WATER OPERATION AND MAINTENANCE

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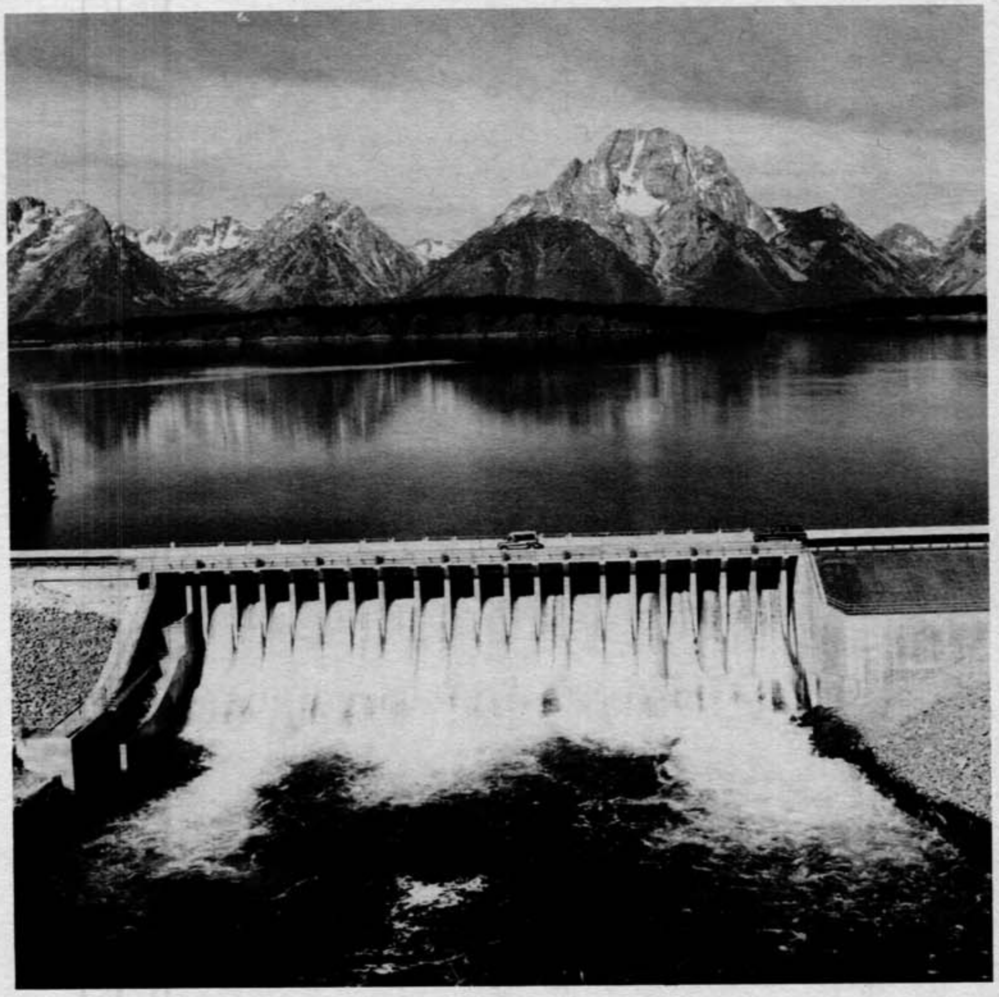

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UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchange information for use by Bureau personnel and water user groups for operating and maintaining project facilities.

While every attempt is made to insure high quality and accurate information, Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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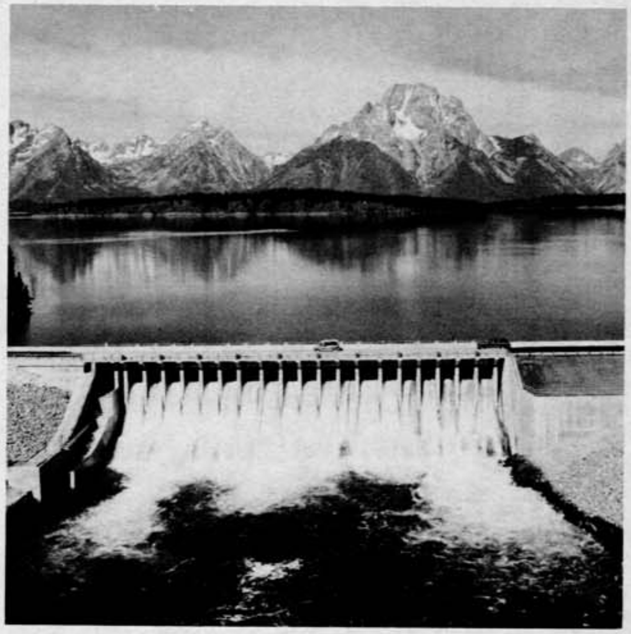

Cover photograph:

Jackson Lake Dam, Minidoka Project, Wyoming, is the spotlight of this issue.

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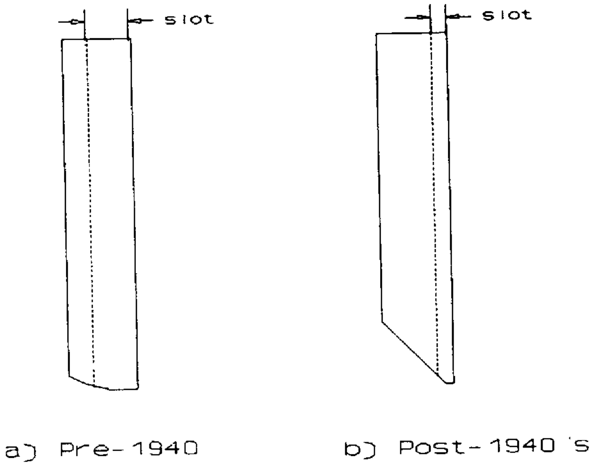
EXPERIENCE WITH CAVITATION IN HIGH-PRESSURE SLIDE GATES

by K. Warren Frizell and Brent W. Mefford[1]

High-pressure slide gates have been used for many years in a variety of applications, usually for controlling flow through the outlet works of dams. The Bureau of Reclamation has installed and operated high-pressure slide gates since 1906. Yet through all the years of operating experience and increased knowledge of the cavitation phenomena, current slide gate designs still occasionally exhibit damage. With a few exceptions, most of the gate and valve installations before the construction of Hoover Dam (1931-1936) were considered relatively low head (<150 feet). Due to the lack of knowledge about cavitation and the damage which could result, slide gates which operated satisfactorily under low head conditions were used in high head installations. Usually, this resulted in massive damage, needing costly repairs and maintenance or modifications [1][2]. In some cases, the gates were abandoned after years of repeated damage. Reclamation has basically had two major designs of high-pressure slide gates over the years. Before 1940, the standard design had a wide seating area and slot, with a curved leading edge on the gate leaf (figure 1a). After many years of operation, this style gate was abandoned as a regulating gate due to continual cavitation damage. During the 1940's, the standard design was modified to include a much narrower seating area and slot with a 45° leading edge on the leaf (figure 1b).



a) Pre-1940 b) Post-1940's

Figure 1. - High-pressure slide gates used by the Bureau of Reclamation.

