, Arizona, September 18, 1985; Jack L. August, Jr., interview with John J. Rhodes, Tempe, Arizona, November 4, 1985, OHC, DAM, ASU; *Arizona Republic,* June 4, 1963.

26. *Arizona v. California et al*. 373 U.S. 587 (1963).

27. *Arizona Republic,* June 4, 1963; August, *Vision in the Desert,* 184.

28. Norris Hundley, Jr., "Clio Nods: *Arizona v California* and the Boulder Canyon Act: A Reassessment," *Western Historical Quarterly* 3 (January 1972), 17-51. Hundley, "The West Against Itself," 32; Elson, "Oral History Interviews," 186.

29. Arizona's team of attorneys was jubilant over the decision. Two who laid the groundwork and who subsequently died during the hearings were Charles Carson and J. H. "Hub" Moeur, who actually filed the lawsuit and served as chief Arizona counsel in its early stages. Arizona leaders close to the proceedings, however, credited attorneys Charles "Charley" Reed of Coolidge and Mark Wilmer of Phoenix, along with their backup staff of attorneys and engineers, for orchestrating the judicial victory. According to distinguished water historian Norris Hundley, Jr., the Court now held that Congress had empowered the Secretary of Interior to determine the water rights of citizens within states and thus eroded the state's rights at the expense of the federal government. Hundley, "The West Against Itself," 32; *Arizona Republic,* June 4, 1963.

30. August interview with Simon Rifkind, October 12, 1986, Ruidoso, New Mexico, author's files. Indeed the majority decision upheld Special Master Rifkind's apportionment of waters to Indian reservations as "present perfected rights" established prior to 1929. Arizona had argued against this part of the master's proposed decree and was therefore opposed to the federal government on this issue. See Hundley, "The West Against Itself," 32-3; Norris Hundley, Jr., "The Winters Decision and Indian Water Rights: A Mystery Reexamined," *Western Historical Quarterly* 13 (January 1982), 17-42; Norris Hundley, Jr., "The Dark and Bloody Ground of Indian Water Rights: Confusion Elevated to Principle," *Western Historical Quarterly* 9 (October 1978), 455-82; *Winters v. United States,* 207 U.S. 564 (1908); *Arizona v. California* et al., 439 U.S. 422 (1979).

31. Hayden, "Memorandum," April 10, 1963; Hayden, "Memorandum," May 10, 1963, Box 2, Folder 4, CHPC, DAM, ASU; "Arizona Seeks Billion Dollar Water Project," *Congressional Quarterly Fact Sheet,* June 5,1963.

32. *New York Times,* June 13, 1963; Edward C. Johnson to Hayden, June 14, 1963; Hubert Humphrey to Hayden, June 4, 1963; Clay Simer to Hayden, n.d., Box 2, Folder 1, CHPC, DAM, ASU, Morris Udall, "Arizona's Water Fight Shifts to Congress," *Congressmen's Report,* June 21, 1963. See also S. 1658.

33. Elson, "Oral History Interviews," 185-7; C. A. Pugh to Hayden, January 15,1963; Roy Elson to Paul Fannin, June 3, 1963; Memorandum to Files, "Statement Made by Secretary Udall to Senator Hayden," July 11, 1963, Box 2, Folder 15, CHPC, DAM, ASU: "Arizona Seeks Billion Dollar Water Project," *Congressional Quarterly Fact Sheet,* June 5, 1963. The technical reports further convinced Arizona leaders of the need for CAP and, for the most part, they were unified in their approach to Congress. The Arizona congressional delegation worked together on the bill, and the three House members, representing both political parties, often issued joint press releases. Both Democratic and Republican governors endorsed the bill. Moreover, early in 1966, a task force of Arizonans who maintained various areas of expertise gathered in Washington to assist the efforts of the congressional delegation. The members and staff were from the Arizona Interstate Stream Commission, Arizona Public Service, Salt River Project, and the Central Arizona Project Association.

34. Elson, "Oral History Interviews," 185-6; Helen Ingram, *Water Politics: Continuity and Change* (Albuquerque: University of New Mexico Press, 1990) 46-7.

35. John Rhodes to Hayden, January 25, 1963, Box 3, Folder 8; Wayne Aspinall to Stewart Udall, November 27, 1962, Box 3, Folder 10, CHPC, DAM, ASU; *New York Times*, January 22, 1963; United States Secretary of Interior, "News Release: Secretary Udall Announces Study for Regional Solution of Water and Power for Problems of the Pacific Southwest," January 22, 1963; Ingram, *Water Politics,* 48.

36. Udall also noted that the long-range Lower Colorado River Basin Plan (PSWP) was patterned in part on the successful Colorado River Storage Project in the upper basin. In addition, he said, "A critical period is at hand, a more critical period lies ahead for millions of people who are flocking to the Pacific Southwest to establish permanent homes. This burgeoning population will require vast quantities of additional water for industrial and municipal use; greater quantities of electricity and other basic services; and more irrigated lands. Piecemeal development cannot do the job. Only regional planning and action will enable us to meet the growth of this area." See U.S. Department of Interior, "News Release," January 22, 1963; Ingram, *Water Politics,* 48; Ernest A. Englebert, *Policy Issues of the Pacific Southwest Water Plan* (Boulder: University of Colorado Press, 1965) 130-5; Hayden, "Fact Sheet on Interior's Pacific Southwest Water Plan," n.d., Box 2, Folder 14, CHPC, DAM, ASU, Hayden to Stewart Udall, February 20, 1964, White House Central Files, (WHCF), NR 7, UT 4 (1963-64), Lyndon Baines Johnson Presidential Library (LBJ), Austin, Texas.

37. Elson, "Oral History Interviews," 186-7. Elson recalled that Hayden wanted a simple CAP bill, but he noted, "Stewart Udall became Secretary of Interior… in '61, during the Kennedy administration. As the thing proceeded from '62 to '63 we heard these rumbles that everyone was complaining that there was not enough water in the river, and immediately we got into a numbers game, and hydrology, what was coming down… through Glen Canyon, and the runoffs of the Upper Basin and the Lower Basin, and the Mexican Water Treaty obligations. You had everything involved in this, international, interstate, the West." See also Stewart Udall to Hayden, December 19, 1963, Box 2, Folder 14; Hayden to Udall, n.d., Box 3, Folder 14, Paul Fannin, "News Release," December 27, 1963, all in CHPC, DAM, ASU. Then-governor Fannin also wrote that "it is already apparent that the report is cleverly written by someone in the Department of Interior to give California a logical excuse for delaying any and all favorable action on either a practical regional water plan or the CAP which is now before Congress." He worried that "in spite of the favorable Court decision… California can and will continue to use our share of the river until we obtain congressional authorization of CAP."

38. Elson, Oral History Interviews," 187; *Yuma Daily Sun*, June 16, 1963.

39. *Arizona Republic*, August 14, 1963; August, *Vision in the Desert*, 185-7,262.

40. Stewart Udall to Hayden, "Personal," August 20, 1963, Box 2, Folder 14; Hayden to Udall, December 5, 1963, Box 2, Folder 1, CHPC, DAM, ASU; *New York Times*, June 13, 1963; *Arizona Republic*, August 14, 1963.

41. Hayden, "Statement Upon Resumption of Hearings on S 1658," n.d., Box 3, Folder 9, CHPC, DAM, ASU; Morris Udall, "Arizona's Water Fight Shifts to Congress," Congressman's Report, June 21, 1963; Reisner, *Cadillac Desert*, 272-3. According to Reisner, in his critique of the Bureau of Reclamation, "politics demanded that CAP be built, and in the 1960s, Arizona had power. Barry Goldwater was the presidential candidate of the Republican Party; Carl Hayden was the chairman of the Senate Appropriations Committee."

42. Hayden also reminded the committee that before any water could be conveyed through proposed PSWP facilities, the federal government had to construct the Auburn-Folsom South Unit ($400 million), the East Side Division of the Central Valley Project ($1 billion), and the state of California needed to complete the aqueduct system under the California State Water Plan. Hayden stated that he opposed "any proposals that would permit consideration to be given to these two California projects in preference to consideration of CAP, which has been waiting before Congress for fifteen years." Hayden, "Statement Upon Resumption of Hearings on S 1658," n.d., Box 3, Folder 9, CHPC, DAM, ASU.

43. August, *Vision in the Desert*, 263; Reisner, *Cadillac Desert*, 273; Hayden to Henry Jackson, February 18, 1964; Hayden, "California and the Central Arizona Project," August 4, 1963, Box 2, Folder 15, CHPC, DAM, ASU. Hayden detailed ten methods in which California obstructed Arizona from putting water to beneficial use from the Colorado River between 1924 and 1963. He included California's refusal to accept the division of water recommended by the Colorado River Basin Governors in 1924 and their insistence on endless negotiations among the lower-basin States. Hayden also pointed to California's strenuous resistance to ratifying the 1944 Mexican Treaty which settled Mexican rights to Colorado River water and the state's consumption of eleven months instead of ninety days required by law in commenting on Interior's Central Arizona Project Report of 1947.

44. See Morris Udall to John Rhodes and Sam Steiger, February 2, 1967, Box 5, Folder 12; Henry Jackson to Hayden, August 15, 1963; Hayden to Henry Jackson, February 18, 1964, Box 2, Folder 15, CHPC, DAM, ASU. Udall wrote his fellow Arizona representatives that "there will be no House bill passed this year (1967) without Arizona, California, and Colorado working together." By early 1967 Arizona's House delegation believed that the "Colorado-California" partnership had been thoroughly sealed. The partnership was based upon seeing a CAP bill that provided for a Northwest study of some kind. Because of this alliance, Arizona's representatives correctly predicted that their bill at the time (H.R. 4671) would be opposed by the three Northwest Republicans and two Northwest Democrats sitting on the subcommittee and full committee. See also Roderick Nash, *Wilderness and the American Mind*, 3d ed. (New Haven: Yale University Press, 1982) 209-35; *Congressional Quarterly Fact Sheet* (November 1, 1969), 3019-31 ; Ingram, *Water Politics*, 52; Reisner, *Cadillac Desert*, 281-91; Hundley, "The West Against Itself," 36; Morris Udall, "Congressman's Report," June 21, 1963.

45. Ingram, *Water Politics*, 52-3; M. Udall, "Congressman's Report," June 21, 1963.

46. The House Interior Committee was burdened with the heaviest workload in Congress. In fact, nearly 30 percent of all bills in the House were referred to this committee. At the time of CAP consideration, the committee was generally favorable to reclamation as many of its members had seen its benefits in their own districts. In recent years, however, reclamation projects had met increasing resistance both in committee and in the House itself due to the marginal quality of some projects and to the reluctance of eastern and urban congressmen to put water to additional lands because of farm product surplus. Moreover, CAP was not the only reclamation bill before the Subcommittee of Irrigation and Reclamation. Since January 1963, no less than fifteen other projects had been proposed and these bills awaited action. The backlog was a critical problem. M. Udall, "Congressman's Report," June 21, 1963; Ingram, *Water Politics*, 48-50; August, *Vision in the Desert*, 194-5, 264.

47. Elson, "Oral History Interviews," 184-90; Reisner, *Cadillac Desert,* 290-1; Ingram, *Water Politics,* 50. Ingram describes Aspinall's role, interests, and motivations in CAP consideration as "mixed and complex." Besides serving as champion of Colorado's interests and especially the spokesman for the Western Slope in water matters, Ingram argues that Aspinall maintained "a general paternity of the whole Colorado River basin and felt a responsibility for peaceful and harmonious development of water resources."

48. The Colorado River Storage Project of April 11, 1956, ch. 203, 70 Stat. 105. August interview with John Rhodes, OHC, ASU; Elson, "Oral History Interviews," 193-4; M. Udall, "Congressman's Report," June 21, 1963.

49. David Brower to President Lyndon Johnson, to Stewart Udall, to Henry Jackson, January 30, 1967, Box 19, Folder NR 7-1, WHCF; Members of the Dartmouth Faculty to Lyndon Johnson, July 25, 1966, Box 145, Folder LE/NR 7-15, WHCF, LBJ Presidential Library. Democratic Governor Sam Goddard and former Arizona senator, governor, and colleague of President Johnson, Ernest McFarland, made attempts to diminish the environmentalist arguments in personal letters to the President. See Sam Goddard to Lyndon Johnson, August 5, 1966, Box 145, Folder LE NR 7-1; Ernest McFarland to Lyndon Johnson, August 5, 1966, Box 19, Folder EX NR&-1/U WHCF, LBJ Presidential Library.

50. Elson, "Oral History Interviews," 193-4; Reisner, *Cadillac Desert,* 285; Ingram, *Water Politics,* 55. According to Reisner, Brower and the Sierra Club led the highly-publicized fight. He recruited Luna Leopold, one of the country's best-known hydrologists and the son of Aldo Leopold, to criticize the Bureau's flow calculations, and Brower deserves the most credit for eliminating Grand Canyon dams from CAP.

51. Hayden wrote a friend who supported the Grand Canyon dams: "I was aware of this future need [hydroelectric power] when Grand Canyon National Park was created by Act of Congress in 1919 when I was a young congressman from Arizona and for that reason made certain that the reservation for future reclamation development was clearly understood. The same question arose when Grand Canyon National Monument was created by Executive Order in 1932, and a letter exists in the Department of Interior files from then-director Horace M. Albright to the Commissioner of Reclamation Elwood Mead, stating positively that creation of the monument would not interfere with construction of Boulder Dam or other dams. Hayden to Oakes, n.d., Box 5, Folder 9, CHPC, DAM, ASU; Hayden to Lyndon Johnson, "Statement of Carl Hayden of Arizona, July 26, 1967, Accompanying the filing of the Majority Report of the Senate Committee on Interior and Insular Affairs on S. 1004 authorizing the Central Arizona Project," Box 1967, NR 7-1/6 FG 145, WHCF, LBJ Presidential Library; August interview with John Rhodes, OHC, ASU; August interview with Barry Goldwater, OHC, ASU; Elson, Oral History Interviews, 194-5; Reisner, *Cadillac Desert,* 287,290; Weatherford and Brown, *New Courses for the Colorado River,* 36, 37; Ingram, *Water Politics,* 55-6; Worster, *Rivers of Empire,* 276.

52. Elson, "Oral History Interviews," 185-6; Hundley, "The West Against Itself," 35-6; Ingram, *Water Politics,* 60-5; August, *Vision in the Desert,* 198-9.

53. August interview with John Rhodes; Jack L. August, Jr., interview with Rod McMullin, Scottsdale, Arizona, August 24, 1984; Jack L. August, Jr., interview with Roger Ernst, Paradise Valley, Arizona, March 23,1983, OHC, ASU; Hayden to Lawrence Mehren, August 14,1964, Box 4 Folder 10, CHPC, DAM, ASU; Hayden to Lyndon Johnson, August 4, 1964, Box 145, LE/NR 7-1, WHCF, LBJ Presidential Library.

54. Ronald Reagan to Raymond R. Rummonds, November 28,1967, Box 600, Folder 6, CHPC, DAM, ASU; Barefoot Sanders to Lyndon Johnson, August 1,1968; James R. Jones to Hayden, August 19,1968, CWH File, LBJ Presidential Library. See also House Committee on Interior and Insular Affairs, Hearings on *Colorado River Basin Project, H R.* 4671 *and Similar Bills,* 89 Cong. (1965- 1966); *Hearings on Colorado River Basin Project,* 90 Cong. 1 Sess. (1967); *Hearings on Colorado River Basin Project, Part* 11, 90 Cong. 2 Sess. (1968); *Arizona Republic,* September 13, 1968. For a narrative chronological history of the Central Arizona Project see T. Richmond Johnson, *The Central Arizona Project, 1918-1968* (Tucson: University of Arizona Press, 1977).

55. For the best analysis of the intraregional bargaining process involved in the Colorado River Basin Project Act see Ingram, *Water Politics,* chapter *4;* Helen M. Ingram, *Patterns of Politics in Water Resource Development: a Case Study of New Mexico's Role in the Colorado River Basin Bill* (Albuquerque: University of New Mexico Press, 1969). See also Hundley, "The West against Itself," 36-7; Reisner, *Cadillac Desert,* 294-5.

56. On several occasions Hayden told close friends, "Dick Russell was my best friend in the Senate. We served together for 36 years. Coming from the South kept him from being President of the United States." Hayden to James Chilton, February 24, 1971, James Chilton Papers,

Los Angeles, California; U.S. Senate Committee on Appropriations, "Press Release, Monday, May 6, 1968"; *Los Angeles Times,* January 5, 1969; *Arizona Republic,* May 7, 1969.

57. August, *Vision in the Desert,* 203; Hayden, "Arizona Report," 1968, Carl Hayden Letters, Folder 7, Arizona Historical Society, Tucson, Arizona; "In Memoriam: Senator Carl Hayden, 1877-1972," Hayden Biographical File, CHPC, DAM, ASU.

58. Walter Prescott Webb, "The American West: Perpetual Mirage," *Harper's Magazine,* 256 (May 1957) 214; Michael McGerr, "Is There a Twentieth Century West?" in William Cronin et al. eds., *Under an Open Sky: Rethinking America's Western Past* (New York: W. W. Norton, 1992) 249,251-6; Philip Fradkin, *A River No More: The Colorado River and the American West* (New York: Alfred A. Knopf, 198 1) 248; August, "Water, Politics, and the Arizona Dream," *Journal of American History,* 410-1.

Federal Reclamation in the Twentieth Century: A Centennial Retrospective

By:
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Abstract

The Reclamation Act of 1902 dedicated proceeds from the sale of public lands in the western half of the United States to the construction of irrigation works. Proponents of the legislation promised on the floor of Congress, that "worthless" lives trapped in the tenements of eastern cities could be reclaimed along with "worthless" desert land in the West. Congress required the farmers who benefited to repay the cost of irrigation works over ten years, so the program was expected to be self-supporting. By the time Theodore Roosevelt left office in 1909, two dozen projects had been launched, at least one in every state and territory, but none had been completed. With notable exceptions, those projects did not live up to expectations. Federal reclamation never became self-supporting, and some projects came to resemble rural slums. Not until the 1930s, when the "High Dam Era" gave the bureau responsibilities for providing water and power to cities as well as farms, did it become the most important federal agency in the West. From 1930 to 1970 the water and power provided by the bureau transformed the region, but since 1970 the bureau has been but a shadow of the robust agency that once dammed the West.

This paper focuses mainly on two periods of bureau history, its first decade and the quarter-century from the end of World War II to about 1970. I make three basic arguments: first, that in 1902 the Reclamation Bureau and its leaders were motivated more by nineteenth than by twentieth-century values; second, that the Reclamation Bureau did as much to decentralize power over water as to consolidate it in Washington; and, third, that federal reclamation died as much because it failed to sustain its original ideals as because it ran out of places to build dams, suffered from the constraints of economic retrenchment, or fell prey to the environmental movement.

When Congress adopted the Reclamation Act in June 1902 it launched potentially the biggest public works program in American history. *Harper's Weekly* proclaimed that

> the bill aims at substantial and enduring effects upon the broader economic development of the nation. There was and still is in some quarters an ill-judged disposition to regard it as of merely sectional interest: but in the true analysis its significance is national not local. … A hundred million [irrigated] acres will give homes for a million families, and afford sustenance for many times that number.

New York City's *Christian Work* applauded the new national program as

> one of the stupendous tasks of the opening century.… The first year of the Roosevelt administration has been rendered not more notable by the

> determination to build the Isthmian Canal than by the passage of the bill to water the dry lands of the great American West.

Philadelphia's *Inquirer* lamented that "the only ultimate regret will be that so beneficent a work was not sooner undertaken," and the *New York Times* applauded the bold new legislation as the last phase in the conquest of a continent:

> The irrigation plan is but adding to the general resources of the nation in furtherance of the impulse which has carried our vigorous race from the little fringe along the Atlantic to the shores of the Pacific and far into Asian waters. [1]

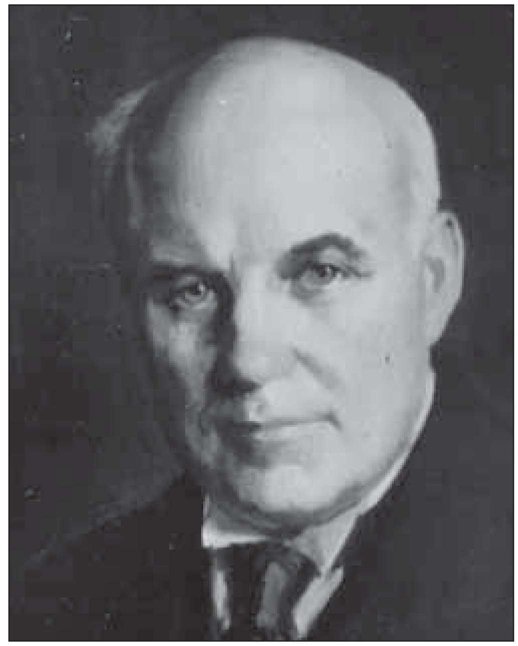
To be sure, the opponents of the legislation quickly reined in the bureau's grand ambitions. Eastern and Midwestern farm organizations feared that the rapid expansion of irrigated land in the West would return the nation to the agricultural depression of the 1890s. Inevitably, they argued, adding 100,000,000 acres to the nation's farmland—an area roughly the size of California—would depress crop and land values. Why not reclaim abandoned land in the East, they asked, land closer to the nation's major cities? Why should prospective farm families have to pay the cost of moving two or three thousand miles to deserts far removed from agricultural markets? Farm organizations such as the National Grange found a strong ally in the U.S. Department of Agriculture, which consistently opposed the national reclamation program. And many easterners within Congress feared that even though the Reclamation Act promised that reclamation would be paid for from sales of public land, and from reimbursement of the cost of the hydraulic works by the farmers who benefited, the day would come when the West demanded money from the general treasury, following the precedent of nineteenth century river and harbor bills. Another concern was that the program would benefit established farmers and private landowners in the West more than those who settled on "virgin land." Few large tracts of arable public land remained, even within the deserts of the West, so the bureau would have to make accommodations with private landowners. In short, even in 1902 support for federal reclamation was thin and brittle.[2]

The misconceptions of the bureau itself compounded the lack of widespread support for the new program. At first, Reclamation Service engineers assumed that all desert land was fertile, given enough water. So strong was this conviction that on many projects the soil was not tested until years after the project had opened. Much of that soil—20 or 30 percent on some projects—had to be abandoned, at great cost to individual farmers as well as to the nation. Then, too, Reclamation Service officials assumed that most desert land would require only one acre-foot of water a year—a supply of water sufficient to cover the land irrigated a foot deep—while most land required three to five times that amount. On many projects, farmers complained that the government could not deliver the water they needed. Another misconception was that the appetite for land within government projects would remain strong for decades to come. After all, the nation had absorbed over 400,000,000 acres of new farm land in the decades after the Civil War as the Great Plains were opened to agriculture. The Reclamation Service could not anticipate changes in technology, agriculture, and the sheer cost of farming that would make virgin land far less attractive in the twentieth century than it had been in the nineteenth. Nor could it foresee how the standard of living of those who lived in America's large cities would increase. Federal reclamation had been launched with the expectation that it would provide a subsistence to small farmers. But by the 1920s, the new consumer economy had redefined the "good life" in the United States, and farm families began to emulate the living standards of urbanites.

Let me begin by challenging the idea that, as part of the Progressive Era's conservation movement, the Reclamation Act represented the ethics of "science," or helped to create the "modern" American state. These are important arguments, foundation blocks of the "organizational synthesis" popularized by historians such as Samuel Hays and Robert Wiebe in the 1960s, and an interpretation that still has considerable appeal to historians of the United States. "The modern American conservation movement grew out of the firsthand experience of federal administrators and political leaders with problems of Western economic growth," Hays wrote in *Conservation and the Gospel of Efficiency*, "and more precisely with Western water development."[3] Like silviculture, hydrology was a new science that promised the rational, orderly use of natural resources. It also promised to promote bureaucratic planning by experts and reorder a constellation of political institutions around the executive branch of government.

Yet this interpretation fails to recognize the strong links between the Reclamation Act and nineteenth century laws and values, particularly the Homestead Act (1862). In 1800, Congress had permitted settlers and speculators to purchase public land on credit, with up to four years to pay. That law proved to be a disaster. Those who purchased the land quickly fell in arrears on their payments. Congress granted many extensions before it excused their debt completely. A century later, in the four years that preceded adoption of the Reclamation Act, most westerners favored using river and harbor appropriations, or proceeds from the sale of grazing permits or timber on the public lands, to pay for the construction of dams and canals. Using proceeds from public lands, and requiring farmers to repay construction costs, was a compromise. In a 1914 letter to Secretary of the Interior Franklin K. Lane, George H. Maxwell, the publicist most responsible for pushing the Reclamation Act through Congress, admitted: "We accepted… repayment from the land because it enabled us to get our bill through. Those who understood political conditions never believed the money would be paid back." From the beginning, federal reclamation was regarded by many westerners as what we would today call an "entitlement program." Government farmers, and the many private landowners who owned land within government projects, resisted repaying their debt to the government long before the hard times of the 1920s and 1930s hit the West.[4]

Federal reclamation looked to the past in many other ways as well. The most fateful early decision made by the Reclamation Service was to launch too many projects too soon. This typified distributional politics: no public works program could be launched that did not distribute benefits as widely as possible. The Reclamation Act required that 51 percent of the proceeds of public land sales be spent within the state or territory in which that land had been sold. Yet the Reclamation Act did not require that so many projects be launched so soon. That was a political decision made by President Theodore Roosevelt. Late in 1901 or early in 1902, Roosevelt warned against undertaking too many government projects at once:



25.1. Secretary of the Interior Franklin K. Lane.

> It would be unwise to begin by doing too much, for a great deal will doubtless be learned, both as to what can and what can not be safely attempted, by the early efforts, which must of necessity be partly experimental in character. At the very beginning the Government should make clear, beyond [any] shadow of doubt, its intention to pursue this policy on lines of the broadest public interest. No reservoir or canal should ever be built to satisfy selfish personal or local interests.[5]

Yet Roosevelt soon changed his mind. When the Reclamation Act passed Congress in June, 1902, Democrats as well as Republicans took credit for the legislation. Indeed, it was Francis G. Newlands, a maverick Congressman from Nevada but nominally a Democrat, who sponsored the bill in the House of Representatives. The Republican Party was dominant in most parts of the West, but Roosevelt expected that Arizona, New Mexico, and Oklahoma would soon join the union, and he wanted to maintain the West as a stronghold of his party. Therefore, two weeks after passage of the Reclamation Act, TR advised the Secretary of the Interior that "instead of starting on a few large [model] enterprises, I should think it would be best to divide up the work among the different States as fairly [that is, widely] as possible." Smaller projects could be completed more rapidly, insuring that the benefits of federal reclamation would be felt before TR left the White House. The greatest public works program undertaken in the history of the United States would be indelibly associated with Theodore Roosevelt and his party.[6]

Perhaps the strongest link to the past was in the attitudes Reclamation Service officials exhibited toward the farmers they served. The first director of the Reclamation Service, Frederick Haynes Newell, had never designed an irrigation system when he assumed that job. The ethics of science and efficiency did not dominate Newell's thinking, and he regarded federal reclamation as an experiment in social Darwinism. Some had to fail so that others could succeed. Newell's chief rival to head the reclamation program, Elwood Mead, deeply believed in social planning, but Newell did not. Few of the first settlers on government projects lasted

25.2. President Theodore Roosevelt.

25.3. Francis G. Newlands while senator representing Nevada.

a decade, but Newell denied that the Reclamation Bureau had any responsibility for their failure and lack of success. The fault lay with the settlers. "The characteristics of present settlers are in many respects entirely different from those of the older pioneer communities," he complained in 1912. "[T]here is not the spirit of cooperation which ruled the early pioneers." In his 1916 textbook on irrigation, written just after he left the Reclamation Service, Newell noted that more than 75 percent of the first settlers on federal irrigation projects had fled the land within a few years of entry. He concluded:

> The irrigators as a body are not only inexperienced, but many of them are disappointed in that they have expected easier things. Thus they do not always appreciate the efforts made in their behalf. There has been attracted to the locality [the arid West] a considerable number of men who have never made a success elsewhere; these attribute their failure to make good under the new conditions not to their own inability, but largely to the faults of the country or system.… He is attracted usually by glowing accounts of the relative ease of acquiring wealth in the West, and with erroneous ideas concerning the conditions to be met… There has thus arisen a class which has been called the "professional pioneer," always seeking for something a little better or for conditions where life will be easier; staying in any locality only a few months and then again seeking El Dorado.

And in 1922 Newell proclaimed that "The reasons for success or failure lie not so much in climate, soil, or markets, but rather in the character of the landowner, his experience, strength, health, and especially the 'will to win,' or possession of qualities which distinguish the pioneer." The biggest problem with federal reclamation, in Newell's mind, was that the virile rural population had gone soft. Newell's ideas—and they were shared by many of his lieutenants—were anachronistic in an age when the cost of setting up a new farm had soared and when city life looked increasingly attractive to the nation's rural residents.[7]

Another part of the organizational synthesis is the argument that conservation and federal reclamation helped to centralize power in Washington. In 1906, the publication *Forestry and Irrigation*, which largely spoke for the bureau, editorialized that "There is probably no law on the statute books which puts in the hands of a single official of government such unlimited powers of expenditure as the [Reclamation Act.]"[8] The Reclamation Act gave the secretary of the interior power to select projects, determine the size of farms, withdraw from entry the public lands needed for farms or towns, purchase or condemn existing dams and canals, approve construction contracts, and set the amount each farmer owed the government as well as operation and maintenance charges. During the administration of Theodore Roosevelt, however, most important decisions were made by the president or in the offices of the Reclamation Service. Neither the secretary of the interior nor the director of the U.S. Geological Survey, of which the service was a part until 1907, ever vetoed a project proposed by the Reclamation Service.

Most historians look at conflicts between Congress, the secretaries of the interior, and settlers on government projects as dominant themes in the Reclamation Bureau's history over the first three decades of this century. The bureau's relationship with the states has been largely ignored, in part because that relationship does not square with the pervasive view that the bureau simply imposed its will on the West. Yet after 1910 or 1911 the Reclamation Service's chronic lack of funds persuaded it to seek assistance from the states, and more often than not resistance to cooperation came from the states rather than from officials within the Reclamation Service. One of the most important amendments to the original Reclamation Act, the Warren Act of 1911, allowed the Reclamation Service to sell surplus water to owners of land outside the government projects, blurring the lines between federal and private water projects. Proponents of the legislation argued that the West's major rivers contained few ideal reservoir sites and that the Reclamation Service could often build a dam that would serve twice as much land as could be irrigated within a government project for little more money. Therefore, the Warren Act permitted the Reclamation Service to contract with private companies, water user associations, or irrigation districts to pay either for part of the dam, or part of the water stored behind the dam. In either case, since the money would be paid into the reclamation fund, providing water to private irrigation projects would produce another source of income. This law proved enormously important to the Reclamation Bureau, and by the 1950s the federal government watered nearly as much land outside its projects as within. In the Snake River Valley, for example, the Jackson Lake Dam at the head of the river provided water to privately irrigated land as far west as Twin Falls, as well as to the government's Minidoka Project near Rupert.[9]

As early as 1904 William Ellsworth Smythe, Francis G. Newlands, and other friends of federal reclamation proposed using irrigation districts to supplement the funds available to the Reclamation Service, particularly in states like California, which offered few opportunities to construct government projects on the public domain. Irrigation districts, which were institutions created by the state with the power to tax the land within their boundaries and issue bonds to pay for hydraulic works, would turn the Reclamation Service into a construction agency responsible for reducing the cost of construction and ensuring the quality of dams and canals—or so Smythe hoped. However, the Reclamation Act of 1902 gave the Interior Department no authority to build such hybrid projects, and within Congress easterners and midwesterners balked at expanding the scope of the law. Moreover, many westerners feared that federal reclamation meant federal control over their surplus water.[10]

In 1915 a Reclamation Service official drafted a plan to create a second reclamation fund exclusively to construct dams and canals within *private* irrigation projects, but nothing came of it.[11] World War I offered the best opportunity for cooperation. At the end of the war, in anticipation of post-war unemployment, Secretary of the Interior Lane proposed a massive program to put 50,000 returning veterans to work clearing stumps, leveling land, laying out townsites, and building houses, barns, and roads. His bill proposed a partnership between the states and central government. The states could donate unimproved land to the federal government, leaving reclamation and settlement to the Reclamation Bureau, or they could pay at least one-fourth of the entire cost, from purchasing the land to building houses, barns and roads. The legislation required the states to create soldier settlement boards to screen applicants and to administer the completed projects. The states would also provide returning soldiers with agricultural training, sharing that cost with the federal government. Particularly after crop and land prices began to fall in 1919, the Lane legislation fell victim to the post-war economic slump and the absence of grassroots support for reclamation or planned settlements.[12]

Throughout the 1920s, the Reclamation Bureau encouraged the western states to play a larger role in federal reclamation, but the states refused. State politicians argued that providing irrigated land was a national responsibility, that there was no demand for more irrigated land, that hybrid projects would threaten state control over water rights, and that constitutional debt limitations prevented the states from buying land, preparing it for cultivation, or constructing irrigation and drainage works. Oddly enough, hybrid projects had the greatest appeal in the state's rights South, not the West. Since the early years of federal reclamation, the Reclamation Bureau had wanted to extend its operations to include swamp and cutover, as well as arid lands. In 1918 Secretary of the Interior Franklin K. Lane, with the encouragement of the Reclamation Service, persuaded Congress to appropriate $100,000 to study the reclamation of wastelands in the South. President Woodrow Wilson heartily endorsed the plan. Additional expenditures followed in 1926, 1927, and 1928. In 1926 a committee consisting of representatives from the federal and state governments, along with private interests, selected four potential project sites. Congress, however, balked at opening new farmland during a time of agricultural depression.[13]

Congressional appropriations for public works increased dramatically during the 1930s, and as the bureau's budget soared its appeals for state aid all but disappeared. Power did increase in Washington as a result of the high dam projects undertaken in the 1930s, but state and local institutions of water management also proliferated. Boulder Dam is a case in point. The Metropolitan Water District (MWD), formed to carry water and power to Los Angeles from the Colorado River, used the irrigation district—a state and local institution—as a model. Even though the Reclamation Bureau operated Parker Dam—the origin of the aqueduct from the Colorado River to Los Angeles—it used funds provided by the MWD. The MWD was also a bridge between the federal government and private utility companies. Apparently, the bureau got the idea of using power revenue to finance Boulder Dam from William Mulholland and E. F. Scattergood, the latter of whom had designed and supervised the water and power systems of Los Angeles. Homer Hamlin, who served as Los Angeles City Engineer during the 1920s, was one of the first to conceive of a multiple-purpose dam in Boulder or Black Canyon, and in 1929 F. E. Weymouth, who had been chief engineer of the Reclamation Bureau under A. P. Davis, was chosen to head the MWD. Weymouth hired many former employees of the Reclamation Bureau who had left government service during the Harding scandals of the 1920s. Here again, the line between federal, state, and private institutions is very blurry.[14]

Thus far I've focused on federal reclamation in the first few decades of the twentieth century. The conventional wisdom among professional historians is that Boulder Dam and the other great dam projects conceived during the 1930s, including Grand Coulee and Shasta, resurrected the bureau's reputation at the expense of the family farm and the rural West. During the 1930s, this interpretation runs, the bureau turned its attention to western cities, and World War II increased the importance of the urban West. But that interpretation is at best misleading. The bureau did much more than build high dams during the 1930s. By 1941 there were forty-six Bureau of Reclamation irrigation projects in the West and another twenty-seven under construction. That was more than double the number of projects in 1920, and preliminary surveys had been completed on an additional forty-eight projects. There was a surprising growth in irrigated land after 1935. From 1920 to 1935 the amount of land irrigated by the bureau increased only modestly—from 1.2 million acres to 1.6 million. By the end of World War II, however, the bureau irrigated twice as much land within the government projects as in 1920.[15]

The Reclamation Bureau had good reason to publicize the glamorous high dams more than its irrigation projects because the chronic and intractable problems it had encountered during the Progressive Era remained. Farmers everywhere suffered from the depression of the 1930s, but nowhere were times harder than on most of the government projects. There were big differences between such successful projects as the Yakima and Salt River and those in Montana. But a 1940 survey of the projects settled between 1931 and 1940 revealed desperate poverty. Sixty percent of the original settlers on the Vale-Owyhee Project in eastern Oregon had left their farms, or leased their land to others. Seventy-five percent of the homes on that project cost less than $350, and half had two rooms or less—even though the average-size farm family numbered five. Forty percent of those Oregon families could not afford to dig a well, so they carried their drinking water five miles or more, and many common diseases, including typhoid fever, went untreated because the settlers were too poor to hire a doctor. On the other hand, many conditions remained beyond the Reclamation Bureau's control. A 1936 study of 136 farmers who had settled on the Klamath Project along the California-Oregon border in 1927 revealed that most who left their farms had homesteaded for speculative reasons, fully expecting to sell out, or they were lured away by the city, or pushed away by old age, illness, or divorce. Not all farmers who abandoned government projects did so because they had "failed," or because they lacked experience or capital.[16]

Nevertheless, for all its problems, the dream of the family farm remained strong in the years following World War II. Most historians who have written about the bureau after the war have failed to recognize the idealism that animated its leaders, at least from 1945 to 1953. In those years, the Interior Department was filled with New Dealers who wanted to build a better world, including Harold Ickes, Abe Fortas, Oscar Chapman, Michael Straus, Arthur Goldschmidt, and Stephen Rauschenbush. Many smaller irrigation projects were designed as much to provide supplemental water outside government projects—to farmers who irrigated but suffered from inadequate water supplies—as to open new land to cultivation. However, the Interior Department hoped to settle 45,000 returning veterans and their families on the government projects—the biggest of which would irrigate one million acres of "virgin land" within the Columbia Basin—opening nearly as many new farms as had been settled from 1902 to 1945.[17]

But the bureau's objectives were not always consistent, and jobs, power, and water for cities often worked at cross purposes with the homestead ideal. At the end of the war, as during the 1930s, the paramount concern was jobs. Officials in the Interior Department concluded that a permanent increase in public works spending would not just prevent the United States from lapsing back into the depression as the nation converted to a peacetime economy, but would provide sustained economic growth and serve as an antidote to the boom and bust cycles inherent in capitalism. Secretary of the Interior Harold Ickes predicted that 14,500,000 would lose their jobs at the end of the war. Such agencies as the Reclamation Bureau, Corps of Engineers, Forest Service, and Soil Conservation

Service had plans for plenty of worthy projects that they could begin within three months of the war's end. In April 1945 the bureau proposed to Congress 415 irrigation and multiple-purpose water projects in seventeen western states. State-by-state the number varied, from a modest five projects in Washington to ninety-six in Montana, and from 101,000 acres in Utah to 2.2 million acres in California. These projects were expected to add 11,000,000 acres of new land to cultivation and provide supplemental water to nearly as many acres of old land. That was twice the amount of land irrigated in 1945. Secretary of the Interior Harold Ickes—who had headed the Public Works Administration during the New Deal—estimated that the post-war work would provide one year's employment for at least 1.5 million returning veterans.[18] The bureau's budget went from 50 million in 1946, to 120 million in 1947, to 200 million in 1948, to over 300 million in 1950. Gone was the idea that dams and canals should be built using the proceeds from land sales or oil leases. Reclamation had become a symbol of national economic growth, and a method to avoid future depressions.[19]


25.4. Secretary of the Interior Oscar L. Chapman.

But federal reclamation meant much more than jobs. Interior Department officials argued that federal reclamation could help win the Cold War, just as the power it produced had helped to win World War II. Nevertheless, Secretary of the Interior Oscar Chapman feared, in his words, that the United States ran

> a grave danger of saddling ourselves with a straight military economy. If that happens we shall find that the old economic freedoms which give American life so much of its richness have disappeared. We shall be supporting an enormous budget, with a huge proportion for defense, and yet find ourselves poor as church mice where our great basic programs are involved. Yet those programs—irrigation and land development projects, proper care for our national park system, intelligent development of our river systems, and so on—are the things which make the difference between the rich cultural society we are used to and a pinched, Spartan existence which is inevitable under a straight military economy. For instance, we are nearing the ceiling on the growth and stability that can be achieved by our Western States without increased, broad-scale irrigation and related water resources development.[20]

Since 1920 a dramatic demographic change had occurred within the West. Parts of the region lost population during the 1930s, but overall the eleven states of the Far West gained 60 percent as compared to a 24 percent increase in the entire population of the United States. During World War II, the difference was even more pronounced. The population of the Far West increased by nearly 18 percent while that of the nation as a whole increased less than 1 percent. Much of that increase occurred within California, Oregon, and Washington, and those states continued to grow at a rapid rate after the war. From 1940 to 1950, their population increased at a rate three times faster than the nation as a whole.[21]

The West's population boom promised to prevent the Reclamation Bureau from returning to the dark years of the 1920s. But most of the region's population growth during World War II was due to war industries, and officials within Interior feared that as those industries disappeared the West would return to an extractive economy, one that attracted raw material producing companies that could profit the cheap power no longer used in such defense industries as ship or plane building. Arthur Goldschmidt, who headed the Interior Department's Division of Power at the end of the war, thought that the region held a disproportionate number of "rural, low income groups." People who lived at or near the subsistence level, in his judgment, "do not contribute to the national welfare or to a healthy economy in any region." He wanted to use cheap hydroelectric power to decentralize industry in the United States so that every part of the nation, in his words, contained a "balanced economy, a combination of agriculture and industry based upon the natural resources of the region itself.... Colonies are out-of-date as mere sources of raw materials and as markets. They are economic anachronisms." During World War II, many British economists and sociologists traveled to the United States to inspect the Tennessee Valley Authority. One visitor, Julian Huxley, likened the American South and West to the colonial problem of the British in Nigeria.[22]

Arthur Goldschmidt called for large-scale planning in the West. At the end of the war, however, powerful opposition surfaced within the West to expanding the "TVA-idea" or river basin planning. While the Reclamation Bureau often sold large water projects as part of the defense effort during the Cold War, they also deepened suspicions about planning and "big government." The 1948 Republican platform called for sharp reductions in foreign and domestic spending, and it opposed the creation of "all-powerful Federal socialistic valley authorities." By 1952 the New Deal had become "creeping Socialism" to conservatives within the Republican Party, and planning had become associated with Communism. In September 1950 on the floor of the United States Senate, Senator William Knowland of California charged that Secretary of the Interior Oscar Chapman, Commissioner of Reclamation Michael Straus, and Assistant Secretary of the Interior William Warne, "have a scarlet left-of-left record that extends back many years, even to the early years of the New Deal." As early as 1938 Knowland charged, Chapman belonged to the American League Against War and Fascism. "This outfit," the senator proclaimed, "has been officially branded as a simon-pure and unchallenged transmission belt of the Communist Party in America." Another employee of the Interior Department, H. Stephen Rauschenbush, was, according to Knowland, "probably the chief prophet of modern American Marxism."[23]

Senator Knowland notwithstanding, no federal bureau had greater prominence in the West during the 1950s than the Reclamation Bureau, and it is interesting to consider why such a powerful agency faded from the limelight so rapidly during the last few decades. Several explanations have been offered, each of which has merit. The environmental movement certainly played a part. In the post-war years, many members of the Sierra Club, Audubon, and other environmental groups considered themselves conservationists. Their battle was over where dams should be located, not the construction of dams per se. Dams should not flood land in national parks or national monuments, nor should they imperil the West's scenic wonders. Some historians think that the battle against dams in Echo Park, the Grand Canyon, Glen Canyon and other parts of the West played a large part in creating the modern environmental movement.[24]

Later, in the 1960s and after, environmentalists began to oppose *all* dams. On some rivers, particularly the Columbia and Snake, massive numbers of fish perished because dams depleted oxygen, reduced water temperatures upstream in reservoirs, increased temperatures in the sluggish water downstream, and limited the ability of rivers to dilute sewage and other contaminants in the water. At the least, dams contributed to the prolific growth of algae, at the most to eutrophication. Water projects also had a profound effect on the habitat of terrestrial animals, contributed to the buildup of alkali, salts and other dangerous elements in the soil (including selenium) and to groundwater depletion. Yet the environmental movement did not kill dam-building in the West. More significant than opposition to water projects from groups outside government was opposition to new dams and canals from federal agencies concerned with water quality and wildlife habitat. In the 1970s, R. L. Coughlin of the Federal Water Quality Administration publicly charged that the Bureau of Reclamation was the prime source of water pollution in the Far West. While the U.S. Department of Agriculture and the Corps of Engineers had been strong critics of the Reclamation Bureau during the early decades of the twentieth century, by the 1970s many other agencies opposed the bureau, notably the Fish and Wildlife Service and the Environmental Protection Agency. In the battle over the Garrison Diversion Unit in North Dakota, they were joined by the President's Council on Environmental Quality, the State Department, the Office of Management and Budget, and the General Accounting Office.[25]

Marc Reisner has provided another answer to the question of what happened to federal reclamation. To Reisner, the collapse of the Teton Dam in 1976, built on a tributary of the Snake River in 1975 despite warnings from U.S. Geological Survey engineers of unstable rock and earthquake hazards in the region, symbolized the end of the dam-building era. When sections of that structure dissolved and washed away, eleven people died, 15,000 were left homeless, 13,000 cattle drowned, the flood stripped topsoil from 100,000 acres of prime farmland, and property damages reached one billion dollars. The Reclamation Bureau had built 240 earth fill dams west of the Mississippi, and this one was the first to fail. A commission of nine engineers spent six months investigating the causes of the disaster and concluded that the bureau had been at fault for using a highly erodible soil for the dam's core and for failing to seal the structure to the rock at either end properly. The wisdom and justice of building dams had been questioned many times before 1976, but seldom had the engineering skills and judgment of the Reclamation Bureau been called into question.[26]

The Teton Dam rested on an earthquake fault, which meant that bedrock was far below the surface debris and sediment. Dam safety was a serious matter because many streams had been plugged so many times that the collapse of one dam would take out a series of structures, producing massive floods, extensive damage, and thousands of deaths. The entire Columbia River had been dammed, except for a fifty-mile stretch near the Hanford nuclear power plant, and in California every major stream save one had been dammed at least once. If Glen Canyon Dam gave way, for example, the resulting flood would destroy Boulder and Davis dams as well—with devastating results to southern California. To be sure, the Teton Dam collapse did not persuade Congress to reexamine wasteful expenditures on public works. If it had, President Jimmy Carter would not have compiled his famous "hit list" of water projects in 1977. Yet this episode did demonstrate a fundamental hydrologic truth: since the deep canyons of the West had all been dammed, new projects had to be constructed at far less desirable sites. And safety was not the only issue. Once the deep canyons were gone, new dams threatened to flood as much farmland as they irrigated. Reisner concluded:

> As Fontenelle [on the Green River in southwestern Wyoming] was an inferior site compared with Flaming Gorge, as Glen Canyon was inferior to Hoover, as Auburn was vastly inferior to Shasta (but six times more expensive, even allowing for inflation) the Bureau was now being forced to build on sites it had rejected forty, fifty, or sixty years earlier. It was building on them because while the ideal damsites had rapidly disappeared, the demand for new projects had not.

The Teton Dam failure raised questions and doubts about many of the projects the Bureau had on the drawing boards, particularly Auburn Dam, which had been authorized for the North and Middle forks of the American River thirty miles north of Sacramento. Less than a year before the collapse of Teton Dam, a 5.9 earthquake hit near Oroville on a seismic fault thought to be dormant. Bureau of Reclamation studies required by the State of California estimated that complete failure of a dam at the Auburn site would flood 750,000 people, inundate the state capital, and close five military bases. Even though more than 200 million dollars had been spent on the project, work was stopped and President Carter added the Auburn Dam to his list of rejected projects.[27]

It is wrong to suggest that all, or even many, of the dams built by the Bureau of Reclamation in the 1960s and 1970s were unsafe. It is not wrong, however, to suggest that the cost of those dams greatly exceeded their economic benefits and that bureau personnel *consciously* doctored the figures to make each dam look as attractive as possible. The Teton Dam was not just built in a bad place. Its cost far outweighed its benefits, and like many projects built during the 1960s and 1970s, it benefited relatively few water users. When the bureau first proposed the project, it used an interest rate of 3¼ percent in calculating benefits even though the rate that prevailed when work began was 5⅜ percent. Yet even at the lower rate, the benefit to cost ratio was less than one—meaning that taxpayers spent more money building the project than it could return to water users.[28]

The Reclamation Bureau manipulated figures in many ways, as did the Corps of Engineers. Not surprisingly, most projects cost far more than original estimates. To reduce construction costs on paper, the bureau used prices that had prevailed five or ten years earlier. It also added "write off" benefits not recognized during the pre-World War II years, such as recreation, habitat improvement, or pollution abatement. Then, too, the bureau often stated power revenue from dams as constant, even though revenue from that source generally declined over the life of the dam. In 1964 Senator William Proxmire of Wisconsin examined 380 pending water projects in the United States, some of them Corps of Engineers projects. He found that more than half had benefit to cost ratios of less than two, and he noted that "I have consistently found that projects with an alleged benefit-cost ratio of less than 2 to 1 provide returns less than their cost. Costs of public works are invariably much greater than originally estimated because of poor estimates and inflationary pressures."[29]

The most common method of padding benefits, however, was to use an artificially low interest rate. For most of the 1960s the bureau used 3⅛ percent, which Congress had set as a benchmark in 1962. However, the actual rate at which the government borrowed money in the middle to late 1960s was closer to five percent than three, and the difference between the two figures became enormous when a project was amortized over fifty or sixty years. As Richard Berkman and Kip Viscusi noted in the influential Ralph Nader study of the bureau, by 1969 the cost of all the projects constructed by the bureau ran nearly three times the original estimates.[30] Nevertheless, despite creative accounting techniques, by the 1960s many large projects still had a cost to benefit ratio of less than one. The Garrison Diversion Project in North Dakota and the Central Arizona Project were glaring examples.[31]

One reason that damage to the environment did not play a larger role in bringing the high dam age to an end was that environmental groups attracted more public support by attacking waste and subsidies than by trying to protect nature. The economist Paul Taylor estimated that within the Central Valley Project the federal subsidy amounted to $92,320 for a farm 160 acres in size, and in parts of the San Joaquin Valley many farms were 2,000 to 3,000 acres in size. The

Westlands Water District was formed in 1952. The San Luis Dam, part of the Central Valley Project, was authorized by Congress in 1960 and completed in 1968, but the Westlands project served almost exclusively corporate landowners, including the Southern Pacific Railroad and Standard Oil Company. According to Marc Reisner, district farmers paid only one tenth of the actual cost of the water they used, and 70 percent of the profit they received from crops came from federal water subsidies.[32]

Federal subsidies to land served by the Bureau of Reclamation increased dramatically from 1902 to 1968, tipping the scale of benefits from national water projects away from the East and upper Midwest. Federal reclamation had been sold to Congress partly as compensation to the West for river and harbor bills that mainly benefited states around the Great Lakes and along the eastern seaboard. But the historian Tim Palmer estimates that from 1950 to 1976, the Northeast received only six percent of the money spent on water projects by the Corps of Engineers and Bureau of Reclamation while the South received 28 percent and the West about half. In effect, residents of the East and Midwest subsidized the growth of cities in the West at the expense of those in the northeast, as crops grown in California and Arizona received greater per acre subsidies than crops raised in other parts of the nation.[33]

Yet the waste of bureau projects, the cost overruns, the environmental damage, the disproportionate benefits to the West and South, and the bureau's arrogance in responding to criticism do not alone explain why the era of dam-building came to an end in the 1970s. To some extent, of course, the Reclamation Bureau suffered from the deep public cynicism produced by the Vietnam War and Watergate. Few institutions of government escaped the crisis in moral authority. Still, the bureau's fall from grace was more significant because it had been built on such high ideals. The Corps of Engineers had never promised to transform society, but the Reclamation Bureau had inspired grand dreams—not just the dream of conquering forbidding deserts but of building a new society there. Often lost in the day-by-day operations of the bureau, these ideals remained the soul of federal reclamation.

Homemaking was the bureau's only mission that appealed to citizens outside the West. As long as the bureau paid homage to the family farm ideal, many of its blunders and failures were forgiven. In many parts of the West, farm size had increased dramatically during the agricultural depression that extended from 1920 to 1940. In Montana the average leaped from 480 acres to 821 acres, and in Wyoming from 749 to 1,866 acres. Tenancy also increased. In 1946, Commissioner of Reclamation Michael Straus promised that within five years the bureau would have opened more than 45,000 family-sized farms on 4,000,000 acres.[34] The bureau's magazine, *Reclamation Era*, promised that the bureau would provide as many homes to returning veterans and their families as it had created on all its projects during the four decades prior to World War II. The first farms would be on the Klamath, Yakima, Minidoka, and Shoshone projects, but the single largest project would be in the Columbia River Basin, where the bureau hoped to have at least 400,000 acres ready for settlement by 1950 or 1951. "The ultimate objective of the Bureau of Reclamation and its staff," *Reclamation Era* reported, "is to develop the West through the creation of permanent family farms on Federal Reclamation projects."[35]

By the end of the 1950s, however, it was clear that the Columbia Basin Project would not resurrect the bureau's mission to create rural homes in the West. At the end of World War II, the Reclamation Bureau had hoped to create 10,000 to 20,000 new farms in the Columbia Basin, but only 2,300 had been opened by 1958. Nor was that land settled by young men looking for a fresh start; the median age of those who took up farms in the Columbia Basin Project was 40. Nor did it provide homes for those who had abandoned farms on the Great Plains; most settlers came from Washington or Utah. These were not rural poor. Over half had family assets of $20,000 or more, and one-third did not live on their farms. In 1968 the Reclamation Bureau turned the project over to three irrigation districts. According to the historian Paul Pitzer, had the bureau finished the project, the results would have been even worse. "It would be a collection of family farms ranging from forty to eighty acres, none of them capable of supplying their owners with a satisfactory living. The area would be a rural slum. It is for the best that this aspect of the project failed."[36]

It was not just that the bureau failed to create new family farms; it also failed to enforce older restrictions on farm size. By the 1970s the hallowed 160-acre limitation on the cheap water each farmer could secure from the bureau became a mockery. From the beginning of its life, the Reclamation Bureau had little choice but to accommodate to large private landowners within the boundaries of its projects. Those landowners consistently opposed bureau efforts to control the sale of their surplus or "excess" land, and the bureau lacked both the staff and the inclination to monitor the sale or title transfers to private lands within projects. The Interior Department gave private landowners plenty of warning before it acted, and sometimes it did not act at all. A married couple could acquire water for 320 acres, and by signing a contract with the Secretary of the Interior to dispose of surplus land, any person who owned more than 160 acres was given cheap water to irrigate *all* the land for a decade or more before he was required to sell it. Moreover, if landowners paid all the construction charges imposed on the excess lands in advance, the Interior Department usually permitted them to sell that land at any price they wished.[37]

The 160-acre limitation had never been enforced, but before the 1930s the vast majority of farms within the reclamation projects—well over 90 percent—were that size or smaller. Nevertheless, new projects undertaken by the bureau in the 1930s and after catered more and more to large landowners, particularly in California, and they were the projects that captured the public imagination. During the 1930s the bureau, with congressional approval, waived the 160-acre restriction on several large projects, including the Central Valley Project (CVP), Imperial Valley Project, and the Colorado-Big Thompson Project. The CVP was the biggest battleground, in part because the Corps of Engineers was ready to build some of the reservoirs within that project as flood control structures that did not require repayment, and that was an attractive option to large farmers. In the south San Joaquin Valley, 700,000 acres were divided into 600 farms and 800,000 acres were divided into 12,300 small holdings. But that pattern of land distribution changed dramatically after World War II. By the time Congress raised the 160-acre limitation to 960 acres in 1982, and waived many other restrictions on large landowners, the family farm seemed more and more of an anachronism. Even more of an anachronism was the notion that federal reclamation should attempt to reform American society and distribute wealth as widely as possible. As Donald Worster has noted, the 1982 law tacitly acknowledged that the economic marketplace should decide the size of farms and the distribution of wealth, not government.[38]

Although the Reclamation Bureau continued to serve many small farms, particularly outside California, the 1982 law convinced many critics of the bureau that it had abandoned its original mission and sold out to agribusiness. Even more serious, by the 1980s the Reclamation Bureau had lost its reputation as the exemplar of new technology. During the 1930s Boulder Dam stood as a monument to human ingenuity, and the dams the bureau built were seen as thoroughly modern—the latest in the technology of managing nature. Boulder Dam was more than a piece of concrete. Among other things it symbolized a powerful idea that had been around since the Progressive Era, the concept of "multiple use." The biggest dams built by the bureau, including Boulder, Shasta, and Grand Coulee all provided flood control and power, as well as irrigation and water for towns and cities. But those were exceptional, not typical dams. The West contained few places to build such dams, which is why small dams were so much more common than large ones. Not only were the sites for large dams limited, but most dams were constructed to serve a particular purpose. It was not easy to use a dam designed mainly to generate power for flood control or irrigation as well.

During the 1930s part of the appeal of high dams was that they would last as long as the pyramids. But after World War II that very "permanence" became a liability. One of the strongest arguments against building dams had always been that it made more sense to move people to water than water to people. Far more water was lost in transit, through seepage and evaporation, than was delivered at the end of the pipeline or ditch. The Cold War raised new concerns. Dams contributed to the concentration of people in large cities, making those cities more attractive targets, and while high dams were very strong, they could not resist a direct hit from a thermonuclear bomb. Many of the West's cities could be as easily paralyzed by disrupting their water and power systems, or by the floods that would result from bringing down one of these dams, as from the detonation of a thermonuclear bomb within the city itself. Even more important was the promise of nuclear power. As a writer in the *Sierra Club Bulletin* observed in 1948,

> we may live to see the regulated use of atomic power a few years from now. If we learn to use it properly… we won't need to harness all the rivers of the land.… At least we might wait a little while and see what happens before we drown our greatest canyons and destroy forever so much natural beauty.

David Brower suggested that atomic energy might make high dams obsolete long before they filled with silt. "Is it not time to reverse the trend of centralization—of concentrating tremendously remunerative strategic targets: of building larger projects to enable more people to live in less space[?]"[39] Silt was not just something that clogged dams; it was a symptom of bad land management. "[T]he real management of rivers begins in the headwaters and on the hilltops... through good land management," a writer observed in 1950 in the *Sierra Club Bulletin*. Yet neither the Corps of Engineers nor the Bureau of Reclamation cooperated with the Soil Conservation Service or the Forest Service in their attempts to fight soil erosion. In the middle of the 1960s, during debate over the proposed Rampart Dam in Alaska, a Corps of Engineers structure that would have created a reservoir larger than Lake Erie, a writer in *Living Wilderness* pointed out that any one of five atomic generators produced by the General Electric Company could produce as much power as the proposed hydroelectric plants at Rampart Dam at half the installation cost. And, she estimated, the price of the power to consumers would be no higher.[40]

But most important was that hydroelectric power no longer seemed as attractive after World War II as it had during the 1920s or 1930s. California was a prime example. In 1910 falling water produced most of the electricity used in the state. Steam power was used mainly to meet peak demands. But the increasing efficiency of steam generators, the falling prices of petroleum and natural gas, and the fact that such plants could be located near large cities, made steam turbines increasingly attractive. In 1920 hydroelectric power constituted 37 percent of the power generated within the United States. That figure fell to 33 percent in 1940, and despite the large hydroelectric plants opened during World War II, only 36 percent of the nation's power came from falling water in 1945.[41]

New technology also reduced the need to expand the supply of water for irrigation. Insecticides, pesticides, and sophisticated farm machinery permitted farmers to raise much more food and fiber on the same land, irrigated or not. Leveling land with lasers, lining canals with concrete, delivering water directly to the roots of plants through underground pipes, utilizing computers to determine exactly the amount of water needed when it was needed in different soils, and raising plants that required less water were just a few of the changes that permitted farmers to stretch their water supplies. Conservation promised to free up a large part of the West's water. And as the cost of irrigating land rose, it made little sense to build new dams and canals.[42]

In retrospect, President Jimmy Carter's famous "hit list" of water projects seems far less significant than it did at the time. Dams had been under fire throughout the 1970s, and many critics of western water policy argued that there was no need to open any additional land to irrigation. On February 21, 1977, Carter released a revised version of the 1977-1978 budget prepared by Gerald Ford's staff. At a time of growing budget deficits and inflation, Carter wanted to balance the budget, and eliminating wasteful spending would help. He deleted nineteen water projects that he deemed improvident, unnecessary, or damaging to the environment. He also launched a review of 320 projects already authorized by Congress. Even such staunch environmentalists as representatives Moe Udall of Arizona and Gary Hart of Colorado came out against the cuts. Initially, environmental organizations strongly supported the president in the hope that Carter would abandon such projects as the Auburn Dam in California and the Garrison Diversion Project in North Dakota, but that support dissipated when—under strong pressure from Congress—Carter compromised so that only nine projects were eliminated. His support for raising the 160-acre limitation to 1,260 acres and for continuing the subsidies to the Westlands Irrigation District also dismayed environmental groups.[43]

The cuts in spending on water projects were more apparent than real. In 1980 Carter approved four billion dollars for water projects, though relatively few of those projects were located within the West. On the advice of his chief economic adviser, David Stockman, and with the support of such disparate groups as the American Tax Reduction Movement, the National Taxpayers Union, Common Cause, the Americans for Democratic Action, and the League of Women Voters, President Ronald Reagan went considerably beyond Carter. Reagan reduced spending on water projects and signed the first bill in American history to "deauthorize" water projects—eight projects that would have cost 2.5 billion dollars. Even more important, Reagan added the requirement that those who benefited from new water projects share in paying for them. Since few water users were willing to use their own money to help pay for water projects, this—and the "stagflation" and deficits that characterized the Carter and Reagan years—did more to end the dam-building era than anything else. No new major Bureau of Reclamation projects were authorized during the 1980s or 1990s. In the 1970s and after, the greatest expansion of irrigation was on the Great Plains, where farmers mined underground water far faster than it could be returned by nature to the aquifers. Nebraska irrigated less than one million acres in 1959, but seven million acres in 1980.[44]

By way of conclusion, what has the experiment in reclamation meant to the West and the nation? Most professional historians have regarded federal reclamation as a disaster, and there is plenty of evidence to support that conclusion. During its first few decades of life, the Reclamation Bureau did not succeed in placing "surplus" human beings on surplus land, it did not succeed in reforming rural institutions in the West, it did not succeed in curbing land speculation, and it did not succeed in producing a more virtuous society. By the 1930s only two or three million acres had been irrigated by the federal government, a far cry from the 30 to 100 million acres promised by various proponents of federal reclamation in 1902. The bureau became a much more popular institution within the West after World War II, but by the 1960s it would be blamed for encouraging rampant urban growth, for squandering tax dollars, for deceiving the public, and for being the region's biggest polluter.

That said, the contribution of the bureau to the West depends on one's perspective. Until the last two decades, most appraisals of federal reclamation focused on economic benefits. In 1919, encouraged by the agricultural boom of World War I, Arthur Powell Davis, then director of the Reclamation Bureau, stated flatly that "national reclamation has amply justified all [that] its exponents declared for it [in 1902]." He estimated that the 122 million dollars spent on federal reclamation had generated 550 million in new wealth. Within the federal projects land that had sold for five or ten dollars an acre in 1902 fetched as much as $200 an acre, and 600,000 westerners lived on or near a government project. In fiscal year 1920 the crops raised on the Salt River Project returned more than twice the cost of constructing that project. To be sure, the poorest states in the West, such as Nevada and Arizona, benefited more than the wealthiest. For example, the population of Phoenix increased more than 400 percent from 1905 to 1917, and much of that growth derived from the Salt River Project. In 1920 as in 1980, the farms and cities of the West were much more closely related than most historians have recognized.[45]

Historians have rarely considered what federal reclamation can teach us about government.[46] Yet there are powerful lessons in the bureau's story. First, the bureau suffered from a split personality from the beginning of its life. It could not reconcile the dream of the autonomous family farm with the goal of promoting regional economic development, as Boulder Dam demonstrates. Repeatedly, it was forced to choose between the two and in the end it did far more to shore up the status quo than to reform western society. Second, as a recent study by the political scientist Daniel Carpenter reminds us, the personalities and vision—or lack of vision—of bureau chiefs matters for as much or more than "bureaucratic culture."[47] The first head of the Reclamation Service, Frederick Haynes Newell, may have been a fine engineer, but he was also blinded by a nineteenth century vision of agriculture that was anachronistic by 1902. Elwood Mead, Newell's chief rival to head the new program, had blind spots of his own, but there is little doubt that from 1902 to 1924 the bureau would have pushed a very different agenda in Congress had Mead been responsible for the program. Third, federal reclamation exemplifies federalism more than the expanding power of the central government. In the United States, power can flow two ways simultaneously. The powers of state and local institutions often increase as federal agencies become more powerful in Washington. As one political scientist has put it, our system of government is more a marble cake than a layer cake. It has to be considered in its entirely. From the beginning of its life, the Reclamation Bureau was forced to accommodate itself to local interests and local institutions. We need to pay as much attention to how the bureau deferred and cooperated with state and local institutions of government, and attempted to fashion new institutions of government, as with how it tried to compete and dominate. Finally, federal reclamation demonstrates the power of sectionalism—within the West as well as the United States. The leaders of the Reclamation Bureau attempted to avoid the pitfalls of public works in the nineteenth century, but Americans have always expected the benefits of government to be spread as widely as possible. In 1902 that meant that 51 percent of the proceeds from the sale of public lands should remain within the state or territory where that land was located, and that decision had dire consequences for federal reclamation. And it is interesting to note that when Jimmy Carter issued his "hit list," he received the strongest opposition from Utah, Wyoming, Colorado, and Arizona, whose political representatives thought that California had received far more than its fair share of federal water appropriations. Whether the water projects they voted for were wasteful or inefficient was beside the point. They wanted to catch up with California by capturing a share of the Colorado River for upstream interests.

It is important to note that the Bureau of Reclamation is still a very important federal agency. The masthead of its website announces that the bureau's mission is "Managing Water in the American West," not constructing water projects. The brief history tells us that the bureau has created "more than 600 dams and reservoirs including Hoover Dam on the Colorado River and Grand Coulee on the Columbia River." Today the bureau supervises or oversees the distribution of water to more than 31,000,000 urban and rural residents in the West, including one-fifth of the region's irrigation farmers, and, we are told, that land produces 60 percent of the nation's vegetables. It is the "Largest wholesaler of water in the country," and the second largest producer of hydroelectric power in the West, after the Corps of Engineers. How times have changed is reflected in the concluding paragraph in the "What We Do" section of the website:

> Today, Reclamation is a contemporary water management agency with a Strategic Plan outlining numerous programs, initiatives and activities that will help the Western States, Native American Tribes and others meet new water needs and balance the multitude of competing uses of water in the West. Our mission is to assist in meeting the increasing water demands of the West while protecting the environment and the public's investment in these structures. We place great emphasis on fulfilling our water delivery obligations, water conservation, water recycling and reuse, and developing partnerships with our customers, states, and Indian Tribes, and in finding ways to bring together the variety of interests to address the competing needs for our limited water resources.

The historian can only smile at those words, both because the mission of the bureau has changed so dramatically over the last few decades, and because the bureau has come back from its deathbed before, particularly during the 1930s. If an agency that generated so much conflict over water in the past is now the region's negotiator and peacemaker, this surely is a brave new world.[48]

Donald J. Pisani is professor of history at the University of Oklahoma and holds the Merrick Chair of Western American History there. He has published numerous books and articles, many of which are closely related to the history of Reclamation, e.g.: "Conflict Over Conservation: The Reclamation Service and the Tahoe Contract," *The Western Historical Quarterly* 10 (April 1979), 167-90; "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *The Western Historical Quarterly,* Volume 18, Number 1 (January 1987), pp. 15-38; "Federal Reclamation and Water Rights in Nevada," *Agricultural History* 51 (July 1977), 540-58; "Forests and Reclamation, 1891-1911," *Forest and Conservation History* 37 (April 1993), 68; *From the Family Farm to Agribusiness: The Irrigation Crusade in California and the West, 1850-1931* (Berkeley, Los Angeles, London: University of California Press, 1984); "George Maxwell, the Railroads, and American Land Policy, 1899-1904," *Pacific Historical Review* 63 (May 1994), 177-202; *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902* (Albuquerque: University of New Mexico Press, 1992); *Water and American Government: The Reclamation Bureau, National Water Policy, and the West, 1902-1935* (Berkeley and Los Angeles: University of California Press, 2002); *Water, Land, and Law in the West* (Lawrence: University of Kansas Press, 1996). A version of this paper was presented at the annual meeting of the Organization of American Historians in April 2002.

Endnotes

1. The quotes are as reprinted in Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902* (Albuquerque: University of New Mexico Press, 1992): 319-20.
2. On the arguments for and against federal reclamation see Pisani, *To Reclaim a Divided West*, 298-319.
3. Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Cambridge: Harvard University Press, 1959): 5. Among other notable contributions to the organizational synthesis, see Robert Wiebe, *The Search for Order* (New York: Hill & Wang, 1967) and James Weinstein, *The Corporate Ideal in the Liberal State, 1900-1918* (Boston: Beacon Press, 1968).
4. George H. Maxwell to Franklin K. Lane, March 23, 1914, Francis G. Newlands Collection, Box 45, Folder 467, Sterling Library, Yale University.
5. The Roosevelt quote is as reprinted in *The U.S. Reclamation Service: Its History, Activities, and Organization* (New York: D. Appleton and Co., 1919), 19.
6. Theodore Roosevelt to Ethan Allan Hitchcock, July 2, 1902, Theodore Roosevelt Papers, Library of Congress, Washington, D.C. Also see Hitchcock to Charles D. Walcott, June 18, 1902, and Hitchcock to Roosevelt, July 9, 1902, Records Group 48, Records of the Department of the Interior, Entry 195, Hitchcock Letterbooks, National Archives, College Park, Maryland.
7. *Eleventh Annual Report of the Reclamation Service, 1911-1912* (Washington, D.C.: Government Printing Office, 1912), 5-6; F. H. Newell, *Irrigation Management: The Operation, Maintenance and Betterment of Works for Bringing Water to Agricultural Lands* (New York: Appleton, 1916), 3; and F. H. Newell, "Federal Land Reclamation: An National Problem," *Engineering News-Record* 91 (November 15, 1923), 803.
8. *Forestry and Irrigation* 12 (March 1906), 110.
9. *Congressional Record*, 61 Cong., 2 sess., Senate, March 25, April 5, April 6, April 14, 1910, 3740-48, 4259-60, 4314-24, and 4662-69, and 61 Cong., 3 sess., House, February 17, 1911, 4662-69.
10. W. E. Smythe, "A Success of Two Centuries," *Out West* 22 (January 1905), 72-6; W. E. Smythe, *Constructive Democracy: The Economics of the Square Deal* (New York: Macmillan, 1905), 381-5; "The Reclamation Service," *Forestry and Irrigation* 11 (June 1905), 280; F. G. Newlands to Secretary of the Interior, January 26, 1905, and Charles Walcott (Director,

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A Tale of Two Commissioners: Frederick Newell and Floyd Dominy

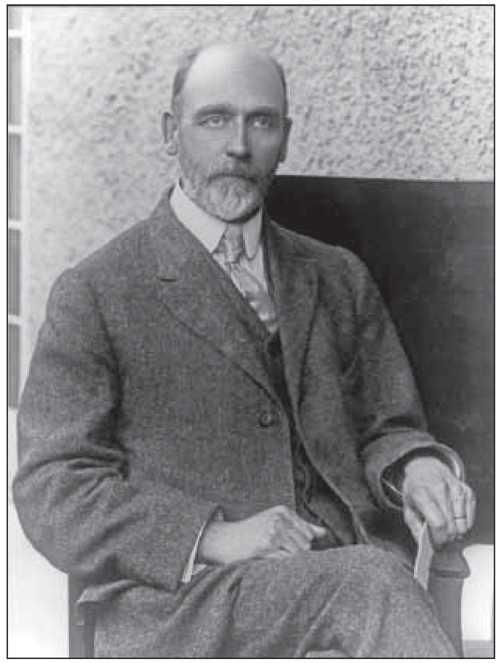
By:
Donald J. Pisani

Tonight[1] I'd like to survey some highlights of the history of the Bureau of Reclamation by looking at the lives and times of two of the agency's most notable directors, Frederick Newell and Floyd Dominy. A principal architect of the Reclamation Act of 1902, Newell directed the federal reclamation program from 1902 to 1914, supervising the construction of 28 irrigation projects—one or more in every state and territory within the American West. Dominy was commissioner of the Reclamation Bureau from 1959 to 1969, during what Marc Reisner has called "the Go-Go years." By that time the high dam symbolized the bureau more than the family farm, and it paid as much attention to the urban as to the rural West. In any one year of the 1960s, the bureau's construction budget exceeded all the expenditures by the Bureau of Reclamation from 1902 to 1933. Yet for all its wealth, I would argue that by the 1960s time had passed the bureau by: it was an agency without a rudder. For reasons largely beyond its control, it had lost the ideals that sustained it through the first six decades of the twentieth century. By the 1970s two fundamental changes had occurred in the West: the family farm had declined dramatically in importance, and the region could no longer claim to be an economically backward province of the East. It could no longer contend that it had a special right to federal aid, a right that transcended the claims of other parts of the nation.

