United States
Department
of Agriculture

Natural
Resources
Conservation
Service

FINAL ENVIRONMENTAL ASSESSMENT

Elm Fork Watershed of the Trinity River Watershed for Multiple-Purpose Structure No. 19 Cooke County, Texas

Prepared By:

U.S. Department of Agriculture
Natural Resources Conservation Service
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In cooperation with:

Upper Elm-Red Soil and Water Conservation District
Denton Soil and Water Conservation District
Montague County Commissioners Court
Cooke County Commissioners Court
City of Muenster
Muenster Water District

March 2001

ENVIRONMENTAL ASSESSMENT
ELM FORK WATERSHED
OF THE TRINITY RIVER WATERSHED
MULTIPLE-PURPOSE STRUCTURE NO. 19

SUMMARY OF ENVIRONMENTAL ASSESSMENT

Project Name: Elm Fork Watershed

Counties in Watershed: Montague, Cooke, and Denton

State: Texas

Sponsors: Upper Elm-Red Soil and Water Conservation District
Denton Soil and Water Conservation District
Montague County Commissioners Court
Cooke County Commissioners Court
City of Muenster
Muenster Water District

Description of Recommended Action:

Install Multiple-Purpose Structure (MPS) No. 19 with M&I water intake and outlet facilities, and recreational facilities on a 22 acre designated park area. See Appendix D - Project Map for location.

Resource Information: Size of Elm Fork Watershed:

253,810 acres (396.57 sq. mi.) in total watershed
Drainage area of MPS No. 19: 9,171 acres (14.33 square miles)

Land Use Required for MPS No. 19:

Dam, emergency spillway and municipal pool will require 96 acres of cropland and 263 acres of rangeland. Detention pool and flowage easement areas will require 94 acres of cropland and 225 acres of rangeland. Recreation area will require 22 acres of rangeland.

Average Size Farms in Watershed: 322 acres

Endangered Species:

Species that could occur in Cooke County (None Identified on project site.)

1. Whooping Crane (*Grus americana*)
2. Interior Least Tern (*Sterna antillarum*)
3. American Bald Eagle (*Haliaeetus leucocephalus*)

Sociological Resources:

Muenster is known as a dairy center, food processing center, and for the annual Germanfest. Population in the watershed area (Cooke County) is 33,742. Breakdown by race is 94.4 percent White, 4.1 percent Black, 0.9 percent American Indian, and 0.6 percent Asian. Of these 5.6 percent are Hispanic.

In 1997 there were approximately 1485 farms in Cooke County. The average size farm was 322 acres. The major agricultural products produced in the county included wheat, grain sorghum, and livestock with a market value in excess of 37 million dollars. Approximately 37 percent of the farms were considered to be full time operating farms with 63 percent having other occupations as the major source of income (Census for Agriculture, 1997).

Problem and Opportunities Identification:

There is a need for a dependable water supply to meet municipal water demand. Flooding of homes, businesses, agricultural properties, roads, and bridges downstream of MPS No. 19 is a problem. There is also a need for water-based recreational facilities.

Impacts of MPS No. 19 on Natural Resources:

Air Quality:

Construction activities will cause temporary dust pollution.

Water Quality and Quantity:

Improve water quality by reducing sediment load and other contaminants downstream from MPS No. 19.

Increase in recharge to the Antlers aquifer in the order of 60 to 125 ac-ft/yr.

Fisheries:

MPS No. 19 will create 309 acres of Lacustrine wetland habitat.

Wildlife habitat:

Installation of MPS No. 19 will convert 94 acres of cropland and 215 of rangeland habitat to aquatic habitat.

Installation of MPS No. 19 will provide an additional source of water for terrestrial species.

Prime Farmland:

MPS No. 19 will inundate 185 acres of soils that are listed as Prime farmland.

Archeological and Historical Resources:

The cultural resources survey resulted in the identification of several historic cultural resources primarily associated with the former route of the Missouri-Kansas-Texas (MKT) Railroad that transects the proposed MPS No. 19 project area. No prehistoric cultural resources were identified as a result of the survey.

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INTRODUCTION

Purpose and Need of Project

The city of Muenster provides municipal and industrial water to the residents of Muenster and surrounding rural area. Water for domestic use in the urban area is supplied from deep wells into the Trinity Sand Aquifer. Potential for future water shortages and degrading water quality is a possibility due to the declining aquifer level. Shallow wells also provide the water for livestock and domestic use in rural areas, with many small ponds furnishing additional supplies for livestock. Long periods of drought have lowered the water table to the extent of endangering the supply of water from the shallow wells. Multiple-Purpose Structure (MPS) No. 19 is needed to supplement the well(s) that currently supply water to the city of Muenster. The statewide water planning initiative established in the 1997 Senate Bill 1 listed this multiple-purpose structure, as one of the alternatives in Region C to provide needed water for the future. Current groundwater use in Cooke County exceeds the Texas Water Development Board's estimated long term reliable supply. The Region C Water Plan shows a net need for immediate additional supplies if all demands and connected supplies are used. (Region C Water Plan)

Flooding on Brushy Elm Creek causes damages to homes, businesses, roads, bridges and other infrastructure. A cheese manufacturing plant's waste treatment facility and the city's sewage treatment plant are endangered by the 500-year flood event (Appendix B, Figure 1). Flood debris swept along by the high velocities of the 500-year event causes additional damages. Damages to the rural agriculture land include reduced productivity, erosion, deposition of infertile sediment and increased production costs.

Texas Parks and Wildlife Department records indicate that there is a deficit of outdoor water-based recreational facilities for this region of Texas.

Prior Work Completed

The original work plan for the Elm Fork Watershed of the Trinity Watershed (hereafter referred to as Elm Creek Watershed) was completed on June 21, 1956 by authority of Public Law 78-534. The work plan as supplemented contains 41 floodwater retarding structures and one multiple-purpose structure (MPS No. 19). The 41 floodwater retarding structures have been constructed.

The "Trinity River Watershed, Final Environmental Impact Statement", dated July 1979, covered the impacts associated with Elm Fork Watershed project which included the installation of MPS No. 19. This assessment is being prepared to update and review items that could be of concern in installing the structure considering the present rules and regulations. Further information may be obtained by reviewing the above noted report.

PROJECT SETTING

Location and Size

Elm Fork Watershed comprises an area of 253,810 acres (397 square miles). It rises near the town of Saint Jo in Montague County, Texas, and flows in a southerly direction for 94 miles, emptying into the Trinity River in the west-central part of Dallas County near the city of Dallas. MPS No. 19 will be located on Brushy Elm Creek, a tributary of Elm Fork, approximately one mile northwest of Muenster, Texas and has a drainage area of 9,170 acres (14.33 square miles) (See Project Map, Appendix D).

Climate

Extreme temperatures range from 12° F below zero to 114° F above zero, with mean temperatures ranging from 43° F in the winter to 83° F in the summer. The average dates of the first and last killing frost are November 7 and March 25 respectively, giving an average growing season of 227 days. The average annual precipitation is 34.2 inches with the greater amounts of rain falling during the months of April, May, June and October. Rains of high intensities are frequent.

Geology

The geologic formations on MPS No. 19 include the Kiamichi, Goodland, Walnut, and Antlers Formations.

Kiamichi Formation - (Lower Cretaceous) - Located in the upper abutments and emergency spillway. The Kiamichi consists of laminated to thin bedded claystone and thin bedded limestone.

Goodland Formation - (Lower Cretaceous) - Located in the upper abutments and emergency spillway. The Goodland consists of moderately hard to hard, thin to medium bedded limestone. A few, thick bedded limestone layers are also noted on the site. These limestone beds grade downward into the Walnut clays.

Walnut Formation - (Lower Cretaceous) - Located in the mid to lower abutments. The Walnut consists of hardness 1 to 2 claystone, containing a few hardness 3 limestone layers.

Antlers Formation - (Lower Cretaceous) - Located in the lower abutments and at depth beneath the site. The formation attains a maximum thickness of 400 feet in the area. The upper portion of the Antlers consists of a hardness 1 to 2 sandstone and claystone, being up to 43 feet thick in the abutments and approximately 20 feet thick beneath the alluvial deposits. The sands are very fine grained and are poorly to noncemented. A few horizons in the sandstone are moderately

hard, being thin bedded and sporadic in their occurrence. The claystone interfingers with the very fine grained sandstone, decreasing in amount with depth.

Within the upper Antlers there is an organic rich layer of variable thickness, which mainly outcrops above the borrow area as a natural asphalt layer. This layer is up to six feet thick. The layer at depth behaves similarly to an oil shale in producing a dark coloring on the surface of mud pits while drilling. In a very few areas there are a minor amount of free hydrocarbons, which may fill microscopic fractures and voids in poorly cemented to noncemented sandstone. Little or no movement of material has been noted in the numerous channels that cross the outcrops or around seeps.

The lower Antlers is a fine grained sandstone, being poorly cemented to noncemented. A few thin calcareous and siliceous cemented layers are present. Some thin claystone layers are present. The fine grained sandstone continues to depth beneath the site, being over 16 feet in thickness.

Soils

Soils that are located at MPS No. 19 include the Bolar, Frio, Lewisvillle, Lindy, Maloterre, Sanger, San Saba, Slidell, and Tinn series. These soil series are described below. Additional information concerning the soils in the project area can be obtained from the USDA-SCS, Soil Survey of Cooke County, Texas.

Bolar Series

Consists of moderately deep, well drained, loamy soils on uplands. These soils formed in coarsely fractured limestone. Slope ranges from 1 to 12 percent.

Frio Series

Consists of deep, well drained, loamy soils on bottomlands. These soils formed in calcareous loamy and clayey alluvial sediments. Slope ranges from 0 to 1 percent.

Lewisville Series

Consists of deep, well drained, loamy soils on stream terraces. These soils formed in calcareous, loamy alluvial sediments. Slope ranges from 1 to 8 percent.

Lindy Series

Consists of moderately deep, well drained, loamy soils on uplands. These soils were formed thick beds of indurated limestone. Slope ranges from 1 to 5 percent.

Maloterre Series

Consists of very shallow, somewhat excessively drained loamy soils on uplands. These soils formed in indurated platy limestone. Slope ranges from 3 to 30 percent.

San Saba Series

Consists of moderately deep, well drained, clayey soils on uplands. These soils formed in calcareous clays underlain by limestone. Slope ranges from 1 to 5 percent.

Sanger Series

Consists of deep, well drained, clayey soils on erosional uplands. These soils formed in calcareous, clayey marine deposits. Slope ranges from 1 to 8 percent.

Slidell Series

Consists of deep, well drained, clayey soils on uplands. These soils formed in calcareous clayey marine deposits. Slope ranges from 0 to 5 percent.

Tinn Series

Consists of somewhat poorly drained clayey soils on bottomlands. These soils formed in calcareous, clayey alluvial sediments. Slope ranges from 0 to 1 percent.

Prime farmland

Prime farmland is land that has the combination of physical and chemical characteristics for producing food, feed, fiber, forage and oilseed crops and that is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner when it is treated and managed according to acceptable farming methods. The prime farmland soils that are located at the project site include Bolar clay loam, Frio clay loam, Lewisville clay loam, Lindy loam, Sanger clay, Slidell clay, and Tinn clay. The county has 117,600 acres of these soils mapped in the county.

Topography

The topography of Elm Fork watershed ranges from gently rolling to rolling with a well-developed drainage pattern. The general stream courses trend to the south and east. Local relief along the major valleys range from a minimum of 50 feet to a maximum of 200 feet near the headwaters. Elevations range from about 510 feet (msl) in the stream channel above Lake Garza-Little Elm to 1,200 feet (msl) at the northern divide.

All of the western part of the watershed drainage area, about 90 percent of the total, lies within the Central Lowland physiographic province, and the small strip along the eastern divide is in the West Gulf Coastal Plain. The oldest formation, which is the Paluxy sand of Lower Cretaceous age, occupies small linear strips along the valleys of headwater streams in the western edge of the drainage. This small area of sandy beds is the only representative of the West Cross Timbers Belt in the watershed. Many of the small streams have entrenched themselves in this formation, and sandy deposits in the upper valleys have been produced by erosion in this area.

Population

Cooke County had an estimated population of 33,742 in 1999. This represents a 9.6 percent increase in population from the 1990 census. Gainesville, the county seat of Cooke County had an estimated population of 15,229 in 1999. This represents a 6.8 percent increase in population over the 1990 census. The city of Muenster had an estimated population of 1,572 in 1999. This represents a 13.3 percent increase in population from the 1990 census. Other towns in the county are Callisburg (377), Lindsay (683), Oak Ridge (191), and Valley View (694) (Texas State Data Center, 1999).

Social and Economic Conditions

Muenster is located approximately 15 miles west of Gainesville Texas, the county seat of Cooke County. Muenster is known as a dairy center, food processing center and for the annual Germanfest. Population in the watershed area (Cooke County) is 33,742. Breakdown by race is 94.4 percent White, 4.1 percent Black, 0.9 percent American Indian, and 0.6 percent Asian. Of these 5.6 percent are Hispanic.

In 1997 there were approximately 1,485 farms in Cooke County. The average size farm was 322 acres. The major agriculture products produced in the county included wheat, grain sorghum, and livestock with a market value in excess of 37 million dollars. Approximately 37 percent of the farms were considered to be full time operating farms with 63 percent having other occupations as the major source of income (Census for Agriculture, 1997).

Land Uses

The land uses in the vicinity of MPS No. 19 are cropland, rangeland and pastureland. The major crops grown on the cropland includes small grains during the winter months and forage sorghums used for hay and silage during the summer months. The rangelands include bluestems, wintergrass, sedges and forbs. The pastureland consists of improved bermudagrass, kleingrass, and K.R. Bluestem.

WATERSHED PROBLEMS AND OPPORTUNITIES

Municipal Water Needs

The city of Muenster provides municipal and industrial water to residents of Muenster and the surrounding rural area. Sources of water to meet the needs of the municipal and industrial supply are groundwater wells. Aquifer levels are receding at the rate of 2 to 3 feet per year resulting in the potential for future water shortages and declining water quality. There are no sources in nearby areas to purchase additional water that will meet their needs. Senate Bill One – Initially Prepared Region C Water Plan points out that the current use of groundwater exceeds the long-term available supply. If no additional water supplies are developed, Region C will face substantial shortages in water supply over the next 50 years. Current groundwater use in Cooke County exceeds TWDB's estimated long-term reliable supply.

Flooding and Sediment Damages

The flood plain within the city of Muenster is mostly confined to non-residential areas. Seven residences have the potential of being flooded during a 100-year flood event, and damages to roads, bridges and other infrastructure would occur. A cheese manufacturing plant's waste treatment facility and the city's sewage treatment plant is endangered by the 500-year flood event. Flood debris swept along by the high velocities of the 500-year flood event causes additional damages. Appendix B, Figure 1 shows the water surface elevation of the 100 and the 500-year frequency flood. Floods damage agriculture land by reducing productivity, erosion, sediment deposition and increasing production costs.

Recreational Needs

Research compiled by the Comprehensive Planning Staff of the Texas Parks and Wildlife Department indicates there is a deficit of outdoor water-based recreation facilities to serve the needs of the people residing in Region 22, which includes the city of Muenster. Region 22 is one of the more heavily populated regions of the state and had a projected population increase through the year 2030. The user-days participation occurring in this region increased 352 percent during the period 1968-1980. Activities in the top ranking consist of fishing, boating, picnicking, swimming, and camping.

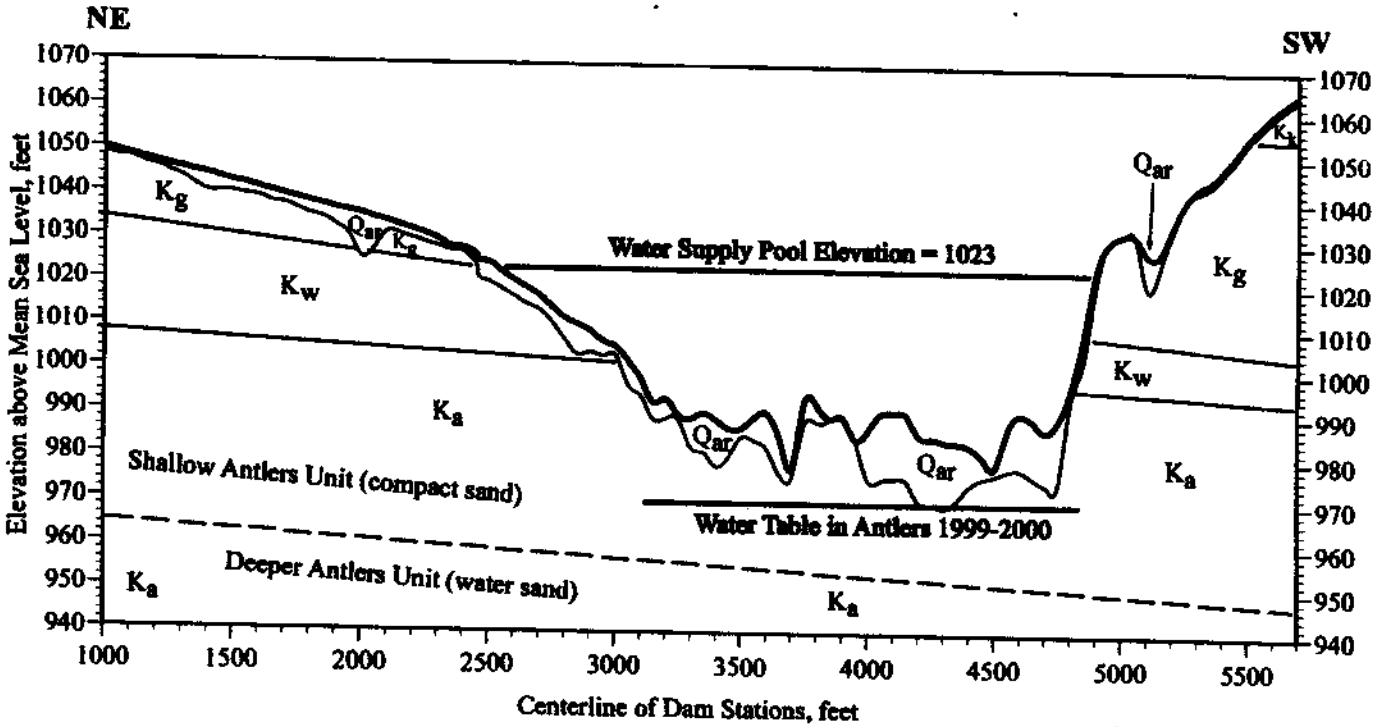
INVENTORY OF RESOURCES

Geology

General Geology and Stratigraphy

The valley of Brushy Elm Creek occurs in the Western Cross-Timbers physiographic province (Nordstrom, 1982). Rolling to hilly upland topography that is dissected into steep hillsides and deep ravines characterize this physiographic province of north central Texas. Sandy soils occur especially where the Antlers Sand serves as the parent material. Heavy growths of post oak and blackjack oak typify the native vegetation.

The convex upward valley wall profiles and lack of a widespread, continuous alluvial blanket underlying the valley floor (Figure 1) provide evidence for geologically recent stream incision in the lower order stream valleys that is typical of the Western Cross Timbers province. The left (i.e., NE) abutment of the proposed dam slopes more gently, on the average, than the right (i.e., SW) abutment. Gentler slopes favor chemical weathering therefore the residuum tends to be thicker on the left abutment than on the right. The steeper right abutment may favor mechanical weathering processes, mass movements (soil creep, slides, etc.), and the possibility of open joints in the bedrock.



Q_{ar} = undifferentiated alluvium and residuum; K_k = Kiamichi Shale; K_g = Goodland Limestone; K_w = Walnut Shale; K_a = Antlers Sand.

Figure 1. Profile along centerline of proposed dam on Brushy Elm Creek, Muenster, Texas. The apparent dips of formational contacts vary from about 0.15° to 0.35° toward the SW in contrast to the regional dip of about 0.25° SE. This may represent the local structural position of the site on the west flank of the Muenster Arch or the influence of lateral facies changes. The water table in the Antlers Sand occurs at about elevation 970 at the site. The hydraulic gradient is most likely toward the NE but is not indicated on the diagram. The initial impact of the pool will be downward infiltration and raising of the local water table in the Antlers. Once the new hydraulic regime approaches equilibrium, most flow will be subhorizontal, moving down the hydraulic gradient in the Antlers and laterally in various directions along permeable horizons in the other formations.

Geologic structure in this part of north central Texas is comparatively monotonous (McGowen et al., 1967; Nordstrom, 1982; Allison, 1997). The regional strike of lower Cretaceous strata is NNE and the strata dip gently toward the ESE. A 3-point solution of the asphalt marker bed in 3 wells gave a strike of N28°E and a dip of about 0.25° SE, which is consistent with the regional dip. The apparent dip of formational contacts at MPS No. 19 differs somewhat from the regional dip (Figure 1). The presence of the axis of the Muenster Arch about 2 miles to the east may account for the discrepancy. Lateral facies changes and the transgressive nature of the contacts with respect to individual bedding planes may also account for the difference.

Stratigraphy at MPS No. 19 consists primarily of a sequence of Lower Cretaceous marine rocks (McGowen et al., 1967; Nordstrom, 1982). The formations occurring at the site are described below and their typical thicknesses and elevations depicted on Figure 1. The descriptions provide a typical range of horizontal permeabilities of each stratigraphic unit. Vertical permeabilities are approximately one tenth (0.1 times) horizontal permeabilities.

Alluvial and Residual Deposits (Quarternary): Located primarily in the flood plain area. The alluvial and residual deposits consist primarily of CL, CH, SM, GC, and GM materials. Thickness varies from 0 to 15 feet. The more plastic clays predominate near the surface with the sand and gravel content increasing with depth. Permeabilities range from 0.00268 ft./day to more than 1.75 ft./day and are higher in the coarser, basal materials.

Kiamichi Formation (Lower Cretaceous): Located in the upper abutments and emergency spillway. The Kiamichi consists of laminated to thin bedded claystone and thin-bedded limestone. Over 12 feet of the Kiamichi is located in the emergency spillway area. The Kiamichi generally occurs above the permanent pool elevations.

Goodland Formation (Lower Cretaceous): Located in the upper abutments and emergency spillway. The Goodland consists of moderately hard to hard, thin to medium bedded limestone. A few thick-bedded limestone layers are also noted on the site. These limestone beds grade downward into the Walnut clays. Approximately 45 feet of the Goodland Formation is located on site. Permeability is largely controlled by narrow fractures in the formation and by degree of weathering. On the left abutment, a permeability of 0.0849 ft./day was obtained. Similarly low permeabilities were noted on the right abutment.

Walnut Formation (Lower Cretaceous): Located in the mid to lower abutments. The Walnut consists of hardness 1 to 2 claystone, containing a few hardness 3 limestone layers. Approximately 13 to 17 feet of the Walnut is located on site. Permeability is generally associated with thin limestone layers and degree of weathering. On the left abutment, a permeability of 0.00367 ft./day was obtained.

Antlers Formation (Lower Cretaceous): Located in the lower abutments and at depth, the Antlers can be subdivided into shallower and deeper units beneath the site. The shallow portion of the Antlers consists of a hardness 1 to 2 sandstone and claystone, being up to 43 feet thick in the abutments and approximately 20 feet thick beneath the alluvial deposits. The sands are very fine grained and are weakly cemented to non-cemented. A few horizons in the sandstone are moderately hard, being thin bedded and sporadic in their occurrence. The claystone interfingers

with the very fine-grained sandstone, decreasing in amount with depth. Permeability in the shallow Antlers is controlled by the amount of silt and clay present in thin layers. The permeability ranged from 0.0042 to .00643 ft./day with the higher reading coming from an upper clayey gravel layer in contact with the alluvium.

The deeper Antlers is fine grained weakly to non-cemented sandstone. A few thin calcareous and siliceous cemented layers are present. Some thin claystone layers are present. The fine-grained sandstone continues to depth beneath the site and is at least 16 feet thick. Permeability in the deeper Antlers is controlled by the amount of silt and clay present in thin layers within the fine grained sandstone and the degrees of compaction and cementation. A permeability of 0.0202 ft/day was obtained beneath the flood plain.

An organic-rich layer of variable thickness occurs in the shallow portion of the Antlers and outcrops as an asphalt layer in the pool area at elevations generally above the borrow area. The asphalt layer attains thicknesses of up to 6 feet but is generally less than 3 feet thick. The layer behaves similarly to an oil shale at depths below the surficial weathering zone and produces a dark color on the surfaces of mud pits during drilling. Minor quantities of free hydrocarbons occur locally and may fill fractures and voids in the sandstone. Discharges of hydrocarbons to the numerous channels that cross the asphalt layer have not been observed.

Hydrogeology and Seepage Losses

The Antlers Sand constitutes a major aquifer in north central Texas. The vertical and horizontal distributions of permeability within the Antlers will largely control seepage losses and aquifer recharge at MPS No. 19. A solution of a 3-point problem suggests a regional water table striking about N-S and dipping about 0.4° E. The dip is steeper than the regional dip of the Antlers itself because of the cone of depression caused by ground water withdrawal in the Muenster water well field.

The seepage losses appear to be relatively low on MPS No. 19, based on the permeabilities found during field tests. At the level of the water supply pool, there is a conservative estimate of 113,000 gallons lost per day, primarily through the Antlers Formation. The calculations show seepage losses to be much less than that lost to evaporation. The basic assumptions for the calculations include:

1. Core trench taken through the upper weathered, fractured limestone of the Goodland and Walnut Formations and into the upper portion of the Antlers Formation.

2. Water level beneath the site is at elevation 970 ft msl.

3. Water supply pool level is at elevation 1023 ft msl.

4. Hillside seepage entering the valley represents the water level in the abutments above elevation 1023 ft msl.

5. Dam constructed with 3:1 side slopes.

6. Water that seeps downward through the upper 20 feet of the Antlers is able to dissipate through the lower Antlers.

7. Area involved is 309 acres submerged by water supply pool.

8. Horizontal permeabilities:
    a. Goodland Limestone - 0.1 ft/day
    b. Walnut Clay - 0.00367 ft/day
    c. Shallow Antlers Sandstone - 0.0042 ft/day
    d. Deeper Antlers Sandstone - 0.0202 ft/day

9. Vertical permeability equals 10% of horizontal permeability.

Water at MPS No. 19 infiltrates downward to the Antlers Sand and will most likely provide recharge to the aquifer. The seepage analysis indicates that recharge might amount to as much as 125 ac-ft/yr. It is possible that at least half the infiltrated water could be diverted by horizontal permeability, reducing the subsequent recharge to about 60 ac-ft/yr.

A number of different models were run to derive the best estimate of seepage from the site. The model used gave a loss of 112,977 gallons per day from the water supply pool elevation. It appears to be conservative in its approach and fits the site conditions. Should a more accurate estimate of seepage be required, a more detailed breakdown of water levels behind the site versus surface area can be determined.

Through the use of the more permeable, clayey gravel for borrow and plating of any permeable layers with clay, the downward seepage losses may be minimized. This will cause a corresponding reduction in recharge to the Antlers aquifer. However, such recharge will exceed that of the present because no pool currently exists at MPS No. 19.

Water Resources and Needs

The purpose of this project is to supplement the ground water supply that is diminishing at a rate of three feet per well in the project area and 10 feet per well per year just 12 miles to the east of in the city of Gainesville. Senate Bill One (SB-1), -Initially Prepared Region C Water Plan, September 2000, states that groundwater from the Trinity aquifer provides all municipal water in Cooke County. The current use from the aquifer is significantly greater that the estimated long-term reliable supply. The city of Muenster has used in the range of 105 to 120 million gallons of water per year in the recent past which is 320 to 370 acre feet per year. Considering future growth in population the city's need will most likely increase in the future. The need for additional supplies for the city of Muenster will be met by MPS No. 19 as the source for the additional supply in the years 2010 through 2050. In addition, the city of Gainesville, county seat of Cooke County, has a need for addition supplies of 2,715 ac-ft/yr. The city of Gainesville is planning on the development of a 1 mgd raw water pipeline and water treatment plant to make

use of a portion of the city's raw water in Moss Lake. TWDB's current estimate of the long-term reliable supply from the Trinity aquifer is inadequate to meet needs, making it necessary for users to find other supplies. Based on the current TWDB estimate of groundwater availability, it is assumed that the municipal water suppliers in the county will use 70 percent surface water and 30 percent groundwater, with ground water used primarily to help meet peak demands.

A Reservoir Operation Study (RESOP) (Erion, 1999) was performed to provide adequate evidence that sufficient water volume will be impounded in the reservoir to meet the planned purposes of municipal water supply and recreation. Water supply and meteorological records were used to simulate the operation of the reservoir through a historical period. The procedure used is a month by month budget of storage in the reservoir where storage at the beginning of a month plus inflow and minus outflow during the month equals storage at the beginning of the next month. Inflow consists of water yield from the watershed and direct precipitation on the reservoir surface, plus in this case, the outflow from upstream floodwater retarding reservoirs. Outflow consists of releases to meet water supply demand, evaporation from the reservoir surface, seepage from the reservoir, and spills through the spillways. The Natural Resources Conservation Service's RESOP was used to perform the storage budget computations.

The historical period used for the study was 1950 through 1974. A 1951 through 1956 drought period is considered to be the most critical in modern times in most of Texas. Water supply data from three U. S. Geological Survey (USGS) surface water gage stations on the Elm Fork of the Trinity River was used to determine the water yield from the watershed area. The selected 25 year study period contains an annual drought with a 2 percent (50-year) frequency, a three year drought exceeding a 2 percent frequency and a 6 year drought exceeding a 1 percent (100-year) frequency. Evaporation for the site was determined using Texas Water Development Board (TWDB) Report 94 and data from the evaporation station at Denison Dam. Estimate of seepage from the reservoir is based on the geologic conditions in the reservoir area. Data including permeabilities of subsurface strata and water table information were obtained during the subsurface investigation of the dam and reservoir and used to make the seepage estimate as described in the Hydrogeology section. National Weather Service (Weather Bureau) records for rainfall at Muenster for the study period were used in the reservoir operation study. The Muenster Water District is authorized to use up to 500-acre feet per year from the reservoir for municipal use.

The reservoir storage at the end of each month was tabulated. The full water supply pool is 4,510 acre-feet. The storage ranged to a low of 1,654 acre-feet in September 1956 near the end of the 1951 through 1956 drought. The maximum permitted draw down is to 945 acre feet storage. Total inflow to the reservoir, evaporation, seepage and spillway discharge is summarized by year in Table 1 below. Demand each year is 500 acre feet. The 500 acre feet demand for municipal water was dependably met each year of the study. As expected the inflow to the reservoir is quite variable, being significantly below the average 12 years, significantly above average 10 years and within 25% of average only 3 years. The water supply demand could be met for one year with no inflow and for two years with as little as 200 acre feet inflow with the reservoir full at the beginning of the period. Evaporation is a significant demand on the reservoir amounting to 2 to 3 times the water supply demand and in a few cases exceeding the inflow for the year. The reservoir operation study was started assuming the reservoir full

January 1, 1950. There was sufficient runoff during 1950 to have filled the reservoir during the course of that year in any case. There are, however, several years in which the reservoir would not have filled had it been put into service that year. It should be expected it would take two or more years to fill the reservoir. Had the reservoir been put into service in 1951 it would not have filled until 1957.

Table 1 Total Inflow, Evaporation, Seepage and Spillway Discharge by Year

YEAR	INFLOW	EVAPORATION	SEEPAGE	SPILL
	Acre-feet	Acre-feet	Acre-feet	Acre-feet
1950	7862	1494	100	6163
1951	1765	1498	94	35
1952	989	1548	83	0
1953	1143	1157	63	0
1954	1814	1284	61	0
1955	1914	1199	63	0
1956	1601	1283	57	0
1957	12967	1328	85	8488
1958	5943	1381	98	4664
1959	3010	1303	91	417
1960	2514	1368	97	1214
1961	1993	1084	95	223
1962	5963	1250	96	3531
1963	1333	1280	96	464
1964	5023	1267	86	2162
1964	3570	1145	100	1920
1966	6567	1338	100	4600
1967	2281	1320	95	598
1968	6380	1312	101	4467
1969	7559	1350	101	5608
1970	5767	1332	100	3905
1971	4925	1443	99	2811
1972	1833	1410	98	173
1973	7118	1337	100	4895
1974	7013	1467	100	5027

General Hydrogeology

Water impounded at MPS No. 19 will primarily come from surficial rainfall runoff. Spring flow and base flow will contribute little to the long-term water yield except for temporary soil throughflow after prolonged rainfall events.

Stratigraphy at MPS No. 19 consists of a sequence of lower Cretaceous rocks (McGowen et al., 1967; Nordstrom, 1982; Eshbaugh and Wright, 2000). The Duck Creek limestone occurs at the highest elevations on ridge crests and is underlain by 20 to 50 feet of shale, limestone, and marls of the Kiamichi Formation (Figure 1). The Kiamichi outcrops in the upper portions of the valley walls along Brushy Elm Creek. The 60-foot thick interval containing the Goodland Limestone and Walnut Clay underlies the Kiamichi and occurs under the valley floor and the valley walls. The Walnut-Duck Creek interval consists of sediments typical of shallow marine deposits.

The Antlers Sand represents the lowermost Cretaceous in the vicinity and consists of about 500 to 650 feet of interbedded clay shale and sand with conglomeratic beds near the base. The Antlers lies unconformably on Permian sediments and marks the great transgression of the Cretaceous Sea onto the North American continent. It outcrops extensively to the northwest and southwest of the watershed and also underlies portions of the valley floor (Figure 1).

The Antlers Sand forms a significant aquifer in the area (a.k.a. "Trinity Aquifer" or "Trinity Sand"). The city of Muenster presently obtains water supply from wells in the Antlers, and numerous rural homesteads in the vicinity undoubtedly have private wells completed in the Antlers. The Walnut-Kiamichi interval probably constitutes a leaky aquitard over the Antlers in the Muenster water well field. The Antlers most likely consists of an unconfined, or water table, aquifer at MPS No. 19.

The maximum reported water level elevation in the Muenster water well field was 804 feet above mean sea level (msl) in 1939. This lies below the creek bed elevation of 977 ft msl and the top of the Antlers at elevation 996 ft above msl at MPS No. 19 (Figure 1). The water table in the Antlers at MPS No. 19 is about elevation 970 ft above msl. Elevations of the water surface behind the proposed dam are expected to range from about 1020 to 1040 ft msl. Once the new water table is established, ground water flow will be easterly down the regional dip and toward the Muenster well field. The net long-term effect of the dam will be to provide recharge locally to the Antlers aquifer.

Preliminary seepage analysis (D. Petefish, personal communication) indicates average vertical and horizontal permeabilities of about 0.0004 and 0.004 ft/day respectively. The vertical permeability governs the recharge rate of Muenster Lake to the Antlers Sand, indicating about 60 to 125 acre-feet per year will be added to the ground water in the aquifer. Horizontal permeability might divert a significant percentage from the aquifer recharge after the new long-term water table has been established. Total average annual seepage represents about 2 to 5% of the lake volumes allocated to water supply and recreation. Typical losses of water from the lake by evaporation are expected to be several times the volumes lost by combined vertical and horizontal seepage.

Aqueous Geochemistry

The aqueous geochemistry of surface water is consistent with constituents derived from weathering of carbonates and associated sedimentary rocks (Hem, 1985). Calcium and bicarbonate are respectively the most abundant cation and anion in surface runoff. Bicarbonate

retains its position as the most important anion in ground water but sodium replaces calcium as the most important cation. Total dissolved solids (TDS) is substantially higher in the ground water. The difference in cation composition can be explained by ion exchange of calcium ions in the water for sodium affixed to clay minerals in shale beds as the surface water percolates downward through the vadose zone to the water table. The higher TDS in ground water is caused by dissolution of oxidation products in the vadose zone and reaction of the percolating water with carbonates and other rock materials.

Ground Water Quality

Water quality in the vicinity of MPS No. 19 strongly reflects the aqueous geochemistry. Ground water in the vicinity is generally enriched in sodium by the ion exchange process. All reported measurements of sodium exceed the strictest EPA health advisory of 20 mg/l and 5 of 13 results exceed the most lenient level of 170 mg/l (van der Leeden et al., 1991). Occasionally pH and iron and manganese concentrations may exceed maximum contaminant levels (MCL) (Hem, 1985; Driscoll, 1986; van der Leeden et al., 1991). TDS measurements reported for ground water were all below the MCL but are significantly higher than concentrations reported for surface water.

Ground water samples were obtained from wells in Muenster, TX municipal well fields. Some samples from additional wells within the watershed of MPS No. 19 were also reported. The state number for each ground water well are reported in Appendix C. The numbers uniquely identify the wells (Nordstrom, 1982). Surface sampling sites reported are located in supportive documents (Eshbaugh and Wright; Soil Conservation Service, 1979). Locations of samples for chemical analysis of surface and ground waters are indicated in Table 2. Location of wells used for water levels are also noted.

Table 2 – Chemical Analysis Locations

Sample Location	West Longitude	North Latitude	Water Level	Chemical Analysis
Ground Water Locations				
1921101	97°27'46"	33°42'36"	X	
1921502	97°26'17"	33°41'24"	X	
1921601	97°23'32"	33°42'04"	X	
1921901	97°22'36"	33°39'28"	X	X
1921902	97°22'49"	33°39'00"	X	X
1921903	97°22'36"	33°39'06"	X	X
1921905	97°23'30"	33°38'39"	X	X
1921906	97°23'40"	33°38'58"	X	X
1921907	97°23'55"	33°38'32"	X	X
1921908	97°22'36"	33°39'28"		X
1921909	97°23'19"	33°39'49"	X	X
1921910	97°23'27"	33°40'04"	X	
Surface Water Sample Location				
Brushy Elm	97°24'03"	33°39'43"		X
Site 6A-1	97°26'46"	33°42'42"		X
Site 6E	97°24'43"	33°40'53"		X
Site 61C	97°24'26"	33°39'39"		X

Test results reported in Appendix C represent samples taken as early as 1944. Methods and their detection limits have varied since that time. Tests were performed by laboratories of the Texas Department of Health, Trinity River Authority, and private laboratories under contract to the USDA NRCS and the city of Muenster. Test methods were generally not reported with the test results but detection limits could be inferred from the reports (e.g., As < 0.002 mg/l implies the detection limit of the test for arsenic is 0.002 mg/l or 2 (µg/l).

According to tests results reported by the Texas Department of Health in 1997 detection limits of the following minor and trace metals in micrograms per liter (µg/l) are Ag: 3; Al: 4; As: 2; Be: 1; Cd: 0.2; Cr: 6; Cu: 6: Fe: 10; Hg: 0.27; Mg: 1; Mn: 8; Ni: 20, Pb: 1; Sb: 2; Se: 2; TI: 1; Zn: 6.