Evolution of the Standard Design

The current design of high-pressure slide gates within the Bureau of Reclamation has evolved through hydraulic model tests and via experience gained from operation of prototype structures. Before 1940, flat bottom slide gate designs were used due to their ease of construction. Wide gate slots were used to provide sufficient structural leaf strength. The relatively flat bottom was found to cause cavitation damage to the bottom of the gate leaf. Wide flat bottom leaves are subject to a short tube effect as the spring

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[2] Numbers in brackets refer to references at end of article.

point of the flow generally forms near the upstream edge of the gate leaf. Wide gate slots allowed flow to impinge on the downstream corners of the slot. This resulted in cavitation damage to the walls and floor of the downstream gate body. Cavitation damage occurred on many of the flat bottom gate structures. Structures such as Rye Patch and Caballo Dams experienced severe cavitation damage at heads well below 100 feet. A history of cavitation damage and poor flow distribution at the exit of the standard slide gate resulted in hydraulic model studies of slide gates for Cedar Bluff and Medicine Creek Dams in the early 1950's. These structures used slide gates to regulate flow discharging into hydraulic jump stilling basins.

Cedar Bluff [2] and Medicine Creek [3] model tests investigated flow pattern effects due to the shape of the upstream gate leaf face, slot width, gate slot flow deflectors, and shape of the downstream gate frame. The studies resulted in the standard slide gate design being changed as follows:

1. The upstream face of the gate leaf was changed from a convex to a flat surface.

2. The standard gate slot width was reduced by about 45 percent.

3. Wedge-shaped slot deflectors were placed immediately upstream of the gate slot to force a flow contraction in front of the slot.

4. The crown of the downstream gate frame was sloped upward from the gate slot to the downstream end of the gate frame. An air vent was placed in the crown immediately downstream of the slot to prevent low pressures along the crown.

5. When using a slide gate to discharge into a stilling basin chute, the sidewalls of the downstream gate frame were flared to improve the flow distribution at partial gate openings.

The flat bottom leaf shape was maintained, possibly due to the ease and low cost of construction. Hydraulic model tests conducted by Lowe [4] on coaster gates for Shasta Dam recommended the gate bottom be changed from a flat arrangement to that of a 45° slope from the upstream to the downstream surface. The sharply sloping bottom moved the spring point to near the downstream edge of the gate leaf and reduced the low pressures on the gate bottom. This reduced the downpull and the potential for cavitation damage to the gate leaf. Although the sloping bottom provided the best flow conditions, the design was considered difficult to construct.

In 1954, a slide gate was designed for Palisades Dam. A research study was conducted by Simmons [5] to develop a regulating slide gate capable of discharging into a stilling basin chute at heads up to 240 feet. The high heads required the standard slide gate design be improved to further reduce the cavitation potential on the leaf and downstream gate frame. The study resulted in the adoption of several additional features to the standard high-pressure slide gate. Simmons concluded:

1. A steep sloping gate leaf bottom reduces possible cavitation damage to the leaf and provides a smooth jet surface. A slope of 45° was chosen as a compromise between hydraulic and structural needs.

2. Gate slots should be designed as narrow as possible. The thickness of the gate leaf which is required based on bending should be reduced at the edges to that required to withstand the shear load in the slots.

3. The downstream slot corners should be offset outward 0.5 inch followed by converging walls to return to the upstream throat dimensions. Flow deflectors upstream of the slot were not used.

As noted by Ball [6], the Palisades outlets were tested for about 30 days at small openings at heads near 200 feet. No cavitation damage was apparent on the gate, although damage occurred to the concrete immediately downstream of the gate. Ball attributed the concrete damage to offsets in the concrete at the junction with the downstream gate frame.

Since the development of the Palisades style standard high-pressure slide gate, numerous slide gates have been installed on Reclamation projects. Many have operated without cavitation damage; however, extensive damage has occurred on several gates for reasons which are unclear. A review of selected case histories points to significant improvements in high-pressure slide gate design from the days of the flat bottomed gate but falls short of showing that a cavitation damage-free slide gate design has been developed.

Case Studies

Vallecito Dam.–Vallecito Dam is a zoned-earthfill structure, 162 feet high, located on the Pine River 18 miles northeast of Durango, Colorado. The dam was constructed between 1938 and 1941. Typical of designs of pre-1940, flat bottomed slide gates were used to regulate releases from the outlet works. Two 5- by 5-foot gates control the flow through a twin-section concrete conduit. The first repair of cavitation damage was done in 1962. At the same time, minor cavitation damage to the gate leaf and downstream frame was patched with an epoxy material. In 1984, an inspection of the gate leaf revealed significant cavitation damage, typical of that experienced previously with this type of gate leaf geometry [7]. In addition to the usual damage to the slots and downstream gate frame, the gate leaf showed extensive damage to the curved portion of the leading edge. Permanent repair to a leaf with this much damage is nearly impossible. In addition, the repair is a temporary fix since the gates will cavitate again if used to control at small openings. At Vallecito, the gate leaf and seats were replaced with the current standard design (45°) leaf. The gate has operated without damage since replacement in 1985.

Joes Valley Dam.–Joes Valley Dam is a zoned-earthfill embankment, with a structural height of 187 feet. It is located on Selly Creek about 12 miles northwest of Orangeville, Utah. Construction was completed in 1961. The outlet works features two 2.25- by 2.25-foot high-pressure slide gates of the current Reclamation standard design. An underwater examination revealed severe cavitation damage downstream of the two regulating gates [8]. The repair was a new approach. In addition to patching the voids with epoxy, two stainless steel bars were attached to the downstream gate frame along the side seats just downstream from the gate slot. These bars are designed such that air can flow down the sidewalls behind them, reducing the chance of cavitation damage. The orifice bars make the slide gate similar to a jet flow gate in concept, allowing the jet emanating from the gate to spring free from the sidewalls. The coefficient of discharge for the modified gate is lower than that of the standard high-pressure slide gate design.

Glen Canyon Dam Left Diversion Tunnel Plug.–Glen Canyon Dam is a concrete arch dam, 710 feet high and located 15 miles upstream from Lees Ferry on the Colorado River. During construction, water passed through three 7- by 10.5-foot high-pressure slide gates, located in the left diversion tunnel. During 1965, these gates (45° leaf) were used for free discharge of over 2 million acre-feet at nearly 350 feet of head [9]. The cavitation damage which occurred is considered minor. The majority of the damage in the gate areas could be attributed to misalignments in construction joints. There was some damage due to gate and gate slot geometry on the upstream sloping surface of the leaf and the gate frame downstream from the gate slot. Neither the stainless nor Monel clad surfaces on the gate leaf or slot areas were damaged.