Frederick H. Newell

Frederick Haynes Newell was born on March 5, 1862, in Bradford, Pennsylvania, a small lumber and mining town in the northwest part of the state, just south of the New York border—a town far-removed from major cities, the closest of which was Erie, 100 miles to the West. "The people [in Bradford] were what might be called typical mountaineers and laborers in the lumber camps, rough, illiterate and with many queer old country habits and superstitions," Newell recalled in his unpublished memoirs, written in 1927. Newell's mother died in childbirth the year after he was born, and so did the child she carried. So young Frederick grew up without siblings, and for most of his youth lived with relatives. As he put it, "I attended many public schools in different parts of the country not staying very long at any one as I moved from place to place." Nevertheless, Newell was a good student, and after attending high school in Newton, Massachusetts, where he lived with an uncle, he entered the Massachusetts Institute of Technology in 1880, in part so that he could live at his grandfather's house in Brookline, Massachusetts.

Not surprisingly, Frederick Newell would exhibit a curious distance and detachment when he wrote about his father, who at various times tried the feed and grain business in Chicago—and got "skinned," as Frederick put it—then sold boilers, machinery, and safes in Detroit; then made furniture; until in mid-life he returned to Bradford, where he found oil and financial success after many failures. Frederick described his father as "always sanguine, full of entrancing schemes.… He was surveyor, engineer and general all around man.… He bought and sold coal and timber lands and went into various ventures, characteristic of the time and place." In short, his father was an American type: wanderer, dreamer and speculator—the kind you find in so many American novels, including Mark Twain and Charles Dudley Warner's *The Gilded Age*. The life of Frederick's father drove home to the boy a Darwinian lesson he would carry with him through life: for many success did not come easily. It comes only to those who are persistent and tenacious, and how people bear hardship is as important as whether or not they achieved success.



26.1. Frederick H. Newell while Director of Reclamation.

In addition, Newell's upbringing produced in the young man a versatility, resourcefulness, and a strong sense of independence. On vacations from high school, Newell became deeply involved in his father's business ventures, and after graduation he returned to Bradford from Massachusetts and plunged

> again into a wide variety of occupations including surveying, printing, bookkeeping… generally for my father. The experience I now appreciate was valuable as it was necessary for me to take the initiative and use my own judgment continually as my father was never a man who would bother with details but who wanted results immediately and economically. There was nothing that I would not undertake… whether laying gas lines, plumbing, designing houses or straightening out the books of some company and discovering blunders or worse on the part of people with whom he [that is, his father] was doing business.

Newell first went west during the summer of 1881, after his father and a few other residents of Bradford invested in mineral land in southern Colorado. Frederick helped organize the Columbia Gold Mining Company, and he became secretary and treasurer—a formidable job for a boy just out of high school.

After Newell graduated from MIT in 1885, with a B.A. in mining engineering, he first returned to Bradford and worked for his father—who hadn't wanted him to go to college in the first place—then caught on with the Ohio Geological Survey studying oil-bearing rocks. At the time geology was in its infancy, and those who knew the most about the subject were more likely to work for the federal or state governments than teach at a university. So Newell's big break came in 1888 when he met John Wesley Powell, the head of the United States Geological Survey in Boston, and later in that year, in Washington, he met two other prominent figures in the USGS, G. K. Gilbert and Henry Gannett. At the time, Powell was organizing the Irrigation Survey within the USGS to investigate and map potential dams and canals in the West, and Powell asked Newell to take charge of a crew of 14 recent engineering graduates from Harvard, Yale, and Troy to study the characteristics and volume of streams in the West. This was far-removed from petroleum geology, but Newell jumped at the chance.

The training camp at remote and isolated Embudo, New Mexico, on the Rio Grande, changed Newell's life. However, Congress cancelled the Irrigation Survey in 1890, and it cut the USGS appropriation by half in 1892. Powell resigned as director of the Survey in 1894, and Newell learned another valuable lesson: western politicians cared little about science but everything about economic development. It was a lesson he would long remember.

Frederick Newell was not a hydraulic engineer, and he never designed an irrigation project—either before or after 1902. He knew a lot about the nature of rivers, and he also prepared the census of irrigation for the United States in 1890 and 1900, but he had little experience with desert agriculture. More than his adaptability, and more than his raw intelligence, what Newell had was the right political and scientific connections. In 1890 he joined the Cosmos Club, which until he found a house in Washington, served, he recalled in his memoirs, as his "main refuge." Within a year he became a regular member of the "Great Basin Lunch Mess," which included G. K. Gilbert, Henry Gannett, W. J. McGee, and Gifford Pinchot. The group met over lunch to discuss the critical natural resource issues facing the nation in the 1890s. In the next few years he became active in the National Geographic Society, the American Geographical Society, and the American Forestry Association, and he gave frequent lectures before scientific and engineering societies—more often on forestry than hydrology. Newell and Gifford Pinchot frequently discussed the need to improve the administration of the national forests, in part to protect the flow of the many streams that originated on the public domain. Through Pinchot, Newell met the then governor of New York in 1900, Theodore Roosevelt. Newell and Pinchot became Roosevelt's closest advisors on natural resources, and it was only natural that when the Reclamation Act passed Congress in 1902, the United States Geological Survey would administer the new program and Frederick Haynes Newell would take charge.

Federal reclamation was such a bold program that it was almost inevitable that those who designed and administered it would make mistakes. In 1800 the

Harrison Land Act had sold land on credit. Farmers quickly fell into arrears on their payments—and finally, after attempting to use the United States Army to evict those who refused to pay, Congress excused those payments entirely. Those who settled the land thought that they were entitled to it for nothing. It was they who gave the land value, they reasoned, not the federal government. As you know, the same thing happened to federal reclamation. By the 1920s, and in some parts of the West long before that, farmers considered the program an entitlement, and so did many of its sponsors. After all, easterners got river and harbor improvements for nothing, why shouldn't farmers who had the courage to try to settle the desert wilderness get their land and water free? Equally important was the massive depression of the 1890s. Congress passed the Reclamation Act with the expectation of jump-starting the western economy. Federal reclamation, it was hoped, would encourage private capital to invest in the region— which it had not done since the early 1890s. Then, too, in 1902, there were three states expected to join the Union before Theodore Roosevelt stepped down as President: Oklahoma, Arizona, and New Mexico. TR wanted to maintain the Republican support he already enjoyed in states like Wyoming and Montana. Therefore, in consultation with Charles D. Walcott, the director of the USGS and the Reclamation Service, and Chief Engineer Newell, Roosevelt made a fateful decision: the Reclamation Service would not build one or two model irrigation projects so that it could learn from experience. Nor would it build the large projects beyond the means of private enterprise that A. P. Davis, J. D. Lippincott and others had favored for the Colorado and Sacramento rivers. Instead, within a few years of 1902 it launched smaller irrigation projects in every western state and territory to spread the wealth of the reclamation fund as evenly as possible. To be sure, Congress required in the Reclamation Act that 51 percent of the money raised from public land sales be spent on reclamation within the state or territory in which that land was located. But that did not mean that the Reclamation Service had to launch 28 projects within a few years. So fast did the Service undertake these dams and canals that it could not profit from mistakes and misconceptions. And by 1915, when Newell left the Reclamation Service, the mistakes were all too obvious: the soils—which had not been tested prior to opening the original projects—were uneven and often of poor quality, inadequate attention had been paid to finding transportation and markets for the crops raised, and those crops were likely to be low value alfalfa rather than the high value citrus fruits or vegetables that promoters of government irrigation had hoped would be raised on the projects in 1902.

By 1909 the Reclamation Service was bombarded with complaints from the projects and from Congress, and Newell had become defensive and evasive. He tried to hide the seriousness of the problems on the projects from the president, from the secretaries of the interior, and from Congress. A. P. Davis remembered a meeting in 1914 with Secretary of the Interior Franklin K. Lane and the so-called "father of the Reclamation Act," Francis G. Newlands, then a United States senator from Nevada. Newlands had long been a friend and supporter of Newell, but at this meeting, according to Davis, even Newlands lost his patience. Davis was a team player and he had gone out of his way to defend Newell. But

Newlands—who was generally mild-mannered—asked "almost savagely," or so Davis later remembered, what Newell's faults were.

> I told the Senator that Mr. Newell's principle weakness was his inability to say "No," and that his principal mistake was in taking up too much work which was the result of his yielding to pressure in various regions, for the sake of avoiding antagonism and criticism, but that it had had the reverse effect. I told him I had often protested against taking up so many projects beyond the capacity of funds to properly push, and that I could prevent this when in the Washington office, but when I was absent in the field… commitments were made to new work which had tied up the funds and made it necessary to ask Congress for additional appropriations. It had also led to delay of the work on all of the projects, so that settlers were exposed to great hardships in waiting for water.…

Newell accomplished a great deal. By 1906 twenty-eight government projects had been selected. When completed, they were expected to irrigate as few as 8,000 acres on the Garden City project in Kansas to as many as 200,000 acres on the Salt River Project in Arizona and the Truckee-Carson Project in Nevada. In all, more than 3,000,000 acres would be reclaimed from the desert and 62,000 farms created. As head of the Reclamation Service, Newell supervised the construction of 100 dams, twenty-five miles of tunnels and some 1,300 miles of canals and ditches that supplied water to 20,000 farmers. At 328 feet, the Shoshone Dam in northeastern Wyoming, completed in 1910, was the highest dam in the world, and Roosevelt Dam, built on the Salt River between 1906 and 1911, was the largest masonry dam in the world. By 1916 Arrowrock Dam, which was 385 feet high, had eclipsed the Shoshone Dam.

Nevertheless, Newell had many blind spots, and for a partial explanation we can go back to his childhood and the decades he was growing up. Newell shared the same faith in Social Darwinism that many Progressives held, and the experience of his father must have suggested to him that the natural order of human existence included failure and uncertainty. What most hampered Newell's judgment is that he refused to recognize how vastly different agriculture was in the United States in 1900 or 1910 than in 1860 or 1880. In one of his annual reports, when he was under heavy fire from Congress, Newell acknowledged some of the "fallacies" that had retarded federal reclamation. The most important, he said, was that "it was not anticipated how difficult it would be to secure the right kind of farmers to handle the reclaimed land, and utilize it to advantage."

Newell was right. Many penniless and inexperienced farmers flooded onto the government projects before water was available, and they were doomed to fail. Nevertheless, those settlers had been encouraged to take up land on the projects by the Reclamation Bureau, and one wonders whether Newell's own versatility—remember that he was neither a hydraulic engineer nor a soil scientist—played some part in the decision to open the projects to all comers. Of course, when those settlers proved less resourceful than he had hoped, Newell quickly lost faith in them. In 1912 he suggested that the problems on the federal reclamation projects were due mainly to character faults in those who settled the government projects, not in the administration of the Reclamation Service or even in limitations imposed by Congress. "The characteristics of present settlers are in many respects entirely different from those of the older pioneer communities," he wrote. "[T]here is not the spirit of cooperation which ruled the early pioneers; the class of people now attracted to the lands are not as capable of adapting themselves to existing conditions and initiating the building of distributing works." Disgruntled farmers, Newell believed, had blamed the Reclamation Service for their own weaknesses. If anything, the Reclamation service had done too much. In a 1913 letter to Gifford Pinchot, Newell observed that the more the federal government did, the more dependent on government assistance farmers became. "On the whole," he concluded, "we have done too much in taking the initiative and in trying to expedite development." Newell drew a sharp distinction between the self-reliant pioneer farmer of the nineteenth century and the twentieth century farmer who refused to work as hard.

> He [the would-be twentieth century farmer] is attracted usually by glowing accounts of the relative ease of acquiring wealth in the West, and with erroneous ideas concerning the conditions to be met.… There has thus arisen a class which has been called the "professional pioneer," always seeking for something a little better or for conditions where life will be easier; staying in any locality only a few months and then again seeking El Dorado.

Newell admitted that more than 75 percent of those who first settled an irrigation project were gone within three or four years. "This is naturally to be expected," he observed, "as the first-comers were usually the more restless members of a community, men who were always on the lookout for something new and when they discovered it were anxious to dispose of their acquisitions and move on to a still better opportunity." In a 1919 address Newell called for a return to the old values: "Let us try to get back to more of the real spirit of democracy, of Americanism, of self reliance, of doing those things for ourselves and for the public which we can best do, not waiting for some governmental bureau, which in turn waits on Congress.…"

Newell was forced to resign from the Reclamation Bureau in 1915 by Secretary of the Interior Franklin K. Lane, and soon thereafter he became head of the Civil Engineering Department at the University of Illinois. He remained very active in national engineering societies, but in the years that followed showed little interest in science or conservation, and he was not in demand as a consultant. He enjoyed academic life but riding herd over nine academic engineers provided little challenge. As he wrote after he left the University of Illinois in 1920: "everything seemed too easy in the sense that there was not enough stimulus to keep an active man from becoming a typical college professor emersed [sic] in petty routine." In 1918 the American Geographical Society, of which Newell had been a prominent member, awarded him its Cullum Gold Medal. One side of the medallion bore the inscription: "He carried water from a mountain wilderness to turn the waste places of the desert into homes for freemen." Yet, ironically, Newell died in 1931 convinced that federal reclamation had been unnecessary and unwise. Congress, Newell argued at the end of his life, had paid too much attention to the arid West; the farms of the humid United States were more than adequate to feed the entire nation. The crops produced on government projects represented less than 1 percent of the value of all farm products raised in the United States and only 6 percent of the value of the arid region's output. There was no demand for new homes and—given farm mechanization, the labor-saving value of electricity, and the continuing migration to cities—the family farm had no future in the West. Newell died an embittered man.

Floyd Dominy

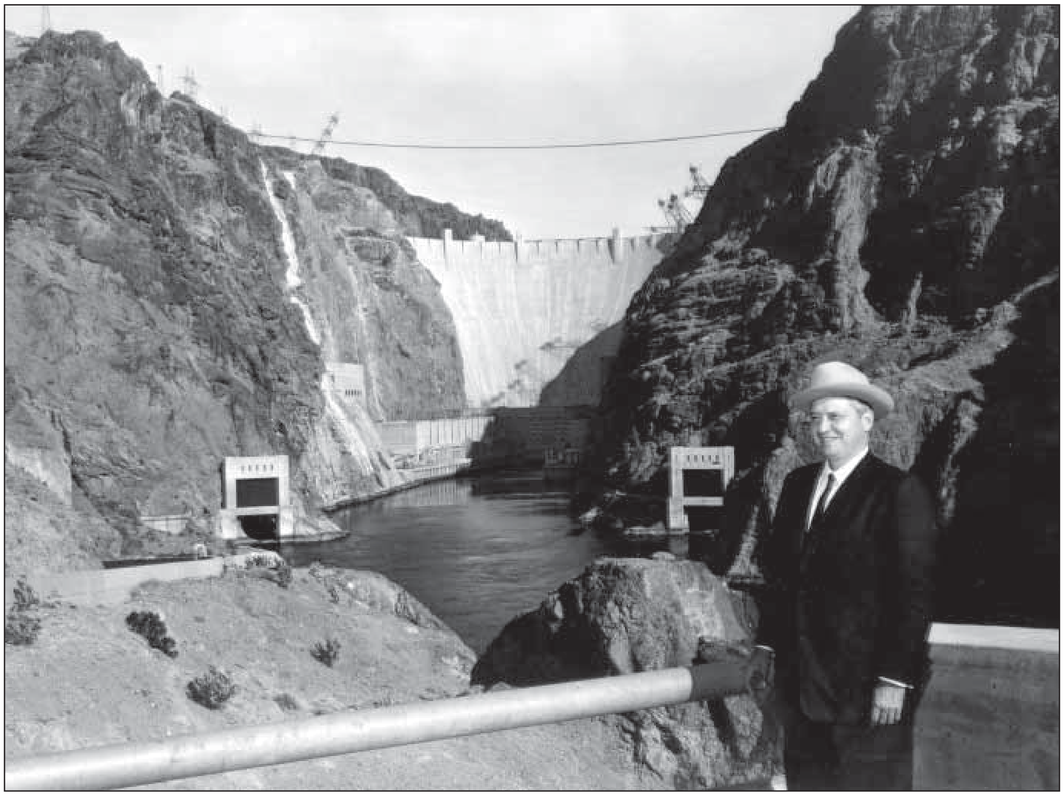
Floyd Dominy has gotten a bad rap from historians. Those of you who have read Marc Reisner's *Cadillac Desert: The American West and its Disappearing Water* (1986) know what I mean. In that book, Reisner likened Dominy to "a Mafia shakedown artist running a recalcitrant store owner out of the neighborhood,"

> "A terrorist" who "ended his term [as commissioner] as a zealot, blind to injustice, locked in a mad-dog campaign against the environmental movement and the whole country over a pair of Grand Canyon dams [Bridge and Marble Canyon]."

Dominy spent many hours talking with Reisner, and one would expect that Reisner would have developed some respect for the former commissioner's honesty and accessibility, if not his policies and values. But *Cadillac Desert* is filled with asides like the following: "At eleven o'clock one morning in the spring of 1980, Dominy, floating on three gin and juices and powered by two cigars, was in a mood to talk.…" Historians are no less given to the love of salacious details than the public at large—perhaps because we are so immersed in the "petty details" that Newell found distasteful as chair of the civil engineering department at the University of Illinois. In any case, Reisner knew that sex sells and that Floyd Dominy had huge sexual appetites. And, in fairness to Reisner, he thought that Dominy's sexual exploits had a bearing on the policies he followed as commissioner. "In the end, it wasn't any of this that did Dominy in," Reisner wrote.

> It was his innate self-destructiveness, which manifested itself most blatantly in an undisguised preoccupation with lust. His sexual exploits were legendary. They were also true. Whenever and wherever he traveled, he wanted a woman for the night. He had no shame about propositioning anyone. He would tell a Bureau employee with a bad marriage that his wife was a hell of a good lay, and the employee wouldn't know whether he was joking or not.

Well, my purpose is not to deny these charges, only to say that while historians have the obligation to look at the seamy side of people, they also have the obligation to look at them whole. Tempting as it is to turn people into cartoon figures, and history into a series of simple morality plays, the past is much more complicated than that. So let me show you another side of Floyd Dominy, a part of his life that influenced the decisions he made just as much as Frederick Newell's childhood turned him into a man who couldn't say no and led him to treat farmers on government irrigation projects with disdain and contempt.



26.2. Floyd E. Dominy at Hoover Dam in 1963 during his term as Commissioner of Reclamation.

Unlike Newell, Dominy was born on a farm near Hastings, Nebraska. In 1958 in hearings before Congress on the 160-acre limitation, Dominy talked about what it was like to grow up on such a farm.

> I want you to know that… it took [my grandfather] from 1876 to 1919 to pay off the $2,000 that he borrowed to make the trek to [Nebraska from Illinois] to provide his home on a public land homestead.… [W]hen my own father reached maturity he took a homestead in the same area, 160 acres. On that farm 6 of us children were born and 6 of us reached maturity on the subsistence of that 160-acre homestead. We had outside plumbing. We did not have deep freezers, automobiles, [or] school buses coming by the door. We walked to school in the mud. We had… one decent set of clothes to wear to town on Saturday. Otherwise we wore overalls. We didn't have the modern things that a farm today must provide.

Dominy attended the University of Wyoming, but unlike Newell he majored in agricultural economics, not engineering. He graduated in 1933, not a good year to begin a career, and after a brief stint at teaching school he became a county agricultural extension agent in Campbell County, Wyoming, which was grazing country.

> I saw there the [bitter] fruits of the 640-acre Homestead Act.…I want everyone in this room and I want this committee to know that most of those 640 acres could not sustain a family under any reasonable economic conditions that have prevailed then or now.

In short, by the time he became commissioner, Dominy's experience growing up in Hastings, Nebraska, and his later experience in Wyoming suggested that the small farm was a thing of the past, given the standard of living of most Americans in the 1950s and 1960s. (Ironically, he ran a family farm himself in Virginia, twenty miles from the capitol, after he came to Washington in 1938. He started with 32 acres and eventually secured 380 acres, but thought that even that was inadequate to make a living.) Soon before he left office in 1969, he observed in a speech that

> The general trend now is… the abandonment of family-sized farms and the deterioration of small communities into ghost towns. In our modern mechanized and high-speed civilization, I see no major changes likely in this trend.

Floyd Dominy was the first commissioner to make this admission, at least publicly. Contrary to what some historians have suggested, the Reclamation Bureau did not abandon the family farm in the 1930s and 1940s. To be sure, the agricultural depression of the 1930s, the growth of cities like Los Angeles, and World War II contributed to the decline of the rural West. But the bureau built many small water projects during the 1930s and 1940s, and at the end of World War II the twin goals of federal reclamation—promoting the family farm and encouraging economic growth—remained intact.

In 1946 Commissioner of Reclamation Michael Straus predicted that within five years the bureau would open more than 45,000 family-sized farms on 4,000,000 acres. This was no small undertaking. The bureau promised to provide as many homes to returning veterans and their families as it had created on all its projects during the four decades prior to World War II. The first farms would be on the Klamath, Yakima, Minidoka, and Shoshone projects, but the single largest project would be in the Columbia River Basin, where the bureau hoped to have at least 400,000 acres ready for settlement by 1950 or 1951. "The ultimate objective of the Bureau of Reclamation and its staff," *Reclamation Era* reported, "is to develop the West through the creation of permanent family farms on Federal Reclamation projects."

The Columbia Basin Project had many objectives, perhaps too many. It was designed both to provide new land for farmers driven off the Great Plains by the dust storms of the 1930s and to prevent a post-war drain of population away from the Pacific Northwest during the reconversion to a peacetime economy. Not only would the construction of dams and canals in central Washington state provide jobs, but the farms might provide homes to displaced workers. By the end of the 1950s, however, it was clear that the Columbia Basin Project would not resurrect the bureau's mission to create small farms in the West. At the end of World War II, the Reclamation Bureau had hoped to create 10,000 to 20,000 new homesteads in the Columbia Basin, but only 2,300 had been opened by 1958. Nor was that land settled by young men looking for a fresh start; the median age of those who took up farms in the Columbia Basin Project was 40. Nor did it provide homes for those who had abandoned farms on the Great Plains; most settlers came from Washington or Utah. And these were not poor people. Over half had family assets of $20,000 or more, and one-third did not live on their farms. In 1968, the Reclamation Bureau washed its hands of the project, turning it over to three irrigation districts. According to the historian Paul Pitzer, had the bureau finished the project, the results would have been even worse. "It would be a collection of family farms ranging from forty to eighty acres, none of them capable of supplying their owners with a satisfactory living. The area would be a rural slum. It is for the best that this aspect of the project failed."

Little wonder, given his background, that Floyd Dominy showed scant interest either in the family farm or in maintaining the 160-acre limitation on cheap water. When federal reclamation began in 1902, Dominy recognized, it was a subsistence program, but by the 1960s, the rural standard of living had changed dramatically. "[In 1902] Those guys didn't think a farmer should have indoor plumbing or electric lights, for heavens sakes," Dominy observed in his oral history. "They didn't think their kids should go to college or to the dentist. They were subsistence farmers. That's all a farmer was supposed to do in 1902 was live, exist. Not prosper, but exist. That's the origin of the 160-acre limit and all that crap."

There were, of course, other forces working to end the era of dam-building besides the decline or erosion of the traditional family farm ideal. Those who have studied Dominy's reign as commissioner of the Bureau of Reclamation have focused on the debate over the construction of Glen Canyon, Bridge, and Marble dams and the Pacific Southwest Water Plan. They have regarded the Reclamation Bureau as far more powerful, and certainly far more autonomous, than it really was. Like all institutions of government, the bureau was subject to historical trends over which it had little or no control.

To begin with, big dams looked far less attractive to Americans—and even to many Americans living in the West—by the 1960s. Traditionally, one of the strongest arguments against such dams had been that it made more sense to move people to water than water to people. Far more water was lost in transit, through seepage and evaporation, than was delivered at the end of the pipeline or ditch. Now many critics of dams began to question whether they represented conservation at all. The Sierra Club regarded silt as more than something that clogged dams; it was also a symptom of the Reclamation Bureau's refusal to cooperate with those agencies that tried to protect the land. "[T]he real management of rivers begins in the headwaters and on the hilltops…through good land management," a writer observed in 1950 in the *Sierra Club Bulletin*. For example, both the Corps of Engineers and the Bureau of Reclamation refused to cooperate with the efforts of the Soil Conservation Service and the Forest Service to fight soil erosion.

In the 1950s and 1960s, environmental organizations did not simply argue that dams were bad for the environment, they also argued that dams represented an outmoded, expensive technology. In the 1930s, part of the appeal of high dams was that they would last as long as the pyramids. But that changed during the Cold War, when the very dams that provided the power to run many of the nation's defense industries became potential targets for Russian missiles and bombs. Many of the West's cities could be as easily paralyzed by disrupting their water and power systems, or by the floods that would result from bringing down one of these gigantic structures, as from the detonation of a bomb over the city itself. And even more important than the danger from the destruction of dams was the promise of nuclear power. As a writer in the Sierra Club Bulletin observed in 1948,

> we may live to see the regulated use of atomic power a few years from now. If we learn to use it properly… we won't need to harness all the rivers of the land.…At least we might wait a little while and see what happens before we drown our greatest canyons and destroy forever so much natural beauty.

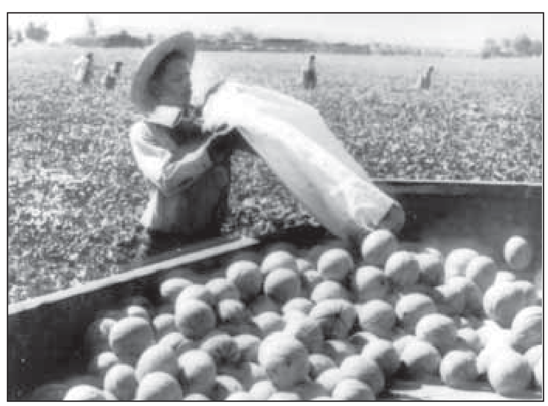
David Brower suggested that atomic energy might make high dams obsolete long before they filled with silt. He asked, "Is it not time to reverse the trend of centralization—of concentrating tremendously remunerative strategic targets: of building larger projects to enable more people to live in less space[?]" In the middle of the 1960s, during debate over the proposed Rampart Dam in Alaska, a Corps of Engineers structure that would have created a reservoir larger than Lake Erie, a writer in *Living Wilderness* pointed out that any one of five atomic generators produced by the General Electric Company could produce as much power as the proposed hydroelectric plants at Rampart at half the installation cost. And, she estimated, the price of the power to consumers would be just as cheap.

By the 1960s and 1970s, hydroelectric power no longer seemed as attractive as it did during the 1920s or 1930s. California was a prime example. In 1910 falling water produced most of the electricity used in the state. Steam power was used mainly to meet peak demands. But the increasing efficiency of steam generators, the falling prices of petroleum and natural gas, and the fact that such plants could be located near large cities, made steam turbines increasingly attractive. In 1920 hydroelectric power constituted 37 percent of the power generated within the United States. That figure fell to 33 percent in 1940, and despite the large hydroelectric plants opened during World War II, even in 1945 only 36 percent of the nation's power came from hydroelectric plants.

Neither waste nor the growing cost of water projects explain the end of the dam-building era any more than the declining number of good dam sites. After all, water projects had **always** been wasteful, and nineteenth century river and harbor improvements had been a method to distribute surplus federal money as much as a way to improve transportation. Nor did this change. Many of the water projects undertaken during the 1930s were "wasteful" by nature because their primary purpose was to provide jobs. Nor were agricultural subsidies new. But after World War II the West and South benefitted more from water projects than other parts of the country. In 1902 federal reclamation had been sold to Congress partly as compensation to the West for river and harbor bills that mainly benefitted states around the Great Lakes and along the eastern seaboard. But the historian Tim Palmer estimates that from 1950 to 1976, the Northeast received only 6 percent of the money spent on water projects by the Corps of Engineers and Bureau of Reclamation, while the South received 28 percent and the West about half. In effect, residents of the East and Midwest subsidized the growth of cities in the West at the expense of those in the northeast, as crops grown in California and Arizona received greater per acre subsidies than crops raised in other parts of the nation.

By the late 1960s, it was very difficult to argue that the West needed or deserved more federal aid than other parts of the country. The region's economy may not have been as diversified as that of the East, but the importance of grazing, mining, lumbering and other extractive industries had declined as the West urbanized. Moreover, the Vietnam War cut into the budgets of virtually all domestic programs, and the lessening of tensions between the United States and Soviet Union reduced the appeal of building dams to power the defense industries of the West.

During the 1960s Dominy was extremely effective in squeezing money out of Congress. But he was successful not just because western politicians were effective at winning the pork, but also because Dominy used a wide variety of effective arguments when he testified before Congressional committees. Federal reclamation projects, Dominy argued, produced many of the nation's vegetables, particularly during



26.3. Loading cantaloupes in a field on the Yuma Project in 1958.

the winter months when crops could be grown only in the warm and sunny Southwest. In 1965 he pointed out that 95 percent of the lettuce, 70 percent of the cantaloupes, 52 percent of the sweet corn, 50 percent of the carrots, and 44 percent of the cauliflower came from land watered by the Reclamation Bureau. After the war, nutritionists argued that Americans should diversify their diet, and by providing fruits and vegetables grown in the winter, federal reclamation improved the health of all Americans. Moreover, in testimony before Congress Dominy repeatedly pointed out that reclamation ministered to the health of the soul as well as the body. The ten most-visited bureau reservoirs attracted more vacationers per year than the ten most heavily used national parks and thus took much of the pressure off the parks. In 1967 he observed that in the previous year more than four million "visitor days" had been spent on Lake Mead and only two and one-half million at the most heavily visited National Park, Grand Teton. Dominy also claimed that irrigating land drove up its value, along with crop values. Increasing wealth expanded the tax base of communities and the quality of their schools and other public services. "[T]he income tax increases as a result of our project growth is greater each year than the total investment in reclamation," he noted.

Above all, Dominy warned that the nation had to prepare to feed a much larger population. The nation's population increased by 15 percent in the 1940s and another 20 percent in the 1950s, and the number of people in the West increased even faster than that. Meanwhile, millions of acres of marginal farmland in the South and Midwest were retired from production after World War II, and Dominy estimated that half the nation's farms were "marginal." In any case, at the end of his term as commissioner Dominy predicted that

> by 1980, the Bureau of Reclamation will be able to go it alone, continuing the program solely out of income. But as in any business venture, it is necessary to spend money to make money. And to get back on schedule, it will be important… to step up the program as the committee has indicated just as soon as the present budget emergency is over.

From 1903 to 1950 the Bureau of Reclamation spent two billion dollars on its projects. It spent another two billion from 1951 to 1961, and the bureau's construction appropriations peaked at $300 million in 1964. In fiscal year 1965, the budget began to shrink and when Dominy stepped down as commissioner in 1969 he observed that "water development is being slighted.… I think our national priorities are not being assessed properly, and that we are spending far too much on space and other elements. If we need to cut back, we should not cut back on the one thing that keeps America strong, its development of resources."

The last major project authorization came in 1968, a year before Dominy left office. That was for the Central Arizona Project, the aqueduct that stretches from the Colorado River to Tucson, via Phoenix. For a man who grew up on the plains of Nebraska, a man who knew rural poverty first-hand, the American

West of 1969 was a far better place to live because of the Bureau of Reclamation. Dominy genuinely believed that the dams and canals built by the bureau had improved the living standards of the region's rural and urban residents. Many of us would argue that that economic growth came at a high, even an intolerable, price to the environment, Native Americans, and to other groups that did not share in the wealth produced by the projects. But that story has been well-told. What I've tried to suggest is that while the personalities and values of individual commissioners certainly helped shape the policies they followed, neither Newell nor Dominy had the power or autonomy attributed to them by many historians. Sometimes the bureau responded effectively to change, as it did in building the high dams in the 1930s and 1940s, but much was beyond its control, from the emergence of a consumer economy and increasing living standards in the 1920s to the Vietnam War and the stagnant American economy of the 1970s. Just as Newell and Dominy were men of a particular time and place, so was the dam-building impulse that drove the bureau during the first seven decades of its life.

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Endnotes

1. Dr. Pisani gave this talk to a plenary dinner session of the history symposium at the University of Nevada—Las Vegas.

One Hundred Years of the Bureau of Reclamation: Looking from the Outside In

By:
Patricia Nelson Limerick

The Bureau of Reclamation is a federal agency very much identified with the American West, thanks to its focus on water management in arid lands. This situation offers wonderful opportunities to historians. A review of the agency's annual reports over the last century offers its own fine microcosm of changes in Western life, economy, and ideology. The officials who have written the Bureau's official reports have been something close to seismic monitors for changes in the settlement patterns of the West, as well as in American attitudes toward the West. As many others have observed, the rise of urban and suburban populations in the West registers clearly in the changing mandate of the Bureau, as hydroelectric power and municipal and industrial water supply have steadily pushed irrigation to the side. Similarly, shifts in popular attitudes toward nature are expertly mirrored in the Bureau's reports, even if they are not always as well reflected in the Bureau's practice.

If we look at the most recent report, for the year 2000, the words "water conservation" are used repeatedly. Quite a number of passages discuss the Bureau's efforts to aid wildlife and preserve or restore its habitat. The Bureau reaffirms its commitment to act in support of the goal of "no net loss of wetlands" (though this might be considered by some to be a textbook case of closing the barn door after departure of the horses). It declares an enthusiasm for the "watershed approach," incorporating "the ecology and interests of an entire basin rather than using a piecemeal approach." The phrase "environmentally and economically sound" is also a popular one.[1]

I suppose one could say that we could and should see the Bureau of Reclamation's rhetorical streak of born-again environmentalism as proof that "even the Devil can quote Scripture" (a proposition that hardly needed any more proof). Still, I would rephrase the proposition slightly, to reflect the constraints under which federal agencies have operated and still operate: "The Devil had better quote Scripture, and quote it often, if He doesn't want any more litigation, or any more trouble with Congress, the electorate, and environmental groups than He already has."

And yet the change in the Bureau's operations has been as enormous as the change in its official rhetoric. As the 1979 Report said, "the Service's [the Bureau had been briefly renamed the Water and Power Resources Service] mission has evolved from a single-purpose irrigation function to a multipurpose water resource development program." The 1989 Report declared that "emphasis is now shifting to activities that respond to the West's current water needs—such as environmental protection, water quality and salinity control, wetlands management, water conservation, groundwater management, drought relief, system optimization, and related research work." As the 1997 Report said, the Bureau's mission has "moved from development to management" of water. All of these remarks can be read as coded ways of saying, "We don't build big dams anymore, though we still have responsibility for quite a few of them." Bureau employees have taken up the use of the term "mission creep," a phrase that could produce many amusing guesses as to its meaning among those who do not frequent agency circles (images of Father Serra on a stealth approach might come to mind), to summarize the proliferation and spread of their activities: the dam-building and irrigation-water-supplying agency has "evolved" into furnishing cities and suburbs with water, providing hydroelectric power, managing recreation sites, designing techniques to restore water quality, trying to accommodate the needs of wildlife, and monitoring and shoring up old dams. In fact, rather than the creeping approach of new missions, the bigger story of change for Bureau staff has involved the mission that crept away from them: the building of big dams.[2]

The shift from construction to maintenance is, itself, one of the most poignant dimensions of the Bureau's "change over time" (and yes, I do think that federal agencies have poignant dimensions—plenty of them). Official discussion of dam safety accelerated after the 1976 collapse of the Teton Dam, and the passage of the 1978 Dam Safety Act. In many recent reports, this observation has appeared: "More than half of Reclamation's facilities are now more than 50 years old." As the 2000 *Report* summed this up, "Reclamation has 457 dams and dikes. Of these 358 would endanger lives if a failure occurred." In the agency's early years, Reclamation Service officials liked to use the adjective "permanent" and the adverb "permanently." "The works to be built by the Government," the *Third Annual Report* declared, "should be permanent in character," and thus "in striking contrast with those built by private enterprise, since the latter are largely temporary in character." But earth shifts; concrete wears away; silt accumulates; ditches and canals leak and seep; hydroelectric production facilities become obsolete. The fact that reclamation structures come with such constrained life spans makes one wonder exactly what meaning the word "permanence" held for Reclamation engineers a century ago. But the fact that the structures that Newell and his immediate successors built now need regular examination and restoration is its own poignant testimony that, even if the founders of the Bureau of Reclamation did not do much to reckon with the passage of time, the passage of time has been pretty merciless in its reckoning with them. (One striking historical irony involves some dams that are now in need of repair and reconfiguration, but, since they are now on the Historic Registry, they can only be rehabilitated in ways that visually match their appearance at the time of construction.)[3]

When it comes to a reckoning with time, centennials, sesquicentennials, quincentenaries, and all the other "metric moments," to use Greg Dening's phrase, do provide a distinctive opportunity. Given the ways in which the history of the Bureau of Reclamation echoes and mirrors the history of the American

West, this particular centennial offers a particularly rich opportunity for metric reflection. Richard White's famous phrase, describing the American West as "the kindergarten of the state" (the place where historians can watch the process as the federal government invented and deployed its domestic powers) provides a useful framework for considering the origins of this particular agency. While I have a few reservations about the use of the human life cycle as a metaphor for federal agencies, its value and applicability are also unmistakable. The phase we call "adolescence," for instance, is as wild a ride for federal agencies and their associates as it is for young people and their associates. And even people who are not fond of metaphors and analogies would have to admit that the Reclamation Service had something that seems well-characterized as a "rough childhood."

For the last decade or so, I have watched federal resource management agencies the way other people watch sports teams. Watching a federal institution maneuver through time and changing contexts has a fascination that may escape others, but it still captivates and enchants those who are susceptible to it. On a number of occasions, I have had the opportunity to speak to employees of federal agencies, reflecting on the relationship between their organization's history and their own, poignant contemporary dilemmas. To prepare for these occasions, I have read official newsletters and reports, and thus I have come to believe that you can learn a lot about an organization by reading, with critical intensity, its official publications. What to others may seem boilerplate often provides a very useful and revealing orientation for a speaker or presenter who wants to invite an audience into an exploration of the connections between an organization's past and present. At the least, official publications display what the agency's officials were willing to put on public record. While there is always some chance that this material will consist of fluff and self-promotion, there is also the fact that federal agencies are in the business of courting public approval, and thus these texts reveal the leadership's assessment of public mood and preference. So, at the very least, these official publications tell us about the organization's perception of changing constituent or electorate tastes; when, for instance, mantras of environmental sensitivity move into publications of the Bureau of Reclamation, you know that an official bow toward preserving the earth and its resources has become very mainstream indeed.

Now it is also true that I rarely have other historians in the room when I am engaged in these exercises in the "applied humanities," and so the occasion today is a somewhat unnerving one. And yet it is also a valuable occasion; as Don Pisani and I anticipate the Reclamation Centennial Conference in Las Vegas this June, this OAH session offers itself as a useful strategy session, or maybe a dress rehearsal or trial run. Most important for me, it provides an occasion for appraising the "social utility" of looking at the past, in this case at an agency's origins, as a foundation for thinking productively and freshly about our current dilemmas in Western resource use. At the core of what I have been trying to do, when speaking to professionals in various federal resource management agencies, is to try to come up with a "better quality of hindsight," to see if there is a way to bring the past to bear on the present in a way that suggests possibilities and encourages flexibility. Our discussion today should provide me with an illuminating consideration of the question of whether this idea of "a better quality of hindsight" is more (or less) than a pipedream.

Reading annual reports from the Bureau of Reclamation may not strike everyone as the most promising way to explore possibilities or encourage flexibility, but I found the experience often engaging, and sometimes hypnotizing and entrancing. It is true that people's literary tastes can change over time; I used to read a lot more novels, or at least want to read a lot more novels, until I had to face up to the fact that what we call "nonfiction" is entirely oversupplied with improbable characters and wild plot twists. Is there any reason why I would need to rely on a novelist's efforts at creativity and originality, when I can simply compare and contrast the "change over time" represented, for instance, in the Bureau of Reclamation's late twentieth century desires to increase "diversity" in its work force in contrast to its Mongolian–excluding origins?[4]

The success of the Reclamation Service, its founding Chief Engineer Frederick Newell said, required men—specifically, "an excellent class of well-educated, efficient, and energetic young men," and the word "white" was the understood and implicit additional adjective in that phrase. While it is true that one would not welcome the assignment of explaining to Newell or any other time traveler what a turn-of-this-century federal agency really means by its desire for "diversity," nonetheless, early twentieth century Reclamation records are their own exemplary case studies in "white maleness" as the unmarked category, the category entirely conceived of as the norm. The 1902 Act banned the use of "Mongolian labor"; three Reclamation projects were sufficiently short of settlers that they were made into Japanese American relocation camps during World War Two; and Indian tribal resources sometimes figured in Reclamation projects, but otherwise race and ethnicity did not register in the reports, because the category of "human beings of significance to Reclamation's mission" so clearly came with an exclusive racial definition.[5]

Review the reports of the early Reclamation Service, and no reason presents itself to doubt the racial exclusivity of the newly founded agency and its intended beneficiaries. But the reports do lead one to question an equally well-established assumption: the assumption that the agency's founders were men of arrogance, over-confidence, and swaggering self-congratulation.

"The engineers who staffed the Reclamation Service tended to view themselves as a godlike class performing hydrologic miracles for grateful simpletons who were content to sit in the desert and raise fruit": that is Marc Reisner's characterization of the agency in his famed 1986 book, *Cadillac Desert*. Here is Donald Worster's portrait in 1985 of the Bureau's powers: "In its first few embryonic [a word that offers an interesting variation on the life-style metaphor] years, when thanks to Congressman Newlands' efforts it was free to use the money from western land sales as it saw fit, the Service was a power unto itself."[6]

To read these characterizations and then to turn to the first reports of the Service is to engage in an episode of general puzzlement. "Godlike class performing hydrologic miracles"? OK, maybe this was a very, very clever godlike class, cleverer than most of the sort, who made a strategic choice to write official reports that would throw readers, past and present, off their trail. Too much swaggering and boasting might confirm hostile judgments and unmask excesses of power; would not an intelligent and foresighted godlike class choose, instead, to put on a show of manifestly unfelt modesty and humility? Well, maybe, but the tone, style, and content of the first decade or two of Annual Reports simply do not bring the words "godlike" or "power unto itself" to mind.

27.1. Official Portrait of Secretrary of the Interior Ethan Allen Hitchcock.

Anyone who has ever founded an organization, and tried to report positively on its beginnings, must surrender to empathy on the very first page of the *First Annual Report*. The Newlands Act passed on June 17, 1902; a few days later, some men who worked for the Hydrographic Branch of the U.S. Geological Survey became the Reclamation Service; a few months passed, and it was time to report to Congress. Here is what Secretary of the Interior E. A. Hitchcock said in his letter of transmittal for the report:

> In view of the short time that has elapsed since the passage of said act, it is impossible to show in this report "the quantity and location of the lands which can be irrigated" from the various projects under consideration, or "the cost of works in process of construction, as well as those which have been completed," for the reason that no works are now in process of construction or have been completed.

I like this passage for a couple of reasons: it is honest; no one could call it arrogant; it has the kind of Lewis Carroll quality that sometimes characterizes federal communications ("we are writing to report that we have nothing to report"); and anyone, with responsibility for an institution or organization, who has received a grant and almost immediately received instructions to report on the outcomes and results of the grant, simply has to know how Secretary Hitchcock and Chief Engineer Newell felt. Under these circumstances, "hitting the ground running" can easily feel like the equivalent of "hitting the ground tottering."[7]

And so the report for 1902 is filled with descriptions of field work undertaken, surveys under way, and investigations of prospective projects, as well as apologetic statements on the order of this one: “The fact that it is impossible to state in advance the plans which ultimately may be recommended for reclamation will result in great disappointment to many persons.” When it came to the selection of sites for projects, the Reclamation Service and land-and-profit-oriented members of the western public were engaged in a great competitive guessing game, with the one certain outcome that a lot of people were going to be angry at the agency. There was, for example, the problem of people who were trying to anticipate rising land values from reclamation:

> The fact that lands have been temporarily set aside is, in the eyes of many, an indication that these lands will be reclaimed; and although every attempt has been made to warn individuals of the futility of filing upon these lands under the homestead law, yet they persist in taking up the land on the bare possibility that the surveys and examinations will show their lands to be reclaimable…It is an unfortunate condition which apparently cannot be corrected at present.

What this passage, along with many others in the First Report, makes clear is that from the time of its creation, from <u>before</u> the time of its creation, the Reclamation Service was ensnarled and entangled in history, tied up in the consequences of actions that preceded any effort on its part to take control of western water development.[8]

The Service began as a unit within the U.S. Geological Survey, which had already had twenty years of complicated institutional life itself, and its first Chief Engineer, Frederick Newell, had been a career employee of the USGS himself. As Newell put it,

> The operations were greatly facilitated by the fact that the work was not new to the men in charge, and that they were able to follow the methods and precedents established by the Geological Survey during twenty years of field work.

“The plan,” Newell said further, was “to gradually enlarge and increase the number of parties in the field without otherwise disturbing the current operations.” [“To gradually enlarge” is totally par for the course; it is a plain and simple historical fact that the Reclamation Service has, throughout its century of existence, led in the national campaign to eliminate active verbs and to fearlessly and shamelessly split infinitives, though I do not believe that this mission was spelled out in its enabling act.][9]

Maybe I romanticize the charms of the true “fresh start” or “blank slate,” but the Reclamation Service never had such a thing. If the Reclamation Service was an “infant” bureaucracy, its cradle was another bureaucracy. From the beginning it was living with its in-laws, operating within existing protocols, never having a clear moment of launching itself into the stream of time.

In a similar way, the Reclamation Service was going to inherit a burden from history in the form of a tangle of land and water claims already imposed on the West's resources. As Newell said in the first report, many western lands had "passed, in whole or in part, into the hands of private owners." Grants to railroads, as well as Spanish land grants, divided up the land; "homesteads and other entries" had been made "along banks of rivers or around springs or other sources of water supply." "The problem of reclamation," as Newell summed it up, "is therefore not simply one of dealing with public land, but is complicated by private ownership." "Complicated" puts it mildly.[10]

Here we get to the territory of greatest interest in this First Report, and perhaps in the whole history of Reclamation. The results of irrigation, as conducted by private enterprise, Newell said, were "not wholly satisfactory, as far as the larger interests of the country are concerned"; "the larger public interests have not been guarded, and the making of homes has not been carried on to the extent which the wisest statesmanship requires." Here is the very interesting dynamic present from the start: at the foundation of federal reclamation was a stern critique of private enterprise, and especially of the speculative element of American capitalistic practice. And yet federal reclamation was itself supposed to run like a business (the repayment provision was the keystone of that idea), and it was, moreover, supposed to serve the mission of creating and sustaining entrepreneurial family farms. If you took the leash off and let Newell's line of thought proceed, he was on his way to a very forceful statement that private enterprise had made a mess of land and water development in the West. Reclamation would, in the words of the Report, have to "accommodate earlier private developments," but in the muddle these developments had created, even such seemingly simple matters as distinguishing, in order to allocate water rights, "between bona fide and fictitious landowners" was "extremely difficult."[11]

So take the restraints off Frederick Newell, and you'd have a recruit for socialism, or at the least, for Henry George's Single Tax campaign against the "unearned increment"? Maybe. But there is no question that the first Chief Engineer of the Reclamation Service had good reason for ambivalence about the workings of American private enterprise. And yet his agency and its staff would be judged by the success with which they served, supported, and won the approval of practitioners of the very economic system that had created the problems they were trying to rectify. This was a tension that would persist through the agency's history; during the Clinton years, for instance, the reports are well-supplied with declarations that the Bureau must be more "business-like" in its operations, and provide "customer" satisfaction to the American people, and the big question, of the trustworthiness and efficiency of private enterprise in water usage and management, remained securely stored under the carpet.

The crypto-critique of private enterprise in the early reports catches the attention, but what strikes the reader most intensely is how poorly Newell's stance in his ten years of reporting fits the word arrogant or even the word confident. Of course, six months after the passage of the Reclamation Act, having to report that there was nothing yet to report would hardly provide the occasion for a display of pride and institutional self-congratulations. Still, over the next ten years, the annual reports retained a quality of modesty and even humility, culminating in the *Eleventh Annual Report* summing up the Reclamation Service's first decade and setting some sort of record for frank admission of mistakes and misconceptions in a governmental statement.

In the *Second Report*, Newell described, with considerable frankness, the very big difference between passing a law and creating an agency: "In an undertaking of this kind there must be encountered many unforeseen contingencies and complications when the general law is applied to actual conditions." In the *Third Report*, Newell took his admission of these difficulties a step further: "Nearly all the projects under consideration here are relatively large and involve engineering difficulties or have complications arising from private or vested interests. Nowhere is it possible to go forward untrammeled." It is possible to read this as merely a statement of frustration, rather than one of modesty and honest admission of limitation, and it is also possible to read it as the quintessential bureaucratic defense: "Don't blame us; we're trying hard; we may not have accomplished much; but our circumstances have been very difficult." Still, it would be hard to describe the statement as arrogant, over-confident, self-congratulatory, or "godlike."[12]

In the *Third Report*, a substantial list of decisions made by the Secretary of the Interior involving the interpretation of the 1902 law indicated that, just three years into the agency's operations, the complexity of managing human beings was entering into the picture as the equivalent in challenge to managing rivers. Within another year or two, the annual report had added a section called "Litigation," listing all the lawsuits filed against the Reclamation Service, giving another indication that the complications of dealing with human beings were adding significantly to the challenge of dealing with rivers. "The engineering side," Newell acknowledged in the *Third Report*, "does not offer usually as great causes of delay as the legal or human element. There are almost everywhere land titles to be adjusted, rights of way to be secured, and claims to water to be considered."[13]

By the time of the *Eleventh Annual Report*, summarizing the first ten years of the Service's experience, perplexity over how best to deal with "the human element" produced a remarkably frank report, cataloguing the misapprehensions that had characterized the beginnings of Reclamation. "The most difficult of the problems are not those of engineering nor of construction," the opening of the report said clearly, "but those having to do with the human side—namely, the attracting or securing of the type of farmer who can and will make a success by intensive agriculture." As many others have noted, Newell was mad at the project settlers, and indeed held them responsible for most of his agency's problems.[14]

But not solely responsible—here, again, the frankness of a section of the Report called "Fallacies Entertained" gives one a new respect for the under-utilized possibilities of federal reporting. "The first, and perhaps the most striking" fallacy embraced by the Service at its founding, Newell reported, was the under-estimating of the cost of reclamation, basing estimates on low-budget and unreliable pioneer enterprises. "Another of the fallacies," he said, "was in the assumption that as soon as water was provided this [would be the] end of necessary expenditures." On the contrary, once the water was available, there was still "the large cost of leveling, subduing, and cultivating the soil." "It was assumed," moreover, "that the soil was necessarily fertile, not appreciating the fact that it frequently lacks the essential elements common in humid regions." And "another oversight…was the neglect of full consideration of drainage and the importance of providing this to prevent much of the more valuable land from being destroyed by swamping or alkali." And then there was a complex of under-recognized factors involving the production and marketing of crops:

> It was not appreciated also that markets could not be had immediately for the crops raised and that much time must be required in developing good markets and in discovering those crops or varieties which are most profitable under the existing conditions of soil, climate, and transportation facilities.

Altogether, the *Eleventh Report* offers quite a prolonged and searching admission of error, and I do not think it has many counterparts in federal reports. In a number of ways, it anticipates the critical appraisals offered by historians like Donald Worster and Mark Fiege.[15]

The admitting of error does shift, at the end, to Newell's anger at the "human element." "Perhaps most important of all, it was not anticipated how difficult it would be to secure the right kind of farmers to handle this reclaimed land, and to utilize it to advantage." It was not simply a problem of recruiting, though it was certainly that, too. "When the act was discussed in 1901 and 1902, it was generally assumed that the principal operations would be those of constructing the larger reservoirs and main-line canals, leaving to the farmers the business of building the distribution system. . . ." Well, no such luck, and Newell resorted to pioneer nostalgia to explain what had gone wrong. Earlier pioneers had been capable of making their own arrangements to get the water to their fields, but

> the characteristics of present settlers are in many respects entirely different from those of the older pioneer communities; there is not the cooperation which ruled the early pioneers; the class of people now attracted to the lands are not as capable of adapting themselves to the existing conditions and initiating the building of distribution works.

Submitting to this post-frontier failure of vigor and enterprise, the Bureau had to "dig canals and laterals aggregating thousands of miles in length," and to face the fact that "a great number of structures must be provided which were not anticipated—for example, bridges and road crossings."[16]

Like many others, Frederick Newell had learned that the agrarian dream was tough on its believers. In many ways, his complaints anticipated the question Richard Hofstader would raise: why would we think of American farmers as people driven by the intrinsic moral virtue of laboring in the earth, when so much of their actual behavior revealed them to be a variety of petty bourgeoisie, considerably more committed to market values and "unearned increments" in land values, than to moral virtue?

In his peevishness over the project settlers' default on pioneer virtue, Newell offered his own version of a lament that would become a familiar one for many engineers in the twentieth century, whose training had left them ill-prepared to deal with the human dimensions of the systems they designed. "The problem is largely one of human nature," Newell said in an archetypal version of the Engineer's Lament. "The problem, as now presented, is not so much one of engineering, or of soil or climate, as it is of purely human elements."[17]

One could say that the *Eleventh Annual Report* was its own exercise in justifying and rationalizing the expenditure of public resources to produce underwhelming results. But the *Eleventh Annual Report* is still a remarkable document for an agency to reckon with in its heritage. In this report, Reclamation's leadership acknowledged and admitted a lot of problems, and thereby got the jump on their latter-day critics. Cost over-runs, problems of drainage, market uncertainties, difficulties in crop selection, wasteful applications of water, tensions with settlers: all these matters got their "public record" exposure barely ten years after the agency's creation. If you return to the "roots" of the Bureau of Reclamation, you find quite an unusual official act of admission of error and misconception. The tone of the *Eleventh Report* was so entirely the opposite of bluff and bravado that one almost wishes it could be made available as a kind of example, template, or role model for organizations today, both governmental agencies and non-profits. Rather than a demonstration of excesses of confidence, the *Eleventh Report* recorded an awareness, not of problems foreseen, but problems already manifested and acknowledged.

"Better quality hindsight" could remind both Reclamation's employees and its critics of this component of the agency's heritage. The swaggering and boasting came later—beginning with the Hoover and Grand Coulee dams, and continuing through Floyd Dominy's time as commissioner. By a certain interpretation of chronology, the era of arrogance was the anomaly—though, heaven knows, an enormously consequential anomaly for the Western environment. By that interpretation, when the Bureau shifted in the last decade and a half to a more modest agenda, making a degree of peace with the end of the era of big dam building, it actually returned to its roots, repossessed its pre-imperial heritage, and recaptured an older willingness to face up to its limitations.

Of course, this was not the preference of many of its career employees. These changes have been matters of political expediency, responses to changing moods among voters and members of Congress. In fact, the hundred years of the Bureau of Reclamation offer their own focused case study in the American West's awkward relationship with the engineering profession. Engineers—mining engineers, dam engineers, electrical engineers, highway engineers, construction engineers, civil engineers, automotive engineers, chemical engineers, foresters (for some reason not called "forest engineers")—have played an enormously important role in setting up the material circumstances of our comfortable and complacent lives. From the point of the view of the engineers themselves, the last century of history could be summed up in these terms: for several decades, society said to the engineering profession, "Create an infrastructure that will supply us abundantly with food, water, electricity, fossil fuels, and roads," and, when that product was delivered, a growing segment of society declared, not its appreciation and gratitude, but its disgust with the injuries done to ecosystems, landscapes, and environments. Engineers, with their minds on technical matters, have been understandably "challenged" when it comes to figuring out society's mandate. It is easy to understand their frustration with the stance of many of the West's contemporary water and power users, a stance that seems to add up to "Make it possible for us to live in comfort, but keep any ugly impacts out of our sight." The terms of an honest and fruitful relationship between a democratic society and the engineering profession remain, in 2002, very much on the drawing board. Lessons drawn from the first hundred years of the Bureau of Reclamation should surely play a part in the redesign of that relationship.

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Endnotes

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2. Letter of Transmittal, *1979 Annual Report*, iii; *1989 Annual Report*, i; *1997 Annual Report*, 1.
3. *2000 Annual Report*, 12, 29, and 30; *Third Annual Report, 1903-1904*, Second Edition, 43.
4. *2000 Annual Report*, 119-21.
5. *First Annual Report, 1903-1904*, 16. References to work with tribes become very central indeed in the most recent reports.
6. Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water* (London: Secker & Warburg, 1990), 119; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985), 170-1.

7. *First Annual Report for 1902-1903*, 11.
8. *First Annual Report for 1902-1903*, 14.
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10. *First Annual Report for 1902-1903*, 17, 18.
11. *First Annual Report for 1902-1903*, 31-2, 44, 70.
12. *Second Annual Report for 1903-1904*, 21; *Third Report for 1904*, 5.
13. *Seventh Annual Report for 1907-1908*, 11; *Third Report for 1904*, 44.
14. *Eleventh Annual Report, 1911-1912*, 2.
15. *Eleventh Annual Report, 1911-1912*, 2, 3.
16. *Eleventh Annual Report, 1911-1912*, 3, 5.
17. *Eleventh Annual Report, 1911-1912*, 16.

From the Colorado River to the Nile and Beyond: A Century of Reclamation's International Activities

By:
Richard H. Ives
and Robert M. Bochar

Since the earliest days of the Bureau of Reclamation (Reclamation), there has been an international component to what essentially has been a domestic program. The development and management of the water resources in the western states have been the primary mission of Reclamation since 1902, although we have routinely ventured outside our borders to learn from and assist other countries.

Just as the map of the world has changed dramatically over the course of Reclamation's lifetime, so has the nature of Reclamation's international involvement. Reclamation employees have worked in more than eighty countries, either on short-term temporary assignments or as part of longer-term resident teams.

Most of Reclamation's international activity has been in the semi-arid or arid regions of the world, primarily in developing countries. Reclamation's overseas presence has also mirrored America's international experience, with the bulk of the activities occurring since World War II (War). Following the War, many large-scale foreign assistance programs emerged for both post-War reconstruction and Cold War efforts to combat the spread of communism.

Like the domestic program, Reclamation's international activities have evolved to meet changing economic, environmental, and political realities. Sometimes dramatic or day-to-day changes have occurred in the International Program due to sudden shifts in U.S. foreign policy, the vagaries of funding, and rapidly changed political conditions in host countries. While we refer to an International Program (Program), this may conjure up an image of an orderly package of interrelated international activities, however, for the most part, that is not the case. The Program comprises an ever-changing array of unrelated international activities and projects which are quite diverse in their nature and objectives.

This paper is not intended to be a comprehensive list of Reclamation's international activities; rather, its focus is to highlight some of the important trends, key initiatives or projects, and a few of the noteworthy people who have been involved with the Program. Although Reclamation has been involved in many hundreds of international activities, a list of some of the larger ones is available at http://www.usbr.gov/international. Finally, Reclamation's activities related to the international rivers shared with Canada and Mexico are largely components of the domestic program and will not be included here.

International Water Resources—Why and How Reclamation is Involved

The primary goal of Reclamation's current Program is designed to provide reimbursable technical assistance and training to assist other nations to better manage their water resources, while supporting U.S. foreign policy objectives, help in the acquisition of new or improved technologies from other countries, and assist American private sector firms in competing internationally.

The Program consists of three main parts: technical assistance, technical cooperation and exchange, and training and visitor programs.

- Technical assistance activities are designed to address specific needs that have been identified by the requesting country. Funds for these activities are generally provided by either the U.S. Agency for International Development (USAID), the World Bank, or the requesting country. Reclamation's technical assistance activities have comprised the largest share of the Program, but they almost always include an important training component which has been designed to upgrade the technical skills of foreign counterparts.

- Through technical cooperation and technology exchange, Reclamation seeks to improve its own capabilities through the exchange of technical staff and joint cooperative projects with international counterparts. Technology exchange activities benefit both partners and each side normally pays for its share of the activities.

- Reclamation also assists water resource agencies from other countries by providing training and visitor programs for their staff. Training programs are tailored to fit specific needs, and all costs are fully reimbursable to Reclamation. Additionally, Reclamation facilities are visited by more than 800 international water resource counterparts on an annual basis, and there is no charge for these short term visitor programs.

Individual activities comprising the current Program cover a wide range of topics, including dam safety, desalination, river basin management, construction supervision (for irrigation projects), water conservation, sedimentation, transboundary water resources cooperation, and integrated water resources management.

The Early Years

A movement to secure Federal funding for the development of irrigated lands in the West emerged at the close of the nineteenth century. It was recognized that some countries were significantly farther along in this arena, and efforts were made to learn from their experience. An engineer named

Herbert M. Wilson from the U.S. Geological Survey (USGS), traveled to Egypt and India in 1889 to inspect large-scale irrigation development and to obtain basic information that would be useful for establishment of an irrigation service in the U.S. This appears to be the first recorded international activity associated with the Reclamation program. Wilson, who had considerable experience conducting land surveys in the West, assessed the vast and sophisticated Indian irrigation works, with some 25 million acres (10 million hectares) of irrigated lands. He recorded the construction, operation, and maintenance costs for these projects, and noted the increased agricultural returns and opportunities for settlement provided by these vast projects. He also studied problems of drainage, salinity, silt, as well as transboundary water resources issues. With the passage of the Reclamation Act of 1902, Congress created the Reclamation Service which the Secretary of the Interior placed within the USGS, virtually assuring that Wilson's findings would be incorporated into the Reclamation program in the West.

In the first few years of the Reclamation Service, some twenty-five water projects were authorized for construction. Consumed by its own ambitious domestic program agenda, and lacking authority to venture into the international arena, Reclamation was involved in minimal international activity during its first few decades. As a side note, however, most of Reclamation's earliest Commissioners were extremely active internationally, before, during, and after, their tenures as Commissioner. However, absent legal authority, Reclamation employees were required to secure a leave of absence to undertake foreign consulting work.

Frederick Newell, who directed Reclamation from 1907 to 1914, traveled to the Isthmus of Panama in 1908 to assist in the engineering details of the Panama Canal. The large earthfill dams being planned by the Isthmian Canal Commission were very similar to those being constructed by Reclamation. His deputy, Arthur Powell Davis, who later became Commissioner of Reclamation (1914–23), had been involved in the Panama Canal investigations prior to his arrival at Reclamation in 1902, and he continued to serve on a board reviewing the feasibility of building the canal. In 1911, at the request of the Russian Government, Davis took a leave of absence to inspect a proposed irrigation project on the Amudarya River in Turkestan. Elwood Mead, Reclamation's Commissioner from 1923-36, spent eight years in Australia (1908-15) where he inaugurated a comprehensive water conservation and reclamation plan. During Mead's tenure as Commissioner, he took several extensive leaves of absence in order to provide assistance to other countries (i.e., Haiti, Cuba, and Palestine) on irrigation-related matters.

Several other Reclamation employees, including Chief Design Engineer John L. Savage, who became world renowned and highly sought, would also take leaves of absence to travel overseas to consult with foreign governments on various water projects.

While Reclamation was only minimally involved in providing direct assistance to others, the early exploits of Reclamation did not go unnoticed. A stream of foreign visitors came to the West to see Reclamation projects. Reclamation's 1911 *Annual Report* indicated:

> There have been an almost continual series of investigations of the work and its results by men both from this country and abroad. Nearly every foreign country having large areas of arid lands has been represented by visitors who have studied the works on the ground, and particularly the methods and analyses of cost. Official and unofficial representatives from Great Britain and its colonial possessions…from various portions of the German Empire, from Austria, Russia, Spain, and other European countries, and from Mexico and South America. These men have been interested not only in irrigation but in the control and conservation of flood waters.

And from Reclamation's 1920 *Annual Report*:

> Irrigation development of hitherto largely unused lands is becoming more and more prominent in Australia, South Africa, Canada, Brazil, Argentine [sic.], Russia, and other countries, and the works of the Reclamation Service have for many years attracted engineers and economists from all over the world. There can be no doubt that much of the stimulus for extended reclamation development of the arid regions of the world has been the direct result of first-hand study of the irrigation problem in the United States, and particularly that as exemplified by the work of the Federal Government.

The construction of Boulder (Hoover) Dam gave impetus to increased worldwide recognition for the skill and resourcefulness of Reclamation engineers. The year 1930 saw the first significant indication that engineering experts were looking to the United States for leadership in matters pertaining to water resource development. Some Reclamation engineers published technical articles that were picked up by newspapers abroad and Reclamation was overwhelmed by requests for additional information. Many who wrote were not content with simply reading about our dams and requested the opportunity to see these structures for themselves. This resulted in a steady stream of visitors who came to marvel at Hoover Dam and other Reclamation facilities. Between 1935 and 1941, more than 500 foreign engineers visited Reclamation projects. Visitors from India, England, France, Egypt, Germany, The Philippines, Thailand, and South Africa, came for varying lengths of time to learn Reclamation practices and procedures.

Reclamation's domestic program was continually evolving through the advancement of large dam design and construction, as well as establishing sustainable rural economies based upon irrigation. Its string of accomplishments in water resources development had encouraged others to want to follow in its footsteps, but the War would intervene and plans would be delayed.

World War II—A Catalyst for Change

The War resulted in restrictions on travel and strict security regulations, effectively curtailing virtually all of Reclamation's international activities. Reclamation's wartime effort focused on work conducted at the Denver laboratories where scientists, engineers, and technicians, who were ordinarily engaged in work on dams and canals, were called upon to design new ordinance and equipment, expedite production and delivery of war materials, and uncover evidence of sabotage in support of the U.S. war effort.

World War II, however, would also serve as a milestone for Reclamation in several important ways. It had diverted attention and funding away from Reclamation's water development activities in the West. The War had also left much of Europe, as well as other parts of the world, in need of reconstruction. The U.S. was moving forward to assume a leadership role in the international arena, a dramatically different position from its pre-War days of isolationism.

In another part of the world, Reclamation's international work began with assistance to China on the Three Gorges Dam on the Yangtze River. Long discussed by the Chinese, Reclamation agreed to assist the Chinese Government with the project, and sent John Savage to China in early 1944. During his six-month stay in China, Savage studied the hydroelectric and flood control possibilities for the Yangtze River and its tributaries. At the end of the War, a large number of Chinese engineers traveled to Denver to begin working with Reclamation staff on the design of the Three Gorges Dam. However, as a result of the ongoing Chinese civil war, the engineers were required to return to China in 1947, and work by Reclamation personnel on the Three Gorges Dam stopped.

Post-War Emergence of International Activities

The movement of Reclamation into the international arena was largely facilitated by broad changes in America's thinking about its international role. To a great extent, the changes were driven in the late 1940s by the Truman Doctrine and the Marshall Plan, which outlined America's strategy to fight the spread of communism and a plan for the reconstruction of Europe, respectively. Of particular importance was the U.S. Information and Educational Exchange Act of 1948 (Smith-Mundt Act), which authorized reimbursable technical assistance and training.

President Truman articulated his Doctrine in the Point IV Program, as an affirmative assistance program to help under-developed countries develop their natural resources as a means to resist threats to their freedom. Point IV, implemented in June 1950 by P.L. 535, was largely the beginning of today's foreign technical assistance program. P.L. 535 required Federal agencies to establish offices for the purposes of directing international activities. It also marked the establishment of the administering agency, a predecessor agency to USAID.

These instruments not only provided the legal authority for Reclamation to assist others, but provided goals and funding as well. Given this new mandate, it was apparent that guidelines would be needed for increasing Reclamation's international involvement. Thus, several key decisions were made, including the creation of a Division of Foreign Activities in March 1951, which would shape the Program in a form that has endured to this day.

Reclamation's domestic program would always have priority over international activities, unless the State Department (State) had indicated that a particular international activity would be in the national interest as part of the U.S. foreign policy. If that were the case, then consideration would be given to engaging in such activity, even though an adverse effect on the domestic program might occur. Reclamation continues to acknowledge the importance of meeting U.S. foreign policy objectives.


28.1. John L. Savage on the Yangtze River.

Reclamation was required to receive reimbursement for costs associated with undertaking international technical assistance and training since, lacking authorization, no funds could be sought from Congress.

While Reclamation strongly supported the notion of assistance to other countries, it determined that it would be inappropriate to initiate such activities, largely because it would raise concerns about private sector competition. In addition to requests for assistance from foreign governments, Reclamation has the wherewithal to respond affirmatively to requests from the Department of State (State), USAID, the United Nations, or an international financial institution such as the World Bank. (Note: In the late 1980s passage of various laws to permit technology transfer between United States Government (USG) agencies and the private sector authorized Reclamation to assist U.S. firms in competing for international work. However, in spite of numerous partnership attempts with American firms, Reclamation has seen only limited success here.)

The Flood Gates Opened—Dramatic Post-War Expansion

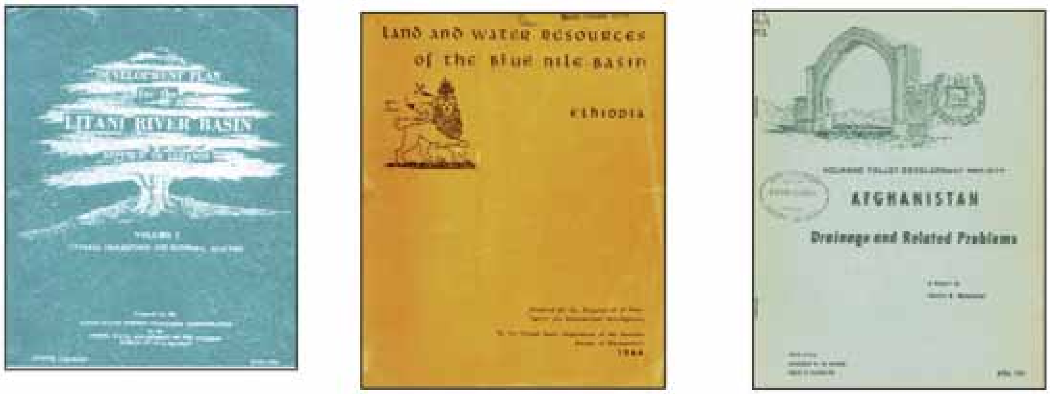
In the years immediately after the War, State received dozens of requests from other countries for assistance in irrigation and water resources development. While State would typically turn to Reclamation for assistance, it retained the lead role. Thus, Reclamation employees served as members of State-led teams addressing irrigation and power-related needs. By the late 1940s, a handful of Reclamation personnel were on long-term assignments in Afghanistan, Ceylon (Sri Lanka), Venezuela, Costa Rica, and El Salvador.