Surface Water Quality

Water quality of surface water in the region is generally good (Nordstrom, 1982; US EPA, 1999; Eshbaugh and Wright, 2000). This observation applies in general to MPS No. 19 but there are some concerns. A water treatment plant will be designed to take care of water quality concerns.

Chemical analyses reported from the watershed of the site indicate that aluminum, barium, iron, manganese, thallium, and fecal coliforms may exceed their respective MCL (USDA-SCS, 1979; Eshbaugh and Wright, 2000). The metallic constituents are frequently affixed to sediment and will be mobilized by erosion during runoff events and delivered to the reservoir. If the turbulent runoff waters contain sufficient dissolved oxygen some of the metals may be released into solution. Following runoff events sediments suspended in the reservoir water may be expected to settle out on the bottom. The metals, with the possible exception of barium and thallium, will precipitate as oxides and hydroxides as free oxygen is depleted from the water. Precipitation of most metals as sulfides will continue after oxygen has been depleted.

Barium has been identified as a potentially serious contaminant of surface waters in this area (USDA-SCS, 1979; York, 1997). Barium is not expected to exist for long at concentrations exceeding its MCL because both surface and ground waters contain appreciable sulfate. The barium will precipitate out of the water because the solubility of barium sulfate is quite low (Hem, 1985).

Significant levels of arsenic have been detected in nearby watersheds but not in the surface waters at MPS No. 19 (USDA-SCS, 1979; York, 1997). Arsenic, if present, will exhibit chemical behavior similar to iron, that is, it will be present in detectable concentrations only under certain oxidation conditions (Hem, 1985). When oxygen levels are low, the condition expected deeper in the reservoir or in ground water, those metals precipitate as sulfides. At modest oxygen levels arsenic exists in solution in the form of arsenite or arsenate anions. If oxygen levels are high the metals form oxide and hydroxide complexes that will also precipitate the arsenic.

Recent water quality tests report the presence of thallium in surface water at concentrations exceeding its MCL (Eshbaugh and Wright, 2000). Thallium is an ingredient in certain pesticides and this is one possible source of the contamination (Eshbaugh and Wright, 2000). The thallium could also originate from the background because it may be present as a minor constituent in sulfide minerals such as pyrite. Thallium occurs in marine organisms and therefore might be present in trace quantities in fossils of the Cretaceous marine rocks. Oxidation of sulfides would release thallium in addition to iron, manganese, arsenic and other metals into solution. Since the solubility of thallium sulfide is low, the thallium will be removed from solution if oxygen is depleted from the water. The oxides and hydroxides of thallium are more soluble than other metals so that high levels of oxygen will not precipitate thallium in the same manner as aluminum, iron, manganese, and arsenic. Zinc replaces thallium in solution and the low levels of zinc reported from water quality tests (Water Quality Report, Appendix A; Table 2) may permit thallium to occur occasionally at levels exceeding its MCL.

All measurements reported for nitrate were below the MCL. Test results for pesticides show no detections (S. Broyles, City of Muenster; Eshbaugh and Wright, 2000). This does not exclude the possibility that higher levels of nitrate and pesticides could occur in the future because of excessive applications in the watershed. Agricultural land uses at the present time are primarily grasslands to support livestock and appear to be well managed from the water quality perspective (Eshbaugh and Wright, 2000). Fecal coliforms and other bacteria generally occur in surface water and will need to be dealt with by the water treatment process. Bacteria will have a greater

impact on recreation uses of the lake. Excessive levels of bacteria, sediment and metals may occur during and immediately following storm runoff events.

Several abandoned oil wells and pipelines occur in the vicinity including 4 within the boundaries of the proposed pool (Allison, 1997). Appropriate offices of the Texas Railroad Commission have been contacted and their records indicate that the 4 wells of concern have been properly sealed (Eshbaugh and Wright, 2000). The well and pipeline locations should be documented for future reference in case upward leakage of hydrocarbons along annular zones around the wells might be suspected. Several actively pumped wells exist in the watershed upstream of the site. A field reconnaissance detected no visual signs of hydrocarbon or brine leakage around the wells and storage tanks. However, there are no containment facilities associated with the tanks to trap catastrophic spills (Eshbaugh and Wright, 2000).

Soil Water Quality

Contaminants in the soil underlying the pool area might affect water quality. Soil contaminants originate from natural and anthropogenic sources. Contaminants originating from the natural aqueous geochemistry have been discussed above. Another naturally occurring potential contaminant at MPS No. 19 consists of asphalt sands in the upper portions of the Antlers (Allison, 1997).

Asphalt sands have been discovered along the east margin of the pool area and at shallow depths along the centerline of the proposed dam. Strike and dip estimates were based on elevations of the top of the asphalt sand and distances between an outcrop in the pool area and occurrences along the centerline of the dam and a nearby oil well (Allison, 1997). The strike is estimated as north-northeast south-southwest and the dip is gently to the east-southeast. This is consistent with known regional dips of Cretaceous strata in this portion of north Texas (McGowen et al., 1967; Nordstrom, 1982). Thickness of the asphalt sand varies from about 0.5 to 3 feet, averaging about 1 foot.

Exposure of the asphalt sands to the pool water can be minimized by either delineating the sands and avoiding them during borrow excavations or by removing the sands to a depth of several feet and backfilling with impervious soil. Alternatively, the raw pool water can be monitored for hydrocarbons that can be removed from the finished water by appropriate treatment (Driscoll, 1986; van der Leeden et al., 1991).

One significant anthropogenic source of contamination was detected at the site. Significant levels of total petroleum hydrocarbons (TPH), barium, chromium, and lead were detected at the Koch Gathering Systems Site (York, 1997). The extent of the potential contaminants has been identified. Remedial work consisting of contaminant removal, soil stabilization, and revegetation has been completed and the site no longer poses a threat to water quality (Eshbaugh and Wright, 2000).

Sediments in the streambed and banks, especially clay minerals and colloids, are likely to contain significant quantities of absorbed contaminants. The sediments will be eroded and transported to

the reservoir during storm runoff events. There may be periods of up to several days during and following runoff events that contaminants such as suspended solids, aluminum, arsenic, barium, iron, manganese, and thallium might be present in the reservoir water in detectable amounts. Nutrients and pesticides, if present in sufficient quantities, will be mobilized in a similar manner. If it is necessary to withdraw raw water from the reservoir at those times, appropriate treatment will be necessary. Most of those contaminants will be considerably reduced in concentration by sedimentation and chemical precipitation as quiet conditions are restored after runoff ceases. Bacteria are always a concern in raw surface water and will be dealt with in the treatment process.

Recreational Resources

Research compiled by the Comprehensive Planning Staff of the Texas Parks and Wildlife Department indicates there is a deficit of outdoor water-based recreation facilities to serve the needs of the people residing in Region 22, which includes the city of Muenster. Region 22 is one of the more heavily populated regions of the state and has a projected population increase through the year 2030. The user-days participation occurring in this region increased 350 percent during the period 1968-1980. Activities in the top ranking consist of fishing, boating, picnicking, swimming, and camping.

The city has an 8 acre park that is utilized during the Germanfest celebration that is held each year.

Wildlife Resources

MPS No. 19 is located 1 mile northwest of Muenster, Cooke County, Texas. Cropland acres are currently being planted to small grains and grain sorghums. Rangeland acres consist of native grasslands, non-managed improved pastureland in fair to poor conditions, and forested riparian areas in poor to fair range condition. Forested riparian area vegetation consists of Pecan (*Carya illinioensis*), Chinkapin Oak (*Quercus muhlenbergii*), Bur Oak (Quercus macrocarpa), Hackberry (*Celtis occidentalis*), American Elm (*Ulmus americana*), Winged Elm (*Ulmus alata*), Texas Ash (*Fraxinus texensis*), Box Elder (*Acer negundo*), Texas Sophora (*Sophora affinis*), Greenbrier (*Smilax rotundifolia*), Grape spp. (*Vitis candicans*), Slender Woodoats (*Chasmanthium sessiliflorum*), *Carex spp.* and other herbaceous vegetation. Forested riparian area along the majority of the channel has been removed to increase acres for crop and forage production. There is some larger acreage of desired riparian vegetation along some channel segments.

The project site has no notable populations of upland game species of white-tailed deer (*Odocoileus virginans*), Rio Grande turkey (*Meleagris gallopavo*), or Bobwhite quail (*Colinus virginianus*). Populations of various small game, non-game species, and avian species can be found in the vicinity of the project area. Raccoon (*Procyon lotor*), Fox squirrel (*Scivrus niger*), Nine-Banded armadillo (*Dasypas novemcinctus*), etc. are the most notable species. Neo-tropical bird species and songbirds (swallows, sparrows, hawks, etc) can be found at various times of the year.

Brushy Elm Creek is identified as an intermittent stream on USGS topographic maps. The stream flows following major rainfall events, and seasonally during the primary rainfall months (March - May, September - November). No major aquatic species are found in the project area. Deep pools may provide habitat for sunfish (*Lepomis spp.*) species, benthics and amphibian species.

Archeological and Historical Resources

A search of files at the Texas Archeological Research Laboratory, University of Texas at Austin was conducted in 1997 to determine if any cultural resources had been recorded in the vicinity of the proposed MPS No. 19 project area. None had been recorded. A follow up search was conducted on the Texas Historic Sites Atlas web site in May 2000 to confirm that no cultural resources had been recorded in the interim.

Intensive cultural resources survey has been be conducted in the Elm Fork Watershed MPS No. 19 area of potential effect in accordance with NRCS responsibility under Section 106 of the National Historic Preservation Act and its implementing regulations (36CFR 800) to identify any previously undiscovered prehistoric and historic cultural resources. The survey strategy was proposed in August 1996 by NRCS and received concurrence of the State Historic Preservation Officer (SHPO) in September 1996. The NRCS cultural resources specialist completed the survey in spring 1999 and a draft report of investigations was submitted to the SHPO in June 2000 for review and comment.

The cultural resources survey resulted in the identification of several historic cultural resources primarily associated with the former route of the Missouri-Kansas-Texas (MKT) Railroad that transects the proposed MPS No. 19 project area. Three historic sites were recorded. None of the sites were considered eligible for the National Register of Historic Places. No prehistoric cultural resources were identified as a result of the survey. NRCS received SHPO concurrence in the survey findings and NRHP eligibility determinations on June 30, 2000.

Threatened and Endangered Species

Correspondence with the U. S. Department of Interior, Fish and Wildlife Service, indicates the endangered whooping crane (*Grus americana*) may be encountered in any county in north central Texas during the migration season. Autumn migration normally begins in mid-September, with most birds arriving in the winter grounds at Aransas National Wildlife Refuge between late October and mid-November. Spring migration occurs during March and April. Whooping cranes prefer isolated areas away from human activity for feeding and roosting, with vegetated wetlands and wetlands adjacent to cropland being utilized along the migration route.

The endangered interior least tern (*Sterna antillarum*) has been documented at Lake Texoma, Lake Moss, and along the Red River in Cooke County. Interior least terns nest on bare to

sparsely vegetated sandbars in rivers and streams in Texas, from May through August. Nesting areas are ephemeral, changing as sandbars form, move and become vegetated.

The threatened bald eagle (*Haliaeetus leucocephalus*) are considered winter and possible spring residents in Cooke County and have been documented at Ray Roberts Reservoir and the Red River. Bald eagles nest, roost, and perch in tall trees near water and feed primarily on fish and waterfowl. Winter habitat includes reservoirs, lakes, rivers, and marshes. Most wintering bald eagles migrate north February through March, however, nesting eagles either stay throughout the entire year or migrate late in summer. None of the species were observed in the project area.

Wetlands

The proposed location of MPS No. 19 is located on Brushy Elm Creek. The Cowardin classification for the stream channel is R/4/SB/A, and R/4/SB/C. There are no hydric soils identified for this channel, though inclusions may be found in some soil mapping units. Soils in the channel are of the Tinn soil series. Brushy Elm Creek only flows following major rainfall events and seasonally during primary rainfall months (March - May, September - November). Approximately 19,000 feet of the channel will be affected by the construction of the dam and municipal pool of MPS No. 19.

Riparian forest vegetation lines some segments of the channel, though much has been harvested in the past to allow for farmed crops and improved pasture. The stream channel was evaluated utilizing the *Stream Visual Assessment Protocol.* Stream channel ranking was rated as poor. This can be attributed to (1) time of year assessed, (2) continuing drought, (3) lack of quality/quantity riparian vegetation.

the planned development of the Cooke County Water Supply System consisting of a raw water pipeline from Moss Lake, a treatment plan, and treat water pipelines to deliver water to users throughout the county. This will include adding a new well and pump in the Woodbine Aquifer. None of this water will be distributed to the city of Muenster. It is to be delivered to other water users throughout the county.

Smaller On-Channel Dam Dedicated Only To Water Supply

In the process of determining the benefits of including multiple purposes in the reservoir, a single-purpose water supply reservoir and dam was proportioned to estimate costs. The dam is classified as a high hazard by Texas Natural Resources Conservation Commission (TNRCC) and NRCS criteria irregardless of whether it is a single purpose or multiple purpose structure. The spillways of the high hazard dam must have the capacity to pass the probable maximum flood (PMF). For the single purpose water supply reservoir without floodwater detention storage a large reinforced concrete spillway is required to pass the PMF. The cost of the smaller dam with the concrete spillway is actually greater than the dam for the planned multiple-purpose reservoir. The reason for this is that a significant portion of the volume of the PMF is detained in the reservoir when floodwater detention is provided and released over a period of time through the conduit. An excavated spillway at a higher level than the concrete spillway can safely pass the portion of the PMF volume not detained in the flood pool, thus the concrete spillway is not required when the floodwater detention is included. The single purpose water supply dam with some non-structural flood protection measures in Muenster is prohibitively costly for the water supply purpose and doesn't meet project objectives for flood control. When the costs of the dam can be shared by providing multiple purposes in the reservoir each purpose becomes more economically feasible.

Non-Structural Flood Control

Deleting the flood control function of the dam and building a smaller inexpensive dam to remove the seven residences from the 100-year flood plain was considered.

The structure size would not be greatly reduced. This would not be a feasible alternative and would not meet the sponsor's objectives of water supply, flood control and recreational use. Only seven residences would be removed from flooding. Since the actual floodwater surface elevations would not be reduced, no other benefits would be realized and the threat to other property damage and loss of lives would still exist. The construction cost of the floodwater retarding structure with detention storage will be less than a municipal water use only structure due to TNRCC requirements that the high hazard structure pass the probable maximum flood (PMF). The smaller structure would have to have a costly large reinforced concrete spillway to safely pass the required storm event. Therefore, the flood control function of the planned reservoir comes at basically no additional cost and enhances the benefits of the structure.

The following alternatives were considered to be viable and practical in evaluating the project.

Alternative No. 1. No Action

Alternative No. 2. Install Multiple-Purpose Structure No. 19

Multiple-Purpose Structure (MPS) No. 19 and its related recreational and municipal water facilities are the remaining structural measures to be installed in the Elm Fork Watershed of the Trinity River Watershed.

The total drainage area of MPS No. 19 is 14.33 square miles. Floodwater Retarding Structure Nos. 6A1, 6E, and 61CC control 3.84 square miles of this area; however the installation of MPS No. 19 reduces the effectiveness of Floodwater Retarding Structure No. 61CC (0.49 square miles). The uncontrolled drainage area used in this structure design is 10.98 square miles.

MPS No. 19 has a total storage capacity of 10,550 acre-feet, of which 6,538 acre-feet are for floodwater detention and sediment storage, 3,585 acre-feet are for municipal water supply, and 427 acre-feet are for recreation. The surface area of the recreation pool is 120 acres. An additional 189 surface acres will be available for recreational use at the maximum elevation of the municipal water supply pool.

The area above the maximum elevation for MPS No. 19 (during passage of the emergency spillway hydrograph) purchased for the development and use of the basic recreational facilities is 22 acres. An additional area of 95 acres above the flood pool line can also be used for public recreation activities.

Classification of a dam is based on the potential damages that would occur downstream if the dam should fail. Where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads, the structure is considered high hazard or a class "C" dam. Based on a breach analysis, MPS No. 19 is a high hazard dam (Appendix B, Figure 2).

The embankment of MPS No. 19 will be protected from wave action by the placement of rock riprap on the upstream embankment slope.

M&I Water Intake and Outlet Facilities

The city of Muenster is to install water intake and outlet facilities that will be designed to deliver water that will meet the present and future needs of the city and the area that it serves. The city now has a population of 1,500 people with approximately 675 water meters and is expecting an increase each year. MPS No. 19 will be able to impound and dependably provide (based on a reservoir operation study, Erion, 1999) at least 500-acre feet per year of water which will meet the needs for municipal use.

Recreation Facilities

Basic recreational facilities will be installed in association with MPS No. 19 on a 22 acre area on the west side of the reservoir (Figure 2). A reservoir operation study (Erion, 1999) shows the reservoir will furnish a year-round water supply for recreation and that the reservoir levels will vary less than 2.5 feet 60 percent of the time. The basic recreational development is in accord with the Texas Outdoor Recreation Plan. Table 2 lists the basic recreational facilities and the proposed number or amount that are to be installed as part of this plan.

All state and local requirements related to public health and maintenance of reservoir water quality will be complied with in the design, construction, operation, and maintenance of the basic recreational facilities.

The majority of the 22 acres is a Bolar-Maloterre soil complex. This soil is a very shallow, gravelly clay resting on limestone bedrock and is not conducive to a septic tank filter drain system. A sewage lagoon system will be used for this reason and it will consist of a 4,200 gallon septic tank with a gravity outlet to an aerobic lagoon with a proposed 135 sq. ft bottom and a design depth of 5 feet. This lagoon will have to be plated with a highly impervious clay. The dimensions of this lagoon are such that the net evaporation on the surface of the effluent will equal or exceed the total effluent volume. An operation study shows the lagoon will contain the effluent without any spillage.

The city of Muenster is planning to stock the reservoir with a combination of fish species to enhance the quality of the basic recreational facilities.

EFFECTS OF ALTERNATIVE NO. 1
NO ACTION

Water Resources Impact

Municipal Water Impact

Potential sources for meeting the needs of municipal water for the city of Muenster are groundwater wells, purchase water from available developed neighboring sources, and development of a surface water source. Groundwater wells are the current source of the city water supply. The aquifer water level is receding at a rate of 2 to 3 feet per year resulting in the potential for future water shortages and degrading water quality. There are no developed neighboring sources where an adequate supply to meet Muenster's water needs can be purchased. This alternative would not provide for the development of a surface water source.

Flooding and Sedimentation Impact

The area downstream of the proposed site will continue to flood and receive sediment at the same rate and at the same frequency.

Recreational Impact

This alternative will not meet the needs of recreation for the city and surrounding area as no recreational facilities will be installed.

Archeological and Historical Resources Impact

There will be no impacts on cultural resources associated with this alternative as no project measures are to be installed by this alternative.

Wildlife Resources Impact

There will be no impacts on wildlife resources associated with this alternative as no project measures are to be installed by this alternative.

Threatened and Endangered Species Impact

This alternative will not affect any threatened or endangered species or their habitat.

Landuse and Prime Farmland Impact

This alternative will not impact any landuses or prime farmland that is located in the project area.

Wetlands Impact

There will be no impacts to wetlands as no project measures are to be installed by this alternative.

Costs of Alternative No. I

There will be no costs associated with this alternative as no project measures are to be installed.

Benefits of Alternative No. 1

There will be no benefits associated with this alternative as no project measures are to be installed by this alternative.

EFFECTS OF ALTERNATIVE NO. 2
INSTALL MULTIPLE-PURPOSE STRUCTURE (MPS) NO. 19

Water Resources Impact

Municipal Water Impact

The major geologic impact of MPS No. 19 will be an increase in recharge to the Antlers aquifer in the order of 60 to 125 ac-ft/yr. Saturation of soil and rock underlying the permanent pool might mobilize minor amounts of liquid hydrocarbons that could float upward into the pool water. Geologic limitations on the construction and operation of a safe and functional dam exist but are comparatively minor and can be remediated by measures such as a cutoff trench and drainage. Seepage losses from the permanent pool will occur but will be substantially less than losses from evapo-transpiration and municipal water use. Seepage losses can be minimized by appropriate construction techniques. A water treatment plant will be designed to take care of any water quality concerns.

Petroleum wells and pipelines in the immediate vicinity of the reservoir have been abandoned and properly plugged according to records of the Texas Railroad Commission. The asphalt sand averages about 3 feet in thickness at the site. The location and aerial extent of the asphalt sand has been documented by the geologic investigation for design of the dam. The asphalt sand will not be disturbed during construction to the extent practical. Where it is disturbed, it will be over-excavated and covered with compacted fill. The asphalt is a comparatively inert hydrocarbon with low water solubility and is not likely to contaminate the reservoir in detectable levels.

Active petroleum wells, pipelines, and storage tanks exist in the watershed upstream from the reservoir. Although leakage is expected infrequently, the risk to water quality is considered higher than that of the asphalt sand and abandoned wells. Since most of the active wells and tanks are in the upper portion of the watershed leaks would affect local ephemeral watercourses more severely than the reservoir farther downstream. Construction of containment structures would reduce the risk (Eshbaugh and Wright, 2000).

Flooding and Sedimentation Impact

Installation of MPS No. 19 will achieve the project objective of flood damage reduction. MPS No. 19 will reduce flooding from the 100-year frequency flood originating from Brushy Elm Creek in the City of Muenster. Flood depths will be decreased by an average of eight feet (Appendix B, Figure 1). Seven homes, some light industry, city parks and sewage treatment facilities will be protected from flooding. It will leave no apparent risk to life in the flood hazard area from the 100-year storm event. This is due to flood depths being reduced by an average of seven feet. This real threat to public safety is reduced to a negligible amount. Also, flooding at road crossings, where the greatest number of flood deaths occur, will be greatly reduced or

eliminated. The economic analysis of the project in the original watershed plan determined that the project is feasible. This feasibility is based upon the benefits provided by the project compared to the installation costs. Owners of agricultural land downstream will also benefit from the reduced flooding.

Without the project, the flood plain within the city of Muenster is mostly confined to non-residential areas. Besides the seven residences that may flood, other damages to roads, bridges and other infrastructure will occur. A cheese manufacturing waste treatment plant and the city's sewage treatment plant are endangered by the 500-year event flood. Flood debris swept along by the high velocities of the 500-year event will cause additional damages.

Appendix B, Figure 2 provides the maximum water surface elevation of the downstream floodplain if MPS No. 19 were to breach following installation.

Recreational Impact

The installation of the basic recreation facilities will provide a needed water oriented recreation area for residents in and near Muenster. It is estimated that 11,000 recreation user-days annually will result from the proposed facilities. The peak design capacity of the park is estimated to be 500 visitors. The recreational area will require 22 acres of rangeland.

The recreational uses associated with the structure will be picnicking, nature trails and fishing from small boats, piers, and from banks. The city has an 8 acre park and is in need of additional park facilities. It should be noted that the park receives considerable utilization during ethnic festivals that often occur in Muenster. The city needs at least 20 acres to meet the requirements of the citizens of Muenster and the surrounding area. The recreational proposal intends to limit access to small fishing boats with electric trolling motors or with motors of 5 horsepower or less. The city intends to work with other lake projects that are similar in size and incorporate appropriate rules and managerial practices. The potential for pollution is always a possibility and the primary purpose for a surface source of water is to supplement the ground water, therefore, the city intends to protect the water quality with whatever management means that become necessary.

Impacts from the construction of the structure will have limited adverse impacts upon the proposed recreation site. Current riparian vegetation is limited to a narrow band (<100 feet wide) directly adjacent to the Brushy Elm Creek channel. The proposed mitigation plan will provide for a diverse, high quality riparian reforestation and the planting of native grasses and forbs that will benefit a large variety of wildlife species that are indigenous to this geographic area. Woody vegetation planned will provide for quality mast production and cover. Grasses and forbs will provide both filtering and forage benefits. The mitigation plan also provides for a fence around the easement area to control ingress and egress. Management for the recreation site will be developed with Texas Parks and Wildlife Department, city of Muenster, Muenster Water District, and USDA-NRCS. Consideration for the use of the recreation site will be taken into consideration to provide for the establishment of planted grass, forbs and woody species.

Though impacts from recreational use are immanent, many parks of similar usage have functioned very well, i.e. Garner State Park, Possum Kingdom, and various COE parks.

Large fluctuations in lake level are generally detrimental to most recreational activities. Fluctuation of the lake level is, however, inevitable for a relatively small reservoir used also for municipal water supply. From the reservoir operation study output, the month by month lake level elevation was determined. For 15 of the 25 years studied, the lake level dropped no more than 2.5 feet below the normal pool level during the year. Normal pool is defined as the elevation of the crest of the principal (ungated) spillway. During four years the reservoir level dropped up to 6 feet below normal pool. A lake level more than 6 feet below normal pool was experienced six years, all during, and the recovery from, the 1950's drought. For several years during the drought the lake level remained below normal pool level. All reservoirs will likely experience lowered lake levels during a drought such as that in the 1950's and although detracting from recreation activities should be considered normal and expected. For the remainder of the study period the fluctuations in the lake level should not be considered excessive or unusual for a small lake, especially considering the demand of providing municipal water and the evaporation from the lake surface. This study shows that during 60% of the years the level varies less than 2.5 feet below normal pool level. During flood flows the lake level rises above the normal pool level. As an indicator of the length of time the lake level is above normal pool level the principal spillway is proportioned to discharge the 100-year runoff in 10 days after reaching its peak elevation. The majority of runoff events will be significantly less than the 100-year 10-day volume; thus, the lake level will be drawn down to within one foot or so of the normal pool in a few days following a storm event. Recreational uses may be effected on a seasonal, yearly basis, depending upon the deviation from the yearly mean rainfall.

Recreational use will be managed to restrict certain uses as deemed necessary due to the current climatic conditions. The Muenster Water District will work in concert with both state and federal agencies to determine when uses need to be restricted. The lake is considered suitable for the recreation activities proposed.

Archeological and Historical Resources Impact

Planning activities for the protection and preservation of historic properties will comply with Section 106 and Section 110 (f) and (k) of the National Historic Preservation Act. The Natural Resources Conservation Service (NRCS) responsibilities for compliance will be met by processes consistent with the Advisory Council on Historic Preservation regulations (36 CFR 800). Identified cultural resources will be evaluated for National Register of Historic Places (NRHP) eligibility in consultation with the State Historic Preservation Officer (SHPO). The NRCS will consult the SHPO and Advisory Council on Historic Preservation to determine a mutually agreeable course of action in the event that properties determined eligible for the NRHP would be adversely effected by the proposed project. The NRCS will take action to protect or recover, or both, any historic properties discovered during construction.

Wildlife Resources Impact

The flood pool of MPS No. 19 will impact approximately 66 acres of Riparian Forest, 10 acres of Brushy Elm Creek's main channel and tributaries, and 457 acres of rangeland and cropland when impoundment of water in the structure flows through the emergency spillway.

Impoundment at the municipal pool stage will back water to a known Common Egret (*Casmerodius albus*) nesting rookery. An informal consultation with the US Fish and Wildlife Service indicates the actual construction of MPS No. 19 will have no adverse impacts on the nesting site. The mitigation plan will plan for no construction disturbance in the rookery location.

Impoundment of water will provide for fisheries and waterfowl habitat where none presently exist. Deep water habitat will allow for a more diverse fisheries habitat that would benefit bass, catfish, and sunfish. Shallow water habitat in the upper reaches and along shoreline will provide for feeding and resting sites for migratory waterfowl. Planned establishment of hard mast and soft mast producing trees and shrubs will provide food and cover for terrestrial wildlife species. Snags that will be created from flooding and inundation of existing tall woody vegetation will provide habitat for bald eagle (*Haliaeetus leucocephalus*), wood duck (*Aix sponsa*), egrets, squirrels and other cavity nesting species.

The project will have no adverse impacts on the riverine system downstream of the proposed project area. Additionally, since the steam is identified as an intermittent stream and flows water seasonally and/or following a major storm event the fluvial geomorphology and lotic habitat will not be adversely effected by the structure. The proposed structure will control approximately 10.98 sq. miles of the 25.5 sq. miles of drainage the make up the Brush Elm Creek watershed.

Variations in water surface elevations should pose no adverse effects upon the vegetated areas along the perimeter of the lake. The natural wetting and drying of the soils will allow for the recruitment and establishment of a greater variety of hydrophyitic and terrestrial plants in the low-lying areas. This process is a natural phenomenon of this geographic region.

Only minimal impacts will be realized on the riverine system downstream of the proposed project area. The development of the project will allow for a slow release of runoff water for a prolonged period of time, reducing flood and erosion damage of the stream channel and floodplain and allowing for longer periods of flow. This extended period of wetness will promote a more diverse aquatic and terrestrial plant community within the channel and in the riparian zone.

Current cultural and agricultural practices will have greater impacts upon the biotic community than that of the project on the hydrology and stream health. The current riparian vegetation establishing along this stream system and others in the area are a result of changes in the management of the land resources. Riparian vegetation historically was found farther down the watershed of the Trinity River and areas along the Red River. The reduction in the frequency of fire has allowed the introduction of woody vegetation into this area of the landscape. In those

areas of which woody vegetation became established, it has been removed and restricted to small bands directly adjacent to the stream channels.

Brushy Elm Creek only flows following major rainfall events and seasonally during primary rainfall months (March - May, September - November). The construction of MPS No. 19 will have no adverse effects upon Brushy Elm Creek downstream of the proposed project. Currently, of the 25.5 sq. miles of drainage area for Brushy Elm Creek 10.98 sq. mi. will be affected by the structure, 4.35 sq. miles are currently being affected by the 3 flood prevention structures already in place. Approximately 11 sq. mi. drainage area are unimpeded and drain directly into Brushy Elm Creek downstream of the structure. Landuse downstream of the project within the floodplain is comprised of approximately 25% cropland, 25% pastureland, and 50 % rangeland. The landuses and landscape are similar to that above the propose project. Riparian vegetation has been removed to allow for crop and forage production, and is restricted to narrow bands adjacent to the stream channel.

The proposed project and associated mitigation measures will provide for a more diverse habitat that will provide, food water, and cover for resident and migrating wildlife species in the area associated with the project. Mitigation measures will include reforestation of riparian areas and selected sites. Herbaceous vegetation beneficial to wildlife species will also be established in areas where none currently exist. Management of these areas will be developed with Texas Parks and Wildlife Department, US Fish and Wildlife Service, Natural Resources Conservation Service and other interested agencies and organizations.

Threatened and Endangered Species Impact

The construction of MPS No. 19 will pose no adverse impacts on threatened and endangered species listed for Cooke County. The mitigation plan will provide quality habitat for the Bald Eagle by the large water body and dense tall woody vegetation.

Landuse and Prime Farmland Impact

The total land required to install MPS No. 19 will be approximately 700 acres. The dam, emergency spillway, and operation and flowage easement area will require about 50 acres which includes approximately 2 acres of cropland and 48 acres of rangeland. The municipal pool area will require approximately 309 acres which consists of approximately 94 acres of cropland and 215 acres rangeland. The detention pool will require approximately 224 acres which consists of approximately 63 acres of cropland and 161 acres of rangeland. The land involved in the detention pool will be inundated only on a temporary basis during flood stages. An additional 95 acres will be required for flowage easements and other uses which consists of 31 acres of cropland and 64 acres of rangeland. The landuse of the detention pool and flowage easement areas are not expected to change. The recreational area will require approximately 22 acres of rangeland.

This altemative will require the use of approximately 270 acres of prime farmland soils. The dam, emergency spillway, and municipal pool area will require about 185 acres of prime farmland soils. The detention pool area will require about 85 acres of prime farmland soils. The recreational area does not contain any prime farmland soils. There are approximately 117,600 acres of prime farmland mapped in Cooke County.

Wetlands Impact

MPS No. 19 dam and municipal pool will inundate approximately 19,000 feet of the main channel in the municipal pool located in two separate tributaries. Approximately 10 acres of stream channel will be inundated at flood stage of the structure.

The stream channel within the municipal pool will change from a Riverine system to a Lacustrine system. The channel within the flood pool will have a change in modifier from a temporary or seasonally flooded water regime to a permanent or intermittently flooded water regime. Variations in water surface elevations should pose no adverse effects upon the vegetated areas along the perimeter of the lake. The natural wetting and drying of the soils will allow for the recruitment and establishment of a greater variety of hydrophyitic and terrestrial plants in the low-lying areas that are adjacent to the waters edge. This process is a natural phenomenon of this geographic region. The vegetation in the detention pool is expected to remain the same as inundation will be on a very infrequent and temporary basis.

MPS No. 19 will provide for a more improved aquatic system where one currently does not exist. It will allow for a more diverse fisheries habitat that would benefit bass, catfish, sunfish, and crappie. Shallow water habitat at upper reaches of the impoundment, and along shoreline will provide feeding and resting habitat for migratory waterfowl. The impoundment of large trees along the shoreline and creek channel will provide snags desirable habitat for the threatened Bald eagle.

The mitigation plan was developed and will provide for an improved riparian forest. Species that will provide food, cover, nesting, and loafing cover are planned.

Costs of Alternative No. 2

The total estimated installation costs for the structural measures is $6,923,687 of which federal costs will be $3,810,525, and the local share will be $3,113,162.

Federal costs include $2,810,375 for construction, $181,950 for engineering services; $305,900 for landrights; and $512,300 for project administration.

The local costs consist of $1,860,275 for construction, $142,050 for engineering services, $723,837 for land rights, $3,000 for water rights, and $384,000 for project administration.

The specific costs of the municipal water outlet structure are allocated to the municipal water supply. Costs are distributed to flood prevention, recreation and municipal uses based on the use of facilities method. Local funds will be used for costs associated with the municipal water supply or any legal fees or engineering services necessary, obtain land rights, or other costs they may incur.

Benefits of Alternative No. 2

Flooding and Sedimentation

The estimated average annual floodwater benefit by type include:

Crop and Pastureland	$ 41,600
Other Agricultural land	$ 18,900
Sediment	$ 3,700
Erosion	$ 13,500
Road and Bridge	$ 22,400
Indirect	$ 13,400
TOTAL	$113,500

M&I Water

The benefits of municipal water supply is calculated as the average annual value of the least costly alternative to the proposed project (Erion, 1999). The average annual benefits to municipal water supply were calculated to be $301,700. The statewide water planning initiative established in the 1997 Senate Bill 1 listed this multiple purpose structure as one of the alternatives in Region C to provide needed water for the future.

Recreation

An estimated 11,000 recreation user-days annually will result from the proposed facilities. It is estimated the planned recreation facilities will produce $88,500 in average annual benefits.

The estimated total average annual monetary benefits, including floodwater, recreation and municipal water supply will be $503,700. The average annual cost is $322,000, resulting in a benefit to cost ratio of 1.6 to 1.0.

PROPOSED ACTIONS

Multiple-Purpose Structure

The proposed action will consist of installing MPS No. 19 with M&I water intake and outlet facilities, and recreational facilities on a 22 acre designated park area.

MPS No. 19 will be installed with capacity to include storage for sediment, municipal water, recreation and flood detention. The municipal pool will require 309 acres for the storage of municipal water, an additional 224 surface acres for detention storage, and 50 acres for construction and maintenance of the dam and spillway. The total area needed for the multiple purpose structure and basic recreational development area is 700 acres.

MPS No. 19's recreational storage and basic recreational facilities will satisfy a need for a public water-oriented park in the immediate vicinity of the city of Muenster. Research compiled by the Comprehensive Planning Staff of the Texas Parks and Wildlife Department indicates there is a deficit of outdoor water-based recreation facilities to serve the needs of the people residing in Region 22, which includes the city of Muenster. Region 22 is one of the more heavily populated regions of the state and has a projected population increase through the year 2030. Activities in the top ranking consist of fishing, boating, picnicking, swimming, and camping.

M&I Intake and Outlet Facilities

The city of Muenster is to install municipal water inlet and outlet structures that will be designed to deliver the amount of water that will meet the present and future needs of the city and the area that it serves. MPS No. 19 will have a total storage capacity of 10,550 acre-feet, of which 6,538 acre-feet are for floodwater detention and sediment storage, 3,585 acre-feet are for municipal water supply, and 427 acre-feet are for recreation. MPS No. 19 will dependably supply at least the 500 acre feet of water needed for municipal use each year.

The water supply outlet works consists of an intake tower in the reservoir, a conduit through the dam, a downstream valve box and a catwalk from the dam to the intake tower. The intake tower is designed to allow water to be withdrawn selectively from one of three elevations for water quality and fishery management purposes. Three feet by 3 feet slide gates are positioned at ten foot vertical intervals on the intake tower. One gate is opened to withdraw water from the desired elevation. To limit the volume of suspended debris and aquatic life attracted to the open gate, the velocity through the gate opening is kept to a low value. At the maximum flow rate of 2.0 mgd the velocity through the opening is 0.34 fps. For the more usual flow rate of 0.2 to 0.5 mgd the velocity is 0.03 to 0.09 fps. A trashrack of ½ inch thick steel bars is planned over the gate openings. Clear opening between the bars is 1½ inches.

The top of the intake tower will be set two feet above the crest of the emergency spillway, which is approximately ten feet below the top of the dam. The inside dimensions of the tower are four

feet by four feet and an access hatch and ladder is provided for access. The conduit through the dam will be reinforced concrete pressure pipe with an embedded pre-stressed steel cylinder, manufactured according to American Water Works Association Standard C301. A catwalk spanning from the dam to the top of the intake tower is planned for access to the tower. A valve box containing flow control valves will be provided on the conduit downstream of the dam.

Recreation Facilities

Basic recreational facilities will be installed in association with MPS No. 19 on a 22 acre area on the west side of the reservoir (Figure 2). The reservoir operation study shows the reservoir will furnish a year-round water supply for recreation use (Erion, 1999). The basic recreational facilities are in accord with the Texas Outdoor Recreation Plan. Facilities to be installed include such items as boat ramps, fishing piers, picnic tables, barbecue grills, access trails, and appurtenant structures. Table 3 lists the basic facilities and the proposed number or amount which will be installed as part of this plan. Figure 2 provides an overview of the recreational area.

TABLE 3 - RECREATIONAL FACILITIES – ESTIMATED MPS No. 19 Elm Fork Watershed, Texas (of the Trinity River Watershed)	
ITEM	Number 1/
Boat Ramp (2 lanes reinforced concrete)	2,000 sq.ft.
Fishing Piers (2 - wood construction)	1,080 sq.ft.
Picnic Tables (w/concrete pad)	25 each
BBQ Grills	10 each
Comfort Station (w/concrete sidewalk)	320 sq.ft.
Septic Tank (4,200 gallons)	1 each
Water System (well, treatment and waterline)	1 each
Sewage Lagoon (5 ft. depth,135 ft. x 135 ft. bottom)	1 each
Water Fountain	1 each
Backstop	1 each
Trash Receptacles	20 each
Traffic Control	4,800 ft.
Electrical System	1 No.
Pole Mounted Lights	6 each
Access Trail	200 ft.
Roads (asphalt surfaced)	4,800 ft.
Auto Parking (asphalt surfaced)	70 each
Auto w/Trailer Parking (asphalt surfaced)	20 each
Grading, Shaping, and Vegetating	6 Ac.
Landscaping (area above pool)	33 Ac.
Entrance Sign	1 each
Fencing (woven wire)	3,400 ft.

1/ Estimated quantity subject to minor variations at time of detail planning.

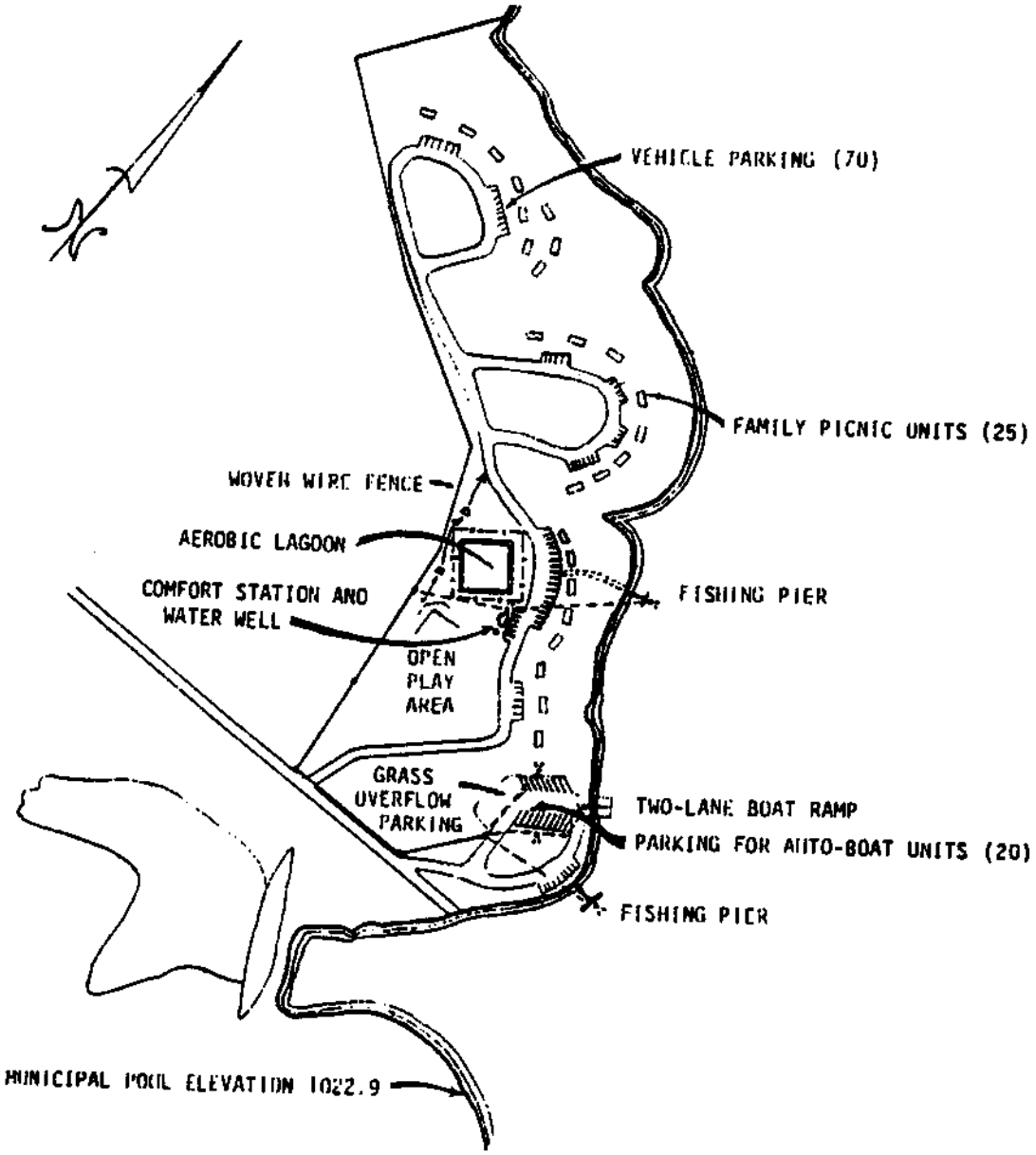


Figure 2

BASIC RECREATION DEVELOPMENT
SITE 19MP

ELM FORK CREEK WATERSHED

(TRINITY RIVER WATERSHED)

COOKE COUNTY, TEXAS

MITIGATION FEATURES

Riparian forest vegetation exists along some segments of the channel, though much has been harvested in the past to allow for farmed crops and improved pasture. The stream channel was evaluated utilizing the *Stream Visual Assessment Protocol.* Stream channel ranking was rated as poor. This can be attributed to 1) time of year assessed, 2) continuing drought, 3) lack of quality/quantity riparian vegetation, 4) cultural farming and ranching operations.

Elm Fork Multiple-Purpose Site 19 (MPS No. 19) will provide water supply, flood control and recreational benefits for the city of Muenster and surrounding communities. MPS No. 19 is identified as a water supply for Region C under Senate Bill 1 planning. The site is proposed to be constructed on Brushy Elm Creek, a tributary of the Elm Fork of the Trinity River Watershed, one mile west of Muenster, Cooke County, Texas.

Historic cultural and agricultural practices have had a great impact on the Brushy Elm Creek stream channel. The narrow bands of riparian forest have been removed in the past to allow for the production of food and fiber. These narrow bands were confined to those areas protected from wildfires. Ecologically this area was a tall grass prairie with narrow bands of woody vegetation along major stream channels. The Muenster Water District (District) has reviewed the historical changes that have taken place on this stream segment and are taking a sequential approach in the planning of MPS No. 19. The District considered and reviewed options to comply with Avoidance, Minimization, and Compensation for loss of aquatic habitat.

Avoidance: In a comprehensive study, all practical alternative measures to develop a water supply and flood prevention dam have been considered to avoid any adverse impacts to the current aquatic system. These alternatives are found in the alternatives considered section of the Environmental Assessment.

Minimization: The District and the USDA - Natural Resources Conservation Service, in an attempt to avoid and minimize any adverse impacts to the current aquatic system, selected the site on a second order stream of the Elm Fork of the Trinity River system. The location was selected as far upstream within the watershed of Brushy Elm Creek as feasible to provide for an adequate drainage area to supply MPS No. 19. Additionally, plans are being developed to release all waters that exceed the municipal pool level, a maximum of approximately 5,946 acre-feet of water annually. The draw down time of impounded floodwaters from 10 to 15 days will provide an extended period of channel wetness down stream, further minimizing impacts of the proposed dam.

Realized Benefits:
1) No significant change in the amount of runoff downstream once municipal pool level has been attained.
2) Greater aquatic benefits downstream from slow release of floodwaters from structure.
3) Increased aquatic habitat down stream for fish, macro-invertebrates, aquatic and terrestrial vegetation
4) Reduction in frequency of high flows (reduced bank and bed erosion)

Compensation: The District, after review of all options for compensation, is proposing the following on-sight measures as compensation and mitigation for impacts on 19,000 linear feet of stream channel and the loss of 60 acres of forested riparian area. The District proposes the restoration and enhancement of forested riparian area on approximately 14,800 linear feet directly adjacent to the municipal pool (68 acres) and an additional 5,000 linear feet (22 acres) of the main channel and tributaries that are located above the permanent pool line and stream segment immediately below the dam. (Appendix B, Figure 3). The District will locate additional (offsite) riverine systems to enter into a rehabilitation program with adjoining landowners. The District will provide funds for private landowners to enter into the Continuous Sign Up for the Conservation Reserve Program for the restoration of approximately 6,000 feet of Brushy Elm Creek directly below the dam and the fee easement area. The District is also currently in dialog with the city of Muenster to assist with the rehabilitation of approximately 1,200 feet of Brushy Elm Creek downstream in the City Park. All forested riparian areas will be planted to native species indigenous to the area, as listed below. The planting of native grasses on the dam, up slope of channel, and forested riparian area will provide a filter strip that will improved water quality. Releases of storm waters in a controlled and extended period of time are points of mitigation as well as minimization for impacts. The complete fencing of the fee simple easement area to control egress and ingress are planned to be completed. Also the release of waters in excess of municipal pool levels will create more aquatic system downstream.

The management of all mitigation measures will be developed in cooperation with USDA-NRCS, Texas Parks and Wildlife (TP&W), US Fish and Wildlife Service (FWS), US Army Corps of Engineers (COE), US-Environmental Protection Agency (EPA), Texas Natural Resources Conservation Commission (TNRCC), Texas Forest Service (TFS) and other interested parties. Management plans will include but is not limited to supplemental watering of planted trees, livestock exclusion, limited access, prescribed burning, etc. Table 6 provides the estimated cost of the mitigation measures that have been proposed.

Mitigation Practices (Simple Fee Easement Area):

1) Restore Forested Riparian Areas With Selected Plants on 19,800 linear feet (90 ac): Riparian vegetation will consist of primarily hard mast producing trees (66.6%), with intermixed soft mast producing trees and shrubs (33.3%). Approximately 300 trees per acre will be planted. (Table 4). Natural growth of native vegetation will be allowed to grow along all drainage ways as long as it does not interfere with the operation and maintenance of the structure. Invasive type brush that could impede the function of the structure will be controlled.
2) Plant Filter Strips With Selected Species (65 ac): Herbaceous material will consist of 75 - 80 percent grasses and 20 - 25 percent forbs. (Table 5)
3) Livestock Exclusion (Fence Project Area)
4) Overseed Dam With Grasses and Legumes Beneficial to Wildlife

Table 4 - SELECTED WOODY SPECIES TO BE PLANTED
300 Trees Per Acre (12X12 spacing):

Woody Species	% of Composition	Deer	Turkey	Squirrel	Raccoon	Neo-Tropicals
Bur Oak	30%	X	X	X	X	X
Pecan	15%	X	X	X	X	X
Green Ash	10%	X	X			
Mulberry	10%	X	X	X	X	X
Red Bud	10%	X	X	X		
Skunkbush Sumac	10%	X	X			X
Plum	10%	X	X	X	X	X
Lespedeza	5%	X	X			

Table 5 - SELECTED HERBACEOUS SPECIES TO BE PLANTED:

Herbaceous Species	% of Composition	Deer	Rabbits	Neo-Tropicals	Quail
Little Bluestem	45%		X	X	
Switchgrass (Alamo)	20%		X	X	X
Indiangrass (Lometa)	15%		X	X	X
Sideoats Grama (Haskell)	5%		X		
Maximilian Sunflower	5%	X	X	X	X
Illinois Bunndleflower	5%	X	X	X	X
Awnless Bush Sunflower	5%	X	X	X	X

Table 6 - ESTIMATED COST OF MITIGATION (approx.):

PRACTICE	COST/UNIT	TOTAL COST
Tree Planting (Approx. 90 Acres)	$400.00/Acre	$36,000.00
Grass Planting (Approx. 65 Acres)	$150.00/Acre	$9,750.00
Exclusion Fence (Approx. 43,700 ft.)	$1.50/Lin.Ft	$65,550.00
Stream Restoration (Approx. 6,000 ft., 14 Acs.)	$400/Acre	$5,600.00
TOTAL		$116,900.00

Realized Benefits:
1) Increased and improved species diversity
2) Decrease in fragmentation of habitat in immediate area
3) Improved water quality from filtering of pollutants
4) Increased habitat for migratory and resident waterfowl, neotropical avian species and the Bald Eagle

Permits Needed

The Muenster Water District has obtained a permit from the Texas Natural Resources Conservation Commission to appropriate state water. The permit authorizes the Muenster Water District to impound 4,700 acre-feet of water. They are authorized to divert at a maximum of 2.2 cfs and not to exceed 500 acre-feet of water per annum from the reservoir for municipal purposes in the City of Muenster and its environs, Cooke County, Texas.

The Muenster Water District is also in the process of gathering information that will be needed to obtain an U.S. Department of Army, Corps of Engineers 404 permit that will allow them to construct the impoundment on waters of the United States. No construction of structural measures to be completed will be carried out until all necessary state and federal permits have been obtained.

If other permits are needed for construction of the project they will be obtained prior to the start of construction.

Operation and Maintenance

The environment will be protected from soil erosion and water and air pollution during construction. Contractors will be required to adhere to strict guidelines set forth in the construction contract to minimize soil erosion and water and air pollution during construction. These standards will be in compliance with the U.S. Department of Agriculture, Natural Resources Conservation Service guidelines. Excavation and construction operations will be scheduled and controlled to prevent exposure of extraneous amounts of unprotected soil to erosion and the resulting translocation of sediment. Measures to control erosion will be uniquely specified at each work site and will include, as applicable, use of temporary vegetation or mulches, diversions, mechanical retardation of runoff and traps. Harmful dust and other pollutants inherent to the construction process will be held to minimum practical limits. Haul roads, excavation areas, and other work sites will be sprinkled with water, as needed to keep dust within tolerable limits. Contract specifications will require that fuel, lubricants, and chemicals be adequately labeled and stored safely in protected areas, and disposal at work sites will be by approved methods and procedures. Clearing and disposal of brush and vegetation will be carried out in accordance with applicable laws, ordinances, and regulations in respect to burning. Each contract will set forth specific stipulations to prevent uncontrolled grass or brush fires. Disposal will be by burying, hauling to an approved location, or controlled burning, as applicable.

Necessary sanitary facilities, including garbage disposal facilities, will be located to prohibit such facilities being injuriously adjacent to streams, wells, or reservoirs in conformance with federal, state, and local water pollution control regulations. Conformance to all environmental control requirements will be monitored constantly by a construction inspector who will be on-site during all periods of construction operations.

The Muenster Water District will be responsible for operating all water control structures, the reservoir, and mitigation areas. Legal measures to operate these structures will be secured and maintained by the Muenster Water District. The Muenster Water District will be responsible for dam safety and other annual safety inspections. An Operation and Maintenance (O&M) agreement will be agreed upon and signed before the project is started. This O&M agreement will include specific provisions for retention, use, and disposal of property acquired or improved with Public Law 83-566 assistance. The O&M agreement will be based on the Natural Resources Conservation Service National Operation and Maintenance Manual. An operation and maintenance plan will be prepared for specific operations and maintenance of the structure and recreational facilities. An Emergency Action Plan will be developed where appropriate for the operation of the reservoir.

CONSULTATION AND PUBLIC PARTICIPATION

The NRCS consulted and reviewed the planning and implementation stages of the original Elm Fork Watershed Work Plan with the appropriate federal and state agencies and others. This process is a continuing process as required by the National Environmental Policy Act of 1969 and environmental executive orders.

The NRCS requested information pertaining to Section 7 of the Endangered Species Act from the U.S. Fish and Wildlife Service on January 19, 2000. Their response and input on February 10, 2000 has been used to develop portions of this Environmental Assessment.

The NRCS has consulted with the Texas SHPO during the survey and evaluation phases of cultural resources investigations.

The Environmental Impact Statement for the Trinity River Watershed prepared in July 1979, which included Elm Fork MPS No. 19, was sent to various state, federal, and local agencies for review during the NEPA process in preparing the Final Environmental Impact Statement for the Trinity River Watershed.

Public meetings were previously held on this project during the development of the Elm Fork Watershed Work Plan. Their purpose was to inform and gather input from the public about the progress and effect of proposed actions. The input from those meetings was used to develop the original plan.

Open public meetings of the Directors of the Muenster Water District have been held at numerous times with discussion on the need of the multiple-purpose structure. There was no public opposition to the project at those meetings. No objections to the project have been noted to any of the directors at this time.

The draft environmental assessment was sent to appropriate state and federal agencies and interested individuals for their input and comment. Letters of comments and responses made by various groups or individuals are located in Appendix A. The US Department of the Army, Corps of Engineers and Texas Parks and Wildlife Departments comments were not received within the specified time limit set by NEPA regulations but were considered in the development of the Final Environmental Assessment.

Comments

Comments on the Draft Environmental Assessment were requested from the following Federal, State, and local agencies and organizations:

Local Interest

Muenster Water District
City of Muenster
Cooke County Commissioners Court
Montague County Commissioners Court
Upper Elm-Red SWCD
Denton Soil and Water Conservation District

State Agencies

Governor of Texas
State Single Point of Contact
TX State Soil and Water Conservation Board
Texas Parks & Wildlife Department
Texas Natural Resource Conservation Commission
TX Water Development Board
Texas Agricultural Experiment Station
Texas Historical Commission
Department of Transportation

Federal Agencies

U.S. Fish and Wildlife Service
US Army Corps of Engineers
USDI-Bureau of Reclamation
U.S. Environmental Protection Agency
USDA - Forest Service
Farm Services Agency

Discussion and Disposition of Comments from letter received on the Draft Environmental Assessment (EA)

Not all of the agencies and groups requested to comment on the Draft Environmental Assessment submitted comments. The responding agencies and groups comments and the disposition of each are as follows:

US Department of Interior, Fish and Wildlife Service

1. Comment: We concur that the proposed recreational facilities would provide additional water-based recreation to the people residing near the City of Muenster and should aid in reducing the deficit illustrated by research compiled by the Comprehensive Planning Staff of the Texas Parks and Wildlife Department (TPWD).

   Response: Noted.

2. Comment: We commend the Natural Resources Conservation Service for proposing to fence the entire project area to assure livestock exclusion. We believe this measure is very important to protect mitigation lands from the devastating impacts of grazing on wildlife habitat.

   Response: Noted.

3. Comment: We recommend a minimum of 100 hardwood trees and shrubs per acre should be planted on the forested mitigation sites in order to provide greater diversity and age classes of trees. We concur with the species list provided with the EA for establishment at MPS No. 19 and only recommend that green ash be replaced by a species with higher wildlife values. The additional species listed below should be utilized if the desired species are not available. The additional tree species include various oaks (e.g., Chinquapin oak, post oak, Bigelow oak, Texas red oak, and blackjack oak), black walnut, sugarberry, honey locust, and American elm. Trees such as green ash, cottonwood, and black Willow are not recommended, since these plants readily invade managed sites, have lower wildlife food values, and usually need to be controlled in order to promote the growth of more valuable wildlife trees. Additional recommended shrubs include species such as Mexican plum, cockspur hawthorn, downy hawthorn, reverchon hawthorn, coralberry, persimmon, rough-leaf dogwood, osage orange, eastern red cedar, and prairie flameleaf sumac. All planted trees and shrubs should be adequately maintained and have a survival rate of at least 75 to 80% after two growing seasons. When a survival rate condition is not feasible, the ratio of plants per acre should be increased to approximately 300 trees and shrubs per acre to compensate for the expected increase in mortality.

Response: The mitigation lands are proposed to be planted with 300 plants per acre. Green ash can be substituted for one of the plants that are listed above based on their availability at the time of planting.

3. Comment: Mowing or other intensive maintenance activities on the mitigation lands should be restricted to the season of the year most compatible with wildlife reproduction, primarily late fall and winter. This would permit vegetation to go to seed, thus providing greater vegetative production. It would also provide greater cover and food values during the spring of the year, when wildlife reproduction and survival are most dependent upon adequate cover and the higher food values provided by lush vegetation.

Response: Mowing activities on the mitigation land will only be scheduled on a as needed basis for maintaining the vegetation from deterioration or from invasion of unwanted plants. Specific scheduling of mowing or other activities have not been determined.

4. Comment: No mowing should occur on any of the forested, wildlife mitigation lands once permanent vegetation is reestablished.

Response: Intensive operation and maintenance activities are to be carried out only on the structural measures that are installed by this project. The dam, emergency spillway, and the 22 acre recreational area are the only areas that will be scheduled for mowing. These areas will only be mowed in a frequency that is needed based on its use and protection from deterioration.

5. Comment: If mitigation lands remain in private ownership, we recommend they receive long term protection through the establishment of deed restrictions or other protective agreements that would transfer with the ownership of the property.

Response: All of the mitigation lands are owned and controlled by the local sponsors. The lands are to remain under control of the local sponsors for the life of the project.

6. Comment: Public recreation use of wildlife mitigation lands be restricted to compatible, low- density activities such as hunting, hiking/nature trails, outdoor education, wildlife observation, or other similar low-density recreation opportunities.

Response: High intensity type recreation activities will be limited to the 22 acres that are to be developed and designated as a public recreational area. The remainder of the fee simple title areas are to be used for low-density recreational purposes such as

hiking/nature trails, wildlife observation, or other low impact recreational activities.

7. Comment: Operation and maintenance funding be provided annually in the Muenster Water District's budget for management of the proposed fish and wildlife features on the mitigation lands.

Response: The Muenster Water District will be responsible for operation and maintenance activities on all of the installed structures and lands associated with the structures. Funds will be available for the operation and maintenance of the vegetational needs of the mitigation lands.

Department of Defense, US Corps of Army Engineers

1. Comment: With regard to water supply, the EA provides little specific information about the present and future water needs of the water district. Does the water district's current demand for water exceed the available supply? If not, when are regular shortfalls in supply projected to begin? What would be the size of the projected shortfall?

Response: The information concerning present and future water needs have been added under the Water Resources and Needs section of the EA.

2. Comment: Please provide a more complete description of the current and future water needs of the water district and an assessment of how these needs affect the practicability of constructing the proposed dam and reservoir.

Response: See response to comment No. 1 above.

3. Comment: Given that there would be a future shortfall in water supply, what other sources of water has the district considered to alleviate or assist in alleviating that shortfall? Would drilling deeper water wells or implementing a water conservation program be practicable and effective in reducing that shortfall?

Response: Information concerning the possibility of deepening existing wells has been added under the alternative section of the EA.

4. Comment: Some entities, such as the city of San Antonio, are making substantial progress in reducing water supply shortfalls by recycling municipal water for industrial and

agricultural purposes, such as irrigating golf courses and parks. Could implementing a combination of these measures allow for the construction of a smaller, less costly, and less environmentally damaging reservoir?

Response: Conservation measures are, of course, to be encouraged. However economies of scale are considerably different for the cities of San Antonio and Muenster. The expectations of the impact of conservation measures should be adjusted accordingly.

5. Comment: The EA should include descriptions of other sources of water and measures that could be implemented to reduce demand. The EA should also include an assessment of the practicability of each water source and water conservation measure.

Response: In terms of groundwater sources as discussed in comment 10 below, the present levels of groundwater withdrawal exceed recharge. Therefore groundwater availability from Antlers Sand near Muenster is inadequate to meet local needs. Reliable supplies of groundwater do not exist therefore additional sources must be sought. Water recycling is not practical due to the conservative amount of water used by the local users (130 gpd). The formation of a groundwater management district for Cooke County might be a way to control the use of this limited resource, prolonging the inevitable if the demand is greater than the long-term supply.

6. Comment: In the EA you should assess the relative threat of flooding to public safety and the practicability of constructing the proposed dam and reservoir to overcome that threat.

Response: Additional information that includes the impacts of flooding on public safety has been added to the Flooding and Sedimentation Impacts section of the EA

7. Comment: The final EA should include a more detailed description of the local need for water-based recreation, the available alternatives for providing that recreation, and the practicability of utilizing each of those alternatives, both singly and in combination. The draft EA notes that high levels of recreational activity, such as boating, could adversely impact water quality. Would the city regulate the use of the lake to ensure that water quality standards are maintained?

Response: Additional information on the need for recreation and the impacts that it will have on the future water quality have been added under the recreation impact of the EA.

7A Comment: The EA should also describe the impact that construction and use of the proposed recreation site would likely have on the forested areas that are currently found at the site and intended to border the reservoir.

Response: Information describing the impact the construction and recreation will have on the forested areas found at the site has been added under the recreational impact of the EA.

8. Comment: Does the water district anticipate relying completely upon the proposed reservoir for its water supply or simply as a supplement to existing and future developed ground water supplies?

Response: The reservoir will be initially used to supplement the declining water supply. At some point in time the wells will not supply a dependable high quality potable supply where as the reservoir will become the sole source of water for the area.

9. Comment: If the water district intends to rely in part upon other sources of water (e.g., groundwater, conservation measures, recycling), how much water would the Muenster Water District actually require in the long term from this reservoir? The EA should address these questions and include an evaluation of the reliability of the proposed reservoir as a municipal water supply that is supported by appropriate hydrologic studies.

Response: A Reservoir Operation Study (RESOP) was made for the structure which shows that the structure will supply an adequate water supply. The RESOP is attached in Appendix D.

10. Comment: The EA should also discuss the reliability of current and future groundwater supplies, understanding that the availability of groundwater can be influenced by some of the same factors that affect the availability of surface water.

Response: See response to Comment No. 3 above. Additional information has been added that reflects the present and future supplies available to the Muenster Water District.

11. Comment: How dependable, on a yearly basis, is the expected net yield of 500 acre-feet stated in the draft EA? That is, would the reservoir be subject to multiple years of inadequate flows relieved only by occasional years of above-normal flows, as is common in reservoirs all across north-central Texas? Does the net yield of 500 acre-feet per year account for losses due to seepage, evaporation, and other unspecified factors?

Response: A Reservoir Operation Study (RESOP) was made during planning and Table 2 has been included to show seepage, evaporation and other losses from the structure.

12. Comment: The final EA should include detailed information about projected inflows, outflows, and uncontrollable losses (seepage, evaporation, etc.). The EA also does not discuss the relative variability in these flows. The final EA should include a basic water budget that includes all inflows and outflows, as well as an assessment of the variability of these flows, in order to better determine the reliability of water supplies in the proposed reservoir.

Response: See response to Comment No. 11 above.

13. Comment: The draft EA states that the water surface elevation of the proposed reservoir would vary less than 2.5 feet 60% of the time. On what water surface elevation is this variation based? How variable would water surface elevations be the remaining 40% of the time? Could variation in water surface elevations outside the 2.5-foot range adversely affect important vegetated areas along the perimeter of the lake, such as wetlands and vegetated shallows? Could variation in the water surface elevations be sufficient to adversely affect the usability of certain recreational facilities, such as the proposed boat ramp and fishing piers? How often would the proposed reservoir be expected to fill to the spillway elevation? The final EA should include a description of the expected variability of the water surface elevations over a greater proportion of the time (such as 95%) and an assessment of how that variability would effect the ecology of the lake, recreational facilities, and the ability of the water district to extract suitably high quality raw water from the lake.

Response: Information concerning the effects of expected variability of water surface elevations on the recreational facilities, vegetation and water quality has been added to the EA.

14. Comment: It appears that the water quality of the proposed reservoir, which would be of critical importance, could be substantially adversely affected by a number of factors including seepage of hydrocarbons from existing asphalt-laden sands, leakage from existing gas/oil wells and pipelines, pollution from boating and other recreational activities, and pollution from commercial and residential development that construction of the reservoir would surely attract. Could the reservoir remain a practicable and cost-effective source of raw water for the Muenster Water District if these sources all contribute to degrading water quality in the lake? The EA should include a description of the range of adverse impact that each source of pollutants could reasonably be expected to have on water quality and an assessment of each factor's relative probability to adversely impact water quality.

Response: Information concerning the range of adverse impact that known pollutants could reasonably be expected to have on water quality and an assessment of each factor's relative probability to adversely impact water quality has been added under the Water Resources Impact section of the EA.

15. Comment: The draft EA also does not describe the type or location of the intake structure that the water district would use to extract water from the lake, which could greatly influence the district's ability to extract reasonably high quality water from the lake under varying lake levels and water conditions.

Response: The type of intake tower the district intends to install in the structure has been added under the Proposed Action section of the EA.

16. Comment: There appears to be no discussion in the EA of other alternatives to the proposed project other than the "No Action" alternative. The EA should describe what other locations, sizes, or configurations for the proposed project were considered. In addition, no alternative sources for increasing water supply or measures for reducing water use were considered. For instance, could suitable water supplies be obtained from deeper wells than currently exist that would obviate the need for a surface water supply? Could the use of deep wells allow for a smaller reservoir, which would likely be less expensive and less damaging to the existing aquatic environment? Could implementation of a water conservation program and/or water recycling program reduce the overall demand for water and also allow construction of a smaller reservoir, or no reservoir at all?

Response: Additional discussion regarding possible alternatives that were considered have been added to the EA.

17. Comment: Was an off-channel reservoir considered? Such a reservoir could capture flood flows diverted from Brushy Elm Creek, yet allow the existing stream and riparian zone to remain intact with a fairly normal nominal flow?

Response: An Off-Channel consideration was considered and has been added under the Alternatives considered section of the EA.

18. Comment: Were a sufficient number of water supply entities in the region contacted to determine the practicability of purchasing water to supplement local sources? These and other possible alternatives should be fully considered and addressed in the EA.

Response: The nearest water supply entity is the city of Gainesville, Texas 13 miles to the east. They also use the Trinity Aquifer as well as the Moss Lake, Reservoir. They currently are losing ten (10) feet per well per year of available water due to lack of recharge ability of the aquifer. They draw on ten wells and have 100 hundred feet less water available for them to provide to their present customers. This information has been added to the Alternative section of the EA.

19. Comment: Could a smaller on-channel dam dedicated only to water supply provide sufficient water for the water district? For instance, a smaller reservoir that contained the proposed municipal water supply, recreational, and sediment pools, but not the flood detention pool would reduce the cost and environmental impact of the project and obviate the need for purchasing approximately 200 acres of land.

Response: A smaller on-channel structure was considered during the original reservoir operation study and has been added to the Alternatives considered section of the EA.

20. Comment: Deleting the flood control function of the dam (building a smaller dam) but adding a relatively inexpensive non-structural flood control project to remove the seven residences from the 100-year floodplain could result in a less expensive project with a higher cost-benefit ratio that still meets the water supply, flood control, and recreational needs. These alternatives should also be addressed in the EA.

Response: See Comment No. 19 above. The structure size would not be greatly reduced. Would not be a feasible alternative and would not meet the sponsor's objectives. Only the seven residences would be removed from flooding. Since the actual floodwater surface elevations would not be reduced, no other benefits would be realized and the threat to other property and loss of lives would still exist.

21. Comment: The location of the proposed dam and reservoir is immediately upstream of a city of approximately 1,500 people. As a result, the proposed dam would be classified by the TNRCC as a high hazard structure. Would the increase in public safety due to the flood control function of the proposed dam outweigh the decrease in public safety associated with a high hazard dam and the additional public safety hazards inherent with operating a reservoir (e.g., drownings, boating accidents)? The EA should include a balanced discussion of the project's beneficial and deleterious impact on public safety.

Response: The increase in public safety due to the flood control function would outweigh the low public safety threat of a properly designed and constructed dam. Flood events have a higher probability of occurrence as compared to a catastrophic dam failure. The hazards of operating a reservoir are acceptable when the proper

restrictions and regulations on the use of the reservoirs are imposed and enforced. The population uses other public works of improvements including highways, parks, etc. with an acceptable rate of accidents that may result in death. The reservoir can provide benefits of flood control, safe drinking water and recreation for the general public. A reservoir that provides these benefits cannot be considered to be "deleterious", or injurious to the public health. Promotional information for the FEMA Flood Insurance program indicates flooding to be the most damaging and results in most loss of life of all other natural disasters, maybe more than all others combined. The threat from dam failure ranks far down the list from natural floods, especially engineered dams with review by federal and state agencies. Participating in recreational activities on a reservoir is a voluntary activity carrying some risk (i.e. of drowning).

22. Comment: In the draft EA, the stream channel was evaluated using the "Stream Visual Assessment Protocol" and given a poor rating. We are not familiar with this technique and, moreover, are concerned about the use of an assessment technique that is affected by the time of year the assessment is conducted and by short-term climatic conditions (e.g., "continuing drought"). We also question the validity of the assessment if it did not include an evaluation of the adjacent riparian zone, which is an integral component of the riverine system, or the aquatic functions that the stream performs. More detailed information about this techniques and, perhaps, a more ecologically robust evaluation of the affected area, should be provided in the EA.

Response: Information describing the Stream Visual Assessment Protocol has been added to the EA. The NRCS Wildlife Biologist feel that this Assessment Protocol adequately evaluates the aquatic condition associated with the stream.

23. Comment: The USACE strongly encourages proponents of projects intended to detain or impound water to construct their project off-channel and avoid adversely impacting riverine aquatic resources to the extent practicable. These considerations should be addressed in the EA.

Response: See responses to comments No. 17 and No. 19 above.

NRCS has considered the impact of replacing a naturally occurring Riverine aquatic system with a man-made Lacustrine aquatic system. The impacts should be considered minimal as the impacted segment of stream channel is on an intermittent steam and is a second order stream of the Trinity River Stream System. NRCS has considered avoidance, minimal effects and compensation of project. To avoid and relocated proposed project off channel would defeat the primary function and benefits of project. NRCS has recognized the need to compensate for loss of riverine habitat and has reviewed the concern with Muenster Water District. The Muenster Water District has agreed with this

concern and has developed plans to mitigate for loss of riparian habitat. Positive impacts from the project will be realized as floodwater protection, deep and shallow water habitat, Forested Riparian Area, filter strips, improved water quality from filtering through wood and herbaceous vegetation associated with project, and improved habitat for aquatic and terrestrial wildlife. Additionally, habitat downstream of the structure will benefit from the prolonged and slow release of discharge waters following major storm events.

24. Comment: In addition, on-channel reservoirs often have a substantial adverse impact on the riverine system downstream of the project. Adverse impacts may include: a substantial reduction in the natural hydrology; loss of suspended sediment (bedload), which is necessary to protect a streambed from downcutting, maintain streambank integrity, and provide in-stream aquatic habitat; loss of channel-forming flows, which are necessary to maintain full functioning of a stream; modification of the natural stream vegetation community; loss of terrestrial and aquatic wildlife habitat (both in-channel and in the adjacent riparian zone); loss of the periodic channel- flushing flows caused by flood events; and increased periods of little or no stream flow. These potential adverse impacts should be addressed in the EA.

Response: Suspended sediment and bedload are not necessary to protect against downcutting and maintain streambank integrity in all types of channels. That situation holds for certain alluvial channels with abundant but not excessive sediment supply (especially sand) in which water and sediment discharges maintain a delicate balance. Irrigation canals in sandy alluvial material are a classic example. Nevertheless construction of an on-channel dam may induce some degree of instability in the downstream channel reaches of Brushy Elm Creek.

The reach of Brushy Elm Creek on which the dam is planned is only a partially alluvial channel. The valley and its channel are entrenched into Cretaceous bedrock and paleo-alluvium and colluvium. Detailed stream channel surveys have been conducted. Design and construction of NRCS structures includes provisions for stable outlets that account for the local channel characteristics.

Only minimal impacts will be realized on the riverine system downstream of the proposed project area. The development of the project will allow for a slow release of runoff water for a prolonged period of time, reducing flood and erosion damage of the stream channel and floodplain and allowing for longer periods of flow. This extended period of wetness will promote a more diverse aquatic and terrestrial plant community within the channel and in the riparian zone. The proposed structure will control approximately 10.98 sq. miles of the 25.5 sq. miles of drainage that make up the Brush Elm Creek watershed.

Current cultural and agricultural practices will have greater impacts upon the biotic community than that of the project on the hydrology and stream health.

Riparian areas down stream will still be restricted to their current landscape placement.

The proposed project and associated mitigation measures will provide for a more diverse habitat that will provide, food, water, and cover for resident and migrating wildlife species.

25. Comment: Without a more detailed comparison of the expected environmental benefit of the proposed planting of 90 acres and the degradation of the aquatic environment that would be caused by the project's adverse impact to 66 acres of forested riparian zone, it is virtually impossible to determine whether the proposed mitigation would adequately compensate for the riparian zone impacts. In mitigating for the loss of forested systems, there must be consideration for the often substantial temporal loss of ecological function that occurs until the mitigation area matures sufficiently to function at the level at which the impacted area was performing at the time it was impacted. In addition, while the proposed tree planting may benefit a man-made lacustrine system, it would not compensate for the majority of riverine system functions that would be lost. Further, the mitigation plan would not compensate for the project's likely adverse impact to Brushy Elm Creek downstream of the proposed dam. The EA should include an assessment of the proposed mitigation plan's ability to adequately minimize and compensate for the project's likely adverse impact on the aquatic environment.

Response: Past and current cultural and agricultural practices have contributed to the fragmentation of quality wildlife habitat. Riparian vegetation has been removed on much of the floodplain that will be affected by the structure. Currently, cropland and improved pastureland practices are being conducted that restrict riparian vegetation to small narrow band directly adjacent to the Brushy Elm Creek channel. Proposed mitigation plans will include the establishment of approximately 90 acres of riparian forest between the 1,022 and 1,039 msl elevations, beginning at the upper reaches of the structure and the establishment of the remaining cropland and disturbed areas to native perennial herbaceous vegetation. Riparian vegetation will consist of hard mast producing trees and intermixed soft mast producing trees and shrubs. Herbaceous material will be established on approximately 65 acres and will consist of 75 - 80 percent grasses, and 20 - 25 percent forbs.

Brushy Elm Creek flows following major rainfall events and seasonally during primary rainfall months (March - May, September - November). The construction of MPS No. 19 will have no adverse effects upon Brushy Elm Creek downstream of the proposed project. Currently, of the 25.5 sq. miles of drainage area for Brushy Elm Creek 10.98 sq. miles will be affected by MPS No. 19, 4.35 sq. miles are currently being affected by the 3 flood prevention structures already in place. Approximately 11 sq. miles of drainage area are unimpeded and drain directly into Brushy Elm Creek downstream of the structure. Landuse

downstream of the project within the floodplain, comprises of approximately 25% cropland, 25% pastureland, and 50% rangeland. The landuses and landscape are similar to that above the propose project. Riparian vegetation has been removed to allow for crop and forage production, and is restricted to narrow band directly adjacent to stream channel.

26. Comment: A fundamental component of the Regulatory Program is the Department of the Army's mitigation policy (33 CFR Part 320.4 (r), which applies to all authorizations, including general and individual permits. Mitigation includes avoiding, minimizing, rectifying, reducing, or compensating for resource losses, as well as avoiding the loss of aquatic resources to the extent practicable. The Department of the Army's mitigation policy requires that mitigation be considered throughout the permit application review process. The district engineer has the authority to require all appropriate and practicable mitigation necessary to minimize adverse project impacts, ensure that the project will not be contrary to the public interest, and satisfy such legal requirements as the 404(b)(1) guidelines ("Guidelines for Specification of Disposal Sites for Dredged or Fill Material," 40 CFR Part 230). USACE policy also states that practicable and appropriate on-site, in-kind compensatory mitigation is generally preferable to other forms of compensation. Other forms of compensatory mitigation, including the use of a mitigation bank or payment of an in-lieu fee, may be approved by the USACE if that compensation would be more beneficial to the aquatic environment. These elements should be factored into your assessment of the adequacy of the proposed mitigation plan.