Conclusions

There has been little additional work to modify the standard high-pressure slide gate design since the Palisades study of the mid-1950's. Reclamation still occasionally experiences cavitation damage to installations with the standard design, even at heads as low as 100 feet. Generally the damage is limited to the downstream gate frame just downstream of the gate slot and occurs at partial gate openings. Due to recurring operation and maintenance problems, Reclamation is involved in a new research program aimed at eliminating cavitation damage from all its high-pressure slide gate installations.

Current Studies and Future Research Needs

The research program will include studies to modify existing slide gate facilities which would mitigate cavitation damage. These tests will include model studies of the present standard design with the objective "to develop a retrofit modification to the gate leaf or frame which would eliminate or greatly reduce cavitation damage." First to be studied are the orifice-type bars discussed earlier which have been installed at Joes Valley and Ridgway Dams. These studies are currently underway with results expected to be available by early 1990.

Future research will build upon Reclamation's 85 years of experience in design and operation of high-pressure slide gates. Research will clarify the causes of damage experienced on many installations of the current design.

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BUREAU OF RECLAMATION-CORPS OF ENGINEERS RESEARCH EFFORT RESULTS IN HIGH-RESOLUTION ACOUSTIC MAPPING SYSTEM[1]

A high-resolution acoustic mapping system for performing rapid, accurate surveys of submerged horizontal surfaces has been developed as part of a joint research and development effort of the Bureau of Reclamation and the U.S. Army Engineer Waterways Experiment Station (WES). The system makes possible, without dewatering the structure, comprehensive evaluation of top surface wear on such horizontal surfaces as aprons, sills, and stilling basins, where turbulent flows carrying rock and debris can cause abrasion-erosion damage.

Developing capabilities such as this for nondestructively evaluating concrete in large structures is a shared interest of Reclamation and the Corps of Engineers, as well as other Government agencies and private sector groups involved in operation and maintenance of water resources projects. Recent heavy emphasis on evaluation of existing water projects and shifts in policy from new construction to repair and rehabilitation of existing structures underscored the need to develop and refine nondestructive testing (NDT) techniques for evaluating the condition of concrete structures. In view of their mutual needs in this area, Reclamation and WES entered into a cooperative research and development effort to increase their NDT capabilities, with each sharing in planning and financial support.

One problem of mutual interest was how to obtain rapid, accurate bottom-contouring data on submerged structures while avoiding the expense of dewatering and the dangers of inaccuracies inherent in diver-performed surveys. A survey of abrasion-erosion damage repairs indicated that dewatering accounts for over 40 percent of total repair costs. Nevertheless, dewatering is often necessary since the extent and location of damage must be known to determine what steps to take to correct the damage and to prepare valid cost estimates for repairs.

It was apparent that a system that would permit surveying without dewatering would be a major breakthrough for water project operators, and Reclamation and WES agreed that the most likely candidate would be a sonic system. However, erosion and differential settlement of submerged structures have always been difficult to map accurately using standard sonic surveys because of limitations of the various systems. Sidescan sonar, fathometers, and similar underwater mapping systems are designed primarily to see targets rising above the plane of the reservoir bottom. Broad sonic beams provide broad coverage. A narrow beam was needed to see into depressions and close to vertical surfaces. This capability is provided by the high-resolution acoustic mapping system.

The system is designed to operate in water depths of 5 to 40 feet and produce accuracies of about 2 inches vertically and 1 foot laterally. The system has been successfully used to survey the stilling basin floor of Folsom Dam, a Reclamation project near Sacramento, California, and the stilling basin of Ice Harbor Dam in the Corps of Engineers' Walla Walla District near Richland, Washington. A detailed description and specifications of the system are available and can be furnished on request.

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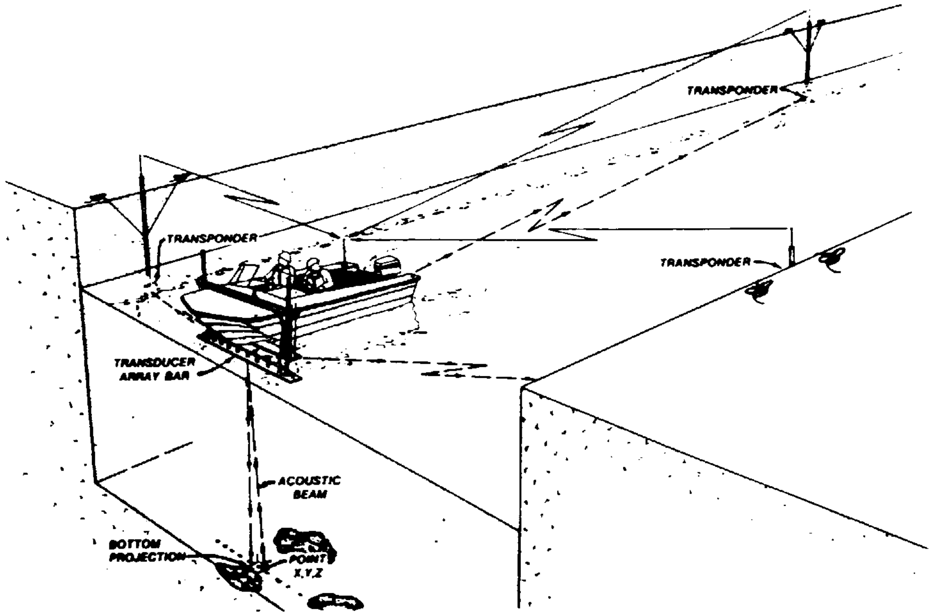
[1] Originally published as Technical Note No. 61; March 31, 1989; Research and Laboratory Services Division, Bureau of Reclamation, Denver, Colorado.



For more information about the acoustic mapping system and the surveys conducted at Folsom and Ice Harbor Dams, as well as for copies of the specifications and a detailed description of the system, write to the Chief, Concrete and Structural Branch, PO Box 25007, Denver, Colorado 80225, or call (303) 236-5989 or FTS 776-5989.

HYDRODEMOLITION SPEEDS AQUEDUCT TUNNEL REPAIR[1]

A unique adaptation of concrete removal hydrodemolition equipment has helped the city of Los Angeles to meet a major challenge in the repair of 144 miles of tunnels and conduits bringing water from the Sierra Nevada mountains to the greater metropolitan area.

Repair work on the first 1,300 feet of a 1.1-mile section midway in the tunnel was completed in early December 1988, in a period of 2 months. The 338-mile gravity aqueduct system runs from Lee Vining Creek on the eastern slope of the Sierra Nevadas and provides the city with 75 percent of its water supply.

Officials of the Los Angeles Department of Water and Power (DWP) who are responsible for maintenance and repair of the 75-year-old aqueduct system say that the availability of hydrodemolition technology has made it possible to renovate concrete tunnel and conduit sections of the aqueduct system at an average cost 17 times less than using conventional concrete demolition techniques. Moreover, the work in the first section has proceeded up to 50 times faster than formerly was deemed possible, and because the operator of the hydrodemolition equipment is able to place himself at a remote position, work has been done in complete safety.