A full-fledged Reclamation-wide Program, with a budget of nearly $2 million (roughly equivalent to $13.5 million in today's dollars) emerged in 1952, after substantial amounts of Point IV funding had materialized. For the next few decades, Reclamation, with its characteristic zeal, contributed to the cause of providing for more food security for the free world. Commissioner Michael W. Straus (1945-53) stated, "wherever it can, Reclamation will continue to cooperate and contribute knowledge to the free world's warfare against want."
(See *Reclamation's Golden Jubilee* in the bibliography at the end of the paper.)

By 1952 Reclamation was working on planning studies involving projects in twenty-one countries, covering some seventeen million acres (6.8 million hectares) of irrigated land, and hydropower of more than 4,200 megawatts of installed capacity. The growth of the Program was so dramatic that the quantity of Reclamation's international work in 1952 exceeded the sum total of all that had occurred in the past. (*Reclamation's Golden Jubilee*)

Reclamation's early Post-War international work was characterized by some of the same basic features that are present in today's program. Reclamation's international activities always responded to the needs that were reflected in the incoming requests for assistance. The work covered a wide range of topics related to water resources development and management, including project planning, design and construction; irrigation management; drainage and land classification; sedimentation; and other topics. In addition, there was a tremendous difference in the level of effort between the individual projects involved, ranging from a temporary assignment of one employee for several days to Reclamation teams assigned overseas for a year or more. In some cases Reclamation would provide advisory assistance and merely assist counterparts in executing an activity, while, at other times, Reclamation personnel would perform specific tasks such as preparing a project appraisal report.

For the next two decades much of the focus of the Program was on planning studies in numerous countries, for entire river basins as well as individual water projects. Some of the larger or better known planning efforts focused on the Litani River Basin in Lebanon (1954-1958), Blue Nile River Basin in Ethiopia (1958-1964), Helmand Valley in Afghanistan (1960-1971), Han River Basin in Korea (1966-1971), Sao Francisco River Basin in Brazil (1964-1973), and the Mekong River Basin and the Pa Mong Project in Thailand and Laos (1964-1974). In Australia, Reclamation participated in the planning, design and construction of the Snowy Mountains Scheme (1951-1961). Each of these activities entailed the assignment of teams of Reclamation technical specialists overseas for several years.



28.2. Report covers from Resident Team Programs.

Reclamation's involvement with the Nile River goes back to the early learning years when we sought information on Egyptian irrigation systems. In the intervening century, Reclamation has provided technical assistance and training at varying times in the Nile River Basin to Egypt, Ethiopia, and the Sudan. Reclamation's Nile River experiences exemplify the nature of our international work, in that we have expended enormous effort over many years in assisting others, but we have had little control over the outcome. Ethiopia and the Sudan both experienced devastating civil wars and enormous political change after we had completed our technical assistance and training programs, thereby largely negating our efforts.

Reclamation has contributed to a wide array of project planning studies, however, many countries have undertaken only a limited amount of water infrastructure development due, in part, to the lack of funding, political changes, and changing environmental values. In addition, the inability of many countries to secure agreement with their neighbors on the use of water in shared international river basins has also greatly hindered development.

28.3. Ethiopia land classification work in Blue Nile. (Old Ways Meet the New)

Winds of Change—Foreign Policy Shifts and New Paradigm

By the mid-1970s the focus on broad-scale river basin planning efforts and large projects had waned in the Program. USAID's movement away from infrastructure development in the 1970s was probably the major cause of this shift in Reclamation's international activities, since USAID had been a major source of funding. Emphasis on water project development was being replaced

28.4. Reclamation advisors assist Pakistani counterparts in drainage work.

by greater diversity in the types of international projects and activities undertaken by Reclamation.

U.S. foreign policy shifts have also had direct impacts on the Program. The oil embargo of 1973 led to the establishment of a joint economic commission with the Kingdom of Saudi Arabia in 1974, with multiple USG agencies participating. Reclamation was soon engaged in a substantial technical assistance effort there with a resident team in the Kingdom. The focus was initially upon irrigation but it ultimately moved into the field of seawater desalination.

With the signing of the Camp David Peace Accord in 1979, foreign policy emphasis shifted to the Middle East, and Reclamation was soon engaged in several substantial efforts in Egypt. The massive American foreign aid program in Egypt resulted in a return to infrastructure development projects. Reclamation was asked to spearhead a twelve-year, $140 million effort funded by USAID to replace the Soviet-built turbines and electrical equipment at the power station of the Aswan High Dam on the Nile.

28.5. Aswan High Dam in Egypt.

Following resumption of normal relations and scientific protocols between China and the U.S. in the late 1970s, the Chinese would again request assistance from Reclamation with the design of the Three Gorges Dam. Due to changes in the U.S. policy, Reclamation in 1984 agreed to provide only limited reviews of some project studies and designs. Work continued off and on until late 1993 when other changes in domestic policies and priorities (i.e., environmental concerns) resulted in Reclamation deciding to cease its assistance to China on the Three Gorges Dam.

Imparting Knowledge—International Training Activities

Reclamation's international training has likely had the most lasting impact upon those who have received our assistance. Training began in 1920, when Reclamation opened its doors for formal training opportunities. The first official trainee was a South African engineer who spent one year with Reclamation before returning to a senior position in his irrigation department. When Mexico was embarking upon an extensive program of water development in the mid-1920s, it turned to Reclamation for technical assistance and training. One of the Mexican trainees would become head of the Ministry of Hydraulic Resources in 1946 and send many trainees to Reclamation after the War (Pratt, p. 3). Similarly, a young engineer from Afghanistan, M. K. Ludin, was a trainee for one year with Reclamation in the late 1930s. When he returned home and created the Afghani Bureau of Reclamation, he adopted many of Reclamation's policies with regard to repayment, acreage limitation, and multipurpose projects. He later became the Minister of Public Works and was instrumental in securing Reclamation's Post-War involvement in Afghanistan.

The phenomenon of young engineers who trained with Reclamation and later rose to senior positions back home was to become commonplace. This greatly contributed to the forging of close long-term relationships between Reclamation and other water agencies. While it is not always readily discernible, there are tangible foreign policy benefits to these relationships. The State Department, particularly during the Cold War, strongly endorsed the building of these bridges between nations and, even today, State continues to fund modest technical exchange programs for foreign visitors.

Reclamation's early involvement with Turkey was notable largely because a young trainee, Suleyman Demirel, who came to Denver in the late 1940s, was destined for greater things. He returned to become head of the Turkish Directorate for Hydraulic Works in the early 1950s, and he was soon instrumental in securing a resident team from Reclamation that assisted him in moving forward with an ambitious water development program. However, Demirel did not stop there, and later became Prime Minister on seven occasions, starting in 1965, and later he became President of Turkey (1993). Undoubtedly our most famous trainee, a Reclamation delegation in 1996 visited Turkey at his behest to witness his country's water-related accomplishment.

28.6. Suleyman Demirel (middle row–center) with Reclamation Resident Team (kneeling in front).

Our formal training programs, which focus upon on-the-job instruction, have played a critical role in imparting Reclamation experience to others. Training programs have also been changing in recent years due to the high costs associated with providing long-term training. Thus, Reclamation has been transitioning to technical seminars and workshops, which have proven to be a cost-effective means of providing programs to a large number of trainees.

Reclamation has been offering international workshops and seminars related to specific technical topics, including dam safety operations, integrated water resources management, and canal automation techniques.

Technical Cooperation and Exchange

While assisting others has largely held the spotlight in the Program, especially through long-term technical assistance and training programs, Reclamation has also sought to broaden its own horizons through contact with others since Wilson traveled in 1889. There are numerous documented instances where Reclamation has acquired improved technical capabilities for application in the domestic program through international cooperation. For example, several Reclamation engineers recently traveled to Sweden to review new power-related technologies and to South Africa to observe Israeli-made evaporative devices for potential application in the Salton Sea Restoration Project.

While Reclamation has been involved in several formal technical cooperation and technology exchange programs (e.g., Israel and Spain), in most cases these activities are carried on informally. Formal programs usually entail an agreement between Reclamation and a counterpart water agency setting forth mutually-agreed-upon activities and goals. Even in the arena of technical cooperation, where Reclamation usually seeks partners on an equal technical footing, foreign policy objectives can play a dominant role. Reclamation's involvement was solicited by State some years back in technical exchange programs involving the former Soviet Union and the People's Republic of China. These programs were designed by State in order to keep lines of communication open and facilitate cooperation between the participants.

The U.S.-South African Binational Commission (BNC) is another, more recent example of a technical cooperation program with strong foreign policy overtones. The BNC was initiated in 1995 by State to bolster the fledgling South African Post-Apartheid Government. Water quickly emerged as an area of interest for the South Africans, and Reclamation was tapped to coordinate the USG effort. There have been a series of exchanges between Reclamation and the Ministry of Water Affairs and Forestry focusing upon a variety of water management topics, many of which have been funded by State.

A New Game Plan—Water as a Means to Promote Cooperation

At the first meeting of the Working Group on Water Resources (WGWR) in the Middle East Peace Process in April 1992, State and its USG water agency partners, including Reclamation, became involved in an interesting and uncharted odyssey that is now almost a decade old. From the outset, State chaired the WGWR and requested Reclamation's assistance to help move technical activities forward. The well-established relationships between Reclamation and water agencies in other key countries involved in the WGWR, and Reclamation's credibility, were useful to State. Reclamation was tasked by State, in 1995, with taking the lead to support an Arab (Omani) WGWR initiative in desalination. For several years, Reclamation technical experts played a pivotal role in virtually every phase of the establishment of the Middle East Desalination Research Center (MEDRC).

The success of water-related activities in the Middle East Peace Process led State to the conclusion that water can be an effective catalyst to promote cooperation between nations. State recently embarked on a program to reduce potential international transboundary conflicts in selected river basins. Reclamation was asked to take the lead in three State-funded initiatives, including ones focused on: the Okavango River Basin in Southern Africa; the Senegal and Niger River Basins in West Africa; and Lake Malawi in East Africa. Reclamation has also been requested to assist in several other activities relating to international water resources-related cooperation involving several countries. In each case Reclamation will offer short-term programs designed to demonstrate the principles of water-related cooperation and integrated water resources management.

The Future—New Challenges

Will there be a need for Reclamation in the international arena in the future? The data regarding water, that is, water scarcity, water for population growth and food security needs, water quality degradation, and others, are bleak. Water is a resource that is in extremely short supply in many regions of the world. Readily available and affordable new water supplies are simply absent. Reclamation continues to be a world leader in a variety of areas related to water resources development and management, and we have a broad array of skills and experience to share that could help make a difference.

So what will the future Reclamation International Program look like? It is likely to look both similar to and nothing like the past! It will be similar to the past in that there will be wide variety of ever-changing external inputs impacting the nature and size of the program. Foreign policy shifts are likely to continue whereby foes can become friends and vice versa. A few years ago we were prohibited from cooperating with the Government of South Africa. Thus, it is difficult to predict the Program's future landscape because dramatic geopolitical changes occur overnight and with these changes, new needs and opportunities emerge. As an example, drought-stricken Afghanistan, where Reclamation had a resident team (1960-1974), is in desperate need of reconstruction and water issues are of major concern. With our broad range of expertise and previous experience there, Reclamation would be well-suited to assist, if funds were to become available.

Certainly Reclamation will continue to provide technical assistance and training to those in need, and to cooperate with others to address our needs.

We can say with certainty that we will fulfill the obligations set forth in our current agreements and commitments with our international counterparts, and we will move forward with activities already planned. We will need to continue to develop programs that are responsive to the needs of our international counterparts and consistent with the requirements and direction of Reclamation's domestic program and U.S. foreign policy.

While the horrific events of September 11, 2001, have caused considerable disruption in the Program, it is likely that it is only a temporary situation. Clearly, we must now address new topics such as security and heightened travel concerns that had not previously been considered, along with the continuing need for funding. History shows that we have adjusted and adapted to new ways of doing business that did not compromise the Program. We will need to be innovative, alert to the winds of change, and responsive to help meet some of the world's water resources challenges in the future.

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In addition, we would like to acknowledge the efforts of the many Reclamation employees who have contributed so much to the International Program over the years. While many romanticize about foreign travel, there are routinely many challenges and obstacles to surmount in living, working, and traveling overseas. That so many employees have repeatedly contributed to the International Program in several different countries is testimony to their desire to make a difference.

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Farms for Veterans: Reclamation Settlement Policies and Results Following the World Wars

By:
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Abstract

Between 1946 and 1964 the Bureau of Reclamation opened over 2,800 farms on federal reclamation projects in Wyoming, Idaho, Washington, Oregon, California, and Arizona. In 1944 Congress had granted veterans a 90-day preference right in applying for homesteads on reclamation projects. Thus, most who filed on these lands had served in the armed forces. In an effort to maximize the veterans' prospects for success as homesteaders, the Bureau drew upon over four decades of experience in creating irrigated homesteads in the West. Particularly the lessons learned by the Bureau in offering farms to veterans following World War I provided a springboard for the Bureau's post-World War II efforts.

Barely sixty percent of the 1,311 settlers who homesteaded on reclamation projects following World War I obtained title to their farms. Of those who did prove up, 75 percent (or about 45 percent of all 1,311 original claimants) retained their farms until 1944—an impressive rate considering the economic volatility of the 1920s and 1930s. However, nearly half (46 percent) of those who had gained title to their homesteads no longer farmed the land themselves in 1944. Persistence rates were greater on the highly productive Klamath Project, where 65 percent of the homesteaders who had proved up continued to farm their land in 1944, than on the North Platte Project in western Nebraska and eastern Wyoming, where only 19 percent still farmed their land.

Bureau employees identified a lack of capital, defects in the farms themselves, inexperience or lack of commitment on the part of the homesteaders and poor health as key reasons for the high attrition rates among post-World War I homesteaders. In an attempt to surmount these obstacles Congress in 1924 authorized the Secretary of the Interior to screen applicants for homesteads on the basis of industry, experience, character, and capital. It also required the Bureau to conduct more careful surveys of the land itself before projects were approved. Both in the 1920s and the 1940s Congress rejected proposals from the Bureau for greater technical assistance and monetary assistance to homesteaders.

Working within the limitations imposed by Congress, the Bureau endeavored to improve economic opportunities and increase residential stability on lands that it opened to homesteading following World War II. In many cases, local examining boards undercut the effectiveness of the screening process for prospective settlers, opting to award homesteads to veterans who possessed very little capital. The screening process did insure that most homesteaders possessed some agricultural experience. Thanks to more careful preliminary studies, veterans generally enjoyed superior farming opportunities on the Bureau's projects in the 1940s and 1950s than their counterparts had received in the 1920s.

Notwithstanding the Bureau's more careful preliminary investigations, enough poor units were included in the post-1945 projects that Congress enacted Public Law 258 in 1953, providing for exchange of submarginal homesteads on reclamation projects. The law was largely inspired by the Bureau's most glaring postwar failure, extensions of the Riverton Project, where seepage and alkaline soils made it impossible for over one-third of the postwar settlers to support themselves.

Despite the Bureau's intent to award farms to individuals who planned to spend their lives on the farm, many who obtained land actually regarded it as a speculative investment. Others who may have intended to reside permanently on the farm became discouraged by the rigors of homesteading or were enticed to leave by the prospect of higher wages or a higher standard of living off the farm. For a variety of reasons, then, many post-World War II homesteaders quickly moved away from their farms.

The percentage of homesteaders who retained their lands roughly two decades after they had been homesteaded was actually higher for the post-World War I cohort on the Klamath and North Platte projects than for the post-World War II group on the Minidoka, Klamath, or Yuma projects. Absentee ownership, however, was less common among the post-1945 cohort than among the 1920s homesteaders. Whereas only 15 percent of all the veteran homesteaders at North Platte and 37 percent of the veterans who homesteaded in the 1920s on the Klamath Project continued to occupy their lands 20 years later, 44 percent of the post-1945 homesteaders on the Klamath Project and 30 percent of the post-1945 homesteaders on the Yuma Project still resided on their farms 20 years after they had filed upon their lands. In this sense at least, the Bureau's efforts to reduce speculation and tenancy by screening settlers and improving the quality of opportunities on its projects had succeeded.

Shortly after World War II ended, 1,305 veterans applied for 86 irrigated homesteads on a federal reclamation project in northern California. One applicant, a Japanese American who had sustained 105 shrapnel wounds on the battlefield in Italy, aptly articulated the allure of a homestead for many veterans. "My entire life up to this moment has been spent on a ranch and it is my wish to keep on being a bona fide farmer," he wrote. "Farming is all that I know.… With a ranch of my own I would have complete freedom of doing as I please…I have much to work for, and the will to succeed is urging me ahead. Obtaining a homestead site will greatly reduce the strain on me. Let me assure you that my utmost desire is to make this project a success and to be one of the many who are planning to make this home community one to be proud of."[1]

This young veteran hoped to win the opportunity to participate in a belated, little-known flurry of homesteading; between 1946 and 1964, an era when homesteading was generally no longer permitted, the Bureau of Reclamation opened over 2,800 farms on federal reclamation projects to veterans in Wyoming, Idaho, Washington, Oregon, California, and Arizona. In an effort to maximize the veterans' prospects for success as homesteaders, the Bureau drew upon over four decades of experience in creating irrigated homesteads in the West. Particularly the lessons learned by the Bureau in offering farms to veterans following World War I provided a springboard for the Bureau's post-World

War II efforts. This paper examines the Bureau's efforts to improve its homesteading program from the 1920s to the 1940s and to counteract or surmount obstacles that had plagued veterans homesteading on its projects following the First World War. It surveys key differences between the Bureau's post-World War I homesteading program and its counterpart following the Second World War and traces some of the reasons for those differences.

Following World War I the Department of the Interior received 196,000 inquiries regarding settlement opportunities on western reclamation projects. In February 1920, responding belatedly to the demand for farms, Congress through Public Resolution 29 granted a 60-day preference right to veterans in applying for homesteads on public lands, including federal reclamation projects. The preference period was later increased to 90 days. Although most veterans who had written to the Department of the Interior were no longer interested by the time that Congress belatedly acted, 10,875 would-be homesteaders applied for 1,311 farms that were opened to settlement on reclamation projects over the next 20 years. Particularly from 1920 to 1922 lands opened to entry were awarded almost exclusively to veterans. Most of these new farms were located on the Klamath Project in California and Oregon and the Shoshone and North Platte projects in Wyoming. The farms were awarded by lottery.[2]

The post-World War I homesteading frontier had its share of impressive success stories. Take the case of Frank Vancluira, one of eighty veterans who took up homesteads on the North Platte Project's Fort Laramie Division early in 1920. A Bohemian immigrant who had moved to the United States in 1911, Vancluira farmed in New York and Nevada and worked in a sausage factory before joining the Army in 1917. One of his legs was severely injured during the war. With $2,000 in capital and a monthly pension from the Veterans Bureau as a result of his wartime injury, Vancluira managed to develop his farm and construct a home without having to borrow money. His knowledge of irrigation as a result of his previous farm work in Nevada, combined with his industriousness and good fortune in receiving an exceptionally fertile homestead, allowed him to prosper. Within four years his farm was valued at $10,000—far beyond the amount of money he had invested in the place.[3]

Despite the success stories, barely sixty percent of the 1,311 homesteaders on reclamation projects during the inter-war years obtained title to their farms. Of those who did prove up, 75 percent (or about 45 percent of all 1,311 original claimants) retained their farms until 1944—an impressive rate considering the economic volatility of the 1920s and 1930s. However, nearly half (46 percent) of those who had gained title to their homesteads no longer farmed the land themselves in 1944. Persistence rates were greater on the highly productive Klamath Project, where 65 percent of the homesteaders who had proved up continued to farm their land in 1944, than on the North Platte Project, where only 19 percent still cultivated their land.[4]

The high percentage of homesteaders who departed without proving up, coupled with the failure of many veterans to farm the land after they gained title to it, concerned the Bureau of Reclamation. Andrew Weiss, superintendent of the North Platte Project, was assigned by Commissioner Elwood Mead to investigate the reasons for the homesteaders' difficulties, focusing upon the Shoshone and North Platte projects. Weiss found that most veterans had arrived on the projects with insufficient funds. For instance, Sam Monaco, an industrious immigrant and World War I veteran, had come to the North Platte Project in 1920 with practically no capital. Monaco "made a very courageous trial for three years, being obliged to undergo every privation to get along." Unable to afford lumber for a pig pen or a hen house, he had sheltered the hens in his own shack and had dug a clay pit for the hogs. Despite his pluck, Monaco was eventually "forced to quit." No amount of ingenuity or hard work could compensate for his penury. Many homesteaders had rented out their farms after proving up, Weiss reported, because they needed more money than their farms could furnish. For instance, E. G. Phelps, a homesteader in southeastern Wyoming, who was described by the project manager as "a very fine type farmer" and a "splendid type of man" who was "intelligent and anxious to learn" had tried to farm and work part-time elsewhere but he had found he "could not make it" financially. Finally he opted to rent his farm and work full time as a power house operator in order to support his family. Weiss estimated that over half (53 percent) of the veterans, like Monaco and Phelps, who homesteaded on the Fort Laramie division in 1920 were poorly prepared financially for homesteading. Only about one in four had arrived with sufficient money for "the necessary fixed improvements" and the "necessary farm equipment and livestock."[5]

On the Frannie Division of the Shoshone Project in northern Wyoming, Weiss discovered that in 1924 only five of the 57 veterans who had taken up lands there in 1920 remained. Even on better farms that had been opened to settlement the following year, only one in five homesteaders remained. Weiss identified their principal impediment as "the lack of capital."[6]

In addition to insufficient capital, defects in the land itself such as poor soil, drainage problems, or unrealistically small farms handicapped some veterans. Hundreds of veterans took up lands in the Goshen Irrigation District in southern Wyoming between 1921 and 1927, and roughly one-fifth "had very little chance of success" because of "poor or submarginal" farms, project superintendent Frank Roush estimated in hindsight. Farming conditions were worst on the Frannie Division of the Shoshone Project, where 95 farms were opened in 1920 and 1921. In 1924 the president of the local water users' association reported that nearly two-thirds of the lands on the division were "practically valueless" because of seepage, alkaline soil and other problems. Draining the lands adequately would cost an estimated $30 per acre, but the land itself was valued at not more than $25 per acre. A commission appointed by the Secretary of the Interior to study reclamation concluded in 1924 that "the lands on the Frannie Division are of such low agricultural value as to make it impossible for them to pay the cost of operation and maintenance of the irrigation works much less to return the construction costs."[7]

Weiss reported that inexperience, coupled with underestimation of the rigors of farm life, had driven others from their farms. Roughly one in three veterans who homesteaded on the North Platte Project in 1920 had never lived or worked on a farm. "Too few of us knew much about irrigated farming when we started here," observed homesteader George "Doc" Haas, one of only nineteen remaining homesteaders in 1947 out of 130 who had come to the Goshen Irrigation District in 1921. "We had every kind of ex-soldier, from piano tuners to paper hangers.…We did not realize that there was no let-up in work, season after season."[8]

Other veterans quickly sold or rented out their farms after proving up because they had always regarded their homesteads as speculative property. Weiss's report showed that 35 percent of those who homesteaded on the Fort Laramie Division of the North Platte Project in 1920 had no interest in farming, preferred some other occupation, or disliked the country and therefore never intended to remain there. For instance, Paul J. Hall, a 30 year old veteran, was characterized by the project superintendent as "not hav[ing] much energy." He lacked capital, farming experience and had "no desire to farm." Moreover, his wife disliked farm life. Willard Wertman, a 35 year old homesteader who had grown up on a farm in Milford, Nebraska, only farmed his unit for one season. He "always seemed to dislike the country and was dissatisfied with nearly every thing in connection with his farm, the community and the government." F. W. Bosse, had been raised on a farm and was a "good worker" but by disposition "not a farmer." Similarly, T. J. Burchell, a railroad engineer and a druggist, "had no desire or qualifications as [a] farmer." Some had homesteaded largely for speculative reasons. A. R. Baker, who had constructed a 10x12 shack on his homestead, had come from a wealthy family but invested little if any capital on the place and engaged only in "poor and nondescript farming." A graduate of the Washington School of Finance, he worked as a financial expert and had only resided on the land long enough to acquire title. He had retained the land, though, "with hopes of higher values and oil boom."[9]

Poor health dogged other homesteaders like L. C. Anstine, a veteran with a fair education, farming experience, and a "good personality," who suffered from a wartime injury. The project manager gauged his prospects for success in 1924 as "poor" because of his "physical handicap" although he noted that Anstine had "made a creditable effort." Likewise, Bruce Morton, a 40-year-old veteran with farming experience, had made only "fair" progress as a farmer although he knew how to farm, was "industrious," and possessed a "good personality." Having been "gassed" while fighting in the trenches, he labored under a "severe physical handicap." The project manager believed Morton would "no doubt make a success if he were able-bodied and had sufficient capital."[10]

In Weiss's view, then, insufficient capital, defects in the land itself, inexperience, lack of commitment, and poor health largely explained the lackluster performance of most veterans who homesteaded following World War I. Twenty years after Weiss filed his report, his successor as project manager, Fred Roush, identified five reasons postwar homesteaders had abandoned their units on the North Platte Project. Roush believed the most important factor to be "poor and submarginal units," followed by "lack of financial aid" to the homesteaders during the farm development phase, the agricultural depression of the 1920s and 1930s, lack of managerial ability or ambition on the part of the veterans, and insufficient instruction of the settlers in irrigation and farming techniques by county agents or other qualified personnel.[11]

Shortly before Weiss completed his investigations of veteran homesteading and two decades before Roush offered his evaluation, the Fact Finders', a blue ribbon commission appointed by the Secretary of the Interior, had identified many of the same problems with homesteading in general on reclamation projects. In their report they had recommended that "new projects or extensions of existing projects should be authorized only after full information has been secured concerning the water supply, engineering features, soil, climate, transportation, markets, land prices, probable cost of development and other factors upon which the success of the project must depend." They had also advocated screening applicants for homesteads on the basis of their "industry, experience, character, and possession of a part of the capital needed in improving their farms." Additionally, they had recommended that the government provide agricultural and economic advisors and short-term, low-interest loans to settlers for livestock, equipment, and farm development.[12]

A conservative Congress in 1924 rejected the Fact Finders' calls for loans and agricultural advisors for settlers. In what became known as the Fact Finders' Act, Congress did stipulate that "no new project or new division of a project shall be approved for construction…until information in detail shall be secured… concerning the water supply, the engineering features, the cost of construction, land prices, and the probable cost of development." After gathering the requisite data, Congress instructed, the Secretary of the Interior must "ma[k]e a finding in writing that it is feasible, that it is adaptable for actual settlement and farm homes, and that it will probably return the cost thereof to the United States" before construction could proceed. Congress also authorized the Secretary of the Interior to appoint examining boards to review the qualifications of prospective homesteaders and to establish minimum qualifications for homesteaders on reclamation projects in terms of "industry, experience, character, and capital." After touring reclamation projects the following year, the Secretary, Hubert Work, concluded that "settlers should have enough capital to enable them to improve and equip their farms."[13]

Following passage of the Fact Finders' Act, the veterans' preference law remained in force through 1940, but the Fact Finders' Act now required all would-be homesteaders, including veterans, to meet minimum standards regarding industry, farming experience, character and capital. Examining boards consisting initially of the superintendent of the project, the county extension agent, and a prominent farmer or businessman residing in the area were appointed by the Bureau to review each applicant's qualifications. The Bureau required applicants to have at least two years of farming experience and to possess $2,000 in capital or assets such as livestock or farming equipment that would be as useful as cash on a farm. Examining boards were required to rate each applicant on the basis of character and industry, and the boards could require applicants to submit medical evidence of good health.[14]

From 1925 to 1937 the four variables—industry, character, farm experience, and capital—were weighted equally. After 1937, though, farm experience was weighted most heavily, followed by capital and then industry and character. While veterans continued to enjoy preference rights in all land openings, as veterans of the World War grew older and became better established, they no longer applied for all available lands. Extensive homesteading almost exclusively by veterans would not again occur until after another World War.[15]

Soon after the veterans preference legislation expired in 1940, western Congressmen including James Scrugham of Nevada and John R. Murdock of Arizona discussed the possibility of extending these benefits for veterans over another two decades. In 1944, with national interest in the returning veterans crescendoing rapidly, Murdock believed the time had come to publicize the desirability of reclamation for veterans. As the House Committee on World War Veterans' Legislation held hearings in the Spring of 1944 on Senate bill 1767, the Servicemen's Readjustment Act (G.I. Bill of Rights), Murdock capitalized upon Congress's interest in the future of America's soldiers and scheduled a meeting with the committee. He reminded them that "after every war our veterans have been taken care of in the public domain, lying in the West." Murdock proposed an amendment to the GI Bill which would entitle veterans to preference over all other applicants for homesteads on reclamation projects. The amendment also sought to enhance the veterans' chances for success by waiving over half of each homesteader's share of the Bureau's cost of constructing the irrigation system. After discussing Murdock's amendment to the GI Bill, the committee discarded it. Some felt that Murdock's amendment had merit but should be considered as a separate bill because it dealt only with the West; others believed the proposal was "too generous."[16]

Three months after Murdock's abortive attempt to amend the GI Bill, J. Hardin Peterson, a representative from Florida who chaired the House Committee on Public Lands, introduced H.R. 5025 in June of 1944, granting preference to veterans in applying for public lands "under the homestead or desert land laws" or under a 1938 law which permitted citizens to file on 5-acre parcels of land. Partly because it made no mention of either the Bureau of Reclamation or the West but applied, in theory at least, to any public lands across the nation that might be opened to settlement, the measure attracted little attention or controversy. One day after H.R. 5025 had been referred to the Committee on Public Lands, Murdock as a member of that committee referred the bill without amendment to the House, recommending its passage and noting that a representative from the Department of the Interior had appeared before the committee to endorse it. Four days later the House approved the bill and submitted it to the Senate. Later that summer the Senate Committee on Public Lands and Surveys recommended passage of the bill and on August 13 the Senate acquiesced. On September 27 President Roosevelt signed the bill into law.[17]

With veterans preference for homesteading on public lands in place, the Bureau of Reclamation and its friends in Congress pushed for more. From their perspective based upon the experiences of post-World War I homesteaders, the veterans' preference law was defective. One defect was that it failed to provide for financial or technical assistance for the veterans. Warned one representative from the Bureau, "We feel that a man should be assisted sufficiently to increase to the optimum point his chances of success on the land.…I think we have had some failures on our projects that could have been avoided if we had given a little additional attention to getting the farm into production quickly and seeing that the farmer was properly coached in the methods of using his water."

29.1. Alfred Fincher and his family arrived on their veteran's homestead on the Vale Project nine days before this picture was taken in September 1936.

In tandem with John Murdock, officials in the Bureau worked to draft H.R. 520. Murdock introduced the bill in the Spring of 1945. Among other things, the bill authorized the Bureau to extend technical assistance to farmers on reclamation projects, permitted the Bureau to contract with settlers or with water users' associations for clearing and leveling land to prepare it for irrigation, and authorized "necessary" appropriations for these activities. The bill proposed other mechanisms for assisting the veterans financially: it permitted governmental agencies "authorized to make provision for the reestablishment of veterans in civil life" to become involved "to the fullest extent" that was legally and administratively feasible in extending "financial assistance" to the veterans "for the acquisition or erection of housing, farm buildings and adjuncts, improvements, equipment, chattels, and operating capital, and for transportation to the project."[18]

Referred to the House Committee on Irrigation and Reclamation, with Murdock as the chair, the bill was made the committee's first item of business. Through the committee's hearings, stretching from April 12 to May 22, Congress probed the relationship of veterans to federal reclamation.

Ultimately representatives of the Department of Agriculture expressed the most influential opposition to the bill. Praising the idea of veterans' preference, Secretary of Agriculture Claude Wickard sharply criticized the second section of the bill. That section authorized the Secretary of the Interior to purchase and sell lands within or near projects, to predevelop project lands including clearing and leveling them, and to provide technical and agricultural guidance and advice to settlers. Such provisions, warned Wickard, would "duplicate machinery already set up for the whole of agriculture in the Department of Agriculture" and would therefore be a "wasteful" use of governmental resources. As Representative J. Will Robinson put it, section 2 appeared to be "setting up some super-agency to take care of the veterans."[19]

As a result of these objections, the committee, in concert with representatives from the Bureau, altered the bill somewhat. The amended bill differed from the original in the sense that it extended veterans preference to those who had served during the First as well as the Second World War and specified the Veterans Administration as the government agency authorized to loan funds to the homesteaders. In response to concerns from the Department of Agriculture, the amended bill authorized the Secretary of the Interior to "obtain through or in cooperation with the State colleges and appropriate agencies of the Government guidance and advice for settlers on lands within the projects in matters of irrigation farming; and to disseminate information by appropriate means and methods," whereas the original bill had authorized the Secretary "to extend guidance and advice to settlers…and to disseminate information," without any reference to cooperation with other government agencies.[20]

Three months after receiving the committee's report, the House turned its attention to H.R. 520. President Truman had urged Congress to approve the bill in order to give "outstanding opportunities for returning veterans." As had been the case in the committee hearings, no one voiced opposition to the concept of veterans' preference. For instance, John W. Flannagan of Virginia, chair of the

House Committee on Agriculture, claimed, "We are all in accord that the veterans should be given preference in the purchase of this reclaimed land."[21]

Although rewarding the veterans seemed to be desirable to all, representatives voiced several arguments against other features of the bill. The foremost argument was that the bill, even as amended, authorized the Secretary of the Interior to become involved in agricultural training and technical assistance although the Department of Agriculture already had similar programs in place. The House Committee on Agriculture, which had met to review the bill that morning, had drafted an amendment eliminating all key provisions of the bill aside from the granting of preferential rights to veterans and the provision of information and financial assistance by the Veterans Administration. Irrigation and Reclamation Committee member Robert Rockwell noted that the committee had not even consulted with the new secretary of Agriculture, Clinton Anderson, who had opposed the bill in writing on the same grounds as his predecessor. Everett M. Dirksen of Illinois charged the bill unduly broadened the activities of the Bureau of Reclamation and the Department of the Interior, duplicating services which were already being furnished by the Department of Agriculture. Similarly, Clarence Cannon of Missouri opposed the duplication of services of two bureaus.[22]

Others objected to the bill's focus upon western lands, arguing that few genuine opportunities awaited the veterans on reclamation projects in the rural West. The bill would play "a dirty trick on the veterans," claimed Jessie Sumner of Illinois, forcing them into unwinnable pioneering situations rather than loaning them funds so that they could buy improved farms. Chester Gross of Pennsylvania questioned the wisdom of veterans' homesteading in the West.

> It induces them now to go out into the West on new lands, where rattlesnakes might bite their children and coyotes and wolves endanger the lives of their wives, and where their greatest asset is sunshine, which never pays mortgages or educates their children and where foxes will kill their chickens and crows pick the eyes out of any livestock that is born outside,

he claimed, concluding, "It is just not right." Rising to the challenge William Lemke of North Dakota retorted that "in many places east of the Mississippi River nothing worthwhile grows even if they have water."[23]

Committee members who favored the bill attempted to refute the criticism of their colleagues. The new Secretary of Agriculture clearly had not taken occasion to compare the former bill with the newly amended one, some insisted; he had merely repeated the objections of the former secretary, which had been addressed and resolved by the committee in redrafting the bill. Strenuously opposing the proposed amendment which would excise most of the bill, committee members argued that it would reduce veterans' preference to a meaningless gesture. Antonio Fernandez of New Mexico maintained that a veterans' preference law which contained no provisions for financial or educational assistance to homesteaders would be "nothing but an empty shell," similar to the preference right that veterans received after the First World War. John Murdock called the amended bill "a mockery" and Will Robinson of Utah warned that those who wanted to strike most of the bill and claimed to be "so strong for the veterans" were actually "leav[ing] a hollow shell for the veterans,… helping them with one hand but…taking everything away [with the other] that was given them by a committee that studied this bill for 3 or 4 weeks." Murdock agreed that "the powers of the Bureau of Reclamation are somewhat extended by the terms of this bill," but he maintained that this was necessary because the projects to be developed were "more difficult" ones with more "difficult engineering problems" than the first projects that had been developed.[24]

At length, opponents of the bill carried the day, although the vote was close. The House voted 76 to 68 to approve the first section of the bill, with its provision for veterans preference, but to jettison most of the other provisions, including any expansion of the Interior Department's jurisdiction. The amended bill was sent to the Senate where it was referred to the Committee on Irrigation and Reclamation, but the amended bill had no strong supporters in the House; after all the lip service that had been paid to the veterans, no one, it seemed, was very interested in this watered down bill's fate in the Senate. Certainly Murdock and his associates on the Irrigation Committee, along with the Bureau of Reclamation, saw no charm in such a limited bill. Perhaps their disinterest stemmed from their belief that the amended bill offered nothing substantial to veterans, although it still did confer preference rights and instructed the Veterans Administration to assist the homesteaders financially. Certainly the bill did nothing for the Bureau or for development of western lands. Preoccupied with other matters, the Senate committee never held hearings on the bill and never referred it back to the full Senate, and so the bill died.[25]

Despite the fate of H.R. 520, the principle of veterans preference still applied to public lands being opened for homesteading, including reclamation projects, due to H.R. 5025, the measure that had been approved without debate in the preceding year. Although Congress had refused to furnish the types of economic and educational assistance advocated by Murdock and the Bureau in the 1940s and the Fact Finders' Commission in the 1920s, strides had been made in terms of screening applicants for homesteads and requiring more rigorous reviews of the agricultural potential of proposed projects. Would these factors improve the quality of economic opportunities for World War II veterans on reclamation projects? Would a higher percentage of homesteaders gain title to their lands and personally cultivate them than had been the case following World War I?

The demand for farms following the Second World War was not as great as pundits during the war had forecast it would be. Nevertheless, the demand for farms, as reflected in applications, remained far greater than the Bureau could satisfy. Despite the fact that the general trend in American society involved leaving the farm behind, farm life, even on raw lands with the risks that it entailed, remained attractive to many veterans. On all projects excluding the mammoth Columbia Basin Project where most of the lands were offered for sale rather than as homesteads, the Bureau received a total of 66,296 applications (many veterans applied for a farm on several projects) for 1,422 farms between 1946 when the first postwar drawing was held and 1957 when 145 farms were awarded on the Northside Pumping Division of the Minidoka Project in Idaho. The ratio of farms to applicants in these drawings was nearly 47 to 1. The ratio of applicants to farms ranged from 8.5 applicants per farm in a drawing on the Riverton Project in Wyoming in 1947 to a high of nearly 309 applicants per farm on a block of land with 11 farms in the Columbia Basin in 1952. Desire for lands actually increased with the passage of time. Whereas the ratio of applicants to farms never topped 100 in the immediate postwar era, beginning in 1951 ratios of over 150 applicants to each farm were commonplace.[26]

With such high numbers of applicants, the Bureau seemingly possessed an ideal opportunity to weed out candidates who possessed insufficient capital or insufficient farming experience. Shortly after the war ended, however, local examining boards were given greater leeway in determining the amount of capital and degree of farming experience that would be required for those applying for homesteads on individual projects. Inasmuch as letters of recommendation submitted by the applicants regarding their character and industry were "invariably… favorable in tone" and "overworked such words and phrases as honest, reliable, morally above reproach, etc." capital and farm experience were the most objective and reliable criteria for determining the fitness of applicants for homesteading. While the policy of allowing local boards to adjust minimum requirements made the process more decentralized and democratic, it also imperiled the original purpose of the somewhat elitist and exclusionary standards: selecting homesteaders with the sufficient capital and experience to virtually insure their success.[27]

On the Klamath Project, site of the first land opening following World War II, representatives of local civic, veterans', and agricultural organizations met with Bureau officials to determine the prerequisites for would-be homesteaders. Under a system implemented by the Bureau in 1936, applicants for homesteads were rated on a scale of 100 points. Those with more than $2,000 in assets could receive as many as 10 points more than those who possessed only the minimum amount. Representing the interests of young, predominantly poor, land-hungry veterans the members of a nearby American Legion post protested, "The whole deal stinks, especially the ten thousand dollar clause." F. D. Rockbice, a World War I veteran who had homesteaded on the Klamath Project in the 1920s, expressed the prevailing sentiment. Rockbice argued that the capital requirements were "not…fair." "Because a man has 10 or 50 thousand does not make him a better farmer, a better man, or a better citizen than the little fellow who wants a home for himself and family and a chance to better himself," he maintained. Rockbice conceded that someone with lots of money would have "very little chance" of "fail[ing] to make good." But he believed the government should be more concerned with preserving the homestead law's intent, which was "to give the man that did not have a home a chance to make one." Ultimately those responsible for fixing standards for the 1946 applicants on the Klamath Project voted to scrap the flexible points system for capital requirements, although they decided by a margin of only one vote that it was "not only fair but necessary in order to assure the success to the entrymen" to require at least $2,000. By refusing to boost capital requirements beyond the level that had prevailed for two decades, though, the examining board increased the likelihood that homesteaders would fail; $2,000 in 1946 would buy far less than it could have bought ten years earlier. In 1948 on the Klamath Project, the examining board went even further, voting by a margin of 26 to 3 that applicants be permitted to substitute a credit rating for capital.[28]

29.2. In December 1946 Frederick Lehman congratulated Mr. and Mrs. Robert Metz on winning a drawing for a homestead on the Klamath Project.

The examining board on the Klamath Project nearly decided to scrap the farm experience requirement as well as the requirement for capital. At a meeting prior to a 1948 land opening on the project, a group of veterans who had constituted a local Veterans' Independent Action Committee opposed any attempt to exclude applicants on the basis of farm experience. Those with appropriate "intention, willingness and ability to learn" should not be penalized for their lack of actual farming experience, their spokesman maintained. Others attending the meeting agreed in principle but wondered how one could gauge intent accurately. One member of the examining board, Nelson Reed, believed that someone who had previously farmed and applied for a homestead would be more likely to "stick on the homestead," knowing in advance what they were getting into. "If he farmed before" and chose to apply for a homestead it was a good sign that he "ha[d] intentions of remaining on the farm." On the other hand, "if he ha[d] no previous farming experience," he would not be able to anticipate the rigors of farm life. How could the board "tell if he [was] sincere" enough to persist in the face of adversity? In "tough years," those without experience might not even "be able to stick it out" without the requisite agricultural skills, a representative from a local chapter of the Veterans of Foreign Wars suggested. At length, those attending the meeting chose by a slim majority to retain the requirement of at least two years of farming experience.[29]

Examining boards on other projects followed similar procedures in establishing minimum qualifications for applicants. The result was that the capital requirements varied considerably. On the Yuma Project, the examining board insisted upon $1,000 in cash and $1,000 in operating capital or assets. Applicants for farms on the Shoshone Project were only required to possess $1,000 in cash or assets and two years of farming experience, but those who possessed more capital (up to $2,500) or more experience (up to five years) were given priority over others. The examining board for the Boise Project required applicants to possess $3,500 in cash or assets that could readily be converted into cash, and stipulated that an applicant's automobiles and household goods could count for no more than $1,000 of that amount. Applicants for lands in the Columbia Basin near Pasco were required to have a net worth of at least $3,700.[30]

Although Congress had rejected calls for the Bureau of Reclamation to provide technical assistance to homesteaders, the Bureau did furnish some assistance and coordinated other assistance with other local, state, and federal agencies through its project land use or settlement specialists. The Bureau cooperated with Washington State College in producing a *Farmer's Handbook* for settlers in the Columbia Basin. The booklet contained information on a variety of topics including farm life, housing, climate, erosion, irrigation, weed control, and pest control. On the Shoshone Project, the Bureau arranged for settlers to use its machines, hand tools, and concrete forms free of charge in a laboratory to pour their concrete drops for irrigation ditches, with supervision from Bureau employees. Under development contracts, the Bureau also furnished prefabricated irrigation structures. Settlers could also borrow equipment such as portable sprayers from the Bureau for tasks such as eradicating weeds. In 1948 Bureau personnel on the project assisted forty-eight homesteaders on their farms with irrigating, surveyed and staked farm ditches on sixty farms, contracted with sixty-eight farmers for farm development work such as land leveling and land clearing, located fence lines on thirteen farms and worked up farm development plans for all 111 farms. Most settlers felt the technical assistance they received was sufficient. In a systematic sampling of 208 settlers on the Columbia Basin late in 1954, only 4 percent identified lack of advice or incorrect advice from public agencies as a major problem they had encountered, and only 6 percent perceived inexperience or uncertainty regarding the proper course to pursue as a major handicap.[31]

Whereas the Bureau succeeded in furnishing technical assistance and disseminating information it was unable to proffer settlers on its projects the capital they desired, although many settlers did obtain loans from the Farmers Home Administration. The level of capital needed by farmers had never been higher. On the Northside Division of the Minidoka Project the cost of clearing land, leveling it, constructing farm ditches, drops and other irrigation works and applying fertilizer averaged $57 per acre. Additionally the government estimated the cost of a modern home; farm buildings; machinery such as tractors, disks, grain drills, checkers, hay mowers and rakes; and domestic water supply at $17,500.[32]

With the exception of settlers on the unusually productive Klamath Project, most veterans found it difficult to secure financing from local banks. In a survey of farmers in the Columbia Basin, over one-fifth cited inadequate credit or capital as a key problem. The experiences of individual veterans illustrate their problems with insufficient capital. In their first year of farming in the Coachella Valley, Pearl and Wayne Mayfield "needed fertilizer bad[ly]" but could not obtain a loan for it because they "didn't own the land" and therefore could not use their farm as collateral. A banker in Moses Lake, Washington, told one veteran that he expected "the first three farmers on these farm units were gonna go broke before one made it…so they weren't gonna have anything to do with [the] farmers at all." The fact that many homesteaders were young and had no credit rating also made bankers suspicious of them. When Jake Colvin applied for a loan from a bank in Yuma, the banker inquired about his credit rating. "I said, 'Best in the world; I've paid cash for everything I ever bought in my life.' 'Well that's not credit. You've got no credit,' they said. 'We just can't loan money to somebody that doesn't have a credit rating.'" To establish a credit rating Elliott Waits borrowed a small amount from one bank in Yuma, deposited it in another, drew some interest, paid the remaining interest on the loan and then repaid the bank in six months.[33]

Alongside settler selection and provision of credit and technical assistance, critics of the Bureau's post-World War I homesteading program had pointed to the need for more rigorous evaluation of actual farming opportunities on the projects including water supply, soil quality, climate, and accessibility to markets. As evidence of the Bureau's more careful preparatory work, settlers in the 1940s and 1950s received contour maps for their farm units showing optimal locations for irrigation structures and detailed classifications of their soils. Reclamation Commissioner Michael W. Straus boasted in 1949 that "almost 100 percent of the new settlers make good." Straus was exaggerating, but veterans did generally enjoy superior farming opportunities on the Bureau's projects in the 1940s and 1950s than their counterparts had received in the 1920s.[34]

Notwithstanding the Bureau's more careful preliminary investigations, enough poor units were included in the post-1945 projects that Congress enacted Public Law 258 in 1953, providing for exchange of submarginal homesteads on reclamation projects. The law was largely inspired by the Bureau's most glaring postwar failure, extensions of the Riverton Project where seepage and alkaline soils made it impossible for over one-third of the postwar homesteaders to support themselves. Assistant Commissioner H. F. McPhail admitted in 1953, "The facts clearly show that large amounts of money have been expended for construction of irrigation facilities on the newer portions of the project without reasonable certainty that the soils were irrigable." Reporter Morton Margolin quoted an anonymous Bureau employee as saying that officials in the Bureau had disregarded warning signs and rushed ahead because "Congress and the Administration were alike in their desire to provide new farm lands as soon as possible" following the Second World War. "Political pressures dictated an expediting of construction, which prevented as thorough an investigation as the Bureau usually makes."[35]

Despite the desire of the Bureau and of local examining boards to award farms to those who intended to spend their lives on the farm, many homesteaders actually regarded their homestead as a speculative investment. Others who may have originally planned to make the farm their home became discouraged by the hardships of homesteading or were enticed by the prospect of higher wages or a higher standard of living off the farm. Turnover rates were lowest on the Klamath Project where the soil was richest. Ninety percent of the homesteaders there remained on their farms at the end of the first four years, and 43.5 percent remained in 1968, 20-22 years after the homesteaders had arrived. On other projects fewer settlers stayed. On the Minidoka Project by the end of 1960, seven years after the first settlers had arrived on the project, 72 percent of a cluster sample of 83 veterans who had acquired a farm prior to 1959 retained their land. Within 20-22 years of the veterans' arrival, 31 percent still owned the land. At Yuma Mesa, where the summertime heat was nearly unbearable, 75 percent of the first group of 54 homesteaders remained on their farms after two years. Ten years after the first settlers had arrived, 44 percent of them were still there, and after twenty years one-third of them remained.[36]

Looking back upon outcomes of homesteading by veterans following the First and Second World Wars, how do they compare? Of all the areas opened to homesteading following 1945, only the Riverton Project witnessed an extensive exodus of homesteaders during the first decade of settlement comparable to veterans' abandonment of the Shoshone Project in the 1920s. However, the percentage of homesteaders who retained their lands roughly two decades after they had been homesteaded was actually higher for the post-World War I cohort on the Klamath and North Platte projects than for the post-World War II group on the Minidoka, Klamath, or Yuma projects. Absentee ownership, however, was less common among the post-1945 cohort than among the 1920s homesteaders. Whereas only 15 percent of all the veteran homesteaders at North Platte and 37 percent of the veterans who homesteaded in the 1920s on the Klamath Project continued to occupy their lands 20 years later, 44 percent of the post-1945 homesteaders on the Klamath Project and 30 percent of the post-1945 homesteaders on the Yuma Project still resided on their farms 20 years after they had filed upon their lands. In this sense at least, the Bureau's efforts to reduce speculation and tenancy by screening settlers and improving the quality of opportunities on its projects had apparently succeeded.

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Endnotes

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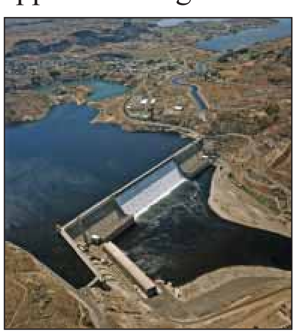
33. *Minidoka County News*, 26 May 1955; 7 May 7 1957; Pearl Mayfield, Interview by Brian Cannon, 20 May 1997; David Hunt, Interview by Brian Cannon, 18 August 1996; Carlos "Jake" Colvin, Interview by Brian Cannon, 24 May 1997; Elliott Waits, Interview by Brian Cannon, 23 May 1997, transcripts in author's possession.
34. *Riverton Review*, 4 December 1947, 29 September 1949.
35. H. F. McPhail to Regional Director, 17 December 1953, Folder Riverton 740, Box 402, Accession 115-66-AU0447, Federal Records Center, Denver; "Annual Project History: Riverton Project, 1953," vol. 36, mimeograph, 10, 75-7; Denver *Rocky Mountain News*, 8 August 1953.
36. Persistence rates on the Northside Pumping Division of the Minidoka Project were calculated using county real estate records for a cluster sample. This cluster sample includes all settlers whose patents were dated 1956 or 1957 and officially recorded in the Minidoka County Recorder's Office by July 15, 1959. Additionally, it includes patents dated 1958 for settlers with surnames beginning with the letters A-L that were recorded through page 71 of Minidoka County Patent Book 6. Persistence rates for the Yuma Project were calculated using Yuma city and county directories located in the Yuma public library. Persistence rates on the Klamath Project through 1952 are based upon a survey conducted by the Bureau of Reclamation in 1952 and reported in "Report on Progress of Settlers on Farm Units in Reclamation Projects Opened to Settlement, 1945-1952," Folder 730: "Lands Settlement and Land Entries, August 27, 1948-February 9, 1958," Historical Records, Bureau of Reclamation, Klamath Falls, Oregon. Information regarding settler persistence through 1968 was calculated from a list of the settlers attached to Reunion Committee to Mr. Lawrence, 11 July 1968, Folder 730: "Klamath Settlement (Homestead Reunion)," Bureau of Reclamation, Klamath Falls, Oregon.

From Water to Water and Power: The Changing Charge of the Bureau of Reclamation

By:
Jay Brigham

The United States Congress did two significant things in 1902, which at the time must have seemed completely isolated from one another. After great debate, Congress passed landmark legislation that established what we now know as the Bureau of Reclamation. Much less fanfare accompanied congressional authorization that instructed the United States Census Bureau to conduct the first, rudimentary, electrical census of the United States. It seems unlikely that many of those in Congress in 1902 who voted on these two authorizations foresaw the day when the Bureau of Reclamation (BR) and electrical generation would become closely intertwined.

Undoubtedly, establishment of the Bureau of Reclamation was the more important of these two congressional acts. For the next 100 years the Bureau brought water to many parts of the otherwise arid West. When the formation of the BR and the 1902 electrical census are considered together, however, they present an interesting interplay. Arguably, in 1902 irrigation and reclamation represented the nation's pastoral ideal and the Jeffersonian notion of the yeoman farmer. Irrigation would open new farmland for Americans to own and cultivate thus giving them a stake in society. Electricity, on the other hand, to many people represented modernity, if not urbanization, at the dawn of the twentieth century. Although some believed that electrical energy would result in decentralization, most people clearly associated electricity with cities and towns and such images as streetcars and great white ways. Electricity generated from water power became the source of much hope and debate in the first decades of the twentieth century leading to passage of the Federal Water Power Act in 1920 after years of intense political debate. The growing dichotomy between urban and rural after the beginning of the twentieth century resulted, in part, because of the growing use of electricity and the images associated with such use. This first occurred in public places with developments such as electric streetcars and street lighting systems and then in private settings through household lighting, heating, and appliance usage.



30.1. Grand Coulee, Hoover, and Glen Canyon Dams and their powerhouses.

The 1902 electrical census revealed that the total generating capacity of commercially- and municipally-owned central electrical stations hardly exceeded 1.2 million kilowatts for the entire United States. Five years later, the same generation capacity had increased nearly 125 percent to more than 2.7 million kilowatts.[1] By comparison, in the year 2000 the total capacity of BR dams in the seventeen western states that the Bureau serves surpassed 14.7 million kilowatts. That generation capacity included electricity from the federal government's largest hydroelectric dam, Grand Coulee (6.8 million kilowatts), from perhaps the most famous federal dam, Hoover Dam (2.1 million kilowatts), and from one of the most controversial federal dams Glen Canyon (almost 1.3 million kilowatts). Not all BR dams have such tremendous output. The power plant in the Bureau's project at Lewiston, Idaho, has a listed capacity of 350 kilowatts.[2]

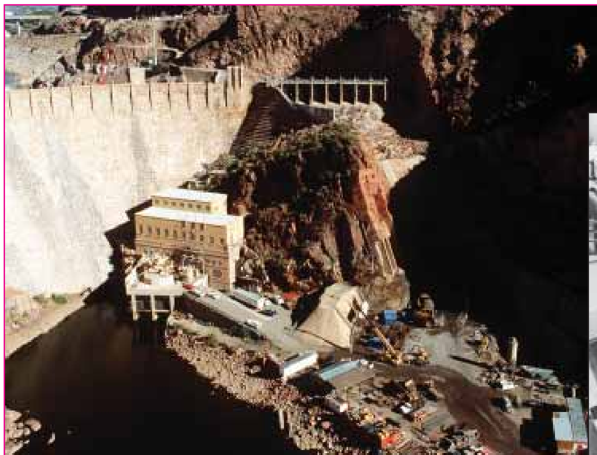
Originally charged with watering the arid West, the Bureau of Reclamation has become one of the country's largest generators of electricity. While water certainly remains the BR's primary objective, electrical generation provides considerable revenue. Examining the first three decades of the Bureau's history, from its formation through the passage of the Boulder Dam Act reveals how the Bureau's mission changed from water to water and power. The Bureau's concern with generation resulted not only from the need to have electricity to pump water, but also out of the emerging belief that the public should retain control of at least some of the nation's hydroelectric development. It also soon became apparent to Bureau officials that electrical generation could result in significant revenue. The Bureau's role in the construction of Hoover and later Grand Coulee Dams also fit well with the emerging view that the federal government should influence the development of the nation's development of electrical resources through the ownership of at least some large federal projects. Federal influence in this regard was exerted in other parts of the country through the Tennessee Valley Authority and later the hydroelectric development of the Saint Lawrence River. Only in the West, however, did reclamation and hydroelectricity become so closely intertwined.

Viewing the early history of BR electrical generation as five concentric circles drawn around a project provides an analytical model for understanding the growing role that electricity played in Bureau projects. Each new circle incorporates the existing circles, plus significant new functions. The innermost circle represents power projects built to facilitate dam construction. In those instances, electricity might have been used to power shovels, drills, and cement mixers. Such generation might have been water or steam power. The next circle represents electricity used for pumping water. Using electrically powered pumps resulted in a significant increase in the distance that the Bureau could move water. Electrical pumps meant that the Bureau was no longer dependent on gravity to irrigate land. The next circle, the third, represents electrical sales to parties that lived close to the dams. Although many of these sales involved relatively small amounts of electricity, they are important because the Bureau was selling surplus electricity. Dams were generating more power than projects required for operation.

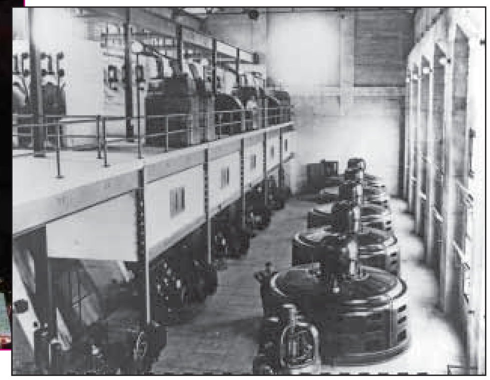
By the first decade of the twentieth century, electrical engineers had solved the impediments to the long distance transmission of electricity by using transformers and alternating current. Such breakthroughs were especially significant in the West where great distances often separated hydroelectric sites from population centers. These technological advances gave the Bureau the capability to transmit power beyond the immediate vicinity of dams. The ability to transmit power more than several miles, often over rugged terrain, resulted in the sale of Bureau power to municipalities and private power companies. Such sales represent the fourth concentric circle. By the mid-1910s, the Bureau's power sales had surpassed $500,000 per year. The fifth circle represents power generation and sales to larger cities with electrical generation being nearly as much of a factor in the political debates regarding project authorization as irrigation. Hoover Dam best represents the fifth concentric circle. Although an irrigation and flood control project, significant and divisive political debate concerning electrical generation, transmission, and distribution preceded Congressional authorization of the project. It is noteworthy that Pelton water wheels generate electricity for use at Hoover Dam, while the Bureau transmits electricity generated from the banks of turbines on each side of the river to distant cities. Although it is beyond the scope of this work to examine the Bureau's activities during World War II, during the war Bureau of Reclamation power developed a sixth circle, the interconnection of Bureau generated power into the developing western power grid.[3]

Congress passed legislation creating what became the Bureau of Reclamation on June 17, 1902.[4] The provisions of the law are well known and hardly need repeating. In ten relatively brief sections, Congress laid out the basis to provide water to the arid west. The act gave the Secretary of the Interior broad power to withdraw land and to authorize projects. The reclamation fund would finance projects. Landownership could not exceed 160 acres, and residency was required. Issues associated with electrical generation, transmission, and distribution do not appear in the law. The word electricity does not even appear in the statute. That all began to change within a few years.

The Salt River Project in Arizona was among the first reclamation projects that the Secretary of the Interior authorized on March 14, 1903.[5] The *First Annual Report of the Reclamation Service*, which covered the period from passage of the law to December 1, 1902, recognized the nascent power potential of the proposed project. The report stated, "[i]n the construction of a great dam one of the most important elements is power." Further discussion followed that included a brief description of the proposed power plant. This represents the first concentric circle. The writer reported that the power house would have a generating capacity of 1,200 horsepower with a fourth of that amount devoted to the cement mill. Bureau officials estimated the total cost of the power house at $215,260.[6]



30.2. Theodore Roosevelt Dam and Powerhouse.



30.3. A 1911 view of the Minidoka Powerplant.

The following year electricity appeared even more prominently in the Bureau's annual report. In discussing the Minidoka Project, another of the Bureau's original endeavors, on the upper Snake River in Idaho the report stated that the site presented an "unusually favorable" location for power development. The Bureau was considering three different plans for the project. The first had an estimated generation capacity of 9,545 horsepower, the second plan's estimated capacity was 11,820 horsepower, and the third plan could generate up to 17,500 horsepower (more than 13,000 kilowatts). The report stated that the Bureau could use electricity to pump water "above the gravity line" south of the river. If the Bureau did not electrically pump water, officials thought that a gravity system could only irrigate about 66,000 acres. Electricity greatly increased that potential. The Bureau estimated that under the first plan, it could irrigate 116,000 acres, while under the second plan an additional 10,000 acres could be irrigated. Finally, under the third, 17,500 horsepower plan, upwards of 172,200 acres would receive river water.[7]

The Bureau's second annual report also contained a section describing the proposed Shoshone Project on the North Fork of the Shoshone River in northwest Wyoming. Jeremiah Ahern, who conducted the project investigation, estimated that at two sites 9,000 horsepower might be generated.[8] The next several Bureau of Reclamation Annual Reports continued to discuss hydroelectric potential. The third and fourth annual reports reviewed the power potential on the following projects: Salt River, Klamath, Minidoka, Crow Reservation, Sun River, and Priest Rapids.[9]

During these early years of the Bureau of Reclamation some prominent national figures began to express concern over what they considered a waterpower monopoly. Gifford Pinchot, James Garfield, Franklin Lane, and others believed that the nation's waterways should be publicly developed to serve the greatest good. These individuals, usually considered as part of the growing progressive-conservationist movement, expressed alarm over what they thought was the purchasing and holding of water power sites for speculative purposes. In 1904 the Bureau of Reclamation addressed the problem in this statement:

> One of the difficulties encountered in putting the reclamation law into effect is the fact that speculative interests have filed upon, or are seeking to file upon, all possible sites for developing power.… The fact that the persons who file upon these water power sites are not compelled to utilize them or expend any considerable amount of money in their development enables a monopoly of this kind to be created at a small expense.[10]

At issue for the Bureau was the possibility that private power interests would monopolize the best dam sites, thereby securing water rights and effectively preventing new reclamation projects.

The same report contained a section titled "Power Development and Pumping," that discussed both hydropower and steam generated electricity for pumping purposes. An electrical engineer in Denver was responsible for making the studies of power possibilities of each project. The report then gave a state-by-state breakdown of the pumping and power possibilities thus far investigated, which included projects in Arizona (Salt River); California (Owens Valley, Yuma, and King River); Colorado (Uncompahgre Valley); Idaho (Minidoka); Nebraska (North Platte); Nevada (Truckee-Carson); New Mexico (Rio Grande); North Dakota (steam generated power); South Dakota (Belle Fourche); Utah (Utah Lake and Bear Lake); Washington (Priest Rapids); and Wyoming (Shoshone).[11]

These early annual reports indicate that a new reality was setting in at the Bureau of Reclamation that recognized electricity as an integral part of any proposed project. A circular letter dated February 2, 1904, discussed the changing situation. The letter stated that

> [t]he feasibility of a project may depend upon the possibilities regarding power development and use, and as much time should be allowed for studying this phase of the undertaking as for the investigation of other engineering questions.

The letter instructed consulting engineers to state in their reports if power development was possible, and if so, how much and for what uses. By issuing these engineering instructions, the Bureau had put electricity on the same engineering level as irrigation and flood control. A circular letter in May of 1904 addressed the concern about speculative withdraws of water power sites. The letter gave the Bureau's approval for withdrawal of potential hydroelectric dam sites if any "reasonable prospect" existed that the Bureau may use the site.[12] Effectively, the Bureau decided to make preemptive claims to protect potential project sites from speculative claims.

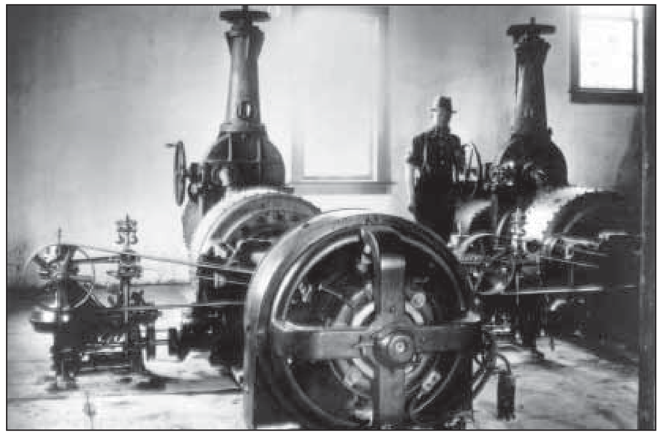
30.4. Bell type 116" turbine runner (Unit 1) at the Siphon Drop Powerplant on the Yuma Project in 1926.

Numerous factors caused the Bureau of Reclamation to reassess the importance of electricity. Independent of the Bureau, electricity was becoming a political, social, and technological issue in America. As increasing numbers of people used electricity, the need for additional generation became paramount. This, in part, led to the speculative purchases of potential water power locations. Water power itself seemed to represent an energy panacea since it did not require the transportation of fuel and once a dam was built supply seemed unlimited. Internally, the Bureau realized that electricity would allow it to irrigate more land then envisioned only a few years earlier. Technology would thus help promote the Jeffersonian yeoman farmer ideal. Bureau projects, especially Salt River and Minidoka, would soon generate electricity in excess of the requirements for pumping water. Surplus electricity meant dollars for the Bureau of Reclamation. Congress addressed the changing circumstances when it amended the reclamation law in April 1906. Section five of the 1906 law gave the Secretary of the Interior the right to lease surplus power for not more than ten years with a preference given to leases for municipal purposes. The government would place revenue from such leases in the reclamation fund and credit the money to the project that generated the electricity. Irrigation remained paramount, however, as a power lease could not "impair the efficiency of the irrigation project."[13] Fourteen years later, when Congress passed the Federal Water Power Act, it also contained a clause giving preference to municipal power systems.[14]

For the remainder of the first decade of the twentieth century electricity continued to increase in importance at Bureau projects. During these years, the Bureau also authorized construction of steam generating plants for pumping purposes at several projects. In May 1906, for example, the Bureau started receiving bids for construction of two steam turbines with a total capacity of 600 horsepower to pump water at the ably named Garden City Project in western Kansas.[15] Steam-driven generators later pumped water on the Williston Project in North Dakota.

Electrical power proved indispensable in the construction of another early project that featured a hydroelectric dam. After several years of study, the Secretary of the Interior authorized the Strawberry Valley Project in December 1905. Located southeast of Salt Lake City, the Strawberry Valley Project evolved out of the agitation of people in the area for irrigation water. Besides water, the project eventually supplied power to several small Utah towns. The project diverted water from the Colorado River watershed into the Great Basin through an

18,500-foot tunnel that carried water from the Strawberry River to the Spanish Fork River.[16]



30.5. In 1906 Reclamation had the exciters in place and ready for operation in the powerhouse on the Strawberry Valley Project.

The project involved two dams: a retention dam on the Strawberry River with a capacity of 250,000 acre feet and then a diversion dam on the Spanish Fork River. The Spanish Fork River dam diverted water into a three-mile long power canal before the water finally entered the irrigation works. Electrical energy proved crucial in construction of the tunnel. Initially workers used electric drills powered by gasoline burning generators to tunnel through the limestone rock. After workers had excavated 1,565 feet of the tunnel, work stopped to await installation of a more sophisticated electrical plant. Work resumed in December 1908 and workers used compressed air drills driven by electrically powered air compressors. Electricity lit the tunnel and helped with ventilation. The project's machine shop was equipped with electrically powered tools and equipment, and an electrically powered locomotive helped clear debris. A power line transmitted excess power to the town of Spanish Forks, which used it for electric lighting. The Bureau planned to move another transmission line built during the construction phase into the valley upon completion of the project and to use the line to carry power to pumping stations. The electrical system went online in January 1909 with a capacity of 3,000 horsepower.[17]

The year 1909 also was eventful in an electrical sense on other Bureau projects. During construction of the Roosevelt Dam on the Salt River Project, the Bureau had installed a temporary power plant that could generate 1,300 horsepower of electricity. Even before the temporary generator began generating electricity, engineers had made plans to install six 900-kilowatt generators in the permanent power house. The first three units began generating electricity in 1909 (unit one in June, units two and three in August). Although designed to power pumps, municipal and industrial customers bought Roosevelt Dam power most notably the privately owned Pacific Gas and Electric Company.[18]

While the permanent generators began producing power at Strawberry Valley and on the Salt River Project, the Minidoka Project on the Upper Snake River in Idaho also began generating electricity in 1909. Power possibilities were among the considerations when the Bureau conducted initial project studies in 1903. The Bureau later sold excess power for lighting, commercial, and industrial uses. In 1909 the Bureau had developed 6,000 horsepower of electricity on the Minidoka Project with another 4,000 horsepower under consideration. The power plant began operation in May 1909, generating power for the project's first pumping station. Water from electrically powered pumps irrigated 3,600 acres on the project in 1909.[19]

The Salt River, Strawberry Valley, and the Minidoka Projects all reveal the changing charge of the Bureau of Reclamation within the first ten years of its existence. Although on all three projects irrigation remained supreme, electricity has assumed an important position. The Bureau and Congress recognized this through new regulation and statute. On all three projects electricity allowed for the pumping of water in greater amounts and over greater distances. Electricity was especially crucial in the construction of the Strawberry Valley Project and to a slightly lesser degree the Salt River Project. In subsequent years, the sale of electricity, especially on the Salt River Project, would result in substantial revenue. In varying degrees, the first three concentric circles had developed around these projects: electricity for construction, electricity for pumping, and electrical sales to individuals and small municipalities. The foundation for the fourth circle, sale to municipalities had clearly been laid with installation of the permanent generating facilities at Salt River, Minidoka, and Strawberry Valley.

As the Bureau entered its second decade of existence, it continued to expand as it constructed more projects, some of which could generate hydroelectricity. The thirteenth annual report, which covered fiscal year 1913-1914, reflected a degree of contradiction in how the Bureau viewed power development. The report noted that projects on large rivers often had hydroelectric capability. Pumping underground water or surface water above the gravity line remained the Bureau's primary reason for power development. Beyond pumping water, the Bureau's interests in electricity, in order of importance, were dam construction, transportation of construction material, and then commercial sales of power. Having stated the Bureau's interest, the report then discussed the rates charged for commercial sales from the Minidoka Project, which were less per kilowatt hour than the rates charged for Niagara Falls power. This statement is of interest because, during the long debate over ownership of electrical systems, public power advocates often used rates at the government-owned plant at Niagara Falls as a yardstick to measure the rates of privately owned utilities in the United States. The report contained the Minidoka Project's rate schedule and noted the Bureau usually sold power nearly at cost.[20]

Data contained in the *Sixteenth Annual Report* shows the extent of the Bureau's electrical development. The Bureau operated thirteen power plants on nine projects. As shown in Table 30.1, those plants generated in excess of 100 million kilowatt hours of electricity. Power sold to customers approached 80 million kilowatt hours and resulted in revenue exceeding $623,000.

Table 30.1. Bureau of Reclamation Power Plants Operated during fiscal year 1916-1917.

Project	Plant	Capacity Kilowatts	Kilowatt Hours Generated	Kilowatt Hours Sold	Power Sales Revenue	Kilowatt Hour Cost.
Salt River	Roosevelt	10,000	48,112,800			
"	Cross Cut	5,000	9,612,000			
"	South Consolidated	2,000	6,148,400	60,964,565	$495,049.56	$0.01
Boise	Boise	1,875	4,228,720			
Minidoka	Minidoka	7,000	40,762,730			
"	Arizona Falls	1,000	2,745,660	17,009,555	$41,529.57	$0.00
Truckee-Carson	Lahontan	1,875	4,758,320	1,023	$16,331.86	$15.96
Rio Grande	Power plant	150	59,100	1,200	$52.21	$0.04
Strawberry Valley	Spanish Fork	850	1,043,661	939,365	$9,756.10	$0.01
Okanogan	Power Plant No. 1	187	6,870	6,870	$140.00	$0.02
"	Power Plant No. 2	187	11,310	11,310	$440.00	$0.04
Yakima-Sunnyside	Rocky Ford	187				
North Dakota Pumping	Williston	1,150	1,222,310	943,050	$60,561.00	$0.06
Total		31,461	118,711,881	79,876,938	$623,860.30	$0.01

Source: Bureau of Reclamation, *Thirteenth Annual Report, 1916-1917 (*Government Printing Office, 1917), 23.

Notes: For Salt River and Minidoka generation totals and revenue are project wide. Salt River units one, two, and three were not in service during fiscal year 1916-1917 according to the report. All plants were hydroelectric except Williston, which was steam.

Although the size of many of the plants listed in Table 30.1 is small by contemporary standards, many towns had similar size plants during the 1910s. The Bureau continued to look for additional sources of electricity. The information in Table 30.2 is also drawn from the *Sixteenth Annual Report*.

Table 30.2. Undeveloped power on Bureau Projects during fiscal year 1916-1917.

State(s)	Project		Kilowatts Minimum	Kilowatt Maximum
Arizona-California	Yuma	Drop in CA Canal	895	895
		Araz	6,714	6,714
		Laguna	2,984	2,984
California	Iron Canyon	Iron Canyon	26,110	26,110
	Orland	Drop, highline to South Canal	506	506
	"	Hat Creek	6,714	8,952
	"	Fall River	5,222	29,840
	"	Big Bend	111,900	111,900
Colorado	Grand Valley*	Main Canal	2,238	2,238
	Uncompahgre*	Various Sites	29,840	29,840
Idaho	Boise	Arrowrock Dam	7,460	14,920
	"*	Various Sites	1,417	1,417
	Minidoka	Minidoka Dam	7,460	7,460
	"	Head of Walcott Lake	22,380	22,380
Montana	Flathead	No. 1 Newell Tunnel	96,980	96,980
	"	No. 2 Buffalo Dam	28,348	28,348
	"	No. 3	14,174	14,174
	"	No. 4	52,220	52,220
	"	No. 5	11,190	11,190
	Huntley	Second Drop, Main Canal	205	205
Montana-North Dakota	Lower Yellowstone*	Lateral K.K. drop	234	234
Nebraska	North Platte*	Pathfinder Dam	12,682	44,760
Nevada	Truckee-Carson	Lahontan	3,730	3,730
	"	26-foot drop	2,163	2,163
New Mexico-Texas	Elephant Butte	Elephant Butte Dam	8,952	8,952
Oregon	Columbia River	Celilo Falls	373,000	596,800
	Deschutes	4 sites	67,140	74,600
	Silver Lake	Silver Creek	2,163	2,163
	Umatilla	Drainage Outfall	108	108
	Warner Valley	Deep Creek	1,492	1,492
	Willamette Valley	Santiam River and Marion Lake	10,444	10,444
	"	McKenzie River, 2 plants	22,753	22,753

	"	Middle Fork Willamette and Waldo Lake Storage	48,490	48,490
Oregon-California	Klamath	Various Sites	7,460	7,460
Utah	Strawberry Valley	Spanish Fork	1,119	1,119
Washington	Columbia River	Priest Rapids	149,200	149,200
	Okanogan	Salmon Creek No. 1	1,492	1,492
	"	Salmon Creek No. 2	1,902	1,902
	Yakima-Sunnyside	Mabton	98	98
	"	Main Canal	206	206
	Yakima-Tieton	Lateral E	2,544	2,544
	Yakima-Wapato	Drop 0	2,186	2,186
	"	Drop 1	3,046	3,046
	"	Drop 2	1,822	1,822
	"	Drop 3	1,110	1,110
Wyoming	Shoshone	Shoshone	29,840	29,840
Total			1,190,335	1,487,989

Source: Bureau of Reclamation, *Thirteenth Annual Report, 1916-1917* (Government Printing Office, 1917), 28. Notes: Asterisk indicates generation from irrigation flow only.

Several things are notable about the data in Table 30.2. Perhaps most significantly is the number of projects, twenty-eight, and the number of possible power plants, at least forty-six. The maximum capacity the Bureau thought these plants could generate (1,487,989 kilowatts) dwarfed the capacity of those plants already generating electricity (Table 30.1: 31,461 kilowatts). The Bureau was certainly thinking big, and that thinking was nowhere more evident then on the Columbia River. Estimates of a dam at Celilo Falls ranged from 1,190,335 to 1,487,989 kilowatts and the estimate for Priest Rapids was almost 150,000 kilowatt hours. The Bureau never did build dams at either of those Columbia River sites. The Grand County, Washington Public Utility District, with financial backing from public and private utilities, built a dam at Priest Rapids in the 1950s. The Army Corps of Engineers built The Dallas Dam flooding Celilo Falls, also in the 1950s. The Bonneville Power Administration transmits power from both projects on its lines.[21] A notable omission from the Bureau's list of potential waterpower sites was the lower Colorado River near Black and Boulder Canyons. That would soon change, leading to ever further expansion of the Bureau's hydroelectric capacity.

Calls for a dam on the lower Colorado River began shortly after the turn of the century from residents of California's Imperial Valley. People in the valley, who wanted a dam for irrigation and to help control the Colorado's devastating floods, began calling for a dam. In time, their demands coincided with the Bureau of Reclamation's plan to establish a comprehensive development program for the Colorado River Basin. Initial discussions usually centered on flood protection and irrigation as the primary reasons for such an undertaking.[22] Yet, many people were beginning to focus more attention on the river's hydroelectric potential.

In 1916 the Department of the Interior through the United States Geological Survey released Water-Supply Paper 395 titled, "Colorado River and Its Utilization." The report was a comprehensive study of the entire river and its watershed. The report contained extensive discussions concerning water supply, irrigation, river control, and water power. Overall, the river's short fall on many parts made much of it unfavorable for generating cheap energy. In some canyons, however, the river fell as much as fifteen feet per mile making those areas suitable for hydroelectric production. The report's author estimated that dams could generate nearly 1.5 million kilowatts of electricity without interfering with irrigation. An elevation profile of the Grand, Green, and Colorado Rivers in the study included a notation that read "Boulder Canyon power site."[23] Within a few years, interest in the river's power potential had spread beyond the federal government.

City officials in Los Angeles announced in 1921 their intention to secure future water and power supplies from the Colorado River, even if it the city had to build a dam on the river. Southern California Edison (SCE) and Southern Sierra Power joined the battle when they agreed that SCE would sell power to Southern Sierra from proposed SCE dams. Southern California Edison filed four applications with federal and state officials to build dams on the river.[24] E. F. Scattergood, the chief electrical engineer of the Los Angeles Bureau of Power and Light, later wrote public power stalwart Senator George Norris that a dam was "necessary to the continued growth of the southwest."[25]

In the early 1920s the Bureau of Reclamation again entered the picture. Congress had directed the Bureau to examine "possible irrigation development of the Imperial Valley in California."[26] The Bureau had done previous investigative work over the years regarding the Colorado River and Bureau Director Arthur Powell Davis used that material in writing his report. A map that followed Davis' transmittal letter to the Secretary of the Interior listed thirteen undeveloped power sites on the river, including the Boulder Canyon site. Also listed were twenty-five dams already built in the Colorado's watershed. In his proposed development program, Davis called for a high dam to generate electricity in addition to flood control and irrigation. Davis thought that the federal government should build the dam and then sell power for compensation. If that proved unfeasible, he thought the government should solicit public or private groups about constructing the dam. Davis' call for a high dam was important since irrigation and flood control did not require a high dam, such as the dam ultimately built.[27]

The river's hydroelectric potential received nationwide attention throughout the 1920s. William Randolph Hearst, for example, repeatedly used his nationwide newspaper chain to blame private power companies for blocking passage of Colorado River legislation. In 1924, during congressional debate over the second Swing-Johnson bill, the Hearst press claimed that a dam in Boulder Canyon could generate 600,000 horsepower of electricity.[28] The Hearst newspaper chain, with papers in eighteen major cities, recognized flood control and irrigation as the principal reasons for building the dam, but said that electrical production remained the major point of contention.[29] In 1928, when Congress finally passed the fourth Swing-Johnson legislation, the Hearst press called Boulder Dam the "billion dollar dam site"–and one of the biggest congressional prizes since Congress allocated railroad land tracts in the nineteenth century. If private power companies had won the prize, the Hearst papers said, they would have dictated the industrial development of the entire southwest.[30]

The discussions regarding potential Colorado River electricity must have been especially pleasing to businessmen in Los Angeles. By the 1920s electricity had become a focal point of the city's business community. Beginning in 1922 the Los Angeles Chamber of Commerce began publishing *Southern California Business*. Throughout the decade, magazine articles associated the continued growth of Los Angeles and the entire Southwest to the construction of a Colorado River dam. Commenting on the Colorado River Compact signed in 1922, one article said "few of us hoped for agreement between these seven great states whose future growth and expansion are intimately connected with and totally dependent upon the development of the Colorado river, both in hydro-electric power and waters for irrigation." An accompanying map showed nine potential power markets in Nevada, Arizona, and California.[31]

In the fall of 1925, *Southern California Business* featured articles that discussed the proposed dam site. "The truly important fact is this…Boulder Dam will guarantee adequate water and cheap power to the cites of Los Angeles, Pasadena, Glendale, and Riverside-and to the entire Colorado River Basin."[32] The Chamber of Commerce's president issued a statement presenting the Chamber's views on the proposed dam. The organization favored a high dam to prevent flooding, provide water, and to "make available a large volume of hydroelectric energy, an important necessity for agricultural, industrial and community development in the Southwest."[33]

During the years preceding authorization of Hoover Dam, the Bureau continued to develop hydroelectricity on other projects. In 1925 the Bureau operated twenty-two power houses on thirteen projects, as compared to thirteen power houses on nine projects in 1917. In addition to those projects and plants listed in Table 30.1, the Bureau operated the Lingle Plant on the North Platte Project, the Pilot Butte Plant on the Riverton Project, the Shoshone Plant on the Shoshone Project, and the Tieton Number One Plant on the Yakima Storage Project. These plants had a combined capacity of 4,020 kilowatts.[34] For the remainder of the decade only one more project, Yuma, began generating electricity. The Bureau did build several more plants on projects with existing hydropower generation that included the Guernsey Plant on the North Platte Project and the Mormon Flats, Horse Mesa, and Stewart Mountain Plants, all on the Salt River Project.[35]

Power sales remained profitable for the Bureau in the 1920s. In 1926 the Bureau placed the total amount spent on reclamation power development at $46,077,649. Gross earning in 1925 equaled $1,067,135 and net earning were $442,619. The Bureau said that the real benefit, however, was not financial, but the advantages that resulted from electrically driven pumps and draglines that improved irrigation. Home use of cheap Bureau power was another benefit to the projects.[36] The larger projects provided considerable income. On the Minidoka Project in 1928 revenue from electrical sales surpassed $150,000. For the same year, electrical sales on the North Platte Project exceeded $220,000.[37]

The Bureau's 1925 annual report listed the "principal" power contracts as of June 25, 1925. On some projects, power went to a single customer such as the Boise Project, which sold power to the Idaho Power Company, and the Newlands Project, which sold electricity to the Canyon Power Company. Power from the Minidoka Project, however, went to at least seventy-three customers that included the cities of Burley and Rupert, and the villages of Albion, Declo, Heyburn, and Minidoka. Minidoka power also went to several power companies and fifty-nine "small contracts" with revenue less than $1,000 a year. The Utah towns of Spanish Fork, Payson, Salem, and Springville bought electricity from another of the Bureau's original power projects, Strawberry Valley.[38]

Returning to the analytical idea of concentric circles focuses attention on the degree of electrical development on Bureau of Reclamation projects by the mid to late 1920s. Electricity was an integral part of dam construction and used for pumping water throughout the West; the first and second circles. The third and fourth circles, electrical sales to parties close to dams and to towns and cities some distance from power plants also had occurred. These sales provided the Bureau with substantial revenue by the mid 1920s.

People fought over issues that the fifth circle represents, sales to large cities with electricity a major part of dam authorization and construction, through much of the 1920s. The United States Geological Survey report in 1916 and the Bureau's report in 1921 both identified enormous hydroelectric potential in the areas around Black and Boulder Canyons on the lower Colorado River. The transmission of large amounts of Hoover Dam electricity to Southern California upon completion of the project clearly represents the fifth concentric circle. The change in the Bureau of Reclamation's mission from water to water and power is evident in the fourth Swing-Johnson legislation that became law in December 1928.

Whereas "electricity" did not appear in the 1902 law establishing the forerunner to the Bureau of Reclamation, "electricity" was prominent in the "Boulder Canyon Project Act" as it is officially titled.[39] The first sentence of the act read, in part, "and for the generation of electrical energy as a means of making the project herein authorized a self-supporting and solvent undertaking . . ." Another part of the first section required construction of a power plant at or near the dam "suitable for the fullest economic development of electrical energy from the water discharged from said reservoir . . ." Electricity was clearly an important aspect of the entire project. Electrical generation was not only a legally mandated part of the project, it was the means to pay for the project. This represented a dramatic departure from the Bureau's organic law and from the 1906 amendment allowing electrical sales and contracts. Instead of revenues from land sales financing project construction, electricity was the financial agent for the dam's construction and completion. Section 5(d) of the act reflected the realization that the power plant would generate great amounts of electricity for transmission to distant cities. In part, the subsection gave any agency with a contract for 25,000 "firm horsepower" or less the legal right to use the transmission lines of any agency with a minimum contract of 100,000 "firm horsepower," the equivalent of 74,600 kilowatts.[40] Essentially, the law said that smaller power users could use the transmission lines of the larger power users. This avoided duplicate power lines and saved money. More revealing is the anticipated size of the contracts, more than 74,000 kilowatts. By comparison, the Bureau's four original hydroelectric plants on the Salt River Project had a rated capacity of 18,000 kilowatts.[41]

In the years following congressional authorization of Hoover Dam the Bureau has built numerous other projects with tremendous hydroelectric capacity, most notably Grand Coulee and Glen Canyon Dams. Those are just a few, today the Bureau operates fifty-eight power plants in eleven states making it the second largest generator of electricity in the United States, second only to the Army Corps of Engineers. Those numbers do not include dams on projects such as Salt River that the Bureau no longer operates. Authorization and construction of Hoover Dam represented the completion of the Bureau's transformation from water to water and power. The intellectual and legal foundations of that change date back to the very first years of the Bureau's existence. By 1909 those foundations were well in place when the Salt River, Minidoka, and Strawberry Valley Projects all began to generate electricity in excess of what was needed for pumping purposes. While irrigation will always remain the central feature of the Bureau of Reclamation's first 100 years, electricity has been a part of that history for nearly as long.

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Endnotes

1. Department of Commerce and Labor, Bureau of the Census, Special Reports, *Central Electric Light and Power Stations, 1907* (Government Printing Office [GPO], 1910), 16.
2. This data is from the Bureau of Reclamation's website: http://www.usbr.gov/power/data/faclcap.htm.
3. For more on the Bureau and World War II see, H. W. Bashore, "Irrigation and Power, Partners on the Home Front," *Rural Electrification News*, August 1943.
4. 32 Stat., 388. The name of the Bureau was changed from the Reclamation Service to the Bureau of Reclamation in June 1923.
5. For the early history of the Salt River Project see, Karen L. Smith, *The Magnificent Experiment, Building the Salt River Reclamation Project, 1890-1917* (Tucson: University of Arizona Press, 1986).
6. Department of the Interior, United States Geological Survey, *First Annual Report of the Reclamation Service from June 17 to December 1, 1902* (GPO, 1903), 96. Hereafter annual reports will be referred to as "annual report" with the appropriate year and number.
Bureau of Reclamation, *Second Annual Report, 1902-3* (GPO, 1904), 258-65.
8. Ibid., 507, 510.
9. Bureau of Reclamation, *Third Annual Report, 1903-4* (GPO, 1905), 151, 210, 236, and 329; and Bureau of Reclamation, *Fourth Annual Report, 1904-5* (GPO, 1906), 220 and 344.
10. Bureau of Reclamation, *Third Annual Report*, 49.
11. Ibid., 118-21.
12. Both letters were reprinted in, Bureau of Reclamation, *Third Annual Report*, 121-22.
13. 34 Stat., 116.
14. 41 Stat., 1063.
15. Bureau of Reclamation, *Sixth Annual Report, 1906-1907* (GPO, 1907), 98-99.
16. Bureau of Reclamation, *Ninth Annual Report, 1909-1910* (GPO, 1911), 267-76.
17. Ibid. Also see, La Rue, Eugene Clyde, *Colorado River and its Utilization* (Washington, D.C., 1916), 145-6.
18, Donald C. Jackson, *Theodore Roosevelt Dam*, Historic American Engineering Record (Loveland, Colorado, 1992), 87-88. The Pacific Gas and Electric Company later became the Central Arizona Light and Power Company.
19, Bureau of Reclamation, *Ninth Annual Report, 1909-1910* (GPO, 1911), 116-27.
20. Bureau of Reclamation, *Thirteenth Annual Report, 1913-1914* (GPO, 1915), 34-39.
21. Gene Tollefson, *BPA & The Struggle for Power at Cost* (Portland, 1987), 307-08, 318.
22. Norris Hundley, Jr. *Water and The West, The Colorado River Compact and the Politics of Water in the American West* (Los Angeles, 1975), 51-53, 103.
23 La Rue, *Colorado River and its Utilization*, 169-70. The report stated potential generation in terms of horsepower, over two million could be generated. If translated into megawatts the 1916 report would have stated about 1,492 megawatts, today the nameplate capacity of Hoover Dam is 2,080 megawatts. The profile of the three rivers is between pages 170 and 171.
24. Hundley, *Water and the West*, 116-17. Hundley notes two of the dams would have been above the Grand Canyon and two below, including one in Boulder Canyon. A holding Company, the California-Nevada Corporation, controlled Southern Sierras Power.
25. E. F. Scattergood to George Norris, January 26, 1925, Norris Papers, box 236, folder "Muscle Shoals and Muscle Shoals Commission (Hoover)," Library of Congress.
26. 41 Stat., 600. Passed May 18, 1920.
27. Arthur Powell Davis, *Report on Problems of Imperial Valley and Vicinity*, submitted to the Secretary of the Interior on February 4, 1922. Also Hundley, *Water and The West*, 13-4. The lack of fall through a low dam's penstocks would not create enough pressure to drive hydroelectric turbines.
28. The equivalent of about 447,600 kilowatts.
29. *Seattle Post-Intelligencer*, May 22, 1924. See Jay Brigham, *Empowering the West, Electrical Politics Before FDR* (Lawrence, Kansas, 1998), Appendix 3.1 for a partial listing of Hearst Newspapers in existence in the 1920s.

30. *Seattle Post-Intelligencer*, January 7, 1928.

31. George P. Clements, "Parceling Out the Colorado River," *Southern California Business*, January 1923, 13. Clements served as the manager of the Chamber of Commerce's agricultural department.

32. John Lewis Brock, "Ten Minutes At Boulder Dam Site," ibid., October 1925, 15.

33. Lucius K. Chase, "The C. of C. Plan For Colorado River," ibid., November 1925, 13. See also "The Chamber's Stand on Colorado River Project," ibid., February 1928. A high dam would not have been necessary for only flood control or irrigation.

34. Bureau of Reclamation, *Twenty-Fourth Annual Report, 1924-1925* (GPO, 1925), 152-53. Also see Entry 7, Records of the Bureau of Reclamation, RG 115, NA-Rocky Mountain Region, Box 172, File 223.03, General Correspondence, Re: Power through 1929," hereafter BR Papers.

35. Bureau of Reclamation, *Twenty-Ninth Annual Report, 1929-1930* (GPO, 1930), 71. Stewart Mountain began operation in March 1930.

36. Department of the Interior, Memorandum for the Press, May 16, 1926, copy in BR Papers, Box 172, File 223.02 General Correspondence Re: Power through 1929.

37. Elwood Mead to George Norris, December 27, 1929, BR Papers, Box 172, File 223.03, General Correspondences re. Power through 1929.

38. Bureau of Reclamation, *Twenty-Fourth Annual Report, 1924-1925*, 71.

39. 45 Stat., 1057.

40. "Firm" energy means energy that is always available, regardless of generating conditions. Because of fluctuating water levels, a hydroelectric dam rarely ever generates at its full capacity. Firm power therefore is for power that plant managers believe always will be available and it represents less than 100 percent of the dam's rated capacity.

41. L. N. McClellen, *Power Development on Government Projects, Present Practice and Proposed New Polices*, extracted from proceedings of Denver Conference, March 13-15, 1929, copy in BR Papers, Box 281, File 320, General Correspondences, re. Power Development, through 1929.

Just Add Water: Reclamation Projects and Development Fantasies in the Upper Basin of the Colorado River

Stephen C. Sturgeon

Abstract

The history of the development of the American West is full of countless examples of promoters seeking to encourage outside investors to buy land, invest in mines, and build railroads. The history of water projects in the region is no different. Residents of communities such as Grand Junction, Colorado, recognized early on the two-fold dilemma that they faced: irrigation and reclamation projects would be critical to the economic growth of the area, and the funding for these projects would have to be obtained from sources outside the region. The promoters of such projects relied upon booster literature in order to entice investors with alluring (and often false) descriptions of the potential wealth to be had in these "irrigated Edens."

While some parts of the American West quickly developed into large-scale irrigation areas, other regions, such as the Upper Basin of the Colorado River, languished. The small population, remote location, and marginal land in this area sharply limited its political and economic clout. These limitations, however, became less problematic following passage of the Reclamation Act of 1902, when the federal government became the funding source of last (or increasingly first) resort for water projects in the American West. Since the federal government had access to larger financial and construction resources than other entities, and federal projects merely had to break even rather than turn a profit, it was now much easier for Upper Basin projects to secure funding.

The advent of federal funding, however, did not eliminate the role of local promoters and booster literature. In fact, their role became even more important because now instead of simply trying to impress a single investor, or even a handful of investors, it was necessary to convince a whole federal bureaucracy as well as Congress about the merits that a particular water project had to offer. Gradually, over time, the scale and nature of these projects began to change. Instead of simple stand-alone irrigation projects, local and regional boosters, with the active support of the Bureau of Reclamation, began to promote massive, multi-phased projects that covered entire river basins.

This essay will examine the booster literature that was used to promote the largest such plan—the Colorado River Storage Project. This six state project received congressional approval in 1956, and the arguments made on its behalf by supporters indicate how much the scope and nature of reclamation projects changed over time. Rather than simply serving irrigation needs, the Colorado River Storage Project was intended to promote rapid and massive industrial development in the Upper Basin region. Instead of touting the benefits this project would have for agriculture, which would have been the norm for promoters in the past, the booster literature also touted the potential for industry, as well as other diverse goals such as increased recreational opportunities and even improved national defense.

> Just as promoters in the past often over-hyped the projects they were supporting, the booster literature for the Colorado River Storage Project also raised unrealistically high expectations. Instead of becoming the new industrial heartland of America, the Upper Basin today still remains a rural, agricultural region. In some instances, such as oil shale, industrial development actually backfired, leading to an economic setback for the region. Thus large-scale water development in the Upper Basin did not ultimately turn out to be the total panacea that local residents had desired.

In the northwest corner of the state of Colorado, straddling the border with Utah, is a 325 square mile federal preserve called Dinosaur National Monument. Although the monument encompasses the scenic canyons of the Green and Yampa Rivers, most tourists visit Dinosaur to see the preserved remains of the prehistoric creatures that give the area its name. The main dinosaur exhibit is located at the visitors' center on the Utah side of the monument, where a modern glass and steel building encloses the uplifted remnant of a prehistoric riverbed that contains the fossils of various ancient reptiles.

Most tourists never journey past the visitor center, but the road does continue on for several more miles. After crossing over the Green River, drivers reach the end of the asphalt pavement and continue on a narrower dirt track. Just to the left of the road are carved petroglyphs, which serve as reminders of the first settlers in this area. Around the next bend in the road is a site that preserves the memory of a more recent one.

A woman by the name of Josie Morris settled here about 1914. Like many things about Morris (her exact age, how many husbands she had—legal or otherwise) this date is open to question. Park historians do know that she lived here until her death in 1964, most of the time on her own, leading a fairly self-sufficient life which she occasionally subsidized through poaching or producing moonshine. The site that Morris chose to homestead was a particularly good one because a natural spring bubbled up out of the ground near her cabin, which provided plenty of water for her own use as well as for irrigating her orchard and garden. She also used nearby Cub Creek for watering her livestock.

Not long after Morris settled at this site a neighbor challenged her use of the water in Cub Creek. He did so, not in the stereotypical Western way of a gunfight, but by taking her to court. Under the legal doctrine of prior appropriation, the downstream neighbor claimed he had first rights to use any water in the creek. Citing this doctrine the judge ruled that Morris could not continue to draw water from Cub Creek. However he then went a step further by ruling that if any water from the spring on her property drained into the creek, the spring could be considered a tributary of Cub Creek; and therefore the neighbor would be entitled to claim that water as well. In order to comply with the court's decision and still preserve her option to use the spring, Morris built several small ponds to catch the water and even flooded some of her own pastures to prevent any spring water from washing into the creek. Only by impounding the water (and in the case of her fields, wasting it) was she able to preserve her right to use it.[1]

Morris's struggle to maintain control of her water supply offers an example in microcosm of the larger struggle over the control and development of water in the American West. In a region that is in large part defined by the absence of high levels of precipitation, this struggle is not just limited to feuds between neighbors but also involves conflict between cities, states, and whole river basins. The effort to control water has typically focused on two issues: determining who has the legal right to use the water, and determining how best to put that water to use. It was this second goal that led to the passage of the Reclamation Act of 1902—legislation which allowed the federal government to assist (as well as subsidize) directly in the development of water resources in the West.

As the title of the legislation might suggest, the primary focus of early federal reclamation projects was on irrigating new crop land. Over time, however, the scope of these federal projects grew and shifted away from being primarily agricultural. Instead they began to include such diverse elements as hydroelectricity, mining, recreation, industrial development, and regional planning. This shift away from agriculture to industry was particularly noticeable in the Upper Basin of the Colorado River over the course of the twentieth century. The Upper Basin also provides a clear example of how this shift, made with the best of intentions, could end up having unintended (or even disastrous) consequences.

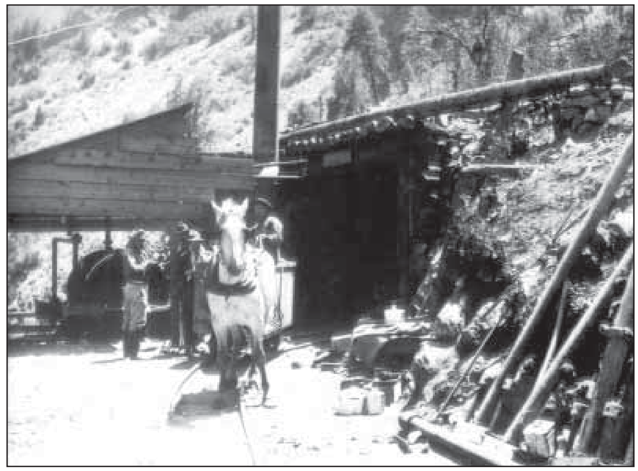
31.1. Federal and state representatives at a meeting of the Colorado River Compact Commission, north of Santa Fe, New Mexico, at Bishop's Lodge. Left to right: W. S. Norviel, Commissioner for Arizona; Arthur P. Davis, Director, Reclamation Service; Ottamar Hamele, Chief Counsel, Reclamation Service; Herbert Hoover, Secretary of Commerce and Chairman of Commission; Clarence C. Stetson, Executive Secretary of Commission; L. Ward Bannister, Attorney, of Colorado; Richard E. Sloan, Attorney, of Arizona; Edward Clarke, Commissioner for Nevada; C. P. Squires, Commissioner for Nevada; James R. Scrugham, Commissioner for Nevada; William F. Mills, former Mayor of Denver; R. E. Caldwell, Commissioner for Utah; W. F. McClure, Commissioner for California; R. F. McKisick, Deputy Attorney General of California; Delph E. Carpenter, Commissioner for Colorado; R. J. Meeker, Assistant State Engineer of Colorado; Stephen B. Davis, Jr., Commissioner for New Mexico; J. S. Nickerson, President, Imperial Irrigation District of California; Frank C. Emerson, Commissioner for Wyoming; Charles May, State Engineer of New Mexico; Merritt C. Mechem, Governor of New Mexico; T. C. Yeager, Attorney for Coachella Valley Irrigation District of California. November 24, 1922.

Like many facets of western water law, the Upper Basin of the Colorado River is a legal fiction. Created during negotiations over the Colorado River Compact of 1922, the basin is defined as that portion of the drainage area for the Colorado River which is located upstream from Lee Ferry.[2] The basin includes portions of five states: Wyoming, Colorado, Utah, New Mexico, and Arizona. The legal concept of the Upper Basin and Lower Basin was created in part to help divide the flow of water in the river between the various competing states, and especially to give the other river basin states protection from California's steadily growing water consumption and political power. Despite assurances and visions that the Lower and Upper Basins would be developed at the same pace, the Lower Basin quickly absorbed the majority of federal reclamation spending. As a result, it would be more than thirty years after the compact was signed before the Upper Basin would see the construction of larger-scale federal reclamation projects.

Reclamation development in the Upper Basin, both public and private, has long suffered from a series of limitations: limited arable land, limited funding sources, and limited local skill and equipment. What the region did not suffer from was a limited desire for reclamation. An examination of the history of reclamation development in the area around Grand Junction, Colorado, shows that almost as soon as the first outside settlers arrived, they identified reclamation development as crucial to the economic potential of the area. The stages of reclamation development in Grand Junction followed a pattern similar to what took place in other parts of the West: small, locally-controlled projects gave way to larger-scale efforts that required outside funding. In the early 1880s farmers near Grand Junction began developing a series of irrigation projects on the banks of the Colorado River (then known as the Grand River). These projects soon proved to be unviable on their own and were consolidated into a larger valley-wide canal project (known as the Grand Valley Canal) designed not only to irrigate land on the banks of the river, but also further away. This more ambitious project exceeded the financial resources available in the Grand Junction area, so a series of outside investors ended up funding construction of the canal. The process eventually culminated in the canal company being owned in 1885 by the Travelers Insurance Company of Hartford, Connecticut.[3]

Even outside, private-sector financial resources, however, were not enough to construct and maintain a viable canal project, and in 1894, following a series of reorganizations, foreclosure auctions, and court challenges, the Grand Valley Canal switched from being a for-profit corporation to a not-for-profit mutual company. This, of course, left project supporters with the same problem as before: how to secure financing for further irrigation development in the valley when such projects appeared unlikely to turn a quick profit. At this point the federal government and the Reclamation Act of 1902 played a key role in changing the direction of development in the West. By merely requiring that projects eventually had to repay their costs (with a liberal definition of repayment), rather than generate immediate profits, the Reclamation Act transformed hundreds of previously uneconomic projects into potentially viable ones.[4]

In the first two decades of the twentieth century, the federal Reclamation Service undertook to build a series of projects in the region around Grand Junction. The most ambitious of these was the Gunnison Tunnel (1909), which diverted water from the Gunnison River through a six-mile tunnel into the Uncompahgre Valley. While federal involvement did allow for the construction of larger-scale projects, it did not always improve the financial success of these ventures. The Grand Valley Project (not to be confused with the Grand Valley Canal), located on the Colorado River upstream from Grand Junction, was approved by the federal government in 1911 with a projected three-year repayment period once the project was finished. Although it was completed in 1917, repayment did not start until 1928, and only after the government changed the repayment period to 40 years, wrote off $812,000 in construction costs, and instituted a reduced payment plan for the first five years. Similarly, the Uncompahgre Project (of which the Gunnison Tunnel was part) originally had a repayment period of 10 years, which the government then extended to 20 and later 40 years. Despite the extensions, however, local farmers proved unable to meet the revised repayment schedules, so in the early 1950s Congress approved an extension for the project that spread the repayment period out over 106 years, and wrote off $1 million of the original $10 million cost.[5]



31.2. The east portal of the Gunnison Tunnel during construction.

While these federal projects were much larger in scope than the previous private-sector ones, they remained much smaller than the development occurring in the Lower Basin of the Colorado River. Early projects there included Laguna Dam, Roosevelt Dam, and Coolidge Dam. Additional projects, such as the All–American Canal and Imperial Dam, followed the completion of the Colorado River Compact in 1922. Despite the seeming success of the Bureau of Reclamation, the federal agency actually had severe financial difficulties during its first thirty years of existence, owing in large part to the chronic cost overruns on projects and the inability of farmers to pay back construction costs in a timely manner. The turning point for the Bureau was Hoover Dam.[6]

Standing 726 feet high, Hoover Dam at the time of its construction in 1935 was the largest reclamation project in the world. The dam, however, not only represented a physically larger project for the Bureau of Reclamation, it also represented a new kind of project. Whereas past efforts had typically focused on irrigation and flood control benefits for the immediate surrounding area, Hoover Dam offered little to the sparse populations of southern Nevada and northern

Arizona. Instead the bulk of the benefits literally flowed down the river to Southern California in the form of improved flood control for the Imperial Valley, and, more importantly, hydroelectricity for Los Angeles.[7]

The advent of hydroelectricity had a two-fold impact on the Bureau: one, it transformed the agency from a financially-troubled program into an economic powerhouse; and two, it encouraged the Bureau to start planning more, and larger, integrated regional projects rather than continuing to concentrate on traditional, stand-alone initiatives. In particular, the financial boom from hydroelectricity led Reclamation officials to start planning for so-called "cash register" dams, which sometimes had no merit other than generating electricity. The profits from these dams were used to offset the losses typically incurred by irrigation projects.[8]

Hoover Dam was the beginning of the so-called "golden age of reclamation," which lasted for the next forty years. The Boulder Canyon Act of 1928, which authorized construction of Hoover Dam, ushered in this era by also authorizing the Bureau of Reclamation to investigate feasible projects in the Upper Basin of the Colorado. In 1946 the Bureau issued its preliminary plan for the region, a wish list of over one hundred proposed dams—one for virtually every river in the Upper Basin. There were so many proposed projects in the plan that to build all of them would have required more water than existed in the basin. The Bureau demonstrated the high level of political power it now had by announcing that it would not consider any projects in the Upper Basin until the states in the area had reached a formal agreement on dividing the Colorado River's water among themselves. The states quickly complied, and the Upper Basin Compact was formally signed in 1948.[9]

Following ratification of the compact by Congress a year later, the Bureau of Reclamation released a revised plan in 1950 entitled the Colorado River Storage Project (CRSP). The CRSP called for the construction of ten major dams and reservoirs on the Colorado and its tributaries. These reservoirs, however, would not serve any irrigation or flood control purpose. Instead they would regulate the flow of the river in order to help maximize the production of hydroelectricity. In turn, the profits from the sale of this electricity would help offset the cost of building a dozen smaller regional irrigation projects.[10]

While the stated core goals of the Colorado River Storage Project may have been water and light, the Bureau and its boosters actually had a much larger agenda in mind: to transform the Upper Basin of the Colorado River from a desert wasteland into a new industrial and recreational center for the United States. Clearly influenced by the model of the Tennessee Valley Authority, which during the New Deal had helped to promote the development of one of the most impoverished regions of the South, the promotional literature supporting the CRSP stressed the broad cornucopia of benefits that would flow from the project—not only for the Upper Basin but the entire nation.[11]

31.3. Signed into law in 1956, the Colorado River Storage Project (CRSP) authorized a broad range of projects in the Upper Colorado River Basin.

Perhaps not surprisingly, one of the major potential benefits the promotional literature touted about the Colorado River Storage Project was that it would unleash the vast untapped wealth of natural resources in the Upper Basin. Pamphlets featuring maps of the region speckled with various resource symbols described the region as the "treasure chest of the nation." Others called it a "yawning giant." Estimates varied about how many valuable minerals were located in the area (ranging between 42 and 200), but among those mentioned were lead, copper, iron, zinc, phosphates, gold, silver, oil, natural gas, gilsonite, gypsum, tungsten, molybdenum, and vanadium. Promoters were quick to emphasize that the Upper Basin was the chief domestic source for such strategic minerals as uranium, and contained the world's largest reserves of oil shale. All that was needed to unleash these potential riches was power and water. Failing to do so, warned a pamphlet produced by the mining industry, "can hurt our entire national economy and our national defense program."[12]

Another benefit that the literature promoted was the potential for industrial development from the CRSP. This industrial growth was directly linked to the expanded use of natural resources. Regional boosters expressed frustration over the fact that while mining took place in the Upper Basin, the extracted raw materials were shipped elsewhere for processing and manufacturing. With power and water from the Colorado River Storage Project, plants could potentially be built within the area to use these materials instead. This in turn would help to diversify the local economy. These same boosters, however, stressed that industrial growth would require "fabulous amounts of water," not just for the manufacturing process but also for the workers who would relocate to the area seeking employment.[13]

31.4. Glen Canyon Dam and Powerhouse.

Boosters did not just expect growth in rural areas; they also anticipated that there would be growth in the cities of the Upper Basin as well. Arguments in support of the need for more urban water took two contradictory forms. Much of the promotion literature claimed that due to "the continued shift of population from East to West," western cities such as Salt Lake City and Albuquerque had reached the limits of their growth owing to a lack of new water supplies. Denver in particular was held up as a dire warning because it had instituted water rationing. (This, however, was a somewhat

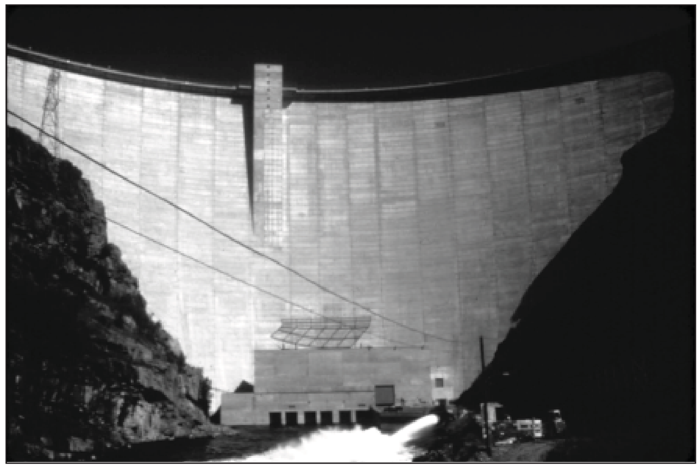
31.5. The scroll case in unit 5 of the Glen Canyon Powerhouse during installation in 1963.

misleading example since the rationing was due to a severe, multi-year drought which hit Colorado in the early 1950s—a fact that the literature did not mention.) In contrast to the literature that claimed more water was needed to catch up with existing growth, others argued that the water was needed to spur on additional growth. These promoters freely admitted that their population growth estimates were "based on the assumption that additional water can be secured," and that "if no additional water is to be obtained only a relative small increase in population can logically be expected."[14]

When examined together these two arguments reveal a clear flaw: if urban growth in the region had reached a limit due to the lack of additional water, then the Colorado River Storage Project, which would introduce a larger but ultimately finite amount of water, could at best only delay this problem but not solve it. The day of reckoning would be merely deferred, not eliminated. The promotional literature also ignored the fact that the CRSP was not designed to serve urban water needs. The cities cited as examples, in fact, are located outside the Upper Basin watershed. The only way for the CRSP to serve these cities was to provide new sources of water for agriculture so that existing water supplies could be diverted out of the basin. The literature also never addressed the question of whether additional growth was necessary or even desirable. (Such a question would undoubtedly have struck the promoters as completely irrational.) Instead promoters argued that the CRSP was necessary so the West "can keep pace with the rest of the nation."[15]

Supporters of the Colorado River Storage Project were quick to point to how the economic benefits of all this anticipated growth would ripple through the region, particularly in the form of increased tax revenue. One promotional publication argued, "[t]he claiming of arable land areas out of desert wastes would add millions to taxable land values in Utah and the Upper Basin. And the adding of supplemental water in areas restricted to early maturing crops would further expand the tax base." Senator Clinton Anderson of New Mexico, a strong proponent of the CRSP, stressed how the project would lead to the development of new industry and "the money that those industries pour into our State in tax revenues will help to support our schools. . . ." These rosy tax scenarios, however, failed to mention the fact that the influx of a larger population to provide the work force for these new industries would necessarily lead to increased public expenditures for more roads and schools, thus raising the question of whether or not the increased revenue would even be sufficient to cover the new expenses. As if to deflect this question, one promoter argued that if the CRSP was not approved "the property values adjacent to the Colorado River in the Upper Basin will diminish in value and waste down the river with the water."[16]

While many of the potential benefits predicted for the Colorado River Storage Project, such as an enhanced agricultural infrastructure and an improved tax base, were similar to those that nineteenth century reclamation boosters had touted, some of the benefits were distinctly new. One such new potential benefit was increased recreational opportunities. Promoters were quick to point out the fact that the bulk of the proposed reclamation projects would be located between “two transcontinental highways and much nearer to the eastern populations desiring” recreational opportunities. The CRSP, it was promised, will “greatly expand the nation’s existing facilities for fishing, boating, camping, water-skiing, swimming and other recreational activities. It will open up new scenic areas, now inaccessible. Colorful natural bridges, spectacular canyons and historic sites will be made available to the people of the nation.”[17]



31.6. Flaming Gorge Dam and Powerplant in 1984.

However, promoters were also quick to stress that the full recreational potential of this region would only be realized if all the proposed projects in the CRSP were built, because it was these individual projects that would allow for access to recreational areas. The construction of Glen Canyon Dam would create Lake Powell, which in turn would allow people to reach Rainbow Bridge National Monument

> by means of a scenic short boat trip. In its current isolated status, Rainbow Bridge is accessible only by an arduous pack trip by horseback or by a long river trip and a 10-mile hike. As a result, comparatively few people have seen this wonder of the world.

Flaming Gorge Dam promised to “make accessible the awesome scenery of the deep gorge of the Green River….” The Echo Park Dam promised to open the Lodore Canyon, which currently is “dangerous for boat trips, even with experienced guides,” “to people who love true beauty.” Additionally promoters claimed that these projects even had scientific value because they would enable “[s]cientists and naturalists [to] have new access to the primitive area.”[18]

Clearly much of this rhetoric was aimed at countering the attacks being made on the Colorado River Storage Project by environmentalists (or as they were called then, conservationists). Promoters of the project sought to combat these attacks in a variety of ways, one of which was by labeling environmentalists as elitists. The rhetoric proponents used suggested that reclamation projects had the potential to make nature more democratic. A few examples are enlightening. “Without the projects, there will be no development, and only a few men with means and with physical stamina and courage to endure dangers will ever be able to see and appreciate the grandeur of these Rocky Mountain canyons.” “[T]he Colorado River Storage Project will provide full enjoyment of areas that are now open only to a few—the people who can afford expensive river trips and the people who care to risk these trips." "It will make available this area to the people instead of restricting it to a few."[19]

Another angle of attack was to claim that development would make nature more family friendly. "The projects will open new vistas for conservationists, tourists, fishermen, nature lovers and the American family." "With development of the dams, many of these areas will be accessible. A few roaring rapids will be turned into placid lakes where a man can take his family for a boating or fishing outing." However, lest promoters be accused of taming too much of the wilderness they were quick to add, "[a]nd there are still a hundred miles of river rapids in the same general area, for those who like this sport."[20]

Promoters even went so far as to claim that the Colorado River Storage Project had the potential to improve nature. CRSP reservoirs promised to "provide numerous havens for ducks and other migratory birds." These havens were "not now present but vitally needed." Additionally,

> the project will turn silt-laden rivers into clear streams. The Green and Yampa rivers now are muddy most of the time because of heavy deposits of silt. Dams to be constructed will hold this silt in check, turning brown rivers into clear and sparkling streams.

"Navajo Dam will turn the muddy, sluggish San Juan River into a clear reservoir." These clear streams in turn would offer new recreational opportunities. "Flaming Gorge Dam will make a clear water fisherman's stream out of the lower Green River now too clouded with mineral deposits to be a game stream." What promoters did not know was that the process by which these rivers became clear would destroy the local river ecology and drive out the native fish. The new fishing holes would be world famous and strictly artificial.[21]

Another group for whom the Colorado River Storage Project would offer a mixed legacy was the Navajo. Promoters, however, promised that the CRSP would be a supreme blessing for the tribe. In order to make this promise, promoters had to take the unusual gambit of attacking the past actions of the federal government and the white settlers in the region. Pro-CRSP literature argued that the Navajo "often go hungry because they have been shunted aside onto marginal lands with inadequate water supplies. They also lack clothing and shelter." The newspaper in Farmington, New Mexico, which published a special supplement in support of the CRSP featuring the plight of the Navajo on the cover, claimed that the reason "30 per cent of the tribe" lived at subsistence levels was because "we Americans have broken so many solemn treaties."[22]

In contrast to this history of past abuse, supporters of the Colorado River Storage Project maintained that reclamation was the key to helping the Navajo. One source of help would be the construction of Navajo Dam on the San Juan River in New Mexico, which promoters claimed would lead to industrial development in the area and therefore provide jobs to tribal members. The second source of help was the proposed Navajo Indian Irrigation Project, which aimed to irrigate up to 125,000 acres of land on the reservation. A third source of help, though one with no obvious link to the CRSP, was the promise that "this project will help provide educational opportunities for the children of the Tribe," by leading to the construction of schools for sixteen thousand Navajo. More broadly, promoters stressed that the CRSP would help in the "rehabilitation of this long-neglected segment of the original American society," and offer "partial fulfillment of promises made to the Navajo people in the treaty of 1868 and never lived up to." Project supporters also offered a more tangible reason than honor for non-Navajos to support these initiatives.

> This project will help the Indians help themselves. In the long run, it will save the government money because it helps the Navajos to become self-supporting, instead of having to be supported by government expenditures.[23]

Promoters, however, seemed to have set a low threshold for success. One document claimed that the construction of Navajo Dam "would give a decent standard of living to <u>one–fifth</u> of [the tribe]. . . ." Unfortunately these lowered expectations proved correct. The Navajo Indian Irrigation Project (NIIP) ultimately turned into a political boondoggle. Unlike other component projects of the Colorado River Storage Project, which were developed and administered by the Bureau of Reclamation, the NIIP was quickly turned over to the Bureau of Indian Affairs where it became a financial black hole, "which yielded few benefits to the tribe and provided far less employment of tribal members than originally negotiated." Perhaps it was this unproductive experience that led the Navajo to oppose further federal reclamation projects on the Colorado River when they were proposed in the 1960s.[24]

Just as the promoters of the Colorado River Storage Project pointed out the ways that the Navajo had suffered injustice, project supporters also pointed out the ways that they perceived themselves to have also been treated unfairly. Ironically, even though promoters argued that the CRSP would create new recreational opportunities and help Indians, they also complained that these two factors had hindered development in the region.

> In the four Upper Basin states, and particularly in Utah, there are expansive areas taken up by Monuments, Parks, Forest Service, Grazing Service, Indian Reservations, and other reserves of various kinds, all tax free. And now some would deprive the common people of this area of one of the few resources which is available for development and use.

Senator Arthur Watkins of Utah expressed jealousy about the economic growth occurring in other parts of the country. "Our Detroits and our Pittsburghs seem to grow ever larger, while the industrial have-not areas content themselves with a few industrial handouts." He later expanded his complaint to include foreign aid projects.

> We have spent 300 millions to help Italians build reclamation projects, yet the Italians are under no obligation whatsoever to repay any of the costs of those projects. We are willing to repay in dollars and cents for the capital on irrigation, and dollars and cents, with interest, for municipal uses and for power.

Senator Frank Barrett of Wyoming took a different tack, borrowing from the states-rights rhetoric of southern politicians. "Overpowering and vital interest [*sic*]of these Western States are involved, and after all, people of the West ought to have the major right to make the decisions affecting their welfare."[25]

While some promoters argued that "justice" required that the Colorado River Storage Project be built, others warned of the regional devastation that would ensue if the CRSP did not receive congressional approval. George Clyde, the Commissioner of Interstate Streams for Utah, offered a legal doomsday scenario. "If the project is not authorized, the rights of the Upper Basin states to their share of the Colorado River will be effectively destroyed." He continued, "Failure of Congress to authorize this project will be the equivalent of their confiscating these rights in the Colorado and making them available to the Lower Basin and Mexico." Others warned that this was the "last watering hole" for the Interior West. "The Colorado River is the last water resource available in many parts of the area to supply additional water for municipal and industrial purposes." "Testimony given . . . left no doubt that the future of [these] states is dependent upon the plan." Congressman Wayne Aspinall of Colorado offered an even direr scenario.

> [S]tand on a canal bank as it winds its way over the land. On the uphill side, you have virtually a barren desert with but scrub growth and little green. On the downhill side you have green and growing crops, houses, cities and life. That is the choice in the West, irrigation or desolation; abundance or scarcity.

Sometimes the apocalyptic predictions promoters used would end up undermining the very argument they were trying to make. "When [the Colorado River's] waters have been used, there is no other substantial supply on tap. The future of the Southwest will have dropped back with its past." Thus, it seems, whether or not the CRSP was built the West was doomed to economic collapse.[26]

An unusual variation on this doomsday theme was the plea by promoters to build the Colorado River Storage Project not for their sake but for the sake of "our best crop, our children." Senator Arthur Watkins in a letter to Secretary of the Interior Oscar Chapman complained, "For many years the young people of my state have been migrating in large numbers to other states where there would be opportunities for homes and livelihoods. The limiting factor in Utah has been lack of water and power." Utah's other Senator, Wallace Bennett, echoed these sentiments but conjured up images of the old orphan trains when he predicted, "We shall have to continue to export our children to other states because opportunity for them is lacking." George Clyde complained, "Utah has long been a feeder state. Its raw materials have been shipped to other centers for processing. Its children have had to seek employment elsewhere." One promoter cited the plight of the children in his attack on efforts by environmentalists to block the CRSP.

> Natural scenery is a beautiful thing, but economic security can also be very attractive. Approximately 30% of the native born population of Utah must seek employment outside the state, after the state has educated and trained them in the art of making a living. Power and water for irrigation would unlock many of Utah's natural resources and enable more [of] the people of the state to remain home.

The Republican Party of Utah endorsed this focus on the future when it passed a resolution supporting the Colorado River Storage Project and claiming that among its many benefits the project "will provide new homes and opportunities for our children and their children. . . ." As another promoter put it, with the CRSP "[o]ur young men and women can build their destiny here."[27]

While much of the promotional rhetoric surrounding the debate over the Colorado River Storage Project focused on local concerns, supporters also were quick to claim that the nation as a whole would benefit in a variety of ways. One area of emphasis was how the national economy would grow as a result of the CRSP. Promoters claimed that the industrial development of the Upper Basin would lead to a higher standard of living in the region. As a result of this, "[t]he people of this reclamation area…will want and need new products—cars, tractors, stoves, refrigerators, household items and equipment. Thus new markets will be created for products manufactured in other parts of the country." Even during the construction phase for the CRSP the country as a whole would benefit "because an estimated 81 per cent of the construction costs will be spent in markets outside the Upper Colorado River Basin." The project was even touted as a financial boon for the federal government due to the increased income tax that would be generated in the newly prosperous region, not to mention the revenue the government would gain from the sale of hydroelectricity generated by the CRSP dams.[28]

While many of the supposed benefits that promoters claimed would come from the Colorado River Storage Project seemed fairly straightforward and conventional, there was one set of benefits that was quite different. Supporters claimed that in addition to all the various economic rewards from the CRSP, this project was vitally necessary in order to increase the security of the United States from the Cold War threat of the Soviet Union. Some promoters emphasized the untapped reserves of strategic minerals, such as uranium, oil shale, gilsonite, and bentonite, among others, located in the region—minerals that could only be fully developed with water and power from the CRSP. Others claimed that the country needed to develop all of its potentially irrigable land. Senator Wallace Bennett warned that recent history had shown that the United States could not rely on foreign supplies during wartime, and that we must develop domestic sources.[29]

Supporters of the Colorado River Storage Project also argued that the project would strengthen the nation's industrial capacity in the event of an atomic war. There were two aspects of this argument that promoters set forth. One was that the CRSP would allow for industrial dispersion into the interior of the United States. Senator Bennett warned how "[t]he overwhelming bulk of our productive capacity could be obliterated by a few well–placed bombs or missiles, for our key industries are concentrated in just a few areas." A group lobbying on behalf of the CRSP produced an entire brochure quoting the testimony of national Civil Defense Administrator Val Peterson on why the project was necessary for national security. In it, he expressed concern about the "[t]he potentially fatal vulnerability of concentrations of industry . . . ." Peterson went on to call "attention to the work that Russia is reported to have done in developing a second line of industry behind the Ural Mountains." Senator Arthur Watkins took this idea a step further when he suggested that "the United States, too, should build its own industrial defense bastion behind the protective peaks of our own 'Urals,' the great Rocky Mountain Range." Local promoters in Utah further suggested that not only was Utah "made up of many valleys, each protected by high and rugged mountains on all sides giving industries the best form of strategic protection," but also that "Utah's geographical position is such that it is a distributing point and has excellent transportation facilities to all the West Coast's harbors, the nation's railroad systems, and/or air bases." Promoters, however, were careful to not present themselves as a threat to the industrial welfare of other parts of the country by clarifying that "[n]o one is advocating that our industries be relocated," rather that they simply be duplicated in the interior.[30]

The second argument concerning industrial security that supporters of the Colorado River Storage Project made was that the Upper Basin not only offered geographic security, but geologic security as well. In comments that seemed to foreshadow the dialogue from *Dr. Strangelove* concerning "a mine shaft gap," Civil Defense Administrator Peterson warned that "the balance of victory between two military powers may well rest with the nation whose civilian population can best minimize the effect of an atomic attack and get up off the ground organized and ready." To help facilitate this, Peterson pointed to the examples of "underground defense plants and military installations in Scandinavia," which he said were cheaper to build "under the rock" than on the surface. Project supporters, seizing on these comments, were quick to point out that "[d]eep gorges abound in the project area. Power plants and industrial plants could be tunneled into the sheer rock walls at canyon floor level, providing protection from atomic blast." Senator Watkins went a step further, envisioning a whole network of underground installations.

> [T]he Mountain West has thousands of feet of solid rock in mountain and canyon walls which can be utilized to protect vital industries and government installations from atomic attack. These natural bomb shelters can be located in the ribs of the aptly named Rocky Mountains. Tunnels

> and caves could be developed in these mountains at widely separated locations to give this nation an impregnable industrial bastion that would be secure even against the awesome weapons of the atomic and hydrogen bombs.

All of this could be possible, CRSP promoters promised, just by developing water and power in the region.[31]

Supporters of the Colorado River Storage Project did not simply worry about the impact of an atomic war upon American industry; they also stressed how the project would benefit civilian evacuations. Senator Bennett pointed out that "[i]f we don't have water for our present needs in some areas, it will obviously restrict our ability to meet our civil defense responsibilities. . . ." Civil Defense Administrator Peterson warned what those responsibilities might be. "In this nuclear age, if an attack is made . . ., it will be necessary, first, to get our people away from our critical target areas, . . . and if a city is hit by a hydrogen bomb, we will not be able to re-enter for some time, and <u>possibly never</u>. . . ." "It would be fortunate if we had areas with water and power facilities far removed from our vulnerable and heavily populated urban centers to which these people could go." "The Upper Colorado Development, by providing water and power, would pave the way for taking care of those who by necessity may be forced to evacuate our West Coast cities." The chief thrust of all these various defense arguments was that an opponent of the CRSP was an opponent of national security.[32]

Despite the "un-American" taint, opponents of the Colorado River Storage Project did manage to get some aspects of the project changed. Chief among them was deletion of the proposed Echo Park Dam that was scheduled to be built inside Dinosaur National Monument. When Congress agreed to drop the dam, environmentalists agreed to drop their opposition to the overall project. (A decision that many of them later came to regret when Glen Canyon was subsequently flooded as part of the project.) As a result of this compromise, the Colorado River Storage Project finally received congressional approval in 1956. Passage of the project, however, did not mean that booster efforts in support of the CRSP came to a halt. Although Congress had agreed to the project in principle, federal reclamation officials still had to obtain annual financial appropriations from Congress in order for the project to continue.

To help secure this on-going funding, project promoters continued their publicity campaign on behalf of the Colorado River Storage Project. Just as the promotional literature in the 1950s had tried to demonstrate how the CRSP addressed various local and national concerns, the new literature evolved over time to reflect changes in those national concerns. By the 1970s the communist threat had been replaced by the energy crisis. Instead of talking about strategic minerals, promoters now focused on the potential fuel sources located in the Upper Basin. Developing these sources would help the United States to meet "our national goal of freedom from reliance on foreign oil." Among the resources waiting to be fully developed in the area were coal and oil shale. As in the past, however, promoters stressed that water was the key component to developing this material. Now, however, they went even further with their water pitch by announcing that "[s]ince the natural supply of the Colorado River will someday be inadequate, ways of augmenting the flow of the river are being investigated." Thus promoters continued to dream about even bigger and more grandiose reclamation projects for the Upper Basin.[33]

When examining the literature that promoters used in support of the Colorado River Storage Project it is clear that the size, scope, and ambition of the CRSP exceeded anything ever envisioned by local boosters in the nineteenth century. One question that comes to mind, however, is whether the boosters in the 1950s were any more accurate in their predictions than the boosters had been in the 1880s? Did the development they foresaw come to fruition with the construction of the CRSP? The quick answer would be "no," but a more complete answer would suggest that the outcome of the CRSP stands as a model for the law of unintended consequences.

Charles Wilkinson, in his book *Fire on the Plateau*, discusses the "Big Buildup" on the Colorado Plateau (a region that substantially overlaps with the Upper Basin) between 1955 and 1975. While there is no doubt that massive development took place in the region during this time period, it was not the type of development that Colorado River Storage Project supporters had envisioned. Instead of extracting and processing natural resources on-site, companies continued the practice of hauling materials away to be processed elsewhere. Virtually no large-scale industrial development took place in the region—even after the CRSP was completed—nor did substantial urban growth occur in the area either. While cities such as Salt Lake City, Phoenix, and Denver, located outside the Upper Basin, have grown exponentially, there continues to be no major urban presence within the region. The Upper Basin instead remains a "plundered province" providing raw materials to other parts of the country.[34]

Ironically, the economically most promising natural resource in the area proved to be the most financially devastating one. Oil shale had long been touted as an energy source that would potentially make the Upper Basin one of the wealthiest regions of the country. The process required to extract the oil from the rock, however, is an expensive and inefficient one, which requires large amounts of water and produces large amounts of spent shale. Promoters of the CRSP proclaimed that the reclamation project was vital to ensure that sufficient water would be available to allow the oil shale industry to grow. When the sharp rise in oil prices took place in the 1970s it appeared that these predictions would, indeed, come true. Major oil companies began buying up property in the area around Grand Junction, Colorado, in anticipation of this new boom. Instead, things suddenly went bust. In May 1982 Exxon, the dominant company in the oil shale business, suddenly shut down its operation, triggering a regional economic depression that lasted for nearly a decade.[35]

The demise of the oil shale industry should not, however, be taken as an indication that the Colorado River Storage Project failed all the objectives that promoters proclaimed for it. The CRSP did result in the Bureau of Reclamation becoming a major hydroelectric producer in the region (although the chief beneficiary has been the Lower Basin rather than the Upper). Perhaps the one area where the CRSP has had the greatest success, however, has been in creating a massive recreation industry in the Upper Basin. The tourist revenue generated in 1997 at Lake Powell alone was $455 million, derived from approximately 2.5 million visitors. While environmentalists have never forgiven the building of Glen Canyon Dam, it is obvious that its construction has had a sizable, long-term economic impact on the region. This is clearly another instance of unintended consequence because, while the promoters did talk about the recreational enhancements that the CRSP would produce, recreation was clearly not the primary benefit they were looking for from the project. Promoters, however, are nothing if not ingenious when it comes to reinventing themselves and their claims. A recent tourist slogan for the man-made Lake Powell is a prime example of this, "Lake Powell: America's Natural Playground."[36]

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Endnotes

1. Information on Josie Morris from a park brochure entitled "Josie Bassett Morris." Information about her water struggle comes from a plaque at the Josie Morris Cabin site. Copies of this information were obtained from David Whitman, Chief Interpreter, Dinosaur National Monument, 4545 East Highway 40, Dinosaur, Colorado 81610–9724.

2. "Lee Ferry" is not a typographic error. This is a different location than, and downstream from, historic Lee's Ferry, Arizona, and is defined in Article II.e. of the Colorado River Compact as "a point in the main stream of the Colorado River one mile below the mouth of the Paria River."

3. While I am not trying to claim that the Upper Basin is simply Grand Junction writ large, I am initially focusing on this particular area for three reasons: Grand Junction became the largest commercial/industrial hub within the Upper Basin, the development patterns in Grand Junction mirror those that took place throughout the basin, and a larger body of historical literature and analysis is available for this area than other parts of the Upper Basin. See William Wyckoff, *Creating Colorado: The Making of a Western American Landscape, 1860-1940* (New Haven, 1999), 226, 231; Lawrence J. MacDonnell, *From Reclamation to Sustainability: Water, Agriculture, and the Environment in the American West* (Niwot, Colorado, 1999), 93–95; and Brad F. Raley, "Private Irrigation in Colorado's Grand Valley," Chapter 9 in *Fluid Arguments: Five Centuries of Western Water Conflict*, ed. Char Miller (Tucson, 2000).

4. MacDonnell, *From Reclamation to Sustainability*, 95.

5. Wyckoff, *Creating Colorado*, 233; MacDonnell, *From Reclamation to Sustainability*, 98-99, 316; Wayne Aspinall, Speech, "Irrigation and Federal Participation in Colorado," July 18, 1977, 8–9, Folder 19, Box 39, Wayne Aspinall Papers (University of Colorado Archives, Boulder, Colorado).

6. Marc Reisner, *Cadillac Desert: The American West and its Disappearing Water* (New York, 1986), 118-124; Donald Worster, *Under Western Skies: Nature and History in the American West* (New York, 1992), 72.

7. Worster, *Under Western Skies*, 66; Richard Lowitt, *The New Deal and the West* (Norman, Oklahoma), 82.

8. Reisner, *Cadillac Desert*, 140–2.

9. The formal name of this report, nicknamed the "Blue Book," was *The Colorado River: A Comprehensive Report on the Development of Water Resources*. The government citation for this report is House Doc. 419, 80th Cong., 1st sess.; Russell Martin, *A Story that Stands Like a Dam: Glen Canyon and the Struggle for the Soul of the West* (New York, 1989), 48.

10. George Sibley, "A Tale of Two Rivers: The Desert Empire and the Mountain," in *Water in the West*, ed. Char Miller (Corvallis, Oregon, 2000) 134-5.

11. Mark W. T. Harvey, *A Symbol of Wilderness: Echo Park and the American Conservation Movement* (Albuquerque, 1994) 43, 73.

12. Utah Committee for the Development of the Colorado River, *Colorado River News Report*, booklet, January 1958, item 36, Book Collection 38 (Special Collections & Archives, Utah State University, Logan); B. H. Stringham, "The Echo Park Dam Problem," radio editorial script, June 1954, p. 9, folder 5, box 14, B. H. Stringham Papers (Special Collections & Archives, Utah State University, Logan); Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; Rocky Mountain mining industry, *Water and Power needed for development of Nation's Rich Treasure Chest of Minerals and Metals*, pamphlet, [1952?], item 28, Book Collection 38.

13. Arthur V. Watkins, "The Upper Colorado River and National Defense," typescript, 1954, p. 5, folder 7, box 13, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; Utah Colorado River Development Committee of Twenty–One Counties, Letter to Oscar L. Chapman, 1950, folder 6, box 14, B. H. Stringham Papers; "The Colorado River Story," typescript, [1954?], p. 14, folder 5, box 13, B. H. Stringham Papers.

14. Trade Promotion Committee of the Vernal Junior Chamber of Commerce, "Principal Statistics Re: Echo Park Dam," typescript, [1952?], folder 5, box 14, B. H. Stringham Papers; *Farmington Daily Times*, "The Colorado River Story: The Factual Background," booklet, [1954?], folder 1, Book Collection 38; "The Colorado River Story," typescript, [1954?], folder 5, box 13, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; I. Dale Despain, "In the matter of the authorization of the Split Mountain and Echo Park dams, in connection with the Upper Colorado River Storage project," typescript, 1950, folder 6, box 14, B. H. Stringham Papers.

15. Utah Committee for the Development of the Colorado River, *The Colorado River Project: Here's What It Means*, pamphlet, [1955?], folder 1, Book Collection 38.

16. Utah Committee for the Development of the Colorado River, *Colorado River News Report*, booklet, January 1958, item 36, Book Collection 38; Transcript of radio broadcast by Senator Clinton Anderson, May 22, 1955, p. 6, folder 7, box 13, B. H. Stringham Papers; Memo of telephone conversation between Lee and Beauregard, March 1, 1950, folder 7, box 14, B. H. Stringham Papers.

17. Utah Colorado River Development Committee of Twenty–One Counties, Letter to Oscar Chapman, 1950, p. 2, folder 6, box 14, B. H. Stringham Papers; Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38.

18. Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; Upper Colorado River Grass Roots Inc., *The Colorado River Storage Project: A project to benefit ALL Americans!*, pamphlet, [1954?], folder 1, Book Collection 38.

19. "To Mr. President [Truman?]," letter, July, 1951, p. 9, folder 3, box 14, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38 (emphasis in the original).

20. Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; Upper Colorado River Grass Roots Inc., *The Colorado River Storage Project: A project to benefit ALL Americans!*, pamphlet, [1954?], folder 1, Book Collection 38.

21. Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; Utah Colorado River Development Committee of Twenty–One Counties,

Letter to Oscar Chapman, 1950, p. 2, folder 6, box 14, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; *The Colorado River Storage Project*, booklet; Utah Committee for the Development of the Colorado River, *Colorado River News Report*, booklet, January 1958, item 36, Book Collection 38; Charles Wilkinson, *Fire on the Plateau: Conflict and Endurance in the American Southwest* (Washington, D.C., 1999) 188, 203.

22. Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; *Farmington Daily Times*, "The Colorado River Story: The Factual Background," booklet, [1954?], folder 1, Book Collection 38.

23. Upper Colorado River Grass Roots Inc., *The Colorado River Storage Project: A project to benefit ALL Americans!*, pamphlet, [1954?], folder 1, Book Collection 38; Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; *Farmington Daily Times*, "The Colorado River Story: The Factual Background," booklet, [1954?], folder 1, Book Collection 38; *The Colorado River Storage Project: A project to benefit ALL Americans!*

24. "The Colorado River Story," typescript, [1954?], p. 14, folder 5, box 13, B. H. Stringham Papers (emphasis added); Charles Wilkinson, *Fire on the Plateau: Conflict and Endurance in the American Southwest* (Washington, D.C., 1999), 202-3.

25. B. H. Stringham, "The Echo Park Dam Problem," radio editorial script, June 1954, p. 9, folder 5, box 14, B. H. Stringham Papers; Arthur V. Watkins, "The Upper Colorado River and National Defense," typescript, 1954, p. 2, folder 7, box 13, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *The Colorado River Storage Project: A project to benefit ALL Americans!*, pamphlet, [1954?], folder 1, Book Collection 38.

26. George D. Clyde, "The Case of the Upper Colorado River Storage Project and its Participating Projects," typescript, September 1954, item 41, Book Collection 38; Upper Colorado River Grass Roots Inc., *Summary of H.R. 3383*, pamphlet, 1955, folder 1, box 13, B. H. Stringham Papers; Wayne Aspinall, Letter to John Dingell, June 6, 1955, "Echo Park Project–1955," Box 69, Wayne N. Aspinall Papers, University of Denver Special Collections; "Story of the Colorado River Storage Project," [1955?], folder 5, box 13, B. H. Stringham Papers.

27. B. H. Stringham, "The Echo Park Dam Problem," radio editorial script, June 1954, folder 5, box 14, B. H. Stringham Papers; Arthur Watkins, Letter to Oscar Chapman, January 26, 1950, p. 3, folder 6, box 14, B. H. Stringham Papers; Wallace F. Bennett, "Statement on the Upper Colorado River Project before the Senate Interior and Insular Affairs Committee," typescript, March 1, 1955, p. 3, folder 7, box 13, B. H. Stringham Papers; George D. Clyde, "Statement presented at the Congressional Hearings on H.R. 4449 in support of the Colorado River Storage Project and participating projects," January 1954, Exhibit "B" p. 1, item 41w, Book Collection 38; G. E. Untermann, "Factual Data," typescript, [1954?], p. 3, folder 5, box 14, B. H. Stringham Papers; "Resolution by Utah State Republican Party," typescript, [1954?], folder 5, box 13, B. H. Stringham Papers; Utah Committee for the Development of the Colorado River, *The Colorado River Project: Here's What It Means*, pamphlet, [1954?], folder 1, Book Collection 38.

28. Upper Colorado River Grass Roots Inc., *Impact: An outline of the many benefits to be derived from the Colorado River Storage Project*, pamphlet, [1954?], folder 1, Book Collection 38; Upper Colorado River Commission, *The Colorado River Storage Project*, booklet, [1956?], folder 1, Book Collection 38; Upper Colorado River Grass Roots Inc., *The Colorado River Storage Project: A project to benefit ALL Americans!*, pamphlet, [1954?], folder 1, Book Collection 38.

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30. Wallace F. Bennett, "Statement on the Upper Colorado River Project before the Senate Interior and Insular Affairs Committee," typescript, March 1, 1955, p. 3, folder 7, box 13, B. H. Stringham Papers; Upper Colorado River Grass Roots Inc., *Our National Defense Demands the Upper Colorado River Storage Project*, pamphlet, 1955, item 33, Book Collection 38; Arthur V. Watkins, "The Upper

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The Bureau of Reclamation and the Civilian Conservation Corps: A Legacy Revealed

By:
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Abstract

Between 1934 and 1942 the Civilian Conservation Corps (CCC) played a vital role within the Bureau of Reclamation. From one initial CCC camp assigned to Reclamation in 1934, the program expanded to a peak of forty-six camps at the height of the CCC program during the summer of 1935. From then on the number of Reclamation camps operating fluctuated between thirty-four and forty-four up until May 1941. Thereafter camps were closed in response to national defense needs. By June 30, 1942, only seven camps remained on Reclamation projects, and they were discontinued shortly thereafter.

The contributions of the CCC to Reclamation are not well known. Though the number of CCC camps operating on Reclamation projects was small in comparison to other agencies, the program had a significant impact and assisted in furthering the goals of Reclamation during the devastating years of the Great Depression. At a time when financially stricken farmers were unable to adequately maintain older Reclamation irrigation facilities, CCC enrollees were instrumental in rehabilitating them. The enrollees also provided the necessary labor to develop supplemental water supplies and construct new irrigation projects. Lastly, CCC assistance afforded Reclamation the opportunity to expand on its primary mission of irrigation to develop recreational amenities at a number of its reservoirs.

This paper explores the contributions and role of the CCC within Reclamation and within the larger context of the national CCC program. Origins of Reclamation's camps, the project work accomplished, the public perception of the camps, the impact on enrollees, and the success of the program are addressed.