Response: Noted. These factors were considered when the mitigation plan was developed.

Texas Parks and Wildlife Department

1. Comment: The Department recommends that the city of Muenster and Cooke County adopt flood plain management plans and enforce strict zoning ordinances to prevent further encroachment on floodplains to avoid future adverse impacts to fish and wildlife habitats.

Response: The city of Muenster passed and approved Ordinance # 235, Flood Damage Prevention Ordinance the Federal Emergency Management Agency requested, on December 7, 1998. This ordinance states that no structure or land shall hereafter be located, altered, or have its use changed without full compliance with terms of the ordinance or other regulations.

2. Comment: The Department does not support development within the flood plain and encourages cities and counties to adopt flood plain management plans and enforce

strict zoning ordinances to prevent further encroachment on floodplains and associated adverse impacts to fish and wildlife habitats.

Response: Noted. See Response No. 1

3. Comment: The EA states that this project would create opportunities for outdoor water-based recreation. While the Department encourages outdoor recreation, it does not consider the need for outdoor recreation to be sufficient justification for construction of a new reservoir.

Response: Noted. The structure is not being justified on the need for recreation but is one of the three purposes of the structure. The city presently has a city park that is 8 acres in size. The city needs to have at least 20 acres to meet the requirements of the citizens of Muenster and the surrounding area. The recreational area associated with the multiple-purpose structure will help meet those needs.

4. Comment: Descriptive or quantitative information describing the habitat that would be impacted should be provided. This information should detail the amount of riparian and riverine habitat that would be impacted both at the reservoir site and downstream. The information offered about adverse impacts to downstream riverine and riparian habitats and the mitigation and management plan is insufficient to adequately understand or anticipate the potential for impacts to natural resources. Management plans for the new reservoir, including the type of dam and outflow plan, also should be included. This Department cannot give you concurrence that your activities will not adversely impact the environment because all impacts (direct and indirect) and proposed mitigation are not described in a manner to predict the level of impact to the natural resources occurring there.

Response: The information concerning the impacts associated with the downstream riverine and riparian habitats have been added to the Wildlife Resources impact section of the EA.

5. Comment: The mitigation plan does not describe what the management plans are for the proposed mitigation areas. A management plan should be developed that addresses how the mitigation areas will be managed for fish and wildlife. The management plan should have component, or maintenance plan, that addresses survivability of the planted areas and replanting ratios.

Response: An Operation and Maintenance Agreement will be completed following the construction of the structure. The survival of the trees as well as other management items by the project sponsors will be developed with the assistance of the Natural Resources Conservation Service, Texas Parks and Wildlife

Department, and Texas Forest Service. A full comprehensive management plan will be developed and agreed to by the sponsors at that time.

6. Comment: Unavoidable impacts to valuable habitat and woody vegetation can be offset by development of a mitigation plan. The Department typically recommends a replacement ratio of 3 trees for each tree lost and development of a maintenance plan to ensure 80% survival of the trees for the first five years. In the case of the loss of habitat resulting from alteration of natural flow in the drainage system, the Department typically recommends a 1:1 acreage replacement of high quality habitat displaced.

Response: Brushy Elm Creek flows following major rainfall events and seasonally during primary rainfall months (March - May, September - November). Riparian forest vegetation exists along some segments of the channel, though much has been harvested in the past to allow for farmed crops and improved pasture. Where construction of the dam and spillway and permanent and periodic inundation will effect the channel and adjoining riparian forest, mitigation plans are being considered. Mitigation plans will include the establishment of approximately 90 acres of riparian forest between the 1022 msl and 1039 msl elevations, beginning at the upper reaches of the structure and the establishment to the remainder of the cropland and disturbed areas to native perennial herbaceous vegetation. Riparian vegetation will consist of primarily hard mast (66.6%) producing trees with intermixed soft mast (33.3%) producing trees and shrubs. Woody vegetation, primarily trees will be planted at the rate of 300 trees per acre. Herbaceous material will consist of 75 - 80 percent grasses, and 20 - 25 percent forbs. Management to address the survival of the trees will be developed with the assistance of the Natural Resources Conservation Service, Texas Parks and Wildlife Department, and Texas Forest Service. With an average annual rainfall of 33 inches, of which 20% of falls between April and September, supplemental watering should be limited to those years in which rainfall is below 25 inches.

7. Comment: The Department supports the recommendations of Eshbaugh and Wright to improve surface water quality. The Department would add that in addition to recommendations to maintain grass cover for a minimum of 150 feet from creek banks, that you include recommendations to allow the natural growth of native woody vegetation along drainages.

Response: Natural growth of native vegetation will be allowed to grow along all drainage ways as long as it does not interfere with the operation and maintenance of the structure. Invasive type brush that could impede the function of the structure will be controlled.

8. Comment: The Department recommends that you contact the U.S. Fish and Wildlife Service to determine if a permit is required for potential impacts to the rookery described in your EA.

Response: NRCS has made informal consultation with the US Fish and Wildlife Service concerning the identified rookery. It was determined that the rookery was far enough upstream that construction of the structure would not pose adverse impacts to the rookery.

9. Comment: The Department is concerned about the construction of water intake and outlet facilities within the proposed reservoir. These structures should be designed to minimize the potential for entrapment and impingement of aquatic organisms. They should not hinder, cut-off, or otherwise endanger species mobility. Submerged pipes should be screened to prevent entrance and drowning of waterfowl. If this project requires a discharge into state waters, this discharge must comply with all Texas Natural Resource Conservation Commission (TNRCC) effluent standards.

Response: The type of intake structure that will be installed has been added under the Proposed Actions section of the EA.

10. Comment: Chapter 86 of the Texas Parks and Wildlife Code places the management, control, and protection of streambed materials under the authority of the Texas Parks and Wildlife Commission in order to ensure that disturbance of those habitats does not pose a significant threat to aquatic life. Disturbing or taking of materials from a state owned streambed without a permit is prohibited, and any material removed incurs a charge per cubic yard payable to the Department. Please check with Mr. Rollin MacRae (512-389-4639) to see if this project requires a permit.

Response: Noted. This will be completed at or prior to the time of construction.

11. Comment: The EA states that water quality is a concern. There are multiple sources of contaminants in the project area. The data provided are insufficient because the time sampling locations are not identified and the methodology and minimum detectable concentrations are not reported.

Response: Data has been added under the Water Resources and Needs section describing sampling locations with the methodology and minimum detectable concentrations being described.

12. Comment: The EA does not include information about soils, other than the qualitative description of the asphalt sands. A more accurate determination of water quality and potential threats could be obtained by establishing a sampling plan and collecting more data points.

Response: The EA does in fact include additional information on soils. The test results from the Koch Gathering Systems site (York, 1997) is included in the EA with an analysis of the results. Soil samples were analyzed by Epic Laboratories in Carrolton, TX. Total petroleum hydrocarbons (TPH) were analyzed by EPA Method 418. 1; As, Ba, Cd, Cr, Pb, Se, and Ag by SW-846 Method 6010A; Hg by SW-846 Method 7470A. Detection Limits of tests in micrograms per gram were TPH: 10; As: 3; Ba: 1; Cd: 1; Cr: 1; Pb: 3; Kg: 0.02; Se: 4; Ag: 1.

13. Comment: The Department recommends a sampling plan be established to collect baseline data before the construction of the reservoir and to determine how often and where these contaminants exceed the MCL. Water quality monitoring should consider fish and wildlife resources in addition to human health.

Response: The EA does in fact provide a baseline of data for water quality assessments. Preliminary indications of magnitudes of contaminants and their frequencies of MCL exceedance can be interpreted from the data tables in Appendix C. It is unlikely that a sampling plan will sufficiently improve this knowledge prior to construction. Some potential sources are numerous (e.g., oil wells and tanks) and others diffuse (e.g., geochemical background). Detection of a contaminant at some specified location in the watershed offers no guarantee the contaminant will be delivered to the reservoir or any other point of concern. Flow events are infrequent and short-lived. Contaminants in the asphalt sand and four capped wells will not be mobilized, if at all, until after filling of the reservoir.

The location of potential contaminant sources in the watershed (Eshbaugh and Wright, 2000) should be updated periodically. Primary sampling will be best confined to the reservoir itself. This will permit assessment of watershed impacts on the reservoir. Downstream discharges from the dam may also be sampled to assess impacts on fish, wildlife, and stream regimen. The nature of the sampling program will vary depending on intended purpose and results of tests on a given sample. For example, detection of hydrocarbons may necessitate temporary sampling of tributaries and inspections of wells and tanks to identify sources. The sampling period and list of constituents for testing will be determined by appropriate operating authorities and regulatory agencies.

Sediment delivered to the reservoir, a fraction of which will be discharged downstream, likely will contain affixed contaminants. The immediate impact of the sediment may be assessed by grab samples of turbid storm water. Constituent concentrations, including suspended solids, may be determined for the total water sample and a portion of the sample passed through a 40-micron filter. Long term

build up of sediment deposits in the reservoir will serve as a sink for certain contaminants. It is possible that oxidation and erosion of sediment during periods of drawdown could reintroduce contaminants to the water. Samples of the sediment should be obtained and analyzed once sufficient sediment accumulates, perhaps after the first 5 years of closure.

Texas Agriculture Experiment Station and Texas Agriculture Extension Service

1. Comment: The proposed structure will provide valuable water supply, flood control, aquifer recharge, wildlife habitat, and recreational services.

   Response: Noted.

2. Comment The assessment is well prepared and impacts on agriculture lands appear to be minor in comparison with the services provided. I have identified no concerns that would warrant delaying construction of the project.

   Response: Noted

Texas Natural Resources Conservation Commission

1. Comment: Staff of the Policy and Regulations Division has reviewed the above-referenced project and has no comments. The environmental assessment addresses issues related to surface and groundwater quality.

   Response: Noted.

2. Comment: It has been determined from a review of the information provided that an Application for TNRCC Approval of Floodplain Development Project need not be filed with TNRCC.

   Response: Noted.

3. Comment: Our records show that the community is a participant in the National Flood Insurance Program and as such has a Flood Hazard Prevention Ordinance/Court Order. Care should be taken to ensure that the proposed construction takes into account the possible Flood Hazard Areas within the community's floodplains.

Please notify the community floodplain administrator to ensure that all construction is in compliance with the community's Flood Hazard Prevention Ordinance/Court Order.

Response: The community flood plain administrator for Cooke County has been contacted and there is no ordinance/court order that will create a problem by the construction of the structure.

Bureau of Economic Geology

1. Comment: I have no comments on the geologic aspects of the information provided. However, I found the summary demographic statistics provided under Sociological Resources (page ii) to be unclear.

Response: The summary demographic information was revised to make them more compatible with information included in the EA.

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LIST OF PREPARERS

Name and Present Title	Education	Experience
James L. Hailey Planning Staff Leader	B.S., M.S. Agricultural Engineering	31 years
Russell Castro Wildlife Biologist	B.S. Range Animal Science	21 years
Jerry Kazda Agricultural Economist (Retired)	B.S. Agricultural Economics	34 years
James Neighbors Resource Conservationist	B.S. Agronomy, M.S. Range Management	32 years
David Petefish Geologist	B.S., M.S. Geology	26 Years
Calvin Sanders Cultural Resources Specialist	B.S. Agronomy, M.A. Anthropology	18 years
Ronnie Skala Hydraulic Engineer	B.S. Agricultural Engineering	21 Years
David Strakos Civil Engineering Technician	High School Diploma	22 years
Pete Waldo Geologist	B.A., M.S. Geology Ph.D Mathematical Sciences	27 Years
Bill Erion, P.E. Civil Engineer (Consultant)	B.S., M.S. Agricultural Engineering	

APPENDIXES

APPENDIX A
Letters of Comment on Draft EA

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
WinSystems Center Building
711 Stadium Drive, Suite 252
Arlington, Texas 76011

FILE COPY

October 5, 2000

Mr. John P. Burt
State Conservationist
USDA Natural Resources Conservation Service
101 South Main
Temple, Texas 76501-7602

Dear Mr. Burt:

This letter consists of our review and comments regarding the draft Environmental Assessment (EA) on the proposed installation of Elm Fork Multiple Purpose Structure No. 19 (MPS No. 19) of the Brushy Elm Creek Watershed of the Elm Fork Trinity River, Cooke County, Texas in accordance with Section 102 (2)(c) of the National Environmental Policy Act of 1969 (Public Law 91-190). Installation of the structure, including dam, emergency spillway, municipal pool, detention pool, flowage areas, and recreational area will require approximately 700 acres. The purpose of this project is to provide municipal water to the Muenster Water District, provide recreational facilities and opportunities to the surrounding area, and to reduce downstream flooding below MPS No. 19.

GENERAL COMMENTS:

The Service has evaluated this project in accordance with the guidelines and directives contained in its *Mitigation Policy* (Federal Register 46[15]: 7644-7663, January 23, 1981). The *Mitigation Policy* provides guidance for Service biologists in the formulation of recommendations to avoid, reduce, or compensate project-related impacts to fish and wildlife resources. Our recommendations are based on the information provided in the EA regarding the value and relative abundance of the affected habitat to fish and wildlife resources.

According to the EA, implementation of the proposed MPS No. 19 alternative would have an unavoidable, negative impact on fish and wildlife resources in the project area. This would result from the direct impact of the alternative on floodplain habitats, especially riparian/bottomland hardwood forest. Fish and wildlife resources impacted by the proposed project include approximately 66 acres of riparian/bottomland hardwood forest and 457 acres of rangeland and cropland.

Numerous federal, state, and private studies have documented the increased vulnerability and scarcity of bottomland hardwood forests in Texas and the rest of the United States. Statewide, more than 63% of the bottomland forests have been lost to human activities such as forestry, agricultural, and water resource development practices. In addition, residential, commercial, and industrial developments in urbanized areas such as Muenster, have resulted in increased adverse impacts to bottomland and riparian ecosystems due to encroachment on the floodplain and the need for flood control.

Based on the value of riparian/bottomland hardwoods to fish and wildlife resources and their vulnerability and relative scarcity, we have classified them as a Resource Category 2 under the *Mitigation Policy*. Our mitigation planning goal for this resource category is "no net loss of inkind habitat value." Generally, this goal can be obtained by avoiding negative impacts, restoring impacted areas, compensating for the impacts by creating or improving habitats at a different location, or through a combination of these measures.

The 457 acres of rangeland and cropland that would be impacted by the proposed project are considered very abundant in the project area as well as the region, state, and nation due to prevalent land use practices. According to the EA, the rangelands include such species as bluestems, wintergrass, sedges, and forbs. Therefore, we would classify the rangelands as a Resource Category 3 under the *Mitigation Policy*. Our mitigation planning goal for this resource category is "no net loss of habitat value while minimizing loss of inkind habitat value." The major crops grown on the croplands include small grains during the winter months and forage sorghums used for hay and silage during the summer months. We would classify the croplands as a Resource Category 4 under the *Mitigation Policy*. Our mitigation planning goal for this resource category is "minimize loss of habitat value." Normally, both of these categories of habitat can be easily restored, and where needed, can be used to mitigate or replace losses of higher valued habitat.

Management to improve the habitat within the mitigation lands should include such measures as selecting and planting species based on their wildlife food and cover value that are native to the project area and would be able to survive seasonal flooding if required; protection of newly established woody vegetation from the damaging effects of beaver or nutria if required; fencing all areas that are converted to fee simple lands to control livestock or human disturbances; and providing or enhancing escape, resting, and nesting cover by introducing nest boxes (for squirrels, passerine birds, and wood ducks), brush piles, stumps, logs, large boulders, or other similar habitat features. Any approved mitigation plan should also include provisions for annual operation and maintenance funding to the management entity, since habitat improvement and restoration would occur throughout the life-of-the-project.

Lands required to mitigate unavoidable, adverse impacts to fish and wildlife resources may be publicly or privately owned. However, in order to increase the habitat value of these lands it will be necessary to dedicate them specifically for wildlife management and restrict public use to compatible activities. Compatible activities could include hunting, hiking/nature trails, wildlife observation, or other similar low-density recreation opportunities. If mitigation lands remain in

private ownership, they must receive long term protection through the establishment of deed restrictions or other protective agreements that would transfer with the ownership of the property.

SPECIFIC COMMENTS:

Page 29, Paragraph 5 - Recreation Facilities: "Basic recreational facilities will be installed in association with MPS No. 19 on a 22-acre area on the west side of the reservoir. A reservoir operation study shows the reservoir will furnish a year-round water supply for recreation use (Erion, 1999). The basic recreational facilities are in accord with the Texas Outdoor Recreation Plan. Facilities to be installed include such items as boat ramps, fishing piers, picnic tables, barbecue grills, access trails, and appurtenant structures."

We concur that the proposed recreational facilities would provide additional water-based recreation to the people residing near the City of Muenster and should aid in reducing the deficit illustrated by research compiled by the Comprehensive Planning Staff of the Texas Parks and Wildlife Department (TPWD).

Page 32, Paragraph 2 - Mitigation Features: "Mitigation is being planned to compensate for the loss of the affected riparian areas. Mitigation will include the construction of a fence around the project area to assure livestock exclusion. Approximately 90 acres of selected woody plants will be planted in a 200 foot band around selected areas of the waters edge of the municipal pool to compensate for the forested riparian areas that will be lost due to the construction of MPS No. 19. Approximately 65 acres of cropland and disturbed areas within the project area will be established to native perennial herbaceous vegetation. Riparian vegetation will consist of primarily hard mast producing trees with intermixed soft mast producing trees and shrubs. Herbaceous material will consist of 75 to 80 percent grasses, and up to 20 to 25 percent forbs."

First of all, we commend the Natural Resources Conservation Service for proposing to fence the entire project area to assure livestock exclusion. We believe this measure is very important to protect mitigation lands from the devastating impacts of grazing on wildlife habitat.

Reforestation of rangeland and/or cropland would require the planting of a large quantity of hardwood trees and shrubs. Initial establishment of these trees and shrubs should utilize state-of-the-art techniques in order to maximize survival from drought and animal damage. Some available techniques include the use of growth hormones, slow release fertilizers, protective sleeves, adequate irrigation, weed control, and other similar measures.

We recommend a minimum of 100 hardwood trees and shrubs per acre should be planted on the forested mitigation sites in order to provide greater diversity and age classes of trees. We concur with the species list provided with the EA for establishment at MPS No. 19 and only recommend that green ash be replaced by a species with higher wildlife values. The additional species listed below should be utilized if the desired species are not available. The additional tree species include various

oaks (e.g., Chinquapin oak, post oak, Bigelow oak, Texas red oak, and blackjack oak), black walnut, sugarberry, honey locust, and American elm. Trees such as green ash, cottonwood, and black willow are not recommended, since these plants readily invade managed sites, have lower wildlife food values, and usually need to be controlled in order to promote the growth of more valuable wildlife trees. Additional recommended shrubs include species such as Mexican plum, cockspur hawthorn, downy hawthorn, reverchon hawthorn, coralberry, persimmon, rough-leaf dogwood, osage orange, eastern red cedar, and prairie flameleaf sumac. All planted trees and shrubs should be adequately maintained and have a survival rate of at least 75 to 80% after two growing seasons. When a survival rate condition is not feasible, the ratio of plants per acre should be increased to approximately 300 trees and shrubs per acre to compensate for the expected increase in mortality.

There would be a loss of rangeland/cropland habitat for all of the mitigation plans, since this cover-type would be converted to bottomland hardwoods on the management area. However, the loss of rangelands/croplands is not a major concern, since the loss of this lower valued cover-type can be compensated by gains in higher resource category bottomland hardwoods in accordance with the *Mitigation Policy* and are considered very abundant in the project area as well as the region, state, and nation due to prevalent land use practices.

In addition to the planting of native hardwood species, mowing or other intensive maintenance activities on the mitigation lands should be restricted to the season of the year most compatible with wildlife reproduction, primarily late fall and winter. This would permit vegetation to go to seed, thus providing greater vegetative production. It would also provide greater cover and food values during the spring of the year, when wildlife reproduction and survival are most dependant upon adequate cover and the higher food values provided by lush vegetation (i.e., green vegetative material, seeds, and insects). Where feasible, mowing of the project area should be restricted to invasive, woody vegetation and not scheduled on a regular basis. No mowing should occur on any of the forested, wildlife mitigation lands once permanent vegetation is reestablished.

SUMMARY:

In order to avoid and reduce project-related impacts from the proposed installation of MPS No. 19 on fish and wildlife resources, we recommend the following:

1. Mitigation lands consisting of approximately 90 acres of reforested native hardwoods and 65 acres of native herbaceous revegetation be specifically dedicated for wildlife management activities. If mitigation lands remain in private ownership, we recommend they receive long term protection through the establishment of deed restrictions or other protective agreements that would transfer with the ownership of the property.

2. The mitigation lands be managed to optimize wildlife habitat values through the reforestation of rangelands/croplands and revegetation of native herbaceous

vegetation. Forested mitigation lands should be planted with a minimum of 100 hardwood trees and shrubs per acre. A minimum survival rate of 75-80% after two growing seasons would need to be attained for tree and shrub plantings. When a survival rate condition is not feasible, the ratio of plants per acre should be increased to approximately 300 trees and shrubs per acre to compensate for the expected increase in mortality.

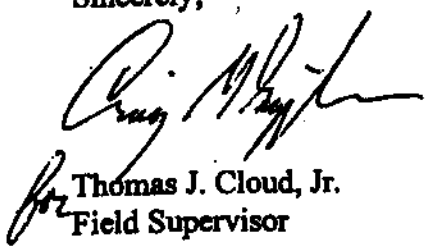
3. Public recreation use of wildlife mitigation lands be restricted to compatible, low-density activities such as hunting, hiking/nature trails, outdoor education, wildlife observation, or other similar low-density recreation opportunities.

4. Operation and maintenance funding be provided annually in the Muenster Water District's budget for management of the proposed fish and wildlife features on the mitigation lands.

5. Mowing and other intensive maintenance activities on mitigation lands be restricted, whenever possible, to the late fall and winter months in order to provide optimum wildlife food and cover during the spring and summer reproductive season. Mowing should be restricted to the removal of invasive, woody species and not scheduled on a regular basis. No mowing should occur on the reforested hardwood buffer following successful establishment of woody vegetation.

We appreciate the opportunity to provide recommendations for fish and wildlife conservation during the planning of the installation of MPS No. 19, near the City of Muenster, Cooke County, Texas. If you have any questions regarding these recommendations please feel free to contact Mike Armstrong of my staff at the letterhead address or telephone (817) 277-1100.

Sincerely,



for Thomas J. Cloud, Jr.
Field Supervisor

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102-0300

REPLY TO
ATTENTION OF:

November 27, 2000

FILE COPY

Environmental Division
Regulatory Branch

SUBJECT: Project Number 199500436

Mr. John P. Burt
State Conservationist
United States Department of Agriculture
Natural Resources Conservation Service
101 South Main
Temple, Texas 76501-7602

Dear Mr. Burt:

Thank you for your letters of August 17, 2000, and November 8, 2000, requesting comments on the draft environmental assessment (EA), "Elm Fork Watershed of the Trinity River Watershed for Multiple-Purpose Structure No. 19, Cooke County, Texas." We understand that the proposed project, which would be funded jointly by the Natural Resources Conservation Service and Muenster Water District, includes the construction of a dam and impoundment across Brushy Elm Creek on 700 acres of land located approximately one mile northwest of Muenster, in Cooke County, Texas. The overall project also includes construction of an emergency spillway, recreational area, raw water intake and outlet facilities, and a municipal water treatment plant. This project has been assigned Project Number 199500436. Please include this number in all correspondence concerning this project. Failure to reference the project number may result in a delay.

We have reviewed this EA with respect to the requirements of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. Under Section 404, the U. S. Army Corps of Engineers regulates the discharge of dredged and fill material into waters of the United States, including wetlands. Our responsibility under Section 10 is to regulate any work in, or affecting, navigable waters of the United States. Any such discharge or work requires Department of the Army authorization in the form of a permit. For more information on the USACE Regulatory Program, please refer to our Internet homepage at www.swf.usace.army.mil (select "Permits").

Based on your description of the proposed project in the draft EA, it appears that this project would require Department of the Army authorization in the form of an individual permit because

the loss of waters of the United States would likely exceed the maximum limits of any general permit. As the Muenster Water District is the prospective permittee, we will address permit-specific issues in future correspondence to the water district; this letter is intended to provide our comments on your draft EA.

Project Purpose and Need

The draft EA states that the purpose of the proposed project is to provide a new water supply for the Muenster Water District, water-based recreational opportunities, and flood control for the City of Muenster. One of our Regulatory Program responsibilities is to evaluate the need for a proposed activity in light of the overall public interest and our program's responsibility to protect the aquatic environment.

With regard to water supply, the EA provides little specific information about the present and future water needs of the water district. Does the water district's current demand for water exceed the available supply? If not, when are regular shortfalls in supply projected to begin? What would be the size of the projected shortfall? Without such information, it is difficult to assess the current and future need for the proposed water supply project. Please provide a more complete description of the current and future water needs of the water district and an assessment of how these needs affect the practicability of constructing the proposed dam and reservoir.

Given that there would be a future shortfall in water supply, what other sources of water has the district considered to alleviate or assist in alleviating that shortfall? Would drilling deeper water wells or implementing a water conservation program be practicable and effective in reducing that shortfall? Some entities, such as the City of San Antonio, are making substantial progress in reducing water supply shortfalls by recycling municipal water for industrial and agricultural purposes, such as irrigating golf courses and parks. Could implementing a combination of these measures allow for the construction of a smaller, less costly, and less environmentally damaging reservoir? Such measures are typically much less expensive means of enhancing water supply. Without adequately evaluating these other opportunities to enhance water supply or reduce demand, it is difficult to determine the extent of the need for the proposed water supply project. The EA should include descriptions of other sources of water and measures that could be implemented to reduce demand. The EA should also include an assessment of the practicability of each water source and water conservation measure.

Based on the information provided in the draft EA, it appears that flooding constitutes a relatively minor hazard to public safety, with just seven residences and a number of roads and bridges lying within the 100-year floodplain. Based on your description of the two treatment plants in the draft EA, we presume that they are already protected from the 100-year flood and therefore subject to inundation only during floods that surpass the 100-year event. If flooding constitutes an unacceptably high hazard to the community, it seems that it would be far cheaper to simply move those few residences outside the floodplain. Such non-structural approaches to flood damage reduction are often eligible for federal and/or state financial assistance. Other

structures, such as parks and transportation infrastructure, are commonly found in floodplains and do not normally suffer serious damage when flooded occasionally. If further protection of the treatment plants is necessary, levee construction/enlargement or other localized flood protection strategies could be far cheaper, have less adverse impact on the aquatic environment, and be equally effective in reducing flood damage. In the EA you should assess the relative threat of flooding to public safety and the practicability of constructing the proposed dam and reservoir to overcome that threat.

The draft EA states that there is a deficit of outdoor, water-based recreation in the region. However, such recreational needs might be more economically provided at existing lakes or in other forms. The Dallas-Fort Worth metropolitan area has many large reservoirs that provide boating and other water-based recreational opportunities to millions of people. Access to Lake Ray Roberts, for example, can be found about 20 miles east of Muenster. In addition, the Red River is only about 10 miles north of Muenster, and other smaller reservoirs are located within a reasonable distance of the city. The EA does not explore these alternatives or describe what portion of the state is encompassed by Texas Parks and Wildlife's "Region 12". The final EA should include a more detailed description of the local need for water-based recreation, the available alternatives for providing that recreation, and the practicability of utilizing each of those alternatives, both singly and in combination. The draft EA notes that high levels of recreational activity, such as boating, could adversely impact water quality. Would the City regulate the use of the lake to ensure that water quality standards are maintained? The EA should also describe the impact that construction and use of the proposed recreation site would likely have on the forested areas that are currently found at the site and intended to border the reservoir.

Water Supply and Water Quality

According to the draft EA, the primary source of water for the proposed impoundment would be runoff from an 11-square-mile (uncontrolled) drainage area, which seems to be an extremely small area for a water district to rely on for long-term water supply. Another north Texas municipality, the City of Throckmorton, has had a very difficult (and recently well publicized) time obtaining adequate water for its municipal water supply reservoir, which depends on a similarly small watershed. Other Texas cities face similar dilemmas. Does the water district anticipate relying completely upon the proposed reservoir for its water supply or simply as a supplement to existing and future developed ground water supplies? If the water district intends to rely in part upon other sources of water (e.g., groundwater, conservation measures, recycling), how much water would the Muenster Water District actually require in the long term from this reservoir? The EA should address these questions and include an evaluation of the reliability of the proposed reservoir as a municipal water supply that is supported by appropriate hydrologic studies. The EA should also discuss the reliability of current and future groundwater supplies, understanding that the availability of groundwater can be influenced by some of the same factors that affect the availability of surface water.

How dependable, on a yearly basis, is the expected net yield of 500 acre-feet stated in the draft EA? That is, would the reservoir be subject to multiple years of inadequate flows relieved only by occasional years of above-normal flows, as is common in reservoirs all across north-central Texas? Does the net yield of 500 acre-feet per year account for losses due to seepage, evaporation, and other unspecified factors? The final EA should include detailed information about projected inflows, outflows, and uncontrollable losses (seepage, evaporation, etc.). The EA also does not discuss the relative variability in these flows. The final EA should include a basic water budget that includes all inflows and outflows, as well as an assessment of the variability of these flows, in order to better determine the reliability of water supplies in the proposed reservoir. Determining the reliability of the water supply is a critical element in assessing the overall practicability of the proposed dam and reservoir as a water supply project.

The draft EA states that the water surface elevation of the proposed reservoir would vary less than 2.5 feet 60% of the time. On what water surface elevation is this variation based? How variable would water surface elevations be the remaining 40% of the time? Could variation in water surface elevations outside the 2.5-foot range adversely affect important vegetated areas along the perimeter of the lake, such as wetlands and vegetated shallows? Could variation in the water surface elevations be sufficient to adversely affect the usability of certain recreational facilities, such as the proposed boat ramp and fishing piers? How often would the proposed reservoir be expected to fill to the spillway elevation? The final EA should include a description of the expected variability of the water surface elevations over a greater proportion of the time (such as 95%) and an assessment of how that variability would effect the ecology of the lake, recreational facilities, and the ability of the water district to extract suitably high quality raw water from the lake.

It appears that the water quality of the proposed reservoir, which would be of critical importance, could be substantially adversely affected by a number of factors including seepage of hydrocarbons from existing asphalt-laden sands, leakage from existing gas/oil wells and pipelines, pollution from boating and other recreational activities, and pollution from commercial and residential development that construction of the reservoir would surely attract. Could the reservoir remain a practicable and cost-effective source of raw water for the Muenster Water District if these sources all contribute to degrading water quality in the lake? The EA should include a description of the range of adverse impact that each source of pollutants could reasonably be expected to have on water quality and an assessment of each factor's relative probability to adversely impact water quality. The draft EA also does not describe the type or location of the intake structure that the water district would use to extract water from the lake, which could greatly influence the district's ability to extract reasonably high quality water from the lake under varying lake levels and water conditions. Without an assessment that considers all sources of pollution and assesses the relative probabilities and likely impacts that each source would have on water quality, both individually and cumulatively, the water district can not know whether it can provide usable water to its customers at an acceptable price.

Alternative Analysis

There appears to be no discussion in the EA of other alternatives to the proposed project other than the "No Action" alternative. The EA should describe what other locations, sizes, or configurations for the proposed project were considered. In addition, no alternative sources for increasing water supply or measures for reducing water use were considered. For instance, could suitable water supplies be obtained from deeper wells than currently exist that would obviate the need for a surface water supply? Could the use of deep wells allow for a smaller reservoir, which would likely be less expensive and less damaging to the existing aquatic environment? Could implementation of a water conservation program and/or water recycling program reduce the overall demand for water and also allow construction of a smaller reservoir, or no reservoir at all? Was an off-channel reservoir considered? Such a reservoir could capture flood flows diverted from Brushy Elm Creek, yet allow the existing stream and riparian zone to remain intact with a fairly normal nominal flow? Were a sufficient number of water supply entities in the region contacted to determine the practicability of purchasing water to supplement local sources? These and other possible alternatives should be fully considered and addressed in the EA.

Could a smaller on-channel dam dedicated only to water supply provide sufficient water for the water district? For instance, a smaller reservoir that contained the proposed municipal water supply, recreational, and sediment pools, but not the flood detention pool would reduce the cost and environmental impact of the project and obviate the need for purchasing approximately 200 acres of land. Also, deleting the flood control function of the dam (building a smaller dam) but adding a relatively inexpensive non-structural flood control project to remove the seven residences from the 100-year floodplain could result in a less expensive project with a higher cost-benefit ratio that still meets the water supply, flood control, and recreational needs. These alternatives should also be addressed in the EA.

The location of the proposed dam and reservoir is immediately upstream of a city of approximately 1,500 people. As a result, the proposed dam would be classified by the TNRCC as a high hazard structure. Would the increase in public safety due to the flood control function of the proposed dam outweigh the decrease in public safety associated with a high hazard dam and the additional public safety hazards inherent with operating a reservoir (e.g., drownings, boating accidents)? The EA should include a balanced discussion of the project's beneficial and deleterious impact on public safety.

Project Impact on the Aquatic Ecosystem

Based on the information included in the draft EA, construction of the proposed dam and impoundment would adversely affect 19,000 linear feet, or approximately 10 acres, of stream channel and 66 acres of forested riparian zone. The impacts would include permanent coverage by the dam and related structures, permanent inundation (areas within the normal pool of the proposed impoundment), and temporary inundation (areas above the normal pool but within the flood pool). The loss of existing stream riparian zone would be compensated for by fencing the

perimeter of the proposed reservoir and planting woody species over approximately 90 acres within a 200-foot-wide band along the majority of the lake's perimeter.

In the draft EA, the stream channel was evaluated using the "Stream Visual Assessment Protocol" and given a poor rating. We are not familiar with this technique and, moreover, are concerned about the use of an assessment technique that is affected by the time of year the assessment is conducted and by short-term climatic conditions (e.g., "continuing drought"). We also question the validity of the assessment if it did not include an evaluation of the adjacent riparian zone, which is an integral component of the riverine system, or the aquatic functions that the stream performs. More detailed information about this technique and, perhaps, a more ecologically robust evaluation of the affected area, should be provided in the EA.

Stream habitats provide varied and important ecological functions in the Cross Timbers and Prairies ecological regions, where this project is located. Replacing the naturally occurring riverine aquatic system with a man-made lacustrine system would drastically alter the type and extent of aquatic functions in local area. Most of the existing riverine functions would be lost and replaced by lacustrine functions. The USACE strongly encourages proponents of projects intended to detain or impound water to construct their project off-channel and avoid adversely impacting riverine aquatic resources to the extent practicable. These considerations should be addressed in the EA.

In addition, on-channel reservoirs often have a substantial adverse impact on the riverine system downstream of the project. Adverse impacts may include: a substantial reduction in the natural hydrology; loss of suspended sediment (bedload), which is necessary to protect a streambed from downcutting, maintain streambank integrity, and provide in-stream aquatic habitat; loss of channel-forming flows, which are necessary to maintain full functioning of a stream; modification of the natural stream vegetation community; loss of terrestrial and aquatic wildlife habitat (both in-channel and in the adjacent riparian zone); loss of the periodic channel-flushing flows caused by flood events; and increased periods of little or no stream flow. These potential adverse impacts should be addressed in the EA.

Mitigation Plan

Without a more detailed comparison of the expected environmental benefit of the proposed planting of 90 acres and the degradation of the aquatic environment that would be caused by the project's adverse impact to 66 acres of forested riparian zone, it is virtually impossible to determine whether the proposed mitigation would adequately compensate for the riparian zone impacts. In mitigating for the loss of forested systems, there must be consideration for the often substantial temporal loss of ecological function that occurs until the mitigation area matures sufficiently to function at the level at which the impacted area was performing at the time it was impacted. In addition, while the proposed tree planting may benefit a man-made lacustrine system, it would not compensate for the majority of riverine system functions that would be lost. Further, the mitigation plan would not compensate for the project's likely adverse impact to

Brushy Elm Creek downstream of the proposed dam. The EA should include an assessment of the proposed mitigation plan's ability to adequately minimize and compensate for the project's likely adverse impact on the aquatic environment.

A fundamental component of the Regulatory Program is the Department of the Army's mitigation policy (33 CFR Part 320.4 (r)), which applies to all authorizations, including general and individual permits. Mitigation includes avoiding, minimizing, rectifying, reducing, or compensating for resource losses, as well as avoiding the loss of aquatic resources to the extent practicable. The Department of the Army's mitigation policy requires that mitigation be considered throughout the permit application review process. The district engineer has the authority to require all appropriate and practicable mitigation necessary to minimize adverse project impacts, ensure that the project will not be contrary to the public interest, and satisfy such legal requirements as the 404(b)(1) guidelines ("Guidelines for Specification of Disposal Sites for Dredged or Fill Material," 40 CFR Part 230). USACE policy also states that practicable and appropriate on-site, in-kind compensatory mitigation is generally preferable to other forms of compensation. Other forms of compensatory mitigation, including the use of a mitigation bank or payment of an in-lieu fee, may be approved by the USACE if that compensation would be more beneficial to the aquatic environment. These elements should be factored into your assessment of the adequacy of the proposed mitigation plan.

In order for the USACE to issue a permit for a project under Section 404, the project must meet the Section 404(b)(1) guidelines (40 CFR Part 230, published in the Federal Register on December 24, 1980) and not be contrary to the public interest. The Section 404(b)(1) guidelines require that no discharge shall be permitted if there is a practicable alternative that would have less adverse impact on the aquatic ecosystem, so long as that alternative does not have other significant adverse environmental consequences (40 CFR Part 230.10(a)). The Section 404(b)(1) guidelines also require that no discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem. We have concerns about whether the proposed project would be able to meet the requirements of the Section 404(b)(1) guidelines and strongly recommend that you consider alternative project locations and/or designs that would have less adverse impact on the aquatic ecosystem and incorporate on-site and off-site measures into your project that would mitigate the project's potential adverse impact on the aquatic environment.

If you have any questions concerning our regulatory program or our review of this draft EA, please contact Mr. David Martin at the address above or telephone (817)978-4625.

Sincerely,

for Wayne A. Lea
Chief, Regulatory Branch

Copies Furnished:

Mr. Troy Hill
Chief, Marine and Wetlands Section (6WQ-EM)
U.S. Environmental Protection Agency, Region 6
1445 Ross Avenue
Dallas, Texas 75202

Mr. Rollin MacRae
Resource Protection Division
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Mr. Thomas J, Cloud, Jr.
Ecological Services
U.S. Fish and Wildlife Service
711 Stadium Drive East, Suite 252
Arlington, Texas 76011

Mr. Mark Fisher
Water Quality Division
Texas Natural Resource Conservation Commission
Mail Code 150
P.O. Box 13087
Austin, Texas 78711-3087

Mr. Bob Bauer
President, Muenster Water District
P.O. Box 208
Muenster, Texas 76252

FILE COPY

November 27, 2000

TEXAS PARKS & WILDLIFE

COMMISSIONERS

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ANDREW SANSOM
EXECUTIVE DIRECTOR

Mr. John P. Burt
State Conservationist
101 South Main
Temple, TX 76501-7682

RE: Multipurpose Structure Number 19, Brushy Elm Creek, Elm Fork Watershed, Trinity River Basin, Cooke County.

Dear Mr. Burt:

This letter is in response to your request for review of the environmental assessment (EA) prepared to identify the impacts associated with the construction of the multipurpose structure referenced above. Texas Parks and Wildlife Department (TPWD) staff has reviewed the document and has the following comments concerning this project.

This project proposes to install Multipurpose Structure (MPS) No. 19 on Brushy Elm Creek approximately one-mile northwest of the City of Muenster. The EA states that this project is needed to supplement the water supply for the City of Muenster, reduce flooding, and create opportunities for outdoor water-based recreation.

In order to receive a water right permit, this new reservoir would have to be included in the Regional Water Plan. If a water right permit were obtained, it should contain special conditions to protect instream flows. It is the position TPWD that sustained instream flows are important and necessary to protect aquatic resources and to ameliorate the adverse impacts of the existing water demands. Department recommends this project be managed in a manner to prevent loss of downstream riverine habitat resulting from inadequate flows.

Historically, public works projects developed and implemented by governmental and public water works organizations generally recognize the benefits of reservoirs for water supply and flood control and discount the adverse impacts of alteration of natural flow in drainage systems and the positive biological effects of flood events on natural systems. This strategy has resulted in a direct loss of stream, bottomland, and riparian habitat from waterway manipulation. Reservoir projects impact ecosytems directly and indirectly. One direct impact of damming a riverine system is flooding of riparian vegetation and loss of lotic habitat within the project area, including areas both upstream and downstream. Projects that alter the natural flow and reduce overbank flooding in drainage systems can generate significant direct habitat losses. The meandering aspect of many streams is a result of physical forces and random natural events acting on

To manage and conserve the natural and cultural resources of Texas for the use and enjoyment of present and future generations.

4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744-3291
512-389-4800
www.tpwd.state.tx.us

the system. Under natural flow conditions, the resulting riverine landscape provides desirable diversity of streamside vegetation, substrate, and flow characteristics (riffles, pools, runs) to support a diverse ecosystem. Channel maintenance is dependent on the scouring effects of flooding. One example of an indirect loss that results from reservoir projects is the increase in timber clearing and subsequent development in areas no longer subject to flooding.

The danger of floods is not a result of an inadequate detention in the watershed, but a lack of development controls, poor agricultural practices and inadequate floodplain planning. The Department prefers non-structural flood control plans including property buyouts and development restrictions in lieu of channel modifications. The Department recommends that the City of Muenster and Cooke County adopt flood plain management plans and enforce strict zoning ordinances to prevent further encroachment on floodplains to avoid future adverse impacts to fish and wildlife habitats.

The EA states that the flood plain is currently restricted to non-residential areas within the City of Muenster. The Department does not support development within the flood plain and encourages cities and counties to adopt flood plain management plans and enforce strict zoning ordinances to prevent further encroachment on floodplains and associated adverse impacts to fish and wildlife habitats.

The EA states that this project would create opportunities for outdoor water-based recreation. While the Department encourages outdoor recreation, it does not consider the need for outdoor recreation to be sufficient justification for construction of a new reservoir.

The EA states that this project would require a total of 700 acres. The project would require approximately 190 acres of cropland and 510 acres of rangeland. The floodpool would destroy 66 acres of riparian forest and 10 acres of stream habitat. Completion of this project would inundate approximately 19,000 feet of main channel of Brushy Elm Creek and the municipal pool would be a located in two separate tributaries.

Descriptive or quantitative information describing the habitat that would be impacted should be provided. This information should detail the amount of riparian and riverine habitat that would be impacted both at the reservoir site and downstream. The information offered about adverse impacts to downstream riverine and riparian habitats and the mitigation and management plan is insufficient to adequately understand or anticipate the potential for impacts to

natural resources. Management plans for the new the reservoir, including the type of dam and outflow plan, also should be included. This Department cannot give you concurrence that your activities will not adversely impact the environment because all impacts (direct and indirect) and proposed mitigation are not described in a manner to predict the level of impact to the natural resources occurring there.

A mitigation plan is a crucial part of any project, in particular a project such as a reservoir that impacts large acreages of fish and wildlife habitat. The EA states that mitigation for this project consists of the following: fence around the project area to exclude cattle; a 200-foot band of woody vegetation would be planted around selected areas of the proposed municipal pool (approximately 90 acres); and perennial herbaceous vegetation would be established on approximately 65 acres of disturbed areas within the project area. However, the mitigation plan does not describe what the management plans are for the proposed mitigation areas. A management plan should be developed that addresses how the mitigation areas will be managed for fish and wildlife. The management plan should have component, or maintenance plan, that addresses survivability of the planted areas and replanting ratios.

A major responsibility of TPWD is to conserve and protect the state's fish, wildlife, and plant resources. Certain categories of these biotic resources warrant special consideration. They include habitats that are locally and regionally scarce, habitat supporting or capable of supporting unique species or communities, stream and river ecosystems, bays, and estuaries, wetlands, bottomland hardwoods, and native grasslands. All projects that could adversely affect these resources should be fully evaluated, and where possible, assessment of less damaging alternatives should be undertaken. Mitigation is defined as a lessening of adverse impacts to fish, wildlife and plant resources. If it is determined that a project or action will potentially affect such resources, mitigation measures should be initiated sequentially as follows:

1. AVOIDANCE: Avoiding adverse impacts through changes in project location, design, operation, or maintenance procedures, or through selection of other less damaging alternatives to the project or action.

2. MINIMIZATION: Minimizing impacts by project modification, or rectification and rehabilitation to restore or improve impacted habitat to pre-project conditions, or through reducing or eliminating the impacts over time.

3. COMPENSATION: Compensating for unavoidable impacts by providing replacement or substitute resources (including appropriate management) for losses caused by project construction, operation, or maintenance.

Mitigation should be an integral part of any action or project that adversely affects fish, wildlife, and habitats upon which they depend. Failure to adequately avoid or minimize adverse impacts or to adequately compensate for unavoidable losses of natural resources is a serious deficiency in any project plan and may cause delays in this Department's review and assessment of the adverse impacts upon fish & wildlife resources. In assessing project impacts, reasonably foreseeable secondary and cumulative impacts should be included.

In order to minimize adverse impacts, please use design and construction methods to avoid adverse impacts to aquatic ecosystems and native vegetation that provides fish and wildlife habitat. The Department recommends avoiding alteration of natural drainage systems and removal of large trees and other native vegetation during project development and mitigation site development. Avoid destruction of inert microhabitats *i.e.* snags, brush piles, fallen logs, creek banks, pools, and gravel stream bottoms as these provide habitat for a variety of fish and wildlife species and their food sources. Please find the attachment entitled *Texas Parks and Wildlife Department Guidelines for Construction and Clearing within Riparian Areas*. These guidelines should be incorporated into your review and planning process to reduce the likelihood your project will impact fish, wildlife, and plant resources.

Unavoidable impacts to valuable habitat and woody vegetation can be offset by development of a mitigation plan. The Department typically recommends a replacement ratio of 3 trees for each tree lost and development of a maintenance plan to ensure 80% survival of the trees for the first five years. In the case of the loss of habitat resulting from alteration of natural flow in the drainage system, the Department typically recommends a 1:1 acreage replacement of high quality habitat displaced. TPWD would be willing to assist in the development of a mitigation plan to compensate for the loss riverine, riparian, and upland habitats. If on-site mitigation is not appropriate or feasible, TPWD could investigate a more appropriate location for replanting or other enhancement.

The Department supports the recommendations of Eshbaugh and Wright to improve surface water quality. The Department would add that in addition to recommendations to maintain grass cover for a minimum of 150 feet from creek banks, that you include recommendations to allow the natural growth of native

woody vegetation along drainages. A combination of trees, shrubs, and grasses would provide the maximum protection against soil erosion and runoff in the riparian zone. Woody vegetation such as trees and shrubs can effectively control large amounts of flowing water. The organic layer that will develop on top of the soil from these plants allows water to quickly infiltrate the soil. There are several advantages to maintaining the trees and shrubs that are already present within the buffer strip. First, using existing vegetation reduces labor and the cost of purchasing new materials. Savings may be significant, especially during seasons of drought when the success rate of newly planted trees will be reduced. Second, since it takes several years for trees to grow, existing vegetation will control erosion while new plants are maturing. Grasses do not permit rapid water infiltration, but are able to efficiently hold soil in place with their network of fine roots. Grasses establish more quickly than trees. They are an excellent choice to use in areas where vegetation has been removed or destroyed while new woody vegetation is being established. A large tract of land is not necessary to establish a working forest buffer strip, however, the higher the slope percentage the wider the buffer strip should be. This is because as slope increases, water flow and the potential for erosion also increase. A 15% slope should have a minimum of 50 feet of vegetative cover.

Native plant and forage species beneficial to fish and wildlife endemic to the project area should be used in landscape design plans. Native plants are adapted to the local environment and will persist through periods of environmental stress. Most exotic plants cannot similarly persist and are also overrated as wildlife food and cover. However, a few exotic species can establish themselves by out-competing native plants. They then become serious persistent pests, difficult if not impossible to control or eradicate. Exotic species should, therefore, be omitted from permanent landscape plans. Invasive non-native plants can cause significant changes to ecosystems, upset the ecological balance and cause serious economic harm to agricultural and recreational sectors.

Vegetation should be planted in an arrangement to maximize value for wildlife. This should include adequate interspersion and allowance for wildlife travel corridors that would link existing shrub thickets or groves of trees. Mast-producing trees (such as acorn, nut, or berry-producing varieties) are valuable to wildlife as food and cover. Enhancement of existing native grasses or prairie remnants can be assisted by the reseeding of exposed areas with a mixture of native grasses and limiting mowing practices. A tallgrass community called he Little Bluestem-Indiangrass (*Schizachyrium scoparium-Sorghastrum nutans*) Series occurs in the project vicinity. Restoration of this native grassland would improve habitat for wildlife in upland areas. Mowing only essential use areas

will allow native grasses to prosper, generally without additional irrigation.

A search of the Texas Biological and Conservation Data System (BCD) revealed presently known occurrences of special species or natural communities in the general vicinity of the proposed project. The BCD has several occurrences of the Little Bluestem-Indiangrass Series in the project vicinity. This broadly defined upland tallgrass grassland once occurred throughout the Blackland, Fayette, and Grand Prairies. Currently, this native plant community is restricted to small, isolated relicts and is endangered throughout its range. The BCD also reports potential for the Texas horned lizard (*Phrynosoma cornutum*) and timber (canebrake) rattlesnake (*Crotalus horridus*) to occur in the project area.

The Department recommends that you contact the U.S. Fish and Wildlife Service to determine if a permit is required for potential impacts to the rookery described in your EA. In order to protect migratory birds and the rookery in the project area construction activities should occur outside the April 1-July 15 migratory bird nesting season of each year the project is authorized and lasting for the life of the project. Construction activities include (but are not limited to) tree felling as well as vegetation clearing, trampling or maintenance. In addition, since raptors nest in late winter and early spring, all construction activities as identified above should be excluded from a minimum zone of 100 meters around any raptor nest tree during the period of February 1-July 15. Rookeries, which often exist near riparian corridors, should also be avoided. Please contact the U.S. Fish and Wildlife Service (711 Stadium Drive East, Suite 252, Arlington, Texas 76011, ph. 817/885-7830) for further information.

Given the small proportion of public versus private land in Texas, BCD includes less than a representative inventory of rare resources in many areas of the state; although, it is based on the best available data to the state regarding rare species. Thus, these data do not provide a definite statement as to the presence or absence of rare species within your project area, nor can these data substitute for an on-site evaluation by qualified biologists. This information is intended to assist you in avoiding harm to species that may occur on your site. To further assist with your evaluation, please find enclosed a list of special species that occur within Cooke County.

The Department is concerned about the construction of water intake and outlet facilities within the proposed reservoir. These structures should be designed to minimize the potential for entrapment and impingement of aquatic organisms. They should not hinder, cut-off, or otherwise endanger species mobility. Submerged pipes should be screened to prevent entrance and drowning of

waterfowl. If this project requires a discharge into state waters, this discharge must comply with all Texas Natural Resource Conservation Commission (TNRCC) effluent standards.

Chapter 86 of the Texas Parks and Wildlife Code places the management, control, and protection of streambed materials under the authority of the Texas Parks and Wildlife Commission in order to ensure that disturbance of those habitats does not pose a significant threat to aquatic life. Disturbing or taking of materials from a state owned streambed without a permit is prohibited, and any material removed incurs a charge per cubic yard payable to the Department. Please check with Mr. Rollin MacRae (512-389-4639) to see if this project requires a permit.

The EA states that water quality is a concern. There are multiple sources of contaminants in the project area. The data provided are insufficient because the time sampling locations are not identified and the methodology and minimum detectable concentrations are not reported. The EA does not include information about soils, other than the qualitative description of the asphalt sands. A more accurate determination of water quality and potential threats could be obtained by establishing a sampling plan and collecting more data points. For example, the EA reveals that one composite sample (EA does not state what kind of composite sample) exceeded the National Recommended Water Quality Criteria for drinking water and consumption of fish (0.0017 mg/L) for thallium. Thallium, which can result in neural, hepatic, and renal injury, is one of the more toxic metals discussed in the EA. However, like much of the rest of the data set, that sample represents one data point in time and space.

The Department recommends a sampling plan be established to collect baseline data before the construction of the reservoir and to determine how often and where these contaminants exceed the MCL. Crucial locations to monitor water quality would be near the asphalt sands, 4 capped wells, and downstream from other oil producing facilities to ensure contaminant levels remain at relatively safe concentrations. Water quality monitoring should consider fish and wildlife resources in addition to human health.

I appreciate the opportunity to review and comment on your project. If you have any questions contact me in San Marcos at (512) 396-9211 or e-mail at rfields@itouch.net. I apologize for the lateness of my response.

Sincerely,

Renée Fields

Renée Fields
Wildlife Habitat Assessment Program
Wildlife Division

/jrf

Attachments

The Agriculture Program

THE TEXAS A&M UNIVERSITY SYSTEM
Jack K. Williams Administration Bldg., Suite 113
2142 TAMU College Station, Texas 77843-2142
Phone 979.845.4747 Fax 979.845.9938 http://agprogram.tamu.edu

Office of the Vice Chancellor for Agriculture and Life Sciences

FILE COPY

August 28, 2000

Mr. John P. Burt
State Conservationist
USDA - NRCS
101 South Main
Temple, Texas 76501-7602

Dear Mr. Burt:

Thank you for the opportunity to review the draft environmental assessment for multi-purpose structure No. 19 in Cooke County, Texas. In my view, the proposed structure will provide valuable water supply, flood control, aquifer recharge, wildlife habitat, and recreation services. The assessment is well prepared, and impacts on agricultural lands appear to be minor in comparison with the services provided. I have identified no concerns that would warrant delaying construction of the project.

Sincerely,

Edward A. Hiler
Vice Chancellor and Dean
Director, Texas Agricultural Experiment Station
and Texas Agricultural Extension Service

Texas Review and Comment System

Review Notification

FILE COPY

Applicant/Origination Agency: Natural Resource Conservation Service, USDA
Contact Name: Mr. John P. Burt, State Conservationist
Contact Phone: 254/742-9871
Email:

Project Name: ELM FORK CREEK WATERSHED# 19/TRINITY RIVER, COOKE COUNTY

Funding Agency: USDA
SAI/EIS#: TX-R-20000826-0001-50
Date Received: 8/24/2000
Date Comments Due BPO: 9/25/2000

Review Participants

Agencies

Bureau of Economic Geology
Scott Tinker, Ph.D.
Director
University Station, Box X
Austin, Texas

Texas Natural Resource Conservation Commission
Ms. Mary Lively
Office of Policy & Regulatory Dev. MC205
P. O. Box 13087
Austin, Texas

Texas Parks & Wildlife Department
Mr. Robert W. Spain
Chief, Habitat Assessment Branch
4200 Smith School Road
Austin, Texas

Texas Historical Commission
Dr. James Bruseth
TRACS Coordinator
1511 Colorado Street
Austin, Texas

State Soil and Water Conservation Board
Mr. Robert G. Buckley
Executive Director
P.O. Box 658
Temple, Texas

Cogs

Texoma Council of Governments
Mr. Kevin Farley
Community Development Director
3201 Texoma Parkway, Suite 200
Sherman, TX 75090

Special Notes/Comments:

Summary of application provided by SPOC. Reviewers should contact applicant directly to receive a full copy for review.

☒ No Comment

Review Agency _____ Signature _____

Return Comments to:

Denise S. Francis, State Single Point of Contact
Governor's Office of Budget & Planning
P.O. Box 12428
Austin, TX 78711
(512) 305-9415

FILE COPY

STATE OF TEXAS
OFFICE OF THE GOVERNOR

GEORGE W. BUSH
GOVERNOR

Monday, September 25, 2000

Mr. John P. Burt, State Conservationist
Natural Resource Conservation Service, USDA
101 South Main
Temple, TX 76501-7602

RE: TX-R-20000826-0001-50

ELM FORK CREEK WATERSHED# 19/TRINITY RIVER, COOKE COUNTY

Dear Mr. Burt:

Your application for assistance referenced above has been reciewed. The comments received are summarized below and are attached.

TNRCC stated that it has been determined from a review of the informaiton provided that an application for TNRCC approval of Floodplain Development Project need not be filed with TNRCC. Care should be taken to ensure that the proposed construction takes into account the possible Flood Hazard Areas within the community's floodplains. Bureau of Economic Geology had no comments on the geologic aspects of the information provided, however, found the summary demographic statistics provided under Sociological Resources to be unclear. No other substantive comments were received.

We appreciate the opportunity to review your proposal. Please let me know if we can be of further assistance.

Sincerely,

Denise S. Francis/mhr

Denise S. Francis, State Single Point of Contact
DSF/mhr

cc: Rural Development Administration

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

September 21, 2000

Ms. Denise S. Francis
Governor's Office of Budget & Planning
P.O. Box 12428
Austin, Texas 78711

Re: TX-R-20000826-0001-50

Dear Ms. Francis:

The following staff of the Texas Natural Resource Conservation Commission (TNRCC) have reviewed the above-referenced project and offer the following comments:

Staff recommends the environmental assessment address action that will be taken to prevent surface and groundwater contamination during and after construction.

If you have questions regarding water quality comments, please feel free to contact Mr. Clyde Bohmfalk, Policy and Regulations Division, at (512) 239-1315.

The Strategic Assessment Division has reviewed the above-referenced project for General Conformity impacts in accordance with 40 CFR Part 93 and Chapter 101.30 of the TNRCC General Rules. The proposed action is located in Cooke County, which is unclassified or in attainment of the National Ambient Air Quality Standard for all six criteria air pollutants. Therefore, general conformity does not apply.

Although any demolition, construction, rehabilitation or repair project will produce dust and particulate emissions, these actions pose no significant impact upon air quality standards. The minimal dust and particulate emissions can easily be controlled with standard dust mitigation techniques by the construction contractors.

If you have any questions regarding air quality, please feel free to contact Mr. Ken Gathright, SIP Development Team, at (512) 239-0599.

It has been determined from a review of the information provided that an Application for TNRCC Approval of Floodplain Development Project need not be filed with TNRCC. Our records show that the community is a participant in the National Flood Insurance Program and as such has a Flood Hazard Prevention Ordinance/Court Order. Accordingly, care should be taken to ensure that the proposed construction takes into account the possible Flood Hazard Areas within the community's floodplains. Please notify the community floodplain administrator to ensure that all construction is in compliance with the community's Flood Hazard Prevention Ordinance/Court Order.

If you have any questions regarding this comment, please feel free to contact Mr. Mike Howard, Floodplain Management Section, at (512) 239-6155.

Thank you for the opportunity to review this project. If I may be of further service, please call me at (512) 239-1454.

Sincerely,

Mary Lively
Office of Environmental Policy, Analysis, & Assessment
Texas Natural Resource Conservation Commission

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

University Station, Box X · Austin, Texas 78713-8924 · (512) 471-1534 · FAX 471-0140
10100 Burnet Road, Bldg. 130 · Austin, Texas 78758-4445

September 5, 2000

Ms. Denise S. Francis
State Single Point of Contact
Governor's Office of Budget and Planning
P.O. Box 12428
Austin, TX 78711

Dear Ms. Francis:

This letter is in response to your request that the Bureau of Economic Geology review the "Environmental Assessment Elm Fork Creek Watershed..." (SAI/EIS #: TX-R-20000826-0001-50).

I have reviewed the summary of application provided by the SPOC. I have no comments on the geologic aspects of the information provided. However, I found the summary demographic statistics provided under Sociological Resources (page ii) to be unclear. If further information or review of this project is needed, please contact me.

I have filled out and signed the form provided by the SPOC, which is attached to this letter.

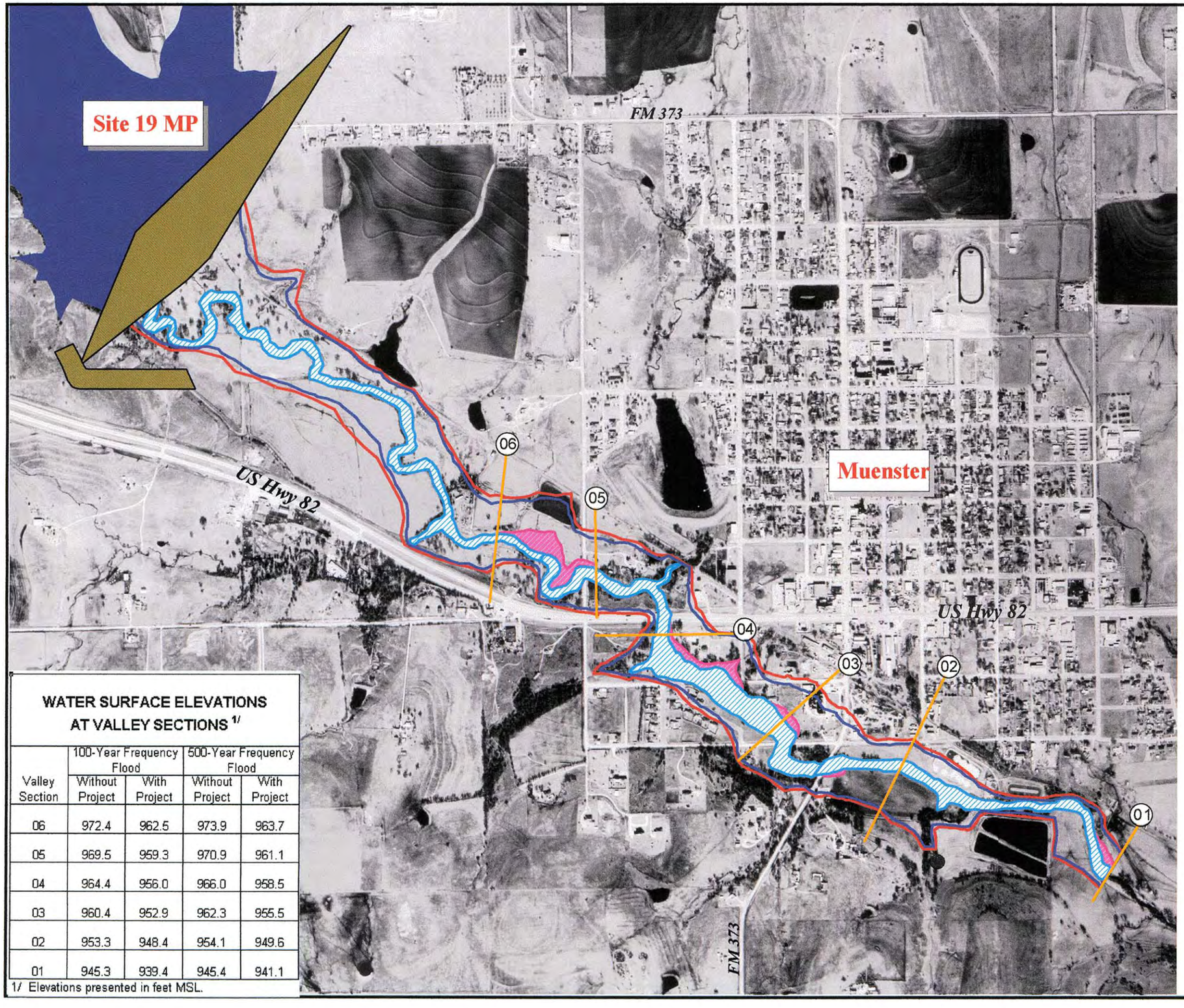
Sincerely,

Jay A. Raney
Associate Director

JAR:wl

xc: S. W. Tinker

APPENDIX B
Support Maps



WATER SURFACE ELEVATIONS AT VALLEY SECTIONS 1/

Valley Section	100-Year Frequency Flood		500-Year Frequency Flood	
	Without Project	With Project	Without Project	With Project
06	972.4	962.5	973.9	963.7
05	969.5	959.3	970.9	961.1
04	964.4	956.0	966.0	958.5
03	960.4	952.9	962.3	955.5
02	953.3	948.4	954.1	949.6
01	945.3	939.4	945.4	941.1

1/ Elevations presented in feet MSL.

USDA NRCS
Natural Resources Conservation Service
Planning Staff -Temple,Texas

Figure 1

Elm Fork of the Trinity River Watershed
MPS No. 19

Urban Floodplain Map
Brushy Elm Creek
City of Muenster

LEGEND

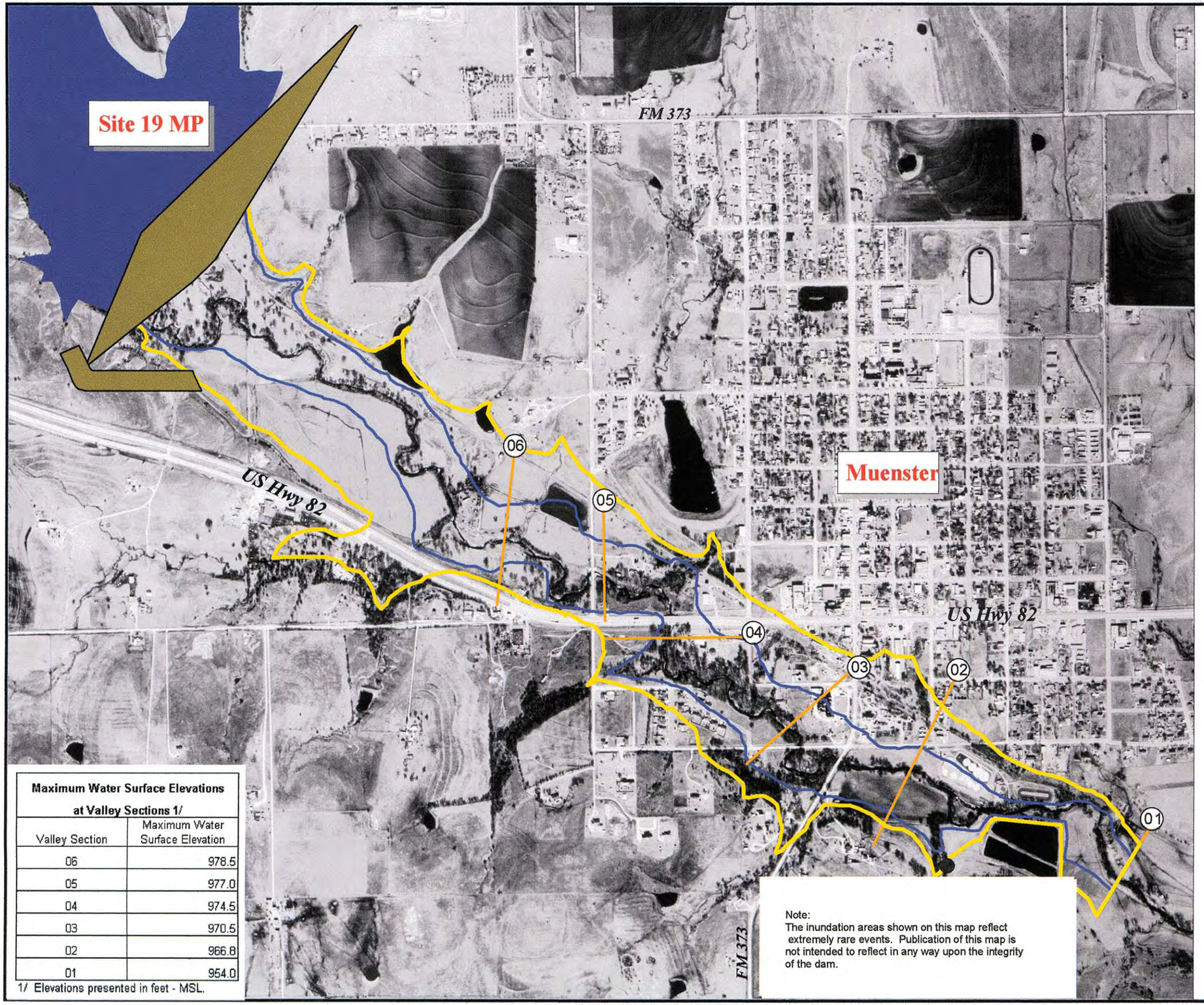
- Conservation Pool (1022.9 M.S.L.)
- Embankment/Auxillary Spillway
- 100 Year Floodplain (without project)
- 100 Year Floodplain (with project)
- 500 Year Floodplain (without project)
- 500 Year Floodplain (with project)
- 01 Valley Section

N
W E
S

1000 0 1000 Feet

Scale 1" = 1000'

March 2001



Maximum Water Surface Elevations at Valley Sections 1/	
Valley Section	Maximum Water Surface Elevation
06	978.5
05	977.0
04	974.5
03	970.5
02	966.8
01	954.0

1/ Elevations presented in feet - MSL.

Note:
The inundation areas shown on this map reflect extremely rare events. Publication of this map is not intended to reflect in any way upon the integrity of the dam.

USDA NRCS
Natural Resources Conservation Service
Planning Staff- Temple, Texas

Figure 2

Elm Fork of the Trinity River
MPS No. 19

Breach Inundation Map
Brushy Elm Creek
City of Muenster

LEGEND

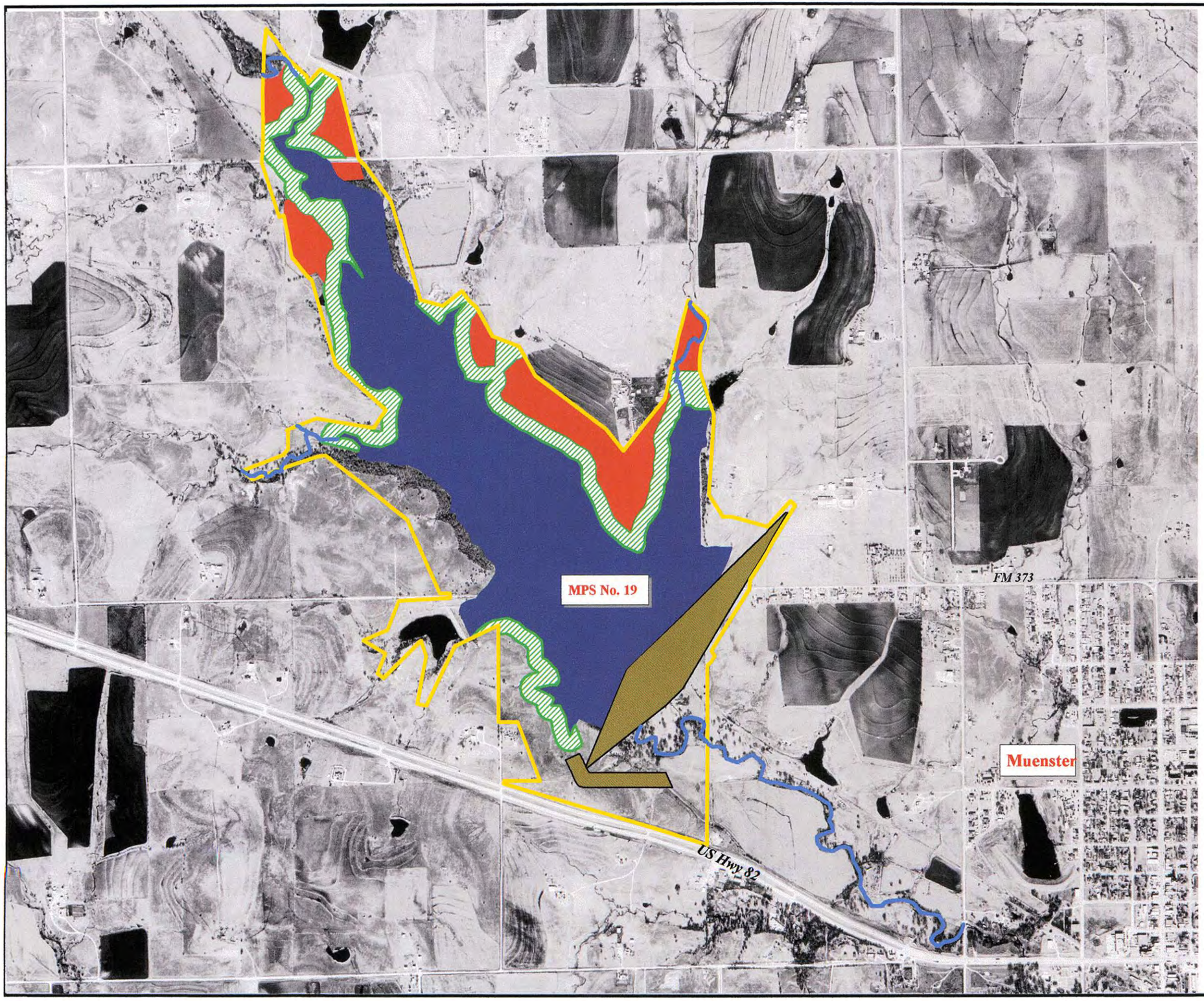
- Embankment/Auxillary Spillway
- 01 Valley Section
- Breach Flood
- 100 Year Floodplain (without project)
- Conservation Pool

N W E S

1000 0 1000 Feet

Scale 1" = 1000'

March 2001



USDA NRCS

Natural Resources Conservation Service
Planning Staff - Temple, Texas

Figure 3

Elm Fork of the Trinity River Watershed
MPS No. 19

Mitigation Plan Map

LEGEND

- Stream Segment Improvement (Approx. 11,000 ft.)
- Herbaceous Plantings (Approx. 65 ac.)
- Woody Buffer Plantings (Approx. 90 ac.)
- Conservation Pool
- Embankment and Spillway
- Fee Simple Boundary

N

0 1000 2000 Feet

Scale 1" = 1320'

March 2001

APPENDIX C
Investigation and Analysis Reports

WATER QUALITY REPORT

Pete Waldo, Phd

General Hydrogeology

Site 19 is located on Brushy Elm Creek with a drainage area of about 13.32 sq. mi. Water impounded at the site will primarily come from surficial rainfall runoff. Spring flow and base flow will contribute little to the long-term water yield except for temporary soil throughflow after prolonged rainfall events.

Stratigraphy at the site vicinity consists of a sequence of lower Cretaceous rocks (McGowen et al., 1967; Nordstrom, 1982; Eshbaugh and Wright, 2000). The Duck Creek limestone occurs at the highest elevations on ridge crests and is underlain by 20 to 50 feet of shale, limestone, and marls of the Kiamichi Formation (Figure 1). The Kiamichi outcrops in the upper portions of the valley walls along Brushy Elm Creek. The 60-foot thick interval containing the Goodland Limestone and Walnut Clay underlies the Kiamichi and occurs under the valley floor and the valley walls. The Walnut-Duck Creek interval consists of sediments typical of shallow marine deposits.

The Antlers Sand represents the lowermost Cretaceous in the vicinity and consists of about 500 to 650 feet of interbedded clay shale and sand with conglomeratic beds near the base. The Antlers lies unconformably on Permian sediments and marks the great transgression of the Cretaceous Sea onto the North American continent. It outcrops extensively to the northwest and southwest of the watershed and also underlies portions of the valley floor (Figure 1).

The Antlers Sand forms a significant aquifer in the area (a.k.a. "Trinity Aquifer" or "Trinity Sand"). The city of Muenster presently obtains water supply from wells in the Antlers, and numerous rural homesteads in the vicinity undoubtedly have private wells completed in the Antlers. The Walnut-Kiamichi interval probably constitutes a leaky aquitard over the Antlers in the Muenster water well field. The Antlers most likely consists of an unconfined, or water table, aquifer at Site 19.

The maximum reported water level elevation in the Muenster water well field was 804 feet above mean sea level in 1939. This lies below the creek bed elevation of 977 feet and the top of the Antlers at elevation 996 at Site 19 (Figure 1). The water table in the Antlers at Site 19 is about elevation 970. Elevations of the water surface behind the proposed dam are expected to range from about 1020 to 1040 feet above msl. Once the new water table is established, ground water flow will be easterly down the regional dip and toward the Muenster well field. The net long-term effect of the dam will be to provide recharge locally to the Antlers aquifer.

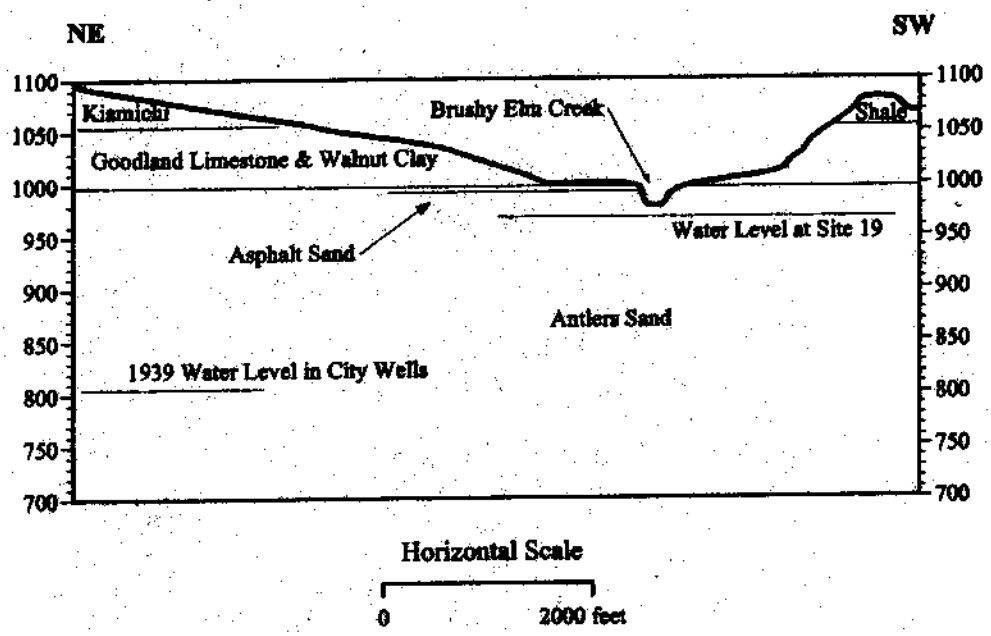


Figure 1. Northeast-Southwest cross-section in the vicinity of Elm Fork Site #19, Muenster, Texas. Approximate elevations of contacts between geologic formations are shown. Outliers of Duck Creek Limestone may occur at the highest elevations of the profile. Surface water impounded at the site will tend to leak downward into the Antlers Sand aquifer and contribute to recharge of the aquifer. Ground water from the Antlers will not contribute spring flow to the reservoir. An asphalt sand occurs near the top of the Antlers or the base of the Goodland in the valley of Brushy Elm Creek. A more highly permeable water sand underlies the valley, the top of which occurs at an elevation of about 950 feet in the Antlers Sand.

Preliminary seepage analysis (D. Petefish, personal communication) indicates average vertical and horizontal permeabilities of about 0.0004 and 0.004 ft/day respectively. The vertical permeability governs the recharge rate of Muenster Lake to the Antlers Sand, indicating about 60 to 125 acre-feet per year will be added to the ground water in the aquifer. Horizontal permeability might divert a significant percentage from the aquifer recharge after the new long-term water table has been established. Total average annual seepage represents about 2 to 5% of the lake volumes allocated to water supply and recreation. Typical losses of water from the lake by evaporation are expected to be several times the volumes lost by combined vertical and horizontal seepage.

Aqueous Geochemistry

The narrative here summarizes chemical analyses of surface water samples taken within the watershed of Site 19 and ground water samples from the water supply wells of the City of Muenster. Data are reported in Water Quality Appendix A and detailed geochemical interpretations in Water Quality Appendix B.

The aqueous geochemistry of surface water is consistent with constituents derived from weathering of carbonates and associated sedimentary rocks (Hem, 1985; Table 1). Calcium and bicarbonate are respectively the most abundant cation and anion in surface runoff (Figure 2). Bicarbonate retains its position as the most important anion in ground water but sodium replaces calcium as the most important cation (Figure 2). Total dissolved solids (TDS) is substantially higher in the ground water (Figure 2, Table 1). The difference in cation composition can be explained by ion exchange of calcium ions in the water for sodium affixed to clay minerals in shale beds as the surface water percolates downward through the vadose zone to the water table. The higher TDS in ground water is caused by dissolution of oxidation products in the vadose zone and reaction of the percolating water with carbonates and other rock materials.

Water Quality at Site 19

Water quality in the vicinity of site 19 strongly reflects the aqueous geochemistry. Ground water in the vicinity is generally enriched in sodium by the ion exchange process (Table 2). All reported measurements of sodium exceed the strictest EPA health advisory of 20 mg/l and 5 of 13 results exceed the most lenient level of 170 mg/l (Water Quality Appendix A; Table 2; van der Leeden et al., 1991). Occasionally pH and iron and manganese concentrations may exceed maximum contaminant levels (MCL) (Hem, 1985; Driscoll, 1986; van der Leeden et al., 1991). TDS measurements reported for ground water were all below the MCL but are significantly higher than concentrations reported for surface water.

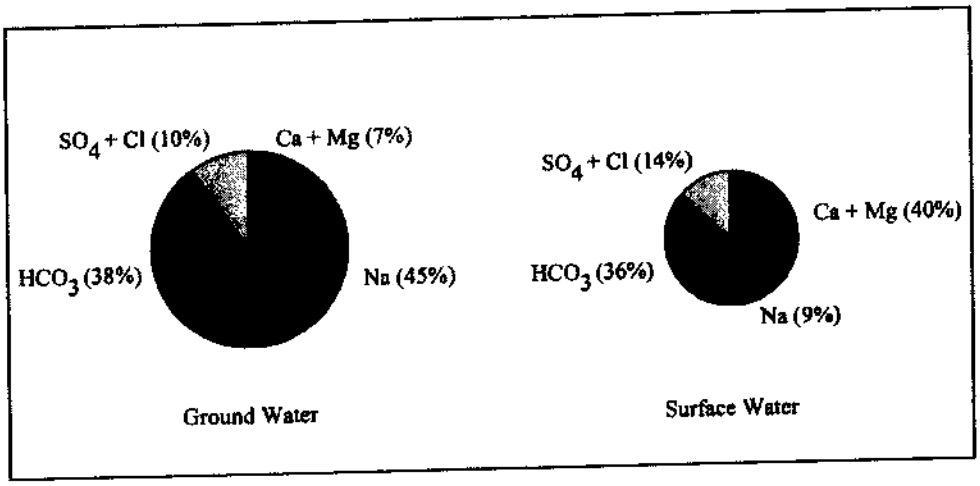


Figure 2. Pie diagram summaries of major cation (Ca, Mg, Na) and anion (HCO_3, SO_4, Cl) concentrations in surface and ground water. Areas of the pie charts are proportional to the overall concentration of major solutes in meq/l -- i.e., concentration of solutes in ground water are approximately twice that of surface water. Note that concentration of anions approximately equals cations in both water types (48% v. 52% in ground water; 50% v. 49% in surface water). Differences are attributable to analytical errors and minor constituents not included in the diagrams. The major geochemical difference between the 2 water types consists of Ca + Mg dominating the cation composition of surface water whereas Na is the dominant cation in ground water. The different cation composition is explained by ion exchange of Ca in surface water for Na absorbed on montmorillinite in shale beds as the surface water infiltrates into the vadose zone and percolates downward to the water table. The additional concentration of solutes in ground water originates from oxidation of sulfides and other matter in the vadose zone and additional dissolution of carbonate minerals in the vadose zone and aquifer.

Water quality of surface water in the region is generally good (Nordstrom, 1982; US EPA, 1999; Eshbaugh and Wright, 2000). This observation applies in general to site 19 but there are some concerns. Chemical analyses reported from the watershed of site 19 (USDA SCS, 1979; Eshbaugh and Wright, 2000; S. Broyles, City of Muenster, personal communication). indicate that aluminum, barium, iron, manganese, thallium, and fecal coliforms may exceed their respective MCLs (Table 2). The metallic constituents are frequently affixed to sediment and will be mobilized by erosion during run-off events and delivered to the reservoir. If the turbulent run-off waters contain sufficient dissolved oxygen some of the metals may be released into solution. Following run-off events sediments suspended in the reservoir water may be expected to settle out on the bottom and the metals with the possible exception of barium and thallium will precipitate as oxides and hydroxides as free oxygen is depleted from the water. Precipitation of most metals as sulfides will continue after oxygen has been depleted.

Barium has been identified as a potentially serious contaminant of surface waters in this area (USDA SCS, 1979; York, 1997). Barium is not expected to exist for long at concentrations exceeding its MCL because both surface and ground waters contain appreciable sulfate. The barium will precipitate out of the water because the solubility of barium sulfate is quite low (Hem, 1985).

Significant levels of arsenic have been detected in nearby watersheds but not in the surface waters at site 19 (USDA SCS, 1979; York, 1997). Arsenic, if present, will exhibit chemical behavior similar to iron, that is, it will be present in detectable concentrations only under certain oxidation conditions (Hem, 1985). When oxygen levels are low, the condition expected deeper in the reservoir or in ground water, those metals precipitate as sulfides. At modest oxygen levels arsenic exists in solution in the form of arsenite or arsenate anions. If oxygen levels are high the metals form oxide and hydroxide complexes that will also precipitate the arsenic.

Recent water quality tests report the presence of thallium in surface water at concentrations exceeding its MCL (Appendix A; Table 2; Eshbaugh and Wright, 2000). Thallium is an ingredient in certain pesticides and this is one possible source of the contamination (Eshbaugh and Wright, 2000). The thallium could also originate from the background because it may be present as a minor constituent in sulfide minerals such as pyrite. Thallium occurs in marine organisms and therefore might be present in trace quantities in fossils of the Cretaceous marine rocks. Oxidation of sulfides would release thallium in addition to iron, manganese, arsenic and other metals into solution. Since the solubility of thallium sulfide is low, the thallium will be removed from solution if oxygen is depleted from the water. The oxides and hydroxides of thallium are more soluble than other metals so that high levels of oxygen will not precipitate thallium in the same manner as aluminum, iron, manganese, and arsenic. Zinc replaces thallium in solution and the low levels of zinc reported from water quality tests (Appendix A; Table 2) may permit thallium to occur occasionally at levels exceeding its MCL.

All measurements reported for nitrate were below the MCL. Test results for pesticides show no detections (S. Broyles, City of Muenster; Eshbaugh and Wright, 2000). This does not exclude the possibility that higher levels of nitrate and pesticides could occur in the future because of excessive applications in the watershed. Agricultural land uses at the present time are primarily

grasslands to support livestock and appear to be well managed from the water quality perspective (Eshbaugh and Wright, 2000). Fecal coliforms and other bacteria generally occur in surface water and will need to be dealt with by the water treatment process. Bacteria will have a greater impact on recreation uses of the lake. Excessive levels of bacteria, sediment and metals may occur during and immediately following storm run-off events.

Several abandoned oil wells and pipelines occur in the vicinity including 4 within the boundaries of the proposed pool (Allison, 1997). Appropriate offices of the Texas Railroad Commission have been contacted and their records indicate that the 4 wells of major concern have been properly sealed (Eshbaugh and Wright, 2000). The well and pipeline locations should be documented for future reference in case upward leakage of hydrocarbons along annular zones around the wells might be suspected. Several actively pumped wells exist in the watershed upstream of the site. A field reconnaissance detected no visual signs of hydrocarbon or brine leakage around the wells and storage tanks that were seen. However, there are no containment facilities associated with the tanks to trap catastrophic spills (Eshbaugh and Wright, 2000).

Soil Quality at MPS No. 19

Contaminants in the soil underlying the pool area might affect water quality. Soil contaminants originate from natural and anthropogenic sources. Contaminants originating from the natural aqueous geochemistry have been discussed above. Another naturally occurring potential contaminant at the site consists of asphalt sands in the upper portions of the Antlers (Allison, 1997).

Asphalt sands have been discovered along the east margin of the pool area and at shallow depths along the centerline of the proposed dam. Strike and dip estimates were based on elevations of the top of the asphalt sand and distances between an outcrop in the pool area and occurrences along the centerline of the dam and a nearby oil well (Allison, 1997). The strike is estimated as northnortheast-southsouthwest and the dip is gently to the eastsoutheast. This is consistent with known regional dips of Cretaceous strata in this portion of north Texas (McGowen et al., 1967; Nordstrom, 1982). Thickness of the asphalt sand varies from about 0.5 to 3 feet, averaging about 1 foot.

Exposure of the asphalt sands to the pool water can be minimized by either delineating the sands and avoiding them during borrow excavations or by removing the sands to a depth of several feet and backfilling with impervious soil. Alternatively, the raw pool water can be monitored for hydrocarbons that can be removed from the finished water by appropriate treatment (Driscoll, 1986; van der Leeden et al., 1991).

One significant anthropogenic source of contamination was detected at the site. Significant levels of total petroleum hydrocarbons (TPH), barium, chromium, and lead were detected at the Koch Gathering Systems Site (York, 1997; Table 3). The extent of the potential contaminants has been identified. Remedial work consisting of contaminant removal, soil stabilization, and revegetation has been completed and the site no longer poses a threat to water quality (Eshbaugh and Wright, 2000).

Sediments in the streambed and banks, especially clay minerals and colloids, are likely to contain significant quantities of absorbed contaminants. The sediments will be eroded and transported to the reservoir during storm run-off events. There may be periods of up to several days during and following run-off events that contaminants such as suspended solids, aluminum, arsenic, barium, iron, manganese, and thallium (Table 2) might be present in the reservoir water in detectable amounts. Nutrients and pesticides, if present in sufficient quantities, will be mobilized in a similar manner. If it is necessary to withdraw raw water from the reservoir at those times, appropriate treatment will be necessary. Most of those contaminants will be considerably reduced in concentration by sedimentation and chemical precipitation as quiet conditions are restored after run-off ceases. Bacteria are always a concern in raw surface water and must be dealt with in the treatment process.

Summary of Water Quality and Impacts of MPS No. 19

Discussions above on geochemistry and water quality issues conceming surface and ground waters primarily focus on the raw water sources available for water supply. In general there are only slight limitations on the use of surface water for water supply, limitations that can be readily corrected by treatment prior to distribution of the finished water. The impacts of the site on water quality may be summarized as follows:

* provide source of municipal water lower in dissolved solids and sodium than the existing source
* trap a major percentage of sediments and other contaminants that would otherwise continue downstream
* provide local recharge to the Antlers Sand that will slightly increase the quantity of water available in the aquifer without affecting water quality
* impound surface water that might be contaminated during periods of storm run-off
* saturate soils underlying the pool area possibly mobilizing locally concentrated hydrocarbons in the liquid phase

Recreational water uses are planned for the lake at MPS No. 19. Recreation might conflict with use of the lake for water supply in certain circumstances. For example, gasoline powered boats might introduce contaminants into the lake. The combination of petroleum products derived from the asphalt sand, leaks from wells and storage tanks in the watershed, and gasoline from motorboats might adversely affect recreational uses of the water. Bacteria may also impact recreation adversely and monitoring of bacteria should be done throughout the recreation season.

The following are the recommendations of Eshbaugh and Wright (2000) to maintain good surface water quality.

1. Maintain Muenster Pond as protection from spills that may occur on Highway 82. The highway is a rather short distance from the Muenster Lake pool area and the pond serves as protection for the drinking water supply from spills that may occur as a result of accidents on the stretch of Highway 82 that is within the Muenster Lake watershed.
2. Implement a cooperative effort with oil producers and landowners to construct adequate dikes on the downhill side of tank batteries to contain the contents of the tanks in case of a leak or

rupture. Tank batteries nearest the pool area and the main drainage pathways are the most critical. The more distant tank batteries may not require containment structures if small nearby ponds capable of containing a release are present in the flowpath.
3. Evaluate the use of gasoline powered water craft on water quality of Muenster Lake and restrict the use accordingly. The pool area of Muenster Lake is about 300 acres which is rather small. Extensive use of gasoline engines on the proposed lake could sufficiently pollute the water to impact water quality.
4. Encourage landowners along Brushy Elm Creek and its major tributaries to leave a minimum of 150 feet from the banks of the drainage in grass. These areas of grass will help stabilize soils near the creek, reduce erosion and capture a portion of the silt carried in storm waters.
5. Promote projects with landowners and government agencies to stabilize the banks of Brushy Elm Creek upstream of the pool area. Bank erosion is evident in a number of places. A thorough evaluation of the creek and tributaries is necessary to identify and prioritize areas of the banks requiring stabilization.
6. Coordinate with Cooke County officials regarding development within the Muenster Lake watershed. Good planning throughout the watershed will help to assure good water quality in the future.
7. Develop information packets for persons living and working in the watershed. Providing information including a list of best management practices (BMPs) can increase the awareness of the importance of the watershed and the impact individuals have on surface water quality. Educating children through the local schools about the Muenster Lake project is also worthwhile. The project during construction and after completion can be utilized as a natural laboratory for a number of interesting educational projects.
8. Conduct additional raw water sampling and analyze for fecal coliform when the reservoir begins to fill and prior to commencement of recreational activities.

Note: Muenster Lake is the same as MPS No. 19

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WATER QUALITY - APPENDIX A

WATER QUALITY DATA

Data are from various sources as noted in the narrative and references. Values reported as zero (0) are test results below detection limits and do not necessarily imply that lesser amounts of the constituent do not occur in the sample. Concentrations of all constituents are reported in units of mg/l in contrast to the modern convention of reporting metals and other trace constituents in units of µg/l.

Source	Date	Water Type	State Number	Well	Temperature °C	pH	Dissolved Oxygen mg/l	Dissolved Solids mg/l	Conductivity µmhos/cm	Hardness mg/l $CaCO_3$	Alkalinity mg/l $CaCO_3$	Silica mg/l
Antlers	3/16/83	Ground	1921909	1	19.4	7.9		430	711	144	326	16
Antlers	2/20/50	Ground	1921908	2		7.6		440		123		15
Antlers	8/6/97	Ground	1921908	2		8.1		440	787	6	318	
Antlers	1/22/52	Ground	1921901	3		8.2		413		124	310	12
Antlers	12/8/55	Ground	1921901	3		8.1		430		92	310	12
Antlers	5/27/60	Ground	1921901	3		7.2		442	697	86		13
Antlers	9/12/63	Ground	1921901	3		8.6		425	765	19	317	
Antlers	11/19/68	Ground	1921901	3		8.5			770	14	313	
Antlers	12/9/55	Ground	1921902	4		8.3		423		12	310	9
Antlers	12/17/56	Ground	1921902	4		8.5		370	610	21	325	
Antlers	5/27/60	Ground	1921902	4		7.9		417	681	9		11
Antlers	10/21/76	Ground	1921902	4	20.6	8.3		410	661	13	308	11
Antlers	6/13/89	Ground	1921902	4	20	8.7			570		311	11
Antlers	2/25/44	Ground	1921903			8		388		9		13
Antlers	12/17/56	Ground	1921903			8.4		410	680	8		
Antlers	10/28/75	Ground	1921905			7.9		393	615	273		15
Antlers	10/28/75	Ground	1921906			8.6		471	765	38		13
Antlers	10/28/75	Ground	1921907			8.5		426	660	217		13
Brushy Elm	3/18/97	Stream				7.9		305	585	241	230	
Brushy Elm	7/14/99	Stream				7.4		199	387	148	137	
Site 61C	11/1/76	Lake				8.1		207	306	112		
Site 6A-1	8/29/78	Lake				8.3	6.4	262	980			
Site 6E	10/22/76	Lake				7.9		180	250	93		
Site 6E	8/29/78	Lake				8.2	6.5	204	975			
Composite	12/9/99	Lake										

Source	Date	Calcium mg/l	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Carbonate mg/l	Bicarbonate mg/l	Sulfate mg/l	Chloride mg/l	Silver mg/l	Aluminum mg/l	Arsenic mg/l	Boron mg/l
Antlers	3/16/83	33	15	121	5	0	398	59	16				
Antlers	2/20/50	26	14	127			366	61	21				
Antlers	8/6/97	2	1	184		0	388	38	29	0	0	0	
Antlers	1/22/52	25	15	128		0	378	59	18				
Antlers	12/8/55	22	9	141		0	378	56	21				
Antlers	5/27/60	19	9.4	132	4.1	0	360	53	13				0.62
Antlers	9/12/63	4	2	168		10	367	41	19				
Antlers	11/19/68	3	2	170		7	367	42	19				
Antlers	12/9/55	3	1	172		12	354	44	21				
Antlers	12/17/56	3	3	247		8	355	39	10				
Antlers	5/27/60	2	1	162	1.5	0	365	40	12				1.3
Antlers	10/21/76	1	2	163			376	36	12				
Antlers	6/13/89	2.5	0.8	211	1.8			42	48			0	0.19
Antlers	2/25/44	2	1	162	3.4		315	38	12				
Antlers	12/17/56	2	1	157			368	40	16				
Antlers	10/28/75	93	10	35			339	61	9				
Antlers	10/28/75	12	2	176			418	53	9				
Antlers	10/28/75	73	9	72			338	82	11				
Brushy Elm	3/18/97	79	11	20		0	281	34	18	0	0.14	0	
Brushy Elm	7/14/99	52	4	18		0	167	16	23	0	0.67	0.0023	
Site 61C	11/1/76	40	3	14		0	96	41	13				
Site 6A-1	8/29/78											0	
Site 6E	10/22/76	34	2	11		0	106	11	15				
Site 6E Composite	8/29/78 12/9/99											0	

Source	Date	Barium mg/l	Beryllium mg/l	Cadmium mg/l	Chromium mg/l	Copper mg/l	Iron mg/l	Mercury mg/l	Manganese mg/l	Nickel mg/l	Lead mg/l	Antimony mg/l	Selenium mg/l
Antlers	3/16/83												
Antlers	2/20/50						0.2						
Antlers	8/6/97	0.036	0	0	0	0	0	0	0	0	0	0	0
Antlers	1/22/52						0.18		0.05				
Antlers	12/8/55						0.7		0.1				
Antlers	5/27/60						1.7						
Antlers	9/12/63												
Antlers	11/19/68												
Antlers	12/9/55						0.08		0.05				
Antlers	12/17/56						0.23		0				
Antlers	5/27/60						0.02						
Antlers	10/21/76												
Antlers	6/13/89	0.06		0	0	0	0	0	0		0		0
Antlers	2/25/44												
Antlers	12/17/56						0.1						
Antlers	10/28/75												
Antlers	10/28/75												
Antlers	10/28/75												
Brushy Elm	3/18/97	0.06	0	0	0	0	0.08	0	0	0	0	0	0
Brushy Elm	7/14/99	0.06	0	0	0	0	0.46	0	0.18	0	0	0	0
Site 61C	11/1/76						0.06		0				
Site 6A-1	8/29/78	103		0.002	0			0			0.03		
Site 6E	10/22/76						0.58		0.07				
Site 6E	8/29/78												
Composite	12/9/99	0.064	0	0	0	0		0		0	0	0	0

Source	Date	Strontium mg/l	Thallium mg/l	Vanadium mg/l	Zinc mg/l	Bromide mg/l	Flouride mg/l	Iodide mg/l	Nitrate mg/l	Phosphorus mg/l	Fecal Coliform No./100 ml
Antlers	3/16/83						0		0		
Antlers	2/20/50						0		6		
Antlers	8/6/97		0		0		0.1		0.07		
Antlers	1/22/52						0.1		6		
Antlers	12/8/55						0.1		0.4		
Antlers	5/27/60						0.2		2.8		
Antlers	9/12/63						0.3		0		
Antlers	11/19/68						0.8		0		
Antlers	12/9/55						0.1		0.4		
Antlers	12/17/56						0.2		0		
Antlers	5/27/60						0.1		0		
Antlers	10/21/76						0.1		0		
Antlers	6/13/89	0.21		0	0	0.33	0	0	0	0	
Antlers	2/25/44						0		2		
Antlers	12/17/56						1.2		0		
Antlers	10/28/75						0.2		3.4		
Antlers	10/28/75						0.2		0		
Antlers	10/28/75						0.2		0		
Brushy Elm	3/18/97		0		0		0.2		0.75		
Brushy Elm	7/14/99		0		0		0.2				32
Site 61C	11/1/76						0.3		0		
Site 6A-1	8/29/78								0.05	0	300
Site 6E	10/22/76						0.2		1		
Site 6E	8/29/78								0.11	0	400
Composite	12/9/99		0.037						0.078	0	

WATER QUALITY - APPENDIX B

ANALYSIS AND INTERPRETATION OF WATER QUALITY DATA

Data are summarized in Water Quality Appendix A. Concentrations of chemical properties and ions are expressed in units of milligrams per liter (mg/l) when interested in mass quantities and milliequivalents per liter (meq/l) when the interest is in comparisons of ionic equivalents.

The low number of water samples – 13 for ground and 7 for surface water – places constraints on the types of statistical analyses and interpretations (SAS Institute Inc., 1995; SPSS Inc., 1997). Missing values for many constituents compound the problem (Water Quality Appendix A). Some important constituents such as oxidation-reduction potential (ORP) have not been reported at all.

Correlations (Tables B1-3) were evaluated at a level of significance of $\alpha = 0.1$. A significance level of $\alpha = 0.01$ is preferred when evaluating a large number of correlations (Stevens, 1992). However, the limited number of observations reported to this study precluded testing at the desired more stringent significance level. Only the correlations judged significant at $\alpha = 0.1$ are reported in Tables B1-3. Additional data might enable more of the correlations to be judged significant.

Correlations are presented for all water samples (maximum N=19) and ground water samples (maximum N=13). Data were too sparse (maximum N=6) for correlations of constituents reported for surface water samples.

The correlations were used as guidance for formulating possible geochemical interpretations and for selecting relationships to examine in more detail (Figures B1-14). Details of geochemical interpretations are presented in the captions of the individual figures.

Spearman's correlation coefficients were also computed (Tables B4-6) because of the limited number of observations and the fact that measurements of water quality constituents are frequently non-normally distributed. The Spearman coefficient may be preferable to the Pearson coefficient in those circumstances. When tested at $\alpha = 0.1$, about 20% of the possible significance tests gave different results when comparing Tables B1-3 to their counterparts B4-6. In spite of this difference, both the Pearson (Tables B1-3) and Spearman (Tables B4-6) correlation coefficients support the geochemical interpretations in Figures B1-14.

Analyses in Appendlx B do not include 5 ground water samples reported in Nordstrom (1982). Analyses here have been checked using the 5 addltlonal samples. The 5 samples did not change any of the interpretatlons so the figures and tables ln Appendlx B have not been revlsed accordlngly. The test results of the 5 samples are, however, reported in Appendix A.

Table B-1. Correlations of Cations to Anions and Index Properties.

Constituent	Calcium	Magnesium	Sodium	Iron
All Water Sample		*(N = 15; N = 11 for Iron)*		
Bicarbonate	-.48	--	.79	--
Sulfate	--	.68	--	--
Chloride	--	--	--	--
Fluoride	--	--	--	--
Nitrate	--	.68	--	--
Date	.41	--	-.40	--
pH	-.40	-.49	.40	-.67
TDS	-.55	--	.77	--
Hardness	.96	.76	-.72	--
Alkalinity	-.52	--	.84	--
Ground Water Samples		*(N = 12; N = 8 for Iron)*		
Bicarbonate	.45	--	-.44	--
Sulfate	.97	.95	-.76	--
Chloride	--	--	--	--
Fluoride	--	--	--	.52
Nitrate	.59	.71	-.52	--
Date	--	--	--	--
pH	-.55	-.52	.59	-.69
TDS	--	--	-.64	--
Hardness	.99	.99	-.73	--
Alkallnity	--	--	.45	--

Table B-2. Correlations of Anions to Other Anions and Index Properties.

Constituent	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate
		All Water Samples (N = 15)			
Bicarbonate	1.00	.61	--	--	--
Sulfate	.61	1.00	--	--	.50
Chloride	--	--	1.00	--	--
Fluoride	--	--	--	1.00	--
Nitrate	--	.50	--	--	1.00
Date	--	-.46	--	--	-.50
pH	--	--	--	.40	-.44
TDS	.97	.67	--	--	--
Hardness	--	--	--	--	--
Alkalinity	.99	.58	--	--	--
		Ground Water Samples (N = 12)			
Bicarbonate	1.00	--	--	--	--
Sulfate	--	--	--	--	.70
Chloride	--	--	1.00	--	--
Fluoride	--	--	--	1.00	--
Nitrate	--	.70	--	--	1.00
Date	.67	--	--	--	-.52
pH	--	-.55	--	--	-.47
TDS	--	--	.59	--	--
Hardness	--	.97	--	--	.65
Alkalinity	--	--	--	--	-.46

Table B-3. Correlations of Cations to Other Cations.

Cation	Calcium	Magnesium	Sodium	Iron
All Water Samples		*(N = 17; N = 13 for Iron)*		
Calcium	**1.00**	**.50**	**-.86**	**--**
Magnesium	**.50**	**1.00**	**--**	**--**
Sodium	**-.86**	**--**	**1.00**	**--**
Iron	**--**	**--**	**--**	**1.00**
		Ground Water Samples (N = 13; N = 9 for Iron)		
Calcium	**1.00**	**.98**	**-.76**	**--**
Magnesium	**.98**	**1.00**	**-.73**	**--**
Sodium	**-.76**	**-.73**	**1.00**	**--**
Iron	**--**	**--**	**--**	**1.00**

Correlations between iron and manganese are as follows: 0.73 for all water samples (N = 10); 0.81 for ground water samples (N = 6).

Table B-4. Spearman Correlations of Cations to Anions and Index Properties.

Constituent	Calcium	Magnesium	Sodium	Iron
All Water Sample		*(N = 15; N = 11 for Iron)*		
Bicarbonate	--	--	--	--
Sulfate	--	.41	--	--
Chloride	--	--	--	--
Fluoride	--	--	--	--
Nitrate	.45	.46	-.43	.56
Date	--	--	--	--
pH	-.54	-.51	.71	-.47
TDS	-.44	--	.49	--
Hardness	.93	.87	-.79	--
Alkalinity	-.50	--	.72	--
Ground Water Samples		*(N = 12; N = 8 for Iron)*		
Bicarbonate	--	--	-.49	--
Sulfate	.90	.68	-.72	--
Chloride	--	--	--	--
Fluoride	--	--	--	--
Nitrate	.50	--	--	--
Date	-.51	-.49	--	--
pH	--	-.50	.73	--
TDS	--	--	--	--
Hardness	.92	.96	-.73	.69
Alkalinity	--	--	--	--

Table B-5. Spearman Correlations of Anions to Other Anions and Index Properties.

Constituent	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate
		All Water Samples (N = 15)			
Bicarbonate	1.00	.48	--	-.41	--
Sulfate	.48	1.00	--	-.45	--
Chloride	--	--	1.00	--	--
Fluoride	-.41	-.45	--	1.00	--
Nitrate	--	--	--	--	1.00
Date	--	-.63	--	--	--
pH	--	--	--	--	-.55
TDS	.64	.65	--	--	--
Hardness	--	--	--	--	-.44
Alkalinlty	.70	--	--	--	--
		Ground Water Samples (N = 12)			
Bicarbonate	1.00	--	--	--	--
Sulfate	--	1.00	--	--	.63
Chloride	--	--	1.00	--	--
Fluoride	--	--	--	1.00	--
Nitrate	--	.63	--	--	1.00
Date	--	-.56	--	--	-.67
pH	--	--	--	--	-.55
TDS	--	--	.55	--	--
Hardness	--	.77	--	--	--
Alkalinlty	--	--	--	--	-.48

Table B-6. Spearman Correlations of Cations to Other Catlons.

Cation	Calcium	Magnesium	Sodlum	Iron
All Water Samples		*(N = 17; N = 13 for Iron)*		
Calcium	**1.00**	**.68**	**-.85**	**--**
Magnesium	**.68**	**1.00**	**-.58**	**.55**
Sodium	**-.85**	**-.58**	**1.00**	**--**
Iron	**--**	**.55**	**--**	**1.00**
		Ground Water Samples (N = 13; N = 9 for Iron)		
Calcium	**1.00**	**.84**	**-.71**	**.67**
Magnesium	**.84**	**1.00**	**-.77**	**.70**
Sodium	**-.71**	**-.77**	**1.00**	**--**
Iron	**.67**	**.70**	**--**	**1.00**

Correlations between iron and manganese are as follows: 0.79 for all water samples (N = 10); insignlficant at $\alpha = 0.1$ for ground water samples (N = 6).

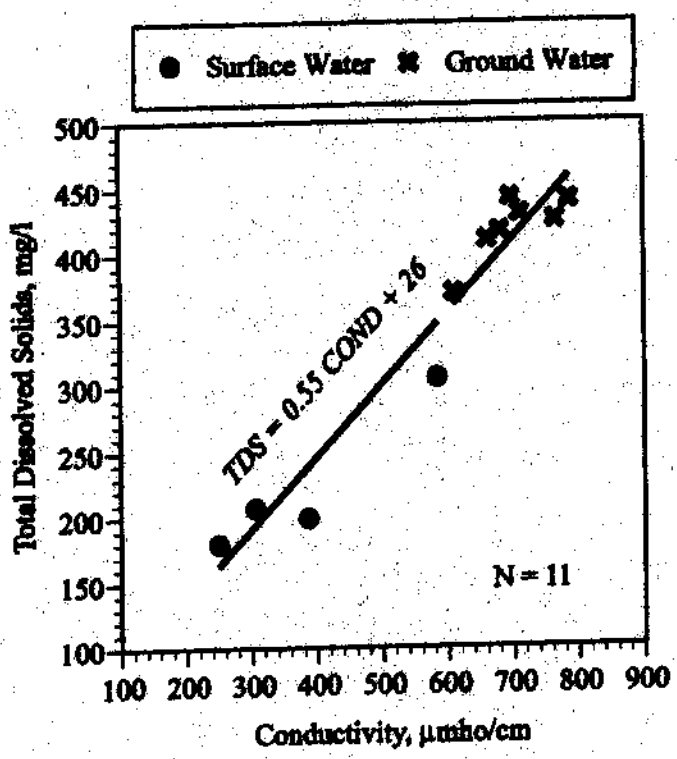

Figure B1. Relationship between total dissolved solids (TDS) and conductivity (COND). This is a useful relationship for predicting TDS from the easily obtained measurements of conductivity. The coefficient 0.55 is at the lower end of the range generally considered indicative of good water analyses. Surface and ground water samples appear to fall on the same general trend, suggesting a general connection between the two types of water. Surface water tends to have lower TDS and COND than ground water which is expected. Infiltration of surface water through the vadose zone to the water table generally dissolves additional mineral matter from the soil and rock. The number of observations is comparatively low (N = 11) and additional data might significantly change the coefficients in the equation.

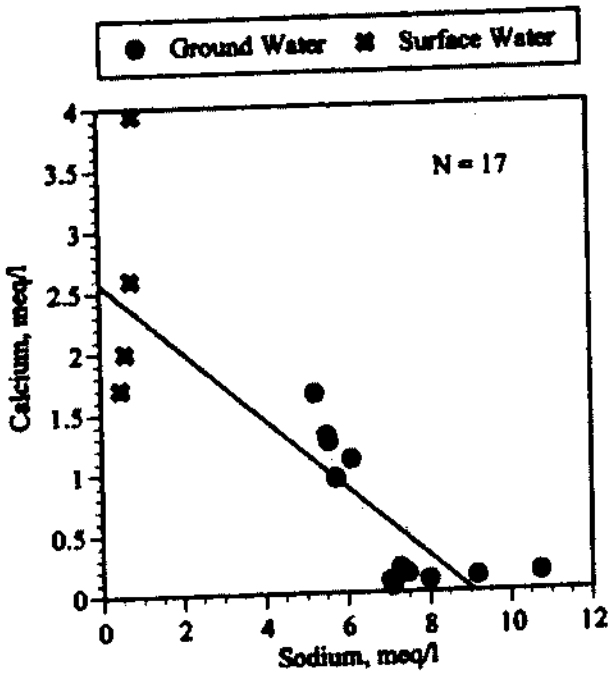

Figure B2. Relationship between calcium and sodium. Concentration of sodium in surface water is low with little variability compared to calcium. Sodium concentration in ground water is more variable and exceeds calcium concentration. A likely mechanism is ion exchange. Surface waters containing calcium infiltrate into the vadose zone and upper parts of the aquifer where they encounter beds of montmorillinitic shale. Calcium exchanges for sodium cations adsorbed to the montmorillinite thereby enriching ground waters in sodium and depleting them of calcium. Other sources of sodium such as dissolution of evaporite beds are less likely because of (1) loss of calcium, (2) lack of increase in chloride, and (3) total dissolved solids in the ground water, although higher than in surface water, do not approach magnitudes expected from dissolution of evaporites.

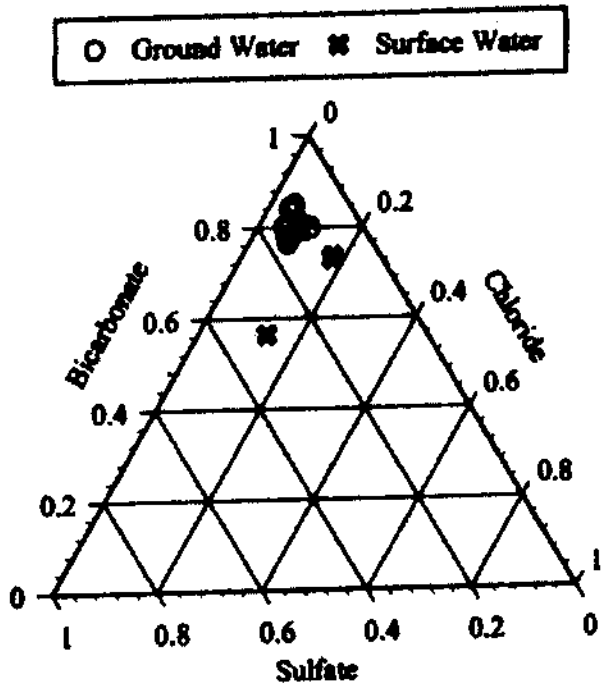

Figure B3. Ternary diagram showing relations among 3 major anions. Percentage of anions represented by chloride is higher in surface water. Sulfate percentage is higher in 1 surface water sample but does not appear to be a general condition. Bicarbonate is the dominant anion in both surface and ground waters. The higher percentage of chloride in surface waters may originate from dissolution of salts from soils by rainfall runoff. The higher percentage of sulfate in the one surface water sample may represent a similar soil leaching process. The dominance of bicarbonate suggests solution of carbon dioxide forms carbonic acid which both dissociates into bicarbonate ions and attacks calcium and magnesium carbonate minerals in the soil and rocks. This is one fundamental process that explains the aqueous geochemistry in the region.

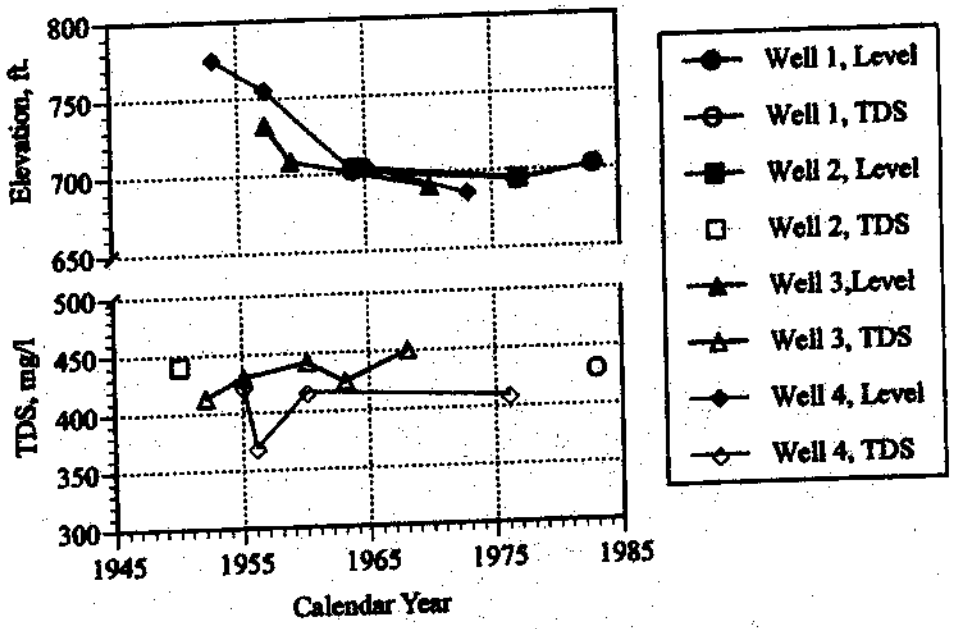

Figure B4. Well water level elevations and total dissolved solids (TDS) v. time. Water levels exhibit a long term decline typical of an aquifer being mined for water supply. TDS in the ground water shows considerable variability over time, but generally maintains an average of about 425 mg/l. Trends in individual wells may deviate from the overall trends. For example, compare TDS v. calendar year in well 3 (increases with time) to well 4 (slightly decreases with time). Differences in local hydrogeological properties or geochemical characteristics of the aquifer rock might account for the different trends, but sufficient information is not available to explain the differences. The overall behavior of ground water levels and TDS content is sufficient knowledge for this study.

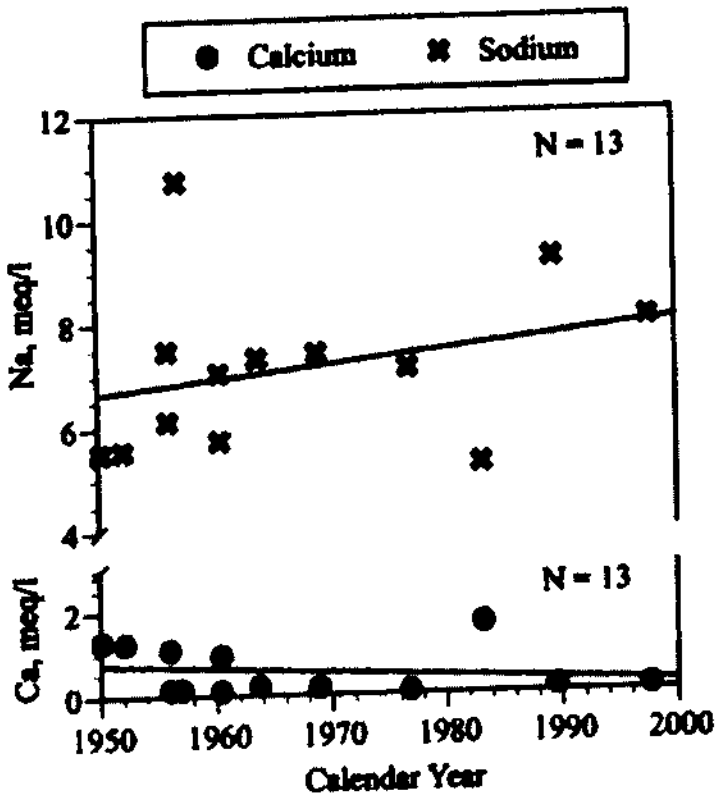

Figure B5. Relationship of calcium and sodium to time in ground water wells. The trend lines are not statistically significant, but visually suggest a long term gradual increase in Na and a corresponding decrease in Ca. This is consistent with an ion exchange reaction that involves replacement of Na attached to montmorillinite grains in shale beds with Ca from the ground water. The gradual statistically insignificant changes in concentrations suggest that ion exchange occurs rapidly to surface waters newly infiltrated into the aquifer and the reaction rate declines for mature ground waters with low calcium and high sodium. The lack of statistical significance of the trends supports the interpretation of lack of trend of total dissolved solids with time (Figure B4).

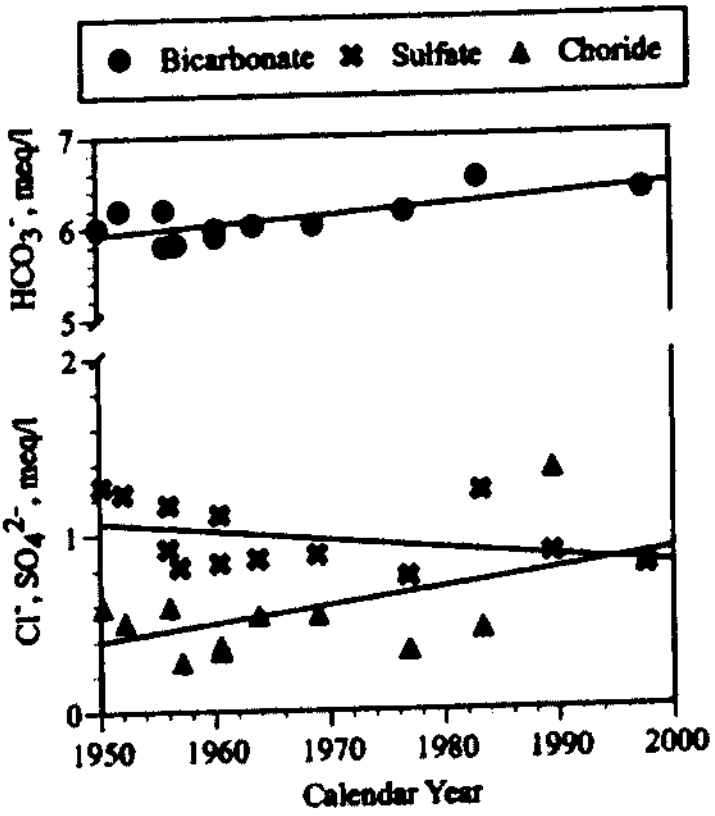

Figure B6. Relationship of major anions in ground water to time. The trend lines are of questionable statistical signicance but visually suggest long term increases in chloride and bicarbonate concentrations and a decrease in sulfate concentration. Bicarbonate and chloride concentrations may increase as water levels in the aquifer are drawn down. Sulfate may decrease because of reduction in an oxygen deficient ground water environment and resultant precipitation of sulfides. These trends are gradual and may not be statistically significant.

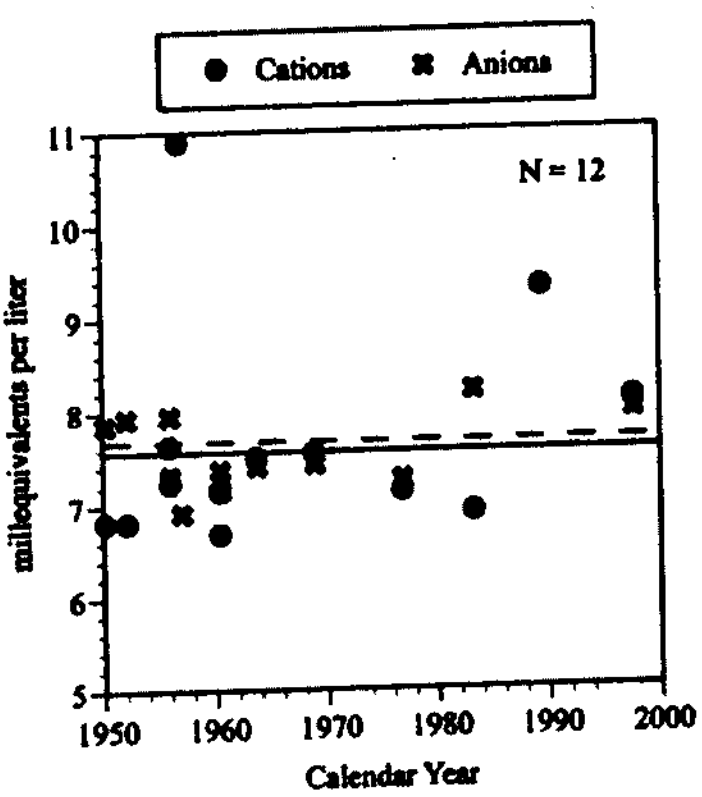

Figure B7. Major cations and anions in ground water v. time. Neither cations nor anions correlate significantly to time. This agrees with the interpretation that TDS in ground water does not correlate significantly to time (Figure B4). Note that the major anions and cations both average in concentration about 7.6 meq/l indicating that water analyses are balanced on the average. The wide scatter from the average suggests considerable variability in the data. In addition, some analyses appear balanced (i.e., cation and anion values in meq/l plot at nearly the same point on the graph) but others are not balanced (cation and anion values for the same analysis have a wide separation on the graph, e.g., analyses of samples taken in 1956 and 1983). The former may represent mature ground water that has resided in the aquifer for considerable lengths of time and the latter may be samples affected by recent chemical events such as influxes of surface water or redox reactions.

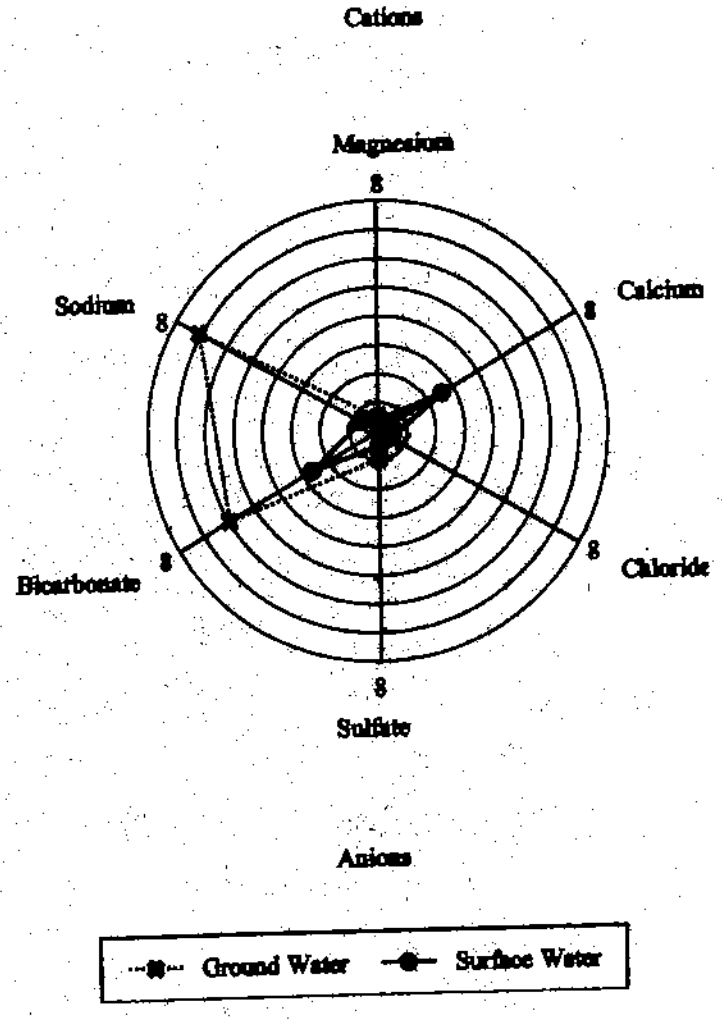

Figure B8. Spider diagram of 3 major cations and 3 major anions in surface and ground waters. The considerably higher concentrations, in meq/l, of Na and HCO_3 in ground water account for the overall higher concentrations of dissolved solids in ground water. Concentration of Na and SO_4 are higher in ground water, but concentration of Ca is higher in surface water. Mg and Cl concentrations are similar in both water types suggesting comparative stability of those 2 ions in the aqueous geochemical system. The chemical relations here are consistent with (1) initial dissolution of carbonates and salts in soils by surficial runoff, (2) infiltration of surface water into the local vadose zone and aquifer, (3) increased concentration of selected ions by additional carbonate dissolution and oxidation of sulfides, (4) ion exchange of Ca for Na, probably from montmorillinitic clay minerals in the shale beds.

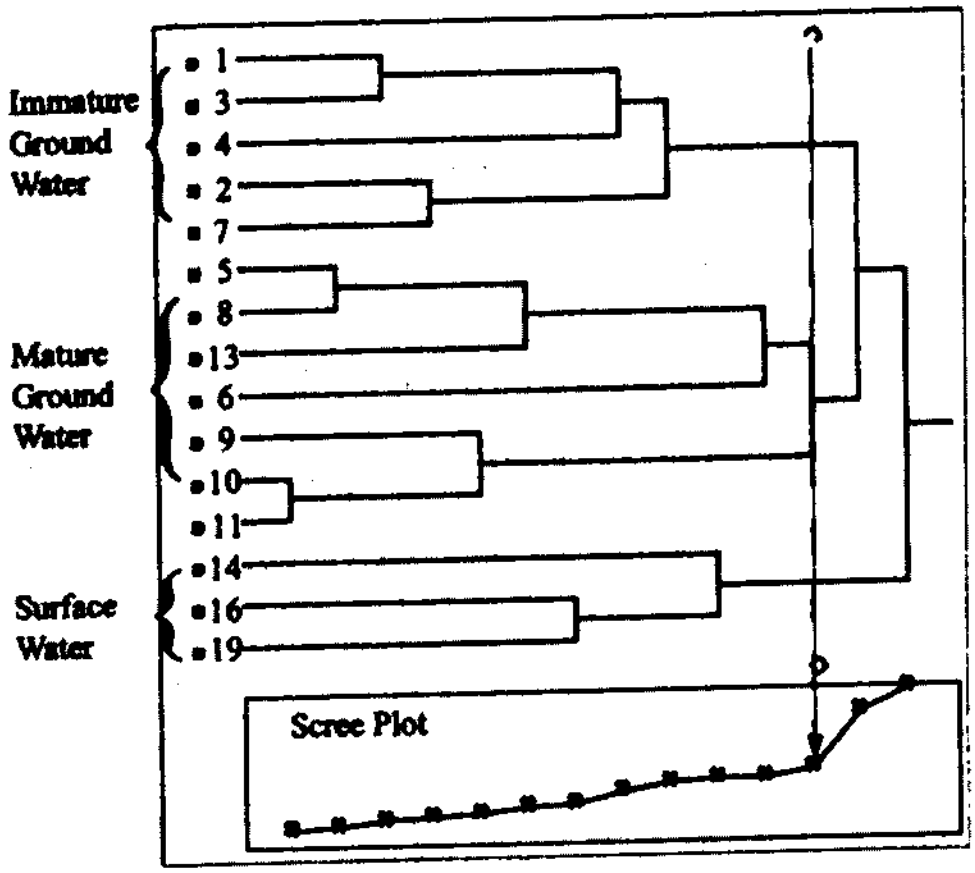

Figure B9. Dendogram from hierarchical cluster analysis by Ward's method of 15 water sample vectors composed of the variables pH, TDS, Ca, Mg, Na, HCO_3, SO_4, Cl, F, and NO_3. The scree plot shows that 3 clusters is a reasonable interpretation. The clusters correspond to surface water, immature ground water, and mature ground water samples. See also Figure B10. The numbers along the left margin of the dendogram refer to case numbers of the individual water samples listed in Water Quality Appendix A.

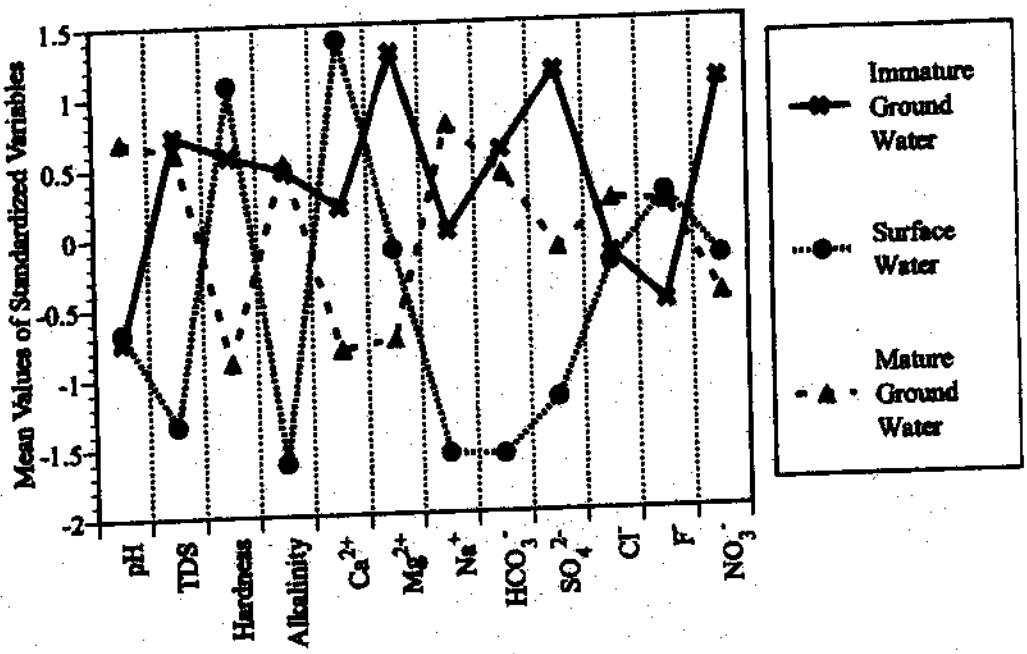

Figure B10. Means of standardized variables by cluster type. See also Figure B9. Hardness and alkalinity were not used to define clusters but are included to show their respective affinities for Ca + Mg and HCO_3. Surface waters tend to be comparatively low in concentrations of TDS, Na, HCO_3, and SO_4. This reflects the short time in which rainfall runoff is in contact with soil minerals. Surface waters are high in Ca suggesting that initial cation content depends on dissolution of carbonate minerals. Immature gound waters have intermediate concentrations of Ca and Mg indicative of initial stages of the ion exchange process. SO_4 and NO_3 are also high suggesting that oxidation of sulfides, other minerals and organic matter contributes additional solutes. Oxidation produces acids that increase the solubility of carbonates resulting in additional Ca that exchanges for Na and higher concentrations of Mg and HCO_3. The high TDS of immature ground water results from the ion exchange and oxidation processes. Mature ground waters exhibit a more nearly stable concentration of constituents. The rates of ion exchange and oxidation reactions have approached equilibrium SO_4 and NO_3 levels drop because the oxidation-reduction level of the mature ground water is most likely low which reduces those anions and precipitates are formed. The reduction reactions and excess Na from ion exchange cause lower H, higher OH, therefore higher pH.

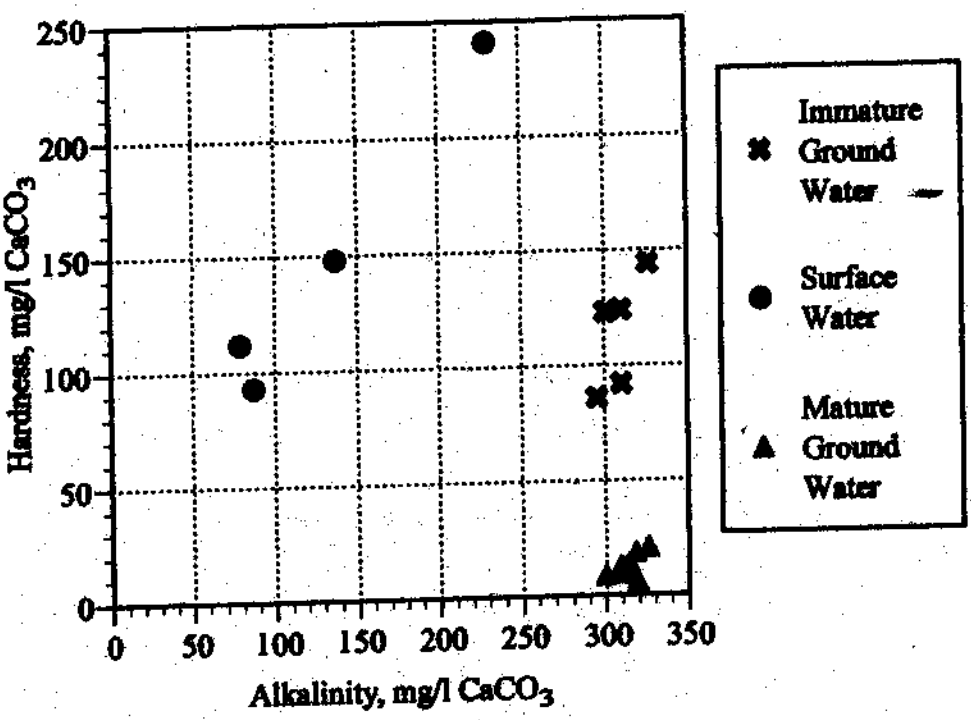

Figure B11. Hardness v. Alkalinity by water type. Surface water is relatively moderate to high in hardness and low to moderate in alkalinity. This reflects the initial solution of soil salts and carbonate minerals from soils by rainfall runoff. Immature ground water is moderate in hardness and high in alkalinity. The high alkalinity results from accelerated dissolution of carbonates caused by acids produced by oxidation of sulfides and other compounds. The moderate hardness arises from corresponding increases in Ca and Mg, but much of the increase is taken up by ion exchange with Na affixed to montmorilinite in shale beds. Alkalinity of the mature ground water is inherited from levels in the immature ground water. The low hardness of mature ground water reflects the nearly complete ion exchange of Ca for Na.

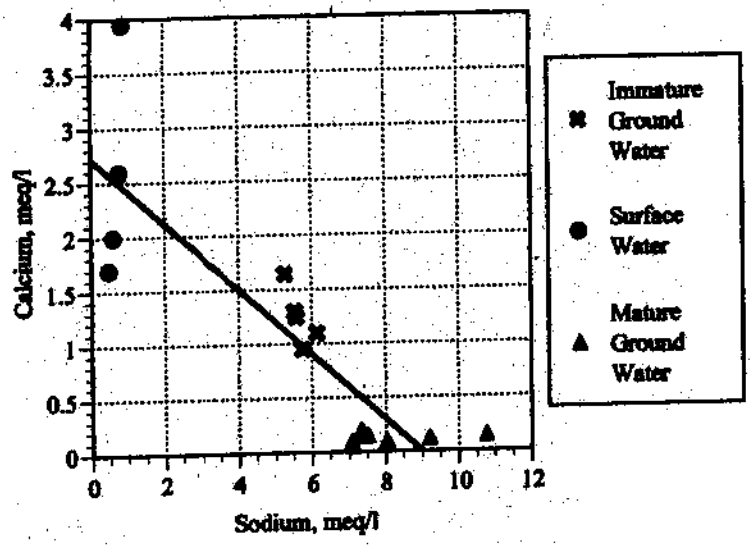

Figure B12. Calcium v. Sodium by cluster. Calcium and sodium demonstrate an inverse linear relationship consistent with an interpretation of ion exchange of calcium in solution with sodium affixed to montmorillinite in shale beds. Maximum sodium concentrations in meq/l exceed maximum calcium concentrations by a factor of 2 to 3. This results from solution of calcium by acids produced by oxidation reactions associated with immature ground waters that simultaneously exchanges with sodium in the shale beds. As the waters mature, the ion exchange reaction approaches completion.

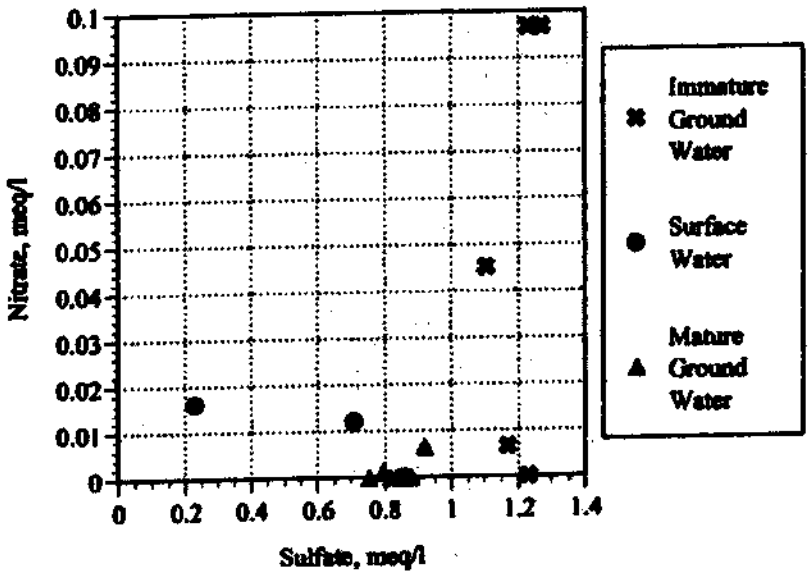

Figure B13. Relationship between nitrate and sulfate by cluster (N = 16). Sulfate exceeds nitrate by a factor of 10 or more in all samples. Immature ground water samples are consistently high in sulfate owing to oxidation of sulfides. Those samples exhibit the highest variability in nitrate suggesting that high levels of nitrate originate by oxidation where nitrogen bearing compounds happen to be present. Surface waters may exhibit higher levels of nitrate than mature ground water because of soil-biotic reactions and/or applications of nitrogen fertilizer in the watershed. Mature ground waters have lower levels of sulfate than immature waters because their lower oxidation-reduction potential causes reduction of some sulfate and precipitation as sulfide minerals.

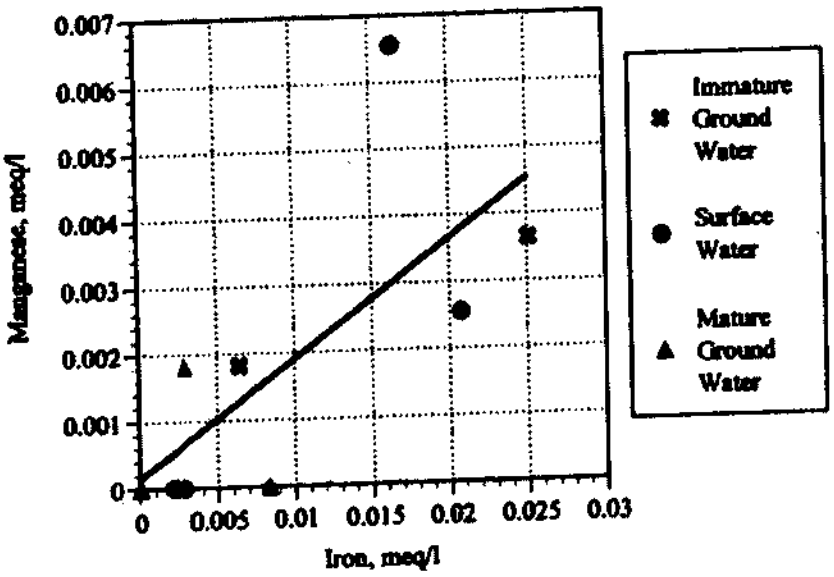

Figure B14. Relationship between manganese and iron by cluster (N = 10). Manganese and iron demonstrate a linear relationship (r = 0.73) suggesting the aqueous geochemistry is similar for both cations. Mature ground water samples tend to be low in both iron and manganese. Otherwise, there is little evidence for distinguishing the behaviors of iron and manganese by cluster type. The actual concentrations of iron and manganese tend to be low in all 10 samples. These cations are soluble only for limited ranges of pH and oxidation-reduction potential (ORP). If ORP is too low (e.g., in mature ground water), Fe and Mn precipitate as sulfides. If ORP is too high (e.g., in immature ground water and surface water), insoluble oxides and hydroxides of Fe and Mn form.

(a)

	Depth		Barium		Lead
Depth	1.00		–		–
TPH	–		–		–
Barium	–		1.00		0.58
Chromium	–		–		0.75
Lead	–		0.58		1.00

Units of measurement are µg/g

(b)

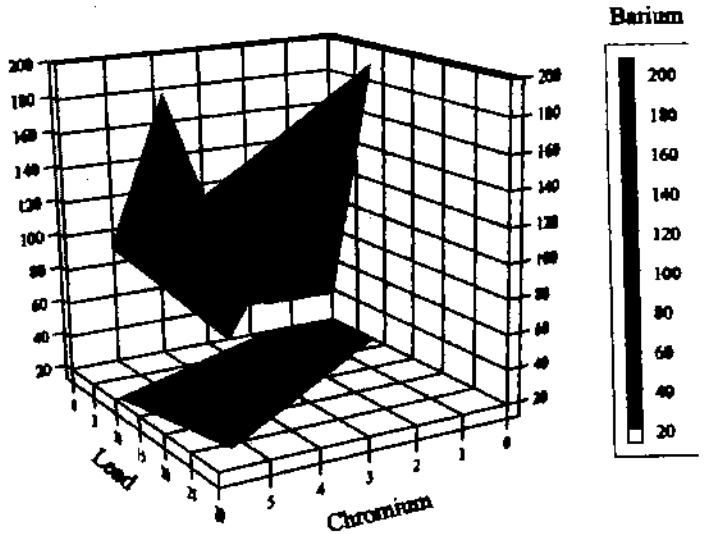

Figure B15. Relationships among constituents detected by soil quality tests (York, 1997). (a) Spearman correlations significant at $\alpha = 0.1$ (N = 9). Constituents are not significantly related to the depth at which samples were taken at the site. Some correlations judged insignificant here might be significant if there were more samples. There is enough information to suggest that total petroleum hydrocarbons (TPH), barium (Ba), chromium (Cr), and lead (Pb) are the primary contaminants at this site and that the contaminants are interrelated. (b) Relationship of Ba to Cr and Pb. The oblong overall shape of the surface as projected onto the Cr-Pb plane results from the moderately strong linear correlation between Cr and Pb. The complex shape of the surface in the Ba coordinate direction suggests little to no relation of Ba to either Cr of Pb. Note that the correlation between Ba and Pb, although significant, is the weakest in the data set. The Ba-Pb correlation may result from the common occurence of Pb in bentonite used for drilling mud, and the practice of adding barite to the mud to increase its weight.

Appendix D
Reservoir Operation Study

RESERVOIR OPERATION STUDY
OF
ELM FORK OF THE TRINITY DAM SITE NO. 19MP
MUENSTER WATER SUPPLY RESERVOIR

MARCH 31, 2000

Prepared for

Muenster Water District
Muenster, Texas

Prepared by

William H. Erion, P.E.
Civil Engineer
Burleson, Texas

RESERVOIR OPERATION STUDY
OF
ELM FORK OF THE TRINITY DAM SITE NO. 19MP
MUENSTER WATER SUPPLY RESERVOIR
FOR
MUENSTER WATER DISTRICT
CITY OF MUENSTER, TEXAS

By William H. Erion P.E.

Description of Project

The Muenster Water District and the Soil Conservation Service, now Natural Resources Conservation Service (NRCS), of the U. S. Department of Agriculture entered into an agreement in 1980 to construct a dam and reservoir to be used for municipal water supply, flood control and recreation. The proposed dam is located on Brushy Elm Creek approximately 1 mile west of the city of Muenster.

Reservoir Operation Study

The purpose of the reservoir operation study is to provide adequate evidence that sufficient water volume will be impounded in the reservoir to meet the planned purposes of municipal water supply and recreation. Water supply and meteorologic records were used to simulate the operation of the reservoir through a historical period. The procedure used is a month by month budget of storage in the reservoir where storage at the beginning of a month plus inflow and minus outflow during the month equals storage at the beginning of the next month. Inflow consists of water yield from the watershed and direct precipitation on the reservoir surface, plus in this case, the outflow from upstream floodwater retarding reservoirs. Outflow consists of releases to meet water supply demand, evaporation from the reservoir surface, seepage from the reservoir, and spills through the spillways. The Natural Resources Conservation Service's computer program RESOP was used to perform the storage budget computations.

Water Yield

Surface runoff from rainfall storm events is the primary source of water yield from the watershed, however any base flow in the channel at the reservoir will also contribute to the yield. The most direct method of determining the water yield would be to measure the flow at the proposed reservoir location over a period of years by means of a daily recording stream gage. This data is not available at this site, however water supply data from three U. S. Geological Survey (USGS) surface water gage stations on the Elm Fork of the Trinity River are available, and useful in this study. Site 19MP is located on Brushy Elm Creek, which joins Elm Fork of the Trinity about 6 miles Southeast of Muenster. The gage on Elm Fork of the Trinity near Sanger (08050500) has a record from 1949 through 1984. The actual location of this gaging station is now submerged in Lake Ray Roberts. This station has 381 square miles of contributing drainage area with Site 19MP in the upper reaches of this drainage area at 14.35 square miles. The gage on Elm Fork of the Trinity near Muenster (08050300) has a record from 1957 through 1973 water years and is located near FM373 road crossing Elm Fork south of Muenster. This station is located upstream of the confluence of Brushy Elm Creek and Elm Fork, so Site 19MP is not included in its drainage area of 46 square miles. The Elm Fork of the Trinity gage at

Gainsville (08050400) is currently in operation with records beginning in 1984. Site 19MP is in the upper reaches of its drainage area. The locations of these gaging stations are shown on the Elm Fork watershed map, Figure 1.

Runoff can also be determined from rainfall and soil and cover parameters. Rainfall records are available for a longer period of time than are the stream gage runoff records. Runoff estimates using monthly rainfall and 30 day runoff curve number were made using rainfall records at Muenster, Gainsville and Forestburg. This data was developed as runoff inches on the watershed. The stream gage data was also reduced to watershed inches. The runoff data developed using rainfall trends generally with the stream gage data. Data of some form, either runoff gage data or runoff developed from rainfall, are available spanning a historical period of nearly 60 years.

Under the assumption past climatological trends are reflections of future trends, the simulation of the reservoir's operation through the most critical period of the last 60 years should give a high degree of confidence of its operation through the most critical conditions in the future 50 to 100 years. To more clearly define critical (drought) periods, the total runoff for the preceding 12 months for each month was determined for each data set. The data is shown graphically in Figures 2 and 3 with the plotted value the total runoff for the 12 months prior. The period 1951 through 1956 is clearly the longest low runoff period and should be included in the reservoir operation study.

Stream gage data adjusted to the watershed and future conditions, when available, is preferable to data developed from rainfall, as the rainfall developed data only approximates the runoff processes. For this study the data from the gage near Sanger covers the critical design period, however it includes the 381 square mile drainage area of the Elm Fork. This is much larger than the approximately 15 square mile drainage area of site 19MP and includes areas likely having different runoff characteristics. The gage near Muenster does not cover the most critical time period, however the watershed area is more representative of the site 19MP watershed. The watershed for this gage is immediately to the south, but does not include the site 19MP drainage. Data for the period of time in which the records overlap are plotted in Figure 3a. On the average the runoff in watershed inches from the gage near Muenster (08050300) is 92% of that from the gage near Sanger (08050500).

Since the 1950's the Watershed has seen a portion of the cropland converted to pasture land and the installation of conservation measures. Both these factors tend to reduce the direct storm runoff but may actually result in an increase in total runoff as rainfall, initially retained on the surface, eventually shows up in the stream as base flow. Credit for increased runoff for future conditions will not be taken for this study as actual future conditions may not reflect this increase and it is not on the safe side.

As stated above it is believed the runoff at site 19MP is better represented by the runoff record of the USGS gage near Muenster (08050300) than the record of the gage near Sanger (08050500). The record for the gage near Muenster does not cover the critical drought period of 1951-1956 while the gage near Sanger includes 35 years of record including the critical drought period. A relationship which describes the runoff at the gage near Muenster as a function of the runoff at

the gage near Sanger is needed. Using the records of both gages for the 17 years of common data, correlation by linear regression resulted in such a relationship for monthly runoff, which has a relatively good coefficient of correlation of 0.92. The relationship predicts the runoff at the gage near Muenster given a value at the gage near Sanger. For low values at the Sanger gage this relationship tends to predict higher than expected values at the Muenster gage. For instance, at 100 cfs – days which equates to 0.01 watershed inches at the Sanger gage the predicted value at Muenster gage is 44cfs – days or 0.04 watershed inches. Also for no runoff at the Sanger Gage 0.025 watershed inches are predicted at the Muenster gage. While for the full range of data the linear regression equation is a good fit, it does not accurately represent the very low flow conditions which are important in this study, thus was not used. Another relationship is simply the ratio of average runoff in watershed inches at the gages. In this case, the runoff used as inflow to the reservoir is 92% of the monthly values for the USGS gage near Sanger (08050500) based on the relationship of this gage data and that from the gage near Muenster (08050300).

A case can be made that the total unit runoff from a watershed (ie. in watershed inches) decreases with decreasing watershed size. Ratios of unit runoff to the log of the watershed area have been used. With the ratio of 1.0 at the gage near Sanger with a drainage area of 381 square miles and 0.92 Near Muenster with a drainage area of 46 square miles, the ratio at site 19MP with 14.35 square miles is 0.88 and at the upstream floodwater retarding structures the ratio is 0.79. The reservoir operation study was run with these runoff values. These are also the most conservative of the values considered. The 25 year period from 1950 through 1974 was included in the study. This period contains a significant drought period plus good evaporation and rainfall data are available for this period.

A statistical frequency analysis of the runoff data from gage 08050500 corrected to the conditions at site 19MP was made. The Pearson Type III method was used with the analysis on the calendar year(s) runoff total. The results are tabulated in Table 1. The analysis indicates predicted drought values for the designated frequency of occurrence.

Table 1

Runoff values in inches

ITEM	1 YEAR	3 YEAR	6 YEAR
Lowest runoff for period in record	**0.54**	**3.22**	**9.29**
Lowest runoff used in RESOP study	**0.71**	**3.22**	**9.29**
1 percent chance of occurrence	**0.60**	**2.63**	**13.23**
2 percent chance of occurrence	**0.71**	**3.34**	**14.40**
10 percent chance of occurrence	**1.23**	**6.06**	**18.33**
Average	**4.69**	**13.99**	**28.50**

The selected 25 year study period contains an annual drought with a 2 percent (50 year) frequency, a three year drought exceeding a 2 percent frequency and a 6 year drought exceeding a 1 percent (100 year) frequency.

Evaporation

The Publication, Monthly Reservoir Evaporation Rates for Texas, 1940 through 1965, by John W. Kane, published by the Texas Water Development Board as Report 94 provides values for use in water supply and reservoir operation studies. Monthly values using all available pan evaporation data in Texas and adjacent states were developed for quadrangles of 1degree latitude by 1degree longitude for the entire state. The introduction to this publication indicates the 1940 through 1965 time period includes as series of both wet and dry years including an extended period of drawdown after 1950. It also states " the drawdown period, ... is generally the critical low flow period in Texas..." which supports similar statements on this subject from other sources. Data from the report was used in the study through the study year 1965. Data from the evaporation station at Denison Dam was used to study years beyond 1965.

The lake evaporation values tabulated in Report 94 are equalivant to those calculated from Class A pan evaporation using a pan coefficient of 0.78. At the Site 19MP location a pan coefficient of 0.70 is appropriate. Adjustment to the appropriate Pan Coefficient is included in the NRCS RESOP computer program. Since Denison Dam is located about 50 miles east evaporation at Site 19MP would be expected to be greater. The ratio of average annual lake evaporation at the Site 19MP location and Denison Dam, from map values included in Report 94, was used to "correct" Denison Dam data to the Site 19MP location.

Seepage

Estimate of seepage from the reservoir is based on the geologic conditions in the reservoir area. The geologic conditions at the dam and reservoir site have been evaluated and reported by NRCS (SCS) geologists Ray Cunningham in 1972, Roy Fields in 1974, and by Curtis Evans, David Petefish, and Peter Waldo in 2000 following the detailed site investigation performed in 1999 - 2000.

The flood plain area comprising the lowest portions of the reservoir are covered with clay and silty clay alluvial and residual soils. More plastic clays predominate near the surface, with the materials becoming more sandy and gravely at depth. The Goodland formation is located in the upper abutments and emergency spillway and consists of thin to medium bedded limestone. Permeability of 0.085 feet per day is representative of the Goodland Limestone. The limestone beds grade downward into the Walnut clays. About 13 to 17 feet of Walnut formation is noted at the site consisting of hardness 1 and 2 claystone and a few limestone layers. Permeability of the Walnut of about 0.0035 feet per day is representative. The Antlers Formation is located in the lower abutments and at depth beneath the reservoir. The upper portion of the Antlers is hardness 1 and 2 sandstone and claystone up to 43 feet thick in the abutments and 20 feet thick beneath the alluvial soil deposits in the floodplain. The Antlers is periodically exposed in the stream channels. Permeabilities of the upper Antlers ranged from 0.004 to 0.0065 feet per day. The Lower Antlers is about 16 feet thick and consists of fine grained sandstone with permeability of 0.02 feet per day.

A relatively simple seepage model for the reservoir was developed by Petefish, Waldo and Evans. This model assumes most of the water moves downward through the Antlers sandstone with lesser amounts moving laterally through the foundation materials. The water level beneath the site is at elevation 970 and with the water surface at the water supply pool level of 1022.9 results in a differential head of 53 feet. A seepage loss of 113,000 gallons per day was estimated with the reservoir level at elevation 1022.9. This is equivalent to 0.4 inches per month over the reservoir surface for computations in the reservoir operations study. With the water surface level at elevation 1012 a seepage loss of 51,000 gallons per day and 0.3 inches per month was estimated. Considering seepage is a small fraction of the estimated evaporation at the site and the computed volumes of seepage are considerably less than the probable error of estimate of the runoff yield to the reservoir, further refinement of the seepage estimate is not warranted.

Rainfall
National Weather Service (Weather Bureau) records for rainfall at Muenster for the study period were used in the reservoir operation study.

Demand
The Muenster Water District is authorized to use up to 500 acre feet per year from the reservoir for municipal use.

Computations
Reservoir operation budget computations were performed with the RESOP computer program. A month by month budget for the upstream floodwater retarding structures, 6E and 6A1 was performed for the study period to obtain outflow from these dams which is inflow to site 19MP. Runoff to these floodwater retarding structures of 79% of the runoff from the USGS stream gage 08050500, as stated above, was used. Evaporation and rainfall as indicated above for site 19MP were used. Seepage was not considered for these dams as it was assumed any seepage would eventually enter site 19MP. There is no demand from these dams to consider in the budget. The month by month budget computations for Site 19MP consider runoff at 88% of the value from stream gage 08050500 plus the outflow from the upstream floodwater retarding structures. Demand of 500 acre feet per year proportioned each month based on historic water use by Muenster City was used for each year. The characteristics of upstream reservoirs were combined into a composite reservoir and the computer program run with two sites in series. Reservoir storage at the end of each month, deficit if any and spill through spillways if any are output.

Results
The reservoir storage at the end of each month was tabulated and plotted in Figure 4. The full water supply pool is 4510 acre feet. The storage ranged to a low of 1654 acre feet in September 1956 near the end of the 1951 through 1956 drought. A bar chart of annual runoff is plotted at the bottom of Figure 4 for reference. The maximum permitted drawdown is to 945 acre feet storage. Total inflow to the reservoir, evaporation, seepage and spillway discharge is summarized by year in table 2. Demand each year is 500 acre feet.

Table 2

YEAR	INFLOW	EVAPORATION	SEEPAGE	SPILL
	Acre feet	Acre feet	Acre feet	Acre feet
1950	7862	1494	100	6163
1951	1765	1498	94	35
1952	989	1548	83	0
1953	1143	1157	63	0
1954	1814	1284	61	0
1955	1914	1199	63	0
1956	1601	1283	57	0
1957	12967	1328	85	8488
1958	5943	1381	98	4664
1959	3010	1303	91	417
1960	2514	1368	97	1214
1961	1993	1084	95	223
1962	5963	1250	96	3531
1963	1333	1280	96	464
1964	5023	1267	86	2162
1964	3570	1145	100	1920
1966	6567	1338	100	4600
1967	2281	1320	95	598
1968	6380	1312	101	4467
1969	7559	1350	101	5608
1970	5767	1332	100	3905
1971	4925	1443	99	2811
1972	1833	1410	98	173
1973	7118	1337	100	4895
1974	7013	1467	100	5027

Several significant points which can be made from the results are:

1. The reservoir met demands through a critical 6 year drought, considered to be the worst in at least the last 60 years, with a reserve remaining.
2. The municipal water demand can be met through droughts of one to two years duration with only a nominal reduction in reservoir storage when the reservoir is near full at the beginning of the drought period. Years 1973 and 1963-64 are examples of this.
3. Evaporation is a significant portion of the demand on the reservoir amounting to 2 to 3 times the water supply demand. In a few instances evaporation exceeded the total inflow for the year.
4. The reservoir operation study was started assuming the reservoir full January 1, 1950. There was sufficient runoff during 1950 to have filled the reservoir during the course of that year in any case. There are, however, several years in which the reservoir would not have filled had it been put into service that year. The District should expect it will take two to three years to fill the reservoir. Had the reservoir been put into service in 1951 it would not have filled until 1957.

Sultabillty for Recreation

Large fluctuations in lake ievel are generally detrimental to most recreational activities. Fluctuation of the lake ievei is however inevitabie for a reiatively small reservoir used also for municipal water supply. From the reservoir operation study output, the month by month lake level elevation was determined. The annual fluctuation of the lake ievel is piotted in figure 5. For 15 of the 25 years studied the lake level dropped no more than 2.5 feet below the normal pool level during the year. During 1973 the reservoir remained full the entire year. During four years the reservoir level dropped up to 6 feet below normal pool. A lake level more than six feet below normal pool was experienced six years, all during, and the recovery from, the 1950's drought. For several years during the drought the lake ievei remained below normal pooi level. All reservoirs will likely experience lowered lake levels during a drought such as that in the 1950's and although detracting from recreation activities should be considered normal and expected. For the remainder of the study period the fluctuations in the lake level should not be considered excessive or unusual for a small lake, especially considering the demand of providing municipal water and evaporation from the lake surface. During 60% of the years the level varies less than 2.5 feet. The lake is considered suitable for recreation activities proposed in the Supplemental Watershed Plan No. II, dated October, 1979.

Concluslons

The conclusion of this study based on computations, data and assumptions described above is that sufficient water will inflow and be impounded in the reservoir of Site 19MP (Muenster Lake) to dependably provide up to 500 acre feet of water for municipal use annually.

Report prepared by:

_____

William H. Erion, P.E.

_____ Date

Elm Fork of the Trinity
SITE 19MP

RESERVOIR OPERATION STUDY

FIGURES

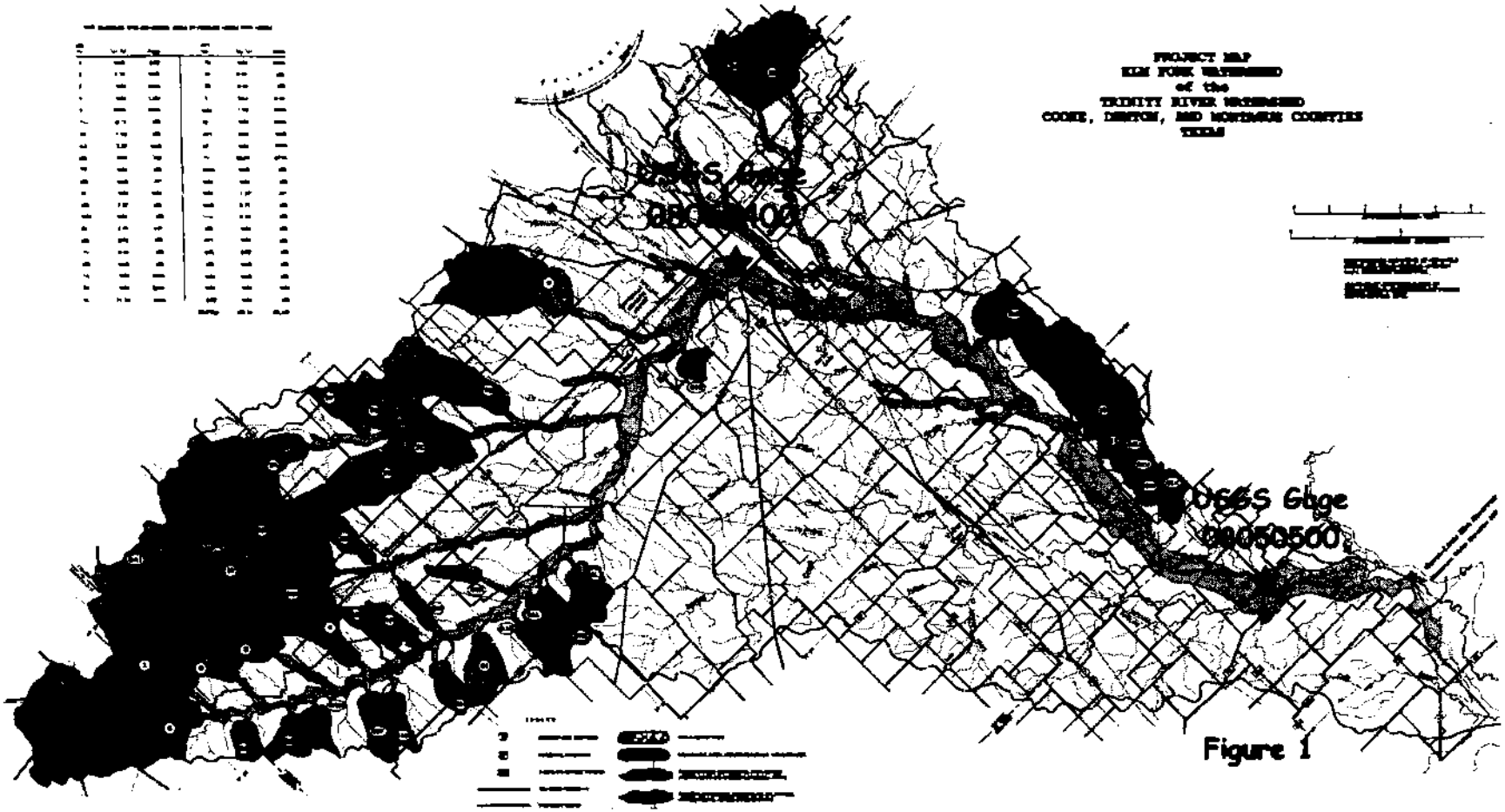
PROJECT MAP
KIM FORK WATERSHED
of the
TRINITY RIVER WATERSHED
COOKE, DENTON, AND MONTAGUE COUNTIES
TEXAS
USGS Gage
08050500

Figure 1

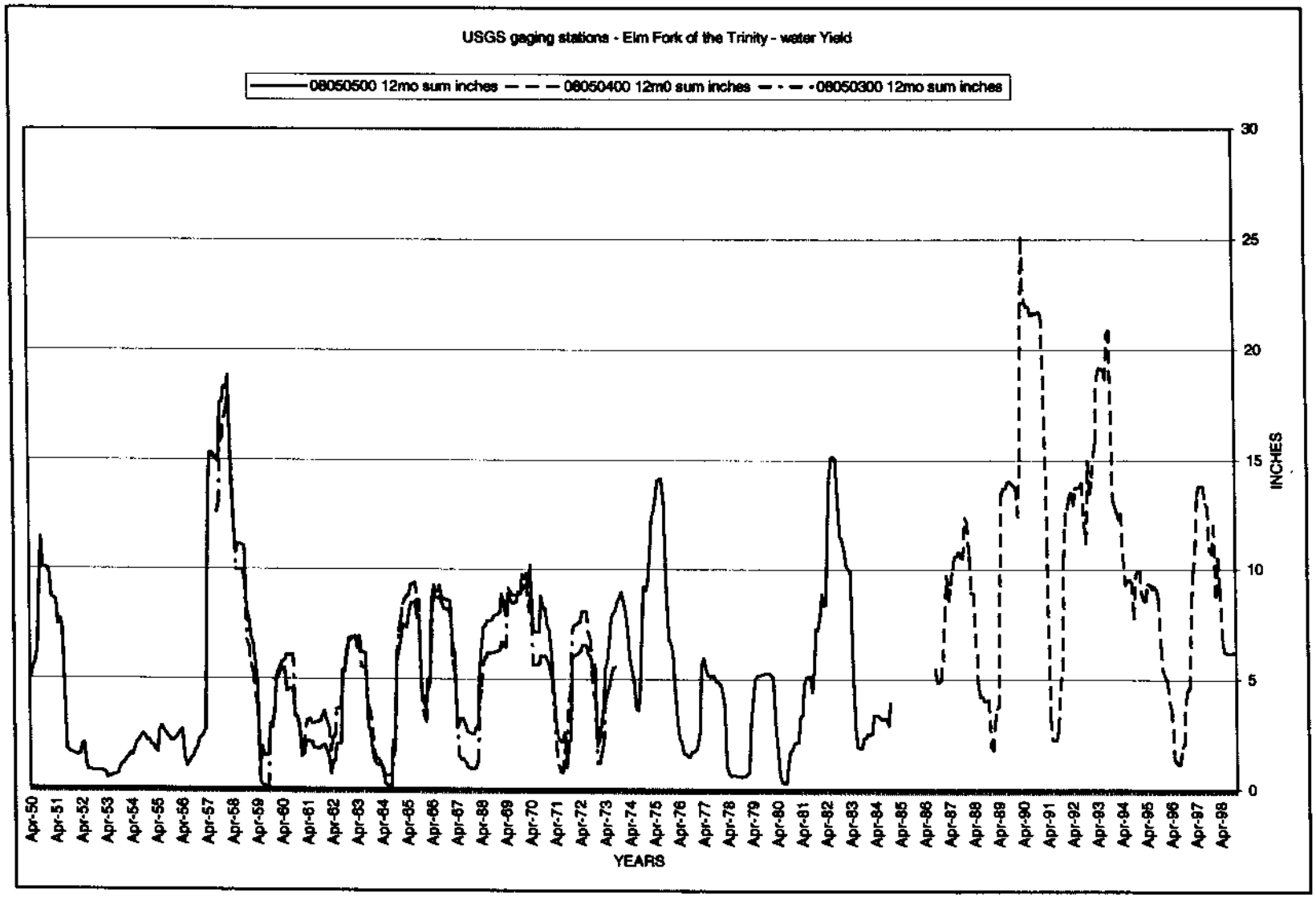
USGS gaging stations - Elm Fork of the Trinity - water Yield
08050500 12mo sum inches
08050400 12m0 sum inches
08050300 12mo sum inches
30
25
20
15
10
5
0
INCHES
Apr-50
Apr-51
Apr-52
Apr-53
Apr-54
Apr-55
Apr-56
Apr-57
Apr-58
Apr-59
Apr-60
Apr-61
Apr-62
Apr-63
Apr-64
Apr-65
Apr-66
Apr-67
Apr-68
Apr-69
Apr-70
Apr-71
Apr-72
Apr-73
Apr-74
Apr-75
Apr-76
Apr-77
Apr-78
Apr-79
Apr-80
Apr-81
Apr-82
Apr-83
Apr-84
Apr-85
Apr-86
Apr-87
Apr-88
Apr-89
Apr-90
Apr-91
Apr-92
Apr-93
Apr-94
Apr-95
Apr-96
Apr-97
Apr-98
YEARS

Figure 2

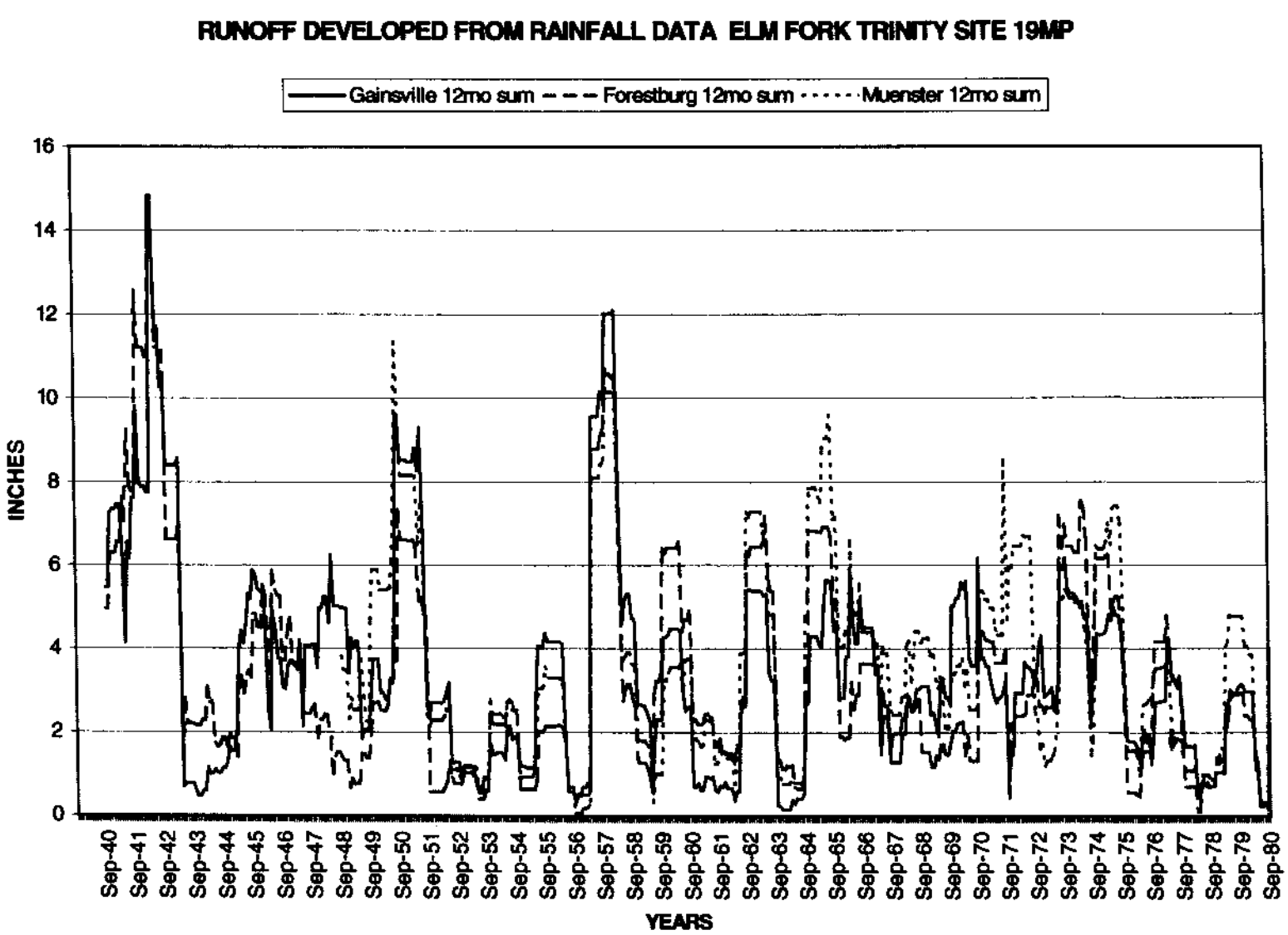
RUNOFF DEVELOPED FROM RAINFALL DATA ELM FORK TRINITY SITE 19MP
Gainsville 12mo sum
Forestburg 12mo sum
Muenster 12mo sum
INCHES
0
2
4
6
8
10
12
14
16
Sep-40
Sep-41
Sep-42
Sep-43
Sep-44
Sep-45
Sep-46
Sep-47
Sep-48
Sep-49
Sep-50
Sep-51
Sep-52
Sep-53
Sep-54
Sep-55
Sep-56
Sep-57
Sep-58
Sep-59
Sep-60
Sep-61
Sep-62
Sep-63
Sep-64
Sep-65
Sep-66
Sep-67
Sep-68
Sep-69
Sep-70
Sep-71
Sep-72
Sep-73
Sep-74
Sep-75
Sep-76
Sep-77
Sep-78
Sep-79
Sep-80
YEARS

Figure 3

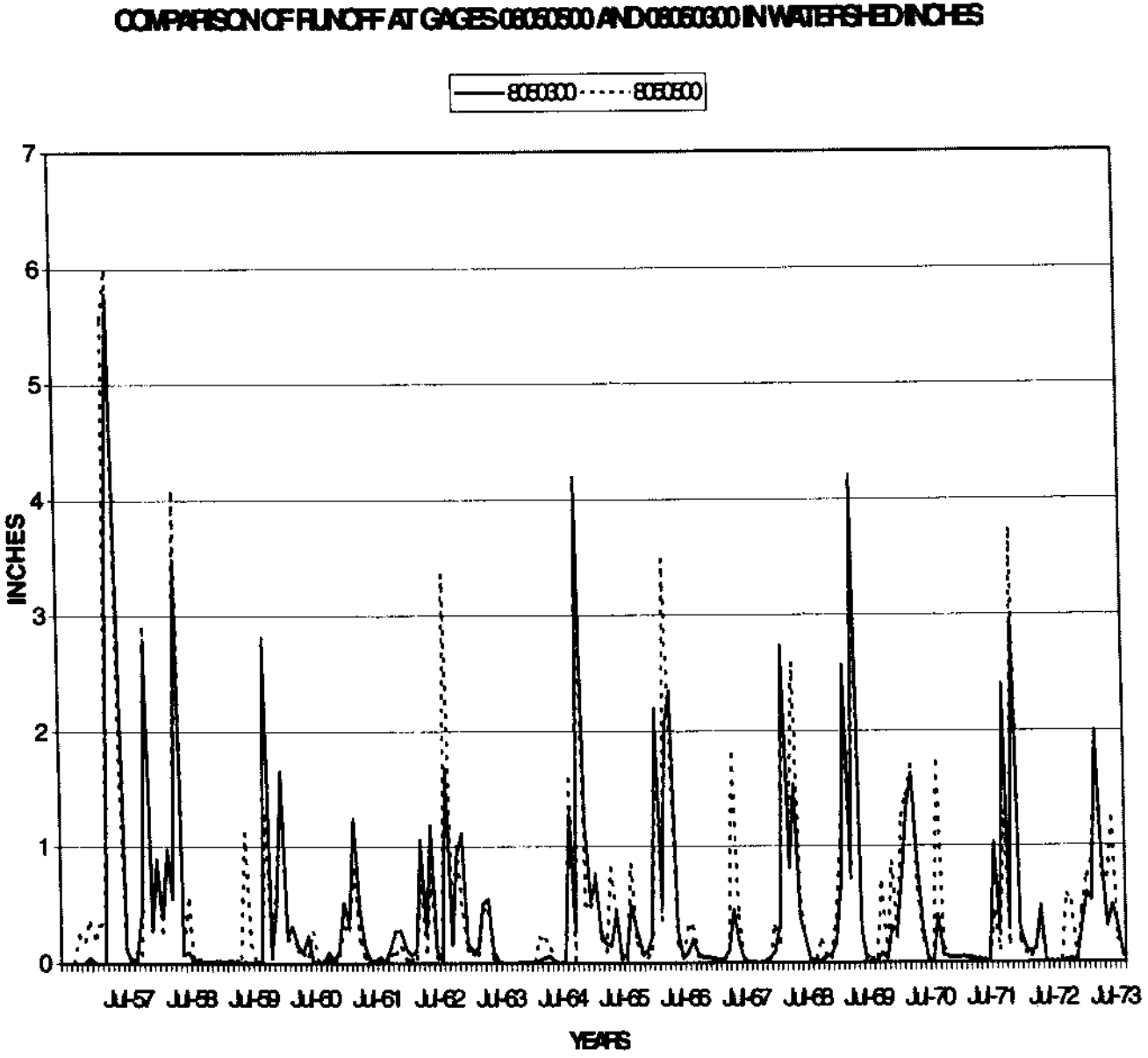
COMPARISON OF RUNOFF AT GAGES 0805500 AND 0805330 IN WATERSHED INCHES
805330
805500
INCHES
0
1
2
3
4
5
6
7
JU-57
JU-58
JU-59
JU-60
JU-61
JU-62
JU-63
JU-64
JU-65
JU-66
JU-67
JU-68
JU-69
JU-70
JU-71
JU-72
JU-73
YEARS

Figure 3A

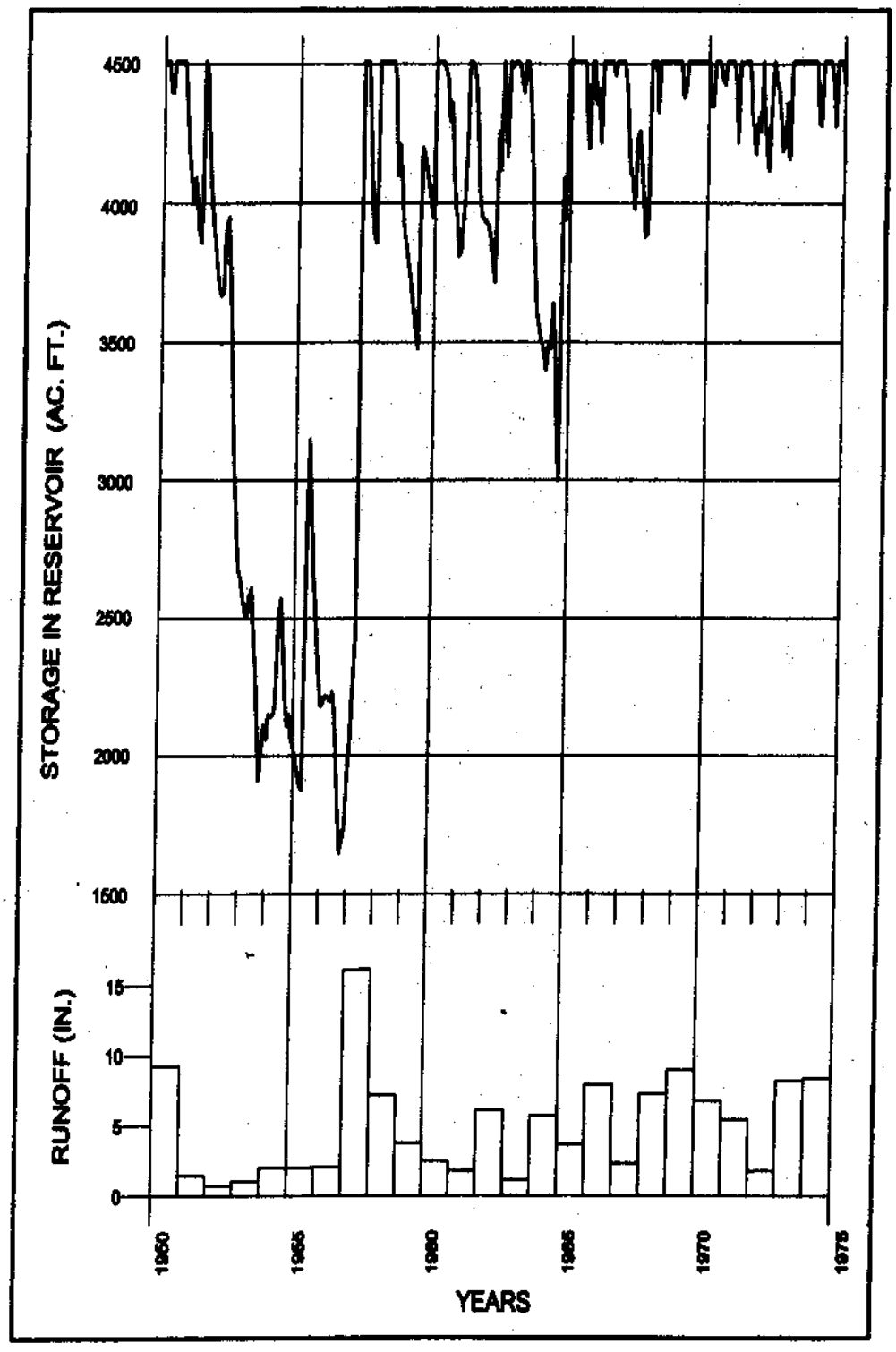

Figure 4 ELM FORK 19MP RESERVOIR OPERATION STUDY RESULTS

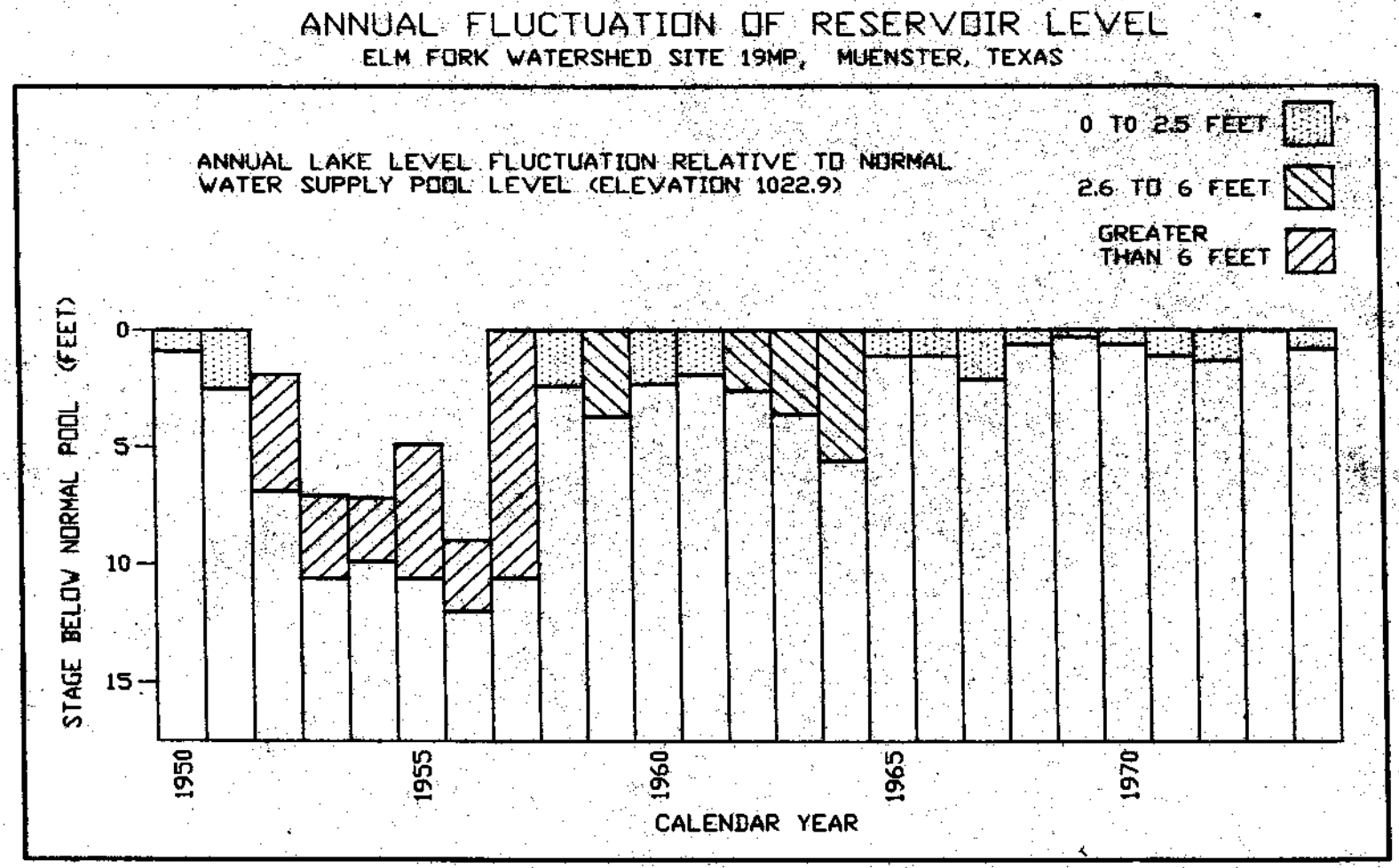
ANNUAL FLUCTUATION OF RESERVOIR LEVEL
ELM FORK WATERSHED SITE 19MP, MUENSTER, TEXAS
ANNUAL LAKE LEVEL FLUCTUATION RELATIVE TO NORMAL
WATER SUPPLY POOL LEVEL (ELEVATION 1022.9)
0 TO 2.5 FEET
2.6 TO 6 FEET
GREATER THAN 6 FEET
STAGE BELOW NORMAL POOL (FEET)
0
5
10
15
1950
1955
1960
1965
1970
CALENDAR YEAR

Figure 5

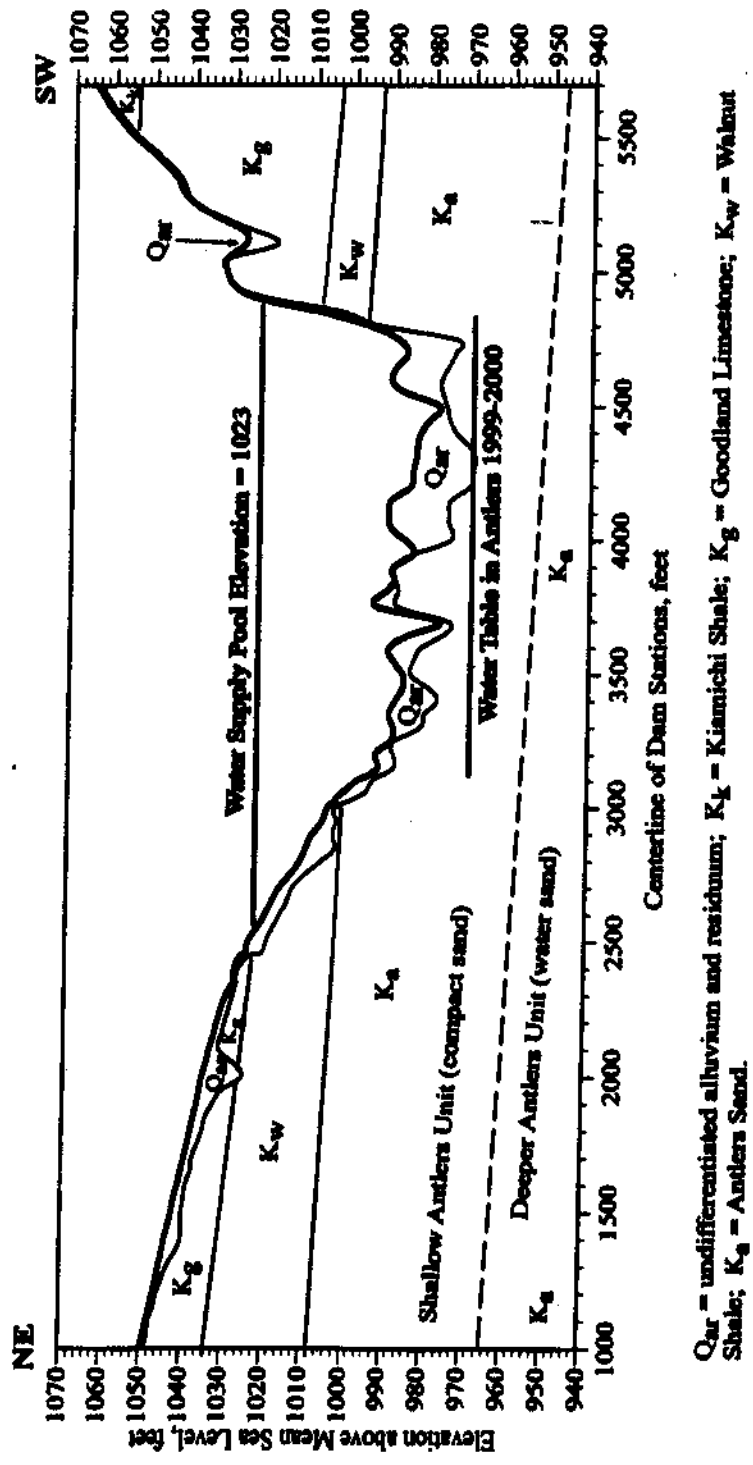

Figure 6 Geologic Profile along centerline of proposed dam site MPS 19, near Muenster, Texas (Waldo, 2000)

APPENDIX B
Project Map

PROJECT MAP
ELM FORK WATERSHED
of the
TRINITY RIVER WATERSHED
COOKE, DENTON, AND MONTAGUE COUNTIES
TEXAS

SITE NUMBERS AND DRAINAGE AREA IN SQUARE MILES AND ACRES

Site No.	Sq. Mi.	Acres	Site No.	Sq. Mi.	Acres
1	4.06	2598	7D	3.38	2163
2	3.34	2138	7F	0.89	570
3	3.84	2458	7G	0.90	576
4	1.88	1203	9	5.54	3546
5	12.50	8000	11B	1.99	1274
5A	0.77	493	12	3.34	2138
5B	1.20	768	16B	2.09	1338
6A1	2.30	1472	18	6.06	3878
6B	1.19	762	19	10.49	6714
6E	1.05	672	61CC	0.49	314
6H	1.12	717	61D	0.56	358
6I	1.83	1171	61F	1.22	781
6J2	1.22	781	61G	0.75	480
6K2	0.91	582	61K	0.58	371
6L	1.47	941	61L	0.72	461
6M	0.78	499	61T	0.40	256
6N	0.73	467	61U	0.69	442
6O	0.77	493	61V	0.58	371
7A	6.92	4429	61W	0.52	333
7B	3.46	2214	61X	1.00	640
7C	11.10	7104	61Q	0.53	339
			TOTALS	105.16	67,305

APPROXIMATE SCALE - MILES

APPROXIMATE SCALE - KILOMETERS

BASE COMPILED FROM USGS QUADRANGLE SHEETS AND TEXAS GENERAL HIGHWAY MAPS, POLYCONIC PROJECTION.

100,000 FOOT GRID TICKS BASED ON TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE.

LEGEND

- INTERSTATE HIGHWAY
- FEDERAL HIGHWAY
- FARM TO MARKET ROAD
- DIVIDED HIGHWAY
- PRIMARY ROAD
- AREA BENEFITED
- DRAINAGE AREA CONTROLLED BY STRUCTURES
- FLOODWATER RETARDING STRUCTURE (COMPLETED OR UNDER CONSTRUCTION)
- MULTIPLE PURPOSE STRUCTURE (PLANNED) (M-MUNICIPAL AND R-RECREATION)