From: "Michael Ryan" <michael.ryan@flower-mound.com>
To: <bill.roberts@twdb.state.tx.us>
Date: 10/5/2006 4:52:28 PM

Mr. Roberts,

Please accept the attached documents as the Town of Flower Mound's written comments regarding the Water for Texas - 2007 draft state water plan. I have also mailed signed hard copies to your office. You should receive those tomorrow. Please let me know if you have any questions regarding the information we have provided or our position relating to the draft plan.

Thank You,

Michael Ryan

Director of Community Affairs

Town of Flower Mound

972.874.6078

CC: "Michael Ryan" michael.ryan@flower-mound.com

October 5, 2006

Bill Roberts
Texas Water Development Board
P.O. Box 13231
Austin, TX 78711-3231

Texas Water Development Board:

On behalf of the residents and the Town Council of the Town of Flower Mound, Texas, please accept this correspondence as written comments regarding the inclusion of the Upper Trinity Regional Water District's proposed Lake Ralph Hall in the State Water Plan.

The Town of Flower Mound is located in southwest Denton County, in the service area for the Upper Trinity Regional Water District. We are the District's largest member and its largest customer. In Flower Mound, we support the concept of regional and state water planning and fully understand that additional water supplies will be needed to meet the demands of projected population growth in Texas.

We are however opposed to the Texas Water Development Board's inclusion of Lake Ralph Hall in the State Water Plan for a variety of reasons including sedimentation issues at the proposed lake site, outdated and underestimated cost projections, and the Upper Trinity Regional Water District's unstable financial condition.

A recent engineering report has indicated that the sedimentation rates for the proposed Lake Ralph Hall site are disproportionately high. Excessive sedimentation can drastically reduce the productive life of a lake, create additional environmental concerns, significantly increase the financial costs associated with the operation and maintenance of the reservoir, and potentially force the funding of costly mitigation measures in the future.

In addition to the sedimentation concerns associated with Lake Ralph Hall, we ask that you also consider the total cost of the reservoir and the understated and outdated cost projections associated with the project. The District estimates that the reservoir will cost $209 million, but an independent engineering report has projected that Lake Ralph Hall will cost more than $260 million. These reports have also indicated that the Upper Trinity's roadway, bridge, and mitigation projections are extremely low. Additionally, this report was produced prior to Hurricanes Katrina and Rita, which resulted in at least a 20% increase in construction costs.

To further add to the uncertainties surrounding the cost projections, when the Upper Trinity Regional Water District and Region C compare the projected per unit cost of water from Lake

Ralph Hall to that of other potential water supplies for our community they include reuse estimates in the projection for Lake Ralph Hall but not the other projects. This deceptive practice produces an artificially low per unit rate for Lake Ralph Hall making it appear to be a more cost effective water supply than other options.
The Upper Trinity Regional Water District's financial situation must also be taken into account prior to the Texas Water Development Board participating in this project. The District has been operating at a financial loss for the past four years and currently has one of the highest debt loads of any comparable organization.

If Lake Ralph Hall is approved, it will elevate the Upper Trinity's combined debt load to an excess of $1.15 billion, an unacceptable level of financial burden to place on the District's members. In addition, the District currently has an outstanding loan with the Texas Water Development Board for more than $55 million, which has already amassed $16 million in unpaid interest, and has yet to even begin paying that debt back.

According to Upper Trinity Regional Water District's most recent Comprehensive Annual Financial Report (CAFR), "Net Assets, Invested in capital assets – net of related debt" is a negative $15.6 million. The UTRWD is the only regional water supplier in Region C that this amount is negative on the CAFR. Considering the District's unusual funding practices and excessive debt load, Lake Ralph Hall appears to be a risky project for the board to fund or participate in.

In closing, we ask that the Texas Water Development Board give serious consideration to the issues and concerns surrounding the proposed Lake Ralph Hall prior to funding it or supporting and approving its inclusion in the State Water Plan. Due to the potential issues and risks surrounding the lake, we would like to request that prior to participating in and funding this project, the TWDB:

1) Require the Upper Trinity Regional Water District to provide a detailed independent study regarding the area's sedimentation and a mitigation plan including cost projections should the sedimentation prove to be an issue during the lake's productive life span.

2) Require the Upper Trinity to provide updated estimates for the total cost of Lake Ralph Hall as well as a cost benefit analysis without considering reuse to provide an apples-to-apples comparison of the cost of water from LRH to that of alternative water supply sources for our region.

3) Require that the Upper Trinity Regional Water District undergo an independent management and fiscal review to provide an unbiased assessment of the District's business practices and financial condition.

There has been no demonstrated need that establishes urgency in building this new reservoir on the timeline proposed by the Upper Trinity Regional Water District. Alternate water supply sources exist that can provide water to our region at significantly lower financial and environmental costs, therefore they should be prioritized over Lake Ralph Hall in the State Water Plan.

Thank you for your time and deliberation of this considerable project. Please contact me at 972.874.6000 if you have any questions regarding our position on, or the issues surrounding, the proposed Lake Ralph Hall.

Thank you,

Mayor Jody Smith
Town of Flower Mound

Town of Flower Mound

Lake Ralph Hall
Sedimentation Potential Study
Phase 2 - DRAFT

July 2006

Prepared for

The Town of Flower Mound

by

KBR

Kellogg Brown & Root

and

HT

Hydrau-Tech, Inc.

July 2006

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EXECUTIVE SUMMARY

The Town of Flower Mound, a major customer of the Upper Trinity Regional Water District (UTRWD), has secured the services of KBR and Hydrau-Tech Inc. to complete a sedimentation potential study in the Lake Ralph Hall watershed on the North Sulphur River. The Upper Trinity Regional Water District (UTRWD) proposes to construct a 160,000 acre-ft reservoir named Lake Ralph Hall in Fannin County near Ladonia, Texas. The on-channel reservoir will be near the headwaters of the North Sulphur River, which flows east through Texas, joining the South Sulphur River in Lamar County to form the Sulphur River, which then flows into Arkansas to its confluence with the Red River. The UTRWD proposes to use this reservoir for water supply to customer cities near the Dallas-Fort Worth Metroplex. The reservoir firm yield is approximately 32,940 acre-feet/year but annual withdrawals can be as much as 45,000 acre-ft to the Trinity River basin for municipal, industrial, and agricultural uses.

The possibility of sediment accumulation and loss of usable reservoir capacity is one of the primary areas of concern for all reservoirs. In general, reservoirs are designed to have a service life of 100 years or more. Although all reservoirs will experience sedimentation as rainfall runoff carries watershed soils into the slow-moving lake flow, unforeseen conditions or factors that are not accounted for in their design cause some reservoirs to fill with sediment much faster, thereby increasing their lifecycle cost and rendering them prematurely useless.

This sedimentation potential study is a quantitative analysis that utilizes both the hydrology and sediment transport in the Lake Ralph Hall basin to identify the type and magnitude of sedimentation problems. The result of this study is an estimate of the service life of the reservoir if sedimentation is left unchecked.

Hydrology can be generally defined as the study of water quantity, both volumetric and rate of flow. This study first calculates the amount of flow reaching the Lake Ralph Hall dam under various rainfall events, such as the 2-, 10-, and 100-year probability events. The daily flow into Lake Ralph Hall is next calculated using gauge data from a USGS streamflow gauge near Cooper, Texas. These average daily discharges (rates of flow) are needed over an extended period of time at Lake Ralph Hall in order to estimate sediment inflow into the reservoir and thereby estimate its service life. An analysis of flow records at the nearest flow gauging station and an independent hydrologic model of the watershed are used to create this daily discharge record.

Sediment transport can generally be defined as the study of the processes that erode and deposit the earth's surface. In this study, sediment transport calculations are applied to determine the probable volume of sediment that will be transported from the Lake Ralph Hall watershed to the North Sulphur River at the dam site. To calculate this sediment transport rate, this study determines the sediment properties such as type and size distribution, and the strength of flows that erode and carry these sediments. A series of sediment samples were collected in the Lake Ralph Hall watershed to define what type of sediment will be transported to the lake. Then a series of models were run to determine the transport capability of those flows and to calculate volumes of sediment transported during a "typical" year of average flow conditions.

HYDROLOGY

The purpose of hydrologic modeling for this sedimentation potential study is to compute average daily discharges over an extended period of time at Lake Ralph Hall dam in order to estimate sediment inflow into the reservoir and thereby estimate its service life. This purpose is accomplished using two methods, which are compared to verify results. The first method uses statistical analysis of an existing flow gauging station operated by the USGS to transform measured flow values from one location to flow values at the Lake Ralph Hall dam site. The second method is to use the U.S. Army Corps of Engineers HEC-HMS model to calculate flow rates at numerous recurrence intervals independent of the gauge records.

Analysis of the period-of-record (1949-2004) for the USGS gauge near Cooper, Texas reveals that in general terms, floods on the North Sulphur River are flashy in nature. The duration of large events is typically 2 to 3 days; flows rise from almost zero to 25,000-40,000 cfs within a day and then recede over a period of 2 days. On the average, the duration of flows with magnitudes up to 80 percent of the peak discharge is 1 day. In other words, the bulk of the flow occurs in a one day window. The flashy character of flows on the North Sulphur River is demonstrated by the fact that approximately 86 percent of the time flows are less than 100 cfs (with numerous no-flow days) and 96 percent of the time flows are less than 1,000 cfs. On the average, discharges in excess of 2,000 cfs occur approximately 6 days per year.

The HEC-HMS modeling results are compared to the statistical analysis (using Log-Pearson Type III and Gumbel analyses) to calibrate results and to verify the appropriateness of using the USGS regional regression equations to transform the USGS gauge flows to the Lake Ralph Hall dam site. Computed runoff hydrographs at Lake Ralph Hall using HEC-HMS show very good agreement with the area-transformed gauge data and the statistical analysis.

The objective of hydrologic modeling is to provide a means for transforming measured flows at the gauge near Cooper to flows at the Lake Ralph Hall dam site for sediment transport calculations. Since instantaneous peak flows are of short duration and the associated sediment transport is not significant, the time series used in sediment computations are the area-transformed average daily flows.

Volumetric Sediment Transport

The North Sulphur River is deeply entrenched in the Tinn Clay formation. According to the NRCS Soil Survey for Fannin County, this soil formation is a very deep, nearly level clay soil found on broad floodplains along streams. The watershed surrounding the channel is composed of a variety of soil types including the Heiden-Ferris Complex and Ferris Clays; both have a severe hazard of water erosion. Other soils surrounding the North Sulphur River have a moderate or slight risk of water erosion but a significant portion of the surrounding soils carry the NRCS survey's moderate to severe rating.

Soils in the Fannin County North Sulphur River watershed are erosive and deep, and will be a long term source of sediment supply to the channel. Landuse is primarily agricultural, and natural vegetation consists of grassland and woodland. Urban areas are very small and sparsely populated. There is no indication that changes in land use in the watershed are imminent and soil supply to the channel from the watershed should remain at existing levels.

In May of 2006 additional sediment data was collected from the upper reaches of the North Sulphur River from the bed and banks of the main-stem and the tributaries to supplement 2005 sample collection. The purpose of the 2005 sampling was to identify the variety of sediment transport mechanisms and potential in the river. The purpose of the 2006 sampling was to identify typical sediment characteristics. In 2005, data was collected at gravel bars and other coarse sediment deposits while in 2006 samples were taken at bed and bank locations that better represent typical conditions. This analysis relies on the 2006 sediment sampling results because they are representative of sediment transport parameters typical in the watershed.

In general terms, 60 to 70 percent of channel sediments are composed of silts (30 to 40 percent) and clays (30 percent). The remaining coarser sediments are sands and gravels. The mean diameter of the coarser sediments is 1 mm (sand). In some study areas, all loose fine material has been washed away and coarse material remains in larger percentage than in other areas; the gravel bar near the FM 38 bridge is an example of this situation. The sediment size analysis shows that sediment supply to the North Sulfur River is mostly fine, easily erodible material; only 10 to 15 percent of the sediment samples contain gravel size fractions. Soils in southeast Fannin County are clay-rich, derived mostly from shale and chalk bedrocks. The channel has eroded to bedrock in many areas. Once exposed, this material is subject to wetting and drying forces that quickly break the formation into fine materials (silts and clays) that are easily eroded away. This broken, eroded material was observed in every study area.

Cross-sectional geometry and longitudinal geometry are both required physical parameters in a hydraulic analysis. To define these parameters, the KBR team surveyed the North Sulphur River and its tributaries in 2005 and 2006. These surveys are supplemented with TxDOT's measurements at the SH 34 and FM 38 bridge sites and by USGS topographic mapping from 1964. Channel bottom widths vary between 50 ft and 200 ft; depths range between 15 ft and 30 ft; the channel bottom slopes range from 0.001 at the downstream boundary to 0.005 at the upstream end of the river. Cross section density is higher in the upper reaches of the North Sulphur River above the Lake Ralph Hall dam site where sediment computations are carried out.

Construction of Lake Ralph Hall will alter sediment transport from the main reach of the North Sulphur River by inundating much of the main reach. However, the tributaries that deliver water and sediment to the main stem will continue to produce sediment inflow. It was determined that the most appropriate method of calculating sediment supply rates is to identify a reach in a semi-equilibrium condition. A reach in this condition is neither aggrading nor eroding and is therefore capable of transporting all sediment supplied. In other words, all of the sediment entering the reach is transported through and the channel is not eroding, an indication that the transport capacity equals the supply. For example, if the reach were capable of transporting 400 units of sediment and it received 500 units, it would aggrade by 100 units; if the reach received 300 units, it would erode to make up the 100 unit deficit. Therefore, if the reach is neither aggrading nor eroding, the supply must equal the capacity of 400 units. The transport capacity of this semi-equilibrium reach is equal to the sediment supply. For this analysis, a semi-equilibrium reach is identified upstream of Allen Creek on the North Sulphur River using results from the December 2005 report "Lake Ralph Hall Sedimentation Potential Study" by KBR and Hydrau-Tech, Inc. The transport capacity of this reach is calculated using two methods.

The primary source of sediment supply to Lake Ralph Hall will be from the tributaries (highly destabilized due to the channelization of the main stem), watershed, and river banks. Although the lake will inundate some of these supplies when full, it will inundate only a portion of the supply zones and it will not stay full—as the reservoir level fluctuates it will initiate erosion from zones destabilized by wetting and drying. The average bottom width, top width, and depth for the surveyed tributaries of the Lake Ralph Hall watershed are 55 ft, 100 ft, and 17 ft, respectively. These tributary channel characteristics closely match the upper North Sulphur River characteristics near BR 590. The average channel slopes along tributaries vary between 0.005 and 0.003. These slopes also closely match North Sulphur River bottom slopes along the upper reaches. Therefore, the hydraulic conditions encountered in the main stem upstream of the Allen Creek confluence are representative of the major tributary channels. Sediment computations using hydraulic parameters from the upper North Sulphur River are therefore also representative of the various sub-basin sediment production rates.

The sediment transport equation used in this analysis is chosen based on experience and applicability of the individual equations to the conditions in the Lake Ralph Hall watershed. The range of depths in the North Sulphur River classifies it as a medium size river. On average, flows are 5 to 10 feet deep. Alluvial sediment fractions that are present in soils forming the river bed and banks are predominantly fine sand and silt. Some gravel fractions are also present among the alluvial material. For fine sands and silts, Yang's (1973) and Yang, Molinas, and Wu's (1996) equations are the most applicable sediment transport equations (using standards given in Yang and Molinas, 1982). For the coarser gravel fractions, Yang's (1984) gravel equation is the most appropriate transport equation. These equations are used to compute sediment transport in the North Sulphur River.

The service life computations in the following tables are based on the primary assumption that all sediment sizes transported to the reservoir are trapped permanently by the reservoir. This assumption recognizes that the reservoir service life can be extended by sediment control measures such as grade control structures, sediment detaining facilities upstream of the reservoir, and proper reservoir operations to flush sediments through the reservoir and to prevent settling of fine sediments. **Therefore, these calculations represent the shortest probable reservoir life based on sediment transport potential.** An analysis of reservoir operational schemes and other control measures needed to extend the reservoir service life is not in the scope of this analysis. However, this study recommends such an analysis be carried out.

Estimated service life of Lake Ralph Hall using Method 1 for different maximum yearly discharges.

Upper Discharge Limit at LRH (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume In Acre-ft	Service Life in Years (including all sediment fractions)
8,000	1,018	1527	160,000	63
10,000	1,220	1830	160,000	52
12,000	1,313	1970	160,000	49

Estimated service life of Lake Ralph Hall using Method 2 for different maximum yearly discharges.

Upper Discharge Limit at LRH (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume In Acre-ft	Service Life in Years (including all sediment fractions)
8,000	1,225	1,837	160,000	52
10,000	1,419	2,128	160,000	45
12,000	1,546	2,319	160,000	41

In arriving at these values, the following assumptions were made:

1. The 55 years of daily flows provide a reasonable basis for calculating an average flow year.
2. Low-probability occurrence events (such as the 25-, 50-, and 100-year events) were excluded from this analysis because they do not represent an average year condition. However, these events have high sediment production rates and could impact the reservoir service life.
3. Along the modeled reach, a single representative sediment size distribution is used. This distribution is defined in Table 3.1 and represents a typical distribution of the 2006 sampling.
4. Total sediment transport is computed by summing the fractional loads. This method is identified in the literature as the bed material fraction method (Molinas, Wu, 2004)
5. Sediment transport for the entire mixture is computed by multiplying the transport for the sand fractions by 2.5. This is based on the distribution of sands (40%) and silts and clays (60%) in the Lake Ralph Hall watershed.
6. Fine sand transport computations are repeated using the Yang, Molinas, Wu (1996) equation. These computations result in approximately the same range of service lives.

This study also investigates regional trends in reservoir sedimentation rates to provide a comparative tool and to couch results in a regional context. Sediment accumulation characteristics of reservoirs in Northeastern Texas are collected using volumetric survey data published by the Texas Water Development Board (TWDB). The sediment accumulation characteristics of reservoirs in Northeastern Texas show that sediment production rates for these reservoirs do not pose a major threat to service life. However, the results from Lake Ralph Hall differ significantly. The following list of factors offers a possible explanation for this difference:

- The results of this study represent the shortest probable reservoir life based on sediment transport potential and exclude the reduction in sedimentation that can be achieved through reservoir operations and other sediment control and conservation measures. Regional results do reflect the benefits gained from these measures.
- The North Sulphur River is unique from regional reservoirs because of its history of channelization and incising. It is a destabilized drainage network (both main stem and tributaries) that produces a much higher rate of sediment than more stable reaches in comparable watersheds.
- Soils in the Lake Ralph Hall watershed are highly erosive. However, a comparison of soil types between the

Lake Ralph Hall watershed and regional watersheds was not part of this study.

- Difference in sedimentation rates can be attributed to differences in landuse, changing landuse, watershed cover type, watershed slope, and drainage network characteristics.

Because any combination of these factors may be the cause of low sediment accumulation and long service life of these reservoirs, it is not a given that all reservoirs in this region will be prone to low sediment production or long service life, nor is the data indicative that the region in and of itself produces low sediment accumulation. Rather, watershed specific analyses are needed to predict individual reservoir sedimentation rates. This study represents that specific analysis for the Lake Ralph Hall watershed and concludes that reservoir sedimentation rates are higher in this region.

1. INTRODUCTION

The Upper Trinity Regional Water District (UTRWD) proposes to construct a 160,000 acre-ft reservoir named Lake Ralph Hall in Fannin County near Ladonia, Texas. The on-channel reservoir will be near the headwaters of the North Sulphur River, which flows east through Texas, joining the South Sulphur River in Lamar County to form the Sulphur River, which then flows into Arkansas to its confluence with the Red River. The UTRWD proposes to use this reservoir for water supply to customer cities near the Dallas-Fort Worth Metroplex. The reservoir firm yield is approximately 32,940 acre-feet/year but annual withdrawals can be as much as 45,000 acre-ft to the Trinity River basin for municipal, industrial, and agricultural uses.

The possibility of sediment accumulation and loss of usable reservoir capacity is one of the primary areas of concern for all reservoirs. Throughout the world and in the United States, reservoir sedimentation is the cause of premature reservoir capacity loss in numerous cases (Albertson, Molinas, and Hutchkiss, 1996). In general, reservoirs are designed to have a service life of 100 years or more. However, due to unforeseen conditions or factors that are not accounted for in their design, some reservoirs are filled with sediment much faster, thereby increasing their lifecycle cost and rendering them prematurely useless. In these cases, owners and communities are faced with costly means of decommissioning these reservoirs, dredging them, or providing structural sediment pass-through features.

This study by KBR and Hydrau-Tech Inc. is a quantitative analysis of the basin hydrology and volumetric sediment transport capacity upstream of the proposed dam.

Hydrology can be generally defined as the study of water quantity, both volumetric and rate of flow. It includes quantification of precipitation and its associated runoff. The first portion of this study is hydrologic calculations used to support the study's second portion, the sediment transport computations. Average daily discharges (rates of flow) are needed over an extended period of time at Lake Ralph Hall in order to estimate sediment inflow into the reservoir and thereby estimate its service life. An analysis of flow records at the nearest flow gauging station and an independent hydrologic model of the watershed are used to create this daily discharge record.

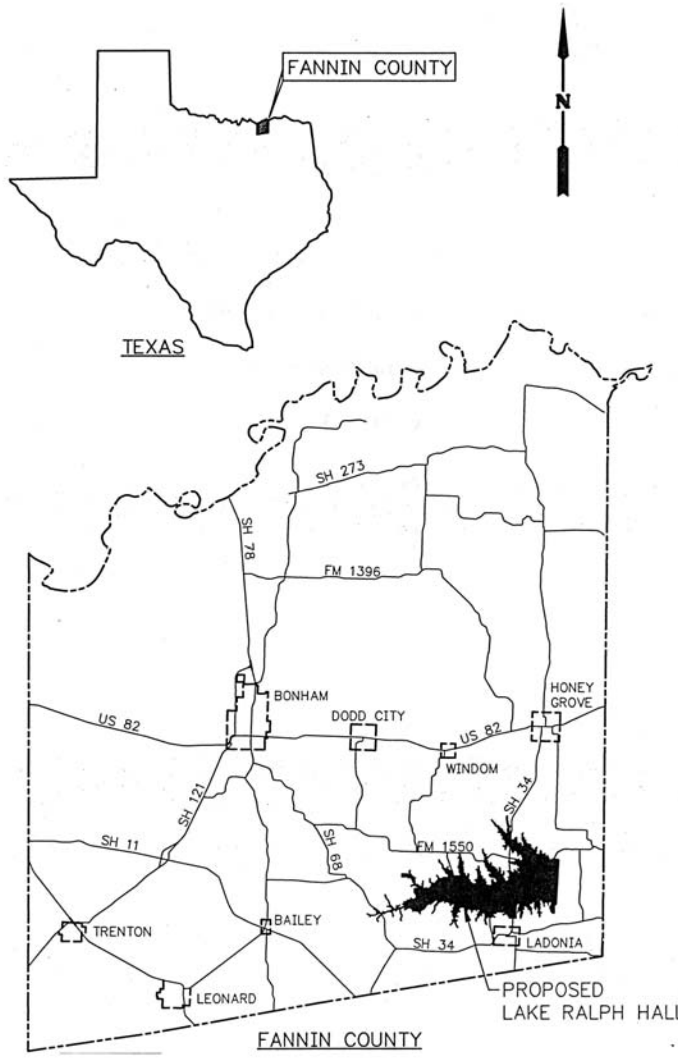

Figure 1.1 – Project location map

Sediment transport can generally be defined as the study of the processes that erode and deposit the earth's surface. In this study, sediment transport calculations are applied to determine the probable volume of sediment that will be transported from the Lake Ralph Hall watershed to the North Sulphur River at the dam site.

Two physical parameters are needed in order to carry out sediment transport computations: the properties of sediments (type and size distribution) and the strength of flows that erode and carry these sediments. In this study, a series of sediment samples are collected along the North Sulphur River at various locations to characterize bed and bank sediments. Using hydrologic information derived using the United States Geological Survey's (USGS) measured daily discharges at Cooper, Texas and cross sections surveyed by the KBR team, the BRI-STARS model (Molinas, 2000) is used to compute a series of hydraulic parameters defining the strength of flows along the North Sulphur River. Combining the results of BRI-STARS with sediment size distribution information, the SEDQWK program is used to compute sediment transport using the Yang (1973) and Yang, Molinas, and Wu (1996) methods. The service life of the proposed reservoir is computed by calculating the number of years required to fill the volume of the proposed reservoir with sediment.

Rather than using a synthetically generated sequence of flows for the sediment transport computations, the 1949-2004 gauged flows are used to represent a typical sequence of 50 years of flows. Flow characteristics are derived from the daily discharge series and the corresponding sediment transport quantities are computed. The average yearly sediment transport computed using the average of the previous 55 years produces a suitable representation of the service life of the proposed Lake Ralph Hall.

2. HYDROLOGY

The purpose of hydrologic modeling for this sedimentation potential study is to compute average daily discharges over an extended period of time at Lake Ralph Hall dam in order to estimate sediment inflow into the reservoir and thereby estimate its service life. This purpose is accomplished using two methods, which are compared to verify results. The first method uses statistical analysis of an existing flow gauging station operated by the USGS to transform measured flow values from one location to flow values at the Lake Ralph Hall dam site. The second method is to use the U.S. Army Corps of Engineers HEC-HMS model to calculate flow rates at numerous recurrence intervals independent of the gauge records.

2.1. METHOD 1: GAUGED FLOW RECORDS

The USGS maintains a network of streamflow gauging stations. The station nearest to the Lake Ralph Hall dam site is gauge 07343000 near Cooper, Texas in Lamar County on the North Sulphur River, upstream of the confluence of the North and South Sulphur Rivers, with a contributing drainage area of 276 square miles. Figure 2.1 shows the location of this gauge relative to the Lake Ralph Hall watershed. It has continuous daily discharge records from 1949 to 2004 in two formats: average daily flow values and instantaneous daily peak flows. As shown in Figure 2.2, during the period of 1949 through 2004, the North Sulphur River experienced a number of large scale events exceeding 25,000 cfs (average daily flow) and extended periods of little or no flows.

The USGS has published regional regression equations to relate peak flow at a specified return period to the physiography, hydrology, and meteorology of a watershed. Lake Ralph Hall is located in Fannin County, Region 7, and has a drainage area greater than 32 square miles. Therefore, the regional regression equations for its watershed are the following:

$$Q_2 = 129\ A^{0.578}\ SL^{0.364} \quad (1)$$
$$Q_5 = 133\ A^{0.605}\ SL^{0.578} \quad (2)$$
$$Q_{10} = 178\ A^{0.644}\ SL^{0.699}\ BSF^{-0.239} \quad (3)$$
$$Q_{25} = 219\ A^{0.651}\ SL^{0.776}\ BSF^{-0.267} \quad (4)$$
$$Q_{50} = 261\ A^{0.653}\ SL^{0.817}\ BSF^{-0.291} \quad (5)$$
$$Q_{100} = 313\ A^{0.654}\ SL^{0.849}\ BSF^{-0.316} \quad (6)$$

Where Q_T = peak discharge in cubic feet per second for recurrence interval, T, in years; A = contributing drainage area in square miles; SL= stream slope in feet per mile; BSF = Basin Shape Factor, dimensionless; subscripts 2, 5, 10, 25, 50, and 100 refer to recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100-year, respectively.

Method 1 uses regional regression equation parameters to transform the gauged flow records from a location near Cooper, Texas to represent flows at the Lake Ralph Hall dam site. This procedure is outlined below:

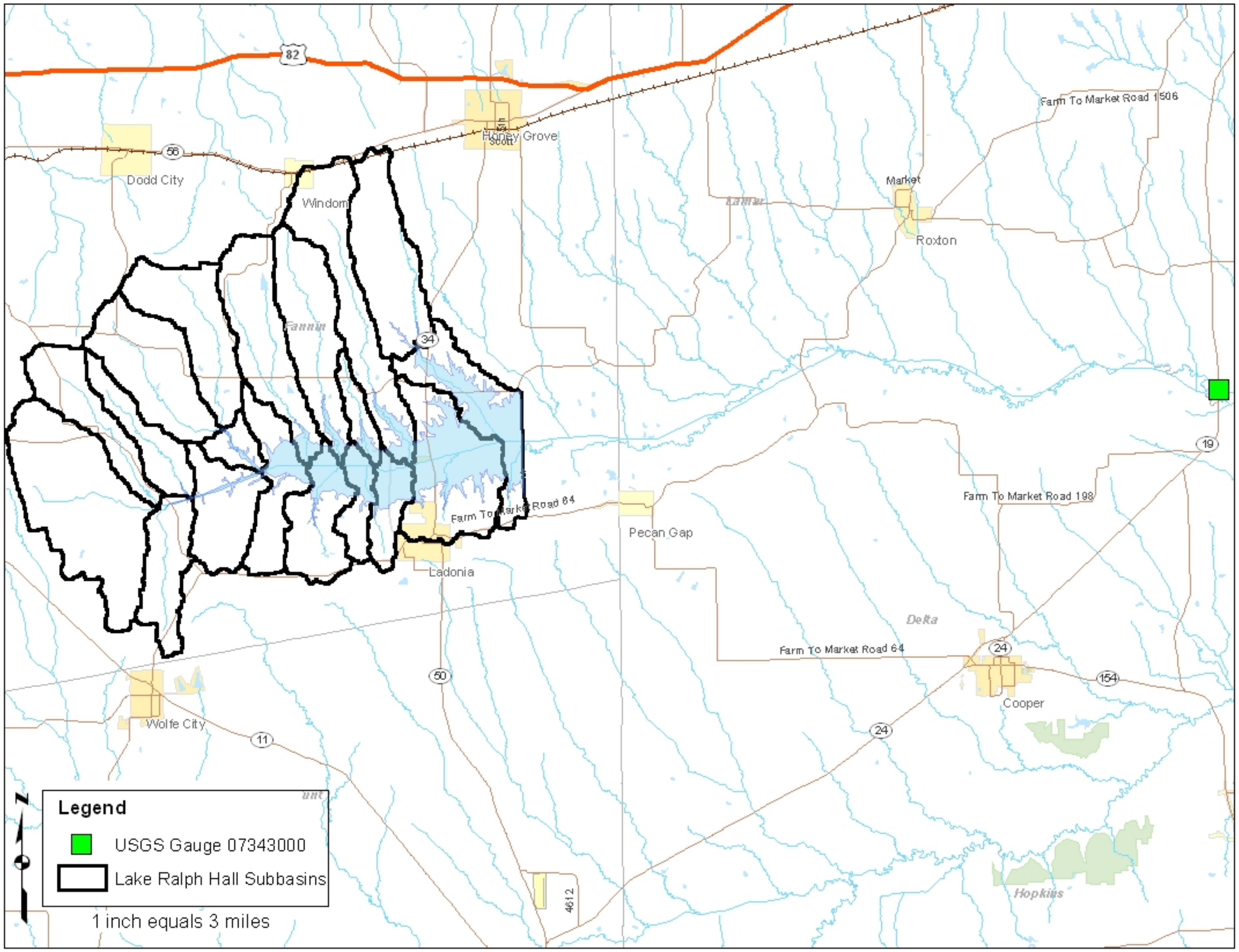

Figure 2.1 – Location of USGS streamflow gauge nearest to Lake Ralph Hall

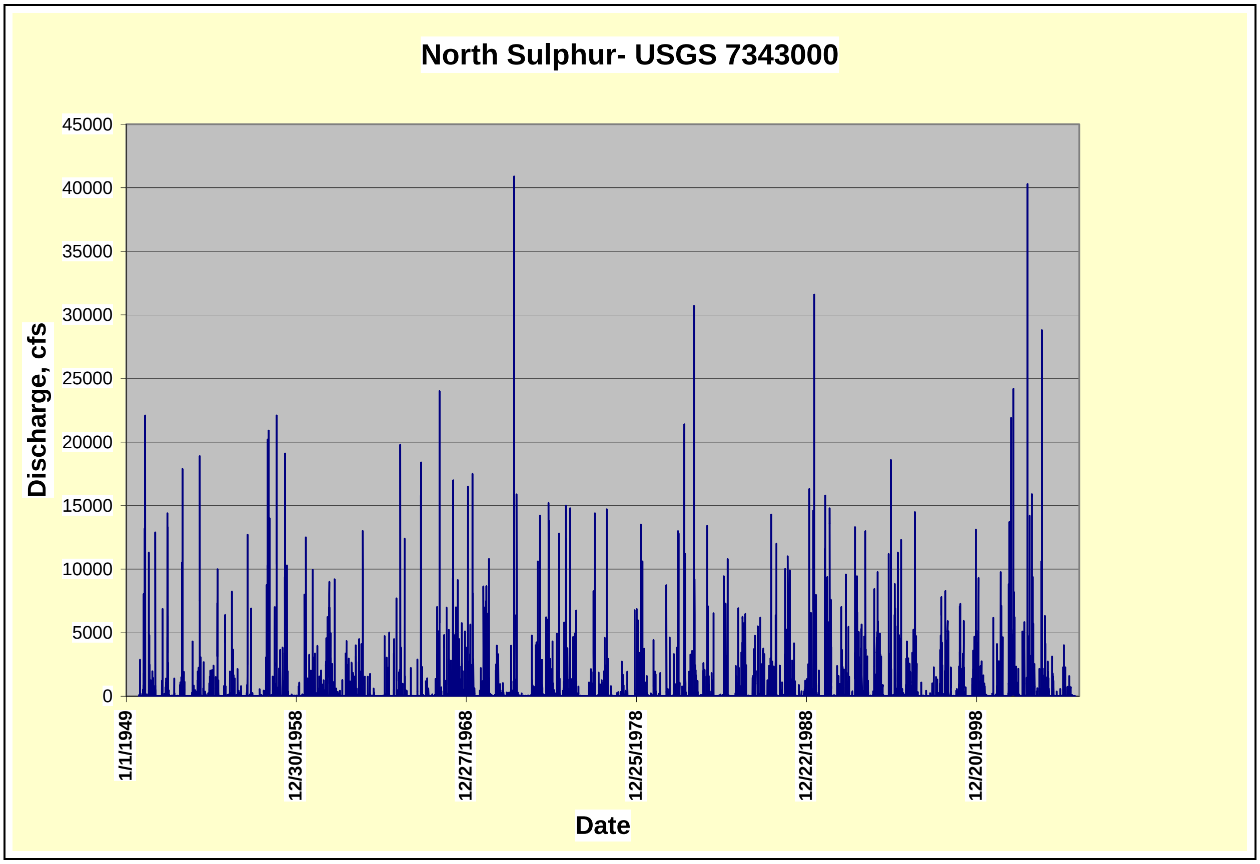

Figure 2.2 – Average daily flows on North Sulphur River near Cooper, Texas at USGS Station 07343000.

1. Using available USGS data, perform a Log-Pearson Type III peak flow analysis to determine 5-year, 10-year, 25-year, 50-year and 100-year return frequency daily flows at the gauge location. Compare these results with results obtained from Gumbel distribution and the Weibul ranking method.

2. Modify the USGS regional regression equations 1 through 6 to express:

$$\frac{(Q_T)_{LRH}}{(Q_T)_{Cooper}} = \frac{(A^a)_{LRH}\,(SL^b)_{LRH}\,(BSF^c)_{LRH}}{(A^a)_{Cooper}\,(SL^b)_{Cooper}\,(BSF^c)_{Cooper}} \qquad (7)$$

   Subscripts *LRH* and *Cooper* refer to corresponding values from the Lake Ralph Hall dam site and the gauge location near Cooper, Texas, respectively; and *a, b, c* = drainage area, stream slope, and basin shape factor exponents, respectively.

3. Assuming the same basin shape factor and stream slope for *LRH* and *Cooper* locations (since the Lake Ralph Hall drainage basin is contained within the gauge drainage basin), it is possible to express the discharge ratio between the North Sulphur River at *LRH* and the North Sulphur River at *Cooper* as:

$$\frac{(Q_T)_{LRH}}{(Q_T)_{Cooper}} = \frac{(A^a)_{LRH}}{(A^a)_{Cooper}} \qquad (8)$$

4. It is possible to assume that the general relationship for expressing peak flow ratios corresponding to major events with given recurrence intervals is also valid for relating daily flows. In other words,

$$\frac{(Q_i)_{LRH}}{(Q_i)_{Cooper}} = \frac{(A^a)_{LRH}}{(A^a)_{Cooper}} \qquad (9)$$

Where the subscript *i* refers to daily flows.

5. Equations 1 through 6 show that the value of the drainage area exponent, *a*, in Equation 9 varies within a narrow range of 0.578 and 0.654. For more frequent events, the drainage area exponent assumes the smaller value. For daily flows, the value of the drainage area exponent *a* can approximated as 0.57. Daily discharges at *LRH* can be expressed in terms of *Cooper* discharges using the area transformation,

$$(Q_i)_{LRH} = (Q_i)_{Cooper}\left(\frac{A_{LRH}}{A_{Cooper}}\right)^{0.57} \qquad (10)$$

2.2. METHOD 2: HEC-HMS MODELING

The US Army Corps of Engineers hydrologic model HEC-HMS is used to compute the inflow hydrograph at the Lake Ralph Hall dam site. Because of the availability of flow gauge data at Cooper, Texas, the hydrologic model is used primarily to calibrate the area transformation described in Method 1 using the procedure described below, and to determine runoff values at various subbasins outlets within the Lake Ralph Hall watershed.

1. Using HEC-HMS and the 5-year, 10-year, 25-year, 50-year and 100-year 24-hour precipitation values, compute corresponding average daily flow runoffs.

2. Correlate these computed values to measured flow values at the USGS gauge near Cooper, Texas using the expression given by equation 9, and determine the best-fit β.

   $$Q_{LRH} / Q_{Cooper} = (Area_{Cooper} / Area_{LRH})^{\beta}$$

   Where β = regional exponent. Drainage area contributing to gauged flows at Cooper is approximately 276 square miles and the drainage area contributing to Lake Ralph Hall is 101 square miles.

3. If the β from step 2 is close to the regional regression β value of 0.57, runoff values from hydrological modeling are meaningful and are consistent with regional observations. Slight deviations are expected and can be attributed to the channelization process over the period of record. Use the computed β from Step 2 to transform daily flows at *Cooper* to daily flows at *LRH*.

4. If the β from step 2 is not close to the regional value of 0.57, revise modeling approach by finer delineation of the watershed, revised modeling parameters, etc.

To produce a representative model of the Lake Ralph Hall watershed, it is divided into 19 subbasins as shown in Figure 2.3. These divisions are based on naturally occurring basin delineators, such as individual tributary subbasins, confluences, and topographic divides. HEC-HMS routes flow through the basin and stream network and calculates a runoff hydrograph at each user-defined location. In this analysis, the key hydrograph is at the Lake Ralph Hall dam site. Figure 2.4 illustrates the flow network that produced this hydrograph.

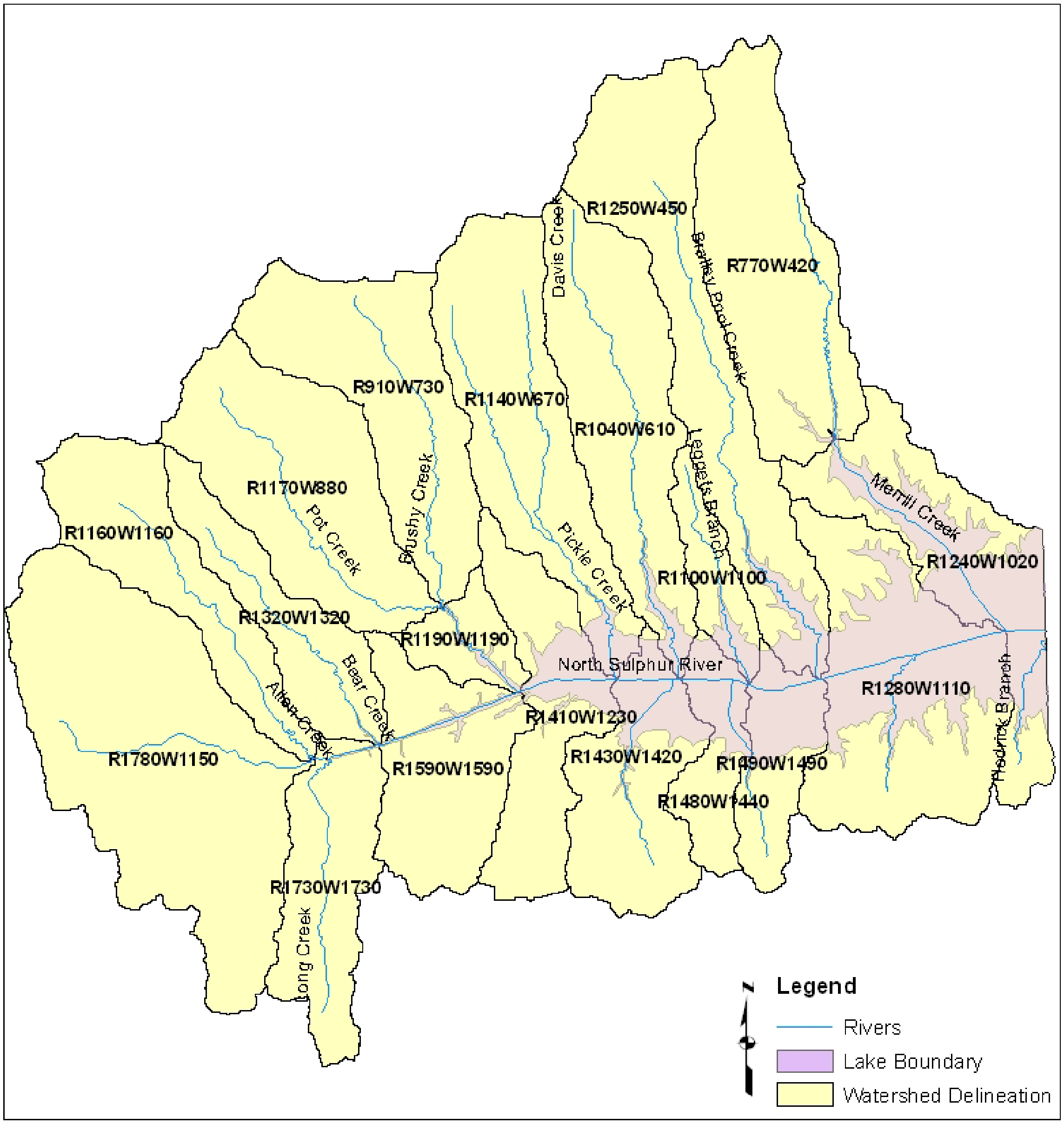

Figure 2.3 – Lake Ralph Hall subbasin boundaries and modeling designations

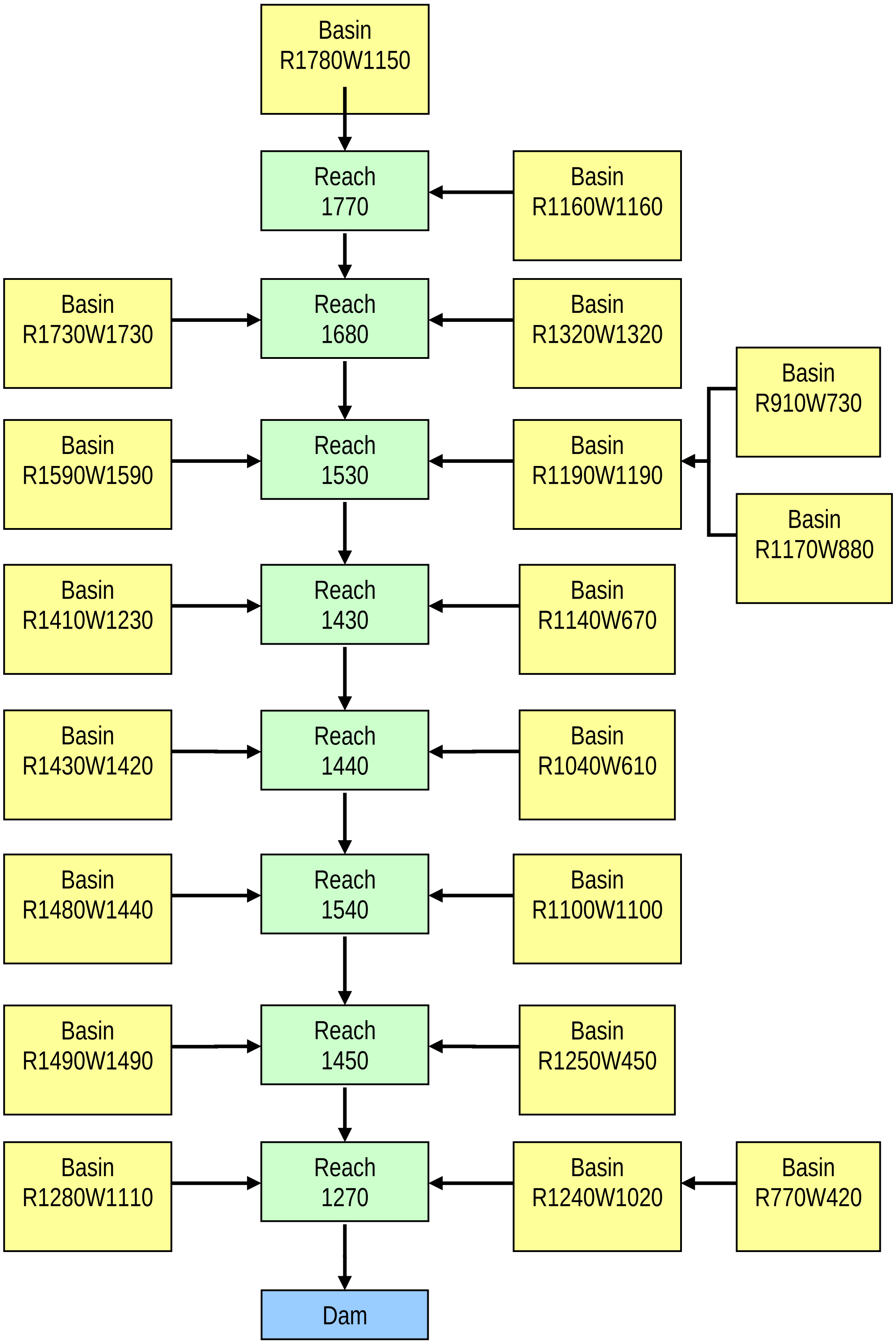

Figure 2.4 – Hydrologic model flow diagram

Key parameters in the HEC-HMS modeling include SCS Curve Number values (to determine soil runoff conditions) and time of concentration. Curve number values are calculated using the Natural Resources Conservation Service (NRCS) digitized soil classification database (STATSGO) for Fannin County. Using GIS, the soil data and digital land use data from the Texas Natural Resources Information System are combined to create a curve number database for each subbasin and an individual CN value is calculated for each of the 19 basins. Because the soils are predominantly hydrologic soil group D and land use is predominantly "cropland and pasture", the average CN value for each subbasin is either 83 or 84 under normal antecedent moisture conditions.

The time of concentration (Tc) and the associated lag time are important parameters that have a large impact on hydrograph development. The Tc for each subbasin is calculated using NRCS procedures as specified in the NRCS document TR-55; the results of these calculations are contained in Table 2.1. This analysis also calculates travel time parameters using the Snyder lag time equation and parameters adopted from the USACE Lake Jim Chapman analysis and the analysis contained in the report "Hydrologic and Hydraulic Studies of Lake Ralph Hall", prepared for the UTRWD on April 27, 2004. The Snyder Ct value is not a physically-based parameter and is best found through calibration, but a logical starting point is the Ct value used on a reservoir designed by the USACE in the nearest watershed. Table 2.1 shows that the Ct value calculated from the NRCS Tc calculations is an average of 0.9, much lower than the 2.5 value used for Lake Jim Chapman. This analysis agrees with the UTRWD report that the Ct value of 2.5 was inappropriate for Lake Ralph Hall but the exact value of the coefficient is unknown. Instead, this analysis computes flows using three different Ct values, as described in the Results section of this report.

Table 2.1 –Tc Calculations based on TR-55 guidelines

Basin	Description	Time of Concentration (hr)	Snyder Ct Back Calculated
R1040W610	Davis Creek	4.40	0.95
R1100W1100	Leggets Branch	1.91	0.68
R1140W670	Pickle Creek	4.61	1.02
R1160W1160	Allen Creek	3.90	0.94
R1170W880	Pot Creek	3.32	0.85
R1190W1190	Brushy Creek (downstream end)	1.45	0.66
R1240W1020	Merrill Creek (downstream end)	2.39	0.75
R1250W450	Bralley Pool Creek	5.04	0.92
R1280W1110	NSR Between Bralley Pool and Merrill Creek	3.06	0.99
R1320W1320	Bear Creek	3.48	0.97
R1410W1230	NSR Between Pickle Creek and Brushy Creek	2.70	0.85
R1430W1420	NSR Between Pickle Creek and Davis Creek	2.45	0.80
R1480W1440	NSR Between Davis Creek and Leggets Branch	2.48	0.86
R1490W1490	NSR Between Bralley Pool and Leggets Branch	2.18	0.74
R1590W1590	NSR Between Long Creek and Brushy Creek	2.82	0.87
R1730W1730	Long Creek	3.16	0.85
R1780W1150	NSR Headwaters	3.22	0.95
R770W420	Merrill Creek	3.97	1.01
R910W730	Brushy Creek (u/s end)	4.05	0.98

2.3. RESULTS

Analysis of the period-of-record (1949-2004) for the USGS gauge near Cooper, Texas reveals that in general terms, floods on the North Sulphur River are flashy in nature. The duration of large events is typically 2 to 3 days; flows rise from almost zero to 25,000-40,000 cfs within a day and then recede over a period of 2 days. On the average, the duration of flows with magnitudes up to 80 percent of the peak discharge is 1 day. In other words, the bulk of the flow occurs in a one day window. Figure 2.5 presents the characteristics of large floods on the North Sulphur River along with an average hydrograph of major events.

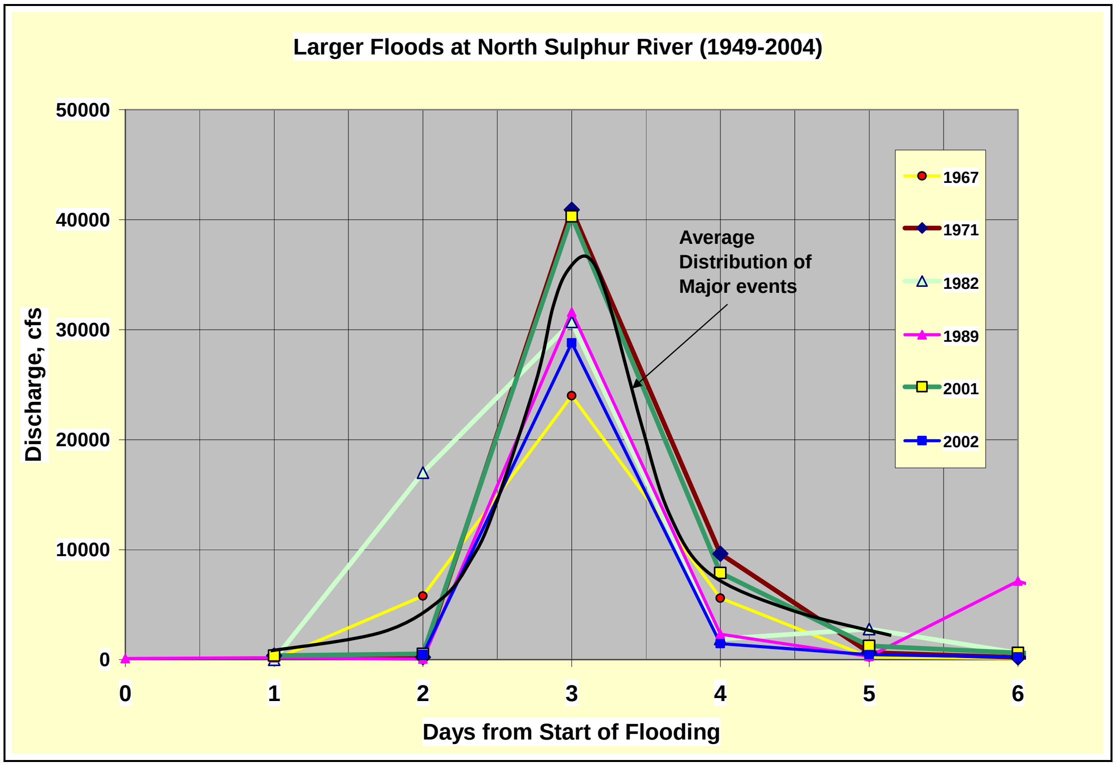

Figure 2.5 – Characteristics of large flood flow events on North Sulphur River.

The maximum daily flows (based on average daily flow values) at the gauge for its period-of-record are given in Table 2.3. Table 2.3 sorts this data in two ways: first by year and second by flow. It also presents the ranking of each discharge (largest first), and the Weibul return period corresponding to ranked discharges. According to Table 2.3, the largest average daily flows on record are 40,900 cfs (57-year event) and 40,300 cfs (29-year event) that took place in 1971 and 2001, respectively.

Using the 55 years of daily flow data from Table 2.3, Table 2.4 presents results of the Method 1 analysis—Log-Pearson Type III (with station and regional skewness adjustment) and Gumbel (with sample size adjustment) analyses. Skewness is the measure of symmetry, rather asymmetry, of the distribution of flood frequencies. For a perfectly symmetrical distribution about a mean value, skewness is zero. In the Log-Pearson Type III distribution, station skewness refers to skewness of the logarithms of maximum daily flows for each year in the period of record. Regional skewness is a published value used to compensate for the deficiencies in using station skewness values for cases where the number of years in the record are small. One of the basic assumptions in any statistical analysis is that a sufficiently large sample size is given. The sample size adjustment refers to an adjustment to compensate for the limited number of data values. In the present analysis, the number of maximum daily discharges for 1949 through 2004 is 56. Because 56 years of record is considered a long record, a limited sample size adjustment is needed. For the the Log-Pearson Type III distribution, the station skewness factor is accepted as adequate.

These results are graphically presented in Figure 2.6 and 2.7. In general terms, the 10-, 20-, 50-, and 100-year flows range between 26,000 cfs and 36,000 cfs using the Log-Pearson Type III analysis (using station skewness adjustment), and they range from 26,000 cfs to 43,000 cfs using the Gumbel analysis with sample size (n=56) adjustment. As shown in Figure 2.6, the Gumbel analysis fits the ranked, observed flow data slightly better than the Log-Pearson Type III with station skewness adjustment.

Because of the changing flow characteristics over time, the skewness is also changing over time. Channelization of the North Sulphur has caused different flow patterns through time. In 1949, relatively soon after initial channelization, flows were still spreading to the floodplain during large events. Over time the river channelized more and more until all flow is now contained within the channel itself. This has affected gauge readings; gauged flows increase over time as flow is concentrated in the channel. This variability over time explains much of the difference between the Log-Pearson and Gumbel analyses.

The area-transformed flood flows using Gumbel and Log-Pearson Type III methods provide an upper and lower bound to watershed modeling results. The fact that the agreement is observed for the entire range of discharges from lowest to highest is an additional assurance that using area transformations to estimate North Sulphur flows at Lake Ralph Hall is appropriate. The sensitivity of results to the β variable was investigated by assigning values to β in the range of 0.57 and 0.65. The conclusions remained the same and therefore the value of 0.57 was selected for the final transformations.

Figure 2.7 also presents the Method 2 analysis—HEC-HMS modeling results at the Lake Ralph Hall dam site for the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year frequency 24-hr precipitation events (7 different events). These results are compared with flood flows from area-adjusted Log-Pearson Type III and Gumbel analysis using an area exponent, β, of 0.57 in Equation 9. Computed runoff hydrographs at the Lake Ralph Hall dam site using HEC-HMS show very good agreement with the area-transformed gauge data.

HEC-HMS is used to calculate hydrographs in the 19 Lake Ralph Hall subbasins under two different unit hydrograph methods: Snyder and SCS. Although the volumetric flow in both methods is the same, the peak flows were widely divergent. Three different values for the Snyder Ct parameter are used: 0.9 is the average Ct value back-calculated from the Tc values based on the NRCS calculation method; 2.5 is the Ct value used by the USACE for Lake Jim Chapman; 1.7 is the average of the 0.9 calculated Ct and the 2.5 Ct used for Lake Jim Chapman. All of these methods result in a higher 100-year peak value than shown in the previous UTRWD hydrology report. This difference can be attributed to the differing CN values and basin timing parameters. However, despite variations in peak flows, the average daily flow values resulting from these computations remain the same; because the sediment transport calculations are based on average daily flow values, sensitivity to the peak flow does not affect the sediment transport computations.

Because of channelization, the characteristics of peak flows in the North Sulphur River are different than in a normal, stable channel. Flow in this channelized reach is much more concentrated (no flow in the floodplain) and moving at a much faster rate than a stable channel. Therefore, the flood peak in the Lake Ralph Hall reach will tend to reach the Cooper gauge before contributions from the watershed reach the gauge. This results in the peak flows at Lake Ralph Hall and the peak flows at the gauge being much closer than typical drainage area proportioning could predict. Therefore, it is reasonable to predict that peak flows at Lake Ralph Hall will be higher than predicted by typical drainage area proportioning.

The objective of hydrologic modeling is to provide a means for transforming measured flows at the gauge near Cooper to flows at the Lake Ralph Hall dam site for sediment calculations. Since instantaneous peak flows are of short duration and the associated sediment transport is not significant, the time series used in sediment computations are the area-transformed (see Equation 9) average daily flows.

Table 2.2 – 100-year peak flow comparisons of SCS and Snyder unit hydrograph methods

Unit Hydrograph	Ct	Peak Flow (cfs)	Notes
SCS	n/a	91,000	Uses Tc values from TR-55 based computations
SCS	2.5	47,400	Uses the Jim Chapman Ct value of 2.5 to back-calculate the Tc values required in the SCS method
Snyder	Average 0.9	55,500	Uses the Tc values from TR-55 calculations to back-calculate the Ct values for the Snyder method
Snyder	2.5	37,500	Uses the Ct value from Jim Chapman
Snyder	1.7	42,500	Uses the average Ct from the previous two methods (0.9 and 2.5)

Table 2.3 – USGS maximum average daily flow data for North Sulphur River at Cooper, Texas for 1949-2004.

North Sulphur Maximum Daily Flows for (1949-2004)		Ordered Discharges			Return Period in Years
Year	Max Q	Rank-m	Year	Discharge	Tr = 1/P
1949	2870	1	1971	40900	57.00
1950	22100	2	2001	40300	28.50
1951	14400	3	1989	31600	19.00
1952	17900	4	1982	30700	14.25
1953	18900	5	2002	28800	11.40
1954	10000	6	1967	24000	9.50
1955	8230	7	1950	22100	8.14
1956	12700	8	1957	22100	7.13
1957	22100	9	2000	21900	6.33
1958	19100	10	1981	21400	5.70
1959	12500	11	1965	19800	5.18
1960	9000	12	1958	19100	4.75
1961	9220	13	1953	18900	4.38
1962	13000	14	1993	18600	4.07
1963	1750	15	1966	18400	3.80
1964	7700	16	1952	17900	3.56
1965	19800	17	1969	17500	3.35
1966	18400	18	1968	17000	3.17
1967	24000	19	1990	15800	3.00
1968	17000	20	1973	15200	2.85
1969	17500	21	1974	15000	2.71
1970	10800	22	1975	14800	2.59
1971	40900	23	1977	14700	2.48
1972	4780	24	1995	14500	2.38
1973	15200	25	1951	14400	2.28
1974	15000	26	1976	14400	2.19
1975	14800	27	1986	14300	2.11
1976	14400	28	1979	13500	2.04
1977	14700	29	1983	13400	1.97
1978	6860	30	1991	13300	1.90
1979	13500	31	1998	13100	1.84
1980	8750	32	1962	13000	1.78
1981	21400	33	1992	13000	1.73
1982	30700	34	1956	12700	1.68
1983	13400	35	1959	12500	1.63
1984	10800	36	1994	12300	1.58
1985	6480	37	1987	12000	1.54
1986	14300	38	1970	10800	1.50

Table 2.3 (continued)

North Sulphur Maximum Daily Flows for (1949-2004)		Ordered Discharges			Return Period in Years
Year	Max Q	Rank-m	Year	Discharge	Tr = 1/P
1987	12000	39	1984	10800	1.46
1988	4170	40	1954	10000	1.43
1989	31600	41	1999	9320	1.39
1990	15800	42	1961	9220	1.36
1991	13300	43	1960	9000	1.33
1992	13000	44	1980	8750	1.30
1993	18600	45	1997	8290	1.27
1994	12300	46	1955	8230	1.24
1995	14500	47	1996	7800	1.21
1996	7800	48	1964	7700	1.19
1997	8290	49	1978	6860	1.16
1998	13100	50	1985	6480	1.14
1999	9320	51	1972	4780	1.12
2000	21900	52	1988	4170	1.10
2001	40300	53	2004	4010	1.08
2002	28800	54	2003	3120	1.06
2003	3120	55	1949	2870	1.04
2004	4010	56	1963	1750	1.02

Table 2.4 – Summary of flood flows with different recurrence intervals at Cooper, Texas.

Return Period of Flood Event (Years)	Flood Flow Estimated from Log-Pearson Type III (Adjusted for station skewness) Analysis using Daily Flow Values (cfs)	Flood Flow Estimated from Gumbel Analysis (Sample size adjusted using n=56) using Daily Flow Values (cfs)
500	41,227	54,957
200	38,588	--
100	36,315	43,507
50	33,694	38,551
25	30,659	33,559
10	25,851	26,830
5	21,383	21,504
2	13,635	13,460
1.25	7,668	--
1.11	5,380	--

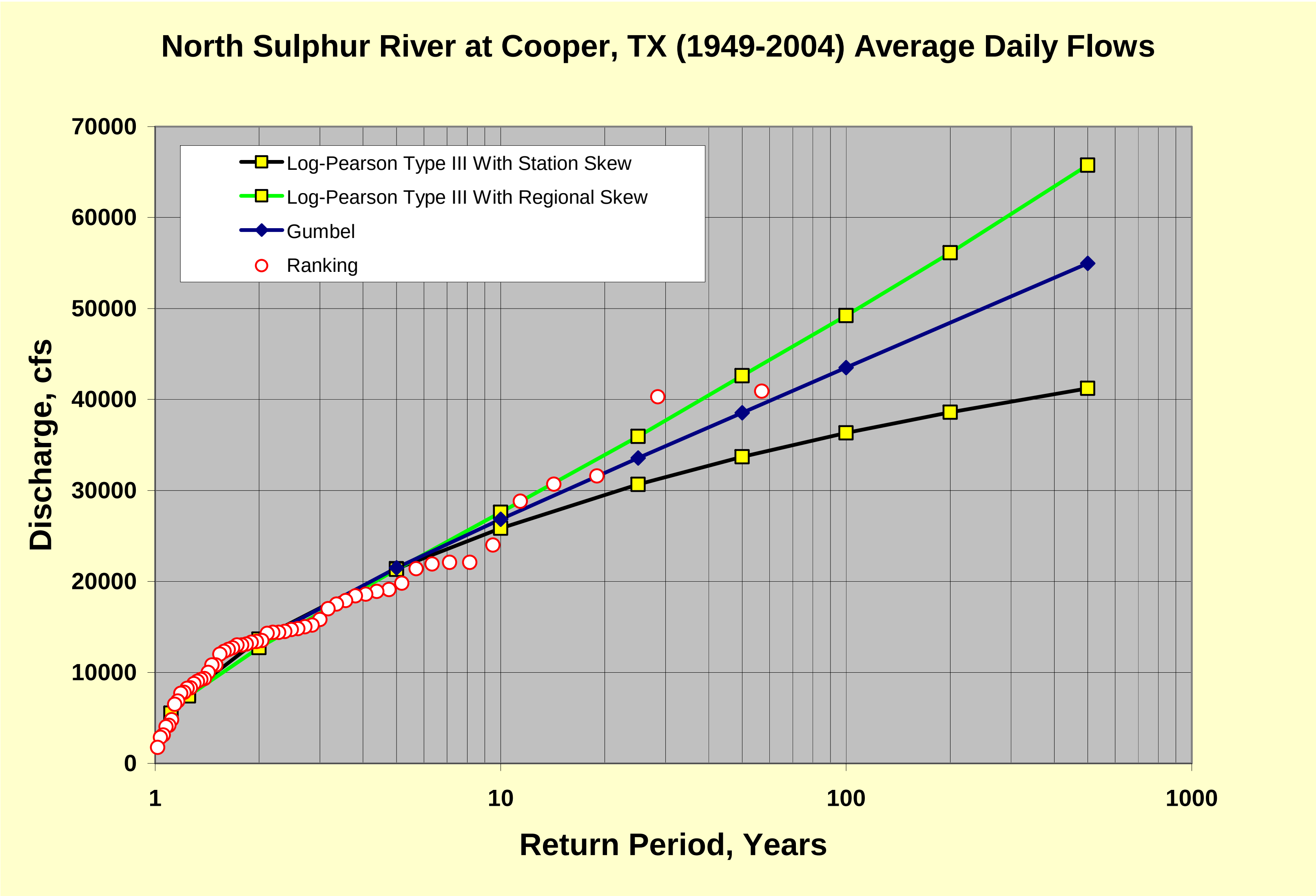

Figure 2.6 – Flood frequencies for North Sulphur River at Cooper, Texas using 1949 through 2004 average daily flow data.

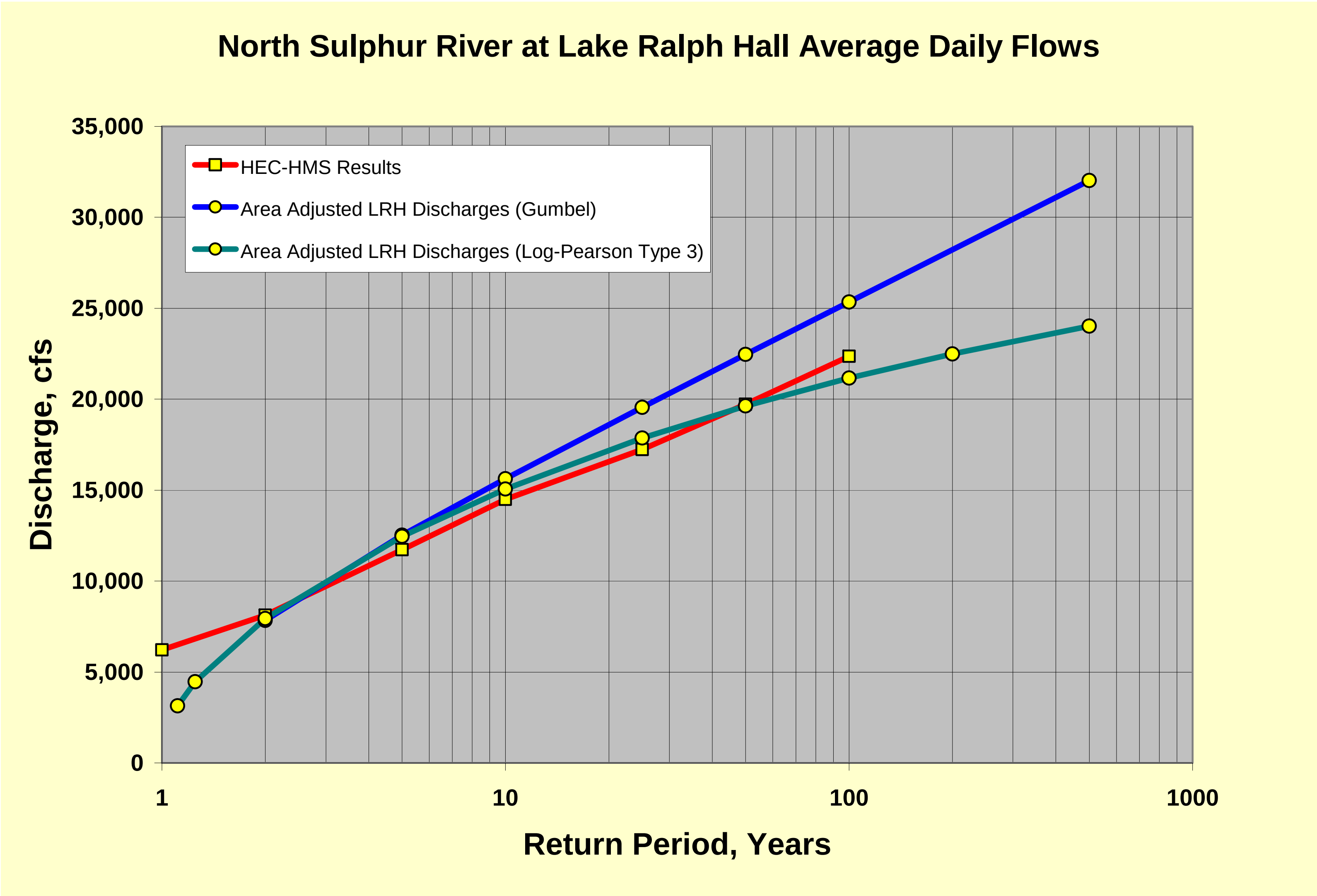

Figure 2.7 – Flood frequencies for North Sulphur River near Lake Ralph Hall dam site using Cooper, Texas data with area adjustments.

2.4. TYPICAL YEARLY FLOWS

Using the results from methods 1 and 2 (described above), a series of daily runoff values are computed for the Lake Ralph Hall dam site to represent a "typical" average year condition. This year-long flow hydrograph represents an average condition that represents the flows Lake Ralph Hall will experience over an anticipated 100-year lifespan. To compute this hydrograph, the gauged flows near Cooper, Texas are transformed as described in Method 1, and then subdivided into flow ranges. The frequency of occurrence for each of these flow ranges and the duration of each frequency is then computed. To compute the duration, the frequencies are transformed into the number of days of occurrence per year by multiplying the percent of time they occur by 365 days to derive "*typical*" yearly flows. Extremities (less than 0.5 days, for example) are excluded from the analysis since these events would not contribute to sediment production; therefore, discharges up to 12,000 cfs (approximately 0.2 day) are significant in computing "typical" yearly sediment transport computations for Lake Ralph Hall

As shown in Table 2.5, the number of occurrences within the period of record is determined for a series of selected discharge intervals. This information is transformed into percentages and subsequently into the number of days of occurrence per year. Figures 2.9 and 2.10 present the results of these computations. The flashy character of flows on the North Sulphur River is demonstrated by the fact that approximately 86 percent of the time flows are less than 100 cfs (with numerous no-flow days) and 96 percent of the time flows are less than 1000 cfs. On the average, discharges in excess of 2,000 cfs occur approximately 6 days per year.

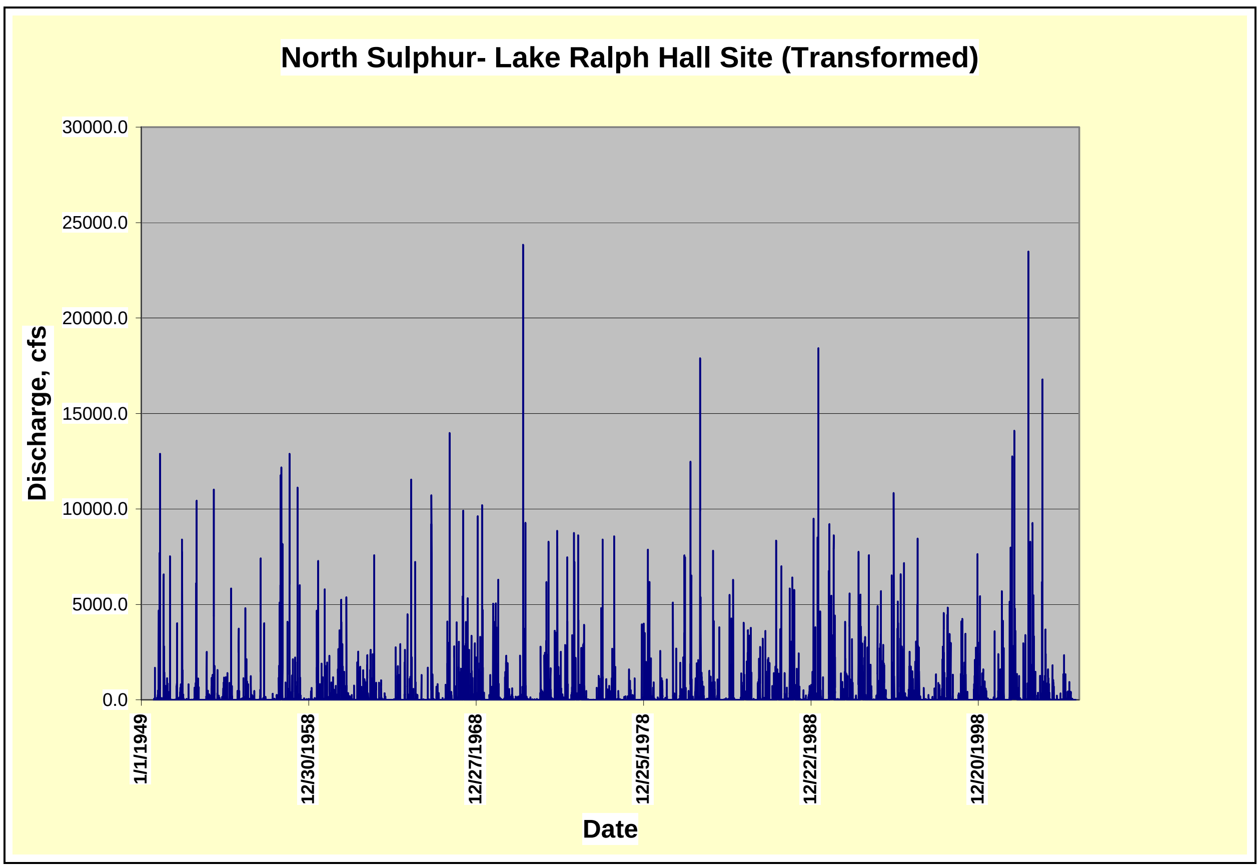

Figure 2.8 – Average daily flows at Lake Ralph Hall for 1949-2004 as derived from Cooper, TX data.

Table 2.5 – Average daily discharges and corresponding frequencies at Lake Ralph Hall dam site from 1949-2004 Cooper, TX data.

Percent Of Time Less Than	North Sulphur Discharges at LRH Site (1949-2004)		Average Discharge for Interval (cfs)	Number of Days/Year	Cumulative Number of Days/Year
	Lower Bound (cfs)	Upper Bound (cfs)			
86.46	0	100	50	315.6	315.6
93.47	100	400	250	25.6	341.2
96.48	400	1,000	700	11.0	352.2
98.28	1,000	2,000	1500	6.6	358.7
99.19	2,000	4,000	3000	3.3	362.1
99.78	4,000	8,000	6000	2.1	364.2
99.90	8,000	10,000	9000	0.4	364.6
99.94	10,000	12,000	11000	0.2	364.8
99.97	12,000	14,000	13000	0.1	364.9
99.97	14,000	16,000	15000	0.02	364.9
99.99	16,000	18,000	17000	0.04	364.95
99.99	18,000	20,000	19000	0.02	364.96
100	20,000	24,000	22000	0.04	365.0
100	24,000	28,000	26000	0	365.0
100	28,000	30,000	29000	0	365.0
100	30,000	35,000	32500	0	365.0
100	35,000	40,000	37500	0	365.0
100	40,000	50,000	45000	0	365.0

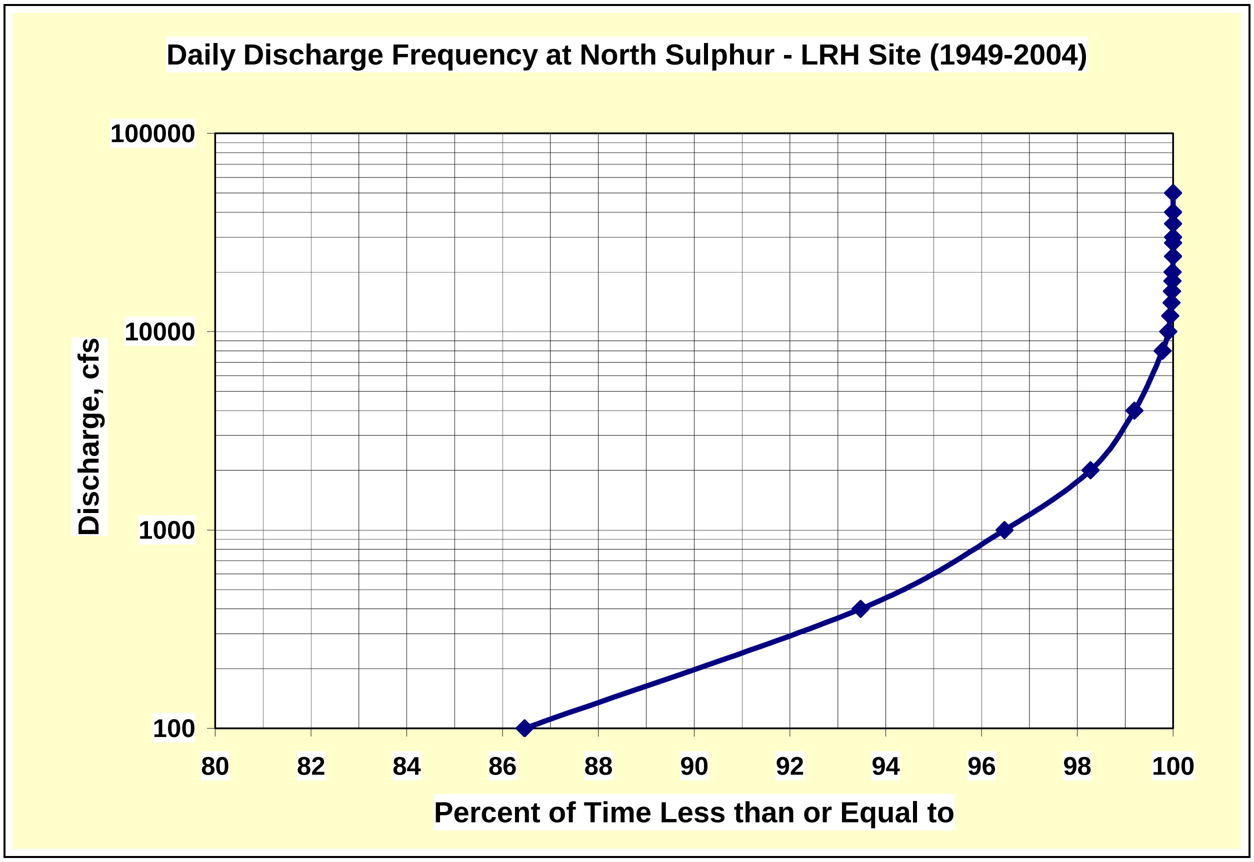

Figure 2.9 – Daily discharge-frequency plot at Lake Ralph Hall dam site from 1949-2004 data.

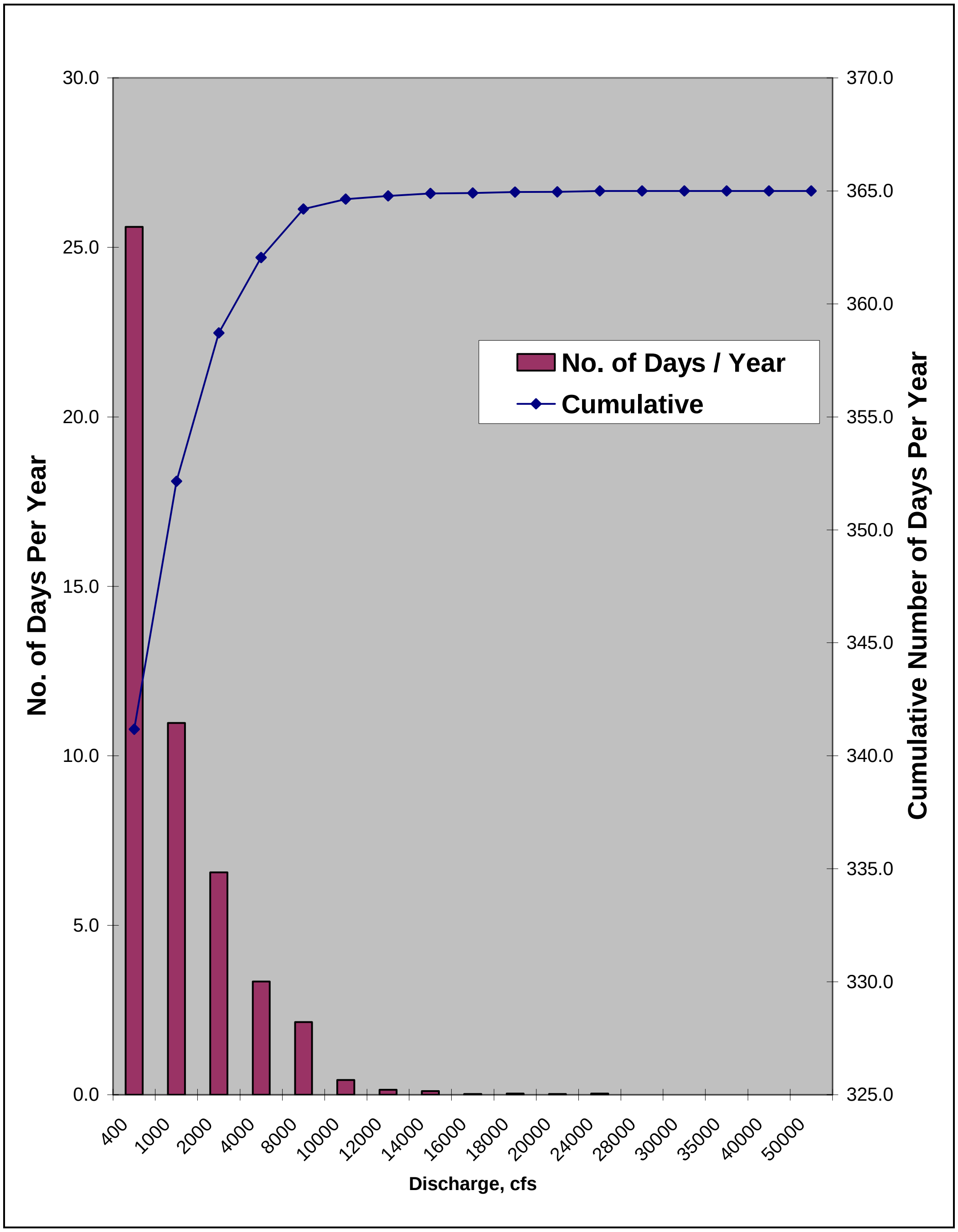

Figure 2.10 – Daily discharge-frequency plot at Lake Ralph Hall dam site for an average year (1949-2004)

3. SEDIMENT TRANSPORT

This section provides quantitative analyses of sediment transport capacity to the proposed reservoir. Two physical parameters are needed in order to carry out sediment transport computations: the properties of sediments (type and size distribution) and the strength of flows that erode and carry these sediments. This section describes data collected to describe these parameters and the methodologies and models used to calculate a probable reservoir lifespan based on sedimentation rates.

3.1. WATERSHED SOIL AND LANDUSE CHARACTERISTICS

The North Sulphur River is deeply entrenched in the Tinn Clay formation. According to the NRCS Soil Survey for Fannin County, this soil formation, shown in blue in Figure 3.1, is a very deep, nearly level clay soil found on broad floodplains along streams. It makes up the predominant soil type along the main stem of the North Sulphur River and its tributaries. The watershed surrounding the channel is composed of a variety of soil types including the Heiden-Ferris Complex and Ferris Clays; both have a severe hazard of water erosion. Other soils surrounding the North Sulphur River have a moderate or slight risk of water erosion, but a significant portion of the surrounding soils carry the NRCS survey's moderate to severe rating. Appendix A contains an overview of soils in Fannin County.

Soils in the Fannin County North Sulphur River watershed are erosive and deep, and will be a long term source of sediment supply to the channel. As shown in Figure 3.3, landuse is primarily agricultural, and natural vegetation consists of grassland and woodland. Urban areas are very small and sparsely populated. There is no indication that changes in land use in the watershed are imminent and soil supply to the channel from the watershed should remain at existing levels.

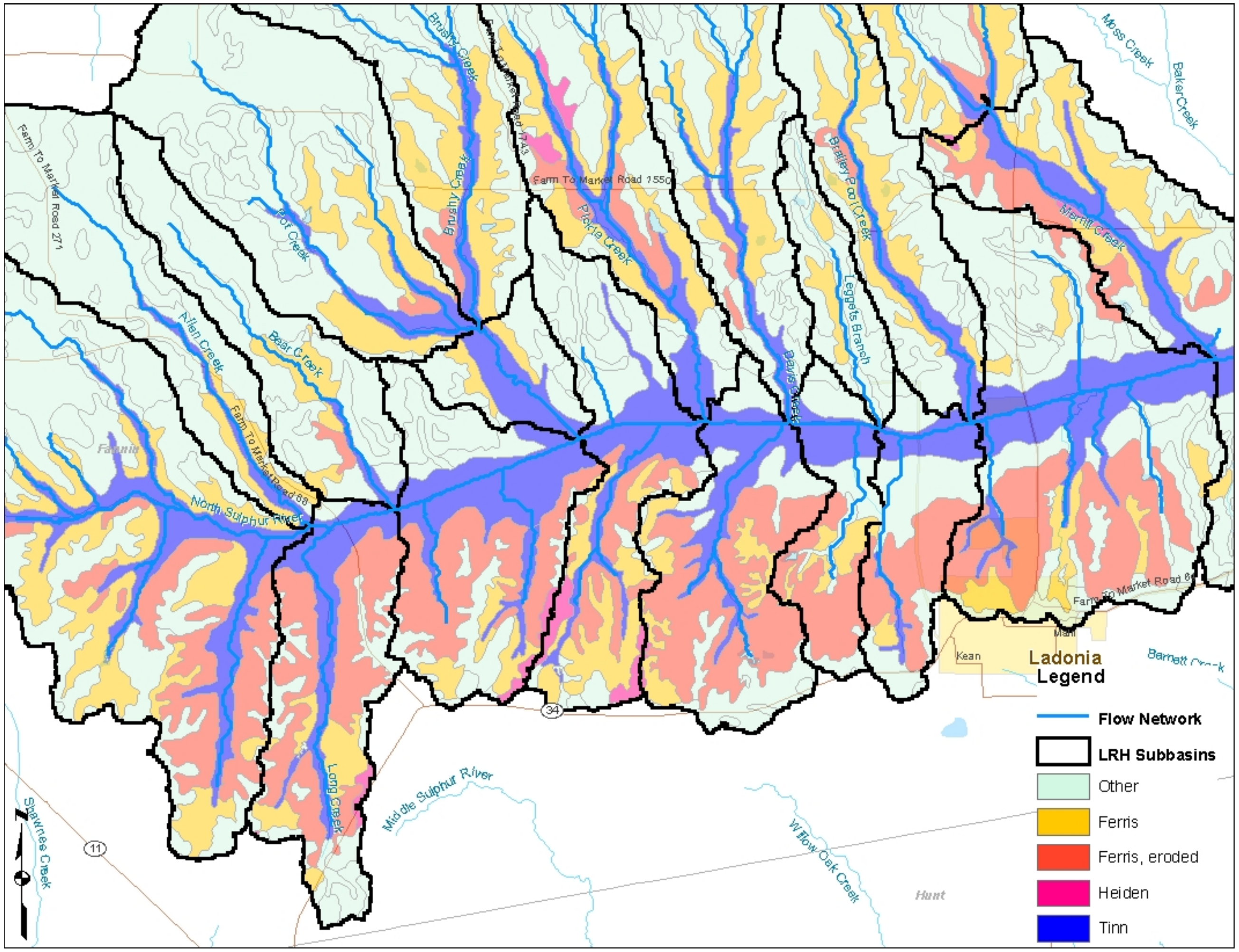

Figure 3.1 – Detailed soil types along North Sulphur River and bordering areas

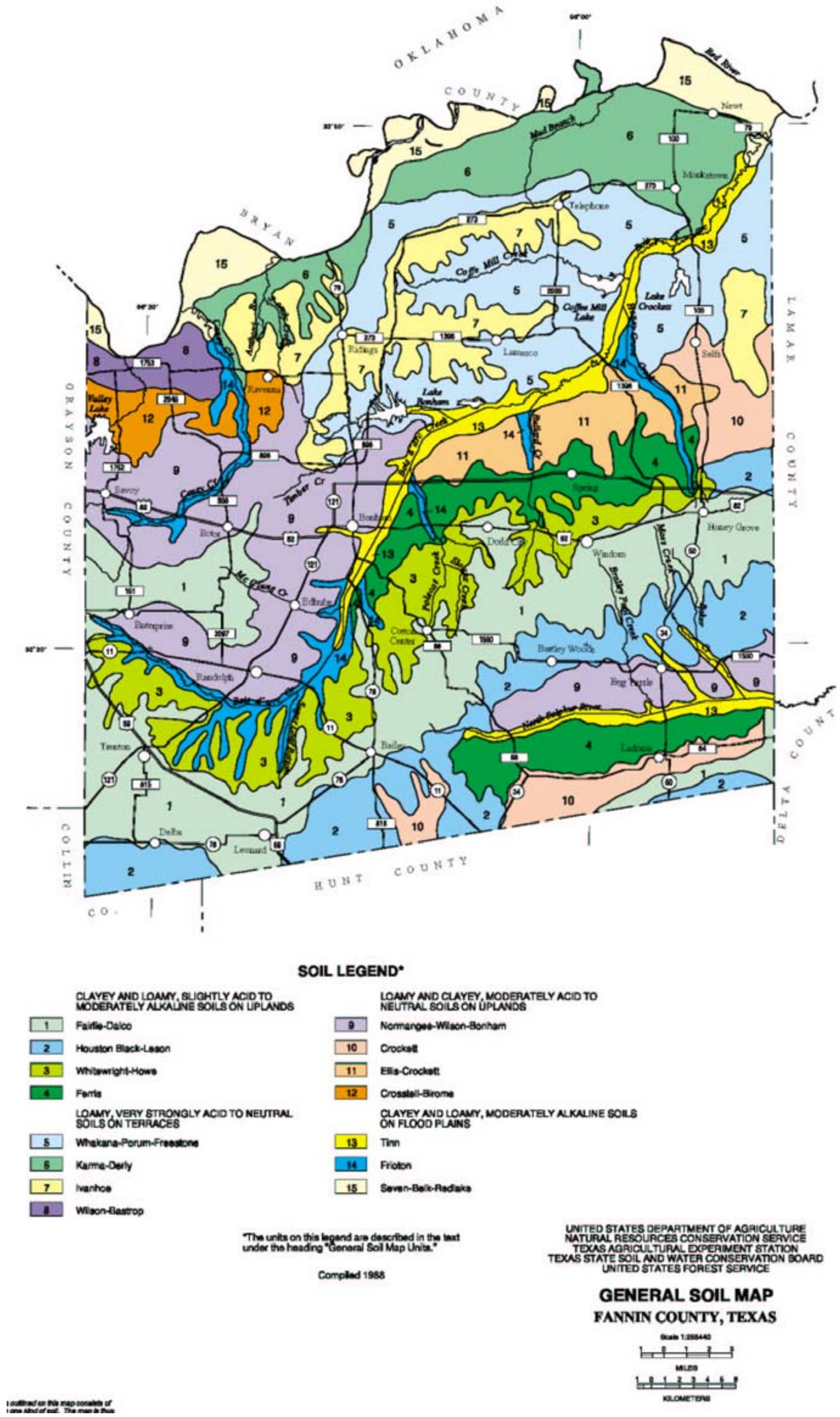

Figure 3.2a – General soil map of Fannin County, Texas

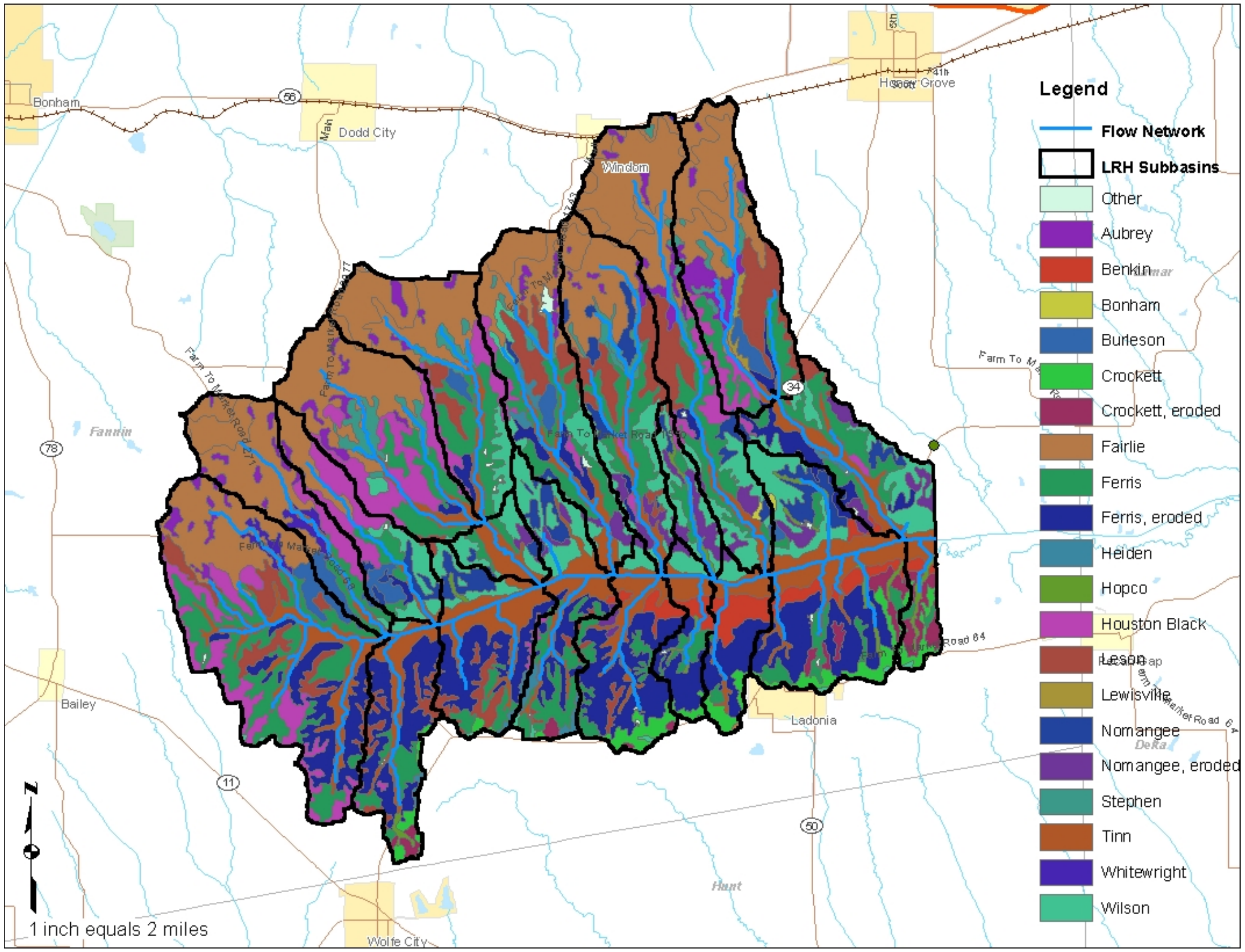

Figure 3.2b – Soil types encountered in the proposed Lake Ralph Hall drainage basin.

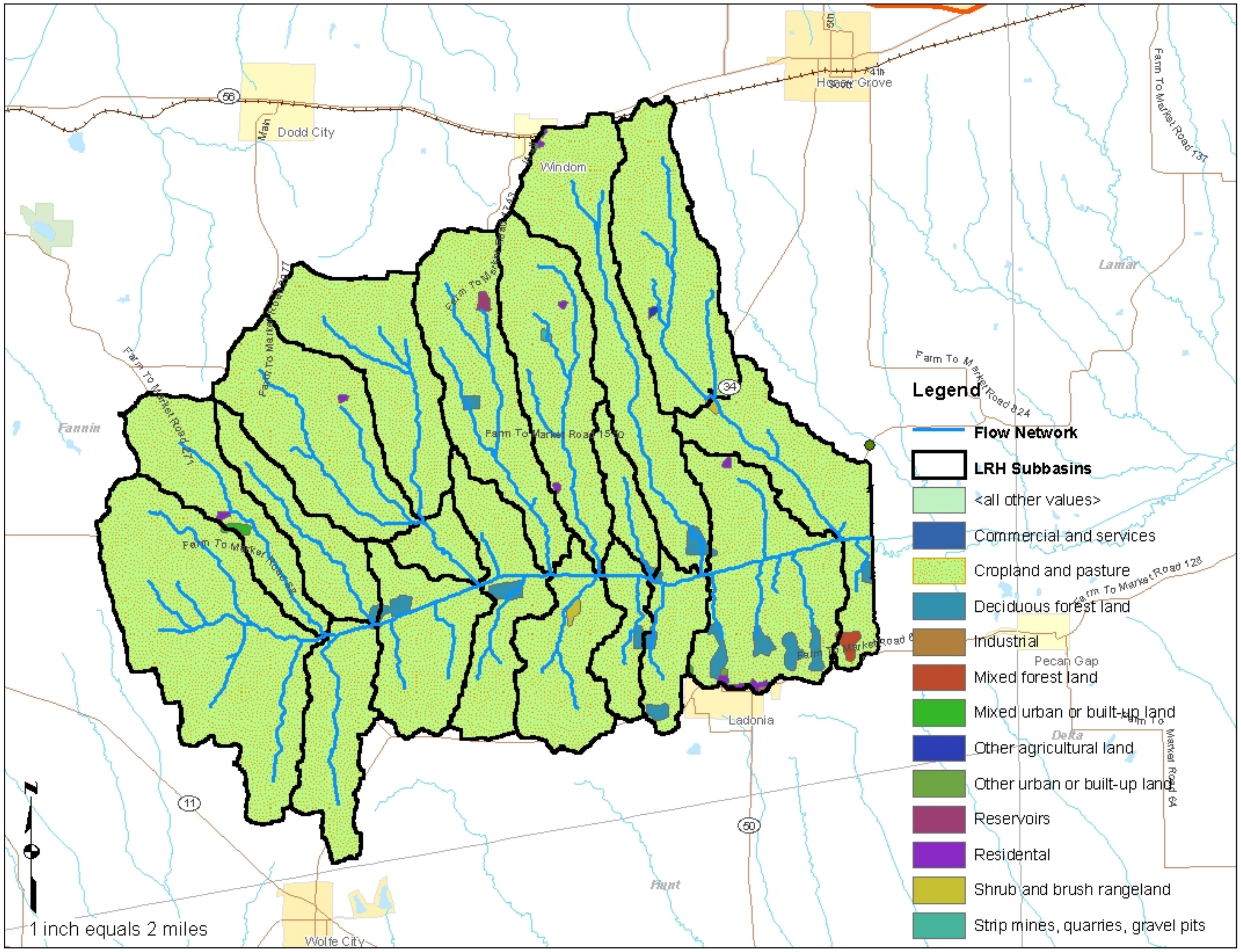

Figure 3.3 – Landuse types encountered in the proposed Lake Ralph Hall drainage basin.

3.2. CHANNEL SEDIMENTS

Sediment samples were collected in the Summer of 2005 and Spring of 2006 from the bed and banks of the North Sulphur River and its tributaries Samples were taken from representative locations to define size gradations of typical channel bed material, bank material, and any gravel bars or other coarse sediment sizes. Appendix B contains gradation results for the May 2006 sampling program. Figures 3.4 through 3.7 show the size compositions of these sediment mixtures.

In May of 2006 additional sediment data was collected from the upper reaches of the North Sulphur River from the bed and banks of the main-stem and the tributaries to supplement 2005 sample collection. The purpose of the 2005 sampling was to identify the variety of sediment transport mechanisms and potential in the river. The purpose of the 2006 sampling was to identify typical sediment characteristics. In 2005, data was collected at gravel bars and other coarse sediment deposits while in 2006 samples were taken at bed and bank locations that better represent typical conditions. The 2006 samples are composed of more fine material (silts and clays) than the 2005 samples. This is primarily due to the location of sampling. This analysis relies on the 2006 sediment sampling results because they are representative of sediment transport parameters typical in the watershed.

In general terms, 60 to 70 percent of channel sediments are composed of silts (30 to 40 percent) and clays (30 percent). The remaining coarser sediments are sands and gravels. The mean diameter of the coarser sediments is 1 mm (sand). In some study areas, all loose fine material has been washed away and coarse material remains in larger percentage than in other areas; the gravel bar near the FM 38 bridge is an example of this situation. The sediment size analysis shows that sediment supply to the North Sulfur River is mostly very fine, easily erodible material; only 10 to 15 percent of the sediment samples contain gravel size fractions. Soils in southeast Fannin County are clay-rich, derived mostly from shale and chalk bedrocks. The channel has eroded to bedrock in many areas. Once exposed, this material is subject to wetting and drying forces that quickly break the formation into fine materials (silts and clays) that are easily eroded away. This broken, eroded material was observed in every study area.

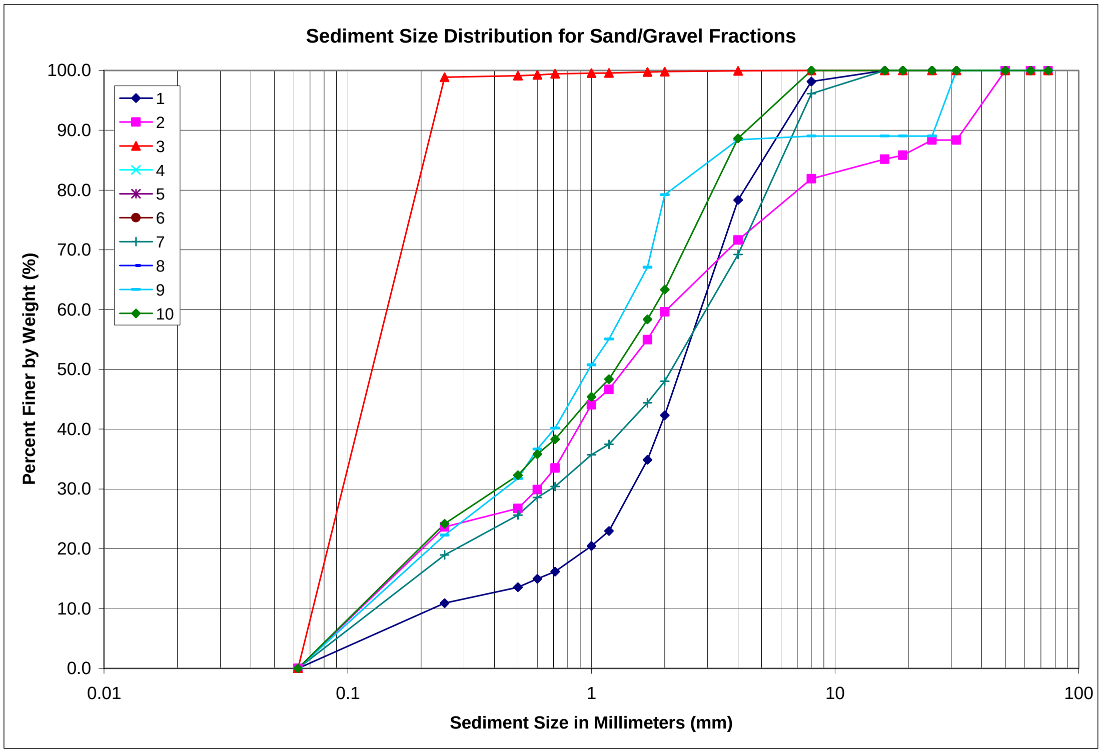

Figure 3.4 – Channel sediment size distributions from 2005 samples in the North Sulphur River for sand/gravel fractions

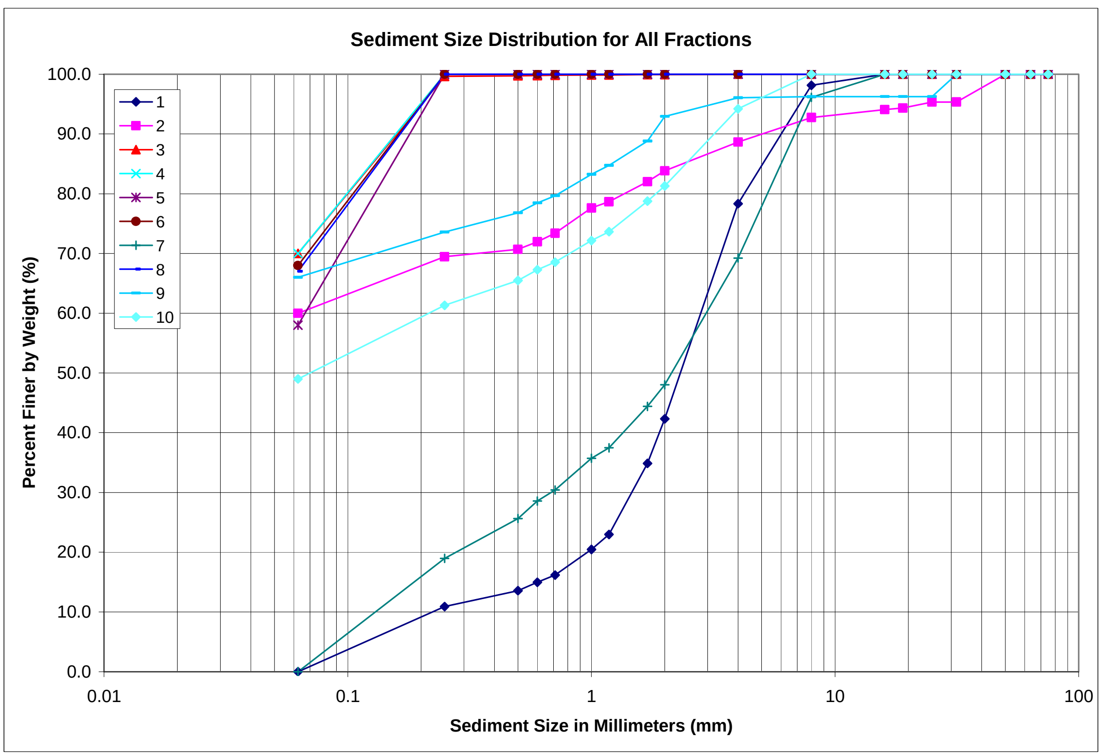

Figure 3.5 – Channel sediment size distributions from 2005 samples in the North Sulphur River for all size fractions.

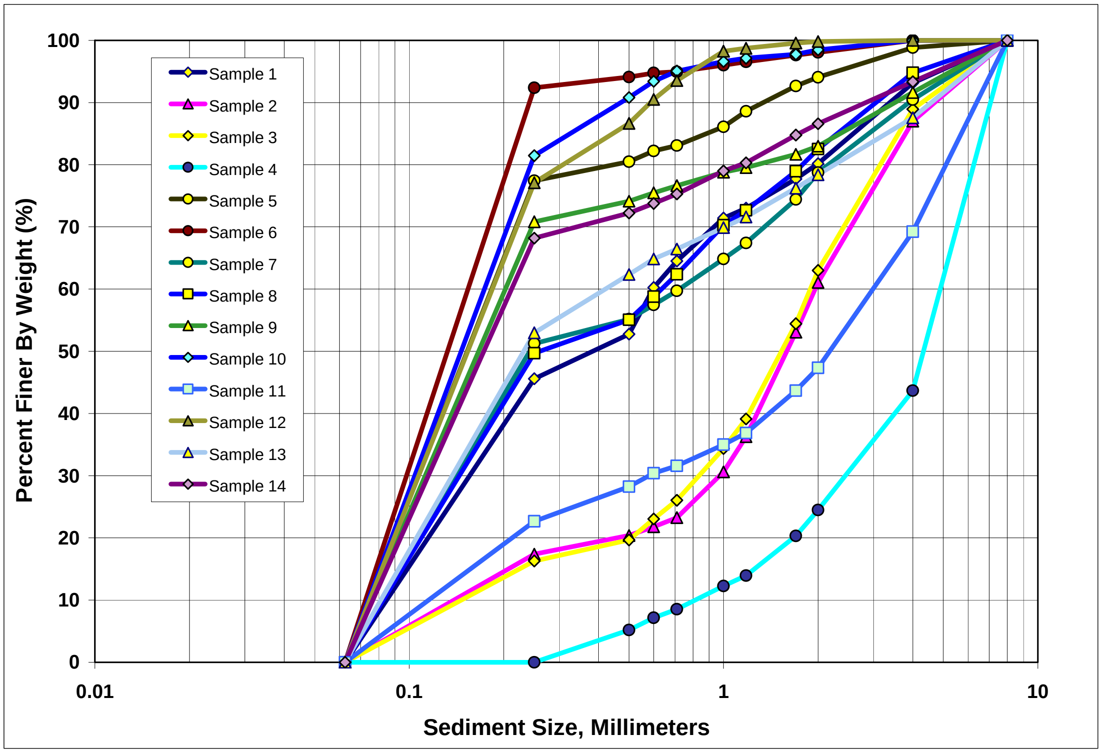

Figure 3.6 – Channel sediment size distributions from 2006 samples in the North Sulphur River for sand/gravel fractions.

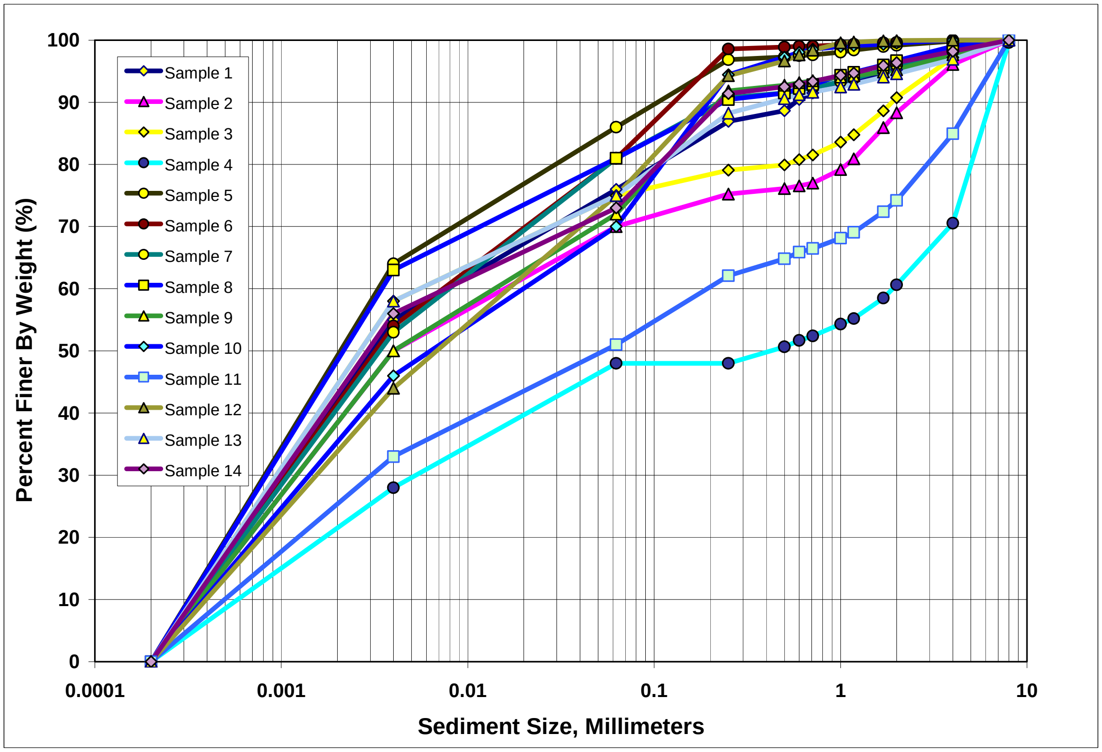

Figure 3.7 – Channel sediment size distributions from 2006 samples in the North Sulphur River for all size fractions.

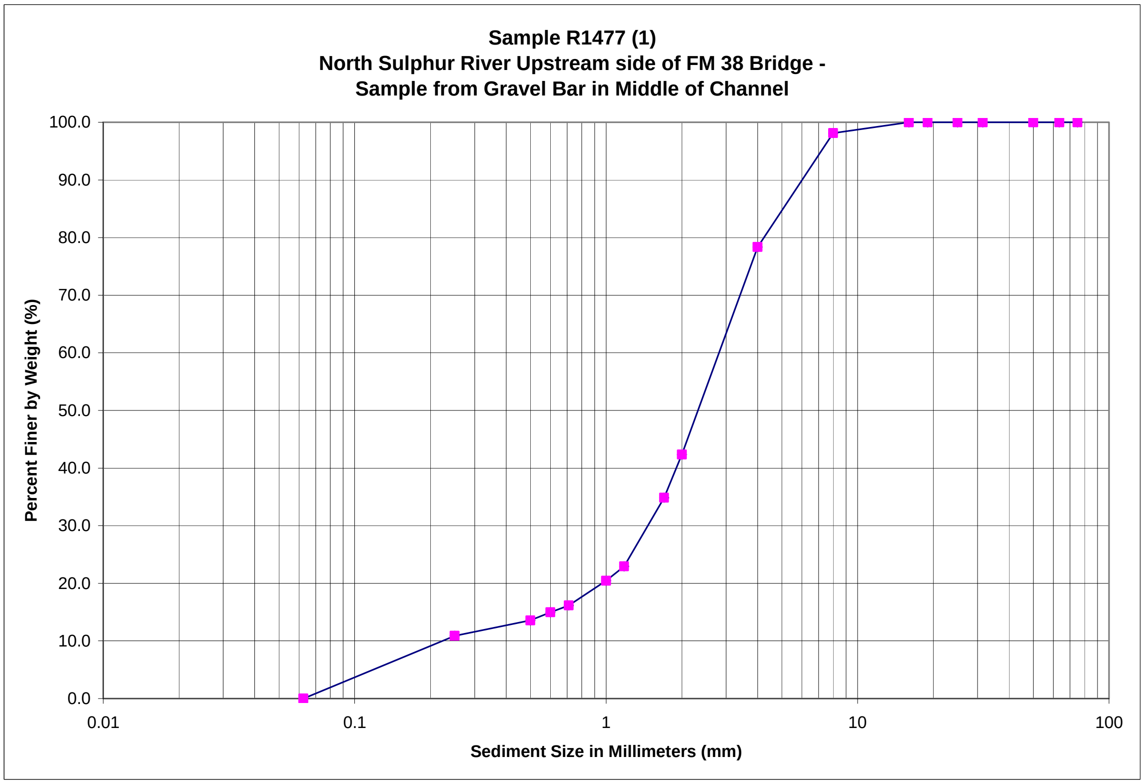

Figure 3.8 – Channel sediment size distribution from a gravel bar upstream of the FM 38 bridge site.

Based on these sediment sampling results, a single representative sediment size distribution is created and used along the reach modeled in this study. Table 3.1 lists the size fractions and percentages within each fraction. The D_{35} (sediment size for which 35 percent is finer by weight), D_{65}, and D_{90} of the sediment mixture are 0.16 mm, 0.70 mm, and 4.5 mm, respectively

Table 3.1 – Representative sediment size distribution

Size Group	Geometric Mean Diameter (millimeters)	Percent Present in Bed (%)
0.0625 – 0.25 mm	0.13 mm	53.0
0.2500 – 0.50 mm	0.35 mm	9.4
0.5000 – 1.00 mm	0.70 mm	7.5
1.0000 – 2.00 mm	1.41 mm	8.5
2.0000 – 8.00 mm	4.00 mm	21.6

Figure 3.9 is examples of sediment sources in the watershed such as the banks of the main channel and tributaries and surrounding farmland. Continued erosion from the tributaries is expected unless a program of channel stabilization is implemented.

The existing channel transport capacity exceeds the sediment supply so that all sediment inflow is transported downstream. The proposed reservoir would create a slow moving backwater upstream of the dam. This backwater area will reduce the channel transport capacity and produce sedimentation. However, this backwater will not extend far enough upstream to reduce the transport capacity at the sediment source. The tributaries will continue to erode and the watershed will continue to contribute sediment at a rate sufficient to reduce the reservoir life span.

Figure 3.9 – Sources of sediment

Figure 3.9 (continued)

3.3. HYDRAULIC PARAMETERS

Cross-sectional geometry and longitudinal geometry are both required physical parameters in a hydraulic analysis. To define these parameters, the KBR team surveyed the North Sulphur River and its tributaries in 2005 and 2006. These surveys are supplemented with TxDOT's measurements at the SH 34 and FM 38 bridge sites and by USGS topographic mapping from 1964.

Figures 3.10 through 3.14 show cross sections that represent the upper-most 20 miles of the North Sulphur River. In the cross section stationing, the downstream boundary (Station 0 ft) was chosen to be 6,912 ft below the FM 38 bridge. Cross section density is higher in the upper reaches of the North Sulphur River above the Lake Ralph Hall dam site where sediment computations are carried out. The proposed Lake Ralph Hall Dam is at Station 46,912 ft and the SH 34 bridge is at Station 59,300 ft. Channel bottom widths vary between 50 ft and 200 ft; depths range between 15 ft and 30 ft. The thalweg (lowest point in the cross section) profiles shown in Figures 3.15 and 3.16 indicate that the channel bottom slopes range from 0.001 at the downstream boundary to 0.005 at the upstream end of the river.

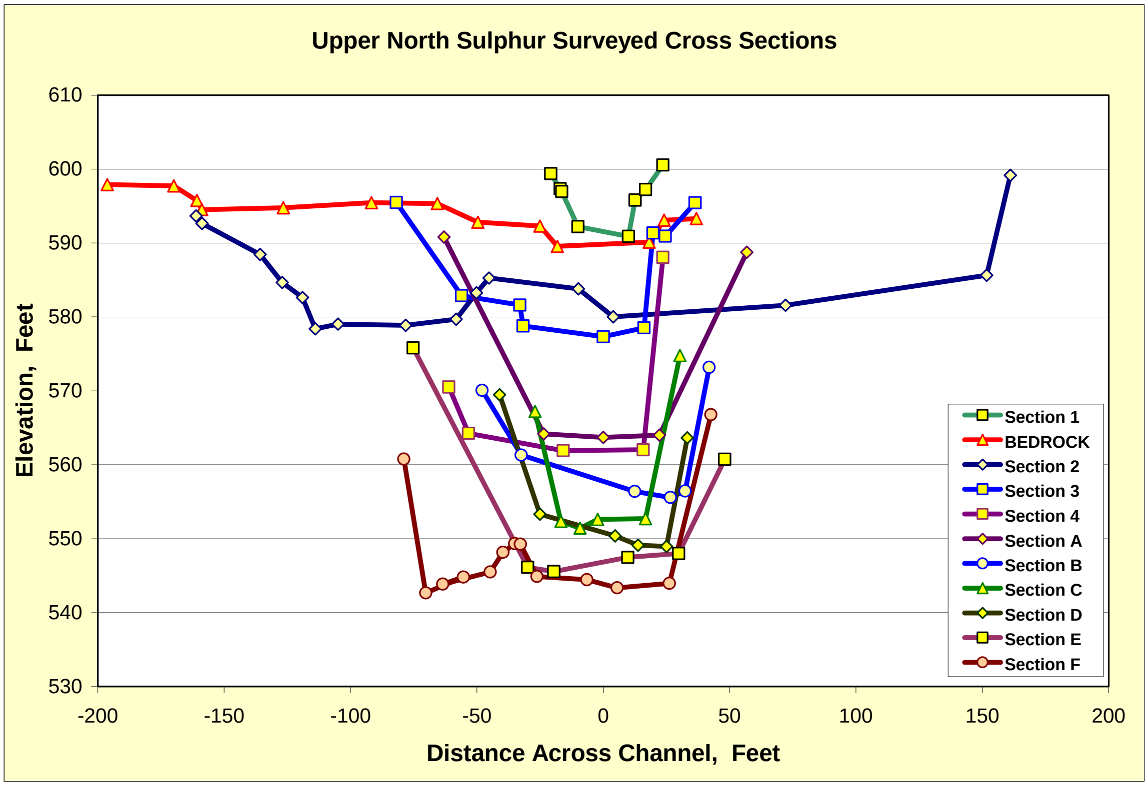

Figure 3.10 – Upper North Sulphur River, surveyed cross sections (Spring 2006).

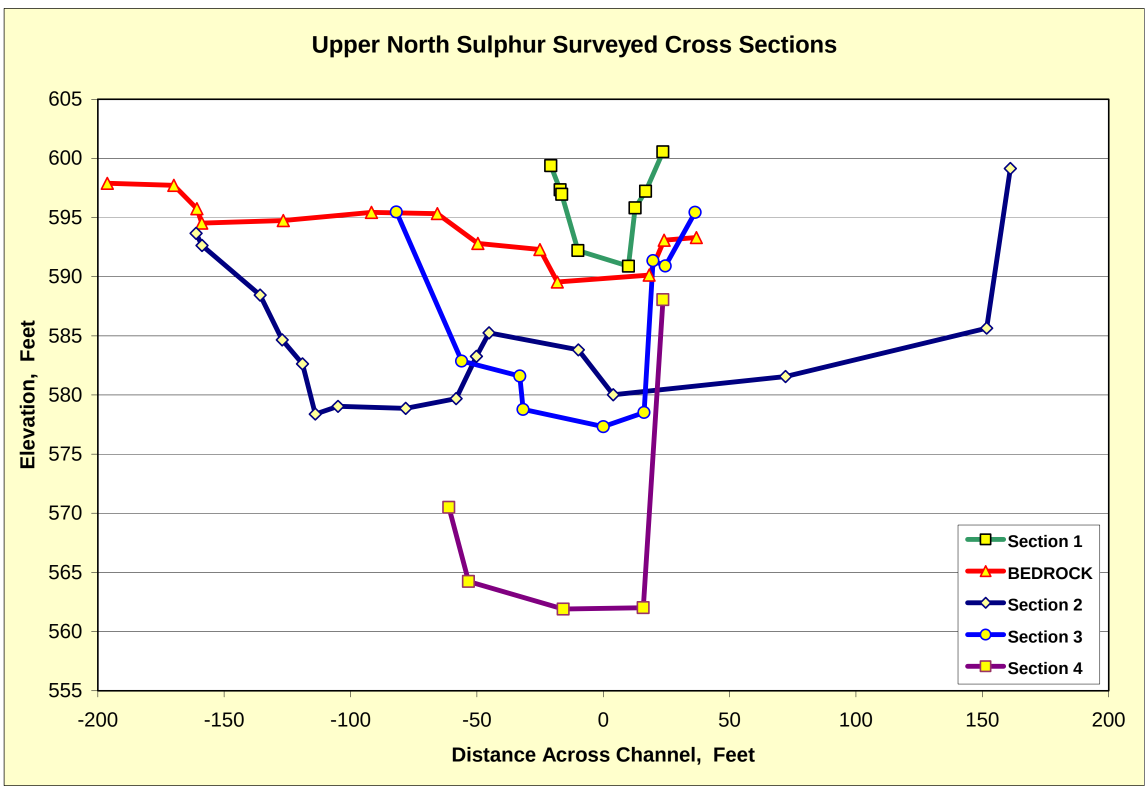

Figure 3.11 – Upper North Sulphur River, surveyed cross sections 1-4 (Spring 2006).

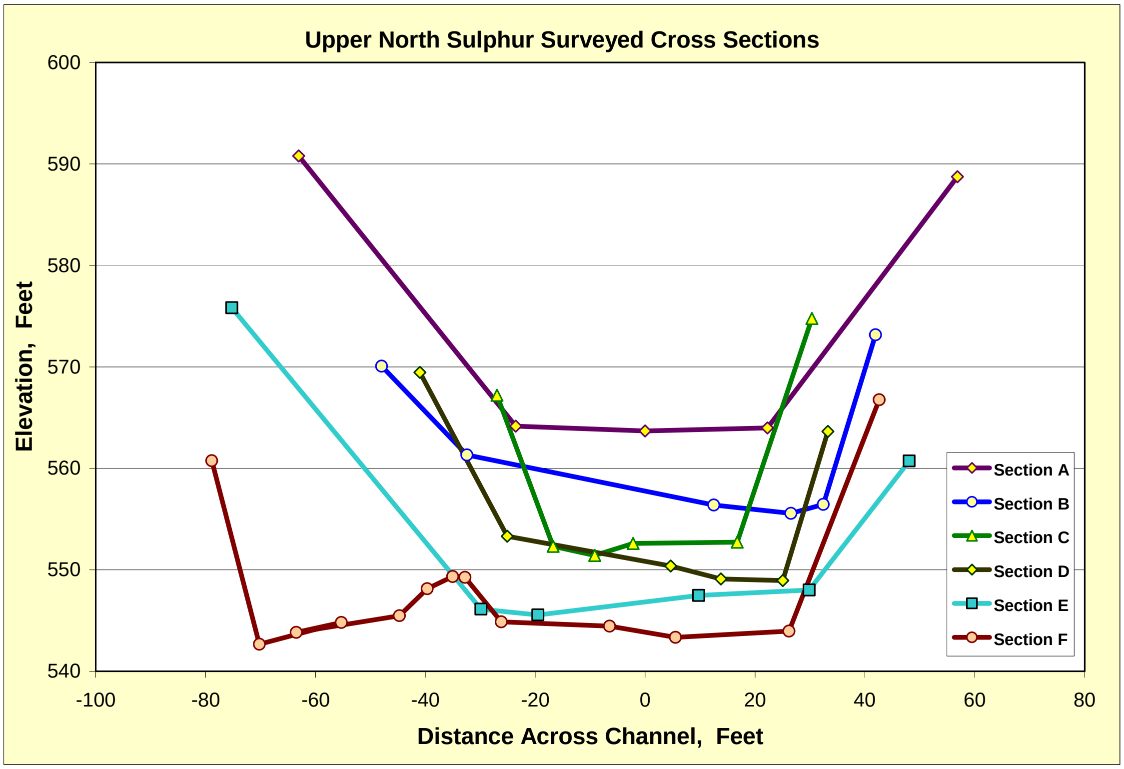

Figure 3.12 – Upper North Sulphur, surveyed cross sections A-F between sections 4 and 5 (Spring 2006).

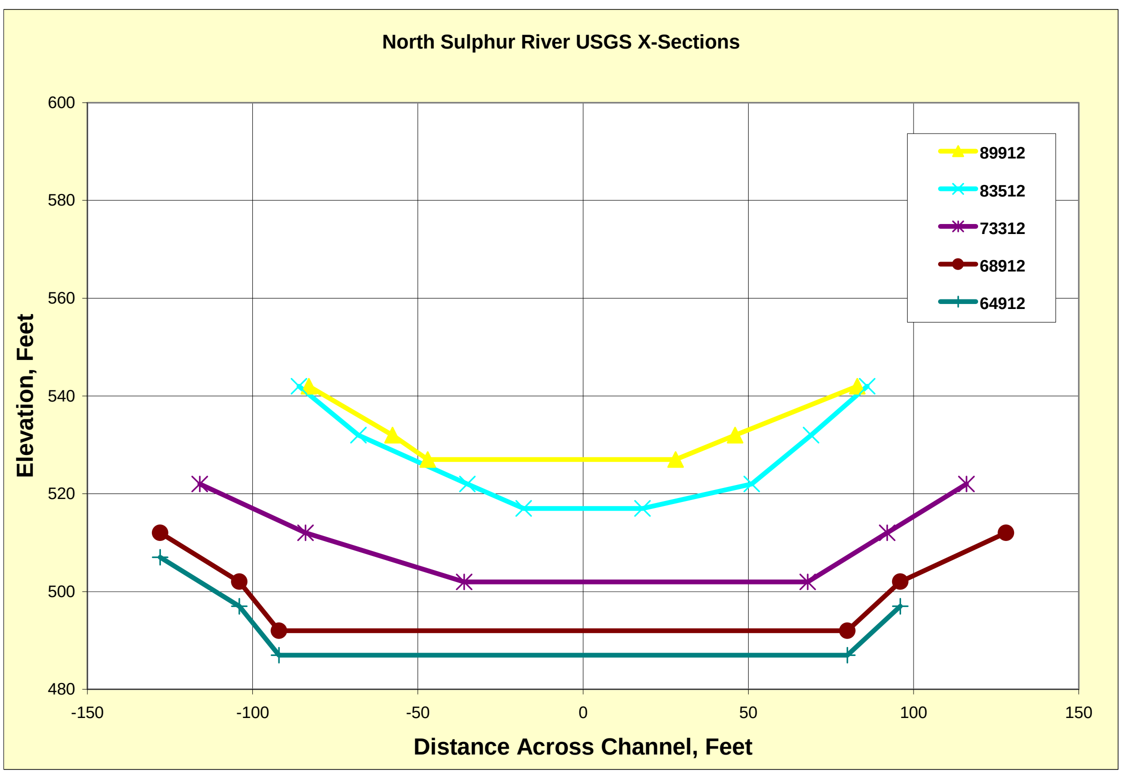

Figure 3.13 – Upper North Sulphur River, cross sections from USGS topographic maps between stations 89,912 ft and 64,912 ft.

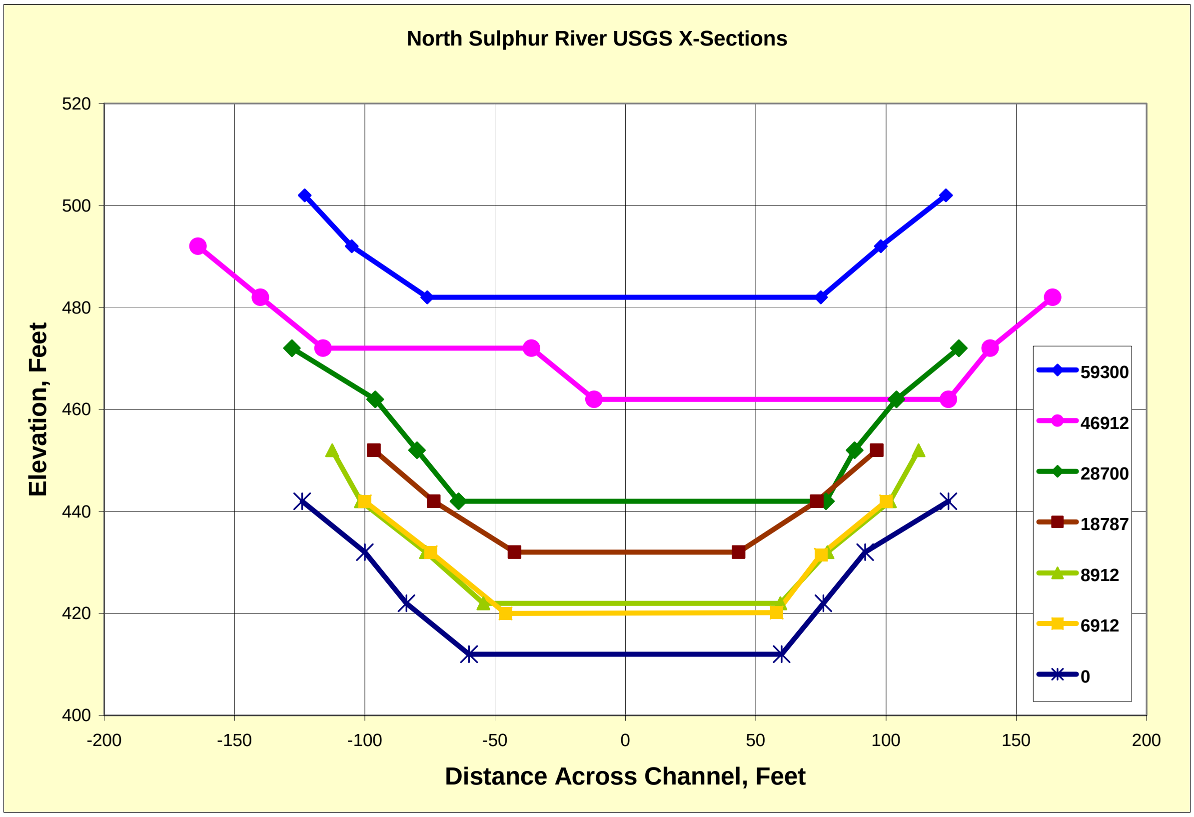

Figure 3.14 – Upper North Sulphur River, cross sections from USGS topographic mapping between stations 59,300 ft and 0 ft (the downstream boundary is below the FM 38 bridge).

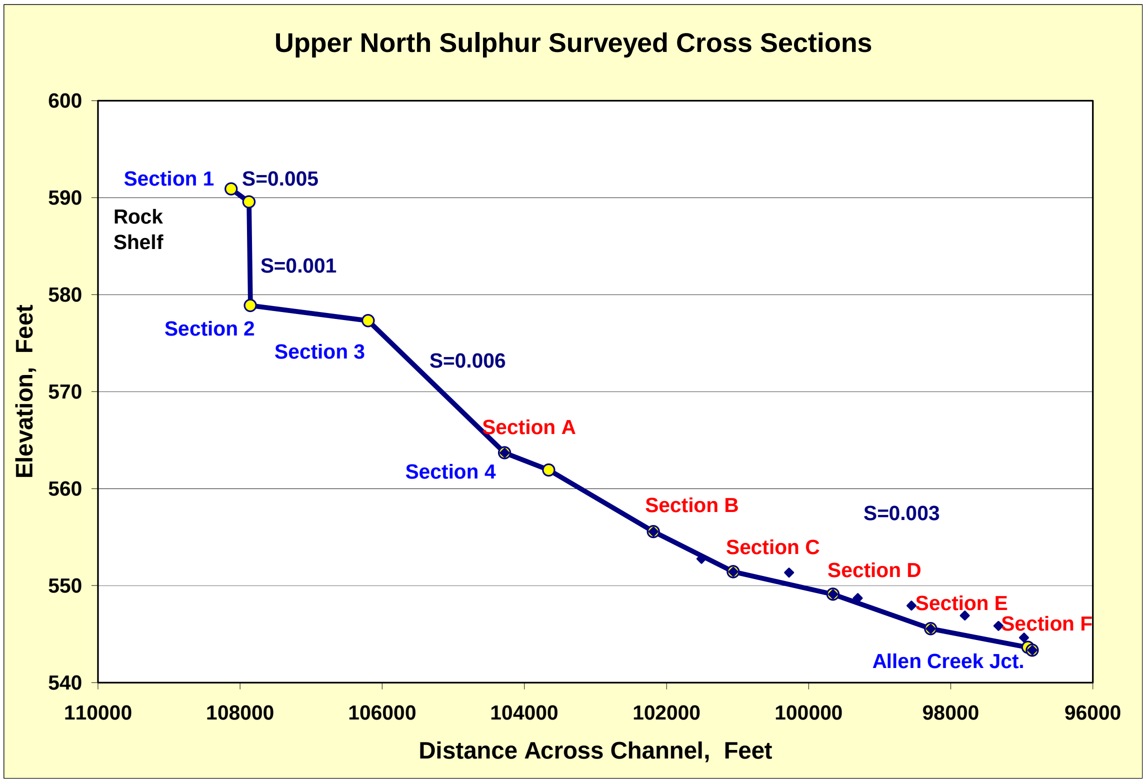

Figure 3.15 – Upper North Sulphur River, surveyed thalweg profile and stationing (Spring 2006).

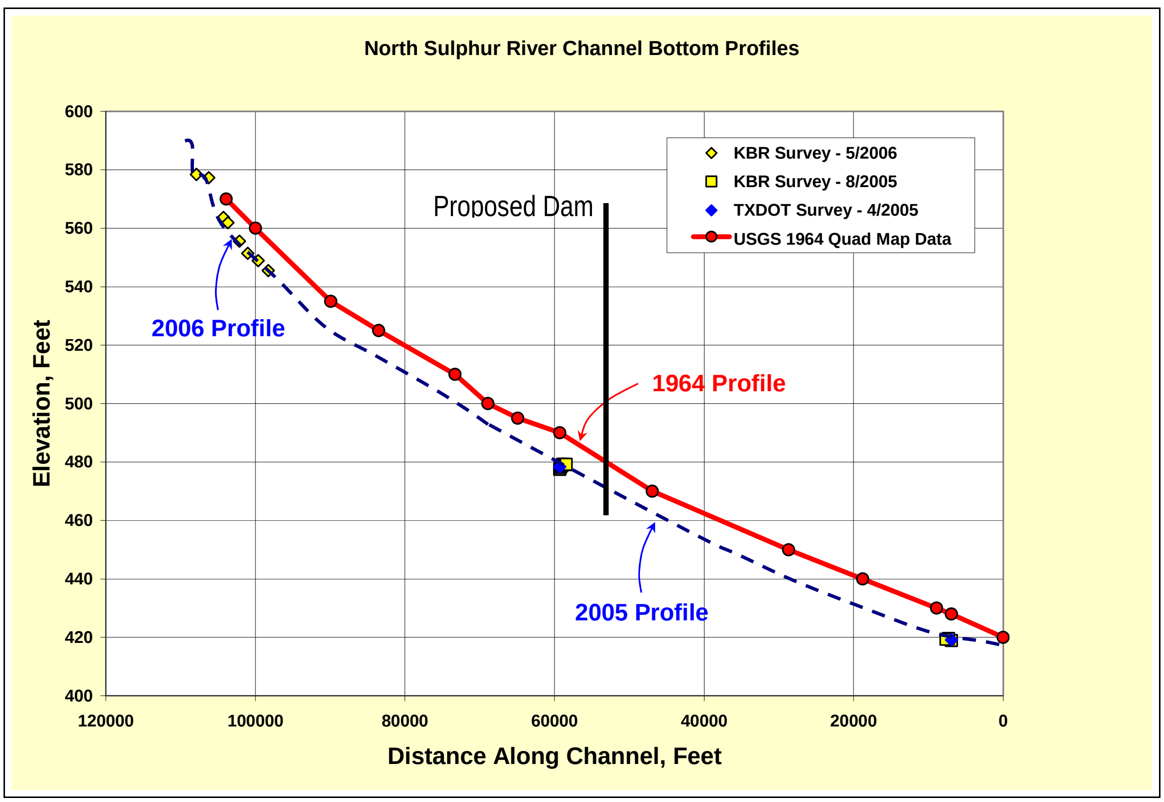

Figure 3.16 – North Sulphur River changes in thalweg profile between 1964-2006.

The North Sulphur River tributaries and their drainage basins upstream of the Lake Ralph Hall dam site are identified in Figures 2.3 and 2.4. As part of this analysis, the KBR team conducted a field survey of representative channel cross sections on some of these tributaries. Figure 3.17 shows these surveyed tributary channel cross sections. The geometric characteristics of these tributaries are summarized in Table 3.2 and Figure 3.18 and compared with the channel characteristics of the main stem North Sulphur River near Bridge BR 590 (Sections C and D) at the upstream boundary.

Table 3.2 – Major tributaries along the upper North Sulphur River and their characteristics

Name	Bottom Width (feet)	Top Width (feet)	Channel Depth (feet)	Side Slope (No. of horizontal units per unit vertical)
Allen Creeek (Middle)	57	70	10	1:1
Long Creek	50	140	22	2:1
Bralley Pool Creek	55	80	18	1.5:1
Pickle Creek	64	85	13	1.5:1
Brushy Creek	60	100	20	1:1
Davis Creek	48	120	21	1:1
North Sulphur at Section C	40	65	22	1:1
North Sulphur at Section D	55	80	20	1:1

From Table 3.2 and Figure 3.18, the average bottom width, top width, and depth for the surveyed tributaries are 55 ft, 100 ft, and 17 ft, respectively. These tributary channel characteristics closely match the upper North Sulphur River characteristics near BR 590. The average channel slopes along tributaries vary between 0.005 and 0.003. These slopes also closely match North Sulphur River bottom slopes along the upper reaches. Therefore, the hydraulic conditions encountered in the main stem upstream of the Allen Creek confluence are representative of the major tributary channels. Sediment computations using hydraulic parameters from the upper North Sulphur River are therefore also representative of the various sub-basin sediment production rates.

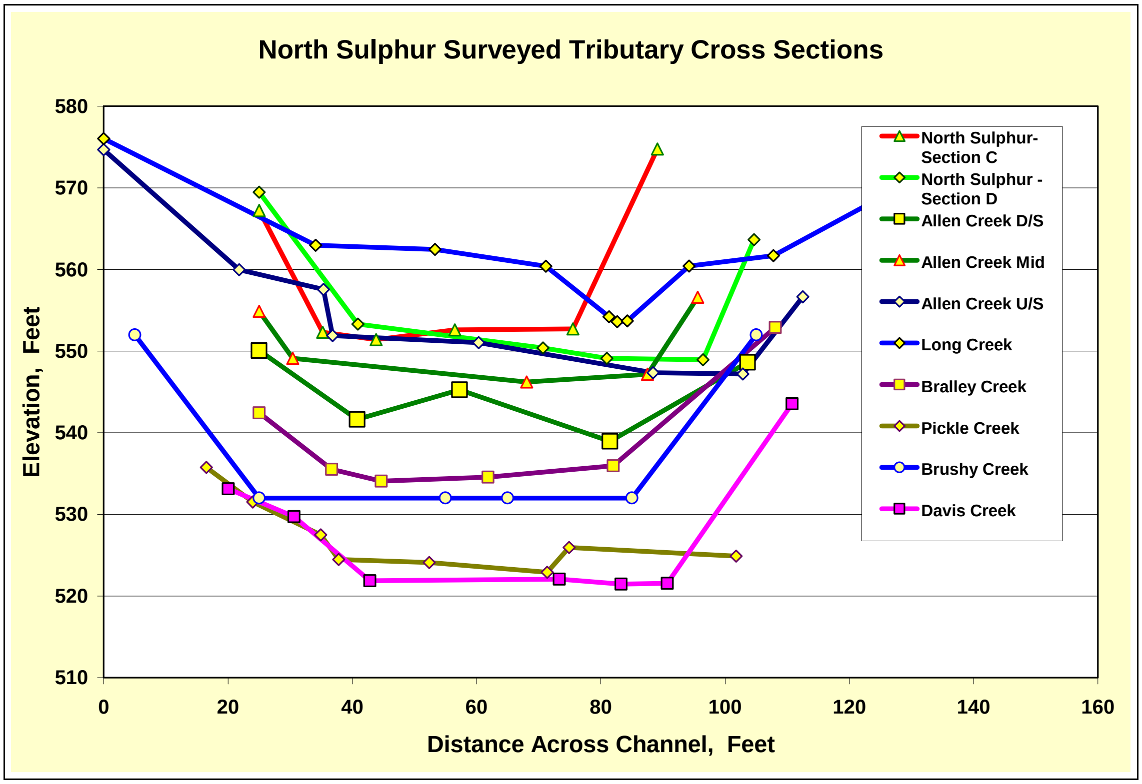

Figure 3.17 – Surveyed cross sections of several tributaries along the upper North Sulphur River above Lake Ralph Hall

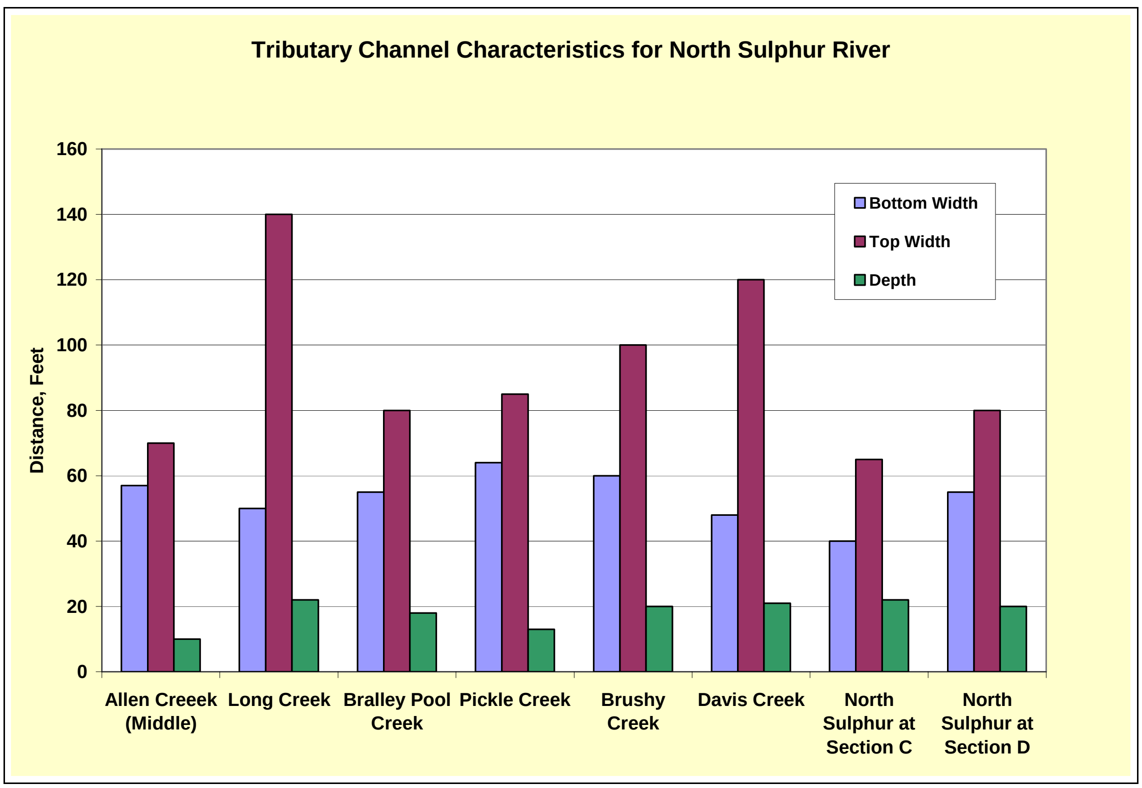

Figure 3.18 – Tributary channel characteristics along the upper North Sulphur River above Lake Ralph Hall

3.4. *SEDIMENT TRANSPORT METHODOLOGY*

This section describes the mechanics of calculating the probable annual sediment transport capacity above Lake Ralph Hall. First, the calculation of sediment supply is addressed. Second, the selected sediment transport equation is documented. Third, the methodologies used to compute annual sediment volumes are delineated.

In KBR's December 2005 "Lake Ralph Hall Sedimentation Potential Study", it was concluded that:

> "The channel has reached a semi-equilibrium state in some reaches and will stop downcutting and widening and will transition from braided to meandering in an attempt to minimize stream power. The tributaries to the upper reaches of the North Sulphur River are unstable and have headcutting, gully erosion, and widening that will continue for decades unless stabilized."

Construction of Lake Ralph Hall will alter sediment transport from the main reach of the North Sulphur River by inundating much of the main reach. However, the tributaries that deliver water and sediment to the main stem will continue to produce sediment inflow. It was determined that the most appropriate method of calculating sediment supply rates is to identify a reach in a semi-equilibrium condition. A reach in this condition is neither aggrading nor eroding and is therefore capable of transporting all sediment supplied. In other words, all of the sediment entering the reach is transported through and the channel is not eroding, an indication that the transport capacity exceeds the supply. Although it is possible that a reach can be sediment starved and not eroding, the North Sulphur River has an ample supply of erosive soils and would therefore not stay in this condition. Therefore, the transport capacity of this semi-equilibrium reach is equal to the sediment supply. For this analysis, a semi-equilibrium reach was identified upstream of Allen Creek on the North Sulphur River. The transport capacity of this reach was calculated using the two methods described below in this section. This section thalweg is above 560, above the conservation pool level of 551, and is therefore not inundated by the reservoir.

The primary source of sediment supply to Lake Ralph Hall will be from the tributaries (highly destabilized due to the channelization of the main stem), watershed, and river banks. Although the lake will inundate some of these supplies when full, it will inundate only a portion of the supply zones and it will not stay full—as the reservoir level fluctuates it will initiate erosion from zones destabilized by wetting and drying.

The sediment transport equation used in this analysis is chosen based on experience and applicability of the individual equations to the conditions in the Lake Ralph Hall watershed. The range of depths in the North Sulphur River classifies it as a medium size river. On average, flows are 5 to 10 feet deep. Alluvial sediment fractions that are present in soils forming the river bed and banks are predominantly fine sand and silt. Some gravel fractions are also present among the alluvial material. For fine sands and silts, Yang's (1973) and Yang, Molinas, and Wu's (1996) equations are the most applicable sediment transport equations (using standards given in Yang and Molinas, 1982). For the coarser gravel fractions, Yang's (1984) gravel equation is the most appropriate transport equation. These equations are used to compute sediment transport in the North Sulphur River.

3.4.1. *METHODOLOGY*

Two methods were used to compute the probable sediment volume transported to Lake Ralph Hall. These methods are described below.

Method 1

1. Using a series of 20,088 daily discharges at Lake Ralph Hall to represent 1949-2004, corresponding discharges are obtained for the upper-most sub-basin (Basin R1780W1150 in Figure 2.3) in the Lake Ralph Hall watershed. These discharges are computed using the area transformation derived from USGS regional equations to relate Lake Ralph Hall discharges to the 12.5 mi^2 upper sub-basin using the basin area ratio exponent of 0.57.
2. The BRI-STARS model was used to compute corresponding hydraulic parameters including velocities, slopes,

stream power values, depths, and shear velocities. Figure 3.19 shows typical water surface profiles along the North Sulphur River upstream of the Lake Ralph Hall dam site corresponding to a range of discharges.

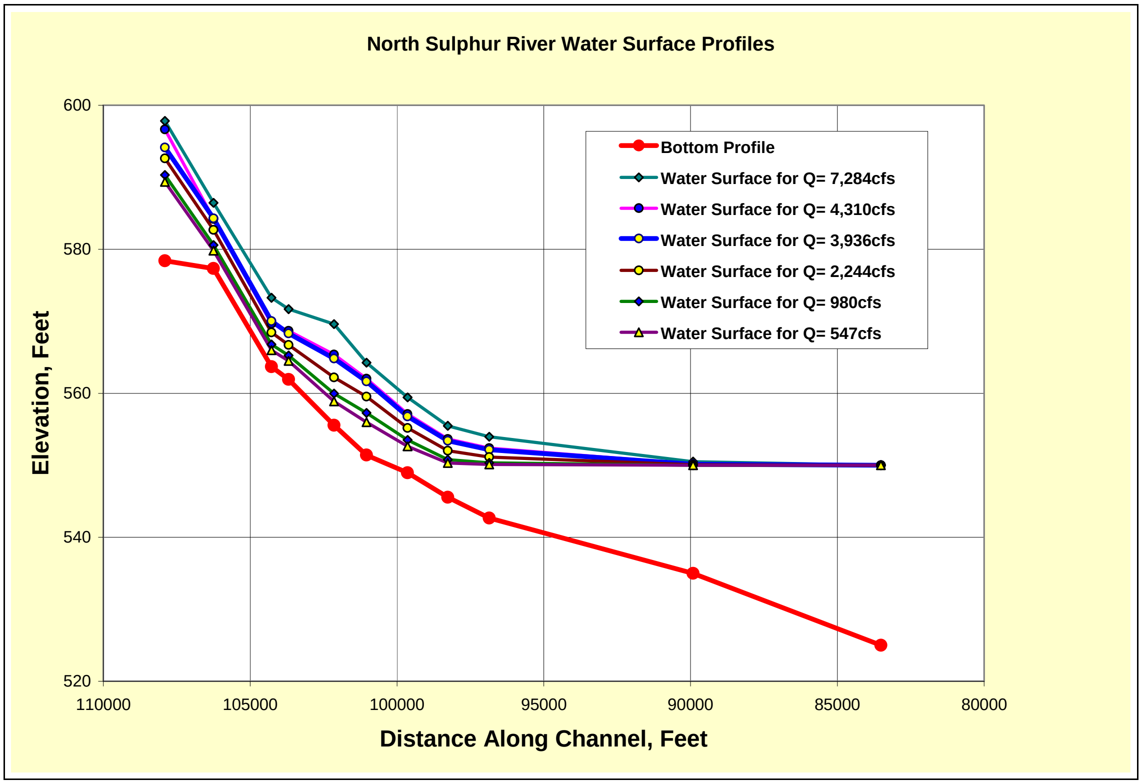

Figure 3.19 – Water surface profiles along the North Sulphur River upstream of Lake Ralph Hall

3. Using these 20,088 sets of hydraulic parameters and a representative sediment size distribution with 5 sand fractions, a series of sediment transport values are computed using the SEDQWK program (Hydrau-Tech, Inc) with Yang's (1973) and Yang, Molinas, and Wu's (1996) methods. The representative sediment mixture is given in Table 3.1; it is composed of 5 size fractions (4 sand fractions and one gravel fraction). The percentage of bed material within each fraction is shown in the third column of Table 3.1.
4. Sediment transport computations are carried out for each of the size groups as if the entire mixture consisted of a single size represented by the geometric mean diameter, D_m, of the size group $D_m = \sqrt{D_L - D_U}$, where D_L, D_U are the lower and upper bounds of the group, respectively. The corresponding sediment transport is then multiplied by the fraction available in the bed to arrive at a fractional load. Total sediment transport is the sum of the fractional loads. This method is identified in the literature as the bed material fraction method (Molinas, Wu, 2004). In this procedure, the sediment transport corresponding to sand size fractions is computed using Yang's (1973) or Yang, Molinas, and Wu's (1996) methods. For the gravel fraction, Yang's (1984) gravel equation is used.
5. An average daily sediment transport rate is computed corresponding to discharges below a set upper limit. This upper limit of discharge was set at 8,000 cfs, 10,000 cfs, and 12,000 cfs at the Lake Ralph Hall dam site (2,445 cfs, 3,057 cfs, and 3,667 cfs at the upper sub-basin, respectively) to reflect the low probability of occurrence for discharges higher than these during an "average-flow" year. As defined in Table 2.5, the number of days these flows occur in an "average-flow" year are 2.1, 0.4, and 0.2 respectively. These flows have a high probability of occurrence and are therefore statistically significant in this analysis.
6. The average daily fine sand and gravel transport is calculated, converted into yearly production, and expressed

in acre-feet of accumulated sediment volume per year.

7. Since it is determined that the sediments are 60-70% silts and clays, the transport of each unit of sand fraction is accompanied by 1.5 units of silt and clay. The units of sand transported are therefore multiplied by 2.5 to arrive at the total annual sediment transport.
8. The annual sediment production from the upper sub-basin is expressed as acre-feet of accumulated sediment volume. This quantity corresponds to approximately 30 percent of the total discharge [$(12.5\ mi^2/100\ mi^2)^{0.57}=0.3$]. Sediment production for the entire basin is determined by normalizing this sediment production rate to 100 percent (multiply by 1.0 / 0.3). Since the hydraulic characteristics of the tributaries delivering the sediment from various parts of the watershed are similar to the North Sulphur River above the Lake Ralph Hall dam, this extrapolation is rational.
9. The predicted service life of the reservoir is calculated as the reservoir volume divided by the yearly sediment transport.

Table 3.3 presents a summary of these computations at a few of the 20,080 days. In Table 3.3, the upper limit of discharge at the Lake Ralph Hall dam site beyond which transport is filtered out is 8,000 cfs (2,445 cfs at the upper sub-basin).

Method 2

1. Using 20,088 daily discharges corresponding to 1949-2004 discharges, the probability of occurrence of a series of five discharge ranges are determined. These are converted into an average yearly series as given in the Hydrology section. Corresponding discharges are then obtained for the upper-most sub-basin (Basin R1780W1150 in Figure 2.3) in the Lake Ralph Hall watershed. These discharges are computed using the area transformation derived from USGS regional equations to relate Lake Ralph Hall discharges to the 12.5 mi^2 upper sub-basin using the basin area ratio exponent of 0.57.
2. The BRI-STARS model is used to compute corresponding hydraulic parameters including velocity, slope, stream power, depth, and shear velocities.
3. Using the pre-selected discharge ranges with probability of occurrence values of 0.5 days or greater, sediment transport for each of the discharge ranges is determined for a representative sediment size distribution with 5 sand fractions, using the SEDQWK program (Hydrau-Tech, Inc) with Yang's (1973) and Yang, Molinas, and Wu's (1996) methods. The representative sediment mixture is given in Table 3.1; it is composed of 5 size fractions (4 sand fractions and one gravel fraction). The percentage of bed material within each fraction is shown in the third column of Table 3.1.
4. Sediment transport computations are carried out for each of the size groups as if the entire mixture consisted of a single size represented by the geometric mean diameter, D_m, of the size group $D_m = \sqrt{D_L - D_U}$, where D_L, D_U are the lower and upper bounds of the group, respectively. The corresponding sediment transport is then multiplied by the fraction available in the bed to arrive at a fractional load. Total sediment transport is the sum of the fractional loads. This method is identified in the literature as the bed material fraction method (Molinas, Wu, 2004). In this procedure, the sediment transport corresponding to sand size fractions is computed using Yang's (1973) or Yang, Molinas, and Wu's (1996) methods. For the gravel fraction, Yang's (1984) gravel equation is used.
5. In computing the sediment transport corresponding to each discharge range, the sediment transport for the lower and upper bounds of the discharge group are first computed [Q_{si}, Q_{si+1}] and then the average of the two sediment transport values is assigned to represent transport for the range.

   Mathematically, sediment transport for the size range [Q_i, Q_{i+1}] is:

$$\overline{Q_{si}} = \frac{(Q_s)_i + (Q_s)_{i+1}}{2}$$

6. Sediment transport for each water discharge group is multiplied by the number of days of occurrence per year and the product of each group is summed to arrive at the yearly sediment transport average.

7. Since it is determined that the sediments are 60-70% silts and clays, the transport of each unit of sand fraction is accompanied by 1.5 units of silt and clay. The units of sand transported are multiplied by 2.5 to arrive at the total annual sediment transport.
8. The predicted service life of the reservoir is calculated as the reservoir volume divided by the yearly sediment transport.

Table 3.4 presents a summary of the sediment transport computations for the ranges of discharges used in Method 2 and the corresponding number of days of occurrence per year as identified in the Hydrology Section. This table was prepared following the procedure outlined above using Yang's (1973) and (1984) equations. Depending on the upper range of discharges included in the analysis, the computed service life of the reservoir shows a range of variability. Table 3.4 was prepared using 12,000 cfs at the Lake Ralph Hall dam site as the maximum daily flow occurring on average 0.2 days per year.

Table 3.3 – Summary of results of sediment transport computations for Lake Ralph Hall using daily flows (Method 1)

Days from Start	Total Sand/Gravel Load, Q_T in Tons/Day	Qs for Fraction 0.06-0.25mm in Tons/Day	Qs for Fraction 0.25-0.50mm in Tons/Day	Qs for Fraction 0.50-1.0mm in Tons/Day	Qs for Fraction 1.0-2.0mm in Tons/Day	Qs for Fraction 2.0-8.0mm in Tons/Day	Discharge in cfs	Total Sand/Gravel Load, Q_T in Tons/Day
1	0	0	0	0	0	0	10	0
2	0	0	0	0	0	0	10	0
3	0	0	0	0	0	0	10	0
4	0	0	0	0	0	0	10	0
5	0	0	0	0	0	0	10	0
6	0	0	0	0	0	0	19	0
7	0	0	0	0	0	0	10	0
8	0	0	0	0	0	0	10	0
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
22	0	0	0	0	0	0	13	0
23	22554	20882	769	367	327	210	511	22554
24	26	23	1	1	0	0	43	26
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
101	8658	7934	305	150	137	132	312	8658
102	1	1	0	0	0	0	24	1
103	105883	99034	3457	1591	1382	419	1325	105883
104	118963	111329	3874	1779	1543	438	1432	118963
105	191	171	8	4	4	5	72	191
106	1711	1531	64	33	31	52	159	1711
107	99	90	4	2	2	0	59	99
108	0	90	4	2	2	0	18	0
109	0	90	4	2	2	0	17	0
.	.	.	.	.	.	.	.	.

Table 3.3 (cont.)

Days from Start	Total Sand/Gravel Load, Q_T in Tons/Day	Qs for Fraction 0.06-0.25mm in Tons/Day	Qs for Fraction 0.25-0.50mm in Tons/Day	Qs for Fraction 0.50-1.0mm in Tons/Day	Qs for Fraction 1.0-2.0mm in Tons/Day	Qs for Fraction 2.0-8.0mm in Tons/Day	Discharge in cfs	Total Sand/Gravel Load, Q_T in Tons/Day
113	0	90	4	2	2	0	10	0
114	0	90	4	2	2	0	10	0
115	0	90	4	2	2	0	10	0
116	0	90	4	2	2	0	10	0
117	0	90	4	2	2	0	10	0
118	0	90	4	2	2	0	10	0
119	0	90	4	2	2	0	10	0
120	0	90	4	2	2	0	10	0
121	0	90	4	2	2	0	10	0
122	249692	234432	7982	3611	3091	576	2351	249692
123	187341	175676	6035	2747	2364	519	1941	187341
124	24020	22251	817	389	347	217	529	24020
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
20083	0	3	0	0	0	0	10	0
20084	0	3	0	0	0	0	10	0
20085	0	3	0	0	0	0	10	0
20086	0	3	0	0	0	0	10	0
20087	0	3	0	0	0	0	10	0
20088	0	3	0	0	0	0	10	0
							Average Q_T (Tons/Day):	1857
							Average Q_T (Acre-ft/Year):	311

Table 3.4 – Summary of results of sediment transport computations for Lake Ralph Hall using ranges of discharges and the corresponding number of days per year from statistical analysis of daily flows (Method 2)

Discharge Increment No.	Upper Bounds of Discharge Range* in cfs	Total Sediment Load in Tons/Day	Qs for Fraction 0.06-0.25mm in Tons/Day	Qs for Fraction 0.25-0.50mm in Tons/Day	Qs for Fraction 0.50-1.0mm in Tons/Day	Qs for Fraction 1.0-2.0mm in Tons/Day	Qs for Fraction 2.0-8.0mm in Tons/Day	Measured Discharge in cfs	Number of Days per Year	Yearly Sediment Load (Integrated) in Tons
1	2	0	0	0	0	0	0	0	156	0
2	31	11	10	0	0	0	0	35	159.6	878
3	122	930	825	36	19	18	34	125	25.6	12,045
4	306	10,435	9,585	365	179	162	144	342	11	62,508
5	611	30,967	28,746	1,044	493	437	247	611	6.6	136,627
6	1,223	96,318	90,045	3,152	1,453	1,265	403	1,247	3.3	210,020
7	2,445	278,509	261,607	8,876	4,005	3,420	601	2,529	2.1	393,568
8	3,057	366,366	344,525	11,577	5,190	4,405	668	3,028	0.4	128,975
9	3,668	477,312	449,354	14,948	6,658	5,614	738	3,598	0.2	84,368
								TOTALS:	**364.8**	**1,028,988** (472 acre-ft)

*Upper bounds of discharge ranges correspond to 7, 100, 400, 1000, 2000, 4000, 8000, 10000, and 12000 cfs at LRH dam site, respectively.

3.5. RESULTS

Table 3.5 presents the average yearly sediment transport production based on Method 1 calculations for sand and gravel fractions using daily discharges between 1949 and 2004. Similarly, Table 3.6 presents the average yearly sediment transport production based on Method 2 calculations for sand and gravel fractions using the ranges of average daily discharges encountered between 1949 and 2004.

The service life computations in the following tables are based on the primary assumption that *all* sediment sizes transported to the reservoir are trapped permanently by the reservoir. This assumption recognizes that the reservoir service life can be extended by sediment control measures such as grade control structures, sediment detaining facilities upstream of the reservoir, and proper reservoir operations to flush sediments through the reservoir and to prevent settling of fine sediments. Therefore, these calculations represent the shortest probable reservoir life based on sediment transport potential. An analysis of reservoir operational schemes and other control measures needed to extend the reservoir service life is not in the scope of this analysis. However, this study recommends such an analysis be carried out.

Table 3.5 – Estimated service life of Lake Ralph Hall using Method 1 for different maximum yearly discharges.

Upper Discharge Limit in (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume in Acre-ft	Service Life In Years (including all sediment fractions)
8,000	1,018	1,527	160,000	63
10,000	1,220	1,830	160,000	52
12,000	1,313	1,970	160,000	49

Table 3.6 – Estimated service life of Lake Ralph Hall using Method 2 for different maximum yearly discharges.

Upper Discharge Limit in (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume in Acre-ft	Service Life in Years (including all sediment fractions)
8,000	1,225	1,837	160,000	52
10,000	1,419	2,128	160,000	45
12,000	1,546	2,319	160,000	41

In arriving at these values, the following assumptions were made:

1. The 55 years of daily flows provide a reasonable basis for calculating an average flow year.
2. Low-probability occurrence events (such as the 25-, 50-, and 100-year events) were excluded from this analysis because they do not represent an average year condition. However, these events have high sediment production rates and could impact the reservoir service life.
3. Along the modeled reach, a single representative sediment size distribution is used. This distribution is defined in Table 3.1 and represents a typical distribution of the 2006 sampling.

4. Total sediment transport is computed by summing the fractional loads. This method is identified in the literature as the bed material fraction method (Molinas, Wu, 2004)
5. Sediment transport for the entire mixture is computed by multiplying the transport for the sand fractions by 2.5. This is based on the distribution of sands (40%) and silts and clays (60%) in the Lake Ralph Hall watershed.
6. Fine sand transport computations are repeated using the Yang, Molinas, Wu (1996) equation. These computations result in approximately the same range of service lives.

3.6. REGIONAL TRENDS

This study investigated regional trends in reservoir sedimentation rates to provide a comparative tool and to couch results in a regional context. In general terms, reservoirs drain water and sediment from watersheds and act as a sink point for the transported sediments. Excluding the effects of dredging and flushing, an analysis of reservoir storage volumes through time reveals sediment accumulation trends experienced in each drainage basin.

Rapid loss of reservoir volume is the result of intense watershed sediment erosion. Factors that influence this rate of erosion are: soil type, watershed slope, runoff potential, landuse, changes in landuse and vegetative conditions, and changes in the drainage network. It is possible to relate the accumulated sediment volumes over time to reservoir volumes, yielding an average yearly percent accumulation. The inverse of this quantity gives the estimated service life of the reservoir, or:

$$\textit{Service Life of Reservoir} = (\textit{Percent Yearly Sediment Accumulation})^{-1} \qquad (1)$$

It is also possible to estimate the average yearly watershed sediment production per unit area by dividing the average yearly volume of sediment accumulation in the reservoir by the watershed area. This quantity, expressed as acre-feet of sediment per year per square mile of watershed, is a measure of the erosion potential of the watershed and should be based on long-term records. In computing the sediment erosion rates from watersheds using volumetric reservoir surveys, it is important to have long-term records and to account for any sediment removal (by dredging or flushing) from the reservoir.

Reservoirs in Northeastern Texas are shown in Figure 3.20. The sediment accumulation characteristics of these reservoirs using volumetric survey data published by the Texas Water Development Board (TWDB) are presented in Tables 3.7 and 3.8. This data shows that sediment production rates for these reservoirs do not generally cause a substantial reduction in service life. However, the results from Lake Ralph Hall differ significantly from this conclusion. The following list of factors offers a possible explanation for this difference:

- The results of this study represent the shortest probable reservoir life based on sediment transport potential and exclude the reduction in sedimentation that can be achieved through reservoir operations and other sediment control and conservation measures. Regional results do reflect the benefits gained from these measures.
- The North Sulphur River is unique from other reservoirs in northeastern Texas because of its history of channelization and incising. It is a destabilized drainage network (both main stem and tributaries) that produces a much higher rate of sediment than more stable reaches in comparable watersheds.
- Soils in the Lake Ralph Hall watershed are highly erosive. However, a comparison of soil types between the Lake Ralph Hall watershed and regional watersheds was not part of this study.
- Difference in sedimentation rates can be attributed to differences in landuse, changing landuse, watershed cover type, watershed slope, and drainage network characteristics.

Because any combination of these factors may be the cause of low sediment accumulation and long service life of these reservoirs, it is not a given that all reservoirs in this region will be prone to low sediment production or long service life, nor is the data indicative that the region in and of itself produces low sediment accumulation. Rather, watershed specific analyses are needed to predict individual reservoir sedimentation rates. This study represents that specific analysis for the Lake Ralph Hall watershed and concludes that reservoir sedimentation rates are higher in this region.

Table 3.7 – Sediment erosion rates in the northeastern region of Texas.

No.	Reservoir Name	Conservation Storage Capacity (Acre-Feet)	Number of Years	Volume of Sediment Accumulation (Acre-Feet)	Area of Drainage Basin (sq. miles)	Average Sediment Yield (ac-ft/yr/sq. mi)
1	Wright Patman Reservoir	110,900	41	34,447	3400	0.25
2	Lake Tawakoni	888,140	37	47,729	756	1.71
3	Lake Bob Sandlin	200,579	20	10,557	239	2.21
4	Lake Cypress Springs	67,690	46	5,095	75	1.48
5	Lake O' The Pines	238,933	39	15,251	880	0.44
6	Lake Fork	604,927	15	31,838	493	4.31
7	Lake Crook	9,195	47	756	52	0.31
8	Lake Bonham	11,026	35	830	29	0.82

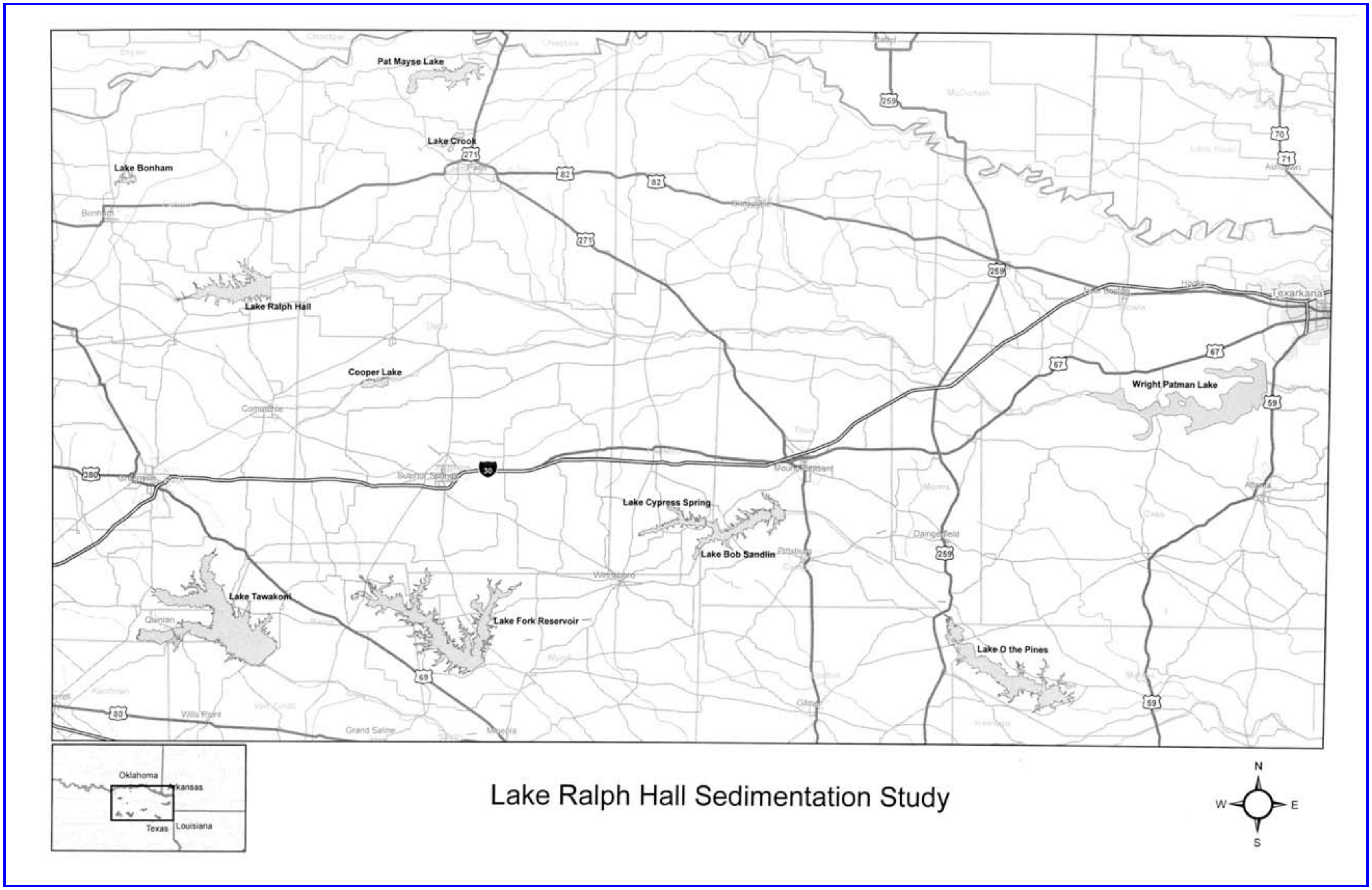

Figure 3.20 – Reservoirs in the northeastern portion of Texas.

Table 3.8 – Volumetric surveys of reservoirs in the northeastern region of Texas.

Number	Reservoir Name	TWDB Survey Date	Conservation Storage Capacity (Acre-Feet)	Last Survey Date	Number of Years	Percent Change in Storage Capacity Since Last Survey	Percent Change per Year	Storage from Prior Survey (Acre-Feet)	Reduction in Storage (Acre-Feet)
1	Wright Patman Reservoir	Jan-97	110,900	1956	41	-23.70%	-0.58%	145,347	34,447
2	Lake Tawakoni	Apr-97	888,140	1960	37	-5.10%	-0.14%	935,869	47,729
3	Lake Bob Sandlin	Feb-98	200,579	1978	20	-5%	-0.25%	211,136	10,557
4	Lake Cypress Springs	Apr-98	67,690	1952	46	-7%	-0.15%	72,785	5,095
5	Lake O' The Pines	Oct-98	238,933	1959	39	-6%	-0.15%	254,184	15,251
6	Lake Fork	Jan-01	604,927	1986	15	-5%	-0.33%	636,765	31,838
7	Lake Crook	Jun-03	9,195	1956	47	-7.60%	-0.16%	9,951	756
8	Lake Bonham	Mar-04	11,026	1969	35	-7%	-0.20%	11,856	830
			Average percent change per year :				-0.25%		

4. CONCLUSIONS

HYDROLOGY

Analysis of the period-of-record (1949-2004) for the USGS gauge near Cooper, Texas reveals that in general terms, floods on the North Sulphur River are flashy in nature. The duration of large events is typically 2 to 3 days; flows rise from almost zero to 25,000-40,000 cfs within a day and then recede over a period of 2 days. On the average, the duration of flows with magnitudes up to 80 percent of the peak discharge is 1 day. In other words, the bulk of the flow occurs in a one day window.

In general terms, the 10-, 20-, 50-, and 100-year flows range between 26,000 cfs and 36,000 cfs using the Log-Pearson Type III analysis (using station skewness adjustment), and they range from 26,000 cfs to 43,000 cfs using the Gumbel analysis with sample size (n=56) adjustment. Computed runoff hydrographs at Lake Ralph Hall dam site using HEC-HMS show very good agreement with the area-transformed gauge data.

HEC-HMS was used to calculate hydrographs in the 19 Lake Ralph Hall subbasins under two different unit hydrograph methods: Snyder and SCS. Although the volumetric flow in both methods is the same, the peak flows were widely divergent. However, both of these methods result in a higher 100-year peak value than shown in the previous UTRWD hydrology report. This difference can be attributed to the differing CN values and basin timing parameters. Despite variations in peak flows, the average daily flow values resulting from computations using both methods remain the same. Because the sediment transport calculations are based on the average daily flow values, the sensitivity to the peak flow does not affect the sediment transport.

VOLUMETRIC SEDIMENT TRANSPORT

Two different methods were used to calculate probable sediment transport: the first computes an average daily sediment transport rate for an entire "typical" yearly flow pattern; the second computes sediment transport rates for discrete flow intervals and then uses those rates to establish a "typical" yearly sediment transport rate. The service life computations in the following tables are based on the primary assumption that *all* sediment sizes transported to the reservoir are trapped permanently by the reservoir. This assumption recognizes that the reservoir service life can be extended by sediment control measures such as grade control structures, sediment detaining facilities upstream of the reservoir, and proper reservoir operations to flush sediments through the reservoir and to prevent settling of fine sediments. Therefore, these calculations represent the shortest probable reservoir life based on sediment transport potential. An analysis of reservoir operational schemes and other control measures needed to extend the reservoir service life is not in the scope of this analysis. However, this study recommends such an analysis be carried out.

Upper Discharge Limit at LRH (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume in Acre-ft	Service Life In Years (including all sediment fractions)
8,000	1,018	1527	160,000	63
10,000	1,220	1830	160,000	52
12,000	1,313	1970	160,000	49

Upper Discharge Limit at LRH (cfs)	Sand and Gravel Load in Acre-ft / Year	Silt and Clay Load in Acre-ft / Year	Reservoir Volume In Acre-ft	Service Life in Years (including all sediment fractions)
8,000	1,225	1,837	160,000	52
10,000	1,419	2,128	160,000	45
12,000	1,546	2,319	160,000	41

In arriving at these values, the following assumptions were made:

1. The 55 years of daily flows provide a reasonable basis for calculating an average flow year.
2. Low-probability occurrence events (such as the 25-, 50-, and 100-year events) were excluded from this analysis because they do not represent an average year condition. However, these events have high sediment production rates and could impact the reservoir service life.
3. Along the modeled reach, a single representative sediment size distribution is used. This distribution is defined in Table 3.1 and represents a typical distribution of the 2006 sampling.
4. Total sediment transport is computed by summing the fractional loads. This method is identified in the literature as the bed material fraction method (Molinas, Wu, 2004)
5. Sediment transport for the entire mixture is computed by multiplying the transport for the sand fractions by 2.5. This is based on the distribution of sands (40%) and silts and clays (60%) in the Lake Ralph Hall watershed.
6. Fine sand transport computations are repeated using the Yang, Molinas, Wu (1996) equation. These computations result in approximately the same range of service lives.

The sediment accumulation characteristics of reservoirs in Northeastern Texasshow that sediment production rates for these reservoirs do not pose a major threat to service life. However, the results from Lake Ralph Hall differ significantly. The following list of factors offers a possible explanation for this difference:

- The results of this study represent the shortest probable reservoir life based on sediment transport potential and exclude the reduction in sedimentation that can be achieved through reservoir operations and other sediment control and conservation measures. Regional results do reflect the benefits gained from these measures.
- The North Sulphur River is unique from regional reservoirs because of its history of channelization and incising. It is a destabilized drainage network (both main stem and tributaries) that produce a much higher rate of sediment than more stable reaches in comparable watersheds.
- Soils in the Lake Ralph Hall watershed are highly erosive. However, a comparison of soil types between the Lake Ralph Hall watershed and regional watersheds was not part of this study.
- Difference in sedimentation rates can be attributed to differences in landuse, changing landuse, watershed cover type, watershed slope, and drainage network characteristics.

Because any combination of these factors may be the cause of low sediment accumulation and long service life of these reservoirs, it is not a given that all reservoirs in this region will be prone to low sediment production or long service life, nor is the data indicative that the region in and of itself produces low sediment accumulation.

Figure 4.1 – North Sulphur River near headwaters at bridge BR 590 site.

Figure 4.2 – North Sulphur River upstream from Brushy Creek confluence.

Figure 4.3 – North Sulphur River at SH 34

Figure 4.4 – North Sulphur River at the proposed Lake Ralph Hall dam site.

Figure 4.5 – North Sulphur River upstream at FM 38 bridge site.

Figure 4.6 – North Sulphur River at FM 38 bridge site.

Brief Map Unit Description

Fannin County, Texas

[Only those map units that have entries for the selected description categories are included in this report]

Map unit: AbC - Aubrey loam, 2 to 6 percent slopes

Description category: AGR

Map Unit AbC, Component AUBREY is 20 - 40 inches thick. Permeability is SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE AUBREY SERIES IS A MODERATELY DEEP, WELL-DRAINED, SLOWLY PERMEABLE SOIL. THESE SOILS OCCUPY GENTLY SLOPING TO MODERATELY STEEP UPLANDS. THE SOIL FORMED IN ACID, CLAYEY SHALE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS BROWN, FINE SANDY LOAM. THE VERY STRONGLY ACID SUBSOIL IS RED IN THE UPPER PART AND RED AND GRAY IN THE LOWER PART. BELOW 27 INCHES, IT IS VERY STRONGLY ACID CLAYEY SHALE.

Map unit: AbE - Aubrey fine sandy loam, 8 to 20 percent slopes

Description category: AGR

Map Unit AbE, Component AUBREY is 20 - 40 inches thick. Permeability is SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE AUBREY SERIES IS A MODERATELY DEEP, WELL-DRAINED, SLOWLY PERMEABLE SOIL. THESE SOILS OCCUPY GENTLY SLOPING TO MODERATELY STEEP UPLANDS. THE SOIL FORMED IN ACID, CLAYEY SHALE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS BROWN, FINE SANDY LOAM. THE VERY STRONGLY ACID SUBSOIL IS RED IN THE UPPER PART AND RED AND GRAY IN THE LOWER PART. BELOW 27 INCHES, IT IS VERY STRONGLY ACID CLAYEY SHALE.

Brief Map Unit Description

Fannin County, Texas

Map unit: AuB - Austin silty clay loam, 1 to 3 percent slopes

Description category: AGR

Map Unit AuB, Component AUSTIN is 20 - 40 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

7C - FRIABLE CLAYEY UPLAND - Moderately deep to very deep friable clayey uplands with slopes 0 to 5 percent; friable when moist; somewhat sticky when wet; high natural fertility; medium to high water holding capacity and fair to good plant-soil-moisture relationship; high production potential.

Description category: RNG

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THE AUSTIN SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, NEARLY LEVEL TO SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN CHALKY LIMESTONE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS CALCAREOUS SILTY CLAY ABOUT 15 INCHES THICK AND IS DARK GRAYISH BROWN IN THE UPPER PART AND DARK BROWN IN THE LOWER PART. BELOW THE SURFACE LAYER AND TO A DEPTH OF 30 INCHES IS BROWN CALCAREOUS SILTY CLAY. THE LOWER LAYER IS WHITE AND VERY PALE BROWN PLATY CHALK.

Map unit: BaC - Bastrop loam, 2 to 5 percent slopes

Description category: AGR

Map Unit BaC, Component BASTROP is >60 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

SANDY LOAM PE 52-64 SITE - Deep, sandy loam soils. Climax vegetation is a post oak, blackjack oak savannah, with associated woody plants and big and little bluestem, indiangrass, purpletop, switchgrass, beaked panicum, longleaf uniola, lespedezas, tickclovers, snoutbeans, tephrosia, butterflypea, partridge pea, bundleflower, and sensitivebrier.

Description category: SOI

THE BASTROP SERIES CONSISTS OF VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE, NEARLY LEVEL TO MODERATELY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN LOAMY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS BROWN AND REDDISH BROWN FINE SANDY LOAM ABOUT 13 INCHES THICK. THE SUBSOIL FROM 13 TO 20 INCHES IS REDDISH BROWN SANDY CLAY AND YELLOWISH RED FROM 20 TO 72 INCHES. FROM 72 TO 80 INCHES IS YELLOWISH RED SANDY CLAY LOAM.

Brief Map Unit Description

Fannin County, Texas

Map unit: Be - Belk clay, rarely flooded

Description category: AGR

Map Unit Be, Component BELK is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 3S dryland and NONE irrigated.

Description category: PHG

1A - HEAVY CLAYEY BOTTOMLAND - Deep and very deep, somewhat poorly to well drained, heavy bottomlands; may overflow; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; high production potential.

Description category: SOI

THE BELK SERIES CONSISTS OF VERY DEEP, WELL DRAINED, NEARLY LEVEL SOILS ON FLOOD PLAINS. THE SOIL FORMED IN CLAYEY AND LOAMY ALLUVIAL SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE IS REDDISH BROWN CLAY ABOUT 26 INCHES THICK. THE UNDERLYING MATERIAL IS STRATIFIED LOAMY SEDIMENTS THAT ARE REDDISH BROWN IN THE UPPER PART AND YELLOWISH RED IN THE LOWER PART. THE SOIL IS CALCAREOUS.

Description category: WSG

On site investigation needed to determine the woodland interpretations.

Map unit: BkA - Benklin silt loam, 0 to 1 percent slopes

Description category: AGR

Map Unit BkA, Component BENKLIN is >60 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is 1.5 - 2.5 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THE BENKLIN SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, NEARLY LEVEL SOILS OF STREAM TERRACES. THE SOIL FORMED IN LOAMY ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAYISH BROWN SILT LOAM ABOUT 6 INCES THICK. THE SUBSOIL IS VERY DARK BROWN LOAM IN THE UPPER 12 INCHES, VERY DARK GRAYISH BROWN LOAM WITH COMMON DARK GRAYISH BROWN AND BROWN MOTTLES IN THE NEXT 15 INCHES AND MOTTLED DARK GRAYISH BROWN, YELLOWISH BROWN AND GRAYISH BROWN CLAY LOAM BELOW 33 INCHES.

Description category: WSG

2o4 - No significant management problems are caused by soil characteristics. Important commercial tree species include water oak, green ash, willow oak, and sweetgum. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 90. The yield from an unmanaged stand over a 50-year period is approximately 210 board feet (Doyle rule) for sweetgum, per acre per year. Native species important to wildlife include water oak, willow oak, Alabama supplejack, yaupon, and American beautyberry. High value grasses and forbs used by livestock include switchgrass, longleaf uniola, pinehill bluestem, and virginia wildrye. Stocking rates depend on canopy density and range from 8-40 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: BmC - Birome fine sandy loam, 2 to 5 percent slopes

Description category: AGR

Map Unit BmC, Component BIROME is 20 - 40 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE BIROME SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, GENTLY SLOPING TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN STRATIFIED SANDY AND CLAYEY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS FINE SANDY LOAM THAT IS BROWN IN THE UPPER PART AND BROWN IN THE LOWER PART. THE SUBSOIL IS CLAY THAT IS RED IN THE UPPER PART AND YELLOWISH RED CLAY LOAM IN THE LOWER PART ABRUPTLY OVER WEAKLY CEMENTED SANDSTONE.

Map unit: BmD - Birome fine sandy loam, 5 to 12 percent slopes

Description category: AGR

Map Unit BmD, Component BIROME is 20 - 40 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE BIROME SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, GENTLY SLOPING TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN STRATIFIED SANDY AND CLAYEY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS FINE SANDY LOAM THAT IS BROWN IN THE UPPER PART AND BROWN IN THE LOWER PART. THE SUBSOIL IS CLAY THAT IS RED IN THE UPPER PART AND YELLOWISH RED CLAY LOAM IN THE LOWER PART ABRUPTLY OVER WEAKLY CEMENTED SANDSTONE.

Brief Map Unit Description

Fannin County, Texas

Map unit: BoB - Bonham silt loam, 1 to 3 percent slopes

Description category: AGR

Map Unit BoB, Component BONHAM is >60 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THE BONHAM SERIES CONSISTS OF DEEP MODERATELY WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN SILTY AND CLAYEY MATERIALS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAYISH BROWN SILT LOAM ABOUT 10 INCHES THICK. THE SUBSOIL EXTENDS TO A DEPTH OF 66 INCHES. THE SUBSOIL IS VERY DARK GRAYISH BROWN SILTY CLAY LOAM IN THE UPPER 7 INCHES, DARK GRAYISH BROWN SILTY CLAY IN THE NEXT 13 INCHES AND MOTTLED OLIVE BROWN SILTY CLAY BELOW 30 INCHES. THE SUBSTRATUM BELOW 66 INCHES IS LIGHT OLIVE BROWN SILTY CLAY.

Map unit: BoC - Bonham silt loam, 3 to 5 percent slopes

Description category: AGR

Map Unit BoC, Component BONHAM is >60 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THE BONHAM SERIES CONSISTS OF DEEP MODERATELY WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN SILTY AND CLAYEY MATERIALS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAYISH BROWN SILT LOAM ABOUT 10 INCHES THICK. THE SUBSOIL EXTENDS TO A DEPTH OF 66 INCHES. THE SUBSOIL IS VERY DARK GRAYISH BROWN SILTY CLAY LOAM IN THE UPPER 7 INCHES, DARK GRAYISH BROWN SILTY CLAY IN THE NEXT 13 INCHES AND MOTTLED OLIVE BROWN SILTY CLAY BELOW 30 INCHES. THE SUBSTRATUM BELOW 66 INCHES IS LIGHT OLIVE BROWN SILTY CLAY.

Brief Map Unit Description

Fannin County, Texas

Map unit: BuA - Burleson clay, 0 to 1 percent slopes

Description category: AGR

Map Unit BuA, Component BURLESON is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

7A1 - HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline in the lower layers; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

BURLESON SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, CLAYEY SOILS ON PLEISTOCENE TERRACES. THEY HAVE A BLACK SLIGHTLY ALKALINE CLAY SURFACE LAYER ABOUT 12 INCHES THICK AND VERY DARK GRAY AND DARK GRAY MODERATELY ALKALINE CLAYEY UNDERLYING LAYERS THAT GRADE TO YELLOWISH RED SILTY CLAY SUBSTRATA. THE SOILS FORMED IN ANCIENT CLAYEY ALLUVIUM.

Map unit: CrB - Crockett loam, 1 to 3 percent slopes

Description category: AGR

Map Unit CrB, Component CROCKETT is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

THE CROCKETT SERIES CONSISTS OF DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL TO STRONGLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN ALKALINE MARINE CLAYS INTERBEDDED WITH LOAMY MATERIAL. TYPICALLY, THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM ABOUT 8 INCHES THICK. CLAY SUBSOIL EXTENDS TO ABOUT 57 INCHES AND IS MOTTLED REDDISH AND BROWNISH IN THE UPPER PART AND OLIVE, YELLOW, BROWN AND GRAY IN THE LOWER PART. MATERIAL BELOW IS MOTTLED YELLOW AND BROWN LOAM AND CONTAINS CARBONATE MