RECLAMATION

Managing Water in the West

APPRAISAL REPORT

Water Supply Augmentation

W.C. Austin Project, Oklahoma

U.S. Department of the Interior
Bureau of Reclamation
Oklahoma-Texas Area Office
Austin, Texas

March 2005

← COVER

Altus Dam at sunset, July 2004.
Photograph courtesy of Bureau of Reclamation, Austin, Texas. Digitally rendered into watercolor.

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Contents

Executive Summary

Altus Dam, 1986. The W.C. Austin Project is the first and only reservoir irrigation project in the State of Oklahoma. Photograph courtesy of Bureau of Reclamation, Denver, Colorado.

Altus Dam, a feature of the W.C. Austin Project, was constructed in 1946 for flood control of the North Fork Red River and to provide a supplemental irrigation water supply in southwestern Oklahoma. For nearly six decades, the Lugert-Altus Irrigation District (District) has delivered water from Lake Altus to local growers, increasing crop yield and value on about 48,000 acres. The demand for water supply and flood control continues to exist much as planned sixty years ago.

The purpose of this Appraisal Report is to analyze the nature of the water resource problems and needs confronting the W.C. Austin Project, and to examine potential opportunities for water supply augmentation. It concludes with a recommendation whether or not to proceed with a feasibility-level study of the alternatives.

Problems and Needs

The primary problem now confronting the District is a decreasing storage capacity due to sediment accumulation in Lake Altus. Sedimentation is a natural occurrence in surface water reservoirs that continually reduces available volume. At present, the sediment in Lake Altus is estimated to have replaced about 37 percent of the original conservation storage capacity. By 2050, sediment is projected to account for over 60 percent of this volume.

This storage capacity reduction is intensified by other factors that reduce net deliveries to farms. The aging delivery infrastructure experiences problems such as excessive conveyance losses and other operational inefficiencies during water deliveries. The present estimate of the total delivery system efficiency is about 65 percent. This means that of the 63,000 acre-feet released from storage by the District in an average year, only about 41,000 acre-feet are delivered to customers.

Because of these problems, Congress directed Reclamation to investigate potential opportunities to augment the water supply of the project.

Alternatives

Three potential alternatives to augment the water supply were developed to a conceptual level. In addition, two other alternatives that would improve operational efficiency were also developed because they would effectively increase the amount of water available for project purposes.

The water augmentation alternatives include the following:

1. Reusing municipal wastewater for irrigation;

2. Constructing a new reservoir upstream of Lake Altus to preserve existing project benefits (Trico Reservoir); and

3. Constructing a new reservoir downstream of Lake Altus to supplement the irrigation water supply (Cable Mountain Reservoir).

The efficiency improvement alternatives include the following:

A. Restoring a hydrologic connection to the upper reservoir pool; and

B. Eliminating system wasteway diversions during irrigation deliveries.

Each alternative was then evaluated with regard to: 1) the degree to which it offset the effects of reservoir sedimentation; 2) the estimated cost per acre-foot of supply made available; and 3) anticipated environmental impacts. This comparison appears in Table ES-1.

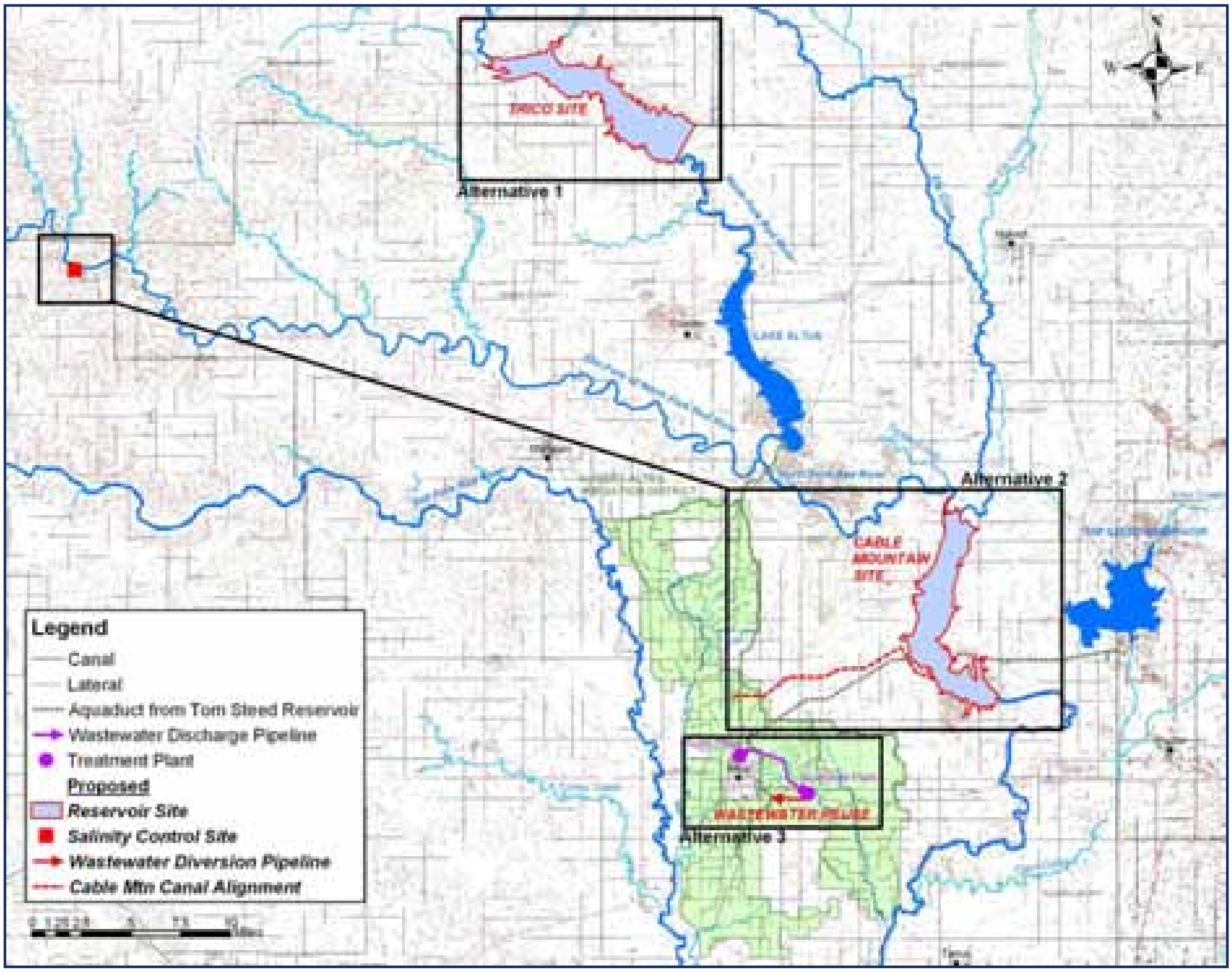
TABLE ES-1: Summary of the alternatives evaluated.

ALTERNATIVE		Estimated Supply (acre-feet/year)	No. of Sediment Equivalent Years Gained	Estimated Construction Cost per Volume ($/acre-foot)	Anticipated Environmental Impact
1	Wastewater Reuse	950 – 1,850	1 – 2	485 – 1,580	Low
2	Trico Reservoir	30,000 – 35,000	128 – 150	8,285 – 14,670	High
3	Cable Mtn. Reservoir	100,000 – 120,000	107 – 128	1,415 – 3,000	High
A	North Pool Restoration	3,000 – 5,000	3 – 5	90 – 240	Low
B	District Modernization	12,600 – 15,750	13 – 17	320 – 960	Low

Findings and Recommendation

The results of this appraisal study indicate a need exists to augment the water supply of the W.C. Austin Project. It is reasonable to expect that the continued reduction in the capacity at Lake Altus from sedimentation will begin to diminish the irrigation benefits of the project within the next 30 to 50 years. In addition, conveyance losses and operational inefficiencies, if not addressed, will continue to intensify water shortages whether from reduced storage capacity or drought.

Alternative 1 (Wastewater Reuse) was found to have an insufficient supply (only about 1,000 to 2,000 acre-feet per year) to justify the operational and maintenance expense, and was therefore not recommended to be investigated in a feasibility study.



Executive summary of the three water augmentation alternatives. Site locations and alignments are conceptual only.

The remaining two augmentation alternatives (Trico Reservoir and Cable Mountain Reservoir) were found to provide sufficient water volume but would incur high costs, have poor environmental acceptability and involve significant uncertainty. Because of these problems, neither of these alternatives was recommended to be investigated in a feasibility study at this time.

However, there do appear to be some feasible opportunities to address the water supply problem in the near-term by improving the operational efficiency of the project. When compared to the augmentation options, Alternatives A (North Pool Restoration) and B (District Modernization) were found to be relatively cost-effective and highly acceptable with regards to anticipated environmental impacts. If implemented, these two alternatives would increase the amount of water effectively available to the District by about 15,000 to 20,000 acre-feet per year. This increase would off-set the effect of lost storage capacity in the reservoir due to sedimentation by an estimated 16 to 22 years. During this period, resolution of issues that presently prohibit further study of augmentation alternatives could be sought, including:

- Conducting a sedimentation survey of Lake Altus to determine a more accurate estimate of the existing sediment volume and the rate of its accumulation. This information would help clarify the period of time during which the existing project benefits can be expected to continue.

- Determining the feasibility of controlling the chloride loading in the Elm Fork of the North Fork Red River. This information would help clarify whether or not surface water in the North Fork Red River could be rendered suitable for beneficial uses, and if so, at what costs.

Once these issues become better understood, a more accurate assessment of the future water supply conditions and opportunities in the study area would be possible. At that time, a re-assessment of potential water augmentation alternatives for the W.C. Austin Project would be prudent.

APPRAISAL REPORT

PART ONE: **Background**

Authority

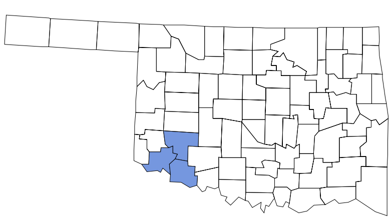
This appraisal study was conducted under the authority of the Federal Reclamation Act of June 17, 1902 (32 Stat. 388, 43 U.S.C. 391), as amended. Funding was provided in the Energy and Water Development Appropriations Act of 2004 (Senate Report 108-105), which states:

> "The Committee has provided $150,000 to expand the scope of the current W.C. Austin Water Availability Study to… *investigate potential opportunities for augmenting water supply* [emphasis added]."

Purpose

The purpose of this Appraisal Report is to analyze the nature of the water resource problems and needs confronting the W.C. Austin Project, and to examine potential opportunities for water supply augmentation. It concludes with a recommendation whether or not to proceed with a feasibility-level study of the alternatives. The information and analysis presented in this Appraisal Report were based on existing data, and the level of detail used to scope and evaluate potential alternatives was conceptual in nature.

The W.C. Austin Project



The W.C. Austin Project is a water supply project constructed by the United States Bureau of Reclamation (Reclamation) in Greer, Kiowa and Jackson Counties, Oklahoma (Congressional District #3, 108th Congress). The main project feature, Altus Dam, is located about 18 miles north of the city of Altus.

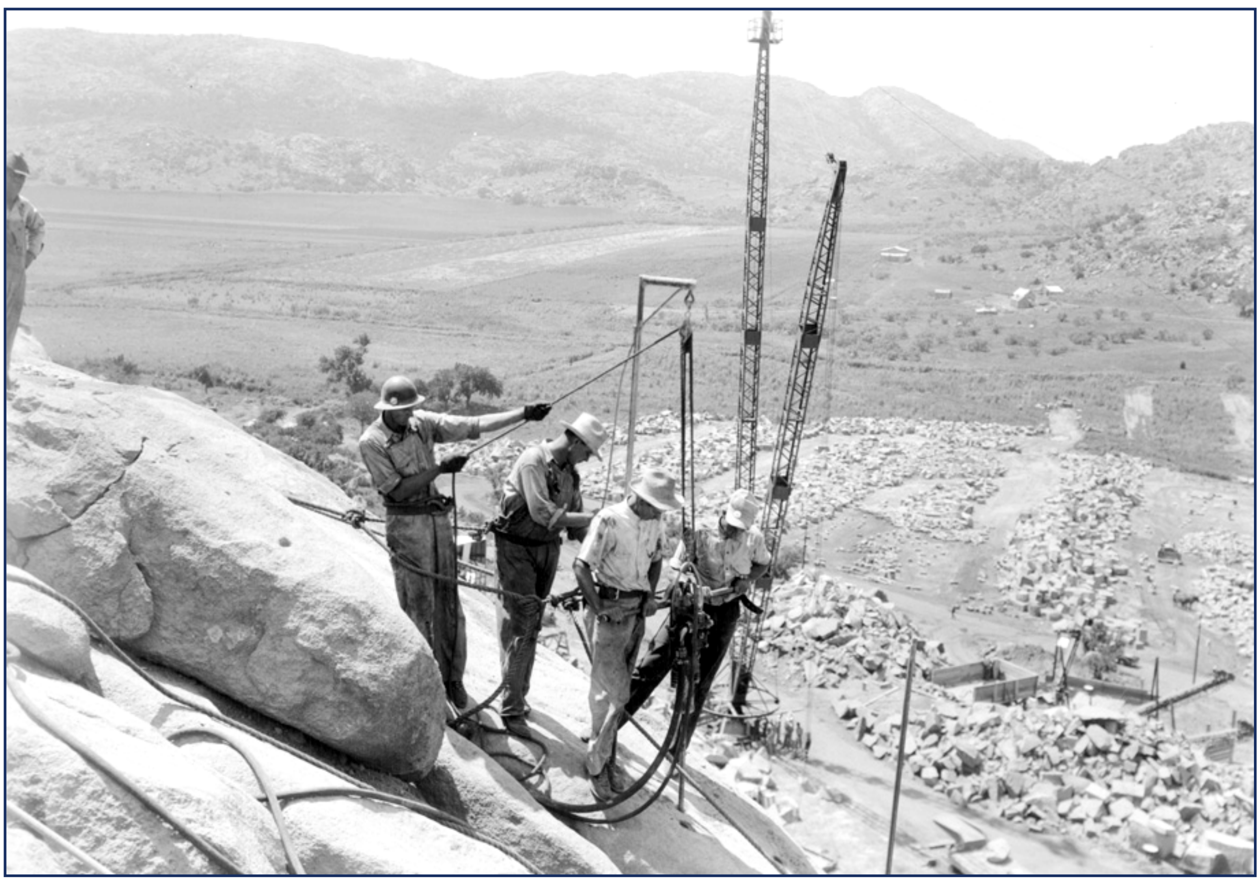
Project History

At the turn of the Twentieth Century in southwestern Oklahoma, the average annual precipitation of 26 inches per year was generally sufficient to produce fair to good dry-land crops. From about 1900 until the early 1940's, there were about 200,000 acres under dry-land cultivation in the region (Thompson and Keimig 1937). The principle crops grown were those which matured prior to the hot, dry weather of mid-summer, or those which were able to withstand that condition. Generally, these included cotton, winter wheat and grain sorghums, but small amounts of oats, corn, alfalfa, and barley were also grown. The long-term average monthly distribution in precipitation was adequate for dry-land farming, but the annual deviations from the average were sufficiently frequent and great to create deficiencies at some point in the growing season almost every year. Therefore, in years when precipitation amounts or distribution were unfavorable, crop yields were generally very poor.

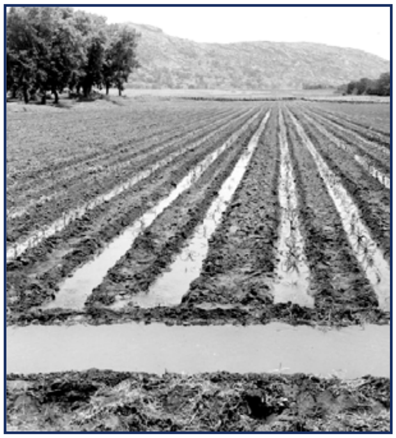
Investigations of the potential to develop the surface water of the North Fork Red River into an irrigation water supply began in the early 1900's and continued into the late 1930's. These efforts were proposed and supported primarily by state and local interests, including the citizens of the Altus and the Oklahoma Planning and Resources Board (now Oklahoma Water Resources Board). The primary objective of this interest was to develop a supplemental irrigation water supply that would support higher value crops and materially increase crop yields (Boegli 1953).

Reclamation initiated the first planning studies of this concept in 1902 and continued development of the project plan in subsequent years. In 1924, the U.S. Engineering Corps (now U.S. Army Corps of Engineers) assumed the lead role in project development through 1937. Then, through coordinated efforts between the War Department, the Resettlement Administration and Reclamation, the project investigations were formally placed back in charge of Reclamation for completion (Thompson and Keimig 1937). Reclamation issued a final report for the planned project in 1937 (United States Senate 1938).

Drilling crew at work on rock face of mountain above quarry bench, July 9, 1941. Below, granite blocks are separated by size and shape for use as facing or riprap in the construction of Altus Dam (National Archives and Records Administration 1941a).



Congress provided construction authority for the W.C. Austin Project under the Flood Control Act of 1938 (Public Law 75-761) in June 28, 1938, for the purposes of flood control and irrigation. Reclamation initiated construction in 1941, but activities were interrupted by World War II. Construction resumed in 1944, and Altus Dam was completed in 1946. Irrigation water was first furnished to a small acreage in 1945, but it was not until 1949 that the remaining distribution system was completed to serve the entire project (Water and Power Resources Service 1981).



Irrigation of field corn on the Demonstration Farm located below Altus Dam, May 29, 1945. This was the first delivery of irrigation water from the project (National Archives and Records Administration 1945). Irrigation water stored in Lake Altus is used to supplement local precipitation, significantly improving crop yield and value.

The significance of this water supply to a region with fresh memories of the 1930's drought is best expressed by the statement of Joe B. Zinn, then President of the Lugert-Altus Irrigation District, in dedication of the W.C. Austin Project:

> "A gigantic wall, cunningly placed, now protects us from the monster, Drouth with his searing breath and dry, dry heart. It is a wall of strength – a wall of promise – storing up future wealth. It is the dam which holds back a reservoir of life giving water for delivery to our crops when needed" (Altus Chamber of Commerce 1947).

On January 12, 1942, the District signed a repayment contract with the United States in the amount of $3,080,000[1] for the construction costs of the project. On November 19, 1990, the District made its last payment and fulfilled its obligation[2].

Project Benefits

Today, the W.C. Austin Project provides flood control of the North Fork Red River and water for irrigation of approximately 48,000 acres of privately owned land south of Lake Altus. In addition to these two original project purposes, the W.C. Austin Project also provides benefits for municipal and industrial water uses by the city of Altus, fish and wildlife conservation, and numerous public recreation opportunities.

The United States retains ownership of the W.C. Austin Project, which is administered by Reclamation. However, various project features are managed by different State entities. The Lugert-Altus Irrigation District (District) operates and maintains Altus Dam and the irrigation distribution facilities. The recreation facilities at Quartz Mountain Nature Park, which provide opportunities for camping, swimming, boating, fishing, hiking, picnicking, etc., are managed by the State of Oklahoma. Finally, the Oklahoma Department of Wildlife Conservation manages the Altus-Lugert Wildlife Management Area in the upper portion of the reservoir area,

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1 This amount was to be repaid in 40 annual installments over the period of 1951 to 1990 (Bureau of Reclamation 1942), and included a contract amount of $1,080,000 with the city of Altus covering the municipal water supply that was underwritten by the District.

2 The cost of funded operation and maintenance in the amount of $182,854 performed by Reclamation during the calendar year 1950 was added to the original repayment contract, bringing the total amount to $3,262,854 (Bureau of Reclamation 1970).

which provides numerous opportunities for a variety of public wildlife based activities.

Project Features

Altus Dam

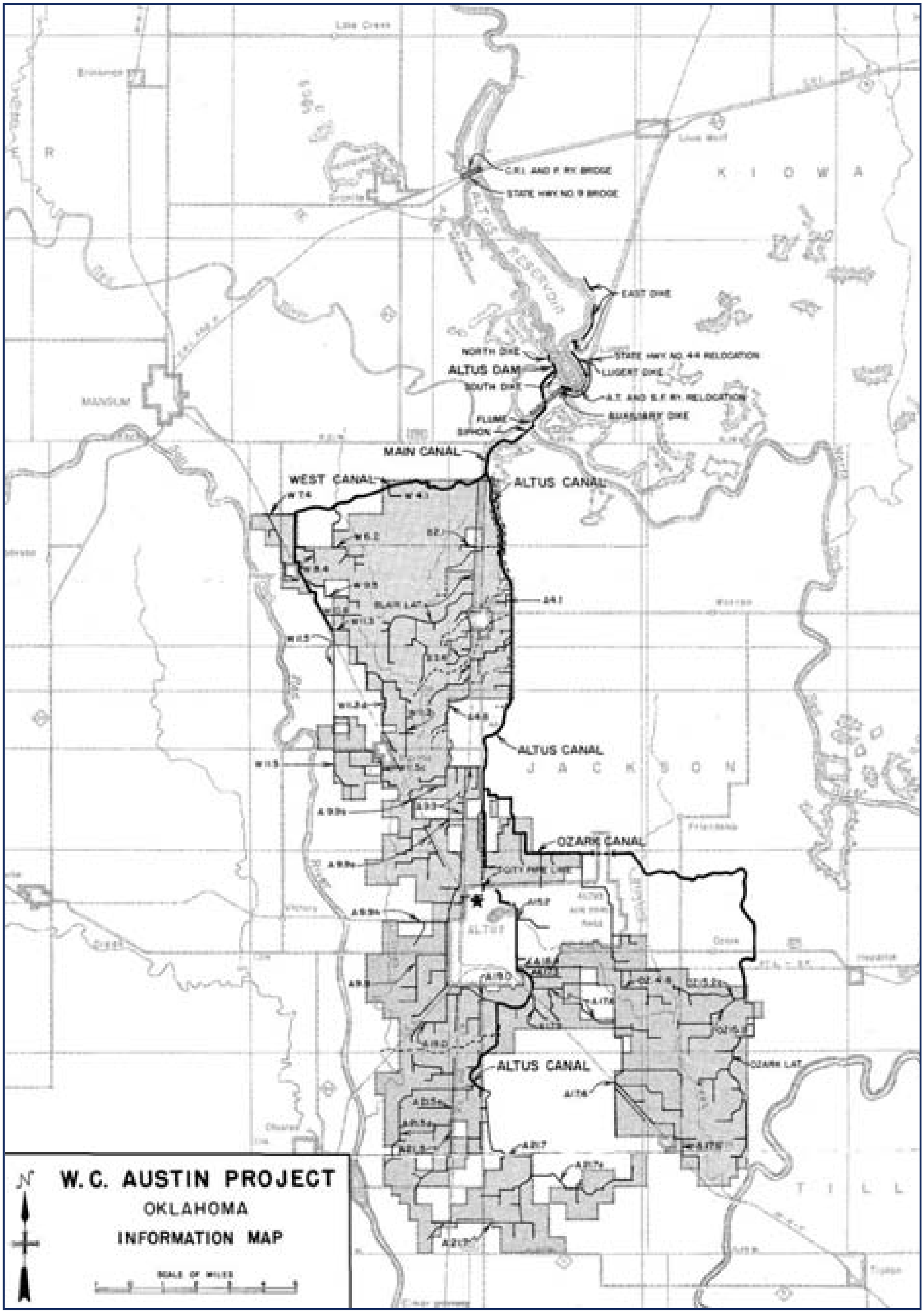
Altus Dam is a concrete-gravity type, partially curved structure rising 110 feet above the streambed and has a crest length of 1,104 feet. The dam is faced with granite masonry, except on the downstream side of the overflow section, and was the last masonry dam build by Reclamation (Autobee 1994). Incorporated within the dam section are both controlled and uncontrolled overflow-type spillways and an outlet works that delivers water to the canal system. The controlled spillway has a design capacity of 58,000 cubic feet per second (cfs) and is regulated by 9 radial gates.

Altus Dam with nine radial gates raised 0.4 feet discharging 2,000 cubic feet per second, June 14, 1949. With a reservoir elevation of 1,560.20, this event was the first intrusion into the flood control pool (National Archives and Records Administration 1949).

Lake Altus is divided into three operational pools, each having a specific purpose. These pools include the conservation pool, flood control pool, and surcharge pool. The conservation pool is the largest pool and is used to store water for irrigation and municipal purposes. The flood control and surcharge pools are smaller and temporarily store water from large rainfall events to reduce downstream impacts from flooding. There is also one small, non-operational pool referred to as the dead pool that is located below the conservation pool.

OPPOSITE PAGE →

The W.C. Austin Project. The primary project features are Altus Dam, Lake Altus and the Lugert-Altus Irrigation District (shaded).


W.C. AUSTIN PROJECT
OKLAHOMA
INFORMATION MAP
SCALE OF MILES
ALTUS DAM
NORTH DIKE
SOUTH DIKE
EAST DIKE
LUGERT DIKE
AUXILIARY DIKE
FLUME
SIPHON
C.R.I. AND P. RY. BRIDGE
STATE HWY. NO. 9 BRIDGE
STATE HWY. NO. 44 RELOCATION
A.T. AND S.F. RY. RELOCATION
MAIN CANAL
WEST CANAL
ALTUS CANAL
OZARK CANAL
OZARK LAT.
BLAIR LAT.
CITY PIPE LINE
ALTUS
MANGUM
K I O W A
J A C K S O N
T I L L

The original elevation of the river channel at the base of Altus Dam was 1,496.7 feet mean sea level (ft msl). The volume between this base elevation and the lowest outlet pipe (1,517.5 ft msl) was allocated to dead pool storage. The volume between the top of the dead pool to the crest of the uncontrolled spillway (1,559.0 ft msl) was allocated to conservation pool storage. From this point to the top of the radial gates (1,562.0) is the flood control pool, and from the top of the flood control pool to the dam crest (1,564.0) is the surcharge pool. The original volume capacities of each individual pool are presented in Table 1.

TABLE 1: Lake Altus pool elevations and original volume capacities.
Source: Lara 1967.

DESIGNATED POOL	Top Elevation (ft msl)	Individual Pool Capacity (acre-feet)	Gross Reservoir Capacity (acre-feet)
Surcharge	1,564.0	14,432	192,842
Flood Control	1,562.0	21,742	178,410
Conservation Storage	1,559.0	152,060	156,668
Dead Storage	1,517.5	4,608	4,608

Appurtenant reservoir structures constructed along with the dam include five dikes located at low places on the reservoir perimeter, including the Auxiliary, Lugert, East, North, and South Dikes. The largest, Lugert Dike, is 4,245 feet long and has a maximum height of 45 feet. Creation of the reservoir also required the relocation of the Atchison, Topeka and Santa Fe railroad and State Highway 44, and the reconstruction of the Chicago, Rock Island & Pacific railroad and State Highway 9 to a higher elevation.

Irrigation System

Water deliveries from Altus Dam are made through the Main Canal. The Main Canal has a design capacity of 1,000 cfs and transports water 4.2 miles to the northern boundary of the project. At this point, deliveries are separated into the West Canal and the Altus Canal. The West Canal, which has a design capacity of 290 cfs, continues from the end of the Main Canal west about 6 miles, then south for another 5.1 miles. The Altus Canal, which is designed to carry the remaining 710 cfs, continues from the end of the Main Canal south for about 21.7 miles through the city of Altus. About three and a half miles north of the city, the Ozark Canal (design capacity of 180 cfs) separates from the Altus Canal and continues generally south and east for a distance of 14.8 miles. The entire irrigation district includes a total of about 51.8 miles of canals, 218 miles of laterals, and 26 miles of drains. This delivery system serves both irrigation and municipal customers.

Water Use

The amount of water flowing into Lake Altus each year varies greatly. Droughts can be lengthy and flooding severe, and an “average” water year is difficult to define. Although Altus Dam was substantially completed in 1946, the facility began to operate in earnest as a multi-purpose reservoir 1951. Since 1951, the most water released and delivered from the project in a single year was 373,556 acre-feet (1997), and the least amount was 15,700 acre-feet (1953). Water releases into the North Fork Red River are made for flood control purposes, while deliveries into the Main Canal are generally made for irrigation, municipal and industrial water demands. Annual release and delivery amounts are summarized by project purpose in Table 2.

TABLE 2: Summary of releases and deliveries from Lake Altus, 1951-2003. All values reported in acre-feet. Source: water supply report data (Bureau of Reclamation 2004b).

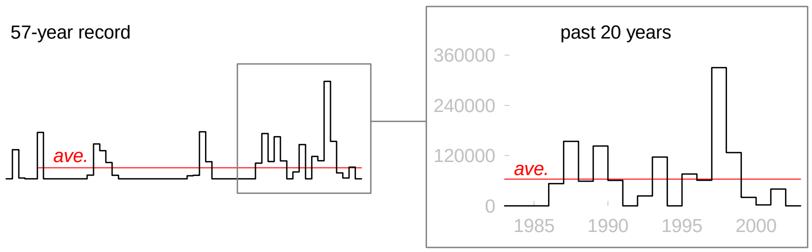
PURPOSE	Total for Period of Record	Annual Minimum	Annual Maximum	Annual Average
RELEASES				
Flood Control	1,956,174	0	330,724	36,909
DELIVERIES				
Irrigation	2,803,924	13,600	106,542	52,904
M&I	44,364	0	4,748	837
Other[3]	95,149	0	15,039	1,795

Irrigated cotton ready for harvest near the West Canal, October 14, 2004. From 2000 to 2003, Jackson County accounted for about one-half of the number of bales of cotton produced in Oklahoma and only about one-fifth of the harvested acres (National Agricultural Statistics Service 2004). Photograph courtesy of Bureau of Reclamation, Austin, Texas.

[3] Since the completion of Altus Dam, releases from Lake Altus for purposes other than flood control, irrigation or municipal and industrial needs have been made for calibration of outlet-works, State uses, adjustments for new area-capacity tables, and seepage (measurements beginning in November 1986) (Bureau of Reclamation 2004b).

Flood Control

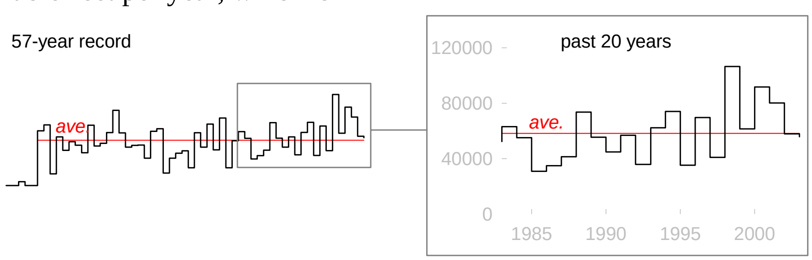
Flood control releases from Lake Altus are made when the reservoir rises into the flood pool. Since the completion of Altus Dam, such releases have been made in 26 out of 58 years, with the maximum annual release of 330,724 acre-feet occurring in 1997. The annual average flood control release since 1951 is about 36,900 acre-feet per year. However, the frequency of these events has increased in recent years. This increase is likely indicative of an increasing trend in precipitation for the region[4] coupled with reduced storage capacity as a result of sedimentation in Lake Altus. Over the past 20 years (since 1984), flood control releases have been averaging about 63,300 acre-feet per year, which is almost twice the historic average.



Irrigated Agriculture

An irrigation water right was granted to the District by the State of Oklahoma in 1939 (Application No. 39-23). This appropriation allows the District to divert up to 85,630 acre-feet per year from the North Fork Red River for the purpose of irrigation.

Annual water deliveries from Lake Altus for irrigation, which usually occur from late June through September, have ranged from a low of 13,600 acre-feet (1953) to a high of 106,542 acre-feet (1998). The average annual irrigation delivery from 1951 to 2003 is about 52,900 acre-feet per year. Over the past 20 years, irrigation deliveries have averaged about 58,200 acre-feet per year, which is slightly above the historic average. However, when the water-short years of this recent period are not considered, the average irrigation delivery is approximately 63,300 acre-feet per year. For the purposes of this Appraisal Report, it is assumed that the estimate of 63,000 acre-feet per year represents the present annual amount of water required from storage by the irrigation district under conditions when the water supply is adequate and water demand on the farm is not suppressed by direct precipitation.



Municipal and Industrial Uses

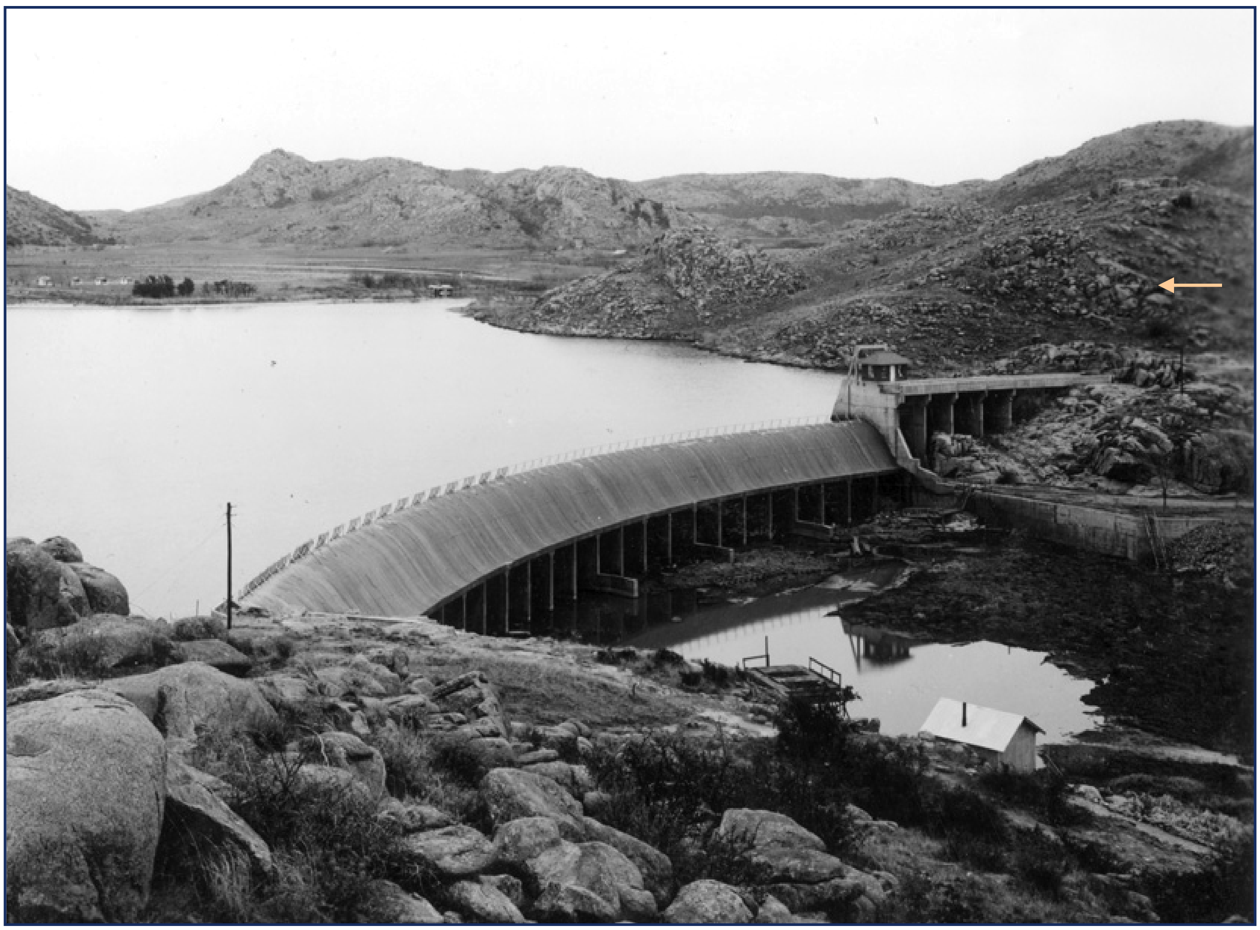
The State of Oklahoma granted the city of Altus a water right on the North Fork Red River in 1926 (Application No. 26-6). This appropriation allows the domestic, municipal and industrial use of the river by Altus through its municipal water supply system in the

[4] After analyzing 100 years of annual precipitation records, Smith and Wahl (2003) found a statistically significant trend for the period of 1945 to 1995, observing that average annual precipitation increased during this 51-year period by an average of 0.14 inch per year, or by a total of 7.14 inches.

amount of 4,800 acre-feet of water annually. In 1927, Altus completed a 46-foot high Ambursen[5] dam on the North Fork Red River to impound their municipal water. Water was delivered from this reservoir to the city by means of a buried redwood pipeline. However, the quantity of silt in the river had been significantly underestimated during project planning. Within 17 years, the use of Lake Altus Dam as a municipal storage facility had been "rendered practically useless" because of sedimentation (Autobee 1994). In the early 1940's Altus entered into contracts with the United States and the District to use the W.C. Austin Project to store their water allocation and deliver it to their treatment facilities. The original dam was then partially torn down during construction of the present Altus Dam, which incorporated the remnant of the Ambursen structure.

Lake Altus Dam, the original Ambursen-style dam built by the city of Altus prior to the W.C. Austin Project, January 4, 1941. The height of the new Altus Dam to be built, represented by a white line painted on the rocks, can be seen at the right end of the photograph as indicated by the arrow (National Archives and Records Administration 1941b).

In 1954, drought conditions seriously threatened the availability of water from the project. In March of that year, the volume of water stored in Lake Altus had fallen below 16,000 acre-feet and the District was preparing for the irrigation season. An injunction to stop the District from making irrigation water deliveries was filed by Altus on March 29th. In settlement of the issue, Altus and the District reached an agreement on April 1st, which stated:

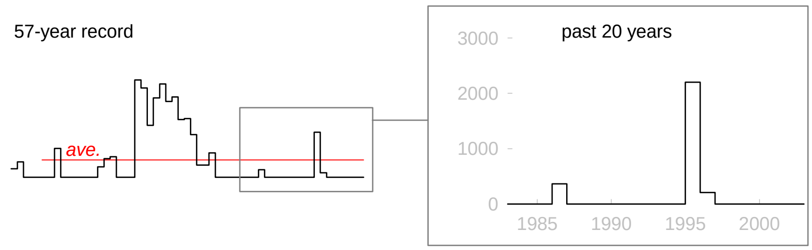


[5] The Ambursen Dam Company of New York City held the patent on this type of concrete and buttress design which was mainly found in the eastern United States (Autobee 1994).

> “The [Lugert-Altus Irrigation] District shall neither make nor order irrigation withdrawals from storage in Altus Dam and Reservoir which will reduce the active storage below 10,000 acre feet... It is understood that it is the intent of the parties hereto that upon completion of any irrigation run and filling of the city reservoirs (lakes) there shall remain in Altus Dam and Reservoir a minimum of 10,000 acre feet of active storage” (City of Altus 1954).

Consequently, although the amount of water appropriated to Altus by the State of Oklahoma had not changed, the effect of the agreement between Altus and the District was to ‘reserve’ 10,000 acre-feet of active reservoir capacity in Lake Altus for municipal needs[6].

Except for the period between 1966 and 1978, the actual municipal and industrial water use from Lake Altus has been minimal. The average delivery from storage for municipal and industrial needs since 1951 has been 837 acre-feet annually, but distribution of this demand is concentrated from the middle 1960’s to the late 1970’s. Over the past 20 years, water deliveries for municipal consumption have also been minimal. The reduced use of municipal and industrial water from Lake Altus beginning about 1978 likely reflects the use of an alternate water supply made available to Altus by the completion of Tom Steed Reservoir[7]. Since its completion in 1979, Tom Steed Reservoir has served as the principal municipal and industrial water supply for the communities of Altus, Snyder and Frederick.



Prior Studies

Water resources conditions in southwestern Oklahoma have been investigated by Federal and/or State agencies for almost a century. Such investigations have focused on a broad range of issues, including quantity and quality assessments, surveys of developmental potential, supply and demand projections, etc. Brief summaries of selected studies relevant to the current work are provided in Appendix A. A list of all sources cited in preparation of this Appraisal Report is presented in the References section.

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6 Since this agreement, the District has, on occasion, successfully petitioned Altus for a variance from the terms of the agreement to allow the District to use all or a portion of the 10,000 acre-foot reserved allocation on a year-by-year basis.

7 The Mountain Park Project, which includes Mountain Park Dam and Tom Steed Reservoir, was authorized by Congress as a Reclamation project in 1968 (Water and Power Resources Service 1981).

PART TWO: **Appraisal**

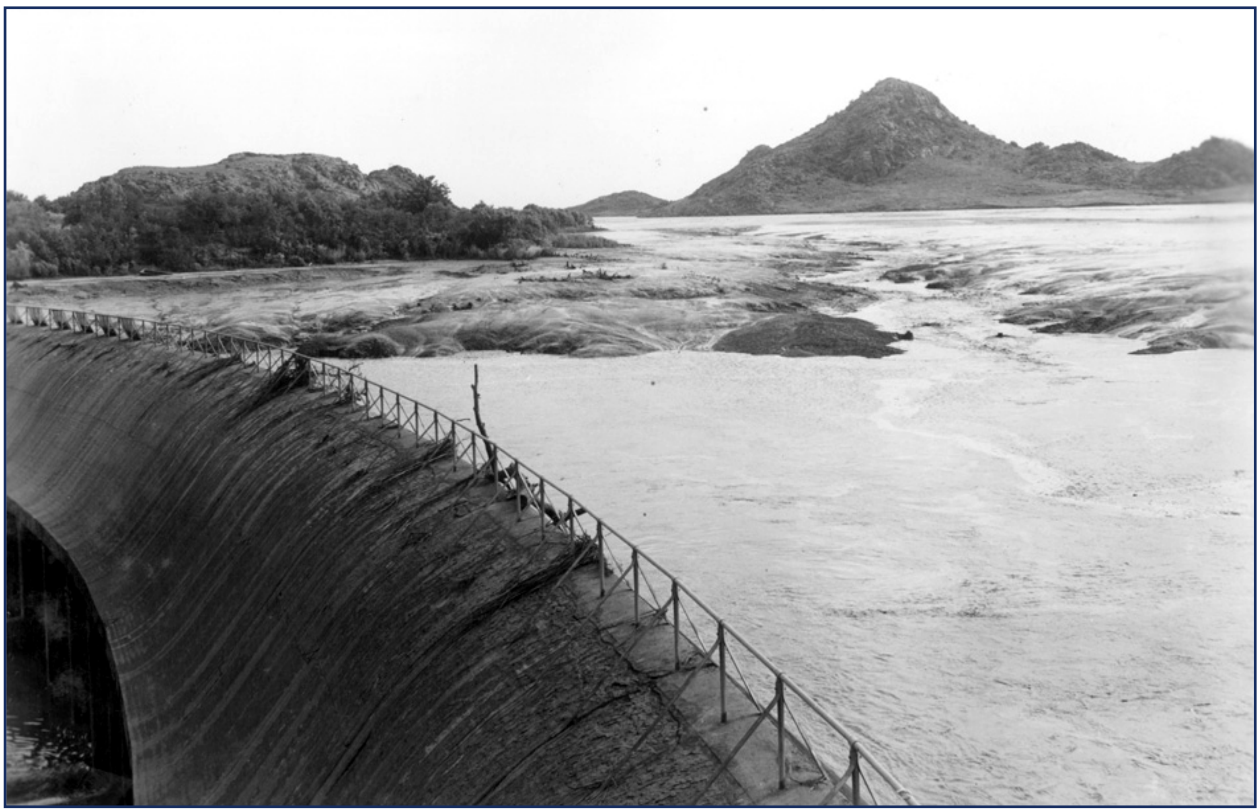
Problems and Needs

Primary Problem: Sedimentation of Lake Altus

Issue As previously discussed, the continued use of the city of Altus' municipal dam (Lake Altus Dam) on the North Fork Red River was quickly diminished by sediment accumulation. In fact, it was estimated that the storage capacity of Lake Altus Dam was reduced from approximately 13,100 acre-feet in 1927 to 4,930 acre-feet in 1937, or at a rate of approximately 911 acre-feet per year during this nine year period (Bureau of Reclamation 1938). By 1944, only about 700 acre-feet of storage capacity remained (Altus Chamber of Commerce 1947).

When the original water supply analysis of the W.C. Austin Project was conducted, an allowance of 43,000 acre-feet was made to account for future silting of the reservoir (Bureau of Reclamation 1938). With the assumption that this volume of reservoir storage capacity would be unusable in supplying irrigation demands, it was determined that water would be available to provide a full irrigation supply for an area varying from 20,000 to 70,000 acres, with an average of 47,000 acres (Bureau of Reclamation 1938).

View of accumulated sediment in Lake Altus Dam prior to the construction of the W.C. Austin Project, June 25, 1942. Captions on other photographs taken the same day indicate that the open water area in the lower right had been manually cleared of sediment prior to this date of the photograph (National Archives and Records Administration 1942). In preparation for construction of the new Altus Dam, the sluice gates of this dam were opened and areas downstream were covered with silt up to 50 feet deep in some places (Autobee 1994).



Since its construction in 1946, Lake Altus has continued to capture inflowing sediments from the North Fork Red River. In 1940, when the original contour survey for this project was conducted, it was calculated that there would be 192,842 acre-feet of storage capacity below the maximum water elevation of 1,564.0 ft msl (Seavy 1949). After its completion, contour and range surveys of Lake Altus were conducted by Reclamation in 1948, 1953 and in 1967. The most recent (1967) survey revealed that the total reservoir capacity had been reduced by about 13 percent due to sediment accumulation during the 26.4 year period since the original survey (Lara 1971). This loss translated into an average sedimentation rate of about 937 acre-feet per year. Since 1967, sediments have continued to accumulate in Lake Altus, but the exact amount or rate is unknown.

Implications The displacement of available reservoir capacity by sediment reduces the ability of the project to provide the designed benefits. For example, sedimentation in the surcharge and flood control pools lessens the volume of water that can be retained during a flood event and thereby reduces the ability of Altus Dam to protect downstream interests. Similarly, sedimentation in the conservation pool reduces the amount of water that can be stored in Lake Altus for irrigation and other purposes, rendering these purposes more vulnerable to dry climatic periods.

Because the effects of sedimentation are realized over time, predicting future impacts to project benefits from sedimentation requires extrapolation of observed rates. Not having more recent survey data available, Reclamation has estimated future sedimentation impacts to Lake Altus based on the results of this 1967 survey. Assuming that sediment had continued to accumulate in Lake Altus at a rate of 937 acre-feet per year, this analysis estimates the present (2005) conservation pool capacity to be approximately 99,350 acre-feet (Ferrari 1991)[8]. If accurate, this estimate would represent a reduction of over 57,000 acre-feet (37 percent) from the original conservation volume. This analysis also indicates that the 43,000 acre-foot sedimentation allowance was filled by about 1989.

Continuing the extrapolation of projected sedimentation into the future, several operational conditions may be defined in terms of their occurrence in time. For example, beginning about the year 2009, the storage capacity of the conservation pool is projected to be insufficient to contain the full irrigation water right held by the District (85,630 acre-feet) and the agreed storage allocation for municipal and industrial water (10,000 acre-feet). Similarly, beginning about the year 2034, the storage capacity of the conservation pool is projected to be insufficient to contain the average annual irrigation use of the District (63,000 acre-feet) and the agreed municipal and industrial storage allocation. Finally, by the year 2050, the conservation storage capacity of Lake Altus is

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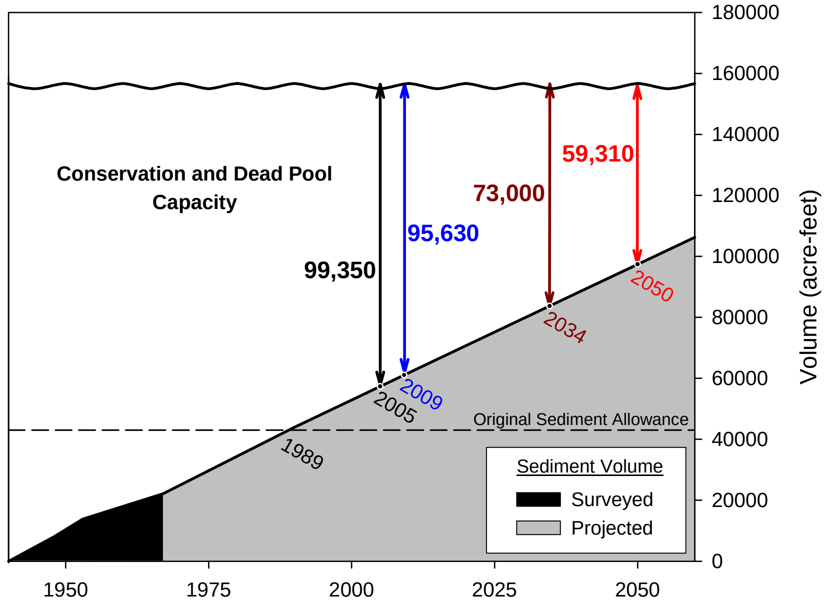
[8] For his study, Ferrari (1991) assumed no future changes in the size of the contributing basin, compaction and density of sediment deposits and trap efficiency of Altus Dam.

projected to be only about 59,300 acre-feet. Each of these temporal relationships may be displayed graphically:

Illustration of surveyed and projected sediment volume in Lake Altus. All values reported in acre-feet using the estimated sedimentation rate and distribution classification reported by Ferarri (1991).



A tabular summary of the surveyed and predicted capacities of Lake Altus is presented in Table 3:

TABLE 3: Summary of surveyed and projected sediment volume in Lake Altus for selected dates from 1940 to 2050. All values reported in acre-feet using the estimated sedimentation rate and distribution classification reported by Ferarri (1991). The black portion of each pie chart indicates the relative (%) volume of accumulated sediment.

DATE	Surcharge and Flood Control		Conservation and Dead Storage		TOTAL RESERVOIR	
	Remaining Capacity	Sediment Volume	Remaining Capacity	Sediment Volume	Remaining Capacity	Sediment Volume
1940 Surveyed	36,174	0	156,668	0	192,842	0
1967 Surveyed	33,568	2,606	134,549	22,119	168,117	24,725
2005 Projected	*33,157*	*3,017*	*99,353*	*57,315*	*132,510*	*60,332*
2009 Projected	*32,961*	*3,213*	*95,630*	*61,038*	*128,591*	*64,251*
2034 Projected	*31,770*	*4,404*	*73,000*	*83,668*	*104,770*	*88,072*
2050 Projected	*31,050*	*5,124*	*59,313*	*97,355*	*90,363*	*102,479*

At some point in time, continuing sedimentation and the associated reduction in reservoir storage capacity will begin to diminish the economic benefits of the project. The analysis presented here indicates that the ability of Altus Dam to store sufficient irrigation water could begin to be limited within the next 30 to 50 years.

From an operational perspective, assuming inflow patterns remain relatively constant, a decreasing available storage volume will result in more frequent and greater magnitude flood releases and spill events. This water will not be available for irrigation, and the District will become increasingly dependent upon direct precipitation. Also, as active storage capacity declines, the impact of seasonal irrigation draw-downs on the water level in Lake Altus will become more dramatic, increasingly impacting and changing the recreational use of the reservoir.

Secondary Problem: Operational Inefficiencies

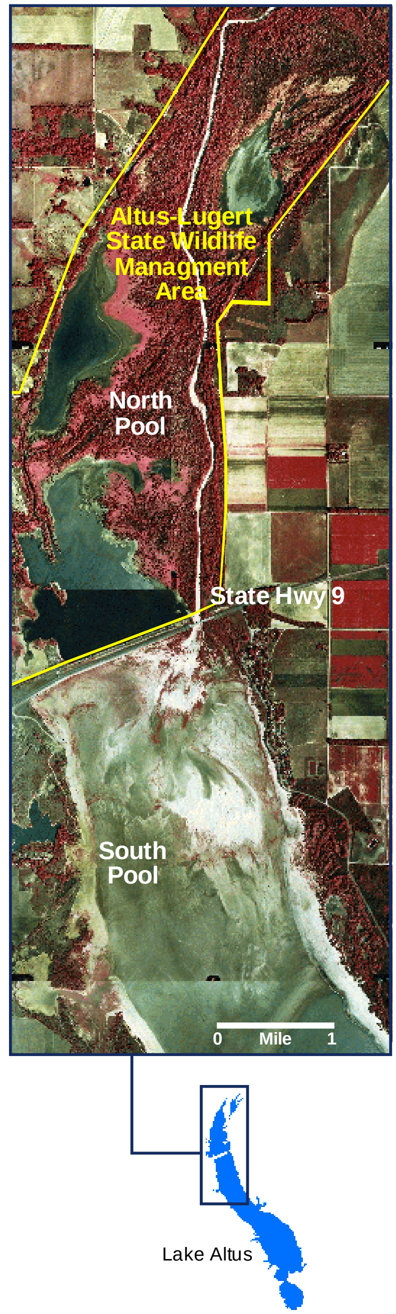
Inaccessible Storage in Lake Altus

Issue The earthen approaches of the reconstructed State Highway 9 crossing (Granite Bridge) effectively separate Lake Altus into two pools by constricting the hydrologic connection between them. For the purposes of this Appraisal Report, these two pools are referred to as the “north” and “south" pools of Lake Altus. Both pools comprise the conservation pool of Lake Altus, and therefore both are used for water storage when inflow is sufficient.

The north pool receives water from the North Fork Red River through either high reservoir elevations or flooding river conditions. Although the river channel maintains a narrow hydrologic connection between the two pools, sediment accumulation[9] along its banks often prevents the natural draining of water into the south pool. The result is the formation of large, seasonal backwater areas in the north pool that are isolated from the lower reservoir area where most recreational use occurs.

Implications Water trapped in the north pool is not accessible from the south pool, and much of it is lost to evaporation during the summer months[10]. Although the volumes involved are relatively small compared to the annual irrigation water need from storage (estimated at about 2 to 4 percent), this loss reduces the amount of water available from the project for irrigation.

Furthermore, this condition also impairs the management of the Altus-Lugert Wildlife Management Area (WMA)[11], which comprises most of the north pool. As previously discussed, the Oklahoma Department of Wildlife Conservation (ODWC) presently manages the WMA for wildlife and waterfowl production. During the spring months, an early spring draw-down is needed to germinate annual vegetation species preferred by waterfowl during the fall and winter. Without control of the water level in the north pool, the WMA is often flooded during the spring season, and a slow draw-down (by evaporation) does not occur until the late summer. This delay limits the development of quality habitat in the area.



Aerial view of the upper reaches of Lake Altus, September 25, 1998. The color infrared imagery, acquired at the end of the irrigation season, clearly shows water inaccessibly stored in the ‘north’ pool of the reservoir. Imagery courtesy of Bureau of Reclamation, Austin, Texas.

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9 Sediment accumulation patters differ between the north and south reservoir pools. The most recent sediment survey conducted in 1967 found the average sediment depth four miles upstream of Granite Bridge was about 14.6 feet, while the average depth for the four miles downstream of the bridge was only 8.8 feet (Lara 1967).

10 At the conservation pool elevation, the surface area of the north pool is estimated to be approximately 1,000 acres. Evaporative loss from this area from June through August is estimated to be about 15 acre-feet per day.

11 At present, the 3,600 acre WMA consists mainly of riparian river and slough corridors, ephemeral pools with emergent and submerged vegetation, and heavily wooded bottomland.

Conveyance Losses

View of freshly laid plastic soil-cement canal lining in West 11.5 Lateral, May 5, 1947. The paver and mixer traveled at a rate of five feet per minute while soil-cement material was distributed into the hopper by hand (National Archives and Records Administration 1947a). This and other low-cost liner applications were used to minimize water loss in high seepage areas of the canal and lateral system.

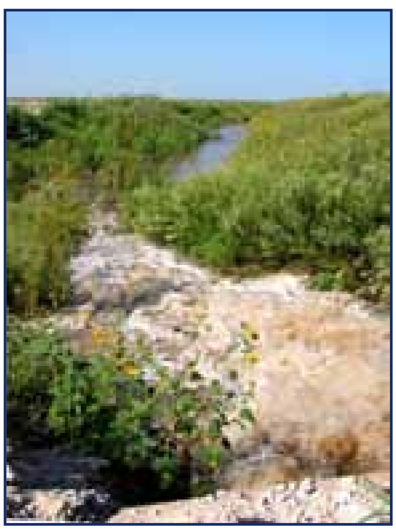
Issue As with most irrigation systems, the conveyance system of the District experiences some degree of water loss while making deliveries. Primarily, these losses are due to canal seepage and wasteway diversions, the later of which are more significant with regard to volume.

As was expected, seepage from the canals and laterals occurred shortly after project irrigation deliveries began in 1946. Since that time, various actions have been implemented to control seepage, including the installation of several main drains in areas with high water tables and the surfacing of several canal sections with low-cost liners[12]. When operation and maintenance of the project was turned over to the District on October 1, 1952, all the major seepage problem areas that had been identified had been or were being relieved (Bureau of Reclamation 1985). At present, canal seepage still occurs to some extent during the irrigation season, resulting in the loss of water and some land forced out of production.

Wasteway diversions occur when the amount of water in the canal system exceeds the actual on-farm demand of the grower. In this case, excess water is diverted into confined wasteway channels and passed into local creeks or rivers. Such diversions are often referred to as system 'spills,' even thought they are controlled and intentional.

Wasteway diversions can occur on a small scale due to inadequate measurement and control capability within the conveyance system or on a large scale when heavy rainfall events leave large quantities of water on fields, quickly reducing the demand for irrigation water. Notwithstanding the cause, water released from storage in Lake Altus but not delivered to end customers is lost to project purposes.

Excess irrigation water being diverted into the wasteway at the end of the Altus Canal, July 16, 2004. The flow rate at the time of the photograph was estimated to be about 50 cubic feet per second. Photograph courtesy of Bureau of Reclamation, Austin, Texas.



Implications The relative volume of conveyance losses may be estimated using crop census data reported by the District to Reclamation each year (Bureau of Reclamation 2003). Analysis of this data indicates that over the past 20 years (1984 to 2003), the total delivery system efficiency of the irrigation system was about 65 percent. Of the 35 percent loss, 13 percent is estimated to be a result of seepage and evaporation and 22 percent is estimated to be a result of wasteway diversions. This means that of the 63,000 acre-feet released from storage by the District for irrigation in an average year, only about 41,000 acre-feet are delivered to the fields of growers.

Throughout the history of the project, the District has proactively pursued financing and implementation of more effective water conveyance, measurement and control technologies. Most recently, the District, with assistance from Reclamation, has begun to implement flow measurement improvements and automate control

12 These liner types generally included compacted clay, sprayed and pre-fabricated asphaltic membranes, and soil-cement (Bureau of Reclamation 1985).

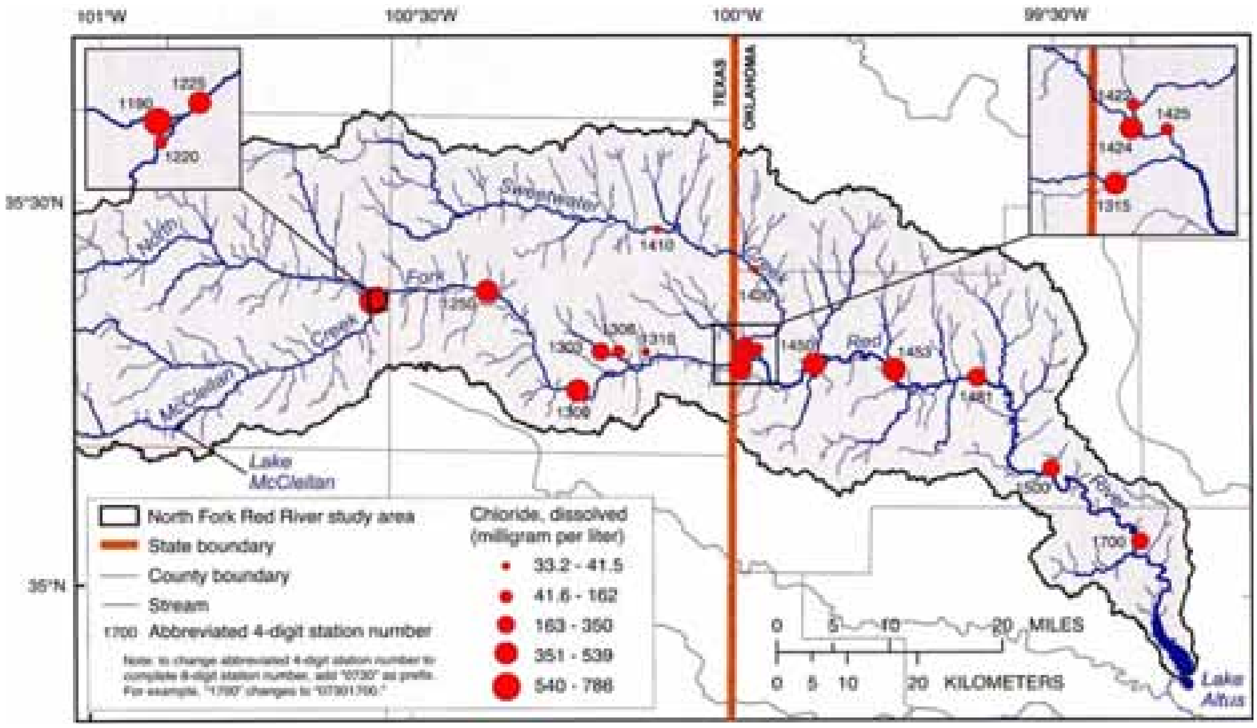
gates. Although these activities are expected to continue as funding allows, significant delivery water losses remain.

Other Problems That Limit Potential Solutions

Poor Water Quality

Issue The U.S. Geological Survey has identified the potential for agricultural practices, petroleum production and natural dissolution of salt-bearing bedrock to adversely influence the quality of surface water upstream of Lake Altus (Smith et al. 2003). In the North Fork Red River, water chemistry has been closely related to the chemical composition of the underlying bedrock. The concentration of dissolved solids, especially sulfate and chloride, generally increases downstream as the river passes over salt-bearing rocks (Smith and Wahl 2003). Of the major tributaries above Lake Altus, Sweetwater Creek provides the best quality of water.

North Fork Red River basin upstream of Lake Altus with graduated symbols representing chloride concentrations, July 8 to 11, 2002. Map originally complied by United States Geological Survey (Smith et al. 2003). With regard to chloride, the difference in concentrations between the two major streams contributing to Lake Altus, the North Fork Red River and Sweetwater Creek, are apparent.



Storage and mixing in Lake Altus serves to average out the loading contributions of various streams and tributaries and to reduce dissolved mineral concentrations. Lake Altus water is extensively used for irrigation[13] even though it has a marginal value for such use due to elevated dissolved solids.

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13 Drainage and associated salt accumulation problems have previously occurred within the boundaries of the irrigation district, primarily in areas adjacent to portions of the main canals and laterals where there is excessive seepage. This problem has been addressed over the years by installing over 26 miles of drainage pipe. Most of the salted out locations in the district have been identified and drainage pipe installed, although a few locations still need work. In general, salt accumulation from applying water to the field is not reportedly a problem as long as there is sufficient drainage (Buchanan 2004).

Regionally, the upper reaches of Otter Creek exhibit the best water quality, but salt concentrations increase in the lower reaches of the stream, probably due to an alluvial influence by the North Fork Red River (Oklahoma Water Resources Board 1967). Water quality in other regional streams, including the Salt Fork Red River, are generally intermediate and lie within that of the North Fork Red River and Otter Creek. The poorest quality of surface water in the region is in Elm Fork of the North Fork Red River, which joins the North Fork Red River just downstream of Altus Dam. Because of this confluence, water quality in the North Fork Red River below Altus Dam is considerably poorer than that above Altus Dam.

Poor water quality in this area of the State, however, is not a recent development. Thompson McFadden, a civilian scout serving in the Indian Territory Expedition, traveled through much of the headwater country of the Washita River, North Fork Red River and Salt Fork Red River for five months during 1874. While in the upper basin of the Salt Fork Red River (Donley County, Texas), McFadden gave the following account:

> "August 29th: Leave McClellan Creek and follow the trail across a high rolling prairie, a distance of twenty-four miles, to Elm Fork of White Fish Creek, a beautiful running stream of water, but scarcely any grass. After a short halt to refresh our horses and ourselves, we proceed twelve miles farther over a very rough country bordering the Salt Fork of the Red River. We camp on the above named stream. The surrounding country is composed of cedar brakes and deep canyons. The vegetation is sage-brush and cactus. The water, what little there is, being very salty, almost unfit to use and a very poor article to quench thirst. Even the Indians had made no halt here. Our horses fared badly for there was absolutely nothing for them to eat.
>
> "August 30th: After a miserable night of thirst and lying in the sand burrs, we are in the saddle at daylight and follow the trail through a very rough cedar canyon country for about six miles. We emerge upon a beautiful stretch of tableland eight miles wide and almost as level as a floor. While riding up a ravine this morning, on the left flank of the column, I came across a beautiful little spring of water bubbling out from under the roots of a cedar tree and sinking into the sandy soil within a few feet of its source. I gave a little cry of delight, which was answered by a friendly nicker from my horse. Springing from my saddle, I laid aside my sombrero and, flopping flat on my belly with a 'Thank God' for the blessing, I gulped down about a gallon of water which was quite cold. I only desisted when out of breath, when, horror upon horrors, I found it more salty than the stream upon which we had camped, with the addition of something as bitter as quinine and puckering my mouth like green persimmon. These bitter springs are a peculiar feature of the country. I don't think I've uttered another prayer today" (Carriker 1971).

Implications Significant natural improvement in the surface water quality of the study area is not expected because much of the problems are predominantly influenced by underlying geology. If this surface water is to be made available for use, salt pollution must either be prevented at the source (control) or removed prior to use (desalinization). Some studies of the greater Red River basin have indicated that salting influences could be feasibly controlled, including those of the Elm Fork Red River (Corps of Engineers 1996). Similarly, existing desalination technologies are widely used and are effective at salt removal. However, in the absence of such actions, the natural pollution of regional streams will continue to limit the suitability of surface water in the study area and preclude its development a source for water supply augmentation (Oklahoma Water Resources Board 1967).

North Fork of the Red River near Headrick, July 8, 2004. The Oklahoma Water Resources Board (1967) found that a "large quantity of water of poor quality" flows down this stream annually with is not suitable for municipal, industrial or irrigation due to the natural pollution coming from the Elm Fork. Photograph courtesy of Bureau of Reclamation, Austin, Texas.

Compact Provisions

The Red River Compact (Compact) was signed by member states in 1978 to resolve and prevent disputes over waters of the Red River Basin that are shared between the neighboring states of Arkansas, Louisiana, Oklahoma and Texas, and to assure the receipt by member states of adequate surface flows and releases[14]. While provisions of the Compact specifically state how much water each signatory state is allowed to develop or store on an interstate stream, the Compact generally provides a means of working out problems between member states in an orderly manner, thus preventing the likelihood of litigation in most cases.

Issue Section 4 of the Compact addresses Subbasin I, which includes the Texas portion of Buck Creek, Sand (Lebos) Creek, Salt Fork Red River, Elm Fork, North Fork Red River, Sweetwater Creek and Washita River, together with all their tributaries in Texas which lie west of the 100th Meridian. Of these, the North Fork Red River and Sweetwater Creek contribute inflow to Lake Altus. Section 4.01(b) prescribes that:

> "The annual flow within this subbasin is hereby apportioned sixty (60) percent to Texas and forty (40) percent to Oklahoma" (82 O.S. §1431).

Reflecting the compromise of a long-standing dispute between Oklahoma and Texas over the water of the North Fork Red River and Sweetwater Creek, Section 4.01(b) of the Compact was modified in part by Section 4.05(b) Special Provisions, which states:

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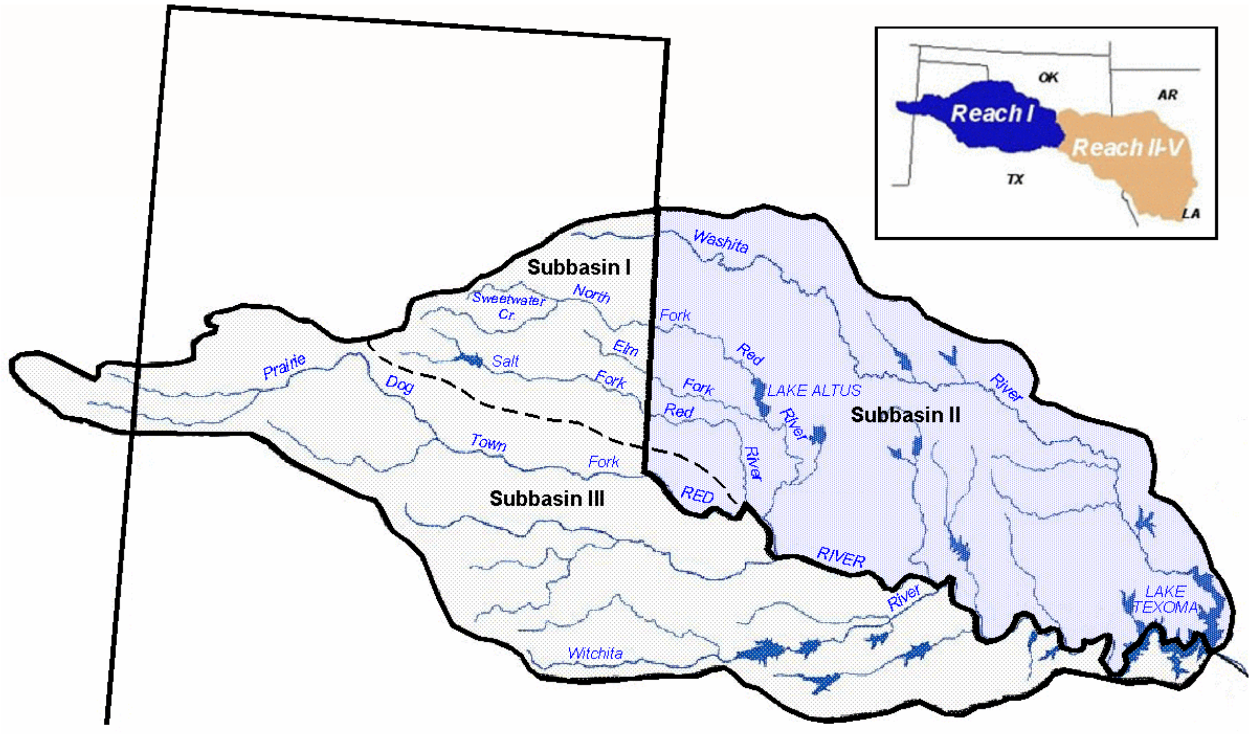
[14] The stated purposes of the Red River Compact are:

(a) To promote interstate comity and remove causes of controversy between each of the affected states by governing the use, control and distribution of the interstate water of the Red River and its tributaries;
(b) To provide an equitable apportionment among the Signatory States of the water of the Red River and its tributaries;
(c) To promote an active program for the control and alleviation of natural deterioration and pollution of the water of the Red River Basin and to provide for enforcement of the laws related thereto;
(d) To provide the means for an active program for the conservation of water, protection of lives and property from floods, improvement of water quality, development of navigation and regulation of flows in the Red River Basin; and
(e) To provide a basis for state or joint state planning and action by ascertaining and identifying the share of each state in the interstate water of the Red River Basin and the apportionment thereof (82 O.S. §1431, Section 1.01).



The subbasins of Reach I of the Red River Compact. The Compact apportions 60% of the annual flow within Subbasin I, which includes tributaries to Lake Altus, to the State of Texas. Subbasin IV (not identified) includes the main stem of the Red River and Lake Texoma.

> "Texas shall not accept for filing, or grant a permit, for the construction of a dam to impound water… for any other purpose other than for domestic, municipal, and industrial water supply, on the main stem of the North Fork Red River or any of its tributaries within Texas above Lugert-Altus Reservoir until the date that imported water sufficient to meet the municipal and irrigation needs of Western Oklahoma is provided, or until January 1, 2000, whichever occurs first" (82 O.S. §1431).

The State of Texas, when planning for the future water demands of the Texas Panhandle, did not propose any additional[15] reservoirs for construction through the year 2050 (Texas Water Development Board 2002). However, the Texas Region A Planning Group (which represents the Texas Panhandle) did recommend that a potential reservoir site on Sweetwater Creek be eligible to receive funding to conduct feasibility studies for evaluating its potential yield (Texas Water Development Board 2002).

Implications With the expiration in 2000 of the Compact limitation placed on impoundments (Section 4.05(b)), Texas can now pursue multi-purpose development of its share of these interstate tributaries under the terms of the Compact. It has been estimated that a reduction of 60 percent to the annual flow from both the North Fork Red River and Sweetwater Creek could decrease the water supply of Lake Altus by about 20 to 30 percent (Bureau of Reclamation 1994).

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[15] The only existing storage reservoir in Texas on the North Fork Red River or its tributaries above Lake Altus is Lake McClellan, a small reservoir constructed on McClellan Creek in the late 1940's. It has a capacity of 5,005 acre-feet and was built by the Panhandle Water Conservation Authority primarily for soil conservation, flood control, recreation, and promotion of wildlife (Texas Handbook Online 2002).

In this case, it is not expected that there would be any significant change to the water quality in the reservoir because inflow reductions from both streams would be proportional (i.e., 60 percent from each). However, were Texas to develop its entire Compact apportionment from just one stream, and that of the best water quality (i.e., Sweetwater Creek), the water supply of Lake Altus would be reduced by less than 20 percent, but water quality in Lake Altus could potentially deteriorate.

Although the Compact does include general provisions that address the application of the Compact to Federal powers, rights, and obligations[16], a consensus among member states regarding the practical interpretation and application of these and other governing sections to the interests of the District has not yet been established. Until the specific terms and conditions of Texas' development of its water allotment under the Compact are known, the reliability of present and future water quantity and quality on the North Fork Red River in Oklahoma will remain uncertain.

View along the crest of Altus Dam, August 18, 2004. Within a 50-year planning horizon, it is reasonable to expect that the ability of this reservoir to store water sufficient to meet current irrigation needs will be meaningfully diminished by sediment accumulation. Photograph courtesy of Bureau of Reclamation, Austin, Texas.

[16] For example, Section 2.07 states, "Nothing in this Compact shall be deemed to impair or affect the powers, rights, or obligations of the United States, or those claiming under its authority, in, over and to water of the Red River Basin" (82 O.S. §1431).

Summary of Need

The demand for water supply and flood control provided by Altus Dam continues to exist much as planned over six decades ago. However, sedimentation, while a natural and planned occurrence in surface water reservoirs, has meaningfully reduced the available storage volume in Lake Altus and will continue to do so. It is reasonable to expect that this reduction will begin to diminish the irrigation benefit of the W.C. Austin Project within the next 30 to 50 years. The aging irrigation infrastructure, if not modernized and made more efficient, will exacerbate water shortages whether from reduced storage capacity or drought.

Therefore, a need exists to augment the water supply of this project and improve the efficiency of its operation if its benefits are to be preserved. However, there continues to be considerable uncertainty with regard to the future water quantity and quality conditions in the North Fork Red River basin. These unknown issues include the current rate of reservoir sedimentation, the effectiveness of potential salt controlling actions, and how potential actions related to the Red River Compact allocations may impact water supplies. The uncertainty imposed by these conditions must therefore be considered when evaluating possible water supply solutions.

Water Augmentation Alternatives

Prior to initiating this Appraisal Report, Reclamation (2004a) prepared a Preliminary Assessment that made an initial evaluation of the potential costs, benefits and impacts of 18 proposed alternatives to improve the water supply of Lake Altus. Based upon the results of the Preliminary Assessment and discussions with the District, Reclamation focused the scope of this Appraisal Report on two types of alternatives: those that would augment the water supply of the W.C. Austin Project and those that would improve the efficiency of water deliveries. The following discussion includes those alternatives that would augment the existing water supply.

ALTERNATIVE 1: **Reuse of Municipal Wastewater**

Under Alternative 1, treated municipal wastewater from the city of Altus[17] would be diverted into the irrigation district conveyance system and used as a supplemental irrigation water supply. At present, Altus receives most of its domestic raw water through the Altus Aqueduct, a 22-mile concrete pipeline which runs from Tom Steed Reservoir, located on West Otter Creek northeast of Altus. This water is treated at a water treatment plant located immediately west of the city of Altus Reservoir, and then delivered to municipal and industrial customers within the community.

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[17] Initially, the cities of Altus, Mangum, Hobart, Blair, Headrick, and Duke were considered as possible wastewater sources. However, after a cursory analysis of their wastewater production volume and distance from the irrigation district, all communities but Altus were ruled out because of the relative small amounts of water available, which ranged from 10 to 75 acre-feet per season (Ward 2004).

OPPOSITE PAGE →

ALTERNATIVE 1: Reuse of Municipal Wastewater. Site locations and alignments are conceptual only.

Wastewater generated by these customers is collected and delivered to one of two municipal wastewater treatment plants owned and operated by Altus for treatment. One wastewater treatment plant is located north of the city and the other southeast. Treated effluent from the wastewater treatment plant on the north side of the city is presently being reused for surface application (Briggs 2004) and was therefore not considered available under this alternative. However, approximately 2 million gallons per day (MGD) of treated wastewater from the treatment plant southeast of the city (Southeast Plant) is presently discharged into Stinking Creek and is not being reused. This Southeast Plant is also intended to be used to treat an additional 1 MGD waste stream from a planned expansion to the existing water treatment plant[18], making the total available effluent from this plant about 3 MGD.

Under this alternative, 3 MGD of treated effluent from the Southeast Plant would be diverted into the Altus Canal through a 2.25-mile long, 16-inch PVC pipeline and mixed with irrigation water. The operation would also require the installation of a small pumping unit[19] and control station to lift the treated wastewater approximately 70 vertical feet from the Southeast Plant to the Altus Canal.

Wastewater diversions would generally be made during the summer when both irrigation demand and effluent production are at their peak. Assuming the average irrigation season begins in the middle of June and ends in September (3.5 months), the water supply of Lake Altus would be augmented by an estimated 950 acre-feet of water per year by this alternative. However, if cropping patterns were altered within a small portion of the district to grow cool weather crops, irrigation could be provided during a longer season. Assuming irrigation was to occur for 9 months in this portion of the district instead of 3.5 months, an estimated 1,850 acre-feet per year could be provided by this alternative.

Over time, the amount of water available under this alternative would vary with changes in the population and water use practices by the citizens of Altus. For example, increases in the population of Altus would generally increase the amount of wastewater available, while improved conservation measures adopted by the city would decrease available effluent. The State of Oklahoma predicts the population of Jackson County to increase by 95 percent between the years 2000 and 2050 (Oklahoma Water Resources Board 1995). Assuming no changes in the per capita use of water by Altus, the water available under this alternative in 2050 could approximately double. However, as a marketable supply of water, treated municipal wastewater may not always be available or affordable to the District.

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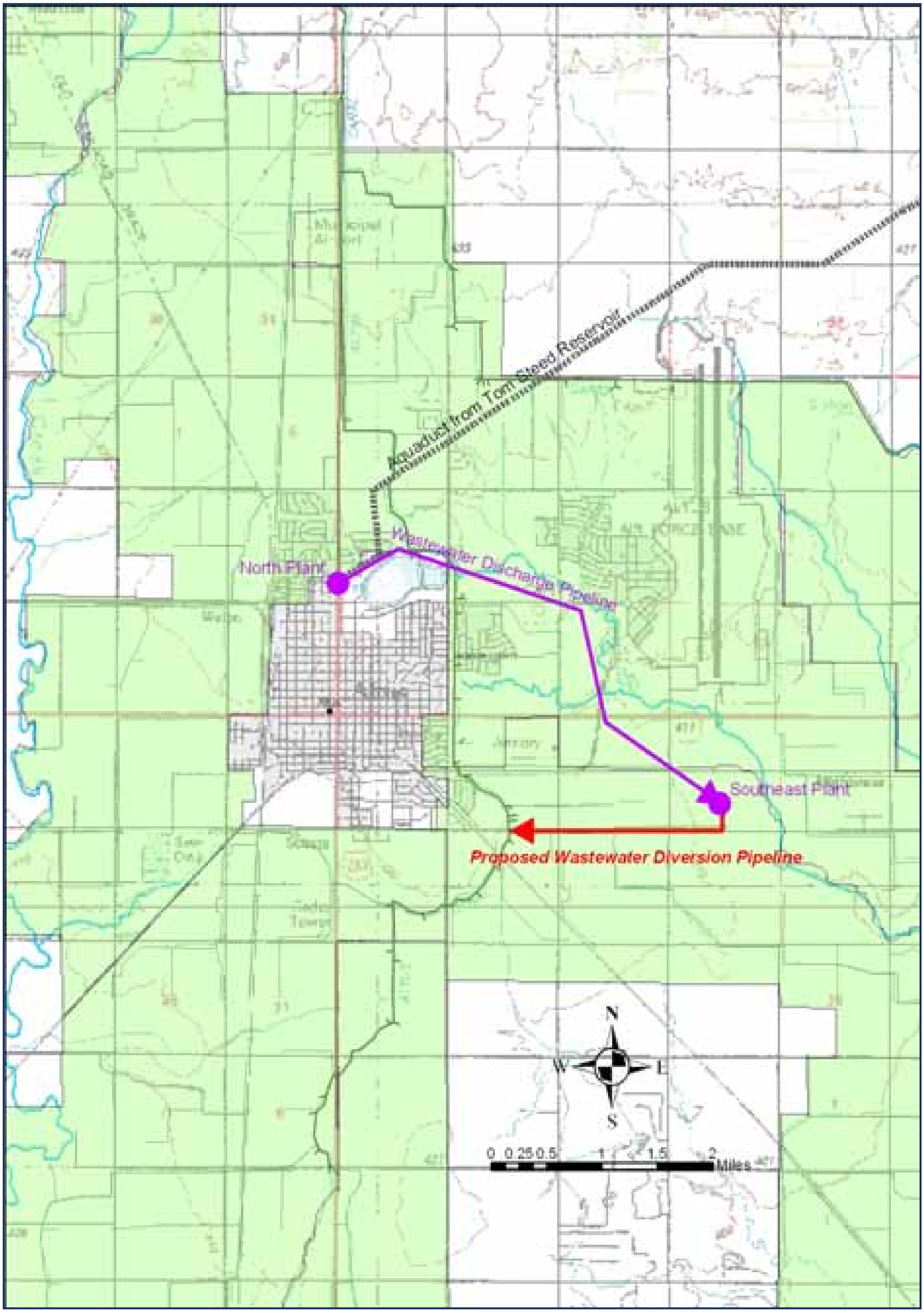
18 This expansion would produce drinking water using a reverse osmosis process to treat raw water from Tom Steed Reservoir. A portion of the effluent from this plant would contain high solids and sediments and would be transported by pipeline directly to the Southeast Plant for treatment and disposal into Stinking Creek.

19 Originally, gravity-flow delivery of this water was envisioned. However, anticipated regulatory requirements for mixing of the effluent with large volumes of irrigation water required a confluence of the pipeline directly with the Altus Canal.


Aqueduct from Tom Steed Reservoir
North Plant
Wastewater Discharge Pipeline
Southeast Plant
Proposed Wastewater Diversion Pipeline
N
W
E
S
0 0.25 0.5 1 1.5 2
Miles

ALTERNATIVE 2: **Trico Reservoir Site**

Under Alternative 2, a new dam and reservoir would be constructed on the North Fork Red River about 10 miles upstream of Lake Altus at a site known as the Tri-County (Trico) site. Trico Reservoir would operate in conjunction with Lake Altus as part of a reservoir system, increasing the storage capacity available to water users of the W.C. Austin Project. Because of its upstream location, Trico Reservoir would also preserve existing reservoir storage by capturing most of the sediment load presently accumulating in Lake Altus[20].

OPPOSITE PAGE →

ALTERNATIVE 2: Trico Reservoir Site. Site location is conceptual only.

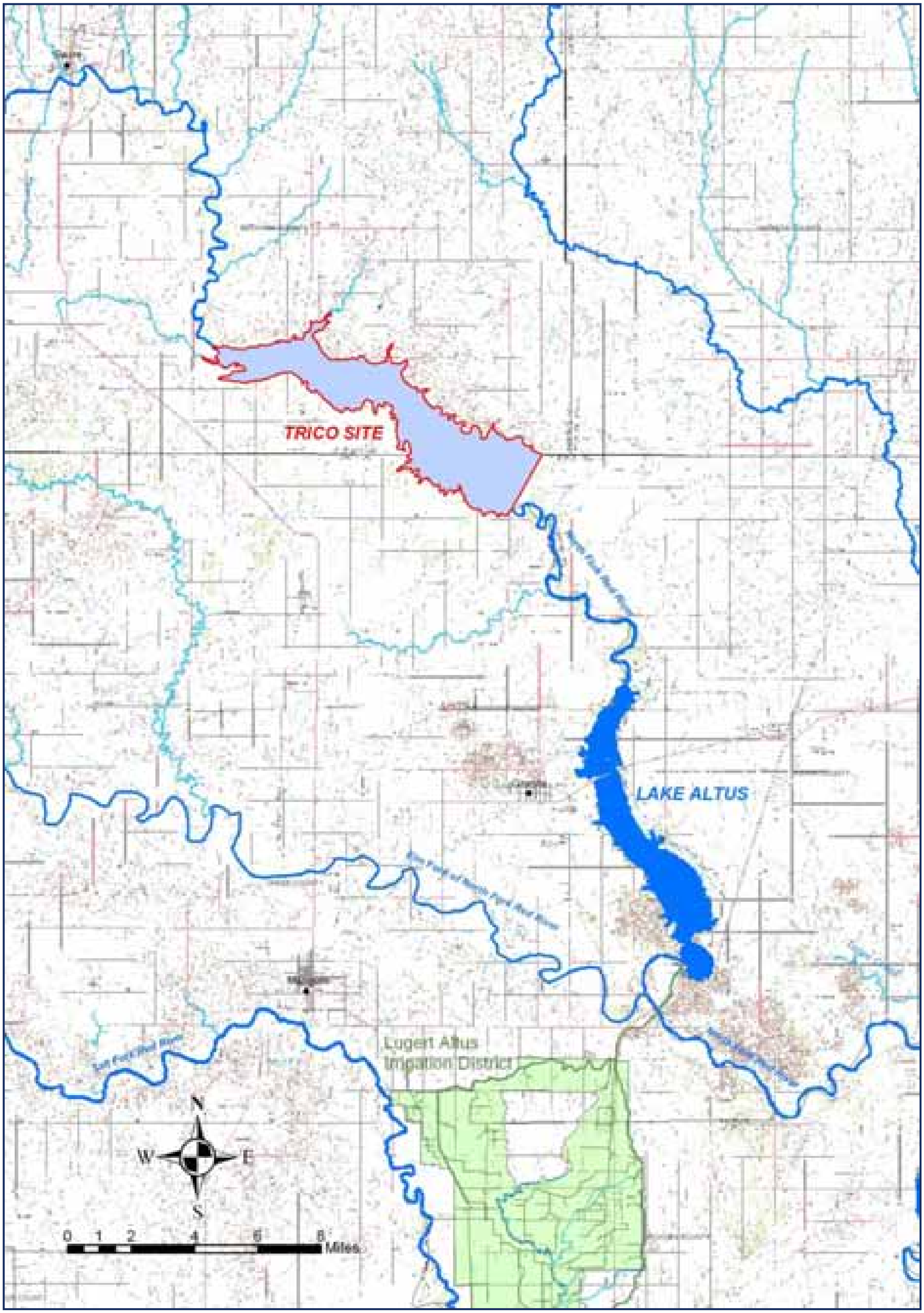
The Trico site was previously studied by both the State of Oklahoma (Oklahoma Water Resources Board 1967) and Reclamation (Bureau of Reclamation 1970). The Trico impoundment structure would be a compacted, zoned, earthfill dam with concrete spillway and outlet works. The top of the dam embankment would be approximately 114,000 feet long with a crest elevation of about 1,720 ft msl. The dam would create a lake of about 11,000 surface acres. The river channel at the upstream toe of the dam would be approximately 70 feet below the water surface at the top of the conservation pool. The impoundment would also include two freeboard dikes, each having a structural height of approximately 10 feet, with lengths of 250 and 750 feet.

Trico Reservoir would have a contributing drainage of approximately 1,900 square miles and a design capacity of approximately 518,000 acre-feet. Of this capacity, 391,000 acre-feet would be assigned to conservation and dead pool storage and 127,000 acre-feet reserved for flood control operations. The yield of Trico Reservoir is estimated to be between 30,000 and 35,000 acre-feet per year[21].

As part of a reservoir system, Trico Reservoir would serve as the principle storage reservoir. The flood control function of Lake Altus would be transferred upstream to Trico Reservoir, and water would be released from Trico Reservoir to meet seasonal irrigation demands in Lake Altus. Similar releases could also be made to meet the needs of other users benefited by the existing W.C. Austin Project. Water level fluctuations in Lake Altus during the year could be greatly minimized from present conditions through management options made possible by a reservoir system. For example, a selected water level in Lake Altus could be maintained by releases from Trico Reservoir. However, this discretion would only relocate the water level fluctuations to Trico Reservoir, and may increase the amount of total water lost to the system from evaporation (i.e., maintaining a greater surface area than minimally required for storage) and decrease water quality.

[20] For planning purposes in this Appraisal, it was estimated that construction of a dam at the Trico site would reduce the effective sedimentation rate of Lake Altus by at least 75 percent. This assumes that the relatively large flood control pool in Trico Reservoir would minimize spills into Lake Altus, and that the sediment contribution of the relatively small intervening watershed between the two reservoirs would be minor.

[21] The Oklahoma Water Resources Board (1967) has estimated the yield of the Trico site to be approximately 32,000 acre-feet per year.


TRICO SITE
LAKE ALTUS
Lugert Altus
Irrigation District
N
W
E
S
0 1 2 4 6 8
Miles

ALTERNATIVE 3: **Cable Mountain Reservoir Site and Associated Components**

Under Alternative 3, a new dam and reservoir would be constructed on the North Fork Red River approximately 40 miles downstream of Lake Altus near Headrick at a site known as the Cable Mountain site. Cable Mountain Reservoir would operate independent of Lake Altus and supplement the irrigation water supply presently made available by the W.C. Austin Project. Because of its downstream location, Cable Mountain Reservoir would not only capture flow in the North Fork Red River, including flood releases Altus Dam, but it would also capture flow from the Elm Fork of the North Fork Red River and Elk Creek. Under this alternative, Lake Altus would continue to experience sediment accumulation at the present rate.

OPPOSITE PAGE →

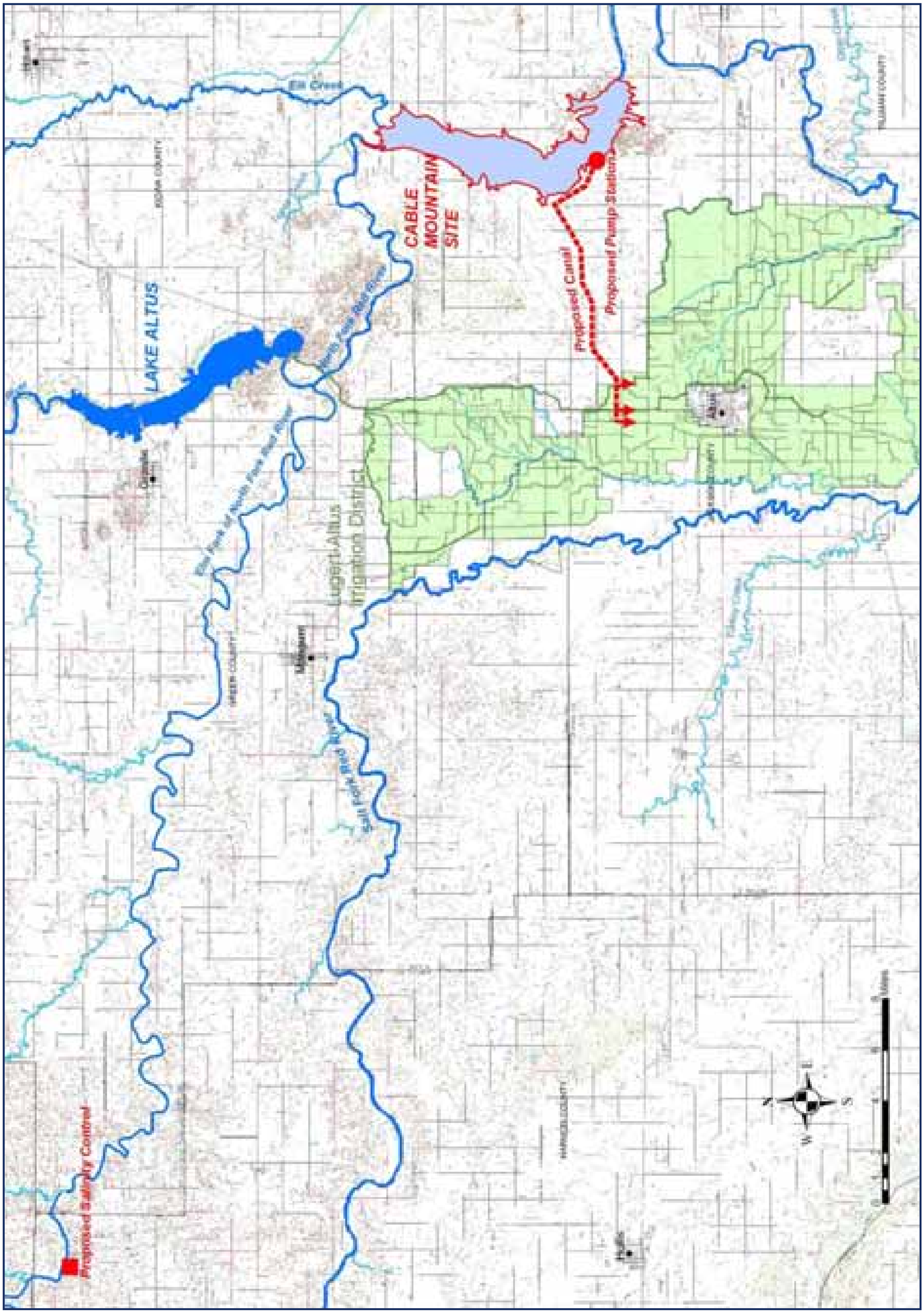
ALTERNATIVE 3: Cable Mountain Reservoir Site and associated components. Site locations and alignments are conceptual only.

Two other components would also be required before this project could effectively augment the water supply of Lake Altus. First, in order for water stored in Cable Mountain Reservoir to be used as a supplemental irrigation water supply in the Lugert-Altus Irrigation District, it must be transported to some point in the existing irrigation system. This conveyance would require a pumping plant at Cable Mountain Reservoir and a pipeline and canal to carry the water. Second, in order for the water of the North Fork Red River to be rendered suitable for irrigation purposes, effective control of salt loading in the Elm Fork tributary must be attained. Cable Mountain Dam and each of its associated components are discussed in more detail below.

Cable Mountain Dam and Reservoir

The Cable Mountain site is located between exposed granite basement rock to the northeast and river bluffs to the southwest, and is one of the narrowest restrictions on the North Fork Red River downstream of Altus Dam. Like the Trico site, the Cable Mountain impoundment structure would also be a compacted, zoned, earthfill dam with concrete spillway and outlet works. However, because of favorability of the site, Cable Mountain Dam would require much less fill material to construct than Trico Dam. The top of the Cable Mountain Dam embankment would be approximately 4,250 feet long with a crest elevation of about 1,430 ft msl. This dam would also create a lake of about 11,000 surface acres. The river channel at the upstream toe of the dam would be approximately 50 feet below the water surface at the top of the conservation pool. The impoundment would also include one freeboard dike with a structural height of approximately 30 feet and a crest length of 7,600 feet. In addition, a 13,000 foot section of the existing 30-inch Altus pipeline which supplies the city of Altus with water from Tom Steed Reservoir would need to be upgraded to withstand the additional external pressures resulting from the proposed reservoir above the line or the line would need to be relocated around the reservoir.

Cable Mountain Reservoir would have a contributing drainage of approximately 3,800 square miles and a design capacity of approximately 413,000 acre-feet. Of this capacity, 342,000 acre-


LAKE ALTUS
CABLE MOUNTAIN SITE
Proposed Canal
Proposed Pump Station
Lugert/Altus Irrigation District
Proposed Salinity Control
Salt Fork Red River
Elk Creek

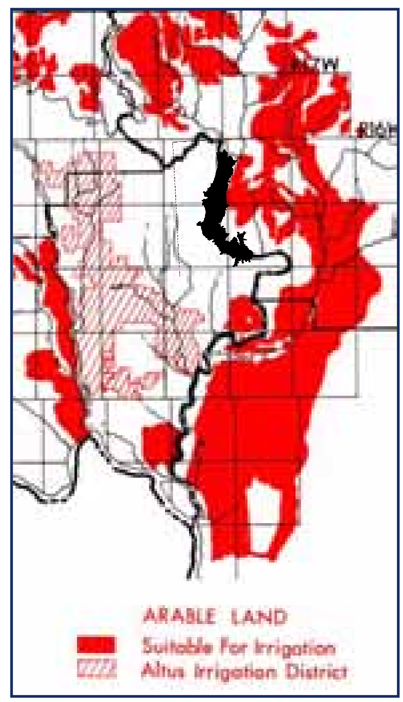
feet assigned to conservation and dead pool storage and 71,000 acre-feet reserved for flood control operations. The yield of Cable Mountain Reservoir is estimated to be between 100,000 and 120,000 acre-feet per year[22].

Component 1: Pumping Plant and Canal

The pumping plant was conceptually located on the south shore of Cable Mountain Reservoir immediately northwest of the granite outcrop near Cable Mountain. The pumping plant would lift water some 75 vertical feet from Cable Mountain Reservoir to the head of a gravity-flow canal via two 2,000-foot parallel pipelines sized to deliver a total of 600 cfs. From there, a 12.5-mile open canal would convey water to the Ozark Canal, Altus Canal, and the A9.9 Lateral where it would be used to supply the southern three-fifths of the Lugert-Altus Irrigation District.

In the near-term, cost considerations would require that the pumping plant only be used on an as-needed basis to meet the full water need of the irrigation district. However, in the long-term, when sedimentation had displaced a majority of the conservation storage capacity of Lake Altus, most of the water supplied to the Lugert-Altus Irrigation District would be pumped from Cable Mountain Reservoir. The remaining two-fifths of the (northern) irrigation district would continue to be supplied by Lake Altus, effectively reducing the irrigation demand on this reservoir.

As a future component to this alternative, additional irrigable land in Tillman County could also be developed and irrigated by gravity flow from Cable Mountain Reservoir. The State of Oklahoma has identified over 700,000 acres in southwestern Oklahoma that is suitable for irrigation (Oklahoma Water Resources Board 1967), much of which is located in Tillman County near the North Fork Red River where irrigation water is already projected to be needed by 2050[23]. Because of the large supply that could be made available by the Cable Mountain Reservoir site, irrigation in both Jackson and Tillman Counties could be supported concurrently. However, regardless of the size of the irrigation demand, the suitability of water impounded by Cable Mountain Dam for irrigation and other uses critically depends upon effective control of the salt loading in the North Fork Red River.



Portions of southwestern Oklahoma with areas indicating land suitable for irrigation. Map originally compiled by the Oklahoma Water Resources Board (1967). Much of the land east of the North Fork Red River (center) could be irrigated by gravity flow from the proposed Cable Mountain Reservoir (black). The outline of Lake Altus is shown in the upper left of the map.

Component 2: Chloride Control

The problematic contribution of salt springs to the flow of the Elm Fork of the North Fork Red River was recognized as early as 1924 (Bureau of Reclamation 1938). The U.S. Army Corps of Engineers has recently determined that about 510 tons per day of chloride is contributed to the flow of the Elm Fork at a site near the border of

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22 The Oklahoma Water Resources Board (1967) identified this site as Navajo Reservoir and estimated its yield to be approximately 108,000 acre-feet per year.

23 The State of Oklahoma projects an irrigation water deficit in Tillman County of 23,000 acre-feet per year in 2050 due to the possible depletion of existing groundwater resources (Oklahoma Water Resources Board 1995).

Harmon and Beckham Counties, Oklahoma (Corps of Engineers 1996). These salt springs are located in three box canyons along the south bank of the Elm Fork. Because of the close proximity of these brine sources, the Corps of Engineers (1996) estimates the total chloride loading of the Elm Fork could be reduced by about 80 to 85 percent, or by about 420 tons per day, through control at this site. The method of brine control conceptualized in this alternative includes intercepting the flow at the emission area and transferring it off-site by a pump station and pipeline for disposal by deep-well injection[24].

However, even if effective control were accomplished, it remains unclear how long it would take for accumulated salts in the intervening alluvium between the emission source and the Cable Mountain site to sufficiently flush. Without such control, the surface water of the North Fork Red River would remain unsuitable for irrigation and other purposes (Oklahoma Water Resources Board 1967).

Efficiency Improvement Alternatives

In addition to water supply augmentation options, alternatives to improve the operational efficiency of the existing W.C. Austin Project were also evaluated. Although these alternatives would not actually increase existing water supplies, they do merit consideration for improving the water supply situation of the project.

ALTERNATIVE A: **Hydrologic Restoration of the North Pool**

The objective of Alternative A would be to restore a hydrologic connection between the north and south reservoir pools, thereby allowing more effective management of the water and land resources of the W.C. Austin Project. This alternative would consist of installing a series of three types of structures[25]. First, a control structure would be a 200-foot pipeline installed under the earthen embankment of State Highway 9 to connect the deepest portion of the north pool to the south pool. This structure would allow seasonal manipulation of water levels (up to 1,559.0 ft msl) in the north pool. Second, at some point on the North Fork Red River a diversion structure or portable pumping unit would be used on an as-needed basis to divert river base flow into the north pool during fall and winter months. This pump would provide the ability to re-fill the WMA after the irrigation season. Finally, a few small regulation structures may be required within the north pool itself to allow management flexibility of the extent and depth of inundation.

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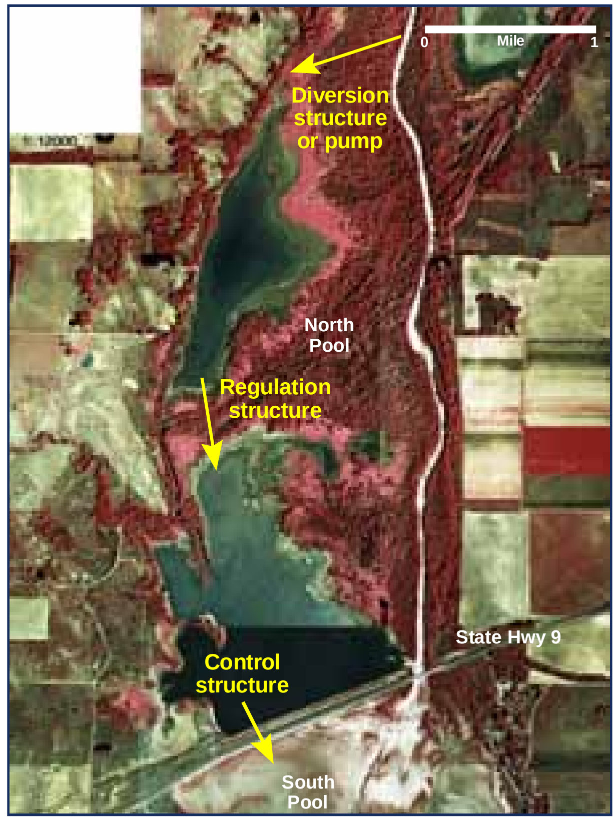
24 Other possible brine disposal alternatives could include concentration for reuse in the local oilfield industry, diversion by pipeline into another surface stream (e.g., Salt Fork Red River), or conveyance into a constructed reservoir for surface evaporation.

25 Additional authority may be required specifically allowing water control structures to be constructed within the designated conservation pool of Lake Altus.

It is envisioned that the restored north pool would operate in such a way as to maximize the management objectives of both the District and ODWC. Although the actual schedule and timing of operational decisions and maintenance responsibilities would be decided between the managing partners, a conceptual operating plan would include the following:



ALTERNATIVE A: Hydrologic Restoration of the North Pool. Site locations and alignments are conceptual only. Color infrared imagery courtesy of Bureau of Reclamation, Austin, Texas.

- During the fall and winter (October to February), a portion of the river baseflow would be diverted into the north pool for seasonal storage (at or below 1,559.0 ft msl). This would result in a minor reduction in south pool inflow, but there would be no net change in reservoir inflow. The full water level in the north pool during this period would provide habitat for over-wintering waterfowl.

- During the spring (March to May), all water stored in the north pool would be slowly released into the south pool. This would effectively consolidate all water stored in the conservation pool of Lake Altus into the south pool in preparation for the irrigation season. In the north pool, the slow draw-down of water would stimulate germination of preferred plant species.

- During the summer (June to September), all water that flowed into the north pool would continue to be passed into the south pool for irrigation use. Suppression of the water level in the north pool would allow continued production of annual seed-bearing plants in preparation for winter.

The amount of water that could be made available by this alternative is difficult to estimate due to the lack of current contour data. At present, it is estimated that when full, the north pool could provide about 1,000 surface acres of water with an approximate storage capacity of about 1,500 to 2,500 acre-feet. Based on a preliminary analysis of the natural flow regime of the North Fork Red River above Lake Altus, the north pool would likely fill an average of twice per irrigation season. Therefore, it is estimated that this alternative could restore a total of about 3,000 to 5,000 acre-feet of water per year to the south pool.

ALTERNATIVE B: **Modernization of the Irrigation District**

The objective of Alternative B would be to minimize or eliminate wasteway diversions by modernizing several elements of the irrigation district. This alternative would not include actions to

View of a recently installed measurement structure in the West Canal, October 13, 2004. This broad-crested weir allows more accurate measurement of flow from the Main Canal into the West Canal. Photograph courtesy of Bureau of Reclamation, Austin, Texas.

recover any remaining losses due to seepage and evaporation[26]. Alternative B would therefore include a combination of the following elements:

- Replacement of about 15 existing check structures with automated gates[27].
- Rehabilitation of about 15 existing measurement structures and installation of about 15 new measurement structures.
- Expansion of the existing Supervisory Control and Data Acquisition (SCADA) capability by the installation of remote monitoring and/or gate automation at approximately 15 sites.
- Replacement or relocation of about 30 to 35 selected farm turnouts.
- Construction of from one to three re-regulating reservoirs within the district, if needed.
- Installation of about 10 wasteway measurement structures.

Implementation of this alternative would be phased. The first phase would include the measurement and control elements. Over the course of several irrigation seasons, the improved water measurement capability would allow more accurate quantification of reservoir releases and system deliveries. The improved flow control capability would provide flow data on a real-time basis, allowing immediate adjustment of flow rates. The farm turn-outs would be replaced next, improving the delivery efficiency at individual farms. Finally, if necessary, re-regulating reservoirs would be designed and constructed to capture any remaining excess water in the canal system and store it on a short-term basis until it may be used.

If all wasteway diversions were eliminated, it is estimated that the irrigation water supply could be effectively increased by 20 to 25 percent. Assuming an average annual diversion of 63,000 acre-feet per year, this alternative would conserve an average of 12,600 to 15,750 acre-feet per year.

Comparison of the Alternatives

To form a basis of comparison, the reliable water supply of each potential alternative was evaluated with regard to 1) the degree to which it offset the effects of reservoir sedimentation, 2) the estimated costs of that supply, and 3) anticipated environmental impacts.

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[26] In 1984, Reclamation (1985) estimated that the cost of rehabilitating canals in the remaining known seepage areas would range from about $1,500 to $4,900 per acre-foot of water recovered.

[27] Any potential public safety issues associated with integrating gate automation into the operation of the irrigation district would need to be adequately addressed prior to implementation.

Addressing the Problem of Sedimentation

Although the continuing loss of storage capacity in Lake Altus by sedimentation is the most significant problem confronting the District, none of the alternatives considered in this Appraisal Report would reduce sediment volume already accumulated in Lake Altus. Although some options for sediment removal were initially considered (Bureau of Reclamation 2004a), these were not found to be cost effective relative to other alternatives. Generally, the redemption of lost reservoir storage by sediment removal is feasible only as a last resort because of the nature of the silt, its distribution throughout the reservoir, the tremendous amount of mass involved, and complications with disposal (Linsley et al. 1949). For these reasons, removal operations such as excavation, dredging, siphoning, draining, and sluicing remain extremely expensive.

Each of the alternatives were evaluated, however, on the basis of how they would off-set the effect of future accumulation. The degree to which the rate is off-set may be quantified and expressed in terms of years. For example, for each alternative except Alternative 2 (Trico Reservoir), the sedimentation rate of Lake Altus can be assumed to remain unchanged. Through 1967, this rate has been estimated at about 937 acre-feet per year. Therefore, the amount of water made available by each of these alternatives, when divided by the rate at which storage capacity is being lost, results in the effective extension of the water supply of the project in terms of years. For Alternative 2, the calculation is the same except that the assumed sedimentation rate of Lake Altus would be reduced because of the trapping influence Trico Reservoir would have on sediments flowing down the North Fork Red River and into Lake Altus. For purposes of this Appraisal Report, the sediment rate in Lake Altus under Alternative 2 was assumed to be reduced by 75 percent to 234 acre-feet per year. The results of this analysis are presented in Table 4.

TABLE 4: Degree to which each alternative would off-set the effect of future sedimentation in Lake Altus.

ALTERNATIVE		Estimated Supply (acre-feet/year)	Assumed Sedimentation Rate in Lake Altus (acre-feet/year)	No. of Sediment Equivalent Years Gained
1	Wastewater Reuse	950 – 1,850	937	1 – 2
2	Trico Reservoir	30,000 – 35,000	234	128 – 150
3	Cable Mtn. Reservoir	100,000 – 120,000	937	107 – 128
A	North Pool Restoration	3,000 – 5,000	937	3 – 5
B	District Modernization	12,600 – 15,750	937	13 – 17

Estimated Costs

As a preliminary means of comparing the potential alternatives, conceptual-level cost estimates were developed for each. For those alternatives with multiple components, cost estimates were developed for each component and then summed to represent the alternative. These estimates should be considered cursory in nature and are intended only for comparing alternatives relative to one another. Reclamation has provided these cost estimates as a resource for decision makers evaluating the potential alternatives. Development of these estimates does not imply support by Reclamation for project authorization or any specific language in an appropriation bill. Where applicable, Reclamation will articulate such support by other means.

Estimated Construction and Operation and Maintenance Costs

Construction cost estimates were based in part on actual costs of similar projects constructed by Reclamation, indexed using Means Historical Cost Indexes and scaled to match the size and scope of the proposed alternatives. Published unit price data were also used in development of the construction cost estimates. These estimates are intended to reflect total project costs including both construction contract and non-contract costs, and other project costs such as land acquisition, but do not include costs for environmental or cultural resources mitigation. Annual operation and maintenance (O&M) estimates were based on professional experience and actual costs for similar projects in Oklahoma and Texas. All cost estimates reflect a January 2004 cost basis and are summarized in Table 5.

TABLE 5: Summary of conceptual level cost estimate ranges for each alternative.

		Estimated Range of Construction Costs ($)	Estimated Range of Annual O&M Costs ($/year)
1	**Wastewater Reuse**[28]	**900,000 – 1,500,000**	**60,000 – 100,000**
2	**Trico Reservoir**	**290,000,000 – 440,000,000**	**150,000 – 330,000**
3	**Cable Mountain Reservoir**	**170,000,000 – 300,000,000**	**2,000,000 – 4,400,000**
	Dam and Reservoir	45,000,000 – 75,000,000	150,000 – 330,000
	Pumping Plant and Canal	50,000,000 – 75,000,000	1,350,000 – 2,070,000
	Chloride Control	75,000,000 – 150,000,000	500,000 – 2,000,000
A	**North Pool Restoration**	**450,000 – 700,000**	**12,000 – 25,000**
B	**District Modernization**	**5,000,000 – 12,000,000**	**70,000 – 120,000**
	Measurement and Control	3,000,000 – 5,000,000	60,000 – 100,000
	Re-regulating Reservoirs	2,000,000 – 7,000,000	10,000 – 20,000

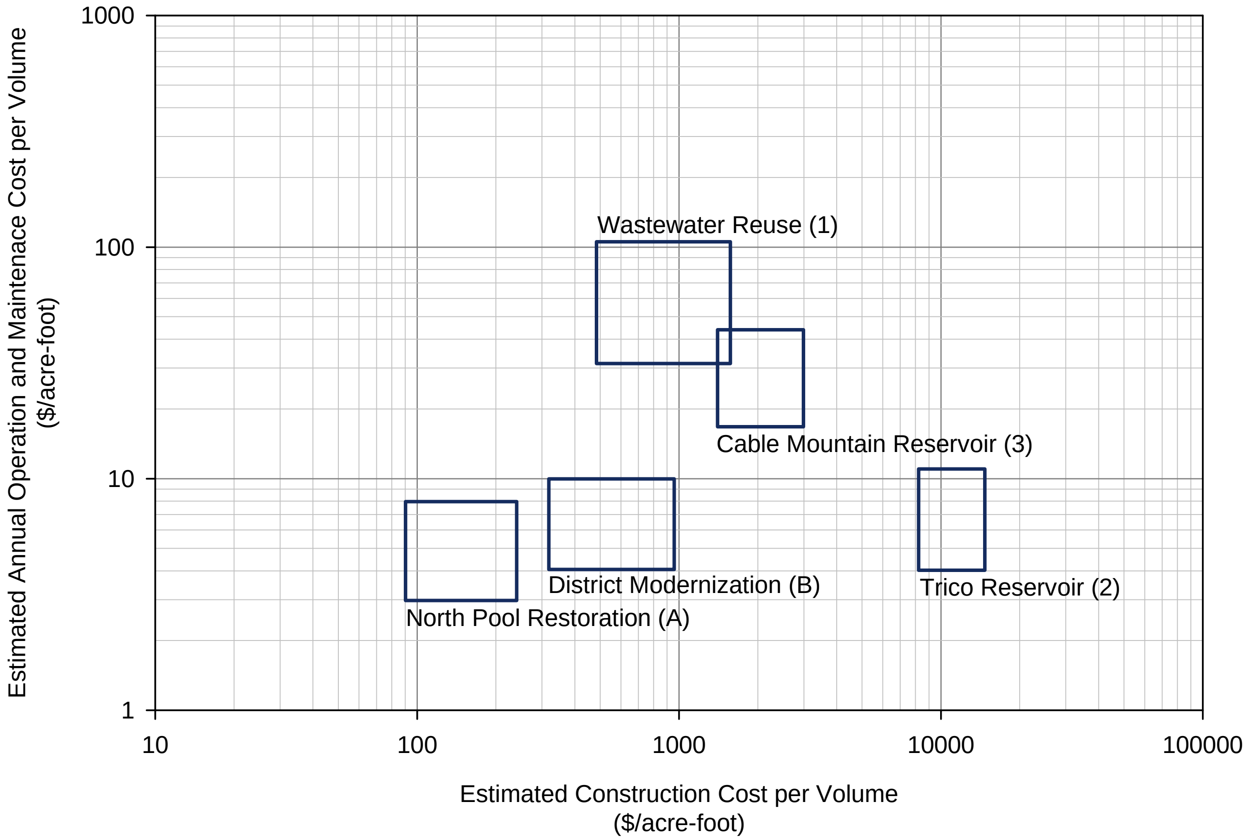
Relative Costs per Acre-foot

Because of the broad variation in scope of the alternatives evaluated, the estimated costs differed among alternatives by up to three orders of magnitude. As a basis of further comparison, the estimated costs of each alternative were divided by the estimated volume of supply. This analysis resulted in a range of estimated costs per acre-foot for each alternative as summarized in Table 6.

[28] The estimated operation and maintenance cost for Alternative 1 (Wastewater Reuse) does not include the annual cost of the wastewater. This cost would most likely be established in a termed-contract between the District and the city of Altus.

TABLE 6: Estimated cost per acre-foot of each alternative.			
ALTERNATIVE		Estimated Construction Cost per Volume ($/acre-foot)	Estimated Annual O&M Cost per Volume ($/acre-foot)
1	Wastewater Reuse	485 – 1,580	32 – 64
2	Trico Reservoir	8,285 – 14,670	6 – 8
3	Cable Mtn. Reservoir	1,415 – 3,000	25 – 31
A	North Pool Restoration	90 – 240	3 – 5
B	District Modernization	320 – 960	4 – 6

For comparison purposes, the cost data in Table 6 may be presented graphically:



Estimated cost per acre-foot of each alternative. The rectangle indicates the range of estimated construction (horizontal) and operation and maintenance (vertical) costs per acre-foot of reliable supply. In general, alternatives closer to the lower left of the graph are relatively less expensive per volume than those closer to the upper right.

Although developed using the best information available, these estimated costs are only conceptual. Many factors unknown at this time would affect the actual construction and O&M expenses of any given alternative. For example, under Alternative 1 (Wastewater Reuse), the specific contract terms for the supply of wastewater, including availability, volume, cost, and duration, are unknown and were not included in these estimates. Similarly, under Alternative B (District Modernization), because the water saving elements would be implemented over time, it is unknown how many re-regulating reservoirs (which accounted for about half of the estimated construction cost) may be needed, if any. Furthermore, for any of the alternatives, it is uncertain what arrangements would be made for cost sharing among interested participants. Although these arrangements may not affect the total estimated cost of the alternative, they could significantly affect the relative share of each participant.

Environmental Considerations

The Fish and Wildlife Service (2004) describes the study area prior to European settlement as supporting a diversity of grassland types, with floodplain forest occurred in the riparian zones of rivers and major tributary streams. Since settlement, land use practices, especially those related to agriculture, have greatly reduced the quantity of native habitat in the area. However, numerous types of fish, wildlife and birds continue to inhabit the area, including several rare and protected species.

Anticipated Impacts

Fish and wildlife resource-related impacts from Alternative 1 (Wastewater Reuse) would be relatively minor, consisting of terrestrial habitat alteration from pipeline construction and reduction of instream flows. Extensive analyses on wastewater quality would be recommended in order to preclude introduction of harmful chemical or biological constituents into the irrigation system. Also, several environmental and human health protection regulations would likely be applicable and could place additional limitation on design or operation of the alternative.

Alternative 2 (Trico Reservoir) would result in the inundation of approximately 11,000 acres of stream, riparian, grassland, and other upland and floodplain habitats. As a result, major large-scale negative impacts would occur to native fishes, shore and wading birds adapted to stream and riparian habitats, resident and migratory songbirds, and numerous other species of mammals, amphibians, and reptiles. Although a new impoundment could benefit the fishery resources of Lake Altus by providing fresh water during hot, low water periods, extensive mitigation would likely be required under this alternative to offset other resource losses.