Introduction[1]

As dry winds and dust storms blew across the western High Plains in the early 1930s leaving devastated farms in their wake, newly elected President Franklin D. Roosevelt was formulating sweeping plans in the nation's capital for emergency disaster relief. The entire country was in the grips of the Great Depression and jobless men everywhere struggled to earn enough money to buy food for their families. For the country's youth, the situation was equally desperate. Hundreds of thousands of young men from economically stricken households were unable to find work. Against this backdrop, Roosevelt outlined his concept for a Civilian Conservation Corps (CCC) during his inaugural address on March 4, 1933. He proposed creating a new program aimed at conserving the nation's depleted natural resources and putting unemployed youth to work. The president told the American people:

> Our greatest primary task is to put people to work. This is no unsolvable

> problem if we face it wisely and courageously. It can be accomplished in part by direct recruiting by the Government itself, treating the task as we would treat the emergency of war, but at the same time, through this employment, accomplishing greatly needed projects to stimulate and reorganize the use of our natural resources.[2]

Within a short time, CCC camps had been established across the country and young men were recruited to work on a myriad of conservation projects overseen by various federal agencies including the Bureau of Reclamation (Reclamation). At the height of CCC enrollment in the summer of 1935, over a half-million men were scattered in 2,652 camps. Of all the New Deal programs instituted by Roosevelt to combat the economic hardships of the Great Depression, probably none was as popular and successful as the CCC.

Those familiar with the accomplishments of the CCC inevitably think of handsomely crafted rustic stone and log structures, walls, picnic shelters and other facilities within National Forests or National Parks. Indeed roughly 75 percent of all CCC camp enrollees worked on projects administered by the Department of Agriculture, the majority of them being on U.S. Forest Service lands. Almost all of the remaining camps were allotted to the Department of the Interior with the National Park Service (NPS) being the greatest beneficiary.

The association between the CCC and Reclamation, also within Interior, is far less well known. As the Federal agency responsible for designing and building large-scale irrigation projects in the western United States, Reclamation was vitally involved in the allocation and use of two natural resources, namely water and soils. Even though the number of Reclamation CCC camps was much smaller than that of other agencies, the program had a significant impact and assisted in furthering the goals of the agency during the devastating drought years of the 1930s. CCC assistance also afforded Reclamation the opportunity to expand on its primary mission of irrigation to develop recreational amenities at a number of its reservoirs.

Creation of the Civilian Conservation Corps

By the close of Roosevelt's first month in office, Congress had acted upon the President's ambitious jobs-creation proposal and passed "An Act for the relief of unemployment through the performance of useful public works and other purposes." On March 31, 1933, the President signed the bill into law (Public No. 5, 73rd Congress) thus creating the CCC (initially called the Emergency Conservation Works or ECW).

With legislation in place, Roosevelt wasted no time in transposing his vision into action. In April 1933 he appointed Robert Fechner director of the CCC and established an advisory council comprised of representatives from the Departments of Labor, War, Interior and Agriculture. The purpose of the council was to coordinate oversight of the program and create a forum for discussing policy issues. The Department of Labor was assigned responsibility for recruiting youths and the War Department (Army) was in charge of enrollee administration, transportation, housing, food, clothing, supplies, medical care, education, discipline, and physical conditioning. The Departments of Agriculture and Interior had the task of locating the conservation work camps and supervising the actual work.

32.1. ECW winter camp at Belle Fourche Dam in 1934.

At the president's urging, the CCC enrolled its first 25,000 young men by April 6, 1933. The initial camp, appropriately called Roosevelt, was established on April 17 on George Washington National Forest near Luray, Virginia. Less than three months after the program's inauguration, about 300,000 men from throughout the country were settled in almost 1,500 camps. Each CCC installation typically housed about 200 men. According to Fechner, "it was the most rapid large scale mobilization of men the country had ever witnessed.[3]

Initial enrollment in the CCC was limited to unemployed single men between the ages of eighteen and twenty-five who were U.S. citizens. For the most part these were discouraged men, unsuccessful in securing jobs because they had no work experience. They were described as "a weaponless army whose recruits came from broken homes, highway trails and relief shelters … "[4] American Indians were at first not eligible but this restriction was soon lifted because of the dire conditions on many of the reservations.

Enrollment was also expanded to include "local experienced men" who served as technical foremen on work projects, and a limited number of World War I veterans. The latter were selected by the Veterans Administration and assigned to special camps operated less stringently than regular ones. Although racial discrimination was officially forbidden in accordance with the CCC legislation, blacks and other minorities did not escape prejudice within the program.[5] The number of blacks enrolled was limited, and they were for the most part restricted to segregated camps.

Reclamation's CCC Program

Due to its role in planning and constructing irrigation projects throughout the arid and semi-arid West, Reclamation was vitally concerned with farmers' welfare during the Depression. Beginning in 1902 the Federal government had invested heavily in construction of dams and water conveyance facilities to provide farmers with essential water. Irrigators who benefitted from Reclamation facilities were required to repay their construction costs over a period of years. Operation and maintenance of irrigation systems were also supported by fees paid by the water users. By the mid-1930s, Reclamation had constructed a network of some fifty small and large projects across the West.

The combined effect of drought and poor agricultural practices exacted a terrible toll on Western farmers during the Depression. Crop prices were low, water supplies had dwindled, and valuable topsoil was swept off of fields in blinding dust storms. The financial hardships faced by farmers meant that irrigation systems were not adequately maintained. Many aging water control structures had deteriorated beyond repair; canals were silted and clogged with vegetation; weeds and gophers infested canal banks; and crop yields dropped drastically with the decrease in water supplies. By 1934 it had become critical for the Federal government to address the plight of western farmers and to safeguard its hefty investment in irrigation projects. The CCC program provided a perfect mechanism for doing both while meeting its objectives of protecting natural resources and aiding unemployment.

The first CCC camp to open on a Reclamation project was established in May 1934 at Lake Guernsey, a reservoir of the North Platte Project, in Wyoming. Designated originally as RS-1 (Reclamation Service No. 1), the camp became known as BR-9. It was obtained under a cooperative agreement with the NPS and along with BR-10, established in July 1934, was responsible for transforming the reservoir shores into a showplace of recreational development. Sturdy log and stone picnic shelters, trails, and a handsome rustic-style museum complete with interpretive displays were built by CCC enrollees. The outstanding significance of their contributions at Lake Guernsey resulted in the designation of Lake Guernsey State Park as a National Historic Landmark on September 25, 1997.

In early September 1934 a second camp was established on a cooperative basis with the NPS at Elephant Butte Reservoir on the Rio Grande Project in New Mexico. Designated BR-8, the camp enrollees, along with those from BR-54 occupied in August 1935, greatly improved the recreational facilities at the reservoir. They also transformed the landscape by building a variety of structures, terracing the hillsides, and planting hundreds of trees. The CCC component is a major feature of the Elephant Butte National Register Historic District, listed in the National Register of Historic Places in February 1997.

In July 1934 six drought-relief camps were also assigned to Reclamation. These were essentially the same as regular CCC camps but were restricted to states suffering severely under the drought and were authorized for one year, rather than the normal six months. Additionally, they were financed under different appropriations.[6] Assigned numbers beginning with DBR (Drought Relief Bureau of Reclamation), the six camps were DBR-1 at Lake Minatare, Nebraska, on the North Platte Project; DBR-2 at Fruitdale, South Dakota, on the

Belle Fourche Project; DBR-3 at Carlsbad, New Mexico, on the Carlsbad Project; DBR-4 at Ysleta, Texas, on the Rio Grande Project; DBR-5 at Heber, Utah, on the Strawberry Valley Project; and DBR-6 at Ephraim, Utah, on the Sanpete Project. The improvements completed on Reclamation irrigation projects by the drought-relief camps were of tremendous value in combating the acute water shortages plaguing farmers. The camp at Lake Minatare can also be credited with construction of a unique Reclamation CCC edifice that still exists: on a point of land extending into the lake, the enrollees built a fifty-five-foot-high native rock "lighthouse" containing a circular staircase. From the observation deck at the top can be seen Scotts Bluff and Chimney Rock, both landmarks of the Oregon Trail.

Initially, work accomplished at Reclamation CCC camps focused on rehabilitating the storage, distribution, and drainage systems of older projects that had been seriously affected by the combination of drought and depressed farm prices. Efforts consisted of returning weed- and silt-filled canals and laterals to a proper cross section; replacing decaying wood structures with concrete; adding new water control structures; building bridges over canals; eradicating weeds and rodents; reconditioning operating roads; placing riprap on canal and lateral banks, and sealing porous canals with earth or concrete linings. Much of the work accomplished was of a seemingly mundane and unspectacular nature but it had far-reaching benefits.

As Reclamation's CCC program expanded from its small beginnings in 1934, the types of project work undertaken by the enrollees grew more varied and broadened to include developing supplemental water supplies and constructing new irrigation projects. The acute water deficiencies experienced during the Depression indicated that a few of the project storage facilities, though adequate under ordinary conditions, were insufficient during drought periods. To remedy this situation, CCC forces were used to build supplemental storage facilities. Examples are Midview Dam and dike on the Moon Lake Project in Utah (BR-11) and Anita Dam on the Huntley Project in Montana (BR-57). Clearing reservoir areas of timber and debris in preparation for new dam construction was another labor intensive task assigned to the enrollees at various camps. The physically demanding work involved felling trees, piling, and then burning them. Utilizing heavy equipment such as tractors and bulldozers provided the enrollees an opportunity to learn new skills. The most prominent of this type of work was accomplished at the Shasta Dam site on the Central Valley Project in California. Enrollees of BR-84 and BR-85 cleared 2,597 acres in the reservoir area during the camps' existence. Similar work was undertaken at Wickiup Reservoir on the Deschutes Project (BR-75, -76, and -77), Deer Creek Reservoir on the Provo River Project (BR-91), Pine View Reservoir on the Ogden River Project (BR-12), Island Park Reservoir on the Upper Snake River Project (BR-28) and Parker Dam Reservoir on the Parker Dam Project (BR-17 and BR-18).

Building new feeder canals to bring additional water to existing reservoirs was another effort to increase water supplies. Examples include the Duchesne

Feeder Canal on the Moon Lake Project (BR-11) and the Strawberry Reservoir Feeder Canal on the Strawberry Valley Project (BR-5). Enrollees cleared the canal right-of-ways, excavated the trenches, trimmed the canal slopes, and, in some cases, poured concrete linings. The CCC also completed improvements to numerous existing storage facilities such as Orman Dam on the Belle Fourche Project (BR-2), Clear Lake Dam on the Klamath Project (BR-41), Moon Lake Dam on the Moon Lake Project (BR-11), and the South Diversion Dam on the Orland Project (BR-78).

32.2. CCC crew placing and finishing concrete at a new Kingman check on the Owyhee Project in 1940.

Another type of work undertaken by the CCC was flood control. Many areas of the West under Reclamation projects were subject to intense localized rainfalls of short duration that had caused severe damage to irrigation systems. The CCC built a number of flood control structures such as Apache and Box Canyon Dams on the Rio Grande Project (BR-39).

As noted earlier, among the most visible contributions of the CCC enrollees assigned to Reclamation projects were the recreational improvements completed. Several of the projects had lands adjacent to rivers, reservoirs, or lakes, which were ideally suited for use as parks, campgrounds, or picnic areas. Some of these lands were developed by the CCC through construction of tables, benches, stoves, fireplaces, water systems, latrines, sewage disposal plants, and landscaping. Swimming, boating, and fishing facilities, and hiking trails built by the CCC provided park visitors with additional amenities. The improvements greatly enhanced public appreciation for the CCC and made Reclamation projects more accessible. The prime examples of recreational development occurred at Elephant Butte Dam on the Rio Grande Project (BR-8 and BR-54), at Guernsey Lake on the North Platte Project (BR-9 and BR-10), and at Lake Walcott on the Minidoka Project (BR-27).

32.3. CCC forces lined small community ditches in Las Cruces, New Mexico, on the Rio Grande Project in 1937.

Auxiliary to these main classes of work, the CCC enrollees were engaged in improvements to wildlife refuges at reservoirs, rodent control operations, weed eradication experiments, and emergency work. In cooperation with the Bureau of Biological Survey (now the Fish and Wildlife Service), Reclamation's CCC enrollees developed wildlife refuges at the Deer Flat Reservoir in western Idaho (BR-24), Tulelake Wildlife Refuge in northern California (BR-20), at Lake Walcott, in southern Idaho (BR-27), and at the Pishkun Reservoir in Montana (BR-33). At Elephant Butte Reservoir, CCC forces constructed a 12-pond fish hatchery (BR-8 and BR-54).

The elimination of troublesome rodents along canal banks and in farm fields was an ongoing endeavor at many camps and was viewed as an "undertaking of major importance to many Reclamation projects."[7] Damage caused by rodents was twofold: in canal banks their burrowing resulted in canal collapses and in fields their activities resulted in substantial crop loss. Pocket gophers and ground squirrels were the primary targets and, in cooperation with the Biological Survey, eradication was accomplished either by trapping or poisoning or both. The work was well suited to the CCC program because it was labor intensive. Small crews performed the task as an adjunct to larger construction projects. By June 1941 CCC enrollees treated 2,510,100 acres for rodent control.

Weed eradication was another activity performed at many Reclamation CCC camps. The presence of noxious weeds, such as Canada thistle, bindweed, and Johnson grass, was increasing on Reclamation projects, and the available labor of CCC recruits was applied towards eliminating this menace. Canals provided easy transportation routes for seeds to all parts of the irrigated lands, and controlling and eradicating weeds was a complex problem. Enrollees did not enter on private property to conduct weed control, but the farmers were shown, by demonstration on government tracts, the methods of attacking various kinds of invasive plants. Sample demonstrations were also performed on the Government canals and laterals for the benefit of the operating personnel. Experiments with different types of grasses that could crowd out weeds on canal banks and that might be useful as a pasture crop were undertaken.[8] On the Belle Fourche Project (BR-2), CCC enrollees demonstrated to farmers the use and methods of growing strawberry clover and brome grass as valuable pasture. Experiments to eradicate noxious weeds using blades and chemicals were carried on at test plots. On the Rio Grande Project (BR-4), considerable effort was expended on that objective. Different methods tried for the control of bindweed included chopping plants out by hand, spraying them with oil, and then burning them.

While the CCC program received a lot of attention for its role in fighting forest fires and assisting in flood disasters, emergency work conducted by CCC enrollees on Reclamation projects attracted little recognition in spite of its great value. The most common emergencies were canal breaks usually resulting from the tunneling activities of rodents. Such breaks, if not repaired promptly, had the potential to cause serious damage by flooding some fields and drying up others. A 1937 *Reclamation Era* article described various emergencies that had been attended to by CCC enrollees. On the Klamath Project in California and Oregon (BR-20 and BR-41), ten recent breaks in canal banks had been repaired. On the Salt River Project in Arizona (BR-14 and BR-19), a serious break in the South Canal occurred in April 1937 and was tended to by enrollees. Early in May 1937 CCC men from the Deaver Camp on the Shoshone Project (BR-7) were called out to help reconstruct 300 feet of the inclined drop below the Ralston Reservoir.

32.4. CCC forces placing steel reinforcement on the Stinkingwater Siphon, Belle Fourche Project, in 1938.

The hazards of winter created numerous emergencies where the help of the CCC was invaluable. The snow season of 1936-1937 was particularly severe in parts of Utah and Nevada, and the CCC youths effectively carried out emergency work to save human lives and livestock. In January 1937 about 50,000 head of sheep were marooned by heavy snows in Pleasant Valley in the Uintah Basin of eastern Utah. A CCC tractor, with a bulldozer attachment, was loaned to the Utah State Road Commission to open a 26-mile road on which to lead the animals out. CCC enrollees from BR-11 on the Moon Lake Project accompanied the tractor to perform any unexpected repairs. Mining and farming districts in western Nevada were particularly hard hit by snowstorms in early February 1937. CCC men and equipment were made available for rescue work. In cooperation with the county, they cleared 380 miles of road, dug out ten towns and outlying ranchers and miners, and permitted feed to be hauled to many isolated cattle herds.

All CCC men at Carlsbad, New Mexico, (BR-3) were called out in early June 1937 to perform emergency flood protection work at McMillan Dam brought about by extreme flood conditions of the Pecos River. A leak caused by the high waters was discovered at the dam on May 31, and for the next six days CCC crews placed sandbags on the reservoir face of the dam to hold back water from any leaks that might occur. The superb efforts of the CCC enrollees were praised. When a small dam failed on June 13, 1937, near Austin, Colorado, and partially flooded the town, CCC forces from the camp in Montrose (BR-23) were brought in to help restore sanitation facilities and repair damaged irrigation ditches.

At the height of the CCC program in the summer of 1935, there were forty-six camps operating on Reclamation projects throughout the West. In addition to and in association with the main camps, side camps also known as spike camps, were sometimes established. These were usually smaller and made up of tents that could easily be dismantled. Typically, camp structures were standard plan, simple frame buildings. Side camps were created when a job was at such a distance from the main camp that it made sense to station a work force in closer proximity. Examples of side camps on Reclamation CCC projects were the ones at Alamagordo Dam (BR-3, main camp) where enrollees constructed improvements for recreational use of the reservoir; on the Hyrum Project (BR-12, main camp) where enrollees constructed a diversion dam on the Little Bear River and built a parapet and curb walls on the Hyrum Dam; and at the river portal to the Gunnison Tunnel (BR-23, main camp) where enrollees worked on widening and reconstructing the old road leading from the top of the canyon down to the East Portal.

32.5. CCC men working on McMillan Spillway No. 2, Carlsbad Project, New Mexico, in 1938.

Some CCC camps established on Reclamation projects were seasonal for climatic reasons. Those at high elevations, such as BR-5 on the Strawberry Valley Project, were summer camps and enrollees were relocated to lower elevations in the winter (BR-11). BR-50 on the Yakima Project was only occupied during the summer because of heavy winter snows and severe weather. Due to the intense summer heat in Yuma, Arizona, enrollees of BR-13 and BR-74 did not occupy the camps during that season for the first few years. The two Salt River Project camps in the Phoenix area, BR-14 and BR-19, operated similarly.

Job Training in Reclamation CCC Camps

When CCC camps were assigned to Reclamation, the agency assumed responsibility for supervising and training the enrollees while they were engaged in project work. The latter was scheduled for five days a week, eight hours a day except in the event of emergencies. Oversight of work activities was carried out by Reclamation field engineers and by project superintendents in charge of the Reclamation projects on which the camps were located. The field engineers directed surveys, inspections, and other field engineering work. They also supervised and approved the construction of the various physical features. The CCC project superintendents, also designated by Reclamation as CCC Regional Directors, had immediate charge of the work activities and directed the CCC supervisory, facilitating, and enrolled personnel in carrying out the work.

During the lifespan of the CCC, Reclamation dedicated an increasing amount of attention to the job-training aspects of the CCC program. Even before a national requirement for ten hours of weekly general education or vocational training was instituted in June 1937 by CCC headquarters in Washington, D.C., Reclamation recognized the valuable skills that enrollees were developing on the job. Constructing canals, roads, dams, and water control features as well as building recreational facilities afforded enrollees a perfect opportunity to gain practical experience. Building concrete structures involved teaching the young men the fundamentals of earth excavation, form building, reinforcement, concrete mixing, concrete finishing, and curing concrete. Other training included working with rock, both in quarrying and the construction of masonry walls; the use of burners and chemicals for weed control; and the shaping of lumber for timber structures. Enrollees became expert at operating all types of heavy equipment such as tractors, trucks, and draglines. In addition to acquiring construction skills, enrollees at Reclamation camps participated in the cooking and clerical operations of the camps.[9]

32.6. Yuma Project. CCC enrollee off-the-job-training class in blacksmithing on the Yuma Project in 1939.

The opportunity to attend classes in the evening was another component of the educational experience offered at CCC camps. Some of the young men enrolled in nearby schools to further their knowledge. With the increased emphasis on education, starting in June 1937 Reclamation expanded its own classroom programs. During the day, foremen were assigned to supervise and explain to enrollees the proper method to do their assigned tasks. One or two evenings a week, the foremen held classes in camp to supplement the practical work with related training. For example, an enrollee whose duty it was to refuel tractors with diesel fuel might learn the essential difference between diesel fuel and gasoline. A standard CCC truck driver's course taught truck drivers how to reduce the cost of vehicle maintenance, to be more efficient operators, and to be safety conscious. Visual aids such as miniature models and motion pictures were often used to enhance the classroom instruction. Foremen attended leadership courses to learn effective teaching methods. Regular Reclamation employees assisted by teaching technical subjects and clerical skills such as property accountability and cost-keeping. Courses mentioned in some of the camp reports include spelling, blueprint reading, bee culture, warehousing, and shorthand.[10]

All sorts of training materials were also available through the CCC education office in Washington. Handbooks containing lists of available films and manuals were sent out to the camps. Manuals ranged in subject from "Brick and Stone Work" to "Common Range Plants" to "Signs and Markers" to "Job Training is a Business Proposition." All camps had libraries supplied with textbooks, reference works, and a selection of daily newspapers. Books useful for on-the-job training as well as for advancing personal skills were available. Titles ran the gamut from “Accountancy as a Career” to “Electricity in the Home and on the Farm” to “Elements of Forestry” to “Amateur Machinist.”

Towards the end of the CCC program, Reclamation directed all of its camps to furnish new enrollees with a series of publications intended to familiarize them with the agency and its role in conserving resources. The list included *Reclamation Home Creating—Wealth Producing—Self Sustaining*, *Grand Coulee Dam, Boulder Dam*, and the *Central Valley Project*. Reclamation had plans to prepare its own pamphlet on the agency’s CCC program, but it is unknown whether this ever occurred.

The training and education paid off for Reclamation’s CCC enrollees. In February 1937 it was reported that CCC men from Reclamation camps had been successful in securing a range of jobs upon leaving the Corps. These included farmer, farm hand, ranch hand, miner, railroad worker, skilled labor helper, lumberjack, highway worker, factory worker, and painter among others. Much of the success of the enrollees was attributed to the experience gained while in the CCC camps. Records indicated that enrollees who served at least a year or longer in the CCC ended up with higher paying jobs than those who served for just six months. Enrollees who were offered positions while in the Corps were honorably discharged to start their employment. It was found that the young men leaving the CCC to accept jobs usually returned to their home state or region. Eastern boys assigned to western camps nearly all returned to the East and western youths preferred to stay in the West. Even before leaving the CCC, individuals who performed outstanding work had opportunities for advancement. They could be promoted to responsible positions as foremen on the technical supervisory staff at camps when vacancies occurred.

From information included in Reclamation’s CCC regular camp reports and in journal articles, it appears that the training offered to enrollees was well-received by them. In fact, with few exceptions the morale of the enrollees was noted as good. For example, at BR-5 on the Strawberry Valley Project, the “enrollees exhibited a fine cooperative spirit and high morale” despite the remote locality of the camp. At BR-20 on the Klamath Project, the enrollees were praised for their hard work in the camp’s first annual report:

> The manner in which the men in both camps (BR-41 as well) applied their efforts was truly remarkable, and it was not long before the camps became well established and the work program began to show signs of progress … The men wanted to work, to prove their worth and better themselves, when given the opportunity. Moreover, they proved this when offered the facilities of the buildings and teaching personnel at the Merrill and Tulelake high schools for evenings.

In addition to the emphasis on developing “strong minds,” CCC camps also promoted building “strong, healthy bodies.” Physical conditioning, in addition to educational training, was considered important for character improvement and for maintaining good camp morale. Planned athletic and recreational activities were part of all camp schedules. Enrollees participated in sports such as baseball, basketball, swimming, ping pong, or tennis. Many camps also offered regular recreational outings to nearby towns and attractions.

A number of the camps produced their own newsletters in which upcoming activities were announced or the results of sports competitions were reported. The newsletters provide a more personal view of daily life at the camps. A column in the October 1937 "Stanfield Echo" (BR-44) advised new enrollees on proper behavior. Among the twenty items listed were the following: "Be careful of the type of language you use around camp and in public;" "Do not smoke or flip cigarettes, or talk after the lights are out;" "The wasting of food is considered serious misconduct and will be punished accordingly;" and "Watch your actions while you are in town, you will be judged accordingly."

Although Reclamation's CCC program was not without its critics, overall it appears to have been viewed as very beneficial by the public. Their initial concerns about having unemployed youths living nearby dissipated over time. Annual open houses at the camps gave outsiders a perfect opportunity to learn of the accomplishments of the enrollees and to better understand the program. Camps participated in numerous local events such as parades and county fairs. Reclamation even produced a film in 1937 entitled *Reclamation and the CCC* which showed enrollees engaged at work on a number of projects. Unfortunately, no copy of the film has been located.

Strong community support is evidenced in newspaper articles published in early 1938 when President Roosevelt contemplated closing all Reclamation camps in response to the criticism that they benefitted private irrigators rather than the interests of the public. In Wyoming, the *Powell Tribune* wrote:

> As to the CCC in reclamation work, we have regarded the camp at Deaver as of great benefit to the general farming community there … We need more CCC camps and fewer jails; we need more CCC camps and less unemployment; we need more CCC camps for the improvement in mind, morals and body of the boys themselves—that is more important and more of value to us all than the work they do.[11]

In February 1938, to counter the accusations lodged against it, Reclamation restricted CCC activities to Federally owned lands, and the government had to have a direct financial interest in all work performed, or it had to be developing recreational facilities for public benefit.

Termination of Reclamation CCC Camps

The outbreak of World War II brought an end to the CCC. As the United States geared up the production of arms and ammunition, the unemployment problem dissolved. The number of CCC camps nationwide dwindled from a peak of 2,652 in the summer of 1935 to 1,500 by April 1939.

With the attack on Pearl Harbor, the country's attention was riveted on a new front. Some six weeks after the bombing, on January 27, 1942, CCC director James L. McEntee announced the immediate reorganization of the CCC on a war basis. He directed the termination of all CCC camps as quickly as possible unless they were involved in war-related construction activities or in the protection of war-related natural resources.

Reclamation justified its continued need for CCC camps during the war on the basis of the urgent need for a reliable and adequate food supply. The effect of the war on Reclamation's CCC program was thus described:

> The defense program and later the all-out war program emphasized the responsibility of the Nation's food growers, and a portion of that responsibility was thus imparted to the camps helping in this work. Meeting the needs of the armed services and industry, the bureau's camps provided one of the sources of supply for trained construction equipment operators. All phases of the training program were emphasized and especially those skills which could augment the supply of needed trained workers.[12]

During the last full fiscal year of the CCC program, 1942, there was a reduction in the number of camps assigned to Reclamation from forty-three camps on July 1, 1941, to seven camps on June 30, 1942. In general, the CCC work activities previously initiated were continued through fiscal year 1942, with impetus added by the war. In planning for the annual CCC "open house" celebrations in 1941, a memo was sent out from Reclamation Commissioner John Page to all CCC field offices urging them to highlight activities contributing the most to the national defense program. Page quoted from a letter that the Director of the CCC had sent out:

> It should be emphasized that the entire pattern of camp life—the daily routine, the training and educational programs, the work projects—all contribute to national security by developing in youth character, discipline, good work habits, health, love of country and the ability to achieve economic independence.[13]

Eight new camps were assigned to Reclamation at the beginning of Fiscal Year 1942. They were established for the purpose of constructing small water conservation and utilization projects (BR-93, -94, -95, -96, -97, -99, -101, -102). Sometimes referred to as Wheeler-Case Projects, they were confined to the Great Plains and other western areas subject to drought and water shortages. As one of several agencies participating in the program, Reclamation's role was to construct irrigation facilities to help meet local water needs. By the end of the year, considerable progress had been made.

Although President Roosevelt urged continuation of the CCC as a means of accomplishing critical defense work, Congress sealed the fate of the program on June 30, 1942, when it voted to liquidate the CCC and allocated $8 million to help cover closing costs. Steps were immediately taken to release the remaining 60,000 enrollees and to discontinue all work programs. Reclamation's remaining camps were shut down the following month. Some of Reclamation's terminated camps were transferred to the Army or Navy for military use. In a number of cases, closed CCC camps were used to house conscientious objectors (BR-75, -76, -77, -93, -95, -97, -99), war prisoners (BR-39) or Japanese evacuees (BR-42). Where no future uses could be contemplated, camp structures were relocated or demolished.

Conclusion

During the life of the CCC program, Reclamation operated camps at eighty-three separate locations on forty-five Reclamation projects in fifteen western states. Even though the agency was but a minor recipient of CCC benefits (in April 1937 Reclamation was assigned thrity-four camps which represented only 1.7 percent of the total number), Reclamation continually touted the positive results attained by the enrollees. The assignment of CCC camps to Reclamation occurred at a time when western agriculture was in critical straits. Work completed by the enrollees helped revitalize an array of existing irrigation projects and brought new water to other areas.

A few figures illustrate the impressive volume of accomplishments of CCC forces on Reclamation facilities: over 60,000,000 square yards of canals and drainage ditches were cleaned or cleared; 1,800,000 square yards of canal were lined with impervious material and 2,800,000 square yards were riprapped for protection against erosion; 3,000 miles of operating roads had been constructed along canal banks; 39,000 acres of reservoir sites were cleared of brush and trees; and 15,800 water control structures had been built. The contributions of the CCC were summarized in Reclamation's final report on the program as follows:

> The fine work of the Civilian Conservation Corps by 1942 had brought the Federal irrigation projects back to a high standard of physical excellence. The irrigation systems are now in generally good condition, able to deliver required amounts of water and by the permanency of their rehabilitation they are insured against interruptions of consequence.[14]

For the enrollees at Reclamation camps, the experience provided invaluable skills, training, and opened new doors for a more promising future. The CCC offered an opportunity "To learn in the great outdoors—how to work, how to live, and how to get ahead."[15]

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skills as an architectural historian. She has published several articles on the history of Reclamation, a book on Reclamation's historic buildings, and a book on the CCC at Reclamation.

Endnotes

1. Portions of this paper are excerpted from "'Happy Days' of the Depression: The Civilian Conservation Corps in Colorado" an article I wrote that appeared in *Colorado Heritage* in Spring 2001.
2. *Objectives and Results of the Civilian Conservation Corps Program* by Robert Fechner, 1938, National Archives, Denver (RG 115, Entry 22, Box 35, file 035).
3. *Objectives and Results of the Civilian Conservation Corps Program,* p. 7.
4. Frederic Haskin, "Praises Record of C.C.C. Camp," *The Sunday Washington Star*, August 11, 1940.
5. Of three amendments to the bill signed by Roosevelt on March 31, 1933, one was submitted by Representative Oscar De Priest, Republican of Illinois, and the only black Congressman. It prohibited discrimination on account of race, color, or creed. (John Salmond, p. 23).
6. Dr. H. T. Cory, "Civilian Conservation Corps Work on Reclamation Projects," *Reclamation Era*, January 1936, p.22.
7. Alfred Golzé, "CCC Accomplishments on Reclamation Projects," *Reclamation Era*, January 1937, p. 26.
8. Alfred Golzé, "Civilian Conservation Corps Accomplishments on Federal Reclamation Projects," *Reclamation Era*, September 1938, p. 192.
9. Alfred Golzé, "Reclamation Work Trains CCC Men," *Reclamation Era*, February 1937, pp. 38-9.
10. Alfred Golzé, "CCC Accomplishments on Federal Reclamation Projects, Fiscal Year 1940," *Reclamation Era*, November 1940, p. 318.
11. "Write Congressmen About This." *Powell Tribune*. January 20, 1938. A copy of this newspaper article as well as the other ones mentioned are located at the National Archives, Denver (RG 115, Entry 22, Box 34).
12. Federal Security Agency. *Annual Report of the Director of the Civilian Conservation Corps*. Fiscal Year Ended June 30 1942, p. 40.
13. Memo from Commissioner, Bureau of Reclamation to All CCC Field Offices, February 24, 1941. National Archives, Denver, (RG 115 Entry 22, Box 1).
14. "Final Report, Civilian Conservation Corps Activities, Bureau of Reclamation."
15. Article from *Congressional Record*. February 2, 1939, National Archives, Denver (RG 115, Entry 28, Box 1).

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In addition to the articles in *Reclamation Era*, the best source of information on Reclamation's CCC camps are the records located at the National Archives, Rocky Mountain Region, in Denver. Reclamation's CCC records can be found in RG 115 under Entries 7, 21, and 22. Information can also be found in Reclamation's project histories located at the National Archives in RG 115, Entry 10.

Lee's Ferry, the Colorado River, and the Development of the Bureau of Reclamation

By:
Douglas E. Kupel

Abstract

The 100-year anniversary of the Newlands Act, which created the U.S. Reclamation Service, now known as the Bureau of Reclamation, will be celebrated in the year 2002. This occasion marks an appropriate time to reflect on the development of the Bureau over time. As the prime focus of Federal activities on the Colorado River, events at Lee's Ferry have made a decided impact on the direction of the Bureau. This paper examines the role of Lee's Ferry as a concrete location and spiritual center for the reclamation movement in a paper prepared for the Bureau's Centennial Symposium.

Established as a refuge from Federal authorities for exile John D. Lee, Lee's Ferry is now the physical and spiritual center of the Federal contribution to Western water history. As scholars look back on the centennial of the Bureau of Reclamation, an examination of the history of Lee's Ferry and the turf battle between the Bureau and the USGS over the future development of the Colorado River provides needed insight. It adds a valuable perspective for westerners concerned with the next hundred years of water history. Known today primarily as the departure point for thousands of white-water rafting thrill-seekers and world-class trout anglers, the future of Lee's Ferry will be every bit as significant as its past.

Introduction

Lee's Ferry is both the physical and spiritual heart of water history in the arid West. As a physical place, Lee's Ferry is the crucial dividing point between the Upper and Lower Basin states as defined by the Colorado River Compact of 1922. Measurements taken at Lee's Ferry govern the amount of water credited to each of the basins, as well as allocations between states within each basin.

As a symbol, Lee's Ferry represents the pivotal position of the Colorado River in the development of the Bureau of Reclamation. First settled as a remote place of exile for fugitive Mormon leader John D. Lee as he sought to escape Federal authorities, Lee's Ferry is now the true "ground zero" for Federal influence on the West. As the focus of Federal activities on the Colorado River, events at Lee's Ferry have made a decided impact on the direction of the Bureau.

Despite its key role in history, the history of Lee's Ferry itself had been left relatively unexamined. Recent work by historian P. T. Reilly and others have only now added new chapters to the complex saga of Lee's Ferry. This new research provides support for the contention that Lee's Ferry is one of the most significant locales in the landscape of Federal water policy.[1]

Lee's Ferry is located between the two largest dams on the Colorado River. Just upstream of Lee's Ferry is the massive Glen Canyon Dam, which creates Lake Powell. Downstream from Lee's Ferry and on the west side of the Grand Canyon is Hoover Dam, which backs up the waters of the Colorado to form Lake Mead. Glen Canyon was constructed in the 1950-1960s and represents the last of the giant concrete dams completed by the Bureau of Reclamation. Hoover Dam, completed in the depression decade of the 1930s, represented the beginning of a new era for Reclamation.

What few people realize today is that there was considerable debate about the relative merits of the two dam locations in the twenties. This vigorous debate pitted representatives of two Federal agencies against each other: the venerable U.S. Geological Survey, tracing its heritage back to the nineteenth century ideals of John Wesley Powell, and the upstart U.S. Reclamation Service, representing a twentieth century conception of water use. Reclamation Service officials lobbied hard for construction of a dam on the lower Colorado to provide needed flood control for Southern California and Arizona while producing hydroelectric power for ready customers in Los Angeles. USGS officials, notably hydrologist E. C. LaRue, argued for the construction of a dam at Glen Canyon to regulate the flow of water between the Upper and Lower basins.

The Bureau won this skirmish between the two agencies, and construction of Hoover Dam sent Reclamation on a path of growth and achievement unparalleled in modern history. Eventually, the Bureau would return to the site of its earlier triumph. Construction of Glen Canyon Dam capped a long era of achievements.

The location of Lee's Ferry carries with it a touch of irony. John D. Lee was sent there by the Church of Jesus Christ of Latter-day Saints (Mormon Church) as an exile to build and operate a ferry. He built the Lonely Dell Ranch for Emma Lee, his seventeenth wife, a few miles below Glen Canyon Dam. By 1873 Lee had built a ferryboat named the *Colorado* and established the first ferry service across the river. Lee was captured by Federal authorities and executed in 1877 for his part in the Mountain Meadows Massacre. The ferry ran continuously until 1928. It was replaced by Navajo Bridge, which was completed across Marble Canyon in 1929.

Geology

The spectacular landscape dominating the canyon country of Northern Arizona is the product of eons of geologic activity: shifting of continents, global rising and falling of sea levels, and creation of highlands now worn and redeposited. At times, deserts dominated the landscape; sometimes freshwater or saltwater seas invaded, leaving rivers to erode the most recently deposited layers. Prevailing winds abetted the process. Periods of erosion account for missing rock strata, layers appearing elsewhere in sequence. Two geologic processes are most responsible for the canyon of the Colorado Plateau: 1) an uplift of the ground itself, and 2) erosion of the rock by many years of constant water flow.

The last uplift of the Colorado Plateau began about sixty million years ago. Uplift made the land rise. The meandering streams of the Colorado River ran faster and faster. As the land rose, the constant erosion of the water cut the canyons that today dominate the Colorado River. This erosion sliced through many geologic layers, which are now visible. Navajo sandstone, the dominant formation, is made of sand dunes hardened by pressure from deposits above them. The deposits eventually wore away and exposed today's sandstone. Other layers contain sea- deposited sediments; still others hold fossils of land or marine organisms that lived millions of years ago. Petrified wood and fossils of dinosaur bones, seashells, and small sea creatures are found in several rock strata in this area.

The deep canyons left by uplift of the Colorado Plateau and the downward force of erosion made access across the vast chasm of the Colorado River very difficult. Only at a few locations from its confluence with the Green River in Central Utah to the lower valley near Topock, California, does the Colorado open its banks to easy access. For hundreds of miles the canyon of the Colorado is an insurmountable barrier, isolating the lands of the Arizona strip north of the river and placing them with easier access to Utah than to the state capitol at Phoenix.

One of the few places along the canyon where the Colorado River can be reached with relative ease is at its confluence with the Paria River. Here, between the depths of Glen Canyon on the upstream side and Marble Canyon on the downstream side, is a break in the canyon walls for a stretch of two miles that allows a difficult and dangerous crossing of the river. Now Anglicized, the word Paria derives from the Indian name Pahreah, meaning a stream of water having willows growing along its banks.[2]

European Discovery

Early Spanish explorers traveled the northern frontier of New Spain (today's Mexico) looking for an overland route to California. Some of these explorers left us detailed accounts of their expeditions. In 1776 two Spanish priests began an expedition that provided the first written record of Lee's Ferry. Father Francisco Atanasio Dominguez and Father Silvestre Velez de Escalante set out from Santa Fe in July to pioneer an overland route from New Mexico to Monterey on the California coast. After three months, the party reached the vicinity of today's Cedar City in Utah, where they encountered an early snow. The inclement weather influenced a decision to turn back to Santa Fe before the full onset of winter. Following the advice of Paiute Indians, Dominguez and Escalante searched for a shallow ford of the Colorado.

Inadvertently turning too far south, the two priests reached what is today known as Lee's Ferry. On October 26 the party reached the Colorado River at the mouth of the Paria River. Here, the river proved too deep to ford on horseback, and too swift to swim across. The men christened their camp *Sal si Puedes* (get out while you can) and they did just that by moving upstream along the Paria River canyon until they reached the Colorado Plateau. The explorers climbed out of the river bottom and made camp near what is today's Wahweap Marina on Lake Powell. They spent four more days searching for a way across the river. Finally, on November 7, they chopped steps in the sandstone wall at a location now called Padre Creek and safely led their pack stock to the banks of the Colorado. Here the crossing was wide but shallow. The site known as the "Crossing of the Fathers" today lies beneath the waters of Padre Bay in Lake Powell.[3]

Mormon Crossing Era

The early development of Lee's Ferry is closely associated with the Church of Jesus Christ of Latter-day Saints (the Mormons or LDS). The river crossing is named for Mormon pioneer John Doyle Lee. The crossing was a key location on the major transportation route for Mormon immigrants to Arizona and, after 1877, for travelers returning to Utah along the "Honeymoon Trail" to the LDS Temple at Saint George to solemnize their unions.

The establishment of the Mormon Church dates to an event in American history known as the "Second Great Awakening," a period of religious revival and evangelicalism in the late 1820s and early 1830s. This revival was national in scope, but had two centers: in the south and in western New York state. In 1830 Joseph Smith received a revelation and a new type of Christian church began. Because of some unusual tenets of the religion, its practitioners were subject to opposition and distrust from more traditional, established religions. One of these early tenets of the LDS Church was polygamy, the practice of men taking more than one wife. From its original location in New York, members of the LDS church moved to Ohio, then to Illinois, and finally on the long trek to the Great Salt Lake in what would become the Territory and later the State of Utah. Members arrived at the present-day location of Salt Lake City on July 24, 1847.

John D. and Emma Lee, 1871-1879

John D. Lee was born in Kaskasia, Illinois, on September 12, 1812, and converted to Mormonism at the age of twenty-six. Lee joined Joseph Smith in western Missouri in 1838, then moved with other church members to Nauvoo, Illinois, after violence forced them to relocate. Lee was a leader in the community and constructed a substantial house in Nauvoo. After further violence, including the murder of Joseph Smith, Lee and the rest of the Mormon faithful began a westward trek. During the move Lee was a leader and able assistant to

Brigham Young on the trip to Utah. After establishing a home in Salt Lake City, Lee heeded his church's call to settle in the southern portion of Utah. Lee and his wives settled and built houses at Parowan, Harmony, and Panguitch in southern Utah.[4]

While living near Harmony, Lee participated in a massacre of immigrants en route to the Pacific Coast. In the summer of 1857 a wagon train under the command of Captain Charles Fancher set up camp at Mountain Meadows, a popular resting spot on the trip west. At the time, leaders of the LDS Church were in a bitter struggle with the Federal government over control of the Utah Territory and were anticipating armed intervention at any moment. The immigrants, many of them from Missouri, taunted the Mormon settlers with tales of how Smith's followers had been driven from the state. On September 11, 1857, local Mormon leaders and Ute Indians joined forces in an attack on the wagon train. Viewed ostensibly as a military campaign against a hostile force, the attack was a massacre from which only seventeen children escaped death. While in many ways a payback for tremendous mistreatment over the years, the Mountain Meadows Massacre of 1857 forever marked its antagonists with the taint of bloodshed and violence.[5]

The massacre opened southern Utah to additional Mormon settlement. Called Utah's "Dixie," because of its comparatively warm climate and southern location, this portion of the territory included the communities of Saint George, Harmony, Panguitch, and Cedar City. This process of colonization was an integral part of church expansion. In addition to southern Utah, church leaders began to look southward into Arizona. Of particular interest for Mormon proselytizers were the sedentary and urban Hopi Indians.

In 1858, 1859, and 1860, Mormon leaders sent expeditions to the Hopi. Led by pioneer Jacob Hamblin, the missionary parties crossed at what would later become Lee's Ferry. These early efforts toward converting the Hopi to the Mormon religion proved disappointing. In time, Mormon leaders directed their attention to the neighboring Navajo. In contrast to the Hopi, who received the Mormon missionaries with indifference, the Navajo were openly hostile to those they considered intruders in their land. By 1860 the Navajo were in a state of open conflict with the U.S. Government, a situation which ended only with the Navajo's defeat at the hands of Kit Carson. While many Navajo lost their lives during the conflict, many more died during the infamous "long walk" to the Bosque Redondo reservation in New Mexico.

The relationship between the Mormons, the Navajo, and the Hopi took on the form of an uneasy truce after 1865. Mormon missionaries remained anxious to convert additional souls, but they also coveted the few well-watered locations in Arizona for settlements. Resident American Indians looked to protect their lands.

As one of the few locations where the Colorado could be crossed, the Paria River confluence served an important military purpose to the Mormons. Control of the crossing prevented incursions by Native Americans north of the river while providing a base of operations for Mormon colonizing to the south. In October of 1869 Hamblin posted guards at the river crossing to control access at this strategic point. Hamblin christened the post "Fort Meeks" in honor of camp leader William Meeks. By 1870 Hamblin had cleared a patch of land along the Paria and planted wheat. As historian A. Gary Anderson has noted, "this crossing on the Colorado River was not unknown when John D. Lee arrived, nor was the idea of a ferry new."[6]

Although U.S. President James Buchanan had issued a general pardon for acts of rebellion arising from the Utah War in 1858, for John D. Lee and other Mormon leaders associated with the Mountain Meadows Massacre the passage of time could not wash the stain clean. In 1870 LDS church officials excommunicated Lee and others for their participation in the event. While church officials were outwardly preparing to fix the entire blame for the affair on Lee, inwardly they still considered Lee as one of their own. Despite the excommunication, for Lee, a faithful member of the flock since 1838, relinquishment of his loyalty to the church would come slowly if at all.

To Lee and the Mormon leadership, the confluence of Paria Creek with the Colorado River served two important purposes. For Lee, it provided a remote and isolated area free from the watchful eyes of Federal authorities. For the church, it was an important link in the Mormon colonization of Arizona.

Lee and two of his families set out for the remote location, arriving shortly before Christmas in 1871. Mormon historian Juanita Brooks credits Emma Lee with naming the locale "Lonely Dell" based on the pioneer wife's initial observations. Wives Emma and Rachel took up residence, one in a dugout and one in a rock structure. In May of 1872 Rachel moved to a location today known as "Jacob's Pools," leaving Emma Batchelder Lee as the woman in charge of Lee's Ferry. Emma was indeed the driving force behind the ferry and the Lonely Dell Ranch, as Lee himself was often absent.[7]

The arrival of Lee created two centers of activity at the confluence of the Paria and Colorado Rivers. The ferry across the Colorado operated from the water's edge, downstream from the juncture of the two rivers. The residential area, starting with some rough cabins and corrals, was upstream along the Paria. This sheltered location back from the Colorado gave the residents some protection from storms that frequently passed through the canyon.

During December of 1871 Lee constructed crude shelters for his two wives and their children. Based on accounts from Lee's diaries, Mormon historian Juanita Brooks described these early structures:

> By January 12 they had finished building two small rooms. One was a dugout with its back and two sides set into the hillside. It had a flagstone floor, and a willow and sod roof. Later, this would be a cellar, and a place where the children could sleep during the scorching midday hours. The larger room was of rock laid up with mud and lime mortar, and had a dirt floor and roof, but two small windows and a solid door.[8]

These first dwellings were mere shelters from the elements. As time went on, Lee constructed a more presentable cabin of driftwood for Emma. He had the assistance of Tommy Smith who arrived in 1872 with lumber for a new ferryboat and considerable carpentry skills. Professor Harvey C. DeMotte, a member of John Wesley Powell's 1871-72 expedition down the Colorado, left us with a description of the building as it appeared in 1872:

> The house of logs and innocent of floor, whose foundations were not laid with square and compass, stood with gable pointing toward the south of east; along one side a shade, composed of leafy boughs, served well the purpose of verandah, from the outer edge of which suspended blankets hid the sun's rays from the evening meal.[9]

John Wesley Powell's trips down the Colorado have received well-justified attention by historians through the years. While Powell and his men achieved a significant accomplishment by being the first to travel downstream on the Colorado River through the Grand Canyon, the records of Powell's exploits also give us some insight into conditions at Lee's Ferry. Powell took two trips through the Colorado, one in 1869 and a second in 1871 and 1872. The second trip was actually undertaken in two parts, with a break at Lee's Ferry.[10]

Powell first visited Lee's Ferry on August 4, 1869. His crew spent the night there, noting the remains of Indian and Mormon campfires. Powell returned on September 30, 1870, during a reconnaissance trip in preparation for his second voyage. Accompanied by Jacob Hamblin, Powell and his men constructed a flat boat called the Cañon Maid to use as a ferryboat to cross the river. Recognizing that Lee's Ferry was an important access point on the river, Powell used it as a location to split his second trip down the Colorado. In 1871 the party left Green River, Wyoming in May and arrived at Lee's Ferry in October. The men cached one boat on each side of the river and disembarked. The Powell party returned to

33.1. This 1871 image of John Wesley Powell's second expedition down the Colorado River was captured at the jumping off point in Green River, Wyoming.

Lee's Ferry in the summer of 1872 to resume their trip.[11]

The main difference between the two trips was that John Doyle Lee had arrived at the mouth of the Paria to establish his residence. Frederick S. Dellenbaugh, a member of Powell's party, noted that in addition to constructing a cabin, "Lee had worked hard since his arrival early in the year and now had his farm in fairly good order with crops growing, well irrigated by the water he took out of the Paria. He called the place Lonely Dell, and it was not a misnomer."[12]

With a good knowledge of Lee's predicament, members of the Powell expedition were not above having some fun with Lee. Dellenbaugh describes one incident:

> Our camp was across the Paria down by the Colorado, and when Brother Lee came back the following Sunday he called to give us a lengthy dissertation on the faith of the Latter-Day Saints (Mormons), while Andy, always up to mischief, in his quiet way, delighted to get behind him and cock a rifle. At the sound of the ominous click Lee would wheel like a flash to see what was up. We had no intention of capturing him, of course, but it amused Andy to act in a way that kept Lee on the qui vive.[13]

In addition to constructing lodging, Lee quickly turned his attention to the establishment of a garden patch. One of his first tasks was to complete a dam on the Paria River to impound water for irrigation. Thus began a continual battle to maintain the dam in the face of frequent floods and to keep the crops watered during times of drought.[14]

In 1872 church authorities desired to open Arizona to colonization and assigned Lee to operate a ferry. A boat was completed by January of 1873. In April of 1873 church officials sent Joseph W. Young, James Jackson, and twenty-five others to improve roads to and from the ferry site. Jackson assisted Mrs. Lee during the frequent absences of John D. Lee from the site.

In 1874 conflict between Mormons and the Navajo led church officials to fund construction of a "Fort" on the banks of the Colorado River. In January of 1874 three Navajo men were killed by settlers in Grass Valley, Utah. Although the protagonists were not Mormons, the incident escalated tensions between Mormon settlers and the Navajo. In May of 1874 Jacob Hamblin suggested that the Mormons construct a Fort at Lee's Ferry to protect the river crossing.

Marshall William Stokes captured Lee in Panguitch on November 7, 1874. It took two trials for Federal authorities to convict Lee of participation in the Mountain Meadows Massacre. Lee was executed at the site of the massacre on March 23, 1877.

Following Lee's capture and execution, his wife Emma operated the ferry. Warren M. Johnson took over operation of the Ferry from Emma on November

30, 1879. Johnson operated the ferry for sixteen years, until 1896. James S. Emett then took over. One of Emett's improvements was the introduction of a cable-ferry in 1899 and the construction of a new access road. Emett continued to operate the ferry until it was purchased by Coconino County in 1910. Custodians for Coconino County ran the ferry until the construction of Navajo Bridge made it obsolete. The last ferry run was in 1928. Navajo Bridge opened in 1929.

Lee's Ferry and Charles H. Spencer, 1909-1912

These three years were ones of rapid change at Lee's Ferry. The Grand Canyon Cattle Company purchased the Lonely Dell Ranch from James S. Emett in 1909, and Coconino County owned the ferry location after 1910. But the greatest change originated from former teamster, bullwhacker, and expert yarn-spinner Charles H. Spencer. Spencer had convinced himself, and soon proved very adept at convincing others, that small amounts of very fine gold could be found in the depths of the geologic strata uncovered by centuries of the Colorado's relentless erosion. The only problem, for Spencer and others, was how to recover it. The Spencer mining operation endured for only a short time, until February of 1912, but it left a lasting mark on Lee's Ferry.[15]

Spencer arrived at Lee's Ferry in May of 1909. He listened carefully as Jerry Johnson, Warren Johnson's son, related the exploits of Robert B. Stanton's early attempts at gold mining along the Colorado. Spencer developed enthusiasm for his project and sent a member of his party to Flagstaff to record several mining claims. He lured financial backers in Chicago to join the operation, incorporated as the Black Sand Gold Recovery Company. By June Spencer and his crew had established a camp on the left bank of the Colorado, near the location of the original ferry and across the river from the Fort.

After several unsuccessful attempts to recover gold from the sands along the left bank of the river in August and early September of 1910, Spencer decided to move his operations to the more developed and spacious right bank. On September 10 and 11, 1910, Spencer and his crew moved to the right bank, making over the old Fort as a mess hall and erecting two tents nearby to serve as the cook's commissary.[16]

After establishing his foothold on the right bank, Charlie Spencer re-grouped to obtain more capital from his Chicago backers. He returned at the first of the year in 1911 and embarked on a massive building program that would change the appearance of Lee's Ferry dramatically. He formed a new company, called the American Placer Corporation, to serve as a holding company for the operation.

Buildings erected by Spencer in 1911 included: an office building to the west of the Fort (American Placer Corporation Office); an addition on the west end of the old Fort; a new mess hall and cook's house; three bunkhouses (west, center, and east); a blacksmith shop; and a laboratory (assay office). Other Spencer contributions included smaller features such as root cellars, chicken coops, outhouses, and a powder storage magazine. The powder magazine, a large dugout excavated out of the right bank, was located up the Colorado River past all other improvements. The most unusual Spencer addition was the construction of a steamboat, christened the *Charles H. Spencer*, that lowered its anchor in the Colorado.[17]

Despite the ability of Charles Spencer to convince others that there was gold in the deposits at Lee's Ferry, he was unable to actually locate any mineral wealth. His talents lay in the area of promotion, not production. The final blow came when his steamboat could not buck the forceful current of the Colorado. It had been constructed to transport coal for the boilers of the gold operation. Without a fuel source, not withstanding the lack of gold, the operation was doomed to failure.[18]

After the *Charles H. Spencer* failed in its maiden voyage in December of 1911, the workers began to drift away. When the investors cut off the money supply, even Spencer himself abandoned his project. Although Spencer would continue to return to Lee's Ferry many times over the next forty years, he never matched his construction efforts of 1910-1911.

USGS/Reclamation Controversy over Dam Construction (1921-1933)

The next scheme of big dreamers that concerned Lee's Ferry centered on a resource that appeared to be plentiful: water. Since the great flood that created the Salton Sea in 1905, plans had been circulated for a dam on the Colorado to provide flood control, generate hydroelectric power, and impound water for use in California and Arizona. Engineers, politicians, and developers in California and Arizona vied to be the first to lay claim to the vast water resources of the Colorado.[19]

Eugene Clyde LaRue of the U.S. Geological Survey played a key role in the development of dams on the Colorado. Although LaRue's ideas were discredited by the politicians of the day, his observations about the flow of the Colorado proved prescient. LaRue began a comprehensive study of the Colorado in 1912. His ultimate conclusion, published in 1916, was that the flow of the Colorado was not sufficient to irrigate all of the lands available for agriculture. To conserve water, LaRue advocated construction of a series of comparatively small dams. This would reduce the total water surface exposed to evaporation, thus conserving stored water for irrigation in both California and Arizona.[20]

Officials at the U.S. Reclamation Service, once a part of the USGS, pursued a different vision for the Colorado. The Reclamation Service conducted its own studies, relying on the work of J. B. Lippincott. The California-based engineer advocated construction of a large dam on the lower Colorado.

Lippincott explained that the advantage of the lower Colorado River dam is that it would be closer to power and water use in California. This idea did not set well with Arizonans who hoped to divert water from the Colorado for use in the desert state.[21]

As it turned out, the Californians were better prepared and financed. They struck first, in 1921. The Southern California Edison Company entered into a cooperative agreement with the United States Geological Survey to conduct a survey of the Colorado River with a view toward determining potential dam sites. Like other travelers before and after, the Edison men selected Lee's Ferry as the base of their operations because of its easy access to the river and land transportation.[22]

In addition to surveying the river for possible dam sites, the Edison and USGS party erected a stream gaging station at Lee's Ferry. Placed in operation in 1921, the stream gage represented the first firm Federal foothold at the ferry, an ironic addition to a location selected by John D. Lee to hide from U.S. government authority. The Federal presence at Lee's Ferry had begun.[23]

Another irony in the Edison program was that the USGS hydrographer E. C. LaRue worked closely with the California company. Because of his prior experience, LaRue was a logical choice to head the survey of potential dam locations upstream and downstream from Lee's Ferry. Both the USGS and the Edison Company provided funds for the project. Although LaRue would later come to a conclusion regarding dam locations that was at odds with the electric company, this association was used by his enemies to discredit LaRue's objectivity.[24]

The Edison Company leased land from the Navajo Nation on the left bank of the Colorado for their headquarters. In 1922 the Edison men erected a boathouse there that served as the base of their operations. This work coincided with meetings of the Colorado River Commission conducted by Secretary of Commerce Herbert Hoover. These discussions in Santa Fe led to agreement on a compact that divided the waters of the Colorado between the upper and lower basin states. However, Arizona refused to ratify this Compact of 1922. The Compact had the effect of splitting the Colorado River drainage into two basins, the upper and lower. The location of the division between the basins was specified in Article V of the Compact as a hypothetical point one mile below the mouth of the Paria River.[25]

Separate Reclamation Service investigations of the Colorado culminated in 1922 with the publication of the Fall-Davis Report, named for Secretary of the Interior Albert Fall and Reclamation Service chief A. P. Davis. The Fall-Davis report recommended construction of a high dam at Boulder Canyon that would serve several purposes: flood control, generation of hydroelectric power, river regulation, and storage of water for agriculture. The report essentially followed the earlier Lippincott plan.[26]

Despite the assistance of the Edison Company, LaRue and the USGS pursued a vision of Colorado River development that differed from the Reclamation Service. LaRue compared the two plans in his second report on the Colorado, published in 1925. LaRue stated that the USGS plans "are based on the theory that major regulation of flow by storage can be developed by dams at or above Lees Ferry." With a large dam at Lee's Ferry as its centerpiece, LaRue then called for a series of smaller dams and reservoirs downstream. These would allow for the generation of hydroelectric power while conserving water for agriculture. The smaller dams would reduce water loss from evaporation. According to LaRue, building a dam at Lee's Ferry would regulate the flow of the river and allow for a comprehensive development of the Colorado's resources.[27]

The Bureau of Reclamation pursued a different vision. Davis and other Reclamation officials preferred the recommendations of the Fall-Davis report which called for the construction of a large dam in Boulder Canyon on the lower Colorado. Accompanying the large dam was a second dam, downstream, that would recapture power releases and allow for agricultural diversions. The large dam was eventually named Hoover Dam, and the smaller was christened Davis Dam.

The Davis plan had the strong backing of the California congressional delegation. The basic elements of the plan were introduced as the Swing-Johnson bill in Congress, named for Representative Philip Swing of San Diego and cosponsored by Senator Hiram Johnson. The bill eventually became law as the Boulder Canyon Project Act of 1928. Construction of Boulder Dam (later Hoover Dam) began in 1930 and was completed in 1936.

Despite the rejection of LaRue's idea for an upstream dam, the USGS soon developed Lee's Ferry into a significant scientific outpost. With the arrival of stream gagers at the ferry, the old Spencer era mining buildings began to see new use. Edison gager Irving Cockcroft and his wife Margery moved into the old Fort on August 20, 1921.[28]

The Cockcrofts established a post office in the American Placer Corporation Office building. The place opened for business on August 12, 1922, and Irving Cockcroft erected a sign stating that the building was the "Lee's Ferry Post Office." Since that time, the building has frequently been referred to as the "Post Office." Another change was the conversion of the east Spencer Bunkhouse into a school. This was done in 1921 under the impetus of Jerry Johnson, but it benefitted the children of the river gagers working for Southern California Edison as well as children of the Mormon residents of Lonely Dell Ranch. The building served as a school for about four years. [29]

The United States Geological Survey assumed complete control for the stream gaging operation at Lee's Ferry on November 1, 1923. On that day Edison gager Irving Cockroft turned over the equipment to USGS employee Jim Klohr. The new man brought his family and the small group soon settled into the old Fort, using the Spencer addition as a bedroom.[30]

Another result of the USGS activity on the Colorado was the designation of the spring at Lee's Ferry, located in the bluff behind the cable ferry, as a public water reserve. The experience of the Edison crew and the USGS men showed the importance of this water supply. By order of the Secretary of the Interior, numerous springs in Arizona, Colorado, Montana, Idaho, Nevada, Oregon, Utah, Wyoming, and New Mexico were designated as "public water reserves" in order to protect the water supply in isolated and arid locations for the public use. Public Water Reserve No. 107, issued on April 17, 1926, included:

> All land within a quarter of a mile of a spring on the north bank of Colorado River near the old site of Lees Ferry east of the mouth of Paria River, and located approximately in what probably will be, when surveyed, Sec. 13.[31]

Charlie Spencer resumed operations at Lee's Ferry early in 1931, sending several laborers to begin sluicing operations on the Chinle Formation. Spencer's men treated the buildings and grounds as if they were their own, resulting in conflict with USGS hydrologist Charlie McDonald. The two groups, USGS gagers and Spencer miners, eventually agreed on exclusive use of separate buildings. While this solved the problem for the moment, it soured the USGS on any further dealings with Spencer. Officials in Washington, D.C., began to contemplate how they might prevent any further trespass by Spencer on the stream gaging operation. After Spencer's backers ran out of money in April of 1931, the brief mining boom came to an end.[32]

USGS Outpost at Lee's Ferry, 1933-1945

The United States Geological Survey consolidated its control over the old ferry site in 1933. On January 18, 1933, President Herbert Hoover issued an executive order setting aside lands near the existing gaging stations on the Colorado and Paria Rivers as an administrative site. President Hoover declared that Section 13 and lots 1, 2, 3, and 4 in Township 40 North, Range 7 East and an unsurveyed portion of what, when surveyed, would be Section 18 in Township 40 North, Range 8 East, were reserved "for occupation and use by representatives of the Geological Survey."[33]

The USGS soon undertook an improvement campaign on the property. It erected a fence to the east of the Fort, west of the westernmost Spencer Bunkhouse (demolished 1943) to demarcate its administrative zone. The Survey also considered demolishing several of the Spencer buildings at this time. These included the old schoolhouse (east Spencer bunkhouse), the chicken house (center bunkhouse, a.k.a. feed and storage room; demolished 1967), and the saddle barn (west bunkhouse, demolished 1943), and the Spencer addition to the Fort.[34]

After 1933 the center of USGS residential activity shifted from the Fort to Spencer's old mess hall (demolished 1967). The USGS converted the mess hall into a residence for its stream gagers. This building became known as the "stream gager's residence."[35]

The depression decade led itinerant hydrographer Frank Dodge to become more of a permanent resident at the ferry site. A fairly frequent visitor to the ferry since 1919, Dodge secured part-time work with the USGS as an assistant hydrologist in 1932. The decision to hire Dodge was justified on the basis that a second person was needed to make readings during periods of high water. Dodge upgraded Spencer's old laboratory (assay office) building (converted into sediment lab 1947; demolished 1967) into a makeshift residence. Over the years, this building became known as "Dodge's Cabin."[36]

A reunion of Mormon pioneers held at Lee's Ferry in 1935 gave the USGS an incentive to clean up its buildings and grounds. The event took place over three days in October. The reunion marked a turning point for Lee's Ferry. A sense of the passage of time and the growth of historical perspective gave rise to a sense of history about the old place.[37]

However, recollections of the past did not always prove accurate. In 1936 historian Frank Kelly visited the area with former resident Robert B. Hildebrand who reminisced about his boyhood at Lee's Ferry. Hildebrand posed for photographs in front of several buildings, one of which he called the original Lee cabin. Other visitors, struck by the apparent age of the Samantha Johnson Cabin, incorrectly began to associate the old building with John D. Lee. Kelly gave these memories a stamp of approval when he described Lee's Ferry in a 1943 article:

> Although some of the old buildings have been destroyed, Lee's original one-room log cabin fortunately has been preserved. Behind it stands his old blacksmith shop, where horses were shod and emigrant wagons repaired, with giant leather bellows still in working order.[38]

As the years passed, and as additional visitors arrived at Lee's Ferry, the story of the Lee cabin and blacksmith shop took on all the elements of truth from constant retelling. With the departure of Jerry Johnson from the property in 1934, no one remained on site that had direct knowledge of the earlier period. Lee's Ferry had now entered the realm of history, but that history took on aspects of myth. As tales were told and retold, some of the stories were embellished.[39]

As part of the USGS operations in the thirties, Government Land Office (GLO) surveyors returned to the Lee's Ferry area in 1937 to survey Township 40 North, Range 8 East. The GLO surveyors noted eight stone buildings and one mine shaft at the old Ferry site. The surveyors described the area in their notes as follows:

> In section 18 there is a strip of land on the north side of the river about one-fourth mile wide and one-half mile long, whereon there are a group of stone cabins, a part of the settlement known as Lee's Ferry. This strip of land is covered by proclamation to the jurisdiction of the U.S. Geological Survey, and a representative of this government bureau occupies one of the cabins. The remainder of the cabins were not occupied at the time of the survey… There is an old mine shaft in section 18 near the group of stone buildings near the base of the canyon wall, but no operations are being carried on at the present time and there is no evidence of valuable mineral deposits.[40]

The land survey coincided with an improvement to the grounds by the USGS late in 1937. The Survey built a water tank and pipeline to convey water from a well to the stream gager's residence (demolished 1967). The engineers added a septic tank, to complement a six-foot by nine-foot bathroom they attached to the building. The arrival of indoor plumbing at Lee's Ferry was not the most dramatic event which ever took place at the site, but it was a significant improvement.[41]

In 1942 the USGS undertook another clean-up of the property. Many of the remaining metal objects from the Spencer mining era were collected as part of a war-effort scrap drive. The only items that remained after the operation were those that were too large to move, such as the boilers Spencer had freighted to the site in 1910. In 1943 the west Spencer Bunkhouse, closest to the ravine and in the worst shape, was razed for stone used to refurbish other buildings.[42]

Change of Tide: World War Two

A number of factors came together during World War Two which brought an end to Arizona's opposition to the Colorado River Compact of 1922 and started its battle for authorization of the Central Arizona Project. The first was the war itself. World War Two generated a tremendous demand for food and fiber raised in Arizona, resulting in an increase in agricultural production and a corresponding rise in water use. Combined with the arrival of defense industries and workers into the state, Arizona experienced an increased demand for water. The need for improved relations with Mexico, spurred by the war, started treaty negotiations in 1941 that resulted in an agreement on water use from the Colorado in 1944. The election of Governor Sidney P. Osborn (who started the first of his four consecutive terms in January of 1941) brought a mature political leader to the executive chair, one who understood that Arizona must change its tactics in order to move forward.[43]

As one of his first legislative efforts, Governor Osborn requested approval of a combined "Water and Power Authority" that could take charge of the state's efforts to develop its resources. In 1941 and again in 1943, during the 15th and 16th Legislatures, Osborn asked for approval of this initiative but was refused each time. In 1943 he received permission from the Legislature to create a State Land Department that would meet some of his goals for more centralized resource planning.[44]

Also in 1943 Osborn persuaded the Legislature to give permission for a committee to negotiate a contract with the Secretary of the Interior for water from the Colorado River. As a condition, the Legislature reserved its prerogative to approve the actions of the committee. This first step opened the door to a final solution in 1944. Governor Osborn convened a special session of the 16th Legislature on February 15, 1944, to consider the ratification of the Compact and the authorization of a contract with the Secretary of the Interior for the use of Arizona's 2.8 maf (million acre feet) designated in the Boulder Canyon Project Act. The legislators responded, and by the end of the special session on February 24, 1944, had passed both measures. In addition, the Sixteenth Legislature allocated $200,000 for use in a cooperative study with the Bureau of Reclamation to devise plans for bringing the water to Central Arizona. Governor Osborn signed the measures ratifying the Compact and authorizing the contract on February 24, and "ended the most controversial issue in the state's history, and marked the beginning of Arizona's fight to put the waters of the Colorado River to beneficial use."[45]

Reclamation Service Arrives at Lee's Ferry, 1946-1962

The postwar period saw a renewed level of activity at the USGS compound. In 1946 a survey crew from the Bureau of Reclamation arrived to investigate possible dam sites and rights-of-way associated with the proposed Central Arizona Project. In 1947 the USGS turned Frank Dodge's old residence—Spencer's assay office—into a new sediment laboratory. That same year the Survey constructed a new hydrographer's residence, measuring 18 by 30 feet (demolished 1967). The Survey followed this by constructing a new building for guest housing (USGS Residence) in May of 1950. Many of the stones for the new buildings were salvaged from old Spencer buildings, contributing further to the deterioration of the mining legacy at the ferry.[46]

The contract between the State of Arizona and the Bureau of Reclamation facilitated studies of potential routes to bring Colorado River water to Central Arizona. The Bureau of Reclamation, spurred by the contribution of $200,000 from Arizona into its study fund, turned its attention to examining plans for the project. During the summer of 1944, U.S. Senator from Arizona Ernest McFarland chaired hearings on the Colorado. On June 6, 1944, the Bureau issued a report which discussed the possibility of diverting water to Central Arizona. The Bureau continued to study the matter, trying to resolve a controversy over the route the water would take.[47]

John T. Sanders made the first Reclamation mark on Lee's Ferry. He arrived on March 21, 1946, and began to take stream flow measurements in anticipation of constructing Glen Canyon Dam upstream from Lee's Ferry. On October 25, a large party of Bureau of Reclamation employees from the Salt Lake City office arrived at Lee's Ferry. Their first order of business was to improve the road from State Highway 89 to Lee's Ferry. Most of this work had been accomplished by November 7.[48]

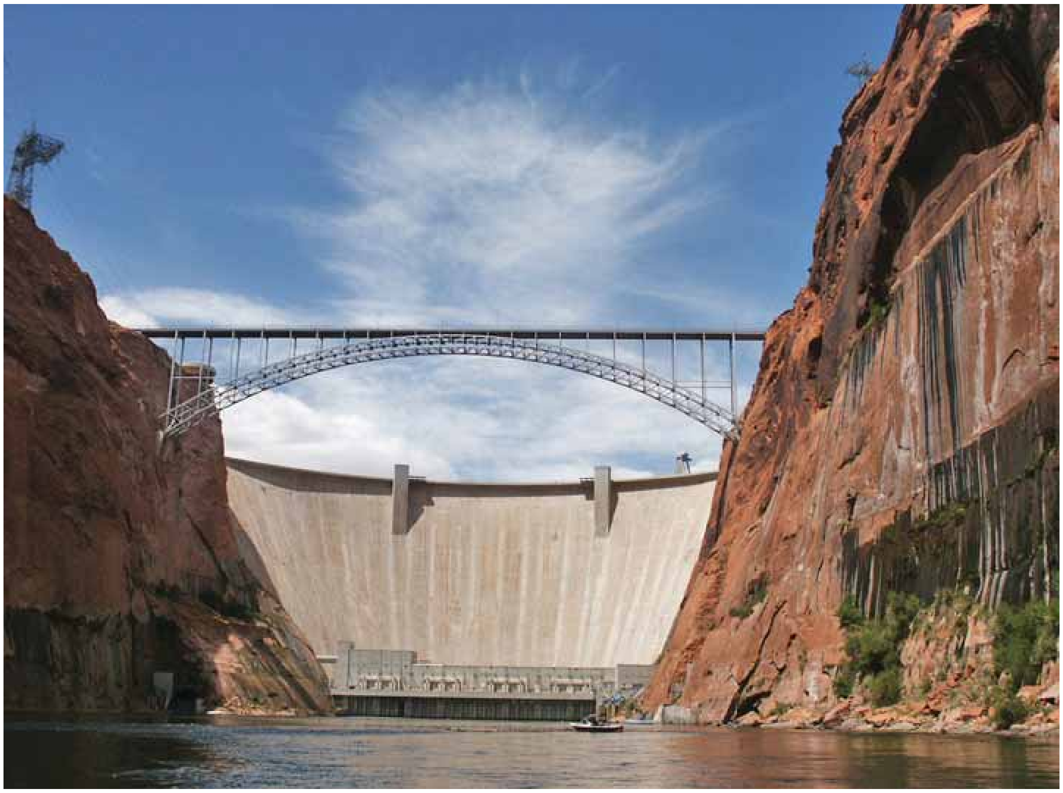
More Reclamation employees arrived in December of 1946. They brought boats and barges to facilitate their work on Glen Canyon Dam. Reclamation workers established a base camp at Lee's Ferry. Surveyors fanned out from Lee's Ferry to begin the preliminary survey work for the new dam. Workers drilled a well in January of 1947, and by the end of March the operation resembled a small city.[49]

The studies convinced Reclamation officials that E. C. LaRue's old plan of a large regulating dam at Glen Canyon was still a solid one. It took additional work to convince politicians in Washington, D.C., and the West that it was a good idea. The plan eventually reached fruition as the Colorado River Storage Project Act. The measure passed Congress on March 28, 1956. President Dwight Eisenhower signed it into law on April 11.

President Eisenhower touched off the first blasts signaling the start of construction of Glen Canyon Dam by telegraph from the Oval Office on October 15, 1956. The long-deferred dream of USGS Hydrographer E. C. LaRue was about to become reality under the auspices of the Bureau of Reclamation. Construction of the dam, completed in 1966, resulted in the creation of Lake Powell, a water recreation wonderland. Glen Canyon Dam also tamed the Colorado through the Grand Canyon, allowing for the development of a white water rafting industry headquartered at Lee's Ferry. The cold water released from the bottom of the dam turned out to be perfect for trout, resulting in the development of a stretch of world-class trout fishing river at Lee's Ferry.[50]

In 1959 USGS personnel apparently burned at least one of the two cabins at the cable ferry site, and possibly both. The burned cabin was the Frank Johnson Cabin, used by Johnson as a residence while he tended the ferry. A second cabin, christened the "Louse House" by travelers who picked up some unwanted companions there, had already lost its wooden upper walls and roof by 1959. According to Crampton and Rusho in their 1965 report, "The cabins were burned by the U.S. Geological Survey for the alleged reason that the agency had neither the men nor the funds to police the buildings against an increasing number of careless tourists." C. Gregory Crampton photographed both structures on September 20, 1959, and reported that the Frank Johnson "Cabin had been burned and was still smoldering when visited."[51]

The Glen Canyon Dam construction project resulted in a number of scientific studies of the history and archaeology of the Glen Canyon region. In June of 1960 C. Gregory Crampton of the University of Utah published his study



33.2. Eugene C. LaRue's dream of a Glen Canyon dam was finally realized in the 1960s.

of historical sites in Glen Canyon from the mouth of the San Juan River to Lee's Ferry. These studies represented some of the first professional historical work at Lee's Ferry. Unfortunately, due to the pressure of completing the studies in a short amount of time, errors crept into the text of these early reports that have confused the history of Lee's Ferry to this day.[52]

The Consortium at Lonely Dell, 1964-1974

In 1964 a group of investors decided to purchase the Lonely Dell Ranch property, the location of Lee's original cabins on the Paria. Known casually as "the consortium," the group shared a vision of turning the place into a destination resort for vacationers. Heading the group was Phoenix architect Denver "Dee" Evans and his wife Jean. Evans, son of noted architect Robert F. Evans who had developed the Jokake Inn and the Paradise Inn in the Phoenix area, hoped to duplicate his father's success with the construction of a resort at Lee's Ferry. Included in the investment group was E. Reesman Fryer, descendant of Mormon immigrants who had crossed at the Ferry in the nineteenth century. Fryer and his wife Ione had a different vision for the Lonely Dell Ranch, one of preservation of its rich heritage.[53]

Five other individuals or married couples formed the consortium: Allen Luhrs and Alma Luhrs, John and Alta Luhrs (both couples doing business as Luhrs & Luhrs, a partnership), Robert L. and Charlotte Brown, Joseph Louis

Refsnes, and Jack and Edythe Whiteman. All were wealthy Phoenix residents. John and Alta Luhrs later sold their share to the partnership, which then created six undivided interests.

According to historian H. Lee Scamehorn, the group acquired the property "to produce unadulterated seed. The site was sufficiently isolated that plants grown there would not be contaminated by vegetation from other agricultural lands." While this explanation seems plausible, it is more likely—given the interest of Evans and Fryer in history—that the property was acquired primarily for its historic attractions. In 1987 Fryer described his labor of love: "I replanted orchards and rebuilt ditches…I think I worked every bit as hard as John D. Lee and Warren Johnson ever did."[54]

The consortium made a large change in the landscape of the property. On June 9, 1965, the new owners began construction of two large holding ponds into which Paria River water could be diverted and impounded. These irrigation facilities served a large orchard of fruit trees that the owners planted south of ranch buildings.[55]

According to historian Scamehorn, the consortium had a large amount of work to do. Years of neglect and deferred maintenance left the Lonely Dell Ranch in poor condition. Scamehorn observed:

> Lee's Ranch showed obvious signs in 1964 of advanced deterioration caused by prolonged neglect…The condition of the property demanded a heavy expenditure for what the partners called "salvage" operations… The ranch buildings also needed extensive repairs. The stone house [Weaver Ranch House] was described by the partners as "primitive." It had to be rebuilt, expanded, and modernized to make it habitable. The so-called Lee cabin and other buildings required refurbishing. Hand-split shingles were put on the cabins, and in other ways they were restored to the appearance they might have had in the 1880s.[56]

The ambitious "salvage" program of the partners was cooled a bit in 1967 when the National Park Service expressed an interest in acquiring the property. The two sides, Park Service and partners, began extended discussion about acquiring the Lonely Dell Ranch property. The main sticking point in the discussions was price. Events reached a climax in 1971 when the Park Service filed suit to condemn the property. This lawsuit was dismissed on a technicality in 1973, opening the way for renewed negotiations.[57]

National Park Service at the Ferry Site, 1962-1974

In 1962 the National Park Service took over administrative control of the Lee's Ferry property from the USGS. However, USGS stream gaging work continued. The NPS presence began with periodic ranger patrols to the site approximately once per week. Permanent duty began on May 19, 1963, with the appointment of Ed Mazzer as the Sub-District ranger. Improvements which accompanied permanent status were the installation of two trailers, one of which served as the Ranger's residence and the second as the Ranger's Office. That same year the Park Service constructed a new bridge across the Paria River, ensuring better access to the Lee's Ferry site.[58]

The acquisition of the old ferry site by the Park Service led to increased development for recreational use. It also led to additional historical investigations and the first steps toward preservation of the historical buildings at the site. On October 6, 1964, NPS Ranger Phil Martin and historian P. T. Reilly conducted a survey of the stone buildings at Lee's Ferry.[59]

The Park Service then issued a contract to historians C. Gregory Crampton and W. L. Rusho to examine the historic buildings at Lee's Ferry. The two men undertook a field visit to the site on December 10 and 11, 1964. The two scholars completed the report in January of 1965, noting:

> It should be stressed that this paper has been put together quickly to meet an early deadline and it is therefore not complete in factual detail nor is it a work of thorough-going scholarship which would have required a longer time to produce. Indeed, the history of Lee's Ferry is amply significant to justify a complete and scholarly study.[60]

In October of 1965 the Park Service sponsored additional research at Lee's Ferry. Architect Walter A. Gathman and draftsman Donald A. Krueger, working for the Park Service's Division of History Studies, surveyed the 1874 Fort at Lee's Ferry. On the basis of the Crampton and Rusho report, Park Service officials felt that the Fort was the most significant building in the old Ferry area.[61]

In March of 1966 the Park Service took action on the studies. After NPS regional historian Bill Brown examined the Fort in person, the Park Service undertook a stabilization treatment. Under the direction of HABS architect Charles Pope, workers sprayed the interior wooden features of the Fort with an epoxy preservative.[62]

Differences between the Park Service and the USGS over the future of the property led to an unfortunate incident in 1967. On February 7 and 8, 1967, the USGS demolished nearly all of the remaining Spencer buildings at the Ferry site. Both the Park Service and the USGS failed to provide an adequate explanation for the destruction. As best as can be surmised, the Park Service and the USGS felt that the Spencer buildings lacked historical significance. However, William E. Brown, NPS Regional Historian for the Southwest Region based in Santa Fe, admitted that:

> Review of the record on the Spencer Buildings indicates that it would be less than candid to avoid a conclusion that a mistake

> may have been made. If so—let it be noted—it was one of omission, not of commission.[63]

In the fall of 1967 the Park Service returned to address the remaining historic buildings at Lee's Ferry in a more positive manner. The condition of the north wall of the American Placer Corporation Office had deteriorated to such a point that immediate stabilization work was needed. Roland Richert of the NPS Ruins Stabilization Unit examined the building on August 30, 1967. Richert returned to Lee's Ferry and between September 18 and 22, worked with skilled mason Willie Yazzie.[64]

NPS personnel returned to Lee's Ferry in 1969 to complete the job of historic building documentation begun in 1965. During the intervening years, many of the Spencer Buildings had been demolished by the 1967 action, leaving representatives of the Division of Historic Architecture, part of the Office of Archaeology and Historic Preservation, to document the remaining buildings. These included the American Placer Corporation Office, the Chicken Coop, the Lee's Ferry Fort Root Cellar, and the Spencer Bunkhouse.[65]

While history continued to be a big draw for tourists at Lee's Ferry, the introduction of trout into the now-frigid waters of the Colorado River that emerged from the depths of Glen Canyon Dam began to lure increasing numbers of tourists starting in the sixties. Many fished from the banks at the river's edge, while others ventured forth in boats. Still others eschewed fishing entirely. Lee's Ferry developed into the prime point of embarkation for raft trips through the Grand Canyon. By 1969, more than 3,000 people were making the river run through the Grand Canyon each year. The change even captured the attention of a writer for the New York Times, who described the bustling scene in 1969 as follows:

> A lively, year-round outdoor recreation center has sprung up at this scenic and history-saturated spot in the shadow of the Vermillion Cliffs. The development, situated along the Colorado River at the northern end of the newly created Marble Canyon National Monument, consists of a motel, a store, a service station and a marina alongside the river and a 28-unit public campground on a bluff nearby. The campground is operated by the National Park Service, and is complete with roofed shelters, tables, firepits, trailer turnouts and toilet facilities.[66]

National Park Service at Lee's Ferry and Lonely Dell Ranch, 1974-present

The National Park Service consolidated its ownership of Lee's Ferry and the Lonely Dell Ranch in 1974 when it acquired the interest of the consortium in the ranch property. This acquisition resulted in full Federal control of the area. It is also significant as the first time since 1909 that both properties had been in the same ownership.[67]

In 1976, in conjunction with the Nation's bicentennial and in preparation for rehabilitation work at the property, the Park Service undertook several examinations of the property. This included an environmental assessment of improvements to the roads, boat ramps, parking lots, and proposed raft boarding jetty. The Park Service issued the assessment in January of 1976. In March the Park Service forwarded a completed National Register nomination of the Lee's Ferry portion of the property to officials in Washington, D.C. The National Register accepted the nomination on May 15, 1976.[68]

Later in the year, the Park Service contracted with University of Colorado historian H. Lee Scamehorn to prepare a historic structure report for the combined property. Scamehorn completed his report in August of 1976. The Scamehorn report is valuable for its detailed analysis of events leading to the purchase of the property from the consortium. However, the report's description of buildings at the Lonely Dell Ranch portion of the property contained several errors. These errors were repeated in later works. Scamehorn noted that questions have been raised about the authenticity of the claims that buildings on the ranch were constructed by Lee, but he did not offer a definitive conclusion.[69]

The historic structure report paved the way for Park Service improvements to the property in 1976-1977. Additional rehabilitation work took place in 1983 and 1984. In 1986 the Submerged Cultural Resources Unit of the National Park Service began investigations of the Spencer mining era historic features at Lee's Ferry.[70]

The project resulted in a report published in 1987 that documented both the vessel and the mining remains. While the report is an excellent and detailed account of the Spencer operation, the authors noted that "much of the physical evidence of an important chapter in regional history was removed with the structures" during the 1967 destruction of the Spencer buildings by the USGS.[71]

The historical evaluation program of the 1990s ended with the completion of a revised National Register of Historic Places nomination in July of 1997. Prepared under the direction of Ann Hubber of Historical Research Associates in Missoula, Montana, the 1997 nomination was an attempt to reorganize and correct the two previous National Register nominations, completed in 1976 for Lee's Ferry and in 1978 for the Lonely Dell Ranch.[72]

Today, visitors to Lee's Ferry are struck with the isolation and desolation of the area. While a thin veneer of civilization has been applied in the form of improved roads and tourist facilities, even those who arrive in modern motor homes and automobiles recognize the sacrifice made by the pioneers who arrived in wagons to cross the mighty Colorado. The buildings that remain at Lee's Ferry and the Lonely Dell Ranch offer mute testimony to that earlier era, an era in which pioneers and settlers clung closely to life at this crucial transportation outpost. Above all, visitors are reminded that it is the Colorado River that made Lee's Ferry such a needed link in the development of Arizona. The river today still retains some degree of its menacing quality, captured in the words of historian Sharlot Hall during her 1911 visit:

> This wild river takes its toll every few months; the very waves as they pass look fierce and tameless and hungry…It was this same wild current that Father Escalante feared to cross in 1776; he turned back after coming down and riding into the river twice. I don't blame him. Death sits mighty close to the bank here.[73]

Established as a refuge from Federal authorities for exile John D. Lee, Lee's Ferry is now the physical and spiritual center of the Federal contribution to western water history. As scholars look back on the centennial of the Bureau of Reclamation, an examination of the history of Lee's Ferry and the turf battle between the Bureau and the USGS over the future development of the Colorado River gives us a better understanding of the mission of the two agencies. The past activity at Lee's Ferry provides a valuable perspective for westerners concerned with the next hundred years of water history.

Dr. Douglas E. Kupel works for the City of Phoenix Law Department where he does research in support of water rights and environmental litigation. He is the author of *Fuel for Growth: Water and Arizona's Urban Environment* (Tucson: The University of Arizona Press, 2003.), and he is active in the history community as a speaker and program participant.

Endnotes

1. The history of Lee's Ferry presented here originated as part of a project published by Robert G. Graham and Douglas E. Kupel, "Historic Structures Report for Lee's Ferry and Lonely Dell Ranch, Glen Canyon National Recreation Area" (Phoenix: Alliance Architects, 2000).
2. For a good summary of the area's geologic history, see David A. Phoenix, "Geology of the Lee's Ferry Area, Coconino County, Arizona." *U.S. Geological Survey Bulletin No. 1137*. Washington: U.S. Government Printing Office, 1963.
3. For a good synopsis of the Spanish era, see W. L. Rusho, "Living History at Lee's Ferry," *Journal of the West* 7 (January 1968): 64-9.
4. The most detailed biographical information about Lee is contained in Manetta (Prince) Henrie, *Descendants of John Doyle Lee, 1812-1877* (Provo, Utah: privately printed, 1960).
5. A recent summary of scholarship on the Mountain Meadows Massacre is Samuel W. Taylor, "Ghost From the Grave," *Restoration* 7 (3) (July 1988): 3-9.
6. A. Gary Anderson, "Events at Lee's Ferry, or Lonely Dell, 1864-1928," in H. Dean Garrett and Clark V. Johnson, eds., *Regional Studies in Latter-Day Saint Church History* (Provo: Brigham Young University, 1989), p. 19.
7. Juanita Brooks, *Emma Lee* (Logan: Utah State University Press, 1978), p. 78. Historian P. T. Reilly credits Jacob Hamblin with the name Lonely Dell; see his *Lee's Ferry: From Mormon Crossing to National Park* (Logan: Utah State University Press, 1999), p. 23. In an interview with the author on July 29, 1999, historian W. L. "Bud" Rusho supported Reilly's contention, believing that the dialog cited in Brook's work was most likely impressionistic rather than literal.
8. Juanita Brooks, *John Doyle Lee: Zealot, Pioneer Builder, Scapegoat* (Logan: Utah State University Press, 1992), p. 308.
9. The description is from Elmo Scott Watson, ed., *The Professor Goes West* (Bloomington: Illinois: Wesleyan University Press, 1954), pp. 99-100. Despite DeMotte's contention that Emma's Cabin was constructed without benefit of "square and compass," Lee descendant Edna

Lee Brimhall donated a carpenter's square the family believed "was used by John D. Lee when he built his house at Lee's Ferry" to the Arizona Historical Society. See Arizona Historical Society (AHS) Manuscript MS 97, collection of Mrs. Edna Lee Brimhall, Tucson.
10. For a description of early travel on the Colorado, see Otis "Dock" Marston, "Early Travel on the Green and Colorado Rivers," *The Smoke Signal* (Tucson Corral of the Westerners) 20 (Fall, 1969): 231-6. For a brief summary of the first Powell expedition see Elwood Bear, "John Wesley Powell—He Tamed the Colorado" *Civil Service Journal* (January-March, 1969): 3-7.
11. W. L. Rusho, *Desert River Crossing* (Salt Lake: Tower Productions, 1998), pp. 20-6.
12. Frederick S. Dellenbaugh, *A Canyon Voyage: The Narrative of the Second Powell Expedition* (Tucson: University of Arizona Press, 1996; originally printed New York: Putnam, 1908), p. 211.
13. *Ibid*., pp. 211-2.
14. Reilly, *Lee's Ferry*, p. 25.
15. For a first-person account of Spencer's operations, see A. H. Jones, "Review of Mining Operations on the San Juan and Colorado Rivers Promoted and Conducted by Charles H. Spencer, et al., 1908, 1909, 1910, 1911," manuscript on file, Glen Canyon NRA Archives, 1960.
16. Reilly, *Lee's Ferry*, p. 228.
17. *Ibid*., p. 242.
18. Reilly, *Lee's Ferry*, p. 248. For a summary of the steamboat fiasco, see W. L. Rusho, "Charlie Spencer and his Wonderful Steamboat," *Arizona Highways* 37 (8) (August, 1962): 34-9.
19. For a description of the controversy surrounding the allocation of water from the Colorado River, see John Upton Terrell, *War for the Colorado River* (Glendale, California: A. H. Clark, 1965).
20. Eugene Clyde LaRue, "Colorado River and its Utilization" *U.S. Geological Survey Water Supply Paper* No. 395 (Washington, D.C.: U.S. Government Printing Office, 1916). The best description of LaRue's career is found in W. B. Langbein, "L'Affaire LaRue" Journal of the West 22: 2 (April 1983): 39-47.
21. Langbein, "L'Affaire LaRue," p. 41.
22. Reilly, *Lee's Ferry*, p. 281.
23. *Ibid*., p. 282.
24. Langbein, "L'Affaire LaRue," p. 44.
25. Reilly, *Lee's Ferry*, p. 289. See also Joyce and Josef Muench, "Taking the Measure of the Colorado River," *Arizona Highways* 23 (6) (June, 1947): pp. 4-7.
26. Langbein, "L'Affaire LaRue," p. 42.
27. Eugene C. LaRue, "Water Power and Flood Control of Colorado River Below Green River, Utah" *U.S. Geological Survey Water Supply Paper No. 556* (Washington, D.C.: U.S. Government Printing Office, 1925), pp. 69-73.
28. Reilly, *Lee's Ferry*, p. 283 and 297. See also Toni Carrel, ed., "Submerged Cultural Resources Site Report: Charles H. Spencer Mining Operation and Paddle Wheel Steamboat" (Santa Fe: National Park Service Submerged Cultural Resources Unit, 1987), p. 32.
29. Reilly, *Lee's Ferry*, p. 297.
30. *Ibid*., p. 303.
31. Information on the public water reserves is found in the records of the Arizona State Office of the Bureau of Land Management, Phoenix. Public Water Reserve No. 107 was later confirmed by Secretarial Order No. 160 (April 8, 1932); Secretarial Order No. 166 (July 16, 1932); and Secretarial Order 265 (December 23, 1940). It turned out that the spring was located in what, when surveyed, was Section 18 of Township 40 North, Range 8 East.
32. Reilly, *Lee's Ferry*, pp. 352-56.
33. Executive Order No. 6002, January 18, 1933, on file at the Arizona State Office, Bureau of Land Management, Phoenix.
34. Reilly, *Lee's Ferry*, p. 381.
35. *Ibid*., p. 352.
36. *Ibid*., p. 353. For additional information, see Frank B. Dodge, "The Saga of Frank B. Dodge," manuscript #18714, on file at Utah State Historical Society, Salt Lake City, 1944.

37.	Glynn Bennion, "There Are Stories Told of the Old Days at Lee's Ferry," *The Deseret News* (Salt Lake City newspaper), November 9, 1935.
38.	Charles Kelly, "Lee's Ferry on the Colorado," *Desert Magazine* 7 (1) (November, 1943): 5-8.
39.	The custom of holding reunions at Lee's Ferry, first started in 1935, still continues. See Kate Ruland-Thorne, "Lee's Ferry Reunion," *Arizona Highways* 65 (14) (September, 1989): 14-5; 30-1. This article is also a good example of how historical myths are perpetuated by constant retelling. For Reilly's analysis of the Kelly contribution to history, see *Lee's Ferry*, p. 394.
40.	Survey Notes for Township 40 North, Range 8 East, Book 4162, page 32, Arizona State Office, Bureau of Land Management, Phoenix; Township plat of Township 40 North, Range 8 East, officially filed September 5, 1941, Arizona State Office, Bureau of Land Management, Phoenix.
41.	Reilly, *Lee's Ferry*, pp. 401-2.
42.	*Ibid*., pp. 418-9.
43.	The best work on the early history of the Central Arizona Project is Rich Johnson, *The Central Arizona Project* (Tucson: University of Arizona Press, 1977).
44.	State of Arizona, Acts, Memorials and Resolutions of the Regular Session, Fifteenth Legislature (Phoenix: State of Arizona, 1941), Senate Bill 74; State of Arizona, Acts, Memorials and Resolutions of the Regular Session, Sixteenth Legislature (Phoenix: State of Arizona, 1943), Senate Bill 72.
45.	State of Arizona, *Acts, Memorials and Resolutions of the Regular Session, Sixteenth Legislature* (Phoenix: State of Arizona, 1943), pp. 228-32.
46.	Reilly, *Lee's Ferry*, pp. 425-33.
47.	A good understanding of contemporary Reclamation thinking about the potential development of the Colorado River in the post-WWII era is found in a three part series that appeared in *The Reclamation Era* in 1946. Titled "Corralling the Colorado" the series featured articles by Carl P. Vetter (September 1946): 190-2; Oscar J. Buttehdahl (October 1946): 218-29; and William E. Warne (November 1946): 240-56.
48.	Reilly, *Lee's Ferry*, p. 425.
49.	*Ibid*., p. 426.
50.	The best summary of Glen Canyon Dam history is by Russell Martin, *A Story that Stands Like a Dam: Glen Canyon and the Struggle for the Soul of the West* (New York: Henry Holt, 1989). See also Jared Farmer, *Glen Canyon Dammed: Inventing Lake Powell and the Canyon Country* (Tucson: University of Arizona Press, 1999).
51.	C. Gregory Crampton and W. L. Rusho, "A Report on the History of Lee's Ferry, Arizona" (Salt Lake City: Prepared for the National Park Service, 1965), p. 13; Crampton photographs PO197 48b:1:4 and 48b:1:5, September 20, 1959, University of Utah Special Collections. In his book, P. T. Reilly dates the fire to 1964 and reports the arsonist as Larry Lopp; see Reilly, *Lee's Ferry*, p. 447.
52.	C. Gregory Crampton, "Historical Sites in Glen Canyon, Mouth of San Juan River to Lee's Ferry," *University of Utah Anthropological Papers* No. 46 (June 1960).
53.	Docket 226 of Deeds, p. 24, Coconino County Recorder, Flagstaff.
54.	H. Lee Scamehorn, "Historic Structure Report Lee's Ranch, Historical Data" (Boulder: University of Colorado, 1976), p. 17. Scamehorn based his conclusion on information obtained by appraiser H. B. Embach during a telephone conversation with Dee Evans. See H. B. Embach, "Appraisal Report: Property of Denver E. Evans, et al." Phoenix: Prepared for National Park Service, 1966, p. 3, Glen Canyon National Recreation Area Archives, Record Group 17516, Folder 12. The Fryer quote is from Ruland-Thorne, "Lee's Ferry Reunion," p. 31.
55.	Reilly, *Lee's Ferry*, p. 450. The provenience of the orchard has caused some confusion. The National Register nomination prepared in 1997 incorrectly attributes the modern orchard to the National Park Service (section 8, p. 46). This error may have been based on the "Lonely Dell Ranch Cultural Landscape Inventory" prepared by Peggy Froeschauer-Nelson in 1996 which stated "A modern orchard covering a little over two acres has been planted and is currently maintained by the NPS." Froeschauer-Nelson further states specifically "the orchard is a modern addition planted by the Park Service." Both quotes from page 2.

56. Scamehorn, "Historic Structure Report," p. 18. It appears that any modifications made by the consortium to the Weaver Ranch House were few, despite what they may have told the appraiser.
57. *Ibid.*, pp. 19-24.
58. The USGS continued to have a resident hydrographer at Lee's Ferry until August 4, 1976. After a short period during which the facility was serviced from Flagstaff, in 1977 the gaging station was equipped with satellite telemetry. See Reilly, *Lee's Ferry*, p. 524.
59. P. T. Reilly, "Survey of Stone Buildings, Lee's Ferry," October 6, 1964, Manuscript Collection No. 275, Box 8, Special Collections, Northern Arizona University, Flagstaff.
60. Crampton and Rusho, "Report", p. iii.
61. Walter A. Gathman and Donald A. Krueger, "Lee's Ferry, Coconino County" HABS/HAER Survey Ariz. 58, Library of Congress, Washington, D.C. (October, 1965; Revised January, 1969).
62. Reilly, *Lee's Ferry*, p. 451.
63. NPS Regional Historian William E. Brown to Dr. C. Gregory Crampton, letter on file William E. Brown Collection, Manuscript No. 1350, Utah State Historical Society, February 15, 1967.
64. Roland Richert, "Ruins Stabilization Report, The Old Post Office, Lee's Ferry, Glen Canyon National Recreation Area" (Globe: National Park Service Southwest Archaeological Center, 1967), p. 1.
65. Gathman and Krueger, "Lee's Ferry."
66. John V. Young, "A New Boom at Lee's Ferry: Recreation Seekers Replace Ore Prospectors," *New York Times* (February 23, 1969): XX, 13.
67. Docket 511 of Deeds, pp. 400-3, Coconino County Recorder, Flagstaff.
68. Glen Canyon National Recreation Area, "Environmental Assessment of Proposed Road, Ramps, Parking Lot, and Raft Boarding Jetty at Lee's Ferry," Glen Canyon NRA, January 1976; Temple A. Reynolds, "Lee's Ferry Historic District National Register Nomination," 1974, on file at Arizona State Historic Preservation Office.
69. Scamehorn, "Historic Structure Report," pp. 24-9. Perhaps the most egregious error in the Scamehorn report was attributing a 1916 date to the Weaver Ranch House. Scamehorn based his conclusion on records at the Coconino County Assessor in Flagstaff, but the original records have since been destroyed and his research could not be duplicated.
70. Toni Carrel, ed., "Report", pp. 2-4.
71. *Ibid*., p. xix.
72. Ann Hubber, "Lee's Ferry and Lonely Dell Ranch National Register Nomination," manuscript on file, Arizona State Historic Preservation Office, 1997.
73. The quotation is from Sharlot M. Hall, *Sharlot Hall on the Arizona Strip: A Diary of a Journey Through Northern Arizona in 1911*, edited by C. Gregory Crampton (Flagstaff: Northland Press, 1975), p. 53. The original diary is at the Sharlot Hall Museum in Prescott.

Memoirs of a Bureau Curmudgeon: Unabridged Version—Politically Incorrect

By:
Thomas J. Aiken

A book has been written and Hollywood has made a movie about a family's history where central to the story is the reverence a father and his sons have for fly fishing in a western river. It is titled, *A River Runs Through It*. I grew up during the fifties and my father and I held the same reverence for fly fishing on the Gunnison River in Western Colorado. Our personal paradise extended from the western edge of the Gunnison River Canyon near the mouth of Steuben Creek to the bridge that led to Iola, which I think was a remnant of a coaling station for the old narrow gauge railroad long since abandoned. The River was lined with tall willow and cottonwood trees as it meandered through a vast hay meadow. Riffles were full of rainbow trout and slow deep holes were full of lunker German browns just waiting for the perfect presentation of a white winged royal coachman or ginger quill dry fly. The rolling river and the willow brush and grasses on the bank created an aroma that was intoxicating, I could not imagine anything more wondrous or beautiful, there was no place else on earth I would rather be.

Then something terrible happened. This paradise began to fall to the woodman's axe in 1960 as a government agency cleared the area for a large reservoir. Reservoir? What kind of no account fishing would that be? Flat water—oh, puleeze! I was to learn that this diabolical agency's name was the Bureau of Reclamation. What did that mean? Reclamation of what? It was destroying paradise, not reclaiming it! It was an outrage! I vowed that some how, some way, some day, I would even the score.

As a business major at Colorado State University (CSU) a few years later, I was in need of another economics class. Without any conscious thought I found myself in "Water Resource Economics E-201." At the bookstore I recall thumbing through the book recommended for the course and there before my very eyes was that despicable name once again "Bureau of Reclamation." What have I done? Now I have to spend three months reading about the "Bureau of Wreck the Nation"! But wait just a minute, on second thought, this might be good. Better to know something about the despoiler than remain ignorant of it and its evil ways. While I did gain some knowledge of the importance of this agency to the economic growth and well being of the Western United States, not to mention how to calculate a benefit cost ratio, I could not begin to forgive it nor think kind thoughts about it.

After college and a stint in the Army, I was back home in Colorado Springs working as an accountant for the City Utilities, but looking for a better job, one offering more challenge and excitement (okay one offering more pay and earlier retirement). I took the old Federal Service Entrance Exam one cold spring day and later found my scores were high enough to qualify me for employment at the GS-5 and GS-7 levels. I sat back waiting for the job offers to roll in. I waited and waited and waited, finally giving up, concluding a Federal job was not in my future (believe it or not, in those days a Federal job was a coveted prize and people respected Federal employees). Then one late summer day (a dog day of August as it were), three job offers arrived in the mail. How exciting! Ripping into the envelopes, the first offer was for a GS-5 in the Army Material Command, Texarkana, Texas (yeah right!—Army—Texarkana???), the next was for a GS-5 with the National Park Service in the Grand Canyon (Hmm …), the last was, oh no!…a thousand times no! … the enemy, despoiler of paradise, the disgusting Bureau of Reclamation. But wait, what is this? … a GS-7? … in Denver? … a few miles north …Hmm … My practical intuitions were kicking in. It was more money and since in those days the government did not pay for your first move, it would cost less to move to Denver than say the Grand Canyon (where do you live at anyway in Grand Canyon? … a lodge miles from anywhere? … a rickety cabin on the edge of the canyon?).


30.1. Building 67 on the Denver Federal Center was completed about the same time that Tom Aiken reported to work at the Bureau of Reclamation.

The interview took place in an office on the fourteenth floor of a brand new fourteen story gray concrete building west of Denver, the one that still sticks out like a sore thumb. Bill Schlichting and Dale Raitt, the two Branch Chiefs in the Program Coordination Division, conducted the interview. Expecting heinous ogres I was on my best defenses, but hey, these were regular, normal guys! (Well, Raitt was an engineer …). Anyway, the job was for a budget analyst reporting to Schlichting. It seemed like something I could handle. Besides, I reasoned that once inside I could seek my revenge. I really, really wanted that job now!

The call from Schlichting came early in September. The job was mine and Bill's question to me was when could I report? I quickly thought—two weeks notice to the City Utilities and, most importantly, a week for my dad and I to make our annual fall trip to the mighty Gunnison. Yes, paradise was lost, but we had found another location upstream at a collection of rustic cabins called Sleepy Hollow. It wasn't the same, but it wasn't bad, and the fishing was good. We could not bear nor force ourselves to even drive down to see paradise lost, now lying under a body of flat water called Blue Mesa Reservoir.

On October 2, 1967, I embarked on a career that I didn't comprehend for one minute would span more than one third of Reclamation's first one hundred years of history. Throughout those many years (that moved far too quickly), I've been excited, bored, frustrated, angry, happy, satisfied, dissatisfied, but most of all, continually mesmerized by the day to day happenings of the United States Bureau of Reclamation. The following is an account of the names, places and events as I recollect and interpret them to be. Whether history agrees or not doesn't really matter to me, this is how I saw it and lived it. I use "Reclamation" and "The Bureau" interchangeably because I always have and at my advanced age, I feel I'm entitled.

If I could have scripted my career, I could not have arranged for a greater start or first boss than Bill Schlichting. He was one of the most honorable and forthright people I have ever met, and he had a genuine interest in getting me off on the right path in Reclamation. He remained a very good friend until his untimely death. I was the new kid on the block in an office of five budget analysts. In addition to Bill, there was Rudy Mezner, Bob Cope and Tom Bumgartner. The rest of the Program Coordination Division, located on the other side of Division Chief George Powell's office, were the program analysts; Dale Raitt, Bill Hilmes, J. R. Smith, Harry Menzel, John Childress, Jim Moomaw, Denby Peeples, and Bill Wiley to name a few. As I mentioned, the offices were in the top floor of the new building, the floors were shiny tile, carpeting was only allowed on "Mahogany Row" (top management), the desks were gray steel and only the big cheeses had offices, the rest of us were in an open bullpen arrangement–probably accounting for my total lack of sympathy for those later in my career who bemoaned the onset of systems furniture and cubicles as opposed to walled offices. As an interesting aside, Congress authorized and appropriated $6 million to The Bureau to construct this new building. After moving in, someone (no doubt a Harvard grad) decided Reclamation should turn it over to the General Services Administration (GSA) to manage. GSA promptly began to charge The Bureau $2 million annual rent. This may explain why Harvard has more prestige than CSU because I haven't yet figured out why this was good for the taxpayers or the farmers and power customers who repay most of what Reclamation spends.

Mezner, Cope, Bumgartner, and particularly Wiley were the first bonafide curmudgeons I met in The Bureau (a curmudgeon is an irascible cantankerous old goat who has tremendous knowledge about the organization, who gets very irritated at those who only think they know everything and who will be damned if they will share this knowledge unless you pay proper homage and appreciate that knowledge). In all of my experience, I have never seen a more concentrated collection of curmudgeons and reprobates in one location. But they were just as critical to my early education as was the formal and "on the job" training Schlichting was providing.

I didn't, of course, recognize it then, but it was the last of the "glory years" of Reclamation. We were truly the shining knights on the white horses. We walked with a swagger that would make John Wayne proud (stone-cold Steve Austin for those too young to remember John Wayne). Our constituency, the water and power users, loved us as we kept providing them with bigger and better facilities. We kept spreading the cost of these facilities over more and more years. Water and power were cheap and plentiful. All was right with the world. A new kid on the block could not be in a more central and advantageous place for an education than in the budget shop, wedged in "Mahogany Row" on the fourteenth floor of the most respected engineering organization in the world, bar none.

As I embarked on this government career, my only source of knowledge about government was the tidbit that stuck in my pea brain from Mr. Heidtsmith's 9th grade Civics class at good ol' North Junior High School in Colorado Springs. I remembered there were three branches of government, the executive, legislative, and judicial. Further, there were two Senators from each State and a bunch of Congressmen and they made up the legislative branch who made up the laws. The President was the executive and he had a bunch of people helping him called the Cabinet and they carried out the laws and ran the government. Finally, there was a bunch of judges called the Supreme Court who interpreted the Constitution and laws. Pretty good, huh! Well, soon enough I learned that things aren't exactly as they are laid out by academia. There is a dynamic called politics that tends to shape, warp, and distort. This is something that has been and will continue to be a tremendous influential force on the policy and day to day activities of Reclamation. In those days The Bureau seemed to me to be more of an agency of the Legislative Branch than of the Executive Branch. I learned the names of the powerful water bloc in Congress—Senators Carl Hayden and Alan Bible and Congressmen Wayne Aspinall, "Bizz" Johnson, Berne Sisk, and John Moss, long before I knew who the Secretary of the Interior was. Commissioner Floyd Dominy seemed way more dialed into the powerful Congressional water bloc than he was anyone in the Executive Branch, particularly Interior Secretary Stuart Udall. The first Secretary I actually met was Rogers Morton. One day, unannounced, he walked into our office and shook my hand. I was stunned. First of all that it happened to a lowly new kid on the block (my desk being nearest the door might have had something to do with it) and secondly by the size of his hand, it engulfed mine and made all two hundred and twenty pounds of me feel downright dainty, it was one huge hand! I have since met and shook hands

30.2. Official Portrait of Secretary of the Interior Rogers C. B. Morton.

with every Interior Secretary until Bruce Babbitt, who ironically has held the office longest. Our paths just never crossed.

Those were heady days, days of bigger than life people conceiving bigger than life projects—the world's largest double curved thin arch dam, the California undersea aqueduct (taking fresh water entering San Francisco Bay and piping it undersea to Los Angeles) controlling the very weather itself, Project Skywater—to name just a few. Floyd Dominy was the Commissioner and was, in fact, a legend in his own time. Enough has been written about his prowess and importance to The Bureau on the political front. Equally important and in some sense more important was the person overseeing the technical front, Chief Engineer Barney Bellport. One day very soon after I started my career, happenstance found me getting on the elevator after lunch—followed by (gulp!) "Mahogany Row." I watched Bellport, his deputy Harold Arthur, Jack Hilf, overseer of design and construction, and Hank Halliday the business manager step in behind me. My instinct was to bolt out and catch another elevator—too late the door had closed. By the time we reached the fourteenth floor, there was absolutely no doubt in my mind as to who was in charge. Bellport was mightily displeased with those present and spent the entire ride climbing up one side and down the other of their collective frame. I wanted to disappear into thin air, turn into a bug and crawl out, become invisible, be anywhere but there. In reality, my presence was probably only noticed by me. Participative management and employee input were concepts whose time had not yet come.

In simplest of terms, the function, budget and organization of The Bureau followed a very logical process in those days. Projects were conceived, triggering a planning process that took the idea through a reconnaissance investigation, appraisal study and, in the early days, a basin survey. This early work was done by planning offices that were funded through the General Investigation appropriation. Generally, the next step would be to provide this information to the Congress, and if they authorized the project, a Feasibility and Definite-plan Report were prepared and construction was started with the funding of the Construction and Rehabilitation appropriation. At completion of construction, the project was brought on line and an operation and maintenance office was set up. All future funding would then be through the Operation and Maintenance appropriation. It was interesting that funds for the General Investigation and Construction and Rehabilitation appropriations were much easier to come by than for the Operation and Maintenance appropriation. Why? Politics. The local Congressman could brag to his/her constituency about this new project he/she is delivering to them. There isn't much glamour or glitz in maintaining something that already exists. Ho hum.

Working in the budget shop in the Chief Engineer's office allowed me to see and learn about virtually every thing that was going on in The Bureau, something that paid off in later years as I left new kid status and gained rising star status moving up the food chain to bigger and better jobs. One issue that became more and more apparent to me was that the Chief Engineer's office was over staffed even considering the large workload. This was, of course, no secret to most, but it certainly wasn't discussed by the curmudgeons gathered at the coffee urn every morning as they whined about their condition in life and longed for the good old days. Being the outspoken and inquiring minded person I've always been (smart aleck), I once asked my curmudgeon educators, "If you are so miserable, why don't you retire?" Ashen silent faces, the new kid had uttered the forbidden "R" word. That part of my education soon enough dried up. What was happening, however, was The Bureau was starting to feel a pinch brought on by a once incredibly large staff resulting from the post World War II repatriation program (provide jobs for the returning GIs) and a more scrutinized budget, ironically because of the ongoing Vietnam War. Thus, the stage was set for a defining moment in my career and the decade that changed Reclamation forever.

By the early 1970s things were becoming more and more clear to me. In spite of the tremendous knowledge about The Bureau working on the budget afforded me, it was becoming routine and boring. Every year same old thing just different numbers. The bread and butter part of my duties was to put out a monthly budget summary report to the Commissioner's office and to put together another quarter inch thick budget report for all the big and medium cheeses in the Denver office. Once, while on a detail to the Commissioner's office (getting all of $8 a day per diem), I looked into what happened to the report I sent back there each and every month. What I found didn't surprise me. The budget secretary received it and filed it, nobody used or even looked at it. I related this to Schlichting and asked if I could prepare it but not send it for a couple of months to see if anyone noticed. He agreed. We never heard a word, not even from the secretary. I quit preparing it. A unique survey method came to my mind for the other report. I would occasionally selectively slip an interesting article from the pages of *Playboy* into one or two of the reports sent to the medium cheeses whom I suspected might discretely enjoy reading. I never heard a single comment and, believe me, some of the articles were really interesting, not to mention really big. My conclusion was that this report got limited review. I never related this to Schlichting and continued to crank out the report. Now, I would not recommend this survey method today, but if someone is so inspired, I would strongly suggest articles from *Field and Stream* magazine. Many things were swirling in my head, the curmudgeons who were eligible to retire had no intention to do so, thus slowing any advancement possibilities, the most important aspect of my job was of little interest to anyone, and intuition told me that those denizens I saw scuttling to and fro in the hallways carrying stacks and stacks of computer punch cards would soon enough figure out how to replace me, my one hundred key Marchant calculator (WWII surplus), and ten key adding machine (Korean War surplus). Where did Personnel keep the vacancy announcements?

Before moving on, it would be fitting to show the character of some of the aforementioned curmudgeons. I'll start with Rudy Mezner. Rudy was one of those people who was a lot older than they look. He had worked for The

Bureau since long before WWII and his defining characteristic was his dapper look. Rudy was about 5' 5" and always dressed in various tailored pin striped suits with monogrammed shirts and a fedora, something on the order of a James Cagney gangster. In those days everyone wore coat and tie, but most came out of the Sears catalog or the rack at J. C. Penney's—government pay being what it was (is?). Bob Cope and Tom Bumgartner were WWII vets with stories to tell. Bob was on a mine sweeper that sank outside San Francisco Bay, and Tom was a bombardier on a B-17 stationed in England. Bill Wiley was a gruff old codger with a black patch over one eye, I pretty much steered clear of him. Denby Peeples was one of the more interesting of the bunch. He was probably at or near seventy years old and as one of the senior analysts, he had a coveted, newfangled, mechanical Friden calculator. Somehow, Denby had figured out the right combination of numbers and the right formula that when he triggered the calculation, the Friden churned out a tune one could dance to. John Childress was a pipe smoker who started more than one fire in waste baskets with his discarded match. Bill Hilmes kept the fire extinguisher between their desks. Bizarre folks were all around the building. The curmudgeons used to talk about one of the engineers who dyed his hair with shoe polish or lamp black. I was later to bear witness to this fact when one rainy day I was on a crowded elevator standing directly behind this person, watching inky black rivulets flowing off the back of his head and down his erstwhile white collar. There was another gent who wore fuzzy earmuffs because he didn't like sound when he worked. I ought to write a book about the characters I've run across in The Bureau.

Ed Hawk, perhaps the most notorious and mysterious of all the curmudgeons deserves his own paragraph. Even though I never met Ed, it was obvious that he carried considerable weight, because I saw his name in several letters as head of various committees—the Ed Hawk Committee. I was later to learn that Ed was a figment created by that now piece of Americana called the Steno-Pool. In those days most of the correspondence was dictated on recording machines and sent to the pool for typing. Ed's real name was "ad hoc." In retrospect, it was amazing how many letters were surnamed and signed without being read. Another piece of correspondence that was signed and sent out made reference to "the source of the scriptures." What the author intended to say was "thesaurus of descriptors." The letter made for some interesting reading.

One more side track and I promise to move on. Earlier I alluded to the $8 daily per diem, let me explain. In those days the bureaucracy was incredibly miserly. The per diem rates were on a sliding scale that reduced the amount allowed the longer you were in detail status. I don't remember exactly what the rates were when I started that particular detail in Washington, probably around $20, but I do remember the $8 I was paid during the last couple of weeks of this training detail in the Commissioner's Office. I stayed in the old Park Central Hotel, it was closest to the Interior building and, for D.C., the rates were reasonable (something in the range of $20). Old timers reading this may recall the Park Central. After the first couple weeks you were on first name basis with the mice and roaches that shared your room. There was no air conditioning, but the window did open. Mine had a nice view of a dirty brick wall about ten feet away. The risk you ran opening the window was letting the rats in with the cooler air. My mice and roach friends did not appreciate sharing the room with rats, so I left the window closed most of the time. Another point to be made on the miserly scale had to do with vehicles. In those days government vehicles were strictly no frills; no radio, no air conditioning. A motor, four wheels and a steering wheel was about it. It wasn't until the '70s that radios and air conditioning started to show up on vehicles.

In 1972 a GS-12 Administrative Officer position in the Durango Planning Office was advertised. Max Stodolski, a friend of mine, had just recently transferred there and a quick call to him convinced me to apply. When I went for the interview with Project Manager Ed Wiscombe, I was armed with budget knowledge of the projects they were studying: San Miguel, Dolores, Paradox Valley, and Animas-La Plata. It must have helped because Ed offered me the job. I reported to Durango, Colorado, in September. My star was on the rise. As a footnote, I should mention my Denver job was abolished after I left (keep track of this). While I was still back in Denver, I was vaguely aware of a law that had recently been passed called the National Environmental Policy Act which meant little to me at the time, but in Durango it was brought up in conversations in staff meeting on a regular basis. It didn't appear to me, or many others at the time, that it was that big a deal. A few more papers to prepare and file. Other events that didn't seem terribly significant at the time were also occurring. Ellis Armstrong became Commissioner, and according to the curmudgeons, there was bad blood between him and Bellport. Bellport retired, moved to California and hung out his consultant's shingle. The Chief Engineer's office became the Engineering and Research Center (ERC) and Harold Arthur assumed the helm. Soon after, Arthur named Donald Duck as his deputy. I kid you not. Donald was married to Dolores and, to my knowledge, they did not have nephews named Huey, Dewey or Louie. Shortly after my arrival in Durango, the ERC was in the middle of a reorganization that saw the first postwar brain drain as its numbers were reduced. Many of the curmudgeons could no longer not think about nor not utter the "R" word. Many reluctantly embraced it. On another front, the members of the water bloc in Congress began to retire or lose elections and our legislative power base began to erode. In 1973 another law was passed that caused the planners to scratch their heads, it was called the Endangered Species Act. What did it mean? How does it relate to that other law? What does it mean consult with the Secretary? Sounds like more paperwork—job security for the planners.

At this point I have to digress to tell you about one man's hog heaven. The Animas River flows right through Durango, it looks to be a clone of the Gunnison AND the then State record German brown trout had been caught under the Main Street bridge. With nostrils flared and fly rod in hand I began to fish and catch fish—all the while eyeing the prime stretch south of town. I was aware I was looking at the Southern Ute Indian Reservation lands, and since I never saw anyone fishing there, I assumed it was not allowed. Imagine my elation when I found out that for five bucks you could get an annual reservation pass, imagine further my pure bliss that, for reasons I never figured out, nobody did. I was truly in hog heaven for the two years I lived in Durango. For all intents and purposes I had a private fishing preserve for a measly five bucks! The fishing was the best I have ever experienced and I never saw another living being, except my dad and a few deer, the whole time I fished there. Hog heaven was to last only two years, however. In the fall of 1974 a decision was reached to consolidate the Durango and Grand Junction offices. My position was to be abolished and I was to be transferred to Grand Junction as the Budget Officer—Enos Stone was the Administrative Officer there and he had about thirty years seniority on me. Where did we keep the vacancy announcements?

One more story, if it survives the editors cut. While in Durango, I was driving a senior Reclamation manager for a visit to Navajo Dam to investigate a pesky leak that had developed in the abutment. He was a rotund and stoic man of little humor and few words. As we started to leave for the drive back, he shouted "STOP!" Startled to hear his voice, I slammed on the brakes and watched him slide forward to become tightly wedged between the seat and the dash. As he dropped off the seat, he … ah … broke wind with a sonic resonance that would make an Arabian stallion proud. I ran around, opened his door and tugged on his shoulders until he popped out and landed on the berm of the road. With all the dignity he could muster, he stood up, picked up his sunglasses from the floor (the reason he wanted me to stop in the first place) and got back in the car. I had my upper lip clenched tightly between my teeth to maintain composure on the long drive back.

Timing and, in the case of rising stars, contacts and mentors are everything. A GS-13 Administrative Officer position was open in Auburn, California, at the construction office for what was to be the world's largest double curvature thin arch dam. I called two people I knew from Denver who were now in the Sacramento Mid-Pacific regional office, Paul Olbert and Hank Masterson. Paul was the Assistant Regional Director for Administration and Hank was a branch chief in Personnel; they both suggested I apply. The interview took place with Project Construction Engineer Don Alexander and, still armed with the knowledge about Auburn Dam I had gained in the budget office, I was able to convince him that I was the man for the job—I suspect with some help from Olbert and Masterson. I reported for duty the week between Christmas and New Years in 1974. What a contrast with the genteel and studious ways of a planning office. I was now in the world of clod kicking, hard hat wearing he-men smoking cigars the size of which would downright impress a Presidential Intern. Gaylord Hay was the soft-spoken Office Engineer, Rod Somerday was the outspoken Field Engineer, and Lou Frei was the ranting Project Geologist. One of the interesting things to observe was the jockeying for position between Lou and Rod to be the "daddy rabbit" for construction operations. Many Auburn employees went on to hold important jobs in The Bureau, mainly in Denver and on the Central Arizona Project.

Auburn Dam's Environmental Impact Statement was one of the first prepared and the first challenged for adequacy. After a rewrite, a judge declared it adequate and, in 1974, work on the massive foundation began. In August 1975 an earthquake occurred some forty or fifty miles north of Auburn that brought into question the seismic safety of the dam being built. A massive seismic/geological investigation began. Then, less than one year later, the defining moment for The Bureau occurred in Idaho at about 7:45 A.M. June 5, 1976, when a survey party noticed a small leak near the right abutment of a newly constructed dam on the Teton River. By noon the crest had collapsed and the embankment was breached. Reclamation's swagger turned into a stagger, and we started to second guess ourselves on everything, including Auburn Dam. Our confidence was rocked. To compound the Auburn situation, President Carter, soon after coming to office, listed Auburn on his "Hit List" of water projects he felt were unneeded. Further construction contracts were put on hold. Hit lists, seismic investigations, no new contracts—where are the vacancy announcements?

I should mention that the 1976 Carter/Ford presidential campaign was the first in my memory (and the first of many to come) where the candidates openly attacked the bureaucracy, in many instances placing blame for the woes of the world on the Federal employee's back and painting us as underworked and overpaid slow moving sloths. We unfairly lost prestige that we have never recovered. The Carter Administration was the first in my experience to place a pure political appointee with no prior Reclamation experience in the role of Commissioner, the former State Engineer in Idaho, Keith Higginson. Although it only lasted the length of his Administration, Carter also gave us a new name, "Water and Power Resources Service" which to me made eminent sense then and now as being a more contemporary, descriptive name for Reclamation–unless anyone wants to argue that we are reclaiming the environment from the family farm (is that a snicker I hear?). One other thing Carter did that has had a role in reshaping The Bureau was to form the Department of Energy (DOE) and transfer the power distribution and marketing function from Reclamation to the newly formed Western Area Power Administration. What were regional divisions under Reclamation became virtual dynasties with fiefdoms spread far and wide under DOE. Many in Congress continue to question the wisdom of that action. Commissioner Higginson began the shift in Reclamation's public policy by placing more emphasis on environmental protection, economic justification and dam safety. Auburn survived the "Hit List," but Carter did not survive his bid for reelection. Some say his attempt to eliminate or curtail the Congressional pork barrel system (Hit List) undermined the effectiveness of his Presidency. At any rate, as the Carter Administration left office they declared that a safe dam could be built at Auburn, but no new construction contracts were to be let until new flow standards on the lower American River were addressed.

The Mid-Pacific Region GS-14 Program Coordination Division Chief's vacancy announcement hit the streets in the fall of 1978. The position reported to Paul Olbert and I was concerned that all the times I called him a blithering idiot when we argued over administrative matters would haunt me. He must have agreed that he was a blithering idiot or he appreciated someone who stood his ground in an argument because I began my new duties right after Christmas. My old job at Auburn was abolished (you're probably catching onto this). In this new job, I was once removed from a Bureau legend that had held the Program Coordination job for many years prior. Remember the story of meeting Rogers Morton when I was a new kid? At about the same time another individual walked into the old budget shop. He was wearing a fedora and a trench coat and my reaction wasn"Wow, the Godfather!". I nearly fell out of my chair when he shook my hand and said "Hi! I'm Mike Catino from Sacramento." Mike went on to be the Regional Director in Sacramento and a lot of us affectionately referred to him as the Godfather.

In those days the Program Coordination Chiefs had status in Reclamation and held one of the most powerful positions in their Regions. We met formally as a group at least four times a year, twice with the Commissioner and all the Regional Directors. We also had a close camaraderie that served The Bureau well. Managing the budget was handled on the phone. If we had surplus funds, I would call Gordon Wendler in Denver or Que Quigley in Boise and move the money around. Conversely, if we had a short fall, a quick call to Dwayne Wynia in Amarillo or Darrel Hogg in Salt Lake City would usually bear fruit. When all else failed, a call to Chuck Lewis in Boulder City would always save the day, simply because he had the Central Arizona Project construction budget under his purview (big bucks). Of course once Mid-Pacific Region's own San Felipe Project got underway, Bill Klostermeyer, The Bureau's Program and Budget guru in the Commissioner's Office, referred to me as the "CEO of the First National Bank of San Felipe." We seemed to always have surplus money thanks to the local beneficiaries continually getting Congressional write-ins added to the budget, even when we didn't need it. This "green eyeshade" team received many kudos from the Department of the Interior and the Office of Management and Budget (OMB) for budget presentation and performance over the years.

Billy Martin was the Regional Director at the time I went to the Region and he was perhaps the most pragmatic Regional Director I have worked for. To illustrate, Billy assigned me to represent the Region before the California Water Commission whenever he was invited to one of their meetings. Those were the days of Governor Jerry "Moonbeam" Brown, and to get a clue as to the makeup of the Commission, I refer you to pages 350 and 351 of the September 1977, edition of the *National Geographic*. The lady living in the tree house on a redwood stump was a member of the Commission. I'm dead serious and if you cannot find the issue, I do have a copy. Needless to say, defending water projects to this group was a character builder. Many who attended the public meetings of the Commission had an aura of burnt rope and rancid bacon grease about them. As this group railed against dams and canals and subsidized water to farmers, I wondered if it occurred to them where bacon came from or, for that matter, what they could personally do with a little water? I feel that, to a large degree, subsidized water for farms occurred because the early estimates on farmers' ability to repay were overly optimistic and later it helped preserve the small family farmer suffering in the Great Depression on their 160 acres. But, it is important to remember that affordable water for family farmers was a public value of the time. In later years corporate (albeit sometimes disguised) farms were becoming the rule. The Reclamation Reform Act of 1982 was passed ostensibly to recognize their existence and to begin to address the subsidized water issue through higher prices for water on excess acreage (something the Act also increased was the acreage that could receive water from 160 acres to 960 acres). Existing long terms (40 years) contracts were a shield around most of the subsidy. However, as these contracts reached their term, new contracts were written to address subsidies.

Throughout this era, The Bureau fought the good fight to keep Auburn Dam on track. The beneficiaries of the project were behind us all the way shouting words of encouragement. Those of us in The Bureau were encouraged when the Carter administration declared a safe dam could be built at Auburn, and we had every confidence in the world when the Reagan administration took office that we would complete the project. Reagan gave Auburn a tentative green light, but insisted on up front cost sharing by the beneficiaries. Not a problem, we thought, until we turned around to find that our supporters knees had turned to jelly in the face of this new bully. Auburn Dam is still in a state of suspended animation and water supply contracts written in anticipation of the yield from Auburn have compounded Reclamation's inability to meet obligations for water throughout the CVP. There are more and more Reclamation projects where enhanced cost sharing has been negotiated; parts of the Central Arizona Project, the Buffalo Bill Modification Project and the Shasta Temperature Control Device come to mind. Also, power users have begun to fund more power related maintenance items on Reclamation powerplants.

The Reagan Administration gave The Bureau its first pharmacist as Commissioner— Robert (Bob) Broadbent. In actuality he was a respected politician from Las Vegas who soon gave the Mid-Pacific Region its first politically oriented and youngest regional director, David Houston. Dave was unquestionably one of the brightest individuals I have ever met. I can remember more than once briefing him on an issue totally new to him while walking down the hall to a meeting, and as the meeting took place he knew more about the topic than I did. In 1984, my friend and mentor, Paul Olbert retired, leaving open the Assistant Regional Director for Administration job. I applied for the position and Dave picked me. You are probably way ahead of me on this by now, but a few years after I left the Program Coordination position, it was abolished.

The decade of the '80s saw two major realignments of The Bureau. Regions were consolidated from the original seven, which incidentally were referred to by number when I first started, to five. In 1985 the Lower Missouri Region (Region 7 to curmudgeons) was consolidated with the Upper Missouri Region (Region 6). Later, in 1988, most of the Southwest Region (Region 5) was folded into the aforementioned region to create the vast Great Plains Region. A small piece of the Southwest Region was added to the Upper Colorado Region (Region 4). Rumors persisted for some time that Mid-Pacific Region (Region 2) and the Pacific Northwest Region (Region 1) would be combined and that the Lower Colorado Region (Region 3) would join the Upper Colorado Region. Neither rumor has panned out—at least not yet. Now, having said all of that, the change from numbers to names, I suppose, was because names were more lyrical and prettier sounding than numbers. Curiously, bureaucrats being bureaucrats, we're not satisfied until we've assigned everything an acronym, we now refer to the regions by letters; GP, MP, UC, LC, PN. Alas . . .

With notable exceptions like the massive Central Arizona Project, and a few smaller projects like Dolores, Paradox Valley and Dallas Creek in Colorado, and San Felipe in California, Reclamation's construction program was starting to wane. One by one, The Bureau construction stiffs began to snuff out the cigars and hang up their hardhats. The exodus in the MP Region was accentuated with the retirement of Bill Hart who managed construction of the San Felipe Project. Bill, a genuine curmudgeon, used to show his disdain for things not specific to construction by wearing bright red Mickey Mouse socks to Regional Office management meetings. Even I picked up on the social comment. Looking back, I think the only overarching authorizing legislation we have had since the '60s involving construction was the "Reclamation Safety of Dams Act of 1978." We have had a few specific authorizations like the temperature control device at Shasta Dam, but the construction heartbeat has become a mere murmur of its former self. In addition to Auburn, other construction projects were stopped midway. Construction on the San Luis Drain in California was halted because of environmental concerns with having the outfall in the Delta. In the interim, drain water was spread in an area designated as the Kesterson Wildlife Refuge. An environmental alarm was sounded when three eyed, four legged birds were found in the refuge, a result of selenium build up from farm drainage. The decade could be defined as a paper decade as volumes of reports on the environment were written and, in the second half, a time of self examination for Reclamation.

The transition between the Reagan and Bush administrations, even though both were Republican, brought on a whole new cast of characters in the politically appointed positions (which seems to be ever expanding). Let me take a moment to illustrate what I have observed during these times.

As the loyal campaigners (or donors) are rewarded with appointments to high-level government jobs, it seems like they all will have stopped at the nearest shopping mall bookstore and bought the latest management technique *du* *jour* book—Management by Objectives, Zero-based Budgeting, Total Quality Management, ad nauseam—as they charge in to show the careerist how they are going to improve our productivity. Swell. Fittingly, they have unwavering loyalty to the administration they helped elect, but they often assume (or demand) the careerist do likewise. It is my experience that except for the chameleon careerist, most careerists first loyalty is with the United States and the agency they work for, otherwise why be a civil servant? Careerists have their own political preferences and occasionally have developed good working relationships with Congressional members and their staffs. I wonder if it occurs to the political appointee just where some of the occasional really dicey questions they are asked at congressional hearings come from? Loyalty is a personal thing.

Most political appointees are decent folks with our Nation's interest at heart and after a few months in office realize that the careerists do actually know a thing or two about what they are doing and a mutual respect begins to develop. However, with every Administration there are the political peacocks who never show respect for the civil servant because, in their minds, they alone hold all of the answers and the careerists are lower caste drones there simply to do their bidding. I have noticed with some level of alarm that in recent years more and more career managers are becoming more and more concerned with "politically correct" than they are with following the letter of the law and accomplishing good public policy. I read once, and believe it to be true, that the career civil servant, the "bureaucracy" if you will, has served as the ballast in the "Ship of State" that keeps it from swinging too far to the right or to the left every time there is a change in the Administration. As more and more politically appointed positions are established further and further down in the hierarchy of an agency the more wildly the "Ship of State" will veer. I truly believe that the Congress should put firm limitations on the number of political appointees to one or two per agency and eliminate the "burrowing in" efforts of political appointees during changes in Administrations. One saving grace is that the strutting and crowing of any given political peacock usually lasts less than twenty-four months and there is always the chance that they will be replaced by an appointee that can develop a mutual respect with the careerist.

Now that I've wound myself up real tight on politics, I'm going to digress to tell you about an interesting near miss I had with politics. During my tenure at the Auburn project, I was befriended by a gentleman by the name of Wendell Robie. Among other things, Wendell was the driving force behind the Winter Olympics at Squaw Valley, owned a bank with branches throughout Northern California, owned a lot of Northern California and was the most powerful man in the Republican party in Northern California. We became friends while I was a member of the Lions Club he chartered in the 1930s when I was the Administrative Officer at Auburn Dam where I worked closely with Wendell on relocating the Western States Trail, another one of his interests. (Allow me an interesting sidebar in this digression)—Wendell once took me for a ride in his car to check out possible trail sites along the canyon of the Middle Fork of the

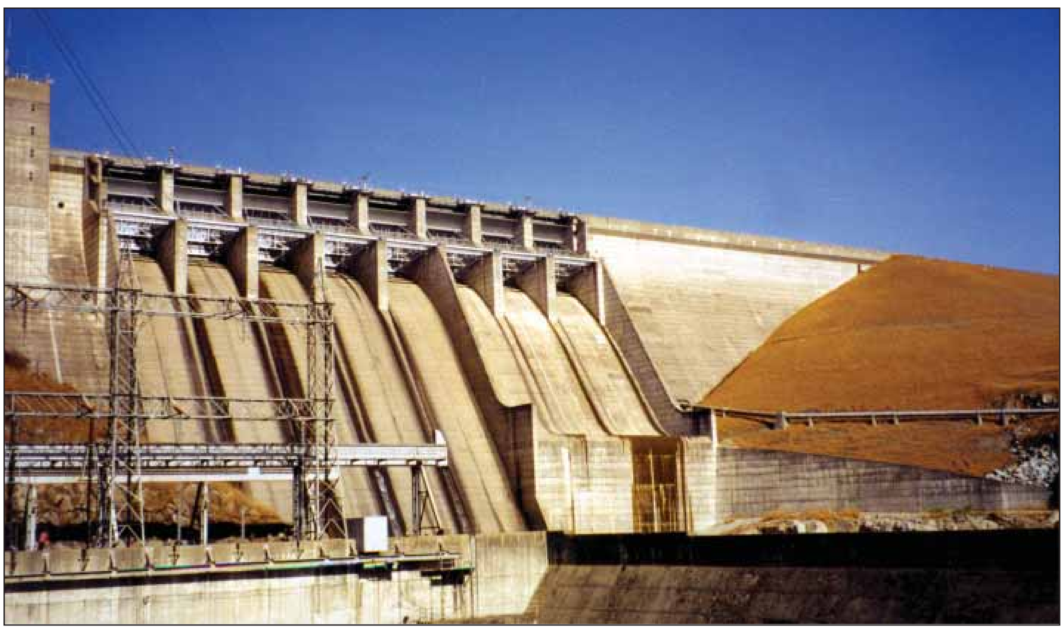
American River. We wound our way down the canyon wall on a poor excuse of a single lane mining road at a place called Ruck-a-Chucky. We got to the bottom of the canyon and stopped at the edge of the water. While I was nervously pondering how we were going to back all of the way out of this predicament, Wendell gunned the engine and we plunged into the river! Somehow I stifled the scream of terror in my throat, drawing courage from Wendell's nonchalant demeanor as water began flowing through the floorboards of his family sedan. We bounced and drifted and finally bounded up on the remains of the mining road on the other side whereupon Wendell opened his door and suggested I do the same to drain out the part of the river that we had captured during the crossing. When the color returned to my face, I thought "That was weird." I was later to learn that we were just ahead of the pulse flow released daily for power production from the upstream dams. Apparently Wendell did this frequently and somehow I figured it was pointless to ask him why he didn't own a jeep.

To get me back on the real point of this digression, it was during one of my many encounters with Wendell that he asked if I wanted a career in politics. He stated that "they" would get me on the Placer County Board of Supervisors and then look to the State Assembly and, in time, national politics. This was not to be taken lightly, because Wendell controlled the GOP in that part of California. I asked him why Bizz Johnson, a Democrat, held the Fourth Congressional seat. Wendell smiled and responded that they had an "understanding" and that when the time was right, he would put his man in. His man was Gene Chappie, a colorful member of the State Assembly that I had met and came to know. The time was right very soon after that, and Gene became the next Congressman to represent the Fourth District. I thought about Wendell's offer, but ultimately thanked him and said no.

30.3. C. Dale Duvall while Commissioner of Reclamation.

In 1987 Commissioner Dale Duvall asked Reclamation to examine the direction of its programs. That examination, "Assessment '87,'" pointed out the need for water conservation, improved management of projects, and the need to address environmental values. The hiring of people with biological science degrees was almost reaching a par with hiring engineers launching yet another metamorphosis of The Bureau. The last decade of the twentieth century was kicked off with an initiative of Commissioner Dennis Underwood entitled, "The Strategic Plan." It used “Assessment 87” as a base and laid out a new long term “A big picture” for Reclamation with specific goals and action plans. The Bureau was beginning to turn greener and greener as the world was presented with the “Strategic Plan” in 1992. That year also saw the passage of one of the most significant laws to affect and change the course of Reclamation, the “Reclamation Projects Authorization and Adjustment Act of 1992”. It was a far-reaching law with forty titles impacting almost all of Reclamation, but nowhere so dramatically as California’s Central Valley Project with Title XXIV, the Central Valley Project Improvement Act (CVPIA). The CVPIA assigned environmental protection and restoration a priority equal to that of water and power deliveries. Implementation of the law has been a difficult process because it so radically changed a paradigm that had existed for over a half a century.

In 1993 Regional Director Roger Patterson suggested that I take the vacant Project Superintendent’s job at Folsom Dam. I at first resisted because it was yet another job at my same grade level (my mentors had long since left The Bureau and my rising star had long since stalled—I guess the other potential mentors I had called blithering idiots had taken the words personally), besides,

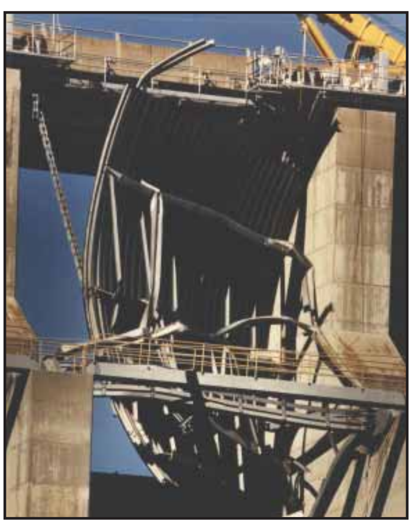


34.4. Folsom Dam spillway in 1998. The dam is a composite structure with a concrete spillway and earth wing dams on the American River above Sacramento, California. The U.S. Army Corps of Engineers built the dam between 1948 and 1956, but Reclamation manages the dam in cooperation with the Corps.

the only thing I knew about electricity was that it could shock you (I was later to learn that a turbine runner was not an Olympian from India). I was aware of, and Patterson pointed out, that we had some real personnel and administrative issues at Folsom that needed attention. Additionally, he indicated he was going to assign more responsibility and consolidate field offices into Area Offices (ours became the Central California Area Office [CCAO]). Silly me, I thought under those circumstances there would be a grade raise someday. Alas. Twenty four years as a GS-14 must be a record. Am I starting to sound like the coffee urn curmudgeons of so long ago? Oh well, it was a much better commute; half the distance, no freeway, dodge deer and count road kill. You probably guessed, but Patterson abolished the Assistant Regional Director-Administration position. For those of you who have not kept score, every Bureau job I have held has been abolished after I've left it (I'm sure that is a record). A record that I might share with a handful of others is that I have worked under ten Commissioners, seven acting Commissioners and eight Presidents.

Another event occurred in 1993 that impacted all of Federal Government. It was a vice-presidential initiative to change the way the government works called the National Performance Review (NPR). "More with less" became the battle cry to "cut red tape, put customers first, empower employees to get results, and get back to basics" (if you are tempted to say "yada, yada, yada" at this point, feel free). Commissioner Dan Beard outlined his plan for the Bureau that flattened management, implemented the Area Office concept and to " … focus on: operating our projects with greater environmental sensitivity …" Impacts on staff were felt throughout the organization, but nowhere as severe as the Denver office, which I think by this time was being called the Reclamation Service Center—I admit I've lost track. Its direction was to de-emphasize design and construction and to provide support to all Reclamation offices at the lowest possible cost. The Denver workforce was reduced and realigned accordingly.

A challenge to Denver's new direction occurred a little after 8:00 A.M. Monday morning, July 17, 1995. I was at my office at Folsom Dam loading my briefcase for a trip to the Regional Office for a round of meetings when Dennis McComb, our O&M Chief, stuck his head in my office and dead panned, "Gate 3 just failed." My reaction was—"what the hell is he talking about?" He repeated and still unbelieving, we jumped in a car and headed for the dam. The sight that unfolded as we came around the bend was incredible. Water was spewing a hundred feet in all directions from the center of the dam—I hope to shout "the gate had failed!" We quickly assembled a team consisting of experts from our Denver Office, the Corps of Engineers, McClellen Air Force Base, and California Department of Transportation, among others to immediately go to work on figuring out how to plug the hole and design a long term fix. The bell had been tolled that Reclamation's aging infrastructure is in need of attention. Still, sufficient budgets to address these problems have been hard coming. You can see why Area Managers sometimes feel like Quasimodo trying to get Esmeralda's attention ringing and ringing the bells of Notre Dame.



34.5. Gate 3 at Folsom Dam after failure July 17, 1995

The ‘90s saw a renewed effort toward bringing about a more diverse workforce. In retrospect we have come a far way during my career, albeit not far enough in the eyes of many. If I could take you back to 1968 and the curmudgeons at the coffee urn and had I told them then that at that very moment there was a grammar school girl on Long Island, New York, named Maryanne Bach who will go on to get an advanced degree in ecology and will become a Regional Director, or that Felix Cook, the black engineer toiling in the catacombs of their building, will go on to head the technical side of Reclamation, they would have looked at me funny and thought to themselves “This poor kid must have suffered a head wound when he was in Vietnam. … what the hell is ecology?” I take personal pride in the small level of career help I’ve been able to provide to some of the women I’ve had the privilege of working with over the years. Donna Darr was a supply clerk in the Auburn Office when we first met. She went on to become Mid-Pacific Region’s most successful liaison officer in the Commissioner’s Office. Dee Winn was my secretary and Marcy Turner was a budget clerk when I became the Program Coordination Chief. By the time I left the position, both were professional graded budget analysts and Marcy went on to be a Branch Chief. Susan Hoffman’s career has proceeded from soil scientist to Mid-Pacific Region’s Planning Officer. On the other hand, try as I might, I was not able to get the grade the CCAO Administrative Officer, Joni Ward, deserved. It is locked in at GS-12. It is particularly a concern because I was a GS-13 Administrative Officer at Auburn and my duties were no greater than Joni’s were when she had the job. Does a glass ceiling exist? Do we have a way to go?

At the turn of the millennium those of us with a part of the CVP were wrapped up in renewing the long term contracts our users had held for forty years. The changes brought on by the CVPIA made the process a contentious one. First of all, the contracts could only be renewed for twenty-five years. A situation that made it more difficult for farmers to get long term loans for farm operations. Additionally, less water was available to the users as more was committed to environmental restoration. And, of course, the water that would be available would have a much higher price. It was a blow felt most severely by smaller family farms and those with marginal lands. The values of the first part of the century, symbolized by the famous picture of the H. J. Mersdorf “Desert-Ranch” with the sign stating “HAVE FAITH IN GOD AND U.S. RECLAMATION,” had been reversed by the end of the century. Because of delays in finalizing the environmental documentation, interim contracts were negotiated to bridge the expired contracts and the new long term contracts. The whole process took over a decade to complete. In the early part of the contract negotiations, I had the privilege of working with The Bureau’s quintessential curmudgeon, Cliff Quinton. Cliff was a repayment specialist and the Central California Area Office’s chief negotiator who had a scowl and demeanor that would make a middle linebacker weak in the knees. He was extremely knowledgeable and was never tripped up in negotiations. For years after his retirement, I was able to keep contractors in line with the mere threat of bringing Cliff out of retirement.

30.6. This image showcasing the Mersdorfs' hopes is an iconic image to Reclamation.

By and large, John Q. Citizen takes water for granted and why shouldn't he? Isn't it always there when he turns on his tap? Isn't there abundant food in the grocery store? Doesn't the air conditioner kick on when the temperature gets above 78 degrees? Aren't all of his favorite golf courses a verdant green? Few people outside of the industry have a clue as to how complex the water world is. As the twentieth century rolled into the new millennium, those who read newspapers and watch the news should have been getting the message that they better start paying more attention to the many faceted water issue. For example, story after story has been in the news about the plight of the West Coast salmon. The fishermen blame the farmers and the dams that supply them, the farmers say the fishermen are over-harvesting the sea, the environmentalists blame the loggers, fishermen, and farmers, **and** they all blame the sea lions. Who is right? Who is wrong? Is the answer to stop fishing? Put farms out of production? Stop logging? No, of course not, people still value plentiful food and good homes! When I first started my career, nearly one third of John Q's disposable income went for food, today it is more like one tenth. John Q. has grown up without being hungry or doing without. He is focused on "me" and "now." More and more of his dollars are spent on entertainment and "toys." He apparently isn't taking time to think about the long term as his parents and grandparents did. By his parents 'and grandparents' standards, his decisions probably seem downright goofy. Thus, as Reclamation's second hundred years begin, the stage is set for water related decisions that would confound the decisionmakers of one hundred years ago. One would hope that John Q. will become aware of the water world and let the elected officials know what his values are. As it stands now, John Q. is complacent to let the special interest or advocacy groups dictate his values for him while he remains in blissful ignorance. I wonder if John Q. understands that as we put more and more farms out of production for environmental values, we become less adaptable to droughts that occur across the nation, and we become more dependent on foreign food. I wonder further if he understands that our growing dependency on foreign foods, in many cases, is leading to massive environmental destruction as more and more rainforests are leveled to make farmland. Whether it is triggered by drought, the West Coast salmon, or the Sandhill Crane in Nebraska, or rolling brownouts throughout the Reclamation West, the issues with water are basically the same; there are more and more diverse demands for water, and not everyone's demands can be met without impacting someone or something else.

Reclamation attempts to inform John Q, but it wasn't always so. Prior to the Teton collapse, The Bureau had a high and mighty self image and public relations was not much more than simply setting up tours for various facilities. The public image of Reclamation continued to erode throughout the late '70s and early '80s. The late '80s and '90s saw Reclamation make concerted efforts to at least respond to negative press and in more and more instances, get ahead of the media on issues through improved media relationships. Press releases are issued on all major issues and events and Reclamation managers are being trained in how to deal with the media. Jeff McCracken, Mid-Pacific Region's Public Information Officer came to Reclamation with an extensive background in the news industry. He fostered good relationships with the various editors, reporters, and news directors by keeping them informed on issues and being forthcoming when they had questions. Because of this, he was able to successfully guide the Mid-Pacific Region through some potential public relation disasters. With the public outreach throughout Reclamation now in place, John Q. has no one to blame but himself for not being informed on water issues.

As Reclamation steps boldly into it's second century we have a new President, a new Secretary of the Interior and a new Commissioner who is one of us, a person who came up through the ranks, John Keys, former Regional Director of Pacific Northwest Region and a pretty good college football referee. For all the curmudgeons, this is a welcome sign; for those who have not worked for a Commissioner with a Bureau background, they will appreciate the depth of understanding of their issues from the start.

A few months after this screed was submitted as part of the Reclamation History Symposium, our nation was attacked by terrorists. Here and elsewhere I have amended my original manuscript. Uncertainty has become the norm as Reclamation struggles to protect the very facilities that the western United States relies upon for water, food production, power and flood protection. Much has changed and more will change in our employees' daily lives and how business is conducted. Already armed guards patrol critical infrastructure

30.7. John W. Keys III as Commissioner of Reclamation.

and other security measures have been brought to bear. Security is a new factor to be budgeted for and executed. Secrecy has entered Reclamation's world. Yet politics are still part of the picture. Two events occurred in 1995 that prompted me to start the ball rolling to get a bridge authorized that would take the public traffic (over eighteen thousand cars a day) off the top of Folsom Dam. They were the Oklahoma City bombing and the failure of the spillway gate which made obvious the vulnerability of Sacramento to a man made flood. At least six separate security reviews before and after 9/11 indicated that public access to the top of the dam presents a serious security risk. Duh! At Congressman Doolittle's request for data, I had an appraisal level study completed so that he might use the data to draft a bill to get a bridge authorized. With the events of 9/11, I thought getting the bridge authorized would be a slam dunk—it was such obvious good public policy. To my great surprise, however, the Department of the Interior came out in total opposition to the proposed legislation, stating that it was a local transportation issue. Never mind that Reclamation over the years allowed the road to become a major artery for two of the fastest growing counties in the United States. Never mind the many vulnerabilities and danger to the lives of hundreds of thousands of people immediately downstream that the dam poses by allowing clear access to the top of all eight spillway gates. How the political people could keep a straight face and say it is a local transportation issue is really beyond me. I had arranged for non-Federal cost sharing, but the bill was written for full Federal funding, which apparently had stuck in somebody in the Department's craw. Congress controls the Federal purse strings and if they say fully Federal, then so be it. The important thing is the safety and security of the structure and the many people who live in immediate harm's way; it is simply good public policy.

To summarize the last third of The Bureau's history, I would make reference once again to the shining knight on the white horse. He was still charging hard in the late '60s, but the noble steed was starting to get winded. The '70s turned out to be an unexpected low hanging branch that knocked him head over heels; squarely to the ground. The '80s found him staggering in search of his steed, but a storm of paperwork and environmental problems buried him and allowed his now dented armor to tarnish and rust. As he laid there, he began to ponder his place in the world. In the '90s, he was propped up and told that the Water Kingdom has changed, the throne was being shared by many rival kings in an uneasy truce. The image of the damsel in distress and the fire breathing dragon was becoming blurred in his eye, "which was which?," he asked. Where does he go from here? The answer most likely is to become gatekeeper and arbiter, like other aging knights of old, to resolve differences and attempt to equitably divide the waters of the Water Kingdom.

On a personal note, I don't know precisely when I became a curmudgeon, but it happened. I suppose it was inevitable. I didn't recognize it until more and more people started to ask me when I was going to retire, and it was driven home when Betsy Rieke, a fellow Area Manager, made that particular reference to both herself and me during one of our manager's meetings. Have I exacted my revenge on The Bureau? Well, I don't know—some probably think so. I do know that I've made The Bureau pay, though, something in the order of $2 million to do something I've had some fun doing. And, I wrangled a GS-15 out of the powers to be. Although it wasn't my intention, I've made a couple of Regional Directors uncomfortable with actions I've taken in the interest of good public policy albeit politically incorrect at the time. I know there will be a sigh of relief in some quarters when I soon announce my retirement. Do I still fish? I can't say I do. The days on the Southern Ute Reservation spoiled me. That coupled with the large crowds and small trout in California lessened the enjoyment. Besides, I rediscovered another passion from my frivolous youth, building hot rods. I get great enjoyment buzzing around town in my '34 Ford with its chopped top and 327 engine, leaving every Harry Highschool, who thinks his Honda is hot stuff, in the dust when the light turns green. Like it or not, things change, people change, values change. As The Bureau proceeds through the next one hundred years, these things are certain; the values we hold today will change, public policy will continue to change, and Reclamation's mission will continue to change. As the Beatles once sang, "O bla dee, O bla dah, life goes on."

Heraclitus was right, you know, you can't step into the same river twice.

Thomas J. Aiken, at the time of the history symposium, was the area manager of the Central California Area Office in Folsom. He has since retired.

The World Commission on Dams: A Case Study on Grand Coulee Dam and the Columbia River Basin Project: Process and Lessons Learned

By:
Paul C. Pitzer

Except for the Great Wall of China, dams are the largest man-made objects on this planet. The World Commission on Dams (WCD) states that there are around eight hundred thousand of them scattered across six of the seven continents. Most are comparatively small in volume, but an estimated forty-five thousand are higher than a five story building, and a few are monumental exceeding ten or more million cubic yards of material.[1] These dams are responsible for about 30–40 percent of the irrigated land worldwide and dams generate 19% of the world's electricity.[2]

Various studies have looked at individual dams—their histories, their politics, their technological achievements, their environmental and cultural impacts.[3] From these it is clear that dams can and have dramatically altered their surroundings. Those changes have brought both positive and negative results and spirited debate continues about which might outweigh the other. Specifically, government bodies, civil society organizations, private contractors, and financial institutions have debated the costs and benefits of dams, large and small. Large dams have come under especially close scrutiny. Proponents point to power production, flood control, irrigation, domestic water supply, navigation, and recreation as worthy enhancements resulting from their construction—this reflecting the nature of many dams as multipurpose projects. Opponents decry adverse environmental, social, and economic impacts that generally follow in the wake of dam construction—with some of those impacts being unanticipated. There is apparently no exact way to determine if the benefits of a dam outweigh the costs, and the heated debate over this has accelerated and continued without resolution. People on both sides of the issue agree that the polarization of opponents and proponents has resulted in a virtual breakdown of constructive dialogue.[4]

One aspect of the argument is the degree to which large dams collectively have successfully accomplished the goals initially projected for them. There have been few comprehensive studies of all large dams on a worldwide basis. "Cooked" figures often cloud the ability to weigh the value of benefits against those of costs. The estimated values of those costs and benefits are generally based on subjective judgments complicated by rapidly changing social priorities. While large dam building in the Industrialized World peaked in the twentieth century and now has more or less stopped, Third World Countries continue to project and build large dams; for example, the Three Gorges Dam on the Yangtze River in China currently nearly completed. The question is whether or not this is wise, and if so, under what conditions and guidelines future large dams should be built to maximize their benefits while minimizing their costs and their detrimental impacts, and guaranteeing achievement of the goals projected for each structure.

In Third World countries many dams have been and are financed by the World Bank.[5] In April 1997 the World Bank, together with the World Conservation Union (IUCN), held a meeting in Gland, Switzerland, to discuss a recently completed World Bank study of fifty Bank-funded dams.[6] Participants[7] agreed that an independent commission should review the "performance of large dams and set guidelines for the future."[8] After subsequent meetings, the result was the recommendation that the World Bank and World Conservation Union create, by November 1997, a World Commission on Dams (WCD) which would work (following a five month preparation period) for two years.[9] It would function under two "overarching goals." First "to review the development effectiveness of dams and assess alternatives for water resources and energy development," and second "to develop internationally-accepted standards, guidelines and criteria for decision making in the planning, design, construction, monitoring, operation, and decommissioning of dams."[10] These goals were elaborated in six objectives:

1. To assess the experience with existing, new and proposed large dam projects so as to improve (existing) practices and social and environmental conditions.

2. To develop decisionmaking criteria and policy and regulatory frameworks for assessing alternatives for energy and water resources development.

3. To evaluate the development effectiveness of large dams.

4. To develop and promote internationally acceptable standards for planning, assessment, design, construction, operation, and monitoring of large dam projects and, if the dams are built, ensure affected peoples are better off.

5. To identify the implications for institutional, policy and financial arrangements so that benefits, costs and risks are equitably shared at the global, national and local levels.

6. To recommend interim modifications—where necessary—of existing policies and guidelines, and promote "best practices."[11]

The planners and stakeholders immediately recognized a few significant problems. First, they needed to insure objectivity and second, they needed to involve representatives of all "stakeholders" in each aspect of the work.[12]

To that end, they recommended an independent commission composed of a chair and eleven commissioners with a "secretariat" appointed by the chair. In addition to the goals and objectives, the final report of the WCD was to include "recommendations on policies, standards, guidelines, best practices and codes of conduct" as well as an "understanding of the accuracy of predictions of costs and benefits used in the dam planning process and of their overall development effectiveness and the need for restoration and reparation where necessary."[13] A third problem was the fact that every dam, regardless of size, is unique in its technical configuration, its effects, and its economic and social/cultural surroundings. The planners recognized that drawing meaningful conclusions from many different and distinct sources and studies would be a formidable task.

Finally, there was the problem of paying for the study. The World Bank agreed to arrange funding in the amount of just under ten million dollars. By June 2000 fifty-one contributors had pledged more than seventy-five percent of that amount.[14] Significant contributions came from the governments of Germany, Norway, Australia, Canada, China, Denmark, Finland, Ireland, Japan, South Africa, Sweden, Switzerland, the United Kingdom, and the United States.

Guidelines for selection of the commissioners included the need for eminent persons with appropriate expertise and experience, objectivity, and integrity, and independence with the ability to represent the diversity of stakeholders and their points of view including various affected regions, communities, and both public and private sectors.[15] Selected as Chair of the WCD was Professor Kader Asmal of South Africa (Minister of Water Affairs and Forestry).[16] Vice-Chair was Lakshmi Chand Jain of India (High Commissioner to South Africa). The remaining commissioners were Donald J. Blackmore of Australia (Chief Executive, Murray-Darling Basin Commission), Joji Cariño of the Philippines (Executive Secretary, International Alliance of Indigenous-Tribal People of the Tropical Forest based in London), José Goldemberg of Brazil (Professor and Director of the Institute for Electro-technical Energy, University of São Paulo), Judy Henderson of Australia (Chair, Oxfam International), Gran Lindahl of Sweden (President and CEO, ABB Asea Brown Boveri Ltd.—a global engineering firm), Deborah Moore of the United States (Senior Scientist, Environmental Defense Fund), Medha Patkar of India (Founder, Struggle to Save the Narmda River), Thayer Scudder of the United States (Professor, California Institute of Technology), Jan Veltrop of Norway (Harza Engineering Company and Chairman of the United States Committee on Large Dams), Shen Guoyi of the People's Republic of China (Director General of the Department of International Cooperation in the Ministry of Water Resources), and Achim Steiner as Secretary-General and ex-officio Commissioner.[17]

On 16 February 1998 in Cape Town, South Africa, Professor Asmal officially launched the World Commission on Dams with an address to its commissioners, members of the press, and other interested parties. He emphasized the diversity of the commissioners and the unanimity finally achieved by the stakeholders in their selection—this apparently after some difficulty and disagreements. He emphasized the overarching goals for the WCD and added,

> At a time when dam building is increasing in some countries, in others, dams are already reaching the end of their useful lives. Clearly consideration may have to be given to the mechanisms, both with existing dams and those being contemplated, for the effective and efficient decommissioning of dams. Indeed this reality now confronts the owners of a number of large dams in the United States.[18]

The WCD hosted the first of its many public meetings on 21 and 22 September 1998 in Bhopal, India. That meeting focused on "Large Dams and Development in South Asia: Experiences and Lessons Learned."[19] Seemingly having had a successful beginning, the Commission went on to a variety of large and smaller meetings during which announcements identified the representative large dams that it would study in depth. Specifically, the Commissioners identified seven individual large dams and river basins for detailed case studies. These were the Tucurui Dam and Amazon/Tocantins River in Brazil, the Glomma Dam and Lagen River Basin in Norway, the Tarbela Dam and Indus River Basin in Pakistan, the Pak Mun Dam and Mekong/Mun River Basins in Thailand, the Aslantas Dam and Ceyhan River Basin in Turkey, the Kariba Dam and Zambezi River Basin in Zambia/Zimbabwe, and the Grand Coulee Dam (GCD) and Columbia Basin Project (CBP) and the Columbia River Basin in the United States. In addition, the WCD would complete country reviews of China and India. A pilot study would first be done on the Gariep/Van der Kloof Dams and Orange River in South Africa.[20]

For each individual case study, the following questions were to be addressed:

1. What were the projected versus actual benefits, costs, and impacts of the dam?

2. What were the unexpected benefits, costs, and impacts?

3. What was the distribution of costs and benefits—who gained and who lost?

4. How were decisions made?

5. Did the project comply with the criteria and guidelines of the day?

6. What were the lessons learned?

Questions three and six were of greatest significance.

In addition to the seven in-depth studies, the WCD announced that it would also do a limited analysis of an additional 150 dams using existing data from as many sources as possible. The WCD urged interested parties to make contact with specific study groups to contribute information and views.

For the following two year period, the WCD established subgroups that began the indicated studies. Commissioners and designated group leaders held extensive meetings and workshops to that end, adhering as much as possible to its "multistakeholder process"—that is, involving representatives of every identifiable aspect connected with that specific project.[21] It is not the purpose of this paper to explore all of those studies but rather to focus specifically on the Grand Coulee Dam study and its findings. Some attention, however, will be given to the final report since the Grand Coulee study contributed to it.

The WCD announced that selection of Grand Coulee Dam for study was based on the dam's size and because of the ongoing debate about its positive and negative impacts. The WCD added that Grand Coulee Dam was also of vital interest since it is a mature dam in a mature democracy where debates about re-licensing, decommissioning, protection of endangered species, and recreational demands on water resources are more advanced than elsewhere in the world.[22]

WCD senior advisors Sanjeev Khangram and Jamie Skinner traveled to Seattle, Washington, in February 1999 to begin work on the Grand Coulee study. To guide and complete the study, the advisors selected Dr. Leonard Ortolano of the Civil and Environmental Engineering Department at Stanford University. Assisting Ortolano was Dr. Katherine Kao Cushing from the University of California at Berkeley.[23]

On 20 May 1999 fifty-six stakeholders met with Ortolano, Cushing, Commissioner Jan Veltrop, and WCD Senior Advisor Sanjeev Khagram (an assistant professor of public policy at the John F. Kennedy School of Government at Harvard University) at Cavanaugh's Inn at the Park in Spokane, Washington. The stakeholders represented government agencies, farmers, industry, and Native Americans. Most of those attending were from the United States but there was some representation from Canada. The meeting was at times contentious as various stakeholders had strongly held views and agendas. Some feared that the whole thing was an attempt by environmentalists to remove more dams—specifically Grand Coulee Dam. In fact, a column in the *Davenport Times* of Spokane had called the Commission an "upstart group of pseudo scientists" who would "come down on the side of removing, abandoning or breaching the mighty Grand Coulee Dam."[24] Columbia Basin Project farmers wanted to redress decades-old grievances concerning cost of the water delivered to them and their desire to expand the project. Native Americans were anxious to discuss their cultural losses resulting from dam construction. Regional politicians were disturbed at the prospect of somehow losing local control. Some questioned the origins of funding for the WCD, wondering who was behind the study and to what end? Bureau of Reclamation Public Affairs Officer Craig Sprankle reported later that after listening to Professor Ortolano and looking at and commenting on the issues and questions to be studied, there was less suspicion.[25]

Antagonisms between project farmers and others involved with irrigation projects is an on-going saga. Farmers, who often pressured the government to build dams and irrigation facilities, later complained bitterly about the cost of the water. Such had been the case on the Columbia Basin Project. Early on in the project's history, many farmers balked at land ownership restrictions and withdrew from the project. In the late 1950s and early 1960s farmers and the Bureau of Reclamation carried on an especially acrimonious debate about renegotiation of costs. The need to raise charges stemmed to some degree from high unanticipated costs needed to install drainage facilities.[26] Easing of land ownership restrictions during the Reagan years has led farmers to want project expansion, but they balked at the anticipated cost which in the 1990s was estimated at about two billion dollars.

In the 1990s the Bureau of Reclamation conducted two environmental impact studies concerning project expansion and concluded that it was not practical at that time.[27] Area farmers dispute the findings and challenge figures—especially the allocation of moneys collected from the sale of power generated at the dam.[28] Many of the "old-timers" remember promises made in the 1920s and 1930s that the water would actually be free, and that power sales would pay all of the costs.[29] All of the deeply held opinions among the participants made it difficult for participants to achieve consensus.

The purpose of the Spokane meeting was to draft a scoping paper delineating the issues to be addressed within the framework of the case study procedure. Eventually the stakeholders divided into breakout groups and addressed the task. Under the headings of Irrigation, Hydropower, Flood Control, Project-Affected People, Ecosystems/Anadromous Fish, Recreation, Distribution of Benefits and Costs, and Basin-Wide Issues, the participants identified 114 issues. These were later arranged into three categories:

- Issues to be addressed in the study
- Interesting background information, and
- Issues of less direct relevance

Forty-three issues were listed as primary for the study, fifty-eight were background information, and eleven were of less direct relevance.[30]

The WCD Grand Coulee team also held a meeting on 4 October 1999 in Castlegar, British Columbia, Canada, to gather additional input. Seventeen stakeholders attended representing BC Hydro, Canadian First Nations, and others. They discussed and added to the results of the Spokane meeting.

In the area of irrigation, the stakeholders directed Ortolano to concentrate on technological changes since the start of the project—specifically increased efficiency, altered attitudes concerning the environment (with emphasis on fish, waterfowl, and groundwater quality), and factors obstructing expansion of the project. Concerning hydropower, the stakeholders urged focus on distribution of low-cost benefits (specifically, the stakeholders pointed out that availability of low-cost power in the region had drawn new industry creating a growing market for power which was resulting in increased costs to all including farmers). There were no concerns aimed at flood control. In the category of project-affected people, stakeholders directed the WCD team to detail the "displacement" of Native Americans, reparations for such displacements, disruption to their cultural lives, and destruction of such culturally significant items as burial sites. With ecosystems and anadromous fish, there was a range of opinions. In general, the stakeholders urged consideration of impacts of Grand Coulee Dam on native species as well as those introduced to mitigate anticipated damage. Concerning recreation, conflict between the need for occasional drawdowns of Franklin D. Roosevelt Lake and the desires of locals for consistent lake levels drew attention. Distribution of benefits and costs led the stakeholders to urge reexamination of the "relationship between hydropower revenues and cost of providing irrigation works and water." In addition, stakeholders pointed to the Columbia Basin Treaty between the United States and Canada, and wondered, "Who pays for what? Who benefits and who loses?" Finally, under basinwide issues, the Canadian stakeholders felt that ". . . basin-wide management system, in some instances, led to a transfer of benefits from Canada to the U.S. (For example, there used to be orchards upstream, now there are none. But there are orchards downstream)." In short, the stakeholders urged the WCD committee to explore fully the Columbia Basin Treaty.[31]

It is significant to speculate, at this point, that the comments of the stakeholders and the degree to which at least some of them pursued their individual agendas rested on a measure of misunderstanding on their part about the nature and authority of the World Commission on Dams. Although none of the stakeholders said as much at the Spokane meeting, or at any other meeting, there was in their comments an implication that they felt the WCD had the power and authority to redress their grievances. Lost was full appreciation of the WCD's charge to examine the dams in question only with the hope of presenting information about past experiences and develop guidelines for future large dam development elsewhere. At no time did the WCD studies intend to influence existing conditions nor did it have the authority to correct problems and injustices however lamentable.[32]

Based on their study so far and the results of the Spokane meeting, in June 1999, Ortolano and Cushing issued their scoping report for the

Grand Coulee Dam and Columbia Basin Project case study.[33] It presented a précis that would act as the guide for the eventual final report. Divided into eight major sections, that final report would contain an introduction explaining the study and naming the participants, an overview of the nature of the Columbia Basin Project, historical analysis of the project's development, discussion of costs and benefits including unexpected impacts, a look at distribution of those costs and benefits, analysis of consistency with planning criteria and norms, basinwide linkages, and finally, an assessment of development effectiveness and lessons learned. The lessons learned would be the heart of the findings and the most significant section that would move on into the WCD's overall final report.

Over the next six months, Ortolano and his team gathered information, conducted interviews, drew together detailed background and historical studies and essays, and began to formulate their final report. Early in December 1999, the team released a circulation draft of the proposed final report.[34] At over four hundred pages, the draft report contained detailed histories, charts, maps, and other findings including analysis of interviews and conclusions based on the data. Copies of the draft circulated among the stakeholders who were then invited to a final meeting.

That all-day meeting was held at the Benson Hotel in Portland, Oregon, on 13 January 2000. Thirty-four persons attended—somewhat fewer than anticipated.[35] Twenty-six were stakeholders; two of the others were WCD Commissioners Jan Veltrop and Deborah Moore, two observers came from the World Resources Institute and Harvard University (both of which were conducting independent investigations of the WCD process), representing the WCD was Senior Advisor Jamie Skinner, and the others were in some way part of the Grand Coulee study team.[36]

After introductions and statements by Commissioners Veltrop and Moore, Professor Ortolano presented the study's main findings. He recited a brief history of the project and detailed its beneficiaries and major cost-bearers. To no one's surprise, he listed the beneficiaries, in order of significance, as Columbia Basin Project farmers or irrigators, Bonneville Power Administration ratepayers, downstream residents and businesses, recreators and recreation-related commerce, and United States residents in the Northwestern states, and Canada.[37] Major cost-bearers were, in order of significance, Native American and First Nations Tribes, environmentalists and environmental non-governmental organizations, commercial fishermen, sport fishermen, non-Native Americans forced to resettle, United States taxpayers, Bonneville Power Administration ratepayers, some United States farmers outside the project area, and Canada.[38]

At first glance, it appears odd that Bonneville Power Administration (BPA) ratepayers appeared on both lists. Grand Coulee Dam is a key component of the Federal Columbia River Power System which supplies seventy-five percent of the power in the region at costs well below the national average. Direct Service

Industries and large industrial customers benefit from even more generous rates. On the other hand, the rates could be lower. BPA ratepayers also underwrite irrigation, fish mitigation programs, and programs to enhance and recover endangered anadromous fish populations. In the area of irrigation, ratepayers cover eighty-seven percent of the irrigators' construction costs—a sizable subsidy which accounts, in large part, for irrigation being the first item among the beneficiaries. In fact, there was nearly unanimous agreement among interviewed stakeholders that the irrigating farmers were the prime beneficiaries of the project. BPA ratepayers would pay even less if they did not subsidize irrigation and fish protection. Hence they both benefit and at the same time, bear some of the costs of the project.

Despite the extensive benefits received by farmers, following in the tradition of their physiocrat predecessors, representatives of the irrigation districts felt the study should reflect what the farmers pay rather than what they do not pay.

> For example, they pay for Operation and Management and equipment replacement. The subsidy irrigators receive is only for construction. Irrigation district representatives felt there was no power subsidy because they pay for primary and secondary pumping costs "at cost." Professor Ortolano responded by saying that what the farmers pay does not reflect the value of power in the open market. The irrigators voiced their objection to the use of the term subsidy.[39]

At no time did anyone point out that without the government underwriting the project and the income from the sale of electricity, the cost to farmers to compensate for the water they receive would be both astronomical and prohibitive.

Native American representatives felt that modern tribal economies and the project's effects on them were not adequately covered in the report. Representatives of the Colville Confederated Tribes agreed to supply Ortolano with additional information detailing specific losses resulting from construction of the dam, the reservoir, and the irrigation project.

Stakeholders were then each asked to fill out a form dealing with the eight "lessons learned," that appeared in section eight of the draft study. Each could indicate strong agreement (sa), agreement (a), no view (nv), disagreement (d), or strong disagreement (sd).

Briefly stated, the eight lessons and the feedback on them were as follows:

1. An open planning process facilitates identifying and resolving conflicts among stakeholders; a closed process serves the opposite purpose.

sa: 7	a: 6	nv: 0	d: 2	sd: 3

2. Periodic, planned re-evaluations of project operations provide a mechanism for incorporating temporal changes in social values into project operations.

sa: 6 a: 4 nv: 1 d: 2 sd: 5

3. Periodic, planned re-evaluations of project operations provide a mechanism for incorporating changes in science and technology into project operations.

sa: 6 a: 5 nv: 0 d: 2 sd: 5

4. While subsidies for water project outputs can accomplish useful social policy objectives, they can lead to situations where resources are not used in an economically efficient manner.

sa: 2 a: 9 nv: 0 d: 4 sd: 3

5. There are limits to government planning in a market-driven, capitalistic system.

sa: 2 a: 9 nv: 2 d: 1 sd: 4

6. In a decentralized resource management decision-making context such as the one existing in the Columbia basin, failure of stakeholders to coordinate can lead to major institutional failures.

sa: 1 a: 9 nv: 2 d: 2 sd: 3

7. Decisions that introduce significant irreversible effects should only be taken after very careful study.

sa: 4 a: 7 nv: 1 d: 2 sd: 3

8. Tools for cumulative impact assessment need to be applied to avoid resource management problems.

sa: 6 a: 6 nv: 0 d: 2 sd: 3

While the minutes of the meeting reflected the analysis that stakeholders mostly agreed with item number one and items five through eight and were split on items two through four, it is clear that there was no consensus or general agreement and that respondents were 'all over the board.' Not all stakeholders responded to each lesson, and one stated later that he had disagreed with all statements simply because he disagreed with the report in general.

Discussion of the lessons learned took considerably longer than anticipated and consequently, participants did not complete the full agenda. Comments included suggestions for an increased list of beneficiaries.[40] Three additional lessons learned were suggested:

1. Once you build a project, there will continue to be debate about how a project is operated, and a plan should be in place for a process to manage these debates about operations.

2. In large projects, most of which are multi-purpose, it is possible for the various purposes to be in opposition, and even mutually exclusive (e.g., foregone power revenues due to irrigation withdrawals).

3. Mechanisms need to be created to address claims by peoples adversely affected by projects.

With all of this in hand, Ortolano and his team prepared the final report which they issued in March 2000. It contained eleven lessons learned; three (number one, number seven—which became number ten, and number eight—which became number eleven) remained the same or nearly the same as in the preliminary study. Altered were numbers two, three, and five and added were five entirely new items. The altered and new items are listed below:

1. Same as #1 above

2. In a multipurpose water project, it is common for project purposes (e.g. flood control and recreation) to conflict. Because conflicts among various purposes are practically inevitable, a process for managing stakeholder contributions to debates on project operations should be institutionalized on future projects.

3. (which was changed from #2 above) For future projects, periodic, planned re-evaluations can provide a mechanism for incorporating temporal changes in social values into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by results of re-evaluations.

4. (which was changed from #3 above) For future projects, periodic, planned re-evaluations provide a mechanism for incorporating changes in science and technology into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by results of re-evaluations.

5. Substantial inflation-corrected cost overruns in GCD and CBP reflect the uncertainties that surround large construction projects. These uncertainties underscore the need for wide-ranging sensitivity analyses to ensure that project goals and objectives are robust and can be met with available resources. Implicit or indirect subsidies need to be evaluated under alternative market conditions to ensure that the subsidies are in line with the project's social objectives.

6. Stakeholders and planners involved in an open planning process need to work with a common conceptual framework and vocabulary in making formal project appraisals. Of particular importance is the distinction between private and social (economy-wide) perspectives. Failure to develop a shared conceptual framework and vocabulary can lead to unnecessary acrimony.

7. In large water resources projects, those who bear the costs may not receive many benefits. Therefore, mechanisms for ensuring just compensation are important. In a project that has impacts that cross international borders, the usual forums for allowing parties to make compensation claims—for example, the judicial system in the U.S.—may not be satisfactory, and alternative forums should be considered. Alternative dispute resolution mechanisms may also be able to speed up the settlements of claims normally brought using the court system.

8. (Which was changed from #5 above) Limits exist on the extent to which government plans can be implemented effectively in a market-driven capitalistic economy.

9. In designing institutions for river basin management, centralization, and decentralization each have their advantages and disadvantages.

10. Same as #7 above.

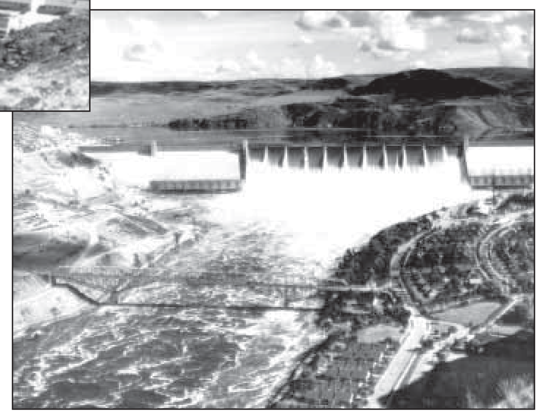
11. Same as #8 above.[41]

The report altered a bit the list of beneficiaries and cost bearers and concluded that the major beneficiaries of the Columbia Basin Project (CBP) were/are, in descending order, the local irrigators and agribusiness people, Bonneville Power Administration (BPA) rate payers (including public utility districts [PUD]), downstream residents, people using the area for recreation, the general economy of the Northwestern United States, and British Columbia Hydro ratepayers. On the distaff side, the cost bearers in descending order were/are United States and Canadian native peoples, persons concerned with maintaining ecosystem integrity, commercial fishing interests in the United States and Canada, sports fishing interests, non-Native peoples who were forced to relocate, United States taxpayers, some United States farmers outside of the CBP area, and some upstream residents and businesses.[42]

No project in American history had been as completely and thoroughly studied prior to its construction as was the Columbia Basin Project. Through the 1920s numerous investigations looked into the various plans to irrigate the Columbia Basin with the definitive report completed by the Army Corps of

35.1. Grand Coulee Dam construction in 1936.

Engineers in 1932; the so-called Butler Report or 308 Report.[43] That report established the "grand plan" for development of the Columbia River, a blueprint largely followed through subsequent decades. It finally established the physical, if not the economic viability of Grand Coulee Dam and the Columbia Basin Project. In the 1940s, Harlan Barrows of the University of Chicago investigated twenty-eight potential problems that would guide the development of irrigation using water from behind Grand Coulee Dam. Barrows, who had been instrumental in planning for the Tennessee Valley Authority, took four years and used over three hundred people to scrutinize every aspect of the project then imaginable with the hope of yielding a planned and orderly development free from significant difficulties. The resulting Columbia Basin Joint Investigations (CBJI) filled many books and acted as the guide for building not only the irrigation works, but also planned communities, industry, and laid out the whole economic and physical strategy for the area.[44] The overarching ideal was to create a "planned promised land" where the economy and the environment were controlled eliminating both financial depression and drought. A holdover from the New Deal, the concept of planning would have been applied as fully as possible.[45]



35.2. Grand Coulee Dam in 1948 after construction.

Repeatedly, the findings of the WCD report indicate the failures of particularly the Joint Investigations.[46] For example, farmers were scheduled to repay fifty percent of the cost of irrigation but they actually pay only about ten to fifteen percent. The CBJI dramatically underestimated productivity per acre on the project. Crop production in 1998 was $637 million, over twice what had been predicted, even with dollar values adjusted for inflation. The investigations projected 80,000 families living in created towns and on something in excess of 10,000 farms of about 160 acres each. The average farm size now of about five hundred acres is much greater than the planners recommended as prodigious changes in farm technology have thwarted the goal that would have fostered the growth of small family farms and rural communities.[47] None of the anticipated planned communities/cities have materialized. Farmers tended to locate in already existing towns rather than in new communities or on their farms.

The CBJI did not envision a third powerhouse at Grand Coulee Dam or any of the large upstream dams that now regulate the flow of the Columbia River. When dollar values are adjusted for inflation, the cost of the original and the newer power generating facilities at the dam have run about thirty percent higher than estimated.[48] On the positive side, among other things, the CBJI in no way anticipated the atmospheric pollutants avoided through the use of hydroelectric power rather than fossil fuel alternatives, a benefit which has a high value but one difficult to calculate.

The WCD report concluded that it would be impossible to assess the success or failure of the Grand Coulee Fish Management Project (GCFMP) which set a target rate of 36,500 salmon passing up the river to spawn annually. In the 1930s, over 70,000 fish were caught annually by commercial fisheries alone. Nobody knows the total number of fish that utilized the river in those days. Today there is no viable commercial fishery as little or no commercial fishing is allowed. This change in conditions renders meaningless any attempts at evaluation.[49]

If nothing else, the case of Grand Coulee Dam and the Columbia Basin Irrigation Project demonstrates the difficulties encountered in trying to plan a large project with multiple and varied impacts existing in a dynamic and rapidly changing society. Anticipating the future with its shifting values and goals is impossible. This author clearly remembers one of his teachers in the early 1950s telling our elementary school class that the large dams on the Columbia River were “conservation projects.” Few knowledgeable teachers would make that statement today.

“At the time GCD was planned, assessing ecological effects of proposed federal projects was neither a requirement nor a priority.”[50] “The state of knowledge of ecosystems at the time was such that virtually no consideration was given to the maintenance of genetic biodiversity.”[51] In addition to the most obvious damage to the salmon (anadromous fish), the project caused dramatic changes in the plant and animal populations of the project area while at the same time creating new wetlands and habitat areas. Little of this was anticipated, and only minimal care is taken now of the new wildlife areas.

In the 1930s and 1940s there was no process for including input from the Colville and Spokane tribes in any aspect of the decision making process. This matter was not addressed for decades and was only somewhat remedied in the mid-1990s when the government finally reached a settlement with the affected peoples.[52]

Trade-offs also exist between regional development and objectives related to equity and the environment. This is clearly shown by the way GCD affected indigenous peoples in the upper Columbia River Basin. In the view of many Native Americans and members of First Nations in Canada, GCD was nothing short of catastrophic. For them, the project had a disastrous effect on their culture.[53]

The WCD report stresses the need to have all stakeholders involved in decision making from the outset, and this is reflected in the lessons learned listed above; especially lesson number one.

The WCD report gave considerable attention to the economic viability of Grand Coulee Dam and the Columbia Basin Project. Because an economic efficiency objective (the condition that economic benefits exceed costs) for water resources projects developed by Reclamation and the Corps did not come about until the late 1930s and early 1940s, this objective had little formal influence on the planning of GCD and CBP. However, concerns about what would now be termed economic efficiency were raised in the context of GCD and CBP. For example, the U.S. Secretary of Agriculture and the Chief of the U.S. Army Corps of Engineers both used economic efficiency arguments to support their opposition to the project.[54]

The WCD report concludes that due to the need for projects to increase employment during the economic depression of the 1930s, Franklin Roosevelt's promise to honor campaign commitments in the Northwest, and the strength and effectiveness of local project supporters, concerns about whether or not the undertaking would be economically viable were ignored or overridden. Furthermore, at the time, there was minimal concern, if any, for the feelings of and cultural stability of the Native Americans involved. The WCD report continues,

> ...the consensus of the 12 individuals we interviewed representing irrigators, PUDs, and local governments in the CBP area was that the net positive impacts of GCD and CBP for the region far outweighed the costs to Native Americans [sic.]. Such regional development arguments frequently ignore the subtleties involved in making arguments related to economic efficiency. Indeed, some of those who trumpet the economic significance of the project do not recognize either the failure to pay interest on the capital cost of irrigation or the lost power revenues associated with providing below-market price energy to pump irrigation water as signs of economic inefficiency.[55]

If judged in terms of only regional development goals, the CBP must be considered a success. Indeed, the WCD report admits that the hydroelectric facilities have had an overwhelmingly positive benefit-cost ratio.[56] However, there have been considerable power cost subsidies to local users such as Public Utility

Districts (PUDs). In other words, had the market price been charged to all, the benefits would have been even greater.

The report's executive summary concludes,

> The regional development objectives of GCD and CBP have, to a considerable extent, been achieved. But they have come at a substantial cost to the rest of the economy, both in terms of direct construction subsidies and in revenues foregone from indirect subsidies in the form of below-market energy prices.[57]

As for the cultural impact of the project, the WCD report states,

> There is no calculation procedure that allows a balancing of these negative social impacts and cultural losses against the substantial regional development benefits that the US Northwest has enjoyed as a result of GCD and CBP.[58]

The report also commented on the irreversible elimination of anadromous fish runs in the hundreds of miles of habitat upstream from Grand Coulee Dam, and the damage done to wild stocks of salmon and steelhead in the mid-Columbia River tributaries with the introduction of hatchery and transplanted fish.

Today, U.S. citizens rely on an open planning process tied to NEPA (National Environmental Protection Act) to help decision-makers become aware of trade-offs: how much of one objective, such as the quality of the environment, must be sacrificed when attempting to augment another, such as regional development. However, nothing equivalent to NEPA existed in the time that President Franklin Delano Roosevelt and his administrators decided to proceed with construction of GCD. Moreover, even the open planning prescribed by NEPA has limitations. For example the NEPA process does not necessarily address the consequences of unequal power among stakeholders, a problem that still plagues the anadromous fish recovery and recreational jurisdiction issues associated with GCD and CBP.[59]

Finally, the WCD report summary concludes:

> After nearly 60 years of project operations, those who have benefited from GCD and CBP have, quite naturally, become focused on maintaining the advantages they have enjoyed as a result of the project—mainly low-cost irrigation water, low-cost electricity, and benefits from flood control and recreation. At the same time, groups that were disadvantaged by the project (i.e., Native Americans and First Nations) are continuing their struggles to obtain compensation for what they perceive as broken promises and grave injustices of the past. It is possible that individuals who gain or lose from future water resources projects will be just as tenacious in defending their gains or seeking compensation for their losses many years after basic project decisions have been made.[60]

The overriding objective of the WCD was to provide guidance for future large dam projects. The preceding quote was aimed toward that end, and it provides a convenient segue into comments about the completed final overall report of the WCD which would assess and meld the findings of all of the regional studies including the GCD and CBP study.

With some fanfare, Nelson Mandela and the WCD Commissioners unveiled the final report at a luncheon held in London on 16 November 2000. Over three hundred invited dignitaries attended including World Bank President James D. Wolfensohn and World Conservation Union Director General, Maritta von Bieberstein Koch-Weser.[61] That report incorporated findings of the worldwide studies of large dams including those from Grand Coulee Dam.[62]

The Final Report found that worldwide sixty to eighty million people have been displaced by dams while sixty percent of the world's rivers have been affected by dams and diversions.[63] The study found the use of water worldwide to be more than twice what it was fifty years ago. The report listed eight significant conclusions:

1. Large dams display a high degree of variability in delivering predicted water and electricity services—and related social benefits—with a considerable portion falling short of physical and economic targets, while others continue generating benefits after 30 to 40 years.

2. Large dams have demonstrated a marked tendency towards schedule delays and significant cost overruns.

3. Large dams designed to deliver irrigation services have typically fallen short of physical targets, did not recover their cost and have been less profitable in economic terms than expected.

4. Large hydropower dams tend to perform closer to, but still below, targets for power generation, generally meet their financial targets but demonstrate variable economic performance relative to targets, with a number of notable under- and over-performers.

5. Large dams generally have a range of extensive impacts on rivers, watersheds and aquatic ecosystems—these impacts are more negative than positive and, in many cases, have led to irreversible loss of species and ecosystems.

6. Efforts to date to counter the ecosystem impacts of large dams have met with limited success owing to the lack of attention

to anticipating and avoiding impacts, the poor quality and uncertainty of predictions, the difficulty of coping with all impacts, and the only partial implementation and success of mitigation measures.

7. Pervasive and systematic failure to assess the range of potential negative impacts and implement adequate mitigation, resettlement and development programmes for the displaced, and the failure to account for the consequences of large dams for downstream livelihoods have led to the impoverishment and suffering of millions, giving rise to growing opposition to dams by affected communities worldwide.

8. Since the environment and social costs of large dams have been poorly accounted for in economic terms, the true profitability of these schemes remains elusive.[64]

The report continued,

> …the WCD Global Review documents a frequent failure to recognize affected people and empower them to participate in the process. As the Global Review of dams makes clear, improving development outcomes in the future requires a substantially expanded basis for deciding on proposed water and energy development projects.[65]

The report made recommendations and commented,

> Social, environmental, governance and compliance aspects have been undervalued in decision-making in the past. It is here that the Commission has developed criteria and guidelines to innovate and improve on the body of knowledge on good practices and add value to guidelines already in common use. Seen in conjunction with existing decision-support instruments, the Commission's criteria and guidelines provide a new direction for appropriate and sustainable development.

Bringing about this change will require:

- planners to identify stakeholders through a process that recognizes rights and assesses risks;

- States to invest more at an earlier stage to screen out inappropriate projects and facilitate integration across sectors within the context of the river basin;

- consultants and agencies to ensure outcomes from feasibility studies are socially and environmentally acceptable;

- the promotion of open and meaningful participation at all stages of planning and implementation, leading to negotiated outcomes;

- developers to accept accountability through contractual commitments for effectively mitigating social and environmental impacts;

- improving compliance through independent review; and,

- dam owners to apply lessons learned from past experiences through regular monitoring and adapting to changing needs and contexts.[66]

The WCD congratulated itself by pointing out that it had conducted "the first comprehensive global and independent review of the performance of essential aspects of dams and their contribution to development."[67] But the recommendations, while commendable, are somewhat utopian. It is clear that consideration of all "stakeholders" in the decisions affecting any given large dam would have meant that few, if any, would ever have been built. Identification of stakeholders itself presents a problem. In the 1930s, at the time of Grand Coulee Dam construction, for example, who could have predicted the advances in power transmission that would make the entire trans-Rockies West a market for the dam's electricity? And if that had been anticipated, would (or should) power interests in California or Nevada have been allowed the same input as those in Oregon and Washington? This is a question of particular significance at this writing (March 2001) as power shortages and brown-outs plague California.

When a government agency implements its act of "taking" through eminent domain, not many feel adequately compensated, and changes in lifestyle or culture are beyond replacement or adjustment. All large dams have involved tradeoffs, and in most cases, the power of government and/or industry have overshadowed the desires of those adversely affected. There is little reason to believe that this will not continue, and in fact, it continues today with the formidable Three Gorges Project on the Yangtze River in China where over a million people have been displaced. Where the environment is concerned, when and where push comes to shove, the demand for power, for example, will undoubtedly overshadow environmental damage. Few Americans are willing to keep their homes cooler in winter, do without air conditioning in summer, and eliminate use of other electrical conveniences.

The studies by the World Commission on Dams were a prodigious and laudable undertaking. Their main contribution may be amassing and assembling information about dams, their histories, and their problems all in one place. Few, if any, of the findings are new or startling. The report, like the final report on Grand Coulee Dam, while acknowledging past goals and how they have changed, clearly reflects and emphasizes the values and concerns of the late 1990s industrialized countries and not those of the times when the various dams were built or the conditions under which they were built. The recommendations are praiseworthy, but only time will tell if they have any significant impact.

> Paul C. Pitzer has published several articles and *Grand Coulee: Harnessing a Dream* (Pullman: Washington State University Press, 1994). He has recently retired from teaching American history in the Portland, Oregon, area, and he served as a consultant to the World Commission on Dams (WCD). Dr. Pitzer contributed four annexes, or appendices, to: World Commission on Dams, *WCD Case Studies: Grand Coulee Dam and Columbia Basin Project, USA,* circulation draft, December 1999 found at http://www.dams.org and in hard copy in the Bureau of Reclamation's library at the Denver Federal Center.

Endnotes

1. The Large Dams Debate, http://www.dams.org/about/debate.htm. The International Commission on Large Dams (ICOLD) estimates that there are in excess of 20,000 dams in China alone. See the Web Page of the World Commission on Dams: Dam Facts and Statistics; http://www.dams.org/consult_region_esea_stats.asp. Note that the extensive and detailed web pages of the World Commission on Dams form the primary source for this paper along with printed copies of the Commission's reports and the personal experiences of this author working on some of those reports. As web pages are fluid and often changing things. Some of the addresses listed in notes below may no longer be functioning. This author has printed copies of all web pages cited. To start with the main page of the WCD, go to http://www.dams.org Note that spellings in all WCD documents (including where such are cited in this paper) conform to British spellings.
2. World Commission on Dams, *Dams and Development: A New Framework for Decision-Making, The Report of the World Commission on Dams*, (London: Earthscan Publications, Ltd. November 2000), Executive Summery, p. xxviii. Examples of such studies would include: Murray Morgan, *The Dam* (New York: Viking Press, 1954); Joseph E. Stevens, *Hoover Dam: An American Adventure* (Norman, Oklahoma: University of Oklahoma Press, 1988); Russell Martin, *A Story That Stands Like a Dam: Glen Canyon and the Struggle for the Soul of the West* (New York: Henry Holt and Company, 1989.)
3. "The Large Dams Debate," http://www.dams.org/about/debate.htm.
4. Social, economic, and environmental problems resulting from dam construction led the World Bank to consider ending funding for dam construction and switch emphasis to coal as a source of power. The problems from burning of fossil fuels led to a renewed interest in dams. See WCD in the Media, 19 April 1997, http://www.dams.org/MediaItem.asp?item=46.
5. The Mandate of the World Commission on Dams; http://www.dams.org/mandate.asp. For a list of participants in the Gland, Switzerland workshop, see: Commission World Dams1, http://www.cwra.org/news/arts/tonydam1.htm.
6. Participants included the Institute of Hydrology, United Kingdom; Tata Energy Research Institute, India; Institute of Population Resources, China; ISAGEN, Columbia; Tropical Environmental Cons. Ltd., Senegal; Intermediate Technology Development Group, United Kingdom; Volta River Authority, Ghana; Harza Engineering Company, USA; Lesotho Highlands Water Project, Lesotho; Movimento dos Atingidos por Barragens, Brazil; Alliance for Energy, Nepal; Electricite de France, France; International Commission on Irrigation and Drainage; Ministry of Water Resources, China; Asea Brown Boveri (ABB), Switzerland; International Finance Corporation; Berne Declaration, Switzerland; Narmada Bachao Andolan (NBA), India; Nam Theun 2 Electricity Consortium (NTEC), Laos; International Rivers Network, USA; Laymeyer International, Germany; California Institute of Technology, USA; International

Commission on Large Dams; Electrowatt Engineering Ltd, Switzerland; The World Bank; IUCH-The World Conservation Union, Switzerland and Laos. World Commission on Dams Overview Http://www.dams.org/overview.asp. Also see Press Release for 11 April 1997, http://www.dams.org/PressReleaseItem.asp?item=42.

7. The Mandate of the World Commission on Dams; http://www.dams.org/mandate.asp.

8. The initial goal was for the World Commission on Dams to start work in June 1998 and file its final report in June 2000. With some delays, the final report, discussed below, was issued November 16, 2000.

9. The Mandate of the World Commission on Dams; http://www.dams.org/mandate.asp.

10. World Commission on Dams Overview Http://www.dams.org/overview.asp

11. A 'Stakeholder' is any person or group that has some interest in or can be in any way affected by a project or undertaking. For creation of the WCD, the World Bank and World Conservation Union identified fifty stakeholders who guided selection of the Commissioners.

12. World Commission on Dams Overview Http://www.dams.org/overview.asp.

13. Contributors included Swedish International Development Cooperation Agency (Sida); Norwegian Ministry of Foreign Affairs; The World Bank; Deutsche Gesellschaft für Technische Zusammen Arbeit (GTZ); Siemens; Kreditanstalt für Wiederaufbau (KFW); South African Department of Water Affairs and Forestry; Harza Engineering; The Government of the People's Republic of China, Ministry of Water Resources; German Federal Ministry of Economic Cooperation and Development (BMZ); Denmark Ministry of Foreign Affairs; Enron; Hydro Quebec; Ministry of Finance - Japan; National Wildlife Federation; Swiss Agency for Development and Cooperation (SDC); World Wildlife Fund; Canadian International Development Agency; United Kingdom Department for International Development; Charles Steward Mott Foundation; Bureau of Reclamation, United States; Coyne et Bellier; Atlas Copco (USA); Berne Declaration; Skanska; Republic of Ireland; United Nations Foundation; Goldman Environmental Fund; United Nations Environment Programme; AusAID, The Australian Government's Overseas Aid Programme; Ministerie van Buitenlandse Zaken-The Netherlands; Ministry of Foreign Affairs, Finland. Funding and Finances, http://www.dams.org/about/funding.htm.

14. The Commissioners, http://www.dams.org/about/commissioners.htm.

15. For additional information on Professor Kader Asmal, see WCD Press Releases 24 September 1997, http://www.dams.org/PressReleaseItem.asp?item=41.

16. The Commissioners, http://www.dams.org/about/commissioners.htm, and http://www.dams.org/comm.asp. It is significant to note that all of the commissioners had multi-national experiences in their professional lives. Selections of some commissioners and of the vice-chair were complicated by controversy and disagreements among the stakeholders. History-Commission Launch, http://www.dams.org/launch.asp.

17. History: Commission Launch, http://www.dams.org/launch.asp. Also see http://www.dams.org/press/pressrelease_4.htm.

18. WCD Press Releases, 7 September 1998, http://www.dams.org/PressReleaseItem.asp?item=37.

19. Focal Dams/River Basin Case Studies, http://www.dams.org/studies/. For individual press releases announcing WCD studies, see WCD Press Releases, 29 January 1999 (Tarbela Dam) http://www.dams.org/PressReleaseItem.asp?item=67; WCD Press Releases, 21 February 1999 (Grand Coulee Dam), http://www.dams.org/PressReleaseItem.asp?item=68; WCD Press Releases, 18 March 1999 (Tucurui Dam), http://www.dams.org/PressReleaseItem.asp?item=71, WCD Press Releases, 20 March 1999 (Pak Mun Dam), http://www.dams.org/PressReleaseItem.asp?item=21, WCD Press Releases, 20 March 1999 (Kariba Dam), http://www.dams.org/PressReleaseItem.asp, WCD Press Releases, 14 June 1999 (Gloma and Lagen River Basin) http://www.dams.org/PressReleaseItem.asp?item=77, Dams Newsletter No. 2, March 1999, http://www.dams.org/newsletter2_studies.asp.

20. Anthony H. J. Dorcey, "World Commission on Dams: a Unique Multistakeholder Process, Agreement and Initiative," http://www.cwra.org/news/arts/tonydam1.html.

21. WCD Press Releases, 21 February 1999 "World Commission to Study Grand Coulee Dam," http://www.dams.org/PressReleaseItem.asp?item=68.

22. Leonard Ortolano and Katherine Cao Cushing, *WCD Case Studies: Grand Coulee Dam and Columbia Basin Project USA* [Final Report], (Vlaeberg, Cape Town, South Africa: World Commission on Dams Secretariat, March 2000.) Ortolano and Cushing added additional authors: Nicole T. Carter (Stanford University), William Green (CCRITFC - Canadian First Nations), Carl Gotsch (Stanford University), Kris May (Stanford University), Tim Newton (B. C. Hydro), Paul Pitzer (Beaverton, Oregon), Sophie Pierre (Canadian First Nations), Josh Smienk (Columbia Basin Trust), Michael Soules (University of California, Berkeley), Marilyn Watkins (Watkins Historical Research—Native Americans), and Harza Engineering (Chicago, Illinois).
23. WCD In the Media, "World Commission Butts Heads With Local Farmers," 26 May 1999, http://www.dams.org/MediaItem.asp?Item=23.
24. WCD In the Media, "World Commission Butts Heads With Local Farmers," 26 May 1999, http://www.dams.org/MediaItem.asp?Item=23.
25. Paul C. Pitzer. *Grand Coulee: Harnessing a Dream* (Pullman, Washington: Washington State University Press, 1990), pp. 291-310.
26. CH_2MHill, "Draft Environmental Impact Statement: Continued Development of the Columbia Basin Project, Washington" (Boise, Idaho: Bureau of Reclamation, September 1989).
27. It is significant to remember that during the early debates that led to the construction of Grand Coulee Dam and the Columbia Basin Irrigation Project, proponents held that the sale of electricity generated at the dam would pay for all of the costs of irrigation. Paul Curtis Pitzer, "Visions, Plans, and Realties: A History of the Columbia Basin Project," unpublished Ph.D. dissertation, University of Oregon, 1990, pp. 247-353. A study by the General Accounting Office further concluded that expansion of the project would not be economically feasible. See: Government Accounting Office, *Water Resources: Issues Concerning Expanded Irrigation in the Columbia Basin Project.* (Washington D.C.: Government Printing Office, January 1986).
28. Pitzer. *Grand Coulee: Harnessing a Dream*, pp. 26.
29. Ortolano and Cushing, *WCD Case Studies [Final Report Annexes]*, pp. A1-1 to A1-12.
30. Ortolano and Cushing, *WCD Case Studies [Final Report Annexes]*, pp. A1-1 to A1-12
31. This comment is based on the personal observations of this author who was present at the 13 January 2000 meeting in Portland, Oregon, which is discussed below.
32. Leonard Ortolano and Katherine Kao Cushing, "Scoping Report for the Grand Coulee Dam and Columbia Basin Project Case Study," World Commission on Dams, 5th Floor, Hycastle House, 58 Loop Street, P.O. Box 16002, Vlaeberg, Cape Town, 8018, South Africa, June 1999.
33. Leonard Ortolano and Katherine Kao Cushing, "Grand Coulee Dam and Columbia Basin Project USA," circulation draft: (Cape Town, South Africa: World Commission on Dams, December 1999).
34. Bad weather that day may explain why some of the stakeholders missed the meeting.
35. "Meeting Minutes: World Commission on Dams—Grand Coulee and Columbia Basin Project Case Study, Second Consultative Meeting," 13 January 2000, Portland, Oregon, p. 1.
36. Ortolano and Cushing, "Grand Coulee Dam and Columbia Basin Project," circulation draft, pp. 5-1 to 5-6. Benefits to Canada resulted from lower costs for power and because the Canadian government used the proceeds from the Columbia River Treaty to build major water projects in Canada. Without those benefits, the government had anticipated building coal-fired powerplants.
37. Ortolano and Cushing, "Grand Coulee Dam and Columbia Basin Project USA," circulation draft, pp. 5-1 to 5-6.
38. "Meeting Minutes: World Commission on Dams—Grand Coulee and Columbia Basin Project Case Study, Second Consultative Meeting," 13 January 2000, Portland, Oregon, p. 2.
39. Additional beneficiaries included hunters on the Columbia Basin Project, contribution to Allied forces in World War II, British Columbia Hydro ratepayers, environmental gains due to the lack of pollutants since coal-burning power stations are not needed, and environmental gains in the various reservoirs and wetlands created. "Meeting Minutes: World Commission on Dams—Grand Coulee and Columbia Basin Project Case Study, Second Consultative Meeting," 13 January 2000, Portland, Oregon, p. 7.
40. Ortolano and Cushing, *WCD Case Studies [Final Report]*, pages 8-1 to 8-16.

41. Note that the major change from the list in the preliminary report was the elimination of Bonneville Power Administration ratepayers from the cost-bearer side. Ortolano and Cushing, *WCD Case Studies [Final Report]*, pages 5-2 to 5-4.

42. Pitzer, *Grand Coulee: Harnessing a Dream*, pp. 21-59. A study required by Congress in its 1925 Rivers and Harbors Act resulted in a report issued on August 12, 1926, called House Document No. 308, 69th Congress, 1st session; it has come to be called the "308 Report" as have most subsequent studies done by the government on the Columbia River. The original "308 Report" called for an extensive survey of a number of rivers including the Columbia River. Congress authorized that study in 1927. Done in two parts, one looked at the river above the confluence with the Snake River and it was supervised by Major John Soule Butler for the Army Corps of Engineers. Although Butler completed most of his work by mid-1930, the finished report was not released to Congress until March 29, 1932, as Columbia River and Minor Tributaries: Letter from the Secretary of War Transmitting Pursuant to Section 1 of the River and Harbor Act approved January 21, 1927,…Containing a General Plan for the Improvement of the Columbia River and Minor Tributaries for the Purposes of Navigation and Efficient Development of Water-Power, the Control of Floods, and the Needs of Irrigation, 2 Vols. (Washington, D.C.: U.S. Government Printing Office, 1933).

43. Pitzer. *Grand Coulee: Harnessing a Dream*, pp. 270-1.

44. Richard Lowitt. *The New Deal and the West* (Bloomington, Indiana: Indiana University Press, 1984), pp. 138-52.

45. Ortolano and Cushing, *WCD Case Studies [Final Report]*, March 2000.), ix.

46. Ibid.

47. Ibid., p. x.

48. Ibid., p. xiii

49. Ibid., p. xii.

50. Ibid., p. xiii.

51. Pitzer. *Grand Coulee: Harnessing a Dream*, p 222.

52. Ortolano and Cushing, WCD *Case Studies [Final Report],* p. xxix.

53. Ortolano and Cushing, WCD *Case Studies [Final Report],* p. xxvii; also 9-3.

54. Ibid.

55. Ibid., xxix.

56. Ibid.

57. Ibid., p. xxx.

58. Ibid.

59. Ibid.

60. Press Release, 16 November, 2000, "World Commission on Dams Launches 'Landmark' Final Report.", World Commission on Dams, http://www.dams/org/press/pressrelease_73.htm. Also see: *The Christian Science Monitor*, 20 November, 2000, editorial; and *The Oregonian*, 17 November, 2000, p. A30.

61. Complete reports from all studies are available on the web page of the World Commission on Dams (http://www.dams.org). The final report is also available at http://www.damsreport.org. That site offers information on purchase of a published copy of the final report titled *Dams and Development: A New Framework for Decision-Making - The Report of the World Commission on Dams*, (Earthscan Publicans Ltd., London and Sterling, Virginia, November 2000).

62. World Commission on Dams, *Dams and Development*, p. xxx.

63. Ibid., p. xxxi. (Note the use of British spellings throughout the report).

64. Ibid.

65. Ibid., p. xxxvi.

66. Ibid., p. xxxvii.

67. "BPA energy crisis may put salmon at risk," *The Oregonian*, 19 January 2001, p. 1. The need to release water from federal dams on the Columbia River to sustain California power needs has decreased the reservoir holdings behind those dams making release of water during the spring and summer salmon runs problematical. This situation backs this author's position that the demand for power, as it has in the past, will continue to jeopardize and/or overshadow environmental considerations. It is significant that as dams in the United States come up for

relicensing, something that happens every fifty years, environmental groups are attempting to use this opportunity to challenge the operations of various dams. At the same time, dam owners and government agencies are seeking to expedite and simplify the process in order to complete it more quickly.

The State of Nature and the Nature of the State: Imperialism Challenged at Glen Canyon

By:
Kevin Wehr

Abstract

This paper investigates the ways in which the American government has built an infrastructure on the landscape of the American West, especially through the discursive construction of a particular nature-society relationship. This relationship is neither static nor uncontested—as it changes over time, different social groups are more and less able to effectively challenge the human domination of nature. I wish to situate this paper in relation to both discourses about nature ("the state of nature") and to processes of state building in the American West ("the nature of the state"). I examine briefly the social and historical context of the high dams in the West, specifically Boulder and Grand Coulee Dams, both built in the 1930s. I then discuss in more detail the rise of an effective oppositional discourse in the late 1950s, centered on the proposal of the Echo Park and Glen Canyon Dams. I argue that this period marked the end of the "golden years" of dam building, and that this episode represents a significant change in the relationship between society and nature. This change is marked by the rise of contestation around Glen Canyon Dam, but its emphasis is more on advocating a shift from a nature-society relationship based primarily on domination and economic-resource maximization to one based in part upon aesthetic and other forms of appreciation. This opposition at Glen Canyon was, I argue, a challenge and an opportunity for the Bureau of Reclamation. In the last 40 years the Bureau has neglected to take up this opportunity to improve its relations with nature and environmentalists, as shown in the rhetoric surrounding the Centennial celebration at Hoover Dam, in June of 2002.

Introduction

Most of the dams in the West were built during the Progressive Era and the New Deal, and consequently reflect an ideology of rational planning and state building based in a faith in scientific progress. State-sponsored infrastructure had myriad environmental and political effects, but the natural formations[1] that the state worked to overcome also had a profound influence on how society developed. Through an examination of the ways that nature, society, and the state have interacted with and mutually constructed one another, this paper will attempt an integration of political and environmental sociology.

The theoretical impetus for this paper is to illuminate the relationship between society and nature. The larger theoretical concerns are twofold. First, political and environmental sociology have contributed important insights towards understanding the ways that culture and politics are linked and the way that society and nature are linked, but rarely are these areas integrated. Through an examination of dams in the American West, this work makes sense of the ways that a central concern of political sociology—state-building—influences and is influenced by the nature-society relationship, which is a central concern of environmental sociology. Second, there were specific social and environmental effects of this state building that contributed to a nature-society relationship that dialectically changes over time. Since the natural environment is not simply a passive object that the state builds upon, historical discourse analysis can help integrate political and environmental sociology by contributing to the understanding of the ways that natural conditions helped and/or hindered state-building. This paper thus asks the specific question: what discursive methods were used to justify or contest the building of an economic and political infrastructure in response to the perceived water scarcity of the American West?

To address this question, this paper examines the discourse around three dams of the American West—Boulder, Grand Coulee, and Glen Canyon: how they were presented to the public by the state and how the public received them. The physical existence of the dams has no inherent meaning; rather, different social groups assign meaning to the dams. The ideology that gives support to the nature-society relationship that is based in domination is one that I, following James Scott, call high modernism. Scott's work, *Seeing Like a State*, argues that high modernism is a world-view in which the "strong version of the beliefs in scientific and technical progress that were associated with industrialization in Western Europe and in North America from roughly 1830 until World War I" was transcendent. Scott defines high modernism as a "supreme self-confidence about continued linear progress, the development of scientific and technical knowledge, the expansion of production, the rational design of social order, the growing satisfaction of human needs, and, not least, an increasing control over nature (including human nature) commensurate with scientific understanding of natural laws." (Scott, 1998: 89) In this paper I argue that the dams of the American West represent an important case study of high modernism. This high modernism that was so well-characterized by the proposal and construction of Boulder and Grand Coulee Dams, began to crumble in the 1950s. The rise of an environmentalist discourse allowed a successful contestation of the Echo Park and Split Mountain Dams in Dinosaur National Monument in Utah.

The Social and Historical Context: Boulder and Grand Coulee Dams

Intense battles marked the beginnings of the debates, actual construction, and even the dedication of Boulder Dam. First proposed by Mark Rose and the Imperial Irrigation District in 1911, the dam was fought over by western states, debated by farmers, power companies, media moguls, Congress, and Bureau of Reclamation engineers. Finally approved in 1928, and constructed from 1931-1935, Boulder Dam established the foundation for state-building discourses that were infused with the rhetoric of dominating nature and subordinating it to human ends. The Colorado River was variously described as a "tyrant," a "raging river," and a "natural menace." In order to overcome nature-imposed barriers, the Bureau of Reclamation, Congress, and several Presidents of the U.S. acted (sometimes in concert sometimes at cross-purposes) to convert the river to a "natural resource."

This conversion occurred as much through discursive deconstruction and reconstruction as it did through the actual building of the dam in the river. The discursive construction of the Colorado River as a natural resource contained elements of appreciation for nature as a productive force as well as a deprecation of nature as "red in tooth and claw." The discursive construction of the river also included strong elements of state-building rhetoric that characterized the river as a potentially useful resource, a key element in the building of an empire in the American West. Various social groups fought over how this empire was to be built—and who would benefit from the resources. Private capital battled for control of the electricity, local farmers and their Congressional delegates fought for water rights, and the many Depression Era jobless jockeyed for employment while union activists struggled to organize them. At Boulder Dam, the first of the high dams in the West, it was the state-sponsored plan that won out at Boulder:[2] the federal government would put forward the money and the design, private capital would contract to build the dam, power would be leased to private utility companies for distribution, and through several strikes and work actions the job site would remain non-unionized.

Boulder Dam inaugurated a golden age of dam building in the United States, dated loosely from 1930 through 1960. In his journalistic style, Marc Reisner called this time "the Go-Go years" (Reisner 1986), while the more academic Lawrence Lee calls it the "Second Phase of Reclamation" (Lee 1980). Boulder Dam started this period as the first high dam proposed and built explicitly for multiple purposes. The legal and technical groundwork established with Boulder Dam determined the course of the other large dams; similarly, the social and political maneuvering required to construct Boulder Dam informed the discourses around Grand Coulee and Glen Canyon.

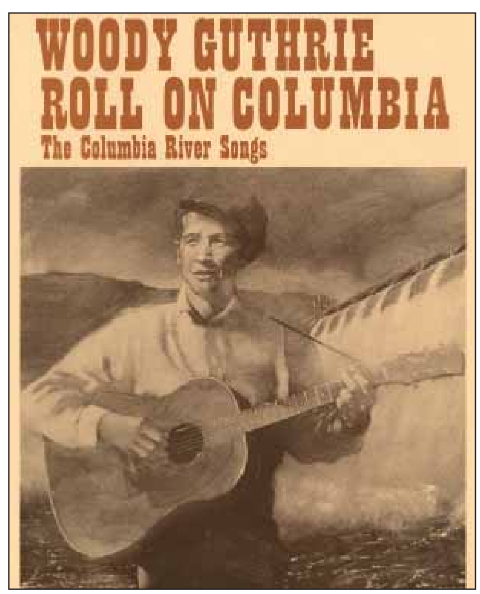
High dams in the West were also an outgrowth of the changing socio-political landscape. Beyond the geographical and physical variation (Grand Coulee in the Pacific Northwest versus Boulder and Glen Canyon in the southwestern desert), the dams differ in important respects in the discourse pertaining to their proposal and construction due to this differing social and political context. Different groups boosted or contested each project for different reasons. The discursive legitimation of the dams required different techniques in each area. Similarly, the solution to political problems of Boulder Dam would set a path for how later dams were negotiated.

Within the discourse around the proposal and construction of Grand Coulee Dam, we can hear the echoes of debates over Boulder. Begun just after Boulder Dam (1931-36), Grand Coulee (1933-41) benefited from popular confidence in such projects, a positive governmental climate towards public works, and technological achievements invented at Boulder. Built on the successful legal foundations of the Colorado River Compact and other enabling decisions, Grand Coulee was also completed by some of the same construction companies and many of the same workers who built Boulder. The continuities are certainly strong, but the contrasts are also important: local boosters, absent at Boulder, were key to the success of Grand Coulee Dam.

36.1. These U.S. Postage stamps of Boulder Dam (1935) and Grand Coulee Dam (1952) demonstrate the strong interest of the government in presenting these iconic structures to the American Public, among whom interest was high at the time.

The discourses at Grand Coulee are both competing and overlapping, but all were built on particular constructions of a nature-society relationship that enabled human domination of the Columbia River, exemplified in Woody Guthrie's lyrics "that wild and wasted stream." These discourses about nature were based in an ideology that helped construct the river as something to be dominated by humans. The river was seen as a wild entity—but one that could nonetheless be harnessed by human endeavor. High modernist discourses characterized much of these rhetorical styles used at Grand Coulee. The dam was part of an imperialist vision and was to be built by the federal government as part of a plan to settle and build up the West. These typical state building goals were, under a period of high modernism, implemented using the scientific and rational engineering techniques that would carry the region, and therefore the nation, along the linear path of progress.

The discourses around Grand Coulee Dam are important in two respects. First, as with Boulder, the lack of an oppositional discourse precluded the possibility that the dam would not be built. Second, the discourses also expose a set of constructions of nature and the nature-society relationship.

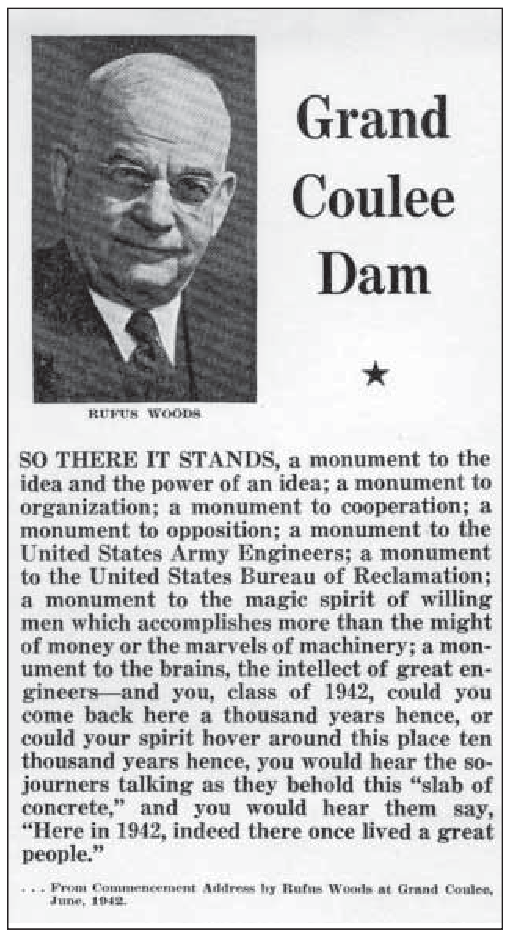


I call the discourses at Grand Coulee "imperialistic," following the terms used by the boosters themselves.[3] Imperialistic discourses justified the dam in terms of building an empire, extending civilization, and made special use of ideas such as manifest destiny. Different groups used this category differently: the national-level discussions were centered around a fairly pure imperialistic high-modernist discourse, while the local proponents fought over specific proposals for the dam using differing styles of imperialistic high modernist rhetoric and individualistic capitalist rhetoric. While the elite groups used an individualistic capitalist discourse that was suffused with the values of unfettered competition and a strong opposition to federal intervention, the local boosters argued from a high modernist perspective that valued the interventions of the state in building large-scale water systems that could not be achieved by local capital alone. It is worth noting that all of these discourses were in favor of *some form* of the dam, none were opposed to building the dam.

The discourses of the two main adversarial groups precluded any discussion of not building a dam. The competition between discourses was instead over who would build the dam and what it would look like. Not only did the state-sponsored, high-modernist plan win approval, but those who were opposed to a state-sponsored plan eventually backed it in order to get their part of the benefits. Even those one might imagine would protest the dam supported it. Local Indian tribes, whose land was inundated by the dam's reservoir, supported the dam due to the promise of water and hydropower benefits. Farmers, who faced competition if new lands were brought into production, supported the dam due to its cheap hydropower. Labor unions, a group that often opposed non-unionized public works, supported the project because of the need for jobs. Woody Guthrie, erstwhile opponent of government, church, and capitalism, supported the dam because of jobs, power, and irrigation. Like all hegemonic ideologies, high modernism was largely successful because it could absorb resistance and suppress dissent, but rhetorical techniques are not the only ways of co-opting dissent of course. Detractors were curbed in part by practical and political considerations.

As well as exposing the ability of high modernism to absorb resistance, the imperialistic discourses also expose a particular construction of a nature-society relationship. The rhetorical strategies employed at Grand Coulee by Rufus Woods, James O'Sullivan, and so many others portray nature in complex ways, but ways that always reveal an attitude of domination on the part of humans.

Woods, for example, declared that "Nature" was on the side of the pumping plan developers. Nature had provided the perfect location, and had even built a canal seemingly just for the purposes of the human inhabitants of the area. This


Grand Coulee Dam

★

RUFUS WOODS

SO THERE IT STANDS, a monument to the idea and the power of an idea; a monument to organization; a monument to cooperation; a monument to opposition; a monument to the United States Army Engineers; a monument to the United States Bureau of Reclamation; a monument to the magic spirit of willing men which accomplishes more than the might of money or the marvels of machinery; a monument to the brains, the intellect of great engineers—and you, class of 1942, could you come back here a thousand years hence, or could your spirit hover around this place ten thousand years hence, you would hear the sojourners talking as they behold this "slab of concrete," and you would hear them say, "Here in 1942, indeed there once lived a great people."

. . . From Commencement Address by Rufus Woods at Grand Coulee, June, 1942.

36.2. Rufus Woods was a tireless promoter of Grand Coulee Dam and the Columbia Basin Project.

characterization of nature points to the complexity of the nature-society relationship as understood by many of the proponents of Grand Coulee Dam. The dam was at once intended by nature, and yet the Columbia River was seen as a mighty force that was nearly impossible to subdue. Humans could harness the river, but it would take an awesome effort. Nature was clearly an active force in his plan: nature was capable of building canals, carving out a reservoir, and providing an ideal dam site. This characterization of nature points to the complexity of the nature-society relationship as understood by many of the proponents of Grand Coulee Dam. The dam was at once *intended* by nature and yet the Columbia River was seen as a mighty force that was nearly impossible to *subdue*. The gendered character of this relationship of domination is inescapable: it is almost as if nature is inviting humans (men) to subdue it (her).

Yet nature was also seen as wild, powerful, and a formidable opponent. Much of the imperialistic rhetoric was obsessed with describing the wild power of the river, albeit in terms of its potential. The river was characterized as the "wildest big stream in the civilized world," and the attempt to harness it would be nearly impossible, "a waste of time an' money." Thus nature was also an active force as well as one that invited humans to dominate it. What are we to make of this complexity and near contradiction? In part, it stems from the contradictory character of the discourses used: imperialism implies domination—both of nature and of other humans—while locals also tended to see their land as blessed by God, and the inhabitants (or immigrants) as a chosen people. Thus nature is simultaneously a resistant force that must be overcome as well as a beneficial force that helps humans toward their glory and destiny.

If the boosters of the dam manipulated interpretations of empirical facts regarding nature to make the dam seem blessed (or at least easy to build), then what does it matter whether nature is a positive or a negative force, whether imperialistic and Hebraic discourses are contradictory? This is to say, in the end the dams were built and most of the competing social groups came out ahead. If so, why did the competing discourses matter? These competing discourses were all self-interested. The imperialistic and Hebraic discourses were both heavily disposed towards a society-centered philosophy. In fact, there were no oppositional discourses that were not self-interested until the rise of the environmentalist discourse during the Glen Canyon debate. Until this powerful environmentalist discourse emerged, there was no apparent opposition, or at least no discursive grounds to root opposition in. Lacking this powerful discursive grounding, the ideology of high modernism was transcendent

Harnessing the Colorado: The Bureau's Grand Plan

In the late 1940s and early 1950s the Bureau of Reclamation built dams at an incredible pace throughout the West. Rivers by the hundreds were dammed for single and multiple purposes as the Bureau rode a wave of public and governmental approval. This golden age of dam building was overseen by Commissioners of

Reclamation Michael Strauss and Floyd Dominy, who pursued further construction with great zeal. One major aim of the Bureau was the total development of the upper and lower Colorado.

In 1946 the Bureau of Reclamation published its plans for this total development of the Colorado River. The ponderous title of the document conveys the enormity of its contents: *The Colorado River: A Comprehensive Report on the Development of the Water Resources of the Colorado River Basin for Irrigation, Power Production, and Other Beneficial Uses in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.* (Bureau of Reclamation 1946) This report reuses the label given to the Colorado 25 years before when Boulder Dam was proposed, the epigram printed on the cover of the report reads: "A natural menace becomes a national resource." This continuity in discourse is important. The Bureau, with its comprehensive report, was attempting to continue its successful development of the Colorado and the West through what had become standard rhetorical techniques. The discourses used at Boulder and Grand Coulee were unquestioningly reused to boost the Glen Canyon and Echo Park dams in the upper Colorado Basin project.[4]

The report outlined a total of 134 projects (including dams, canals, diversions, and pumping systems) in the upper and lower Colorado Basin, totaling $2,185,442,000. Included in these were proposals for dams at Echo Park, Split Mountain, and Glen Canyon. In the report, the Bureau outlines the justifications for such a massive series of projects:

> Future development of the water resources of the Colorado River Basin is needed to relieve economic distress in local areas, to stabilize highly developed agricultural areas, and to create opportunities for agricultural and industrial growth and expansion throughout the Colorado River Basin. (Bureau of Reclamation 1946: 21)

The Bureau used a typical rhetoric of economic progress to justify its proposals. It emphasized the industrial and agricultural growth that will be spurred by the projects, as well as the relief of local economic distress. Such arguments had become, by the late 1940's, standard techniques for legitimation. The Bureau's new projects, however, would be both bigger and, it argued, more beneficial.

For example, in their 1946 proposal, the Bureau claimed that the cost to benefit ratio was higher than 1.0. "These benefits indicate that a basin-wide plan for full development of the water resources could return to the Nation $1.30 for each dollar required to construct, maintain, and operate the projects" (ibid. 1946: 18).

And yet, the Bureau did identify some cause for hesitation. Through a careful reading of the document it is clear that the Bureau admits "there is not enough water available in the Colorado River system for full expansion of existing and authorized projects and for all potential projects outlined in the report" (ibid 1946: 21). So why did the Bureau propose them if there was not enough water?

The answer may be that the Bureau saw the Colorado River as teetering on the brink. With just a small ($2 billion) nudge, the Bureau could knock the Colorado into the realm of completely harnessed. The Bureau argued that:

> Yesterday the Colorado River was a natural menace. Unharnessed it tore through deserts, flooded fields, and ravaged villages. It drained the water from the mountains and plains, rushed it through sun-baked thirsty lands, and dumped it into the Pacific Ocean—a treasure lost forever. Man was on the defensive. He sat helplessly by to watch the Colorado River waste itself, or attempted in vain to halt its destruction (ibid. 1946: 25).

The Bureau here was engaged in the discursive construction of the river. The river was simultaneously a powerful actor ("a natural menace") and also an entity that was treasured as a potential economic resource. The justification based on an imperial modernist ideology of expansion and development by the federal state for the utilitarian benefit of all society was founded in such a rhetorical construction. It is no mistake that only "villages" populate the area through which this unharnessed resource travels. The state was interested in building up civilization in these areas—never mind that Los Angeles, San Diego, and Phoenix were already sprawling metropolises at the time.

Man was portrayed as defensive against the active river, but through courageous action, the river can be tamed:

> Today this mighty river is recognized as a national resource. It is a life-giver, a power producer, a great constructive force. Although only partly harnessed by Boulder Dam and other ingenious structures, the Colorado River is doing a gigantic job. Its water is providing opportunities for many new homes and for the growing of new crops that help to feed this nation and the world. Its power is lighting homes and cities and turning the wheels of industry. Its destructive floods are being reduced. Its muddy waters are being cleared for irrigation and other uses (ibid. 1946: 25).

The river had been tamed and transformed through the beneficent hand of the state. The Colorado now gave life rather than taking it. It had been put to work, had built new homes, gardens, and fields, contributing to national prosperity. The proper role of the river had been achieved, with a little help from humankind. And yet the job was not done, according to the Bureau.

The river was only partially harnessed. Given the terrific benefits gained already, what a shining future the river had before it:

> Tomorrow the Colorado River will be utilized to the very last drop. Its water will convert thousands of additional acres of sagebrush desert to flourishing farms and beautiful homes for servicemen, industrial workers, and native farmers who seek to build permanently in the West. Its terrifying energy will be harnessed completely to do an even bigger job in building bulwarks for peace. Here is a job so great in its possibilities that

> only a nation of free people have the vision to know that it can be done and that it must be done. The Colorado River is their heritage (ibid. 1946: 25).

In this amazing nationalistic passage, the Bureau claimed legitimacy for its state-building proposals through the great prosperity to be gained from further development. The 134 dams and canals in its proposal were labeled as the heritage of past Americans, those free frontiersmen who worked so hard to build upon the vision of manifest destiny. The Colorado River remained a "part of America's frontier" (ibid. 1946: 71), the inheritance of all Americans, whom the Bureau glowingly called "empire builders" (ibid. 1946: 45).

The Bureau's grand plan had many supporters; most prominent was the State of Arizona. Officials from Arizona used the same discourse of imperial modernism to boost Glen Canyon Dam. Arguing that although the dam was long overdue, it was required to bring development to their state. In April 1957, for example, *Desert Magazine* described the benefits to arise from Glen Canyon Dam, using similar rhetoric as the Bureau (Murbarger 1957):

> When man erects a mighty dam across the Colorado River at Glen Canyon . . . a new era will dawn. . . . A city will rise from the desert floor; new factories will turn their wheels with power from the impounded water.

The building of the dam was hailed as the start of a new era, one filled with prosperity for the population and industry. The article further boosted the dam with discussions of the benefits of recreation on the reservoir and the huge areas of shoreline that would be created by the lake for tourists to explore.

The Phoenix periodical *Action* published an article in its October 1957 issue boosting the dam, arguing that the long range benefits for Arizona were clear:

> No doubt about it, northern Arizona, particularly Flagstaff, will benefit from the building of the Glen Canyon Dam. Phoenix, because of its strategic position in the state's economic pie, will also benefit.

Arizona boosters focused on the economic benefits that the dam would produce, combined in part with flood control. The discourse they used to do so was strikingly similar to that of the imperial modernist discourse used at Boulder and Grand Coulee. Echoing the Bureau of Reclamation's recycling of a successful discourse, the Arizona supporters discursively constructed the river as an economic resource that was finally being developed so as to bring Arizona what was due.

In what appears to be an attempt to counter protests about the building of the dam, some periodicals engaged in discourse that constructed the area as a wasteland. In February of 1957 the magazine *Western Construction* argued that:

> The entire area is a vast expanse of wasteland, uninhabited except for a few ranchers on the northwest side of the river and scattered Indian families on a reservation to the southeast (McClellan 1957: 29).

In fact, the Navajo Nation Reservation (the largest in the U.S.) had thousands of inhabitants and one of the most developed rangeland economies of any reservation. The construction of the area as one that could easily be sacrificed can be seen as a response to the environmentalist discourse highlighted in the next section.

The Bureau of Reclamation and its allies in civil society recycled many of the rhetorical strategies that were successful in the 1920s and 1930s for boosters of the Boulder and Grand Coulee Dams. This state-building discourse combines legitimation through the interpretation of history (frontiersmen of vision who built a foundation for the future) with the rational application of science and technology to benefit all society (reduction of a flood menace, improvement of an economic resource). This combination allowed the discursive reconstruction of the Colorado River into a natural economic resource. The river was tamed and harnessed and put to work for society.

The only problem with this discourse was its overuse; the Bureau could have had no idea that this was reducing the efficacy of the discourse, for it had been so successful in the past. A new way of thinking about nature was growing in the American West, however, and its rise eclipsed the Bureau's dominance in western development.

Chanting down Echo Park

The environmentalist discourse used to oppose Echo Park and Split Mountain Dams in the 1950s was not actually new. It was a derivation of the nature-as-aesthetic-resource argument that John Muir unsuccessfully used from 1907 to 1913 in fighting the Hetch Hetchy Dam in California. In fact, elements of its expression can be seen in works that date back at least 120 years (Nash 1967/1982). John Muir was one of the first advocates of wilderness preservation in the Sierra Nevada Mountains of California and Nevada. His founding of the Sierra Club in 1892 was partially in response to the conversion of Yosemite State Park into the second National Park. As stated in a 1911 bulletin, the Club's goals were primarily to "take the lead in all matters involving the preservation of the wonderful natural scenery which California is so fortunate as to possess, and in calling the attention of the world to these wonders" (Sierra Club 1911).[5]

In 1908 these goals were threatened by the proposal of a dam in Hetch Hetchy Valley, adjacent to Yosemite Valley and partially within the Park boundaries. Muir led the battle to save Hetch Hetchy Valley, arguing in a 1908 letter to Sierra Club members that Yosemite and Hetch Hetchy held an "unrivalled aggregation of scenic features" and that it should be "preserved in pure wilderness for all time for the benefit of the entire nation" (Muir 1908). Muir argued that the government should respect the boundaries of Yosemite National Park, or else all such boundaries would be meaningless. In the end, Muir's battle was lost, and San Francisco built a dam for its municipal water supply in Hetch Hetchy Valley. But this oppositional discourse was resurrected forty years later by very group that Muir had founded—a discourse that placed inherent aesthetic value in nature.

The 1946 proposal by the Bureau of Reclamation to build a set of dams at Echo Park and Split Mountain, as part of the grand plan to develop the Upper Colorado River Basin, would back water into Dinosaur National Monument. Bernard DeVoto broke this story of a latter-day Hetch Hetchy in the 22 July 1950 issue of the *Saturday Evening Post*. From his regular *Harper's* column "The Easy Chair," DeVoto had denounced cattle barons and Bureau of Land Management grazing leases (Thomas 2000). DeVoto's article "Shall We Let Them Ruin Our National Parks?" was a similarly incendiary piece, full of fighting energy and inflammatory rhetoric. Under the large-font title, the piece opens with a mid-sized-font sentence in offset text asking, "Do you want these wild splendors kept intact for your kids to see? Then watch out for the Army Engineers and the Bureau of Reclamation—because right where the scenery is, that's where they want to build dams" (DeVoto 1950:17).

DeVoto challenges the democracy under which we ostensibly live:

> No one has asked the American people whether they want their sovereign rights, and those of their descendants, in their own publicly reserved beauty spots wiped out (ibid. 1950:17).

DeVoto's warning cry to Americans not to let the engineers of the Bureau perpetrate this crime against "unspoiled natural beauty" continued with an admonition: "No one can doubt that the public, if told all the facts and allowed to express its will, would vote to preserve the parks from any alteration now or in the future" (ibid. 1950:17).

DeVoto's muckraking article argues quite clearly that Americans would never choose to let this go forward, if only they knew. The piece is a bit disingenuous, for the Bureau engineers were not trying to pull the wool over anyone's eyes. They were in communication with the Park Service throughout the planning stages, and fully believed that the reservoirs represented a beneficial recreational opportunity for Americans. DeVoto, however, disagreed with this assessment. To DeVoto, the area was perfect as it was, and should not be altered in any way. If given all the facts, DeVoto argued, Americans would not support the project.

Amidst half-page photographs of Dinosaur National Monument, DeVoto goes on to describe the scenic quality of the area as well as the ruin that it will become. Though he never explicitly compares the Dinosaur case to Hetch Hetchy, DeVoto's article proved quite significant to groups like the Sierra Club. The

Reader's Digest reprinted the article later in 1950, and Martin Litton, reporter for the Los Angeles *Times*, wrote several articles exploring the case in more depth. It was this series of articles outlining the imposition on a wilderness area that caught the attention of David Brower, Executive Director of the Sierra Club (Litton 1992).

Brower took the lead in opposing the dam in Echo Park, seeing in the fight the possibility of redeeming Muir's loss at Hetch Hetchy nearly forty years before. Brower assembled a coalition of individuals and groups committed to keeping national parks and monuments free from development. He led the fight by coordinating a massive letter-writing campaign and helping to publish many pamphlets and several books. Among the many notable figures involved in the fight were wilderness photographers Eliot Porter and Ansel Adams, novelist Wallace Stegner, and publisher Alfred A. Knopf.

Brower was very concerned about the encroachment of a reservoir into a national monument, and he recruited Wallace Stegner to edit a book on the Dinosaur situation, in an attempt to bring national attention to the cause, to be published by Alfred K. Knopf (Thomas 2000: 164). *This Is Dinosaur: Echo Park Country and Its Magic Rivers* combined the writing talents of Stegner, Knopf, and several others with thirty-six striking photographs of the region, six of which took advantage of the new, and expensive, full-color printing technology. The book's aim was to introduce people to this little-visited area, and to convince them that it was worth saving.

Wallace Stegner's contribution discussed the history of the national monument, an "almost 'unspoiled'" wilderness area. With his deep understanding of the intertwining of human history and natural environment, Stegner notes that Dinosaur National Monument is a "palimpsest of human history, speculation, rumor, fantasy, ambition, science, controversy, and conflicting plans for use, and these human records so condition our responses to the place that they contain a good part of Dinosaur's meaning" (ibid. 1955: 3).

In describing the area, Stegner talks lovingly of "cliffs and sculptured forms [that] are sometimes smooth, sometimes fantastically craggy, always massive" that "have a peculiar capacity to excite the imagination; the effect on the human spirit is neither numbing or awesome, but warm and infinitely peaceful" (ibid. 1955: 4).

Stegner's call for wilderness protection came at a time when he was still relatively unknown as a writer. In 1955 his important early work *The Big Rock Candy Mountain* was ten years old, and he had just finished his nonfiction novel on John Wesley Powell's adventurous exploration of the Colorado, *Beyond the Hundredth Meridian*. His Pulitzer Prize winning novel *Angle of Repose* would not be written until fifteen years later. Stegner was taking a chance by being politically outspoken. He was, as Thomas argues, in some ways attempting to fill the role left empty by the death of his friend Bernard DeVoto in 1955 (Thomas 2000: 166). Alfred A. Knopf was, in many ways, taking a bigger chance.

Knopf published *This Is Dinosaur* and presumably put forward much of the capital needed for the expensive camera work. His chapter, entitled "The National Park Idea," argues forcefully for preservation of wilderness areas for both people and wildlife. The national park "is not a resort, though there will always be those who try to make it so. And the very special purposes of recreation, education, refreshment, and inspiration for which Parks and Monuments have been set aside prohibit many economic uses which are thoroughly legitimate elsewhere" (ibid. 1955: 85). Knopf argued that there were many other places where such economic purposes could be pursued, but that National Parks and Monuments had to be defended categorically and on general principle, or else all such areas would be threatened in the future.

After arguing philosophically for the preservation of Dinosaur National Monument, Knopf argued from logic. Such a threat is not just temporary, but permanent:

> If you flood a canyon, as it is proposed to flood the Dinosaur canyons with dams at Echo Park and Split Mountain, that canyon is gone forever, buried first under water and eventually under silt (ibid. 1955: 86-87).

Much of the piece is spent arguing against perceptions of the American public about the southwestern lands (exemplified in articles such as the one previously quoted from *Western Construction*). Knopf is at pains to point out that

> Dinosaur is not expendable wasteland, not a profitless desert, but a scenic resource of incalculable value that has been preserved this long precisely because of its inaccessibility. . . . Dinosaur deserves to be more visited. . . . That is all it would take, that democratic groundswell, to insure that Dinosaur and the other superlative places will be passed on, unimpaired, to our grandchildren's grandchildren (ibid. 1955: 93).

Knopf ends by calling on the legitimacy of history and the myth of democratic America. Americans are wise people, and can see value when it is shown to them. They deserve their heritage, and so do their grandchildren. This treasure can be saved through the use of our democratic powers to stop the tyrannical exercise of authority by a faceless bureaucratic agency.

Knopf and Stegner's book enjoyed quite a good reception. It is styled as a coffee-table book, and was sold all over the country through Knopf's powerful distribution channels. In combination with the massive letter-writing campaign that Brower organized through the Sierra Club, the Wilderness Society, and the Isaac Walton League, the fight for Dinosaur ranged from American's living rooms to Capitol Hill.

Brower initiated a storm of protest over the proposed dam at Echo Park, a key element of which was the flooding of the Department of Interior and Congressional Representatives with letters of outrage. Letters were addressed to President Eisenhower, Secretary of Interior Douglas McKay, and individual Senators and Representatives. Most letters were forwarded to the Secretary of Interior, who cataloged many of them, now collected at the National Archives and Records Administration. The catalog for 1954 contained a listing of 2,875 letters that the department received that year. The letters are signed by individuals writing as rangers, lawyers, citizens, or members of conservation groups. All of these letters exhibit some form of an environmentalist discourse, often combined with an economic argument, such as evaporation problems, cost-benefit arguments, and even the perception that hydropower was obsolete due to the expansion of atomic energy (perhaps a very un-environmental argument).

The environmentalist discourse that the proposed dam at Echo Park brought out was focused on the quality of the place in and of itself. The construction of the river canyon as an economic resource was resisted vociferously. Instead, the river, the canyon, and the entire area were discursively constructed as a natural and aesthetic resource that was of such value for recreation and inspiration that to destroy it for economic purposes would be a great evil.[6] Letter writers sounded this tone over and over, in many creative ways.

This environmentalist discourse was straightforwardly exemplified by Edward Thatcher of Eugene, Oregon (8 March 1954), who cited the "magnificent natural beauty" of Dinosaur National Monument. Thatcher argued that the proposed Echo Park Dam would inundate the "canyon scenery and rock formations incomparable in their value to citizens of this country."[7]

Russell D. Butcher of Millbrook, New York, spent a bit more time explicating his position. On 15 January 1955 Mr. Butcher wrote to the President, saying that he was "greatly disturbed" and that

> it is my belief that this country should protect its great parks from commercial and private developments. . . . I do not consider any one of these plans to be of great enough importance, or without perfectly good alternatives, to warrant a breaking away from park principles—of keeping them "intact and in their entirety for the enjoyment, education, and inspiration of all the people for all time." Also, because these park service areas comprise only about one-half of one per cent of the entire U.S., I truly believe that we should preserve them as a last remnant of the once vast primeval America. . . . It is merely opening the way for further encroachment upon other areas. It is very easy to visualize a slow eating away of the park system, as one by one they are opened up to commercial interests. I believe therefore, that we should start thinking about this problem now before we suddenly find ourselves without any of these fine parks; that we should pass them on to the next generations, unspoiled.

Vera Moran, of Santa Rosa, California, was not nearly as congenial and circumspect as many writers. Ms. Moran wrote to Secretary McKay saying:

> Those who want to benefit themselves by stealing public resources—
> whether forests, parks, national monuments-or however derogated—are
> Public Enemies
> Of the United States
> When they get through with it, America the Beautiful will no longer be
> beautiful—it will be stripped and stark.
> . . . protect the public and public interests by saying to these predators and
> public enemies:
> Keep Out!!

Such arguments about the splendid beauty of Dinosaur were clearly heart-felt. Many writers went even further in their claims about the uniqueness of the area. A. Weston Niemela, of the Chemketan Conservation Committee, a conservation group within the Oregon Indian tribe, wrote on 5 March 1955 that "Many of us in the Chemeketans have been to the Monument and can testify to its unique beauty; as an area of recreational and spiritual value it could never be replaced." In the nuanced version of the Chemeketans discourse, the uniqueness of this area in terms of its beauty and recreational qualities is combined with a spiritual element. The spiritual aspect of their discourse makes a larger set of claims that evokes John Muir's idea of nature as a cathedral for worship: inundation equals desecration.

On 28 April 1955 Eleanor Roosevelt Elkott, of Birmingham, Michigan, wrote to the President, saying

> The United States is a big country. The citizens derive spiritual and moral strength from their land—touring, camping, fishing, golfing. It is not fair for citizens who believe in freedom and democracy to be overuled [sic] by men sitting in offices who want to make money. . . . We must not build Echo Park Dam.

Her association of golfing with spirituality not withstanding, Ms. Elkott makes a case that was echoed by many writers.

The preservationist argument tended to be a popular environmentalist discourse that cited the spiritual, recreational, and inspirational qualities of wilderness in general and the American Southwest in particular. The letter writers intensely resisted the construction of the Monument as a wasteland or as an economic resource. Instead, they saw the canyons and the rivers as an incomparable aesthetic resource that should not be squandered in the name of progress and economic development.

In the face of nearly 3,000 letters, Secretary McKay could respond only with a formula letter, citing the complexity of the situation. He acknowledged the "vexing situation" and its complex of contested views and interests. His position, though, in the face of this first wave of letters remained steadfast. It would take a larger coordination of national groups to sway him. In combination with published books and letter-writing campaigns, the Sierra Club, the Wilderness Society, and the National Park Association, continually published updates and excoriations of the Department of the Interior, the President, and the Bureau of Reclamation in their house organs: *Sierra Club Bulletin, Living Wilderness*, and *National Parks Magazine.*

Starting in 1954 and continuing without abatement for a full year, in its *Bulletin* the Sierra Club published articles, editorials, and photographs of Dinosaur National Monument. The Sierra Club argued unrelentingly against the dam at Echo Park, discursively constructing the river as a natural aesthetic resource worth saving.

The Sierra Club called members to action with direct textual requests and by the presentation of images. The cover of the February 1954 issue of the *Sierra Club Bulletin* carried an image of the Yampa River as it flowed through an area called Rainbow Recess in Dinosaur National Monument. Underneath was the headline in large font "Trouble in Dinosaur" and some short text describing the

> primitive paradise unequalled anywhere . . . a unique gem of the National Park System . . . are needlessly threatened. You can prevent the destruction. Men of vision saved this place for us. Now it's turnabout.

Underneath this text reads a large, underlined font "URGENT: Please read this issue now—and lend a hand."

The Wilderness Society, in a coordinated effort, sent the February 1954 issue of the *Sierra Club Bulletin* to their members with an additional message on the cover: "The Wilderness Society sends you this issue to stress the urgent need to act promptly." The lead article in this issue is entitled "Two Wasteful Dams—Or a Great National Park?" and argued forcefully against the need for them, contrasting this with the great inherent value of the place itself. Highlighting the aesthetic value of the area, the article quoted the National Park Service in saying that "the effects upon 'irreplaceable … values of national significance would be deplorable'" (Sierra Club 1954: 3). The article continued by arguing that there were alternative sites, that the Secretary of Agriculture is currently worried about surpluses, and most importantly, that the "proposed Echo Park and Split Mountain dams would destroy the park value of Dinosaur; the unique would give way to the commonplace and would imperil the entire Park System" (ibid. 1954: 4). To the argument that the reservoirs would make the area more accessible to tourists, the author responded by pointing out that this would be true: "you can look at part of the setting [the highest 100 feet of exposed canyon]—after we've lost the priceless gem" (ibid. 1954: 4). The discourse used to defend Echo Park and Dinosaur National Monument continually reverted to a defense of the "priceless" aesthetic quality of the place. Nature, the Sierra Club argued, was irreplaceable, while the reservoirs had plausible alternatives.

The National Park Service, in an extraordinary conflict within the Department of Interior, fought strenuously against the Bureau of Reclamation plans for Dinosaur National Monument, dovetailing its arguments with the Sierra Club and the Wilderness Society. Though much of this conflict remained hidden from public view, some of it was apparent, and the results of the conflict can be seen in the subsequent restructuring of the National Park Service after the decision to drop the Echo Park and Split Mountain Dams.

Early in the process of developing the grand plan of the Bureau of Reclamation, the National Park Service appears not to have been concerned with the encroachment on the Monument that would occur due to the building of the two dams in Utah. In fact, a "memorandum of understanding" between the Bureau of Reclamation and the National Park Service, dated 4 November 1941, indicated that the "The Dinosaur National Monument region and its water control possibilities" is a most vital area for study.[8] Furthermore, "concerning the Dinosaur National Monument region, it seems not improbable that a policy similar to that already agreed to in principle for the Grand Canyon National Monument situation could be applied. Although legislation would be required in both cases to effect this policy, i.e., change the status of the areas from monument to recreational areas, the National Park Service does not believe such legislation would be difficult to secure." This change in status would allow development; a recreational area is a lesser category that does not limit usage the way that a National Park or Monument does.

Even through January of 1954, just before the Sierra Club issued its call to action, the Park Service was still interested in budgetary allocations from the Department of Interior so as to improve the section where the reservoirs would be located. In an internal memorandum, the Park Service estimated a cost of $21,000,000 needed to improve the recreational facilities, including boating and swimming.

The Park Service was interested, no doubt, in making the best of a situation. At this point, the Secretary of Interior and the President were both set on moving forward with the Bureau's plans. In the face of this apparent juggernaut, the Park Service could at least capitalize on these plans by making the area accessible and developing it for maximum tourism.

Between 1949 and 1954, however, factions within the Park Service became more and more concerned about the precedent set at Dinosaur. Other Reclamation projects were being designed in or near National Parks or Monuments in Kings Canyon (California), Glacier Park (Montana), and the Grand Canyon (Arizona). Some Park Service officials feared a continuing loss of power vis-à-vis the Bureau of Reclamation. Reclamation already had a budget of more than five times the Park Service, and some Park officials worried that increasing their budget to develop recreational opportunities would not be worth the trade off of the precedent of inundating part of the Monument (Stratton and Sorotkin 1955).

As early as 1949 the conflict within the Park Service was apparent in some memorandums circulated inside the Service and even forwarded to the Secretary of Interior. One such memo stated outright that the Monument's "preservation in its natural state represents its highest use" (Stratton and Sorotkin 1955: 70). The Bureau and the Park Service continued attempts to balance their conflicting interests, and contradictory memos such as the 1949 and 1954 examples above must be seen in this light: they represent negotiations between several interest groups within the Department of Interior.

Just how much rancor existed between the Bureau and the Service is apparent in the accusations that the Park Service was behind the publication of Bernard De Voto's July 1950 article in the *Saturday Evening Post*. Michael Straus, then Commissioner of Reclamation, wrote to Newton Drury, Director of the Park Service, asking where DeVoto had gotten the photos for his article, as they were attributed to the Park Service.

These internal confrontations and accusations destabilized the Department of Interior and to some extent allowed Park Service personnel to coordinate with outside groups such as the Sierra Club and the Wilderness Society. For example, Park Service Director Drury wrote to a conservationist organization, regarding the Park Service's correspondence with the Bureau of Reclamation. This continued information exchange between the two agencies would, Drury hoped, "enable us to alert the conservationists of the Nation and more effectively with respect to remaining threats to national park areas from dam building" (Stratton and Sorotkin 1955: 76).

In 1953, just before the public controversy exploded, some members of the Park Service also took a long-term view of this controversy. Commenting in a private correspondence that the conflict could actually improve the state of conservation movement in the United States, one official wrote "I'm beginning to think the dam controversy will prove a good thing in the long run." The recipient replied: "I believe it has done more to bring the various conservation groups together than anything I can remember" (Stratton and Sorotkin 1955: 75). This assessment of the national situation was indeed accurate, perhaps even more so than the writer imagined. For in the next two years the public outcry took the shape of an oppositional discourse, in part defined by the National Park Service's defense of its preserved lands.

The National Park Service had a public sphere group that advocated for protection and expansion of the Park System: the National Parks Association. In their quarterly periodical National Parks Magazine, rangers and officials of the National Park Service joined citizens and activists in writing about the "incomparable" loss that the Park System would suffer from the dam project, making them "useless for monument purposes" (National Parks Association 1954: 3).

The *National Parks Magazine* used the same environmental discourse as the Sierra Club and the Wilderness Society, with the additional legitimacy provided by the liberal inclusion of national and state park officials' statements, as well as pro-development voices, such as the Manager of Winter Park, Colorado, Stephen J. Bradley. Bradley wrote of his visit to Dinosaur National Monument in the April 1954 issue of *National Parks Magazine*, that "we were in a scenic area, the like of which for sheer dramatic beauty—of color, form, movement and sound—I had never experienced anywhere, and I have visited one-third of our National Parks." The discursive construction of the river canyons as an aesthetic treasure worth preserving was thus propounded from many sides, public and private.

In addition to their monthly publications and organizing efforts, the Sierra Club also internally distributed several policy manuals, guides for political action, and a "Public Relations Primer," with "how-to" procedures for contacting the press, making speeches, etc. (Sierra Club 1957).

One section of this primer, entitled "misconceptions frequently encountered" lists a specific suggestion for responding to challenges such as "The Sierra Club opposes progress; it is always opposing dams and roads." Readers were directed to respond with

> The Sierra Club does not blindly oppose progress, it opposes blind progress. It opposes dams when it is proposed to build them in, or where they will affect, dedicated scenic wilderness and wildlife areas, especially when alternatives exist" (Sierra Club 1957: 9).

Such clear training of its members helped the Sierra Club effectively oppose the dams at Echo Park and Split Mountain.

Unity of message, along with the many variants offered by members and affiliates in their letters to government officials, helped convince Secretary of the Interior Douglas McKay to drop the dams that would flood portions of Dinosaur National Monument. In late November of 1955 McKay announced his decision not to build the dams.

36.3. Douglas McKay, Secretary of the Interior during the term of Dwight D. Eisenhower.

Regarding the victory, David Brower noted in his diaries on 1 December 1955: "Recent events prove that people really believe in preserving portions of America's original beauty—and that the strength of their belief shapes policy." The victory, for David Brower, was sweet. It certainly confirmed that Americans could exercise some form of direct democracy, and that enough of them believed strongly in preservation to sway the government. In short, he was witnessing the birth of a powerful new discourse—one that would electrify the environmental movements in the United States. It would, however, turn out to be a hollow victory for the Sierra Club and environmental organizations in general, and even a personal defeat of great significance to Brower. In order to remove the dams at Dinosaur, the Sierra Club was essentially locked into not protesting the great storage dam at Glen Canyon. Though the oppositional discourse at Echo Park focused on keeping Dinosaur as a Monument in order to preserve the wilderness area, the victory was won in part by showing how other aspects of the upper Colorado Basin development plan could substitute for the Echo Park and Split Mountain projects. In a letter to Secretary McKay on 20 May 1955, David Brower asked about increasing Glen Canyon Dam by 35 feet, pointing out that this could offset the loss of Echo Park and Split Mountain: "Would it be physically possible to substitute for some of this storage? …by adding 35 feet to the present 700-foot height planned for the Glen Canyon Dam."

Through this strategy, Brower and the Sierra Club effectively shut themselves out of protesting Glen Canyon Dam. Many accounts at the time describe this as an agreement or a trade off, but there is little evidence of any formal pact. Instead, the Sierra Club had made a political mistake in granting the legitimacy of the Glen Canyon site and the upper Colorado project as a whole by suggesting raising the Glen Canyon Dam's crest height to offset the loss of Echo Park and Split Mountain. As Luna Leopold commented to Stegner and Brower: "if the Sierra Club gets into the problem of suggesting alternatives for Echo Park and Split Mountain Dam you are going to let yourself wide open" (Thomas 2000: 174). By granting this legitimacy the Sierra Club could hardly fight Glen Canyon Dam.

The Glen Canyon Compromise: *The Place No One Knew*

The victory at Echo Park was based on Brower's own presentation to Congress, where he made the explicit comparison to Hetch Hetchy, and told the Representatives not to make the same mistake twice. He also went on to show how Bureau engineers had failed in their math. Brower pointed out that the Glen Canyon Dam could be raised in height to increase capacity and thereby make up the loss of storage at Echo Park. The Bureau could thus back down on Echo Park while saving its upper Colorado development plan. It was a Faustian bargain for the Sierra Club though, as Brower soon understood, for Glen Canyon was an astoundingly beautiful place that few people knew about.

Glen Canyon was so remote from Anglo society—there were several rough roads to it in the Navajo Reservation to the south, but none leading to the river from the north—that it was virtually unknown even halfway into the twentieth century.

It was in this "place that no one knew" that Glen Canyon Dam was built, begun in 1956 and finished in 1964. The Sierra Club mourned the loss with several publications, most notable the coffee-table book of Eliot Porter photographs published by the organization and edited by David Brower, *The Place No One Knew* (Porter 1963). In the Foreword to the book, Brower helped to entrench the environmentalist discourse that constructed the river and its immediate environs as a remarkable natural aesthetic resource:

> Glen Canyon died in 1963 and I was partly responsible for its needless death. So were you. Neither you nor I, nor anyone else, knew it well enough to insist that at all costs it should endure. When we began to find out it was too late (ibid. 1963: 7).

The building of a dam is equated with river death, and Brower admits culpability. After Secretary McKay's decision was made to remove Echo Park from development in favor of increasing Glen Canyon Dam's height, Brower went on several trips down that stretch of the Colorado, and described the area as some of the most magnificent scenery he had ever seen. Porter's camera recorded the beauty for other Americans to see.

Eliot Porter wrote much of the text that accompanied his photographs. When combined with the images, his words repudiate the discursive construction of the river as a "menace" by the Bureau. The river is characterized as "serene" and "overwhelming:"

> The eye is numbed by the vastness and magnificence, and passes over the fine details, ignoring them in a defense against surfeit. The big features, the massive walls and towers, the shimmering vistas, the enveloping light, are all hypnotizing, shutting out awareness of the particular (ibid. 1963).

The superlatives in his text are easily matched by the photographs, printed in stunning clarity and color. Porter's images linger on the general features for only the first moments and are soon caught up in the finer details that were originally overlooked. The photographer turns from the wide-angle to the macro close-up and an intimacy of the canyon becomes apparent.

Porter continually moves between the macro and the micro in his text and his photographs. He records what this "place that no one knew" was like before it was inundated. The larger picture that emerges from the collection of images and text is that of a tremendous aesthetic asset that has been lost. The work argued forcefully, if indirectly, against the discursive construction of the river as a menace, a tyrant, or an agent of chaos.

Another author who experienced the river before the dam was put into place was Edward Abbey. The book that brought fame to Abbey was *Desert Solitaire*, which contains a chapter called "Down the River." This piece describes Abbey's raft trip through Glen Canyon all the way to the site of the dam, just as the foundation was being poured. It opens with Abbey's characteristic acerbity:

> The beavers had to go and build another goddamned dam on the Colorado. Not satisfied with the enormous silt trap and evaporation tank called Lake Mead (back of Boulder Dam) they have created another even bigger, even more destructive, in Glen Canyon (ibid. 1968: 173).

Abbey's chapter continues on, using corrosive sarcasm, to belittle the Bureau of Reclamation and the federal government in general. In the midst of this rant, Abbey finds time to describe the scenery in the canyon, which will be submerged under 400 feet of water in a matter of months: "white sands," "green willows," "a sculptured landscape."

The Navajo Indians also bore witness to the damming of Glen Canyon. The Navajos were not politically well organized in the mid-1950s. They had recently suffered a great deal of hardship due to Bureau of Indian Affairs herd reduction programs in the late 1930s (White 1983: 313). This social disarray led to an official, but essentially meaningless, approval of Glen Canyon Dam by the Navajo Tribal Council. The Council, a group that was formed at the behest of the Bureau of Indian Affairs to handle the sale and leasing of rich oil lands on the reservation in 1927, had very little legitimate governing power over the diverse and widespread peoples of the reservation. They did, however, pass motions approving proposals from the Bureau of Indian Affairs (such as herd reductions) and the Bureau of Reclamation (Glen Canyon Dam). Raymond Nakai, the Chairman of the Tribal Council at the time that the dam was built, said "A conservationist is one who is content to stand still forever. Major Powell would have approved of this lake. May it ever be brimmin' full" (McPhee 1971: 196).

Nakai's comments notwithstanding, many Navajos did not approve of the dam, though little of this contestation made it into the historical record. There was significant disagreement about the benefits that would flow to the Navajo. There were many who, gesturing to history, asked what the Navajo had ever seen of other promises made by the government. Others believed the Bureau of Reclamation promises of hydropower and irrigation water (John 2000). In the end, the dam was built, based in part on the approval of the Tribal Council. The Navajo have, forty years later, not received any benefits from the dam aside from increased tourism in the area.

Though Abbey and the Navajos did not directly attack the Bureau's discourse, Brower, in the Foreword to *The Place No One Knew*, did argue against the discursive construction of the Colorado as an economic resource:

> Good men, who have plans for the Colorado River whereby "a natural menace becomes a natural resource," would argue tirelessly that the Colorado must be controlled, that its energy should be tapped and sold to finance agricultural development in the arid West. But our point here is that for all their good intentions these men had too insular a notion of what man's relation to his environment should be, and it is tragic that their insularity was heeded. The natural Colorado—what is left of it—is a

> miracle, not a menace. The menace is more likely the notion that growth and progress are the same, and that the gross national product is the measure of the good life (ibid. 1963: 7-8).

Brower met the Bureau's arguments head-on. The river was not, Brower contended, a menace. The menace instead was that constellation of forces that push for what Brower called "blind progress"—those that rate value only by economic measures. Brower clearly showed his bitterness in this work: his comments regarding "what is left of" the river, the selling of energy to finance agriculture, the argument for storage that Brower asserts is "absolutely not needed in this century, almost certainly not needed in the next" (ibid. 1963: 7).

In the years to come, Brower and the Sierra Club would indeed have occasion to wage battle against the Bureau's developmentalist mindset. They fought hard to lower the storage level of Glen Canyon so as to avoid the inundation of Rainbow Bridge National Monument. The original height of Glen Canyon Dam was to be 580 feet, but with the compromise it was raised to 730 feet. When it was found that this would bring the water level to the base of Rainbow Bridge, one of the natural wonders of the world, the Sierra Club lobbied for protection. Many schemes were put forward, including a check dam below Rainbow Bridge to keep the reservoir water out. Eventually the Bureau accepted a proposal to keep the water level of the reservoir at 3700 feet above sea level, and to build the dam to just 710 feet high.

The Sierra Club's loss at Glen Canyon may have been a high price to pay, but the failure in many ways galvanized the new environmentalist discourse in the United States. Since the building of Glen Canyon Dam no more high dams have been built in the U.S. The Sierra Club was successful in stopping several more dams on the Colorado, including two in Grand Canyon. The Club has continued to grow in strength and purpose over the nearly four decades since the "death of Glen Canyon." In 1993 the Club attempted to avenge its loss of Glen Canyon by helping to write legislation to breach the dam and restore Glen Canyon. The legislation remains stalled, but the discourse continues to be a powerful force in America.

Conclusion: Challenging Imperialism and Avoiding the Challenge of Environmentalism

Through the struggle to save Dinosaur National Monument, and in the mourning of Glen Canyon, a new oppositional discourse became established. This oppositional discourse, which I have labeled environmentalist, constructed nature as a priceless treasure that needed to be protected from blind progress. Drawing on the lessons learned from Muir's failed Hetch Hetchy battle, activists successfully fought against the intrusion into the National Park System by the Bureau of Reclamation. They were able to discursively reconstruct a river—as an entity that had value in and of itself, not simply something that could be economically beneficial to society.

In a dramatic shift from the lack of oppositional discourses regarding the proposal of Boulder and Grand Coulee, a powerful new discourse was born in the struggle over the proposal of Echo Park and the building of Glen Canyon Dam. This discourse highlighted an inherent value that existed in nature and wilderness, a value that was worthy of preservation over exploitation.

This shift in the valuation of nature points to a larger transformation of the relationship between nature and society. This transformation is certainly something that is in process, unevenly completed, and perhaps will never be as hegemonic as imperial modernism was. This new view of the nature-society relationship, a view based on preservation and inherent natural value, has destabilized the hegemonic imperial modernist ideology. In offering an effectual foundation for oppositional discourse, the environmentalist ideology has stopped the damming of the rivers of the West, and forced society to re-examine its relationship to growth, natural resources, and state building.

Some commentators have identified the Echo Park-Glen Canyon episode as a significant moment of the development of environmentalism in the late twentieth century. Though the discourses used were not new, they were mobilized on a massive level and in an effective way for the first time. Gottlieb (1993: 41) notes the historic significance of this battle over wilderness in his book on the origins of the modern environmental movement, and Mark Harvey (1994) picks out Echo Park as a "symbol of wilderness" that was "a great test to the sanctity of the park system." (Harvey 1994: xiv) Though the use of the singular "movement" by Gottlieb should be questioned, the importance of Echo Park and Glen Canyon for the set of environmental movements that have blossomed in the last 40 years is clear.

The imperialistic modernist discourse about the domination of nature and the building of a state infrastructure in the West was transcendent from at least the early 1920s through the middle 1950s. This hegemonic discourse brought together aspects of state building and the domination of nature (control of nature, control of the population, and the boosting of economic development) into a monolithic discourse that defined the relationship between nature and society. With the rise of an oppositional discourse at Echo Park and Glen Canyon, this hegemony was first successfully contested.

The emergence of an oppositional discourse can be seen as both a challenge to the Bureau of Reclamation (surely this is how David Brower and Floyd Dominy saw it), but it can also be viewed as an opportunity. The Bureau of Reclamation could have picked up on this new and powerful social movement and taken its concerns to heart. Indeed, there has been some change within the Bureau, but the Bureau has hardly "gone green," and could embrace environmental ideas to a much larger extent than it has.

Instead, the Bureau still uses the old rhetoric of imperialism and triumph rather than absorbing the environmentalist concerns. At the Centennial celebration in June 2002, the several official speakers continued the tone of imperialistic discourse that was used through the middle of the twentieth century. The Commissioner of Reclamation declared that "stability, progress and development" are the cornerstones for the Bureau's next 100 years. John Keys continued, relying on notions of nationalism, declaring that "the sounds coming from the generators are the sound of freedom."

The Secretary of the Interior kept up the beating of the drum, declaring that "we can do it before and can do it again." Just what it is that the Bureau will do remains to be seen. But it seems clear that what it has not done is take to heart the challenges of the environmental movements of the last forty years. The Bureau remains stuck in a discourse of imperialism, and it risks losing legitimacy in the eyes of those who need it most: the people of the West.

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Endnotes

1. Throughout this work I will use the term natural to indicate non-human processes, entities, or characteristics. I counterpoise this to the term social, which exclusively involves human endeavor. As I will discuss, however, these two realms *are* thoroughly imbricated in one another through history and historical recollection and reconstruction. Thus, natural formations such as climate, geography, or soil composition, should be differentiated from social barriers such as the ways that humans respond to nature in the built environment. For example what is normally construed as a "natural disaster" such as a flood destroying a town is more appropriately termed a "social disaster," for it was social decision to place a community in a flood plain.
2. Black Canyon is the name of the site where Boulder Dam was built. The name of the dam is after the original site, Boulder Canyon, slightly upstream from Black Canyon. In his 1922 report to Congress, Arthur Powell Davis, Commissioner of Reclamation, suggested a dam "at or near the vicinity of Boulder Canyon." (Bureau of Reclamation, Albert B. Fall 1922: 21) Thus in 1928 Congress passed the Boulder Canyon Act, and the project was officially named after Boulder Canyon even though Black Canyon was ultimately chosen as a more appropriate site for the high dam. The name was eventually changed to Hoover Dam by an act of Congress in 1947.
3. The boosters of Grand Coulee Dam published many pamphlets and bulletins, gave speeches, and wrote letters to officials. The many documents drawn on for this work are contained in the National Archives and Records Administration, Denver, RG115, Central Classified Files, Entry 3, boxes 228-325, and in the archives at the University of Washington. For more detail, see Wehr, 2004. All quotations in the following section are drawn from these sources.
4. This is officially known as the Colorado River Storage Project (CRSP).
5. Letters and pamphlets held in the Sierra Club Collection, Bancroft Library, University of California, Berkeley (Sierra Club 1911-1970).
6. The idea of the river as an "economic resource" as opposed to a "natural" and "aesthetic" resource is a false dichotomy. Activists constructed this binary so as to fight the economic logic of using the river for society's ends. But what they did not recognize (or chose not to make explicit) was that the aesthetic use of the river is just as anthropocentric as an economic use, though it may be more sustainable. Activists did use some rhetoric about the qualities of the river in and of itself, this was largely understood to be a benefit for humanity in terms of recreation, spiritual regeneration, or simply aesthetic pleasure. As Cronon (1996) has shown, wilderness is a human creation, a mirror that reflects "our own unexamined longings and desires."

7. All letters quoted in this section are held by the National Archives and Record Administration, College Park, Maryland, Record Group 48, Central Classified Files, entry number 4-4; boxes 360-64.

8. This memorandum is held by the National Archives and Record Administration, College Park, Maryland, Record Group 48, Central Classified Files, entry number 4-4; box 363.

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Writing Water in the West: Reclaiming the Language of Reclamation

By:
Nancy Cook

My essay examines the language used to write about water in the West. In this piece, I begin an analysis of discourses about water: official language vs. literary language, bureaucratic narrative vs. personal narrative, scientific language vs. quotidian language, wet vs. dry texts. Through the use of an extended "glossary," I work to include western American writers as integral to the conversation about the role of water issues in the West. The Bureau of Reclamation (USBR) has materially changed the face of the West; yet it has just as certainly changed the language of water in the West. Within the context of the USBR's history, I argue that the languages we use to talk about, write about, and analyze water in the West are critical components of the water actions taken. How we say what we say about water is integral to how we think about water and what we do about it. I claim that creative writers engage water in a way that is crucial to public policy decisions, and that richer, more dynamic, and more deeply critical conversations must take place as we face yet another period of hydraulic crisis in the western United States.

The glossary works to bring various discourses into play with one another, demonstrating that first we need an adequate hydraulic language before any substantive analysis and change can take place. Throughout my essay, I employ official discourse from sources such as Bureau of Reclamation and the United States Geological Survey; the discourse of personal narrative and poetry from such writers as Wallace Stegner, William Kittredge, Richard Hugo, and Ripley Schemm; as well as my own observations. Bureaucratic discourse often operates like an aircraft carrier turning at sea: it takes a long time to alter its course. Creative discourses, however, respond quickly and sometimes subtly to changes in an author's experience, as Ivan Doig, Stegner, and others have so elegantly shown us. These more intimate voices can articulate the local, the personal, and the private, offering readers deeply-placed stories that render the complexity and dynamism of water-use issues in the West. Rather than the exclusively urban, polemicist, or public policy voices so often heard in discussions of Western water issues, these are the voices from the West's outback: experienced on the land, observant of change, and cognizant of the myriad effects one simple alteration of water policy can create.

Each of the writers I engage here resists simple binaries, inflated rhetoric, and the pyrotechnics associated with other western writers such as Edward Abbey. While Abbey's work remains popular and important, I think we can learn more about the history of federal land and water-use policy, about water in the West, and about creative solutions from the more measured voices among western writers.

Issues of public vs. private have vexed both policy makers and western writers for decades, and the friction between them is nowhere more apparent than in the discourse of water rights. The arid West has more public land than any other part of the United States, while at the same time, private property rights have been defended most vigorously in the West. And more than any official cost-benefit analysis, creative juxtaposition of the language of water reveals other parameters of any cost-benefit analysis. My essay asks that we try putting varied discourses into conversation, creating new ways of thinking about aridity, about public and private, about rights and responsibilities as we manage a dynamic and complicated set of hydraulic systems.

Plenty of people have claimed that aridity is the great fact of the American West—John Wesley Powell, Walter Prescott Webb, and Wallace Stegner, immediately come to mind. What happens if we look at the West, and western writing using discourses of water as our lens? Instead of close readings of literary texts, here I offer a glossary, maybe even a primer, of water and words in the West. Stegner, among many others, suggests that humans, like other species, are conditioned by climate and geography. What's western about westerners? For the moment, let's imagine it's our relationship to water and its words.

Ablation:

1. "The process by which ice and snow waste away owing to melting and evaporation" (USGS website).[1] 2. Look up in June from any of a thousand parched valleys, and imagine the gift of iciness. Look up again in July from the same task and the same valley, and your dreams have evaporated. It's easier to imagine evaporation than melting, for your sweat has dried, leaving a salt line that marks your labor as clearly as the snowline retreats, recoiling from your parched and thirsty glare.[2]

Acre-foot.

1. "A unit for measuring the volume of water, is equal to the quantity of water required to cover 1 acre to a depth of 1 foot and is equal to 43,560 cubic feet or 325,851 gallons. The term is commonly used in measuring volumes of water used or stored" (USGS website). 2. How many acre-feet for Las Vegas golf courses, fountains, the lushness of even the median strips in San Diego, alfalfa crops, water slides, swimming pools, restaurant water glasses, full flushes, long showers, head lettuce, clean towels, car washes? Who uses more water, one of William Kittredge's eastern Oregon buckaroos, or the actor who plays the cowboy on screen?
3. After the movie people leave our ranch in New Mexico, the wind takes the porta potties and knocks them down, spilling life-giving moisture and death-dealing disinfectant onto the parched earth. Math teaser: How many twelve-ounce plastic bottles, half full of water from France, rolling with the winds, taunting jackrabbit and coyote alike, does it take to cover one acre in one foot of water?

Arid.

1. "A term describing a climate or region in which precipitation is so deficient in quantity or occurs so infrequently that intensive agricultural production is not possible without irrigation" (USBR website).[3] 2. The defining fact of the inter-mountain West. Perpetually in the rain shadow. When I hang clothes on the line, they snap in the wind and are nearly dry before I finish hanging them. The downpour of yesterday is invisible today. 3. "Aridity, and aridity alone, makes the various West one. The distinctive western plants and animals, the hard clarity (before power plants and metropolitan traffic altered it) of the western air, the look and location of western towns, the empty spaces that separate them, the way farms and ranches are either densely concentrated where water is plentiful or widely scattered where it is scarce, the pervasive presence of the federal government as landowner and land manager, the even more noticeable federal presence as dam builder and water broker, the snarling states'-rights and antifederal feelings whose burden Bernard DeVoto once characterized in a sentence–'Get out and give us more money'–those are all consequences, and by no means all the consequences, of aridity."[4]

Backwater.

1. "Water backed up or retarded in its course as compared with its natural condition of flow" (USGS website). 2. "A small, generally shallow body of water with little or no current of its own. Stagnant water in a small stream or inlet" (USBR website). 3. Any of the places off a state or county road, with no stoplight to impede the flow of children and dogs, sheep and cattle, pick-ups and tractors. The places of the heart for Wallace Stegner, Ivan Doig, William Kittredge, and Deirdre McNamer.

Claim.

1. "Asserts one's right to."[5] 2. Water claims, mining claims, proving up a homestead claim. 3. The West *does* create a type, different from your garden-variety easterner. 4. See "reclamation."

Condensation.

1. "The process by which water changes from the vapor state into the liquid or solid state. It is the reverse of evaporation" (USGS website). 2. A matter of faith when digging in a desert wash, visqueen sheeting in hand, praying water will collect, that evaporation can be reversed. It takes a long time to get a drink. 3. The process by which the flood of memories becomes words–nouns, verbs, landforms. See also Ivan Doig, Mary Austin, and John Muir.

Consumptive waste.

1. "The water that returns to the atmosphere without benefitting man." (Thomas, 1951, p. 217, in USGS website). 2. Virga. You watch it rain a mile away on the valley's western slope, and here, where cacti, not

timothy reign, you see the atmosphere take back the rain, even as it tries to fall your way. 3. Where snowpack goes when the river remains low, where your alfalfa crop goes when you can't pump from the river.
4. When your canoe runs aground every two minutes, scraping away your confidence. At least you don't hear the irrigation pumps when the river is low.

Control.

1. "A natural constriction of the channel, a long reach of the channel, a stretch of rapids, or an artificial structure downstream from a gaging station, that determines the stage-discharge relation at the gage" (USGS website). 2. John Wesley Powell's struggle on the Colorado, to keep the men on the river, to reach long into the future with a watershed-based law of ownership. 3. Glen Canyon Dam, and the lake that bears his name.
4. Edward Abbey's Hayduke and a jeep full of dynamite. 5. The great sin that William Kittredge writes penance for in *Hole in the Sky, Taking Care, Who Owns the West?*, and here, in *Owning It All:*

> I saw the beginnings of my real life as an agricultural manager. The flow of watercourses in the valley was spread before me like a map, and I saw it as a surgeon might see the flow of blood across a chart of anatomy, and saw myself helping to turn the fertile homeplace of my childhood into a machine for agriculture whose features could be delineated with the same surgeon's precision in my mind.[6]

6. The central debate in John McPhee's *Encounters with the Archdruid*.

Dam.

1. "A barrier built across a watercourse to impound or divert water. A barrier that obstructs, directs, retards, or stores the flow of water. Usually built across a stream. A structure built to hold back a flow of water" (USBR website). Example: As children we made toy dams in the eroded fissures after a big rain. We imagined we had equipment like our father had. We chanted "keyway, spillway, cat, riprap, carryall, scraper," hoping to conjure the kind of power the Connecticut Yankee had in that book by Mark Twain. 2. The epithet used to conjure Floyd Dominy into his appointed circle of hell.

Dominy.

The damned great Floyd, Satan in Mark Reisner's *Cadillac Desert*, dominated and controlled river flows throughout the West, married reclamation to recreation, and gave us houseboats in place of "the place no one knew," Glen Canyon. For Dominy, Glen Canyon Dam:

> Is food for growing America, drinking water for dwellers in an arid country, electric energy to provide the comforts of life and

> to turn the wheels of industry. It is jobs and paychecks—in the West and across the nation—and it is also taxes for the United States Treasury.
>
> *Most significant of all*, however, it is health and fun and the contentment of contemplating Nature's beauty for thousands who might never experience these thrills of the outdoors if engineers had not inserted between the steep walls of Glen Canyon a mammoth concrete slab to control and clear the erratic river that used to be known as the "Big Red."[7]

This April Fool's Day speech of 1965 promises that control is an absolute good, that nature's messy and erratic processes should follow government interests, that the dirty "Big Red" will be cleansed, made "fun" for those seeking the "thrills of the outdoors." Examples: As a teenager, I jumped boat wakes on Lake Powell, happy for the warm water and the miles of uninterrupted water skiing. The roar of the outboard motor covered the sound of wakes slapping the "steep walls" of sandstone, and almost covered the great echoing crashes as the water-weakened sandstone broke off in slabs and sank into the placid waters of Lake Powell. Glen Canyon Dam has begun to silt in, as many said it would, water allocations exceeded "streamflow" and sometimes leave the Central Arizona Project—hundreds of miles of open concrete canal—dry as bones in the desert. Abbey's characters seek to void the Dominys, blast the "mammoth concrete slabs" to smithereens, and stop the Catherine "wheels of industry." John Pfahl's photographic series of submerged petroglyphs inscribes the erasure of those remnants of a culture (see "traditional cultural property" [USBR website]) that dwelled in arid country without benefit of houseboats, air conditioning, or paychecks. Dominy has survived his foes–Brower, Reisner and Abbey all dead, while Floyd sips bourbon in a Vegas hotel, feted by an acre-foot of Water Board officers.

> "There was this nice old man," my mother drawls in her Tennessee accent, "His late wife was Southern, you know. I think he was a big deal…He got an award. He used to work for the government."
>
> "Floyd Dominy?" I asked, incredulous.
>
> "How did you know his name? There was some book," she continues, "that made him angry. He said he would have sued for libel if his wife had been alive to read those lies. People told him the author was dead, and he just laughed.
>
> 'Survived 'em all,' he said."

Would Dominy have sued in Federal Court, in Water Court? Will Floyd survive Glen Canyon Dam?

37.1. Floyd E. Dominy while Commissioner of Reclamation.

Domination.

See Dominy.

Drainage.

1. "Process of removing surface or subsurface water from a soil or area. A technique to improve the productivity of some agricultural land by removing excess water from the soil; surface drainage is accomplished with open ditches; subsurface drainage uses porous conduits (drain tile) buried beneath the soil surface" (USBR website). 2. What westerners call canyons, arroyos, deep indentations in mountains or hills, because *sometimes* they contain water. Is there water in the La Jara drainage? Will it water the cattle in the section 7 pasture? Do we have to *improve* the water? Can we *divert* it without a permit? 3. What William Kittredge's family did to reclaim swamp land for agriculture:

> The most intricate part of my job was called 'balancing water,' a night and day process of opening and closing pipes and redwood headgates and running the 18-inch drainage pumps. That system was the finest plaything I ever had (60).

Drawdown.

"Lowering of a reservoir's water level; process of depleting a reservoir or ground water storage. …The amount of water used from a reservoir" (USBR website). Example: The drawdown of the Snake River, as discussed by Mary Clearman Blew and Ripley Schemm in Schemm's poem, "For Mary, On the Snake":

> "But the most amazing thing of all,"
> You continue, "was the reappearance
> of the river itself." I write it back
> To you so you hear the poem your words
> sing: "Underneath has been a tough
> western river all along with sandbars
> and a real current. Day by day
> it emerged, and it was like gradually
> recognizing a lost part of myself."
> But then you tell how they closed
> the gates, how you saw the river widen,
> hardly stirring again. "Apparently,"
> You end, "it's not possible to have both
> Placid surface and mean current."

> I have to write you back, Mary. Think how
> the mean current works, always there,
> deceptive, below the surface.[8]

Feds.

Western term for any employee of the government or collective noun for any policy makers back east who make stupid decisions, as in "The feds say I can't kill coyotes with 1080 anymore. I'd like to show the feds my dead sheep." One's antagonism toward the feds is a key element in western identity. Bernard DeVoto once characterized westerners' attitude toward the feds in one sentence—"Get out and give us more money" (in Stegner, 9). Urban westerners resent the idea of the West as a dumping ground for national wastes, while lamenting the lack of federal regulation of utilities. Rural westerners resent almost all federal policy, but depend on federal subsidies for roads, telephone service, postal delivery, and agricultural entitlements. Stegner reminds us that another distinguishing feature of the West is the high percentage of federally owned land. The feds are our landlords and our neighbors. Feds are us.

Firn.

"Old snow on the top of glaciers, granular and compact but not yet converted into ice. It is a transitional stage between snow and ice" (USGS website). Example: Firn is what John Muir could see and name, but his fellow travelers could not. Here is Muir from his trip with the Harriman expedition:

> The earnest, childish wonderment with which this glorious page of Nature's Bible was contemplated was delightful to see. All evinced eager desire to learn.
>
> "Is that a glacier," they asked, "down in the canyon? And is that all solid ice?"
>
> "Yes."
>
> "How deep is it?"
>
> "Perhaps five hundred or a thousand feet."
>
> "You say it flows. How can hard ice flow?"
>
> "It flows like water, though invisibly slow."
>
> "And where does it come from?"
>
> "From snow that is heaped up every winter on the mountains."
>
> "And how, then, is the snow changed into ice?"
>
> "It is welded by the pressure of its own weight."
>
> ". . . Are those bluish draggled masses hanging down from beneath the snow-fields what you call the snouts of glaciers?"
>
> "Yes."
>
> "What made the hollows they are in?"
>
> "The glaciers themselves, just as traveling animals make their own tracks."

> “How long have they been there?”
>
> “Numberless centuries,” etc. I answered as best I could,…while busily engaged in sketching and noting my own observations, preaching glacier gospel in a rambling way, while the Cassiar, slowly wheezing and creeping along the shore, shifted our position so that the icy canyons were opened to view and closed again in regular succession, like the leaves of a book.[9] (122-123)

Firn, a monosyllable, like Muir’s short affirmatives. “Welded by the pressure of its own weight,” as desertification is welded to the West by the weight of urbanization, irrigation, and recreation. Muir’s snouts of glaciers nose smaller and higher reaches of the mountain West, receding like the animals—bears, wolves—whose habitat shrinks as we reject the doctrine of “consumptive waste,” responding to the call of Muir’s “glacial gospel” with mining and petroleum effluvium. “How long have they been there?” ask Muir’s companions. “Numberless centuries,” etc. Western writers attend to the “etc.,” asking us to consider “numberless centuries” against a diminished present and an evaporating future. The glaciers of Glacier National Park suffer ablation, taking “firn” out of the glossary and into the antiquarian’s dictionary, signifying the ablative case. [Grammatical case indicating separation, direction away from, and sometimes manner or agency.]

Hydrology.

1. “Scientific study of water in nature: its properties, distribution, and behavior. The science that treats the occurrence, circulation properties, and distribution of the waters of the earth and their reaction to the environment. Science dealing with the properties, distribution and flow of water on or in the earth” (USBR website). 2. Modified to hydro-philology. The attentive and loving study of the language of water. 3. The mysteries of virga, hail, hot springs, capillary forces, alluvium, fetch, riffles. The wonderful suggestiveness of mud cake, littoral, ephemeral creek, jeopardy opinion, eddy, morning glory spillway, muck, flocculation, gravel blanket, paradox gate, sheepsfoot roller, or sticky limit. 4. The multiculturalism of arroyo, playa, reservoir, revetment. 5. The great disappointment of the scientific and bureaucratic hijacking of Eolian, fatal flaw, future without, grapple, grizzly, groin, horsehead, reach, resilience, rill, sinuosity, and weep hole.

Infiltration.

1. “The flow of fluid into a substance through pores or small openings” (USGS website). 2. Infiltration within federal, state and local government to change the language of laws away from ownership of acre-feet, miner’s inches, prior appropriation, to a Powellian language of the communal—use, rather than ownership, biotic and human use, as opposed to self-interested use. As Kittredge claims:

> In the American West we are struggling to revise our dominant mythology, and to find a new story to inhabit. Laws control our lives, and they are designed to preserve a model of society based on values learned from mythology. Only after re-imagining our myths can we coherently remodel our laws, and hope to keep our society in a realistic relationship to what is actual. (64)

In situ.

"In place, the original location, in the natural environment" (USBR website). Example/question: Is Rainbow Bridge really "in situ"?
2. Where the language of water needs to be resettled.

Irretrievable.

"Commitments that are lost for a period of time" (USBR website). Only in bureaucratic language could this mean "lost for a period of time." Fear not, futurists: Hetch Hetchy is "irretrievable," but in the government sense.

Precipitation.

1. "As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water …[.] The term 'precipitation' is also uncommonly used to designate the quantity of water that is precipitated." (Meinzer, 1923, p. 15 in USGS website). 2. The abundant precipitation in the winter of 1955 left Northern California flooded to heights still not duplicated. Although we were not in the flood plain, our December lambs turned green from mold (only last year did I learn that this was fatal), and I have suffered from lifelong allergies to molds. 3. In Northern New Mexico when it rains two inches in an hour, dirt roads turn to gumbo. You stop where you are, and if you want to get home from town, you walk, even in your town clothes, watching as the earth clings to you, wanting to keep you in place. That sucking sound is the lip-smacking earth feeding on your best shoes.

Reclamation.

Not listed in USGS glossary. Not listed in USBR glossary. 1. Code word for dam building in the first two thirds of the twentieth century. The Bureau of Reclamation, a federal agency that spent tax dollars to subsidize agriculture, but more often agribusiness, utility companies, and urban development. See Floyd Dominy. 2. Act of re-appropriation, reclaiming the West as an "emotional homeland." 3. Coincident with the new language of USBR, reclaiming federal power for conservation and preservation. 4. Reclamation of language and representation in the service of biotic communities and even backwaters.

Relict.

1. "A species, population, etc., which is a survivor of a nearly extinct group. Any species surviving in a small local area and widely separated from closely related species" (USBR website). 2. Floyd Dominy, the farmer with a D8 and a dream of a little dam. 3. Relicts now gone: Edward Abbey; Everett Reuss, who walked away in Canyonland; Maynard Dixon, who dared to paint aridity; Arth Chaffin, almost alone at Hite Ferry; Mary Austin's pocket miners.

Scour.

1. "Erosion in a stream bed, particularly if caused or increased by channel changes" (USBR website). 2. The ailment in cattle that makes day-use recreationists write letters to their Congressmen. Get those cattle with diarrhea off our range. My new hiking boots are ruined!

Things we can actually do with these words:

1. Play: the language of water is becoming indigenous to the West, and it's a language rich with possibility: Acequia, braided channels, crick, ditch rider, diversion, drought, sometimes drouth, ephemeral, floodgate, headgate, irrigation, subirrigation, meander, submeander, meromictic, miner's inches, mirage, parched, rain shadow, riffle, riparian, riprap, runoff, spring box, tanks, troughs, throughfall, virga, water crop, water court, water gap, water law, waterpocket fold, water master, water witch.

2. Twist them, divert them: here's a post-timber sale tongue twister: How much water will a watershed shed if a watershed gets waterlogged from logging?

3. Read them: A short of list of western books both wet and dry: wet books: MacLean's *A River Runs Through It,* Roosevelt's *Ranch Life and the Hunting Trail, The Journals of Lewis and Clark,* Doig's *Bucking the Sun,* Stegner's *Angle of Repose,* McNickle's *Wind from an Enemy Sky,* and Nichols's *The Milagro Beanfield War*, Anaya's *Bless Me, Ultima;* dry books: Austin's *The Land of Little Rain,* Abbey's *Desert Solitaire,* Cather's *My Ántonia,* Silko's *Ceremony,* McCarthy's *Blood Meridian*.

4. Reclaim them: Why can't ownership become owning up? Stewardship? Why can't the land own us?

One final term from the USBR Glossary:

Author's signature. "This is the signature of the person or persons with primary responsibility for writing the document. Signature of the document by the author(s) signifies that a draft document was provided to team members and that they had an opportunity to comment on the draft. The author's signature also implies that comments were considered and that any critical issues or influencing factors were incorporated into the document" (USBR website). I await the chance to place my "author's" signature on this document.

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Endnotes

1. W. B. Langbein and Kathleen T. Iseri, "General Introduction and Hydrologic Definitions," *Science in Your Watershed,* USGS <http://water.usgs.gov/wsc/glossary.html> (May 23, 2001). All subsequent quotations from USGS glossary will be noted by parenthetical citation, USGS.
2. All definitions that are not in quotations are my own.
3. United States Bureau of Reclamation, Glossary <http://www.usbr.gov/cdams/glossary.html> (June 28, 2001). All subsequent quotations from USBR glossary will be noted by parenthetical citation, USBR.
4. Wallace Stegner, *The American West as Living Space* (Ann Arbor: University of Michigan, 1987), 8-9.
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