At each pass the Conjet unit removes deteriorated concrete from a 30-inch-wide section; then moves on leaving a 30-inch "rib" before cutting out the next section.

The system used on the job was designed by Atlas Copco, which adapted its Conjet hydrodemolition equipment normally used for removal of deteriorated concrete from bridges, parking lots, and airport runways to the DWP tunnel system.

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[1] Reprinted with permission from the Editor, Public Works, July 1989 issue.

The Aqueduct System

The Los Angeles aqueduct system is the brainchild of the city's turn of the century Chief Engineer William Mulholland, and was completed in 1913 at a cost of $24.5 million following 6 years of construction. The original 233-mile system of tunnels, conduits, reservoirs, and open canals has been added to over the years so that today a 338-mile system delivers 430 Mgal/d of water to the greater metropolitan Los Angeles area, supplying 11 power stations along the way, power generating stations that produce 1.12 billion kilowatt-hours of pollution-free hydroelectric power. The entire system is fed by gravity, without reliance upon any pumping.

Although the aqueduct system has held up well over the 75 years of its existence, some deterioration has occurred in the 144 miles of concrete-lined tunnels and conduits of the system, and following the annual 1-week inspection in 1987, it was determined that repairs over a period of years should begin in 1988.

According to the DWP's Superintendent of Construction and Maintenance Theodore J. Sterling, spalled segments of concrete in some areas were actually decomposing and breaking loose and exposing underlying rotted wooden timbers and lagging originally installed to hold back the overhead rock and earth. In some instances, the tunnels are as deep as 600 feet below the surface of the mountains through which they pass.

The original concrete tunnels were built without steel reinforcement bars, cement having been poured in and around the supporting wooden timbers and lagging at varying thicknesses ranging from 4 to 20 inches. Shapes of the tunnels vary in size and configuration, depending upon hydraulic grade. (The steeper the grade, the smaller the dimensions.) The 1,300-foot section recently completed is horseshoe shaped, 8 feet wide and 8 feet high, with a rounded top that normally is above the water line. The flat bottom has a slight invert in it.

Repair Problems

In preparing to repair the deteriorated sections, several problems presented themselves:

1. The time factor.–To repair the tunnels, water must be shut off. This means that the city must rely on the second Los Angeles aqueduct constructed in 1972 and reservoirs closer to the city for a supply of water. Although these reservoirs are large, they can provide water for only a limited time without replenishment. Thus speed of repair is very important.

Adding a complication to the time factor is the matter of limited water storage behind the closed-off section as a result of streamflow and runoff.

Sterling estimated that with available manpower, conventional removal of deteriorated concrete and replacement with form-poured concrete could proceed reasonably at an average rate of only 5 feet during a 10-day period. This means that it would take more than 7 years to repair the first 1,300 feet of tunnel.

2. Cost.–Proceeding with the method described, Sterling estimated that cost of repairs would amount to $50,000 for each 5 feet of progress, or $13 million for the first 1,300 feet.

3. Safety.–Using conventional equipment, the operator must stand directly underneath the area of concrete being removed. The possibility of falling concrete, rock, or timbers resulting in injury is always present.

Sterling says that in terms of the time factor, the cost factor, and the safety factor, conventional methods of repairing the deteriorated tunnel sections were ruled unsatisfactory.

Several alternative approaches were considered but were rejected. One alternative was to simply line the existing deteriorated sections with wire mesh and shotcrete it with a 2-inch surface. This approach was immediately ruled out since it could reduce the size of a tunnel section and thus decrease waterflow significantly.

Another alternative rejected was to insert a rubber bladder in the tunnel. Although the rubber would prevent concrete detritus from entering the water supply, it would not be able to provide support or stop further deterioration of the tunnel.

A final alternative that was deemed too costly was to build entirely new sections alongside the deteriorated sections.

The Hydrodemolition Unit

With the need to start repairs becoming urgent, Sterling consulted with engineers at Atlas Copco to see if hydrodemolition technology normally used for surface concrete demolition could be adapted to a tunnel application. Working on the problem, the firm succeeded in developing a Conjet hydrodemolition unit small enough to fit easily into an 8- by 8-foot tunnel space, and with a moveable arm capable of rotating in a 360° arc, equipped with two powerful high-pressure water nozzles that could remove deteriorated concrete up to 20 inches thick in a 30-inch-wide section.

The Conjet unit was delivered to the DWP field office at Mojave, California, where it was tested for 2 weeks in a 50-foot-long open air mock-up tunnel. Following a few adjustments, the Conjet unit performed, according to Sterling, "beyond our wildest dreams."

The Conjet arm was programmed to make its 30-inch-wide pass starting at 14 inches up from the tunnel floor and proceeding up to the water line. This is the area where the deterioration had taken place. (Repairs to the floor of the tunnel were made in 1938, and the floor was found to be in good shape.) Water was sprayed through two 1.5-mm nozzles (occasionally 1.1-mm nozzles) under 17,000 lb/in^2 pressure on both an up and down pass of the rotating arm. The two passes succeeded in removing the deteriorated concrete.

After each 30-inch-wide section was removed, the unit was then moved forward, skipping a 30-inch section, to begin removal of deteriorated concrete on another section, leaving behind a 30-inch supporting "rib" for shoring. After the areas where the removed concrete was filled in with new reinforced concrete, the unit returned to remove the ribs and complete the repair job.

The Conjet was operated by one man standing at a remote location. The unit operated during one 10-hour shift, 7 days a week, from 3:30 p.m. to 2 a.m. A cleanup crew using two skid-steer tractors and three mine cars mucked out from 11 p.m. to 9:30 a.m. A crane was used to haul the muck to the surface through an 8- by 12-foot equipment hole.

A shotcrete crew, two operators and three finishers, worked a shift from 7 a.m. to 5:30 p.m. The shotcrete mixture consisted of concrete mixed with silica fume and a super plasticizer reinforced with 1-1/2-inch deformed steel fibers. It was mixed in a batch plant 1 mile below the valley, and was trucked to the tunnel entrance where it was pumped to the repair section through a slick line.

The Conjet tunnel robot was powered by a diesel generator and diesel driven high-pressure pump in a 20-foot container at the tunnel entrance. High-pressure water jets on the robot require 35 gallons a minute that is fed from a 1,000-gallon tank in the container. As is standard, water was filtered through two 50-micron screens and one extra 5-micron screen.

High-pressure water was pumped from the container to the robot for long distances, up to 1,300 feet. There was no loss of pressure to diminish concrete removal performance.

Gravity flow of water in the tunnel was stopped by a sandbag barrier at a location below the equipment hole, and water was pumped out to the surface.

Specific results reported by DWP's Superintendent Sterling:

1. Rate of progress, 25 feet of tunnel repaired in a 24-hour period, as opposed to an estimated 5 feet projected in a 10-day period, using jackhammers. Or, at a rate of 12 to 25 minutes versus 10 hours for the same work area covered.

2. Two-man operation versus six men as projected in the above scenario, using jackhammers.

3. Cost of $14,000 for 25 feet, as compared with an estimated $50,000 for only 5 feet in the jackhammer projection.

4. One-hundred percent safety rating by the California office of OSHA.

Sterling says that when the Conjet unit is not in the tunnel, it will be substituted for many sandblasting jobs carried out by the DWP, in a move to eliminate the use of hazardous material.

As for its use in repairing the Los Angeles aqueduct system tunnel network, the Conjet equipment, Sterling says, has already made an outstanding contribution at a reasonable cost.

"This is the wave of the future," he says. "This is the most cost-effective way to proceed with this kind of repair work today."

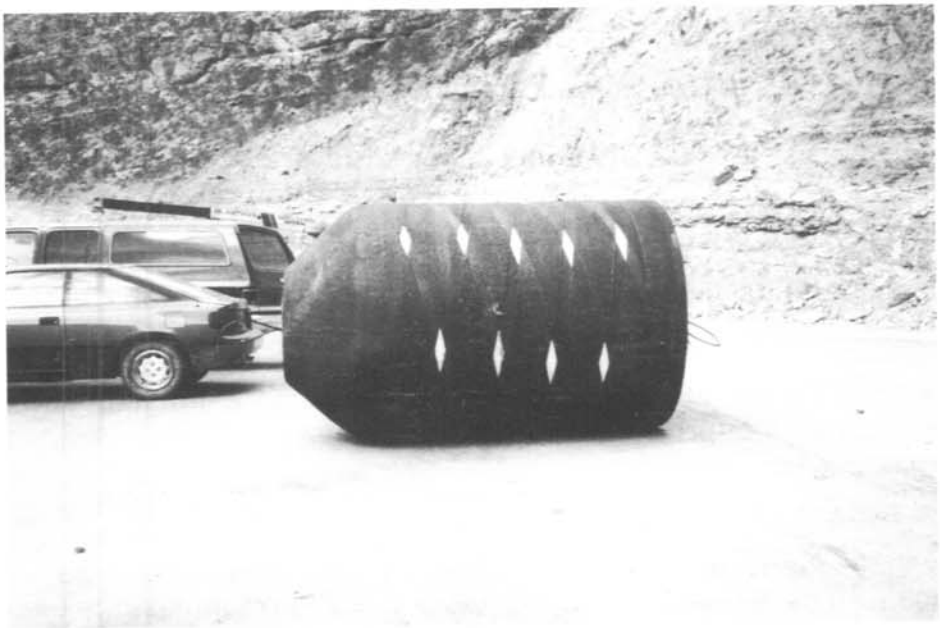
PIPECLEANING WITH PIGS[1]

by Chuck Carney[2]

The Quail Creek water system, finished in 1985, is located in southern Utah near Hurricane City. It consists of a diversion dam that takes water out of the Virgin River and diverts it to 8 miles of cement-lined steel pipe. There are two hydroelectric plants, 600 kW and 2,340 kW, along the pipeline, plus an outlet works for releasing irrigation water. The pipeline is 66 inches in diameter for the first 4.5 miles, and then changes to 48 inches for 3.5 miles.

Quail Creek suffered a drop in flow capacity after several years of operation. A decrease in available head followed the drop in flow. Since one of our primary uses for the pipeline is power generation, the loss of head and flow was costly to us.

The solution to this problem was easy, albeit unusual. We stuffed three pigs into the 8-mile-long pipeline to clean the buildup of river crud, returning the pipeline to a like-new condition. These are not your everyday, live-in-a-pen pigs. These pigs are Texas-made out of open-cell polyurethane foam and weigh 600 pounds dry, and up to 5,000 pounds wet.



A carbide chip pig, 66 inches in diameter.

At first, we were unsure of the cause of head and flow loss. The entire pipeline was drained and inspected, and air-vacuum valves were inspected for air-pocket elimination. Project engineers Creamer & Noble and the pipe manufacturer determined that the smooth interior of the pipeline had developed scaling and roughness, up to 3/8 inch thick, from the buildup of sulfates and fine silt.

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[1] Reprinted from the June 1989 issue of Hydro Review. Two other articles on "pigs" were printed in Bulletins No. 132 and 142.

[2] Chuck Carney is the Maintenance and Operations Supervisor for the Washington County Water Conservancy District, PO Box 583, St. George UT 84770; telephone (801) 673-3617.

We were referred to Flowmore Services, Houston, Texas, by our engineers. Flowmore usually handles the cleaning for oil pipelines. They recommended three different types of foam pigs to clean the pipeline. The pigs resemble large bullets, approximately 6 feet long. The first pig was soft foam, 2 lb/ft^3. A 5-lb/ft^3 urethane covered pig to remove scale was next. The last pig also weighed 5 lb/ft^3 with carbide chips imbedded in a urethane coating to remove the hardest scale.

Left to right, 66-inch pigs: (1) pig with urethane coating embedded with carbide chips, (2) pig with urethane coating only, (3) lightweight foam pig.

It was necessary to pass the pigs through both 66- and 48-inch pipe. The foam construction allowed the pig to be "squashed" through the smaller pipe.

The pigs entered the pipeline at the diversion structure through a specially constructed "pig launcher." The launcher is an existing concrete vault with a temporary "pig funnel" to guide the pig into the pipeline. It is then wedged as far as possible into the pipe and held down with chains to prevent it from escaping while it is filling with water.

We monitored progress through the pipeline via a radio transmitter inserted in the pig. Waterflow in the line determined the speed; we ran ours through the pipe at 3 - 4 ft/s. The pig was shunted off the main line into a pig receiver where it was allowed to drain. The pig receiver consists of a 48-inch wye at the main line, reducing to a 36-inch gate valve, ending in a 72-inch pig trap equipped with bulkhead and drain valve. A bypass line routes the flow of water from the pig trap back to the main line. Once the pig is caught, water is routed back through the main line. The trap is drained and the pig is removed through the bulkhead.

After running three pigs through the pipeline, we noted a 20 percent increase in power production. We now plan to use the pigs twice a year.

Cost of the cleaning project, including fabrication of the pig launcher and receiver, and pig manufacture, was $42,000. We estimate the increased power production will provide an additional $100,000 of revenue. Normally, the pigs cost $7,000 to $8,000 each, but we were charged for two pigs. Flowmore provided a third "guinea pig" free of charge.

Damage to the pigs prevents their reuse. We think this is because of the reductions in the pipeline — 66-inch to 48-inch to 66-inch — and because of the speed of the pigs.

For more information on pipecleaning with pigs, contact Flowmore Services Corp., 19515 FM 149, B-150, Houston TX 77070; (713) 351-7979.

PIPELINE SETTLING PONDS[1]

Necessity or Accessory?

Are settling ponds a luxury or should they become a standard on pipeline inlets? The St. Mary River Irrigation District (SMRID) feels that by using a settling pond at the head of their pipeline systems, they have found a solution to the problem of sand and silt entering their lines. A settling pond, as the name implies, is a pond of water which allows the sand and silt particles to settle out prior to entering the pipeline system.

Their ponds are constructed approximately 40 m (131 feet) long by 5 m (16 feet) wide at the bottom with 2.5:1 side slopes and range from 2 m (6 feet) to 4.5 m (15 feet) deep. They consist of inlet and outlet structures with an inlet trashrack having 25-mm (1-inch) clear openings. A precast concrete baffle is usually placed near the downstream end of the pipe entering the pond to slow down the velocity of the water flowing through the pond. The ponds are usually plastic lined and gravel armored on their interior slopes.

The settling pond constructed in 1989 on the SMRID's Coaldale Lateral is lined and gravel armored.

The SMRID uses two design aids in determining what size to construct a settling pond. One is the Van Hjulstrom diagram which plots particle size versus velocity in the pond and predicts whether a particular sized particle will settle out, be transported, or cause erosion. The other aid is Stokes Law which is used to determine the downward velocity of a certain sized particle.

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[1] Reprinted with permission from the Editor, Water Hauler's Bulletin, Summer/89 issue.

The Board of Directors of the SMRID, on the recommendation of their "Screening Committee," passed a motion that states "settling ponds should be installed on pipelines where feasible." This motion was incorporated as policy in their district.

The question of feasibility must be addressed for each proposed pipeline settling pond. For example, it may not be economical to provide a settling pond for a short pipeline or municipal regulations may also make settling ponds not feasible. One such municipal regulation states that the outside edge of the pond must be 38 m (125 feet) from the centerline of the county road. Because of this regulation, it is often difficult to obtain the necessary right-of-way from the landowner. Not all landowners want a settling pond constructed 28 m (92 feet) inside their property line.

Ron Hadden, former assistant district engineer for SMRID says that he had a problem last fall at a water users' meeting where all of the farmers wanted a settling pond built at the head of a proposed pipeline except for one. The one "holdout" was the landowner where the proposed settling pond was to be located.

Another problem which may not make a settling pond feasible is a high bank elevation. In some cases, the pond may have to be self-leveling with the supply canal, resulting in very high banks to contain the water. This may not be esthetically acceptable to the landowner.

Cost factors can prohibit the building of a settling pond. Excavation, liner materials, and gravel armor all mount up, but the one cost that can make construction prohibitive, if the haul distance is great, is the cost of obtaining earth borrow material. Ron Renwick, district engineer, says in many instances the cost of construction of a settling pond is no more than the purchase and installation cost of the equivalent amount of large diameter pipe that would be required to replace the in-line settling pond.

At this point, one may ask why bother with a settling pond at all. Fortunately, there are benefits that the SMRID feels outweigh the problems associated with the construction of a settling pond. These can be broken down into two categories; namely, farmer benefits and district benefits.

The farmer benefits by "direct hookup" to the pipeline to utilize any available pressure which, depending on the location, may be substantial. Gone is the need for his own little on-farm settling pond which requires land being taken out of production, not only for the pond itself but also for any seepage or wet areas that may result. The large in-line pond at the head of the pipeline is more efficient in removing sand and silt, thus the farmer has less wear and tear on his sprinkler heads. Also lessened, is the chance of the sprinkler mainline plugging up with silt and sand that may be still suspended. Hadden feels that a direct hookup gives the farmer the added benefits of cleaner water, a neater pumping setup, and none of the operational problems associated with the small individually owned settling pond.

Districts' benefits are no small piece of the pie either. Monty Flexhaug, operation's manager for the SMRID says an in-line settling pond means once a day cleaning of a trashrack compared to four times without one. The overall design life of a PVC or polyethylene pipe has to be greatly extended by not being exposed to constant abrasion by sand particles.

The SMRID has installed several settling ponds on their pipeline systems in the past few years and has found them working satisfactorily. Hadden feels that the maintenance required, on occasion, to remove sand and silt buildup in the ponds by draglines is not a problem.

In conclusion, both Renwick and Hadden feel that the Board's decision to use settling ponds where feasible, at the head of pipeline systems, is a good one and that the pond is a benefit to both the farmer and the district.

For more information, contact Ron Renwick, District Engineer, St. Mary River Irrigation District, PO Box 278, Lethbridge, Alberta T1J 3Y7; telephone (403) 328-4401.

SPOTLIGHT ON JACKSON LAKE DAM

Minidoka Project, Wyoming

Jackson Lake Dam and Reservoir are storage features of the Minidoka Project. "Minidoka" is a Shoshone Indian word meaning "wide expanse" and was used to describe the wide valleys and plains of the Snake River area. Jackson Lake Dam provides storage and regulation of water for irrigation and flood control. Located in Grand Teton National Park, the reservoir is a popular recreation and vacation site.

Jackson Lake Dam and Reservoir are located approximately 38 miles north of Jackson, Wyoming, on the South Fork of the Snake River at the outlet of Jackson Lake. Encompassing 310,000 acres, Grand Teton National Park was created 44 years after the dam was constructed, incorporating lands bordering Jackson Lake and the dam. As a result, Jackson Lake Dam is now located within the boundaries of a national park.

History

Jackson Lake, as a reservoir, dates back to 1902 and 1903 when the first surveys were made by the Reclamation Service (now known as the Bureau of Reclamation) in relation to the Minidoka Project and a gauging station established at the natural lake outlet on September 1, 1903. The original natural lake had a surface area of 17,100 acres. During 1905, 1906, and 1907, a temporary timber-frame dam was constructed at the outlet to provide about 200,000 acre-feet of storage for the Minidoka Project until the storage requirements could be ascertained. This temporary dam failed prior to completion of negotiations for a high dam. Jackson Lake Dam was constructed in 1910 and 1911 to provide 380,000 acre-feet of storage. Under the Jackson Lake Enlargement Project, the dam was raised 17 feet and the present concrete section installed. This work was completed in 1916.

SOD (safety of dams) modifications were performed from 1986 to 1989 to make the dam safe for earthquakes up to the maximum credible earthquake (MCE). The modifications performed were removal and replacement of the existing north embankment, densification of the north embankment foundation, treatment of the concrete dam foundation to provide stability, modifications to the outlet works, and modifications to the spillway piers. Jackson Lake Dam was rededicated July 17, 1989, following completion of the SOD modifications.

The outlet works modification consisted of the installation of 15 new slide gates and construction of new piers and a transition section in the conduits. Fifteen 72- by 96-inch cast iron gates with motor-operated lifts were installed for the outlet works on the face of the concrete section of Jackson Lake Dam. The gates are used to regulate the main flow of water through the dam. The outlet works invert elevation is 6728.0 feet.

Jackson Lake Dam

The dam is a concrete gravity dam with zoned earthfill embankment wings. The concrete gravity section is 222 feet long and has a structural height of 84 feet. The spillway and outlet works are located in the concrete section. The embankment section is approximately 4,540 feet long. Structural height is 52 feet, and crest width is 30 feet at elevation 6780.5.