Similar to Trico Reservoir, Alternative 3 (Cable Mountain Reservoir) would result in the inundation of large areas of stream, riparian and terrestrial habitats and incur the similar large-scale negative impacts. However, because of the location of the proposed structure, this alternative would likely have a more profound adverse impact on the flow regime of the North Fork Red River downstream from the impoundment. Also, an effective chloride control component on the Elm Fork of the North Fork Red River would adversely affect the native flora and fauna along the river corridor that have adapted to high-concentration conditions, especially fish and plant communities. Extensive mitigation would also likely be required under the Cable Mountain alternative.

No adverse impacts would result from Alternative A (North Pool Restoration). Assuming an appropriate operating plan could be developed and implemented, this alternative would benefit wildlife resources in the Altus-Lugert Wildlife Management Area by improving the ability to manage for moist soil plants.

View of the North Fork Red River flowing through the Altus-Lugert Wildlife Management Area, June 2003. Wildlife habitat in this area could be improved with the ability to manage water levels seasonally. Photograph courtesy of Bureau of Reclamation, Austin, Texas.

Finally, the modifications to the canal system by the installation of measurement and automation equipment on control structures proposed under Alternative B (District Modernization) would not likely affect wildlife resources. Some adverse impacts could occur to fishery resources in streams that presently receive wasteway diversions as a result of seasonal flow reductions during summer months. The development of new re-regulation reservoirs could result in a negative, but relatively minor, impact on fish and wildlife habitat. However, there would be an opportunity to offset these impacts if habitat values were incorporated into the design of such reservoirs (e.g., including vegetated buffers, etc.).

Views of Other Resource Agencies

In preparation of this Appraisal Report, the views of state and Federal resource agencies with regard to the conservation and development of fish and wildlife resources were solicited. The U.S. Fish and Wildlife Service (2004) provided Reclamation with planning aid information that also represented the views of the Oklahoma Department of Wildlife Conservation. In summary, the resource agencies expressed the most concern with alternatives that would impact large areas of stream, riparian and other important habitats, which would include Alternatives 2 (Trico Reservoir) and 3 (Cable Mountain Reservoir). The Fish and Wildlife Service also cited their and other agencies' previously stated opposition to the potential impacts of chloride control in the Red River Basin, citing concerns with the potential impact to Sandy Sanders State Wildlife Management Area and water quality changes in Lake Texoma[29].

Of the remaining alternatives, the resource agencies believed that the reuse of municipal wastewater (Alternative 1) and modernization of the irrigation district (Alternative B) would have minimal environmental impacts, while hydrologic restoration of the north pool (Alternative A) could improve habitat values in the area.

Federal Interest

The Federal interest in addressing the identified water supply need is two-fold. First, through original project authorization in 1938, Reclamation was directed by Congress to construct and operate the W.C. Austin Project for the purposes of irrigation and flood control. Since its construction, this project has continued to provide the

Flood irrigation of a cotton field outside Altus irrigated by water from Lake Altus, *circa* 1947. Aluminum siphons (foreground) were used to draw water from the canal into the fields. Photo courtesy of the Museum of the Western Prairie, Altus, Oklahoma. Used with permission.

29 More recently, the State of Oklahoma has expressed some support for a focused evaluation of the potential for chloride control on the Elm Fork of the North Fork Red River, including full and proper evaluation of environmental issues and agency consultations (State of Oklahoma 2004).

specified project benefits under the management and operation provided by the District. Second, in 2004, Congress directed Reclamation to investigate potential alternatives for water supply augmentation. This Appraisal Report has been initiated in pursuit of this directive.

PART THREE: **Findings**

Appraisal Summary

Based upon the preceding assessment of problems, needs and alternatives, several conclusions may be reached. First, within the next 30 to 50 years, augmentation of the water supply of the W.C. Austin Project will likely be necessary. Second, the need exists to improve the operational efficiency of the project. Third, a range of alternatives appear to be available that could meet both the augmentation and efficiency improvement needs. Finally, Congress has established a Federal interest in meeting the water supply needs of the project by authorizing the original project and directing Reclamation to investigate augmentation alternatives.

Evaluation of the Alternatives

When the alternatives were compared relative to one another, a wide range of estimated supply, costs and environmental impacts resulted. In preparation for recommending a course of action, the potential feasibility of each alternative was evaluated by testing it against four criteria: Effectiveness, Efficiency, Acceptability and Completeness. The definitions of these evaluation criteria and the results of the analyses are presented in the following sections.

Criteria and Definitions

Effectiveness *The effectiveness of an alternative refers to the extent to which it would augment the water supply of the W.C. Austin Project*. Effectiveness is important because it indicates the degree to which an alternative satisfies the stated objective of this Appraisal Report.

Efficiency *The efficiency of an alternative refers to the relative difference between the estimated costs of an alternative and its estimated supply*. Efficiency is important because it indicates how cost-effective an alternative would be in meeting the identified need. This criterion includes an assessment of estimated construction and O&M costs on a cost per acre-foot basis[30].

Acceptability *The acceptability of an alternative refers to the extent to which it is compatible with existing environmental laws, regulations and public policies*. Acceptability is important because

[30] It should be noted that no effort was made in the Appraisal Report to address issues related to cost/benefit, ability to pay or other related economic analyses. These issues are more appropriately addressed in a Feasibility level investigation when detailed cost estimates, cost share allocations, and reimbursable allotments would be known with more certainty.

it indicates how complicated, controversial or expensive an alternative could be to implement. This criterion is determined, in part, by an estimation of the anticipated environmental impacts and the views of other resource agencies.

Completeness *The completeness of an alternative refers to the extent to which it accounts for all necessary investments or other actions to assure the realization of the planned effects.* Completeness is important because it indicates how much additional investigation may be necessary prior to design and implementation.

Results and Discussion

The results of the evaluation analysis are summarized in Table 7 and discussed below:

TABLE 7: Relative degree to which each alternative meets established evaluation criteria. The ratings are subjective in nature and reflect the professional judgment of the inter-disciplinary planning team that prepared this Appraisal Report.

	ALTERNATIVE	**Effectiveness** The extent to which an alternative would augment the water supply of the W.C. Austin Project.	**Efficiency** The relative difference between the estimated costs of an alternative and its estimated supply.	**Acceptability** The extent to which an alternative would be compatible with existing environmental laws, regulations and public policies.	**Completeness** The extent to which an alternative accounts for all necessary investments or other actions to assure the realization of the planned effects.
1	Wastewater Reuse	low	low	Moderate	Moderate
2	Trico Reservoir	HIGH	low	low	Low
3	Cable Mtn. Reservoir	HIGH	low	low	Low
A	North Pool Restoration	–	HIGH	HIGH	Moderate
B	District Modernization	–	Moderate	HIGH	Moderate

Effectiveness Each of the two reservoir alternatives (Trico and Cable Mountain) would significantly increase the amount of available water in the study area. Trico Reservoir would be located upstream of Lake Altus and would require no additional infrastructure for water delivery. In addition, Trico Dam would greatly extend the expected project life of the existing W.C. Austin Project facilities by capturing a majority of inflowing sediments. Cable Mountain Reservoir, located downstream of Lake Altus, would augment the water supply of the current project, but not for all of the existing irrigated acreage. Furthermore, were Cable Mountain Reservoir constructed, sedimentation in Lake Altus would continue at the present rate resulting in the eventual loss of that reservoir as a viable irrigation water supply.

Alternatives A (North Pool Restoration) and B (District Modernization) were not rated with regard to this criterion because they would not augment the water supply of the project. These two efficiency improvement alternatives, therefore, were not considered in the final feasibility recommendation because they do not meet the primary directive of Congress for this investigation. Alternative 1 (Wastewater Reuse) had the lowest supply volume of any of the alternative, and therefore was considered to have a low effectiveness rating.

Efficiency Both efficiency improvement alternatives (North Pool Restoration and District Modernization) were the most cost-effective alternatives. Although Alternative A (North Pool Restoration) was slightly less expensive per volume than Alternative B (District Modernization) [31], both fell within the range of hundreds of dollars per acre-foot for construction and about 5 dollars per acre-foot for annual O&M. Alternative 1 (Wastewater Reuse) had a similar construction cost range but it was rated low in Efficiency because of its large estimated O&M cost per volume. The most inefficient alternative with regard to construction cost per acre-foot was Alternative 2 (Trico Reservoir), which ranged from 10 to 150 times higher than the other alternatives.

Acceptability The two efficiency improvement alternatives (Alternatives A and B) were the most acceptable with regard to environmental impacts, while the two reservoir alternatives (Alternatives 2 and 3) were the least acceptable due to the significance of anticipated impacts. Alternative 1 (Wastewater Reuse) was rated moderate in Acceptability because of the potential regulatory requirements necessary for use of municipal effluent for agricultural purposes.

Completeness Because of the conceptual nature of this Appraisal Report, each of the alternatives exhibited some degree of uncertainty with regard to design, costs and potential supply. However, Alternatives 2 (Trico Reservoir) and 3 (Cable Mountain Reservoir) were rated low in Completeness because of the uncertainty of the future water quantity and quality of surface water in the North Fork Red River. The potential development by Texas of its Red River Compact allocation significantly limits the ability to plan with certainty future water uses of this river in Oklahoma. Alternative 3 (Cable Mountain Reservoir) was also rated low because of the unknown short- and long-term effectiveness of the chloride control component.

Feasibility Recommendation

Recommendation Based upon the results of this evaluation, it is recommended that none of the augmentation alternatives evaluated in this Appraisal Report be investigated to feasibility level at this time.

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[31] It should be noted that much of the estimated construction cost of the District Modernization alternative is attributable to the re-regulation reservoirs. In the phased implementation approach anticipated under this alternative, the re-regulation reservoirs would be sized and constructed on an as-needed basis. If the actual size and number of these re-regulation reservoirs needed was less than described in this Appraisal Report, then the Efficiency rating of this alternative could improve considerably.

Although some potential alternatives were identified that would augment the water supply of the existing W.C. Austin Project, each was rejected because of low cost-effectiveness, poor acceptability and significant uncertainty. Alternative 1 (Wastewater Reuse) was found to be ineffective at augmenting the water supply of the project, providing only about 1,000 to 2,000 acre-feet per year. Also, because of a high estimated annual O&M cost per volume, this alternative was also found to be inefficient.

Alternatives 2 (Trico Reservoir) and 3 (Cable Mountain Reservoir) were found to be the most effective alternatives in augmenting water supply, with Trico Reservoir having an advantage over Cable Mountain Reservoir because of the degree to which it would off-set future sedimentation of Lake Altus. However, the two reservoir alternatives were found to be inefficient due to extremely large estimated construction or O&M costs relative to the other alternatives. Both alternatives were also found to be the least acceptable with regard to environmental impacts, and until the uncertainty of future water quantity and quality conditions imposed by the Red River Compact is resolved, any supply they may provide would not be fully reliable.

Future Opportunities

Even though an alternative to augment the water supply of the W.C. Austin Project is not recommended for further study at this time, there are opportunities to improve the present water supply condition of the project by improving operational efficiency. Alternatives A (North Pool Restoration) and B (District Modernization) were found to be the most cost-effective of any alternative evaluated. In addition, these alternatives were also highly acceptable with regards to their anticipated environmental impacts and relatively complete in their conceptualization.

If implemented, these two alternatives would increase the amount of water effectively available to the District by a total of about 15,000 to 20,000 acre-feet per year. This increase would off-set the effect of lost storage capacity in the reservoir due to sedimentation by an estimated 16 to 22 years. During this period, resolution of issues that presently prohibit further study of augmentation alternatives could be sought, including:

- Conducting a sedimentation survey of Lake Altus to determine a more accurate estimate of the existing sediment volume and the rate of its accumulation. This information would help clarify the period of time during which the existing project benefits can be expected to continue. This survey data would also contribute necessary information associated with the design requirements of Alternative A (North Pool Restoration) and planning needs of Alternative 2 (Trico Reservoir).

- Determining the feasibility of controlling the chloride loading in the Elm Fork of the North Fork Red River. This information would help clarify whether or not surface water in the North Fork Red River could be rendered suitable for beneficial uses, and at what costs.

- Resolving the potential for development by Texas of water resources in the North Fork Red River and its tributaries under terms of the Red River Compact. This information would help clarify the future quantity, and possibly more importantly, the future quality, of surface water resources within this basin.

Once these three issues become better understood, a more accurate assessment of the future water supply conditions and opportunities in the study area would be possible. At that time, a re-assessment of potential water augmentation alternatives for the W.C. Austin Project would be prudent.

Lake Altus at sunset, July 2004.
Photograph courtesy of Bureau of Reclamation, Austin, Texas.

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Construction of the redwood pipeline that carried water from the original Lake Altus Dam south to the city of Altus, *circa* 1927. Photo courtesy of the Museum of the Western Prairie, Altus, Oklahoma. Used with permission.

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A view of the Main Canal extending southward from Lake Altus, *circa* 1947. Photo courtesy of the Museum of the Western Prairie, Altus, Oklahoma. Used with permission.

View of ongoing reconstruction of Oklahoma State Highway No. 9 bridge across the upper end of Lake Altus, July 7, 1947 (National Archives and Records Administration 1947b). The earthen approaches of this bridge constrict the lake and have effectively separated the reservoir into two pools, one upstream (right) and one downstream (left) of the crossing.

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Photograph of rock quarry after the blast, December 17, 1940. Workers are dumping small rocks over the fill to be used as riprapping material. Larger rocks were to be cut into blocks for use in Altus Dam (National Archives and Records Administration 1940b).

APPENDIX A: **Prior Studies**

Altus Project, Oklahoma: Survey of the North Fork of the Red River with Respect to Flood Control and Irrigation (United States Senate 1938). Congress based their decision to authorize construction of the W.C. Austin Project on this final project report. The document includes a detailed description of the proposed dam and irrigation facilities, the project purposes to be served, and an estimate of the costs and benefits of the project.

Appraisal of the Water and Related Land Resources of Oklahoma: Region I (Oklahoma Water Resources Board 1967). This report was part of a state-wide survey of water and related land resources in Oklahoma. The geographical focus of this report, Region I, included all the area drained by the North Fork Red River and its tributaries, Salt Fork Red River and its tributaries, and Prairie Dog Town Fork Red River and its tributaries, all within Oklahoma. The report found that Region I included more land under irrigation (111,607 acres) and more land suitable for irrigation (over 700,000 acres) than any area of similar size in Oklahoma. However, the report concluded that there was not sufficient water of good quality to develop the related land resources in Region I, and that in order to develop to the fullest extent the related land resources and furnish a dependable supply of water for municipal and industrial uses, it would be necessary to bring in water from other sources.

Plan of Development for Retrop Project, Oklahoma (Bureau of Reclamation 1970). The objective of this report was to modify the existing W.C. Austin Project to 1) insure the safety of this project during the occurrence of a design flood computed from updated data and analysis criteria, and 2) extend the economic life of the project which was being extinguished by sedimentation. Alternatives evaluated to insure dam safety included modification of reservoir operating procedures, developing additional storage (Trico Reservoir site), and structural modification of Altus Dam. Alternatives considered for offsetting project sedimentation included development of an upstream sediment trap (Lone Wolf site), dredging of Lake Altus, and structural modifications of Altus Dam to increase reservoir capacity. The alternative selected as most feasible involved the modification of Altus Dam, spillways, and dike system.

Changes In Streamflow And Summary Of Major-Ion Chemistry And Loads In The North Fork Red River Basin Upstream From Lake Altus, Northwestern Texas And Western Oklahoma, 1945-1999 (Smith and Wahl 2003). The purpose of this U.S. Geological Survey report was to study historic streamflow conditions and surface-water quality in the North Fork Red River basin upstream from Lake Altus, Oklahoma. It presents statistical trends in precipitation and streamflow, and summarizes water quality chemistry. The report found a statistically significant increase in precipitation occurred in the study area during the period of 1945-1995 at an average rate of 0.14 inches per year. It also found that the USGS streamflow gage at Carter (located on the North Fork Red River immediately upstream of Lake Altus) had a significant increasing trend in the base-flow index and a significant decreasing trend in annual peak flow. Finally, the report found that water chemistry in the North Fork Red River is closely related to the chemical composition of the underlying bedrock. The concentration of dissolved solids, especially sulfate and chloride, generally increases downstream as the river passes over salt-bearing rocks.

W.C. Austin Project Water Availability Assessment: Final Report (Stephens 2003). The purpose of this Oklahoma Water Resources Board study was to gather water quality and quantity data from the groundwater and surface waters associated with the North Fork Red River watershed to assist in evaluating the interaction between surface and groundwater in the basin. The study was intended to compliment an investigation by Smith and Wahl (2003) of historic streamflow and water quality conditions in the North Fork Red River above Lake Altus. The study concluded by summarizing its findings on aquifer parameters, groundwater quality characteristics, surface water quality characteristics, water use, and groundwater-surface water interactions. The report found that if groundwater usage develops to the level where base flow discharge to the rivers and streams is significantly affected, flows in the river would begin to decrease. However, the investigation found no indicated that groundwater development has reached this level.

W.C. Austin Water Augmentation Study: Preliminary Assessment of Proposed Alternatives (Bureau of Reclamation 2004a). The purpose of this assessment was to make a cursory evaluation of the potential costs, benefits and impacts of proposed alternatives to augment the water supply of Lake Altus, and to make a comparison of these alternatives relative to one another. A total of eighteen different alternatives were conceptually defined and then evaluated with regard to possible engineering solutions, estimated costs, hydrologic results, and environmental impacts.