Jackson Lake Dam has a spillway capacity of 8,690 ft^3/s and outlet capacity through 15 modified outlets of about 22,400 ft^3/s, both at reservoir water surface elevation 6769.0 feet. Total drainage area on the Snake River above the dam is 824 mi^2. The spillway, consisting of 19 timber-faced radial gates, was not modified during the SOD modification.

A Facility Manager operates and maintains the facility, residing at Jackson Lake Dam year-round.

Benefits

Jackson Lake Dam creates a reservoir for the storage and regulation of water for irrigation and flood control. The reservoir provides an active conservation storage of 847,000 acre-feet at elevation 6769.0 feet. The reservoir has a surface area of some 25,540 acres at elevation 6769.0 feet, and provides 70 miles of shoreline along its 16-mile length. The average annual outflow from the lake was 1,017,901 acre-feet of water from 1916 to 1982.

Construction of the dam at the headwaters of the Snake River contributed to the early expansion of the uninhabited sagebrush desert around the present cities of Burley and Rupert, Idaho. The combined facilities of the Minidoka Project eventually brought water to nearly 1.2 million acres in the arid Snake River Valley of eastern and southern Idaho, directly serving 170,000 people with project waters.

Jackson Lake storage presently provides benefits to functions which were not authorized as part of the original project. These additional benefits include headwater storage power enhancement on the Upper Snake River system, flood control, river recreation through fishing and float trips, and lake recreation through boating and fishing.

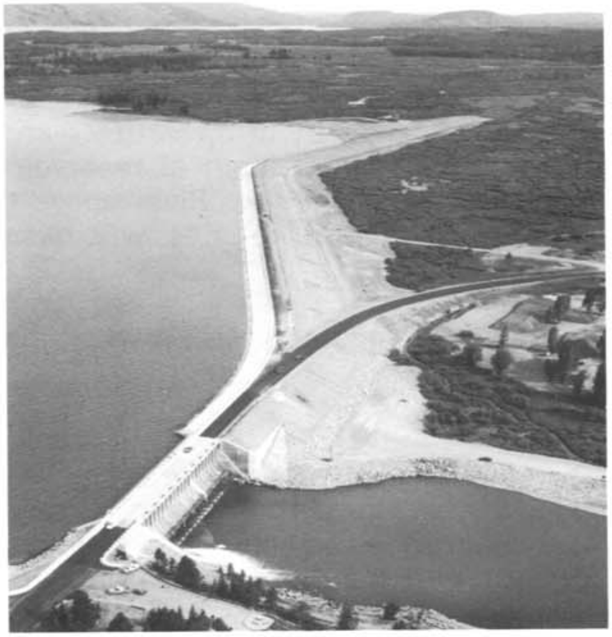


Photo 1. - Aerial view of Jackson Lake Dam looking north from south side of river showing completed dam and progress of reservoir filling. Reservoir is at elevation 6765.4 (maximum elevation is 6769.0). — Bureau of Reclamation photo by G. Walker. 6/20/89

Photo 2. - Aerial view looking north showing general view of Jackson Lake Dam with a full reservoir elevation 6769.0. Releases from the reservoir were 1700 ft^3/s at time photo was taken. — Bureau of Reclamation photo by Glade Walker. 7/17/89

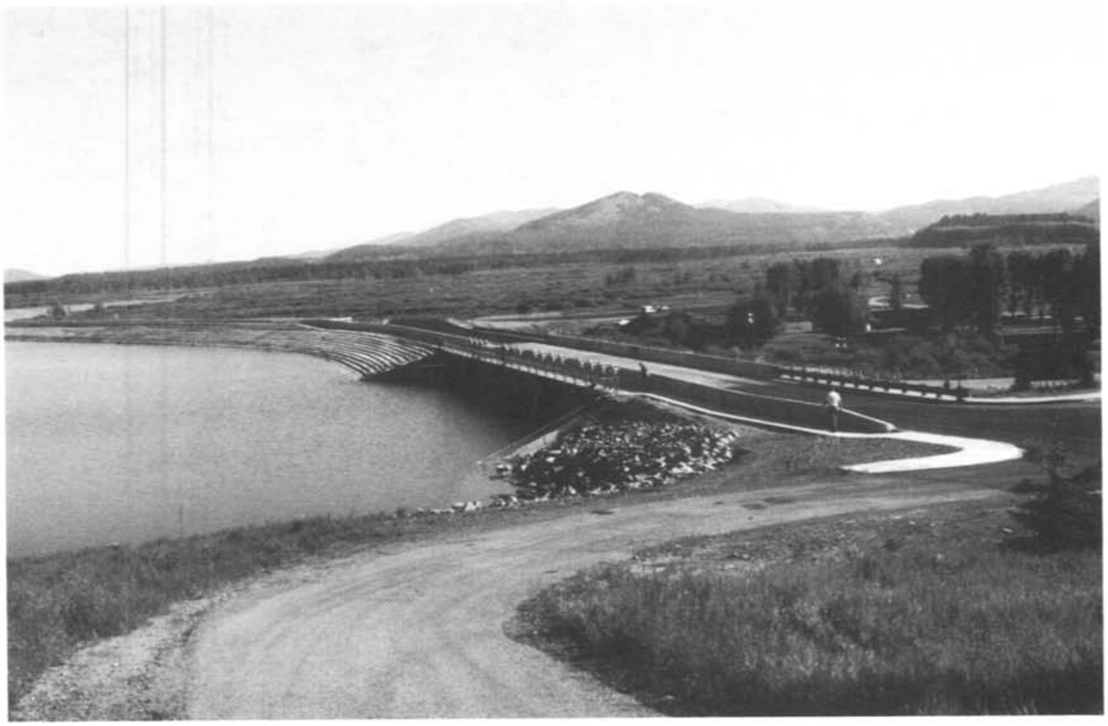


Photo 3. - View of Jackson Lake Dam and Reservoir at water surface elevation 6766.8. — Bureau of Reclamation photo by S. Bareis. 6/27/89

Photo 4. - The photo shows subcontractor constructing a new drainage ditch and rebuilding the embankment of the Teton Park Road to a 2.5:1 slope. Stockpiled fill material is at left, new ditch and temporary CMP at center, and alignment of old ditch (beneath loader) is at right. — Bureau of Reclamation photo by S. Bareis. 6/29/89

Photo 5. – View of warehouse building being moved from the old Reclamation maintenance area. This area will be turned into a parking lot, and the building will store boats at Colter Bay. — Bureau of Reclamation photo by S. Bareis. 6/26/89

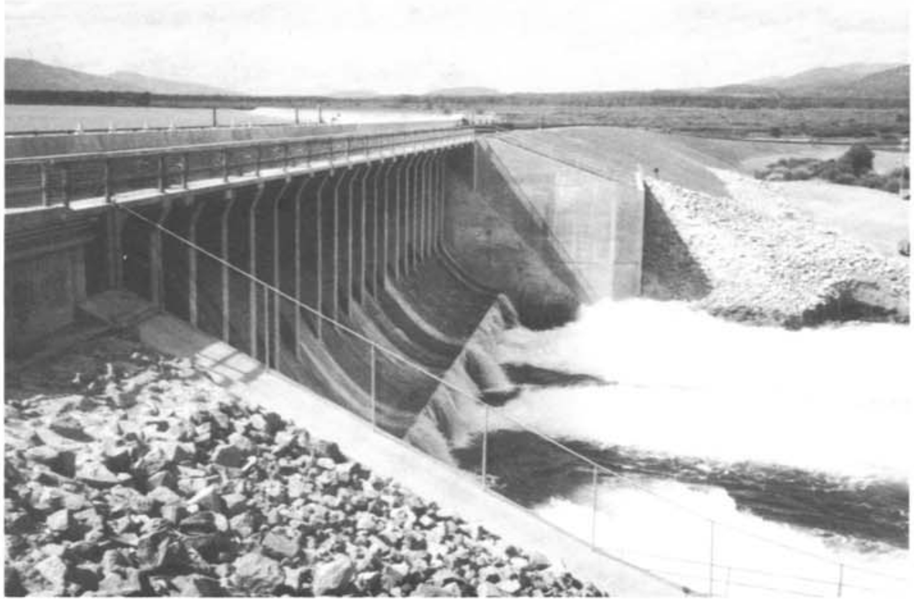


Photo 6. – Jackson Lake Dam discharging about 1,610 ft^3/s through the outlet works. — Bureau of Reclamation photo by Bill Bouley. 7/27/89

Photo 7. – Jackson Lake Dam spillway radial gate discharge.
— Bureau of Reclamation photo by Bill Bouley. 7/27/89

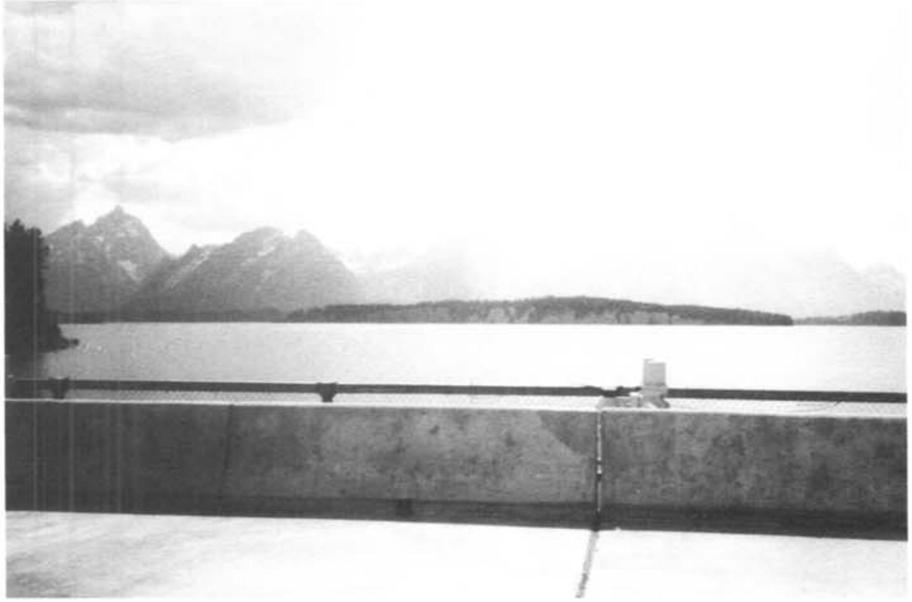


Photo 8. – Jackson Lake and the Grand Tetons as viewed from the dam operating deck. Lake elevation 6768.7 feet. Bureau of Reclamation photo by Bill Bouley. 7/27/89

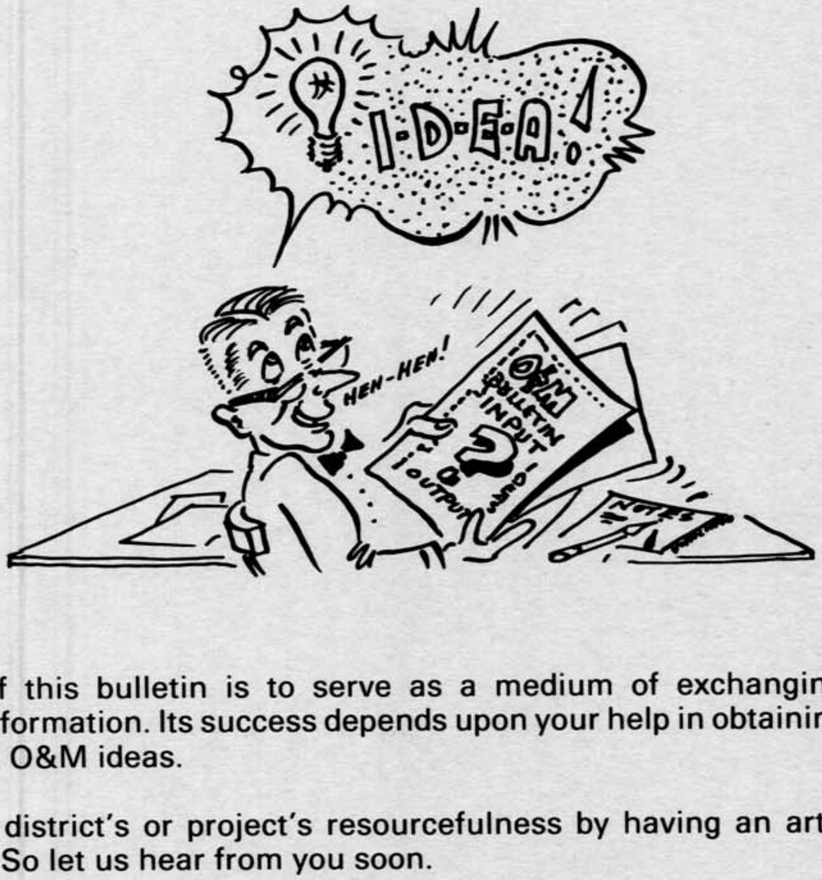
GPO 831-132

Mission of the Bureau of Reclamation

The Bureau of Reclamation of the U.S. Department of the Interior is responsible for the development and conservation of the Nation's water resources in the Western United States.

The Bureau's original purpose "to provide for the reclamation of arid and semiarid lands in the West" today covers a wide range of interrelated functions. These include providing municipal and industrial water supplies; hydroelectric power generation; irrigation water for agriculture; water quality improvement; flood control; river navigation; river regulation and control; fish and wildlife enhancement; outdoor recreation; and research on water-related design, construction, materials, atmospheric management, and wind and solar power.

Bureau programs most frequently are the result of close cooperation with the U.S. Congress, other Federal agencies, States, local governments, academic institutions, water-user organizations, and other concerned groups.



The purpose of this bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin! — So let us hear from you soon.

Prospective material should be submitted through your Bureau Regional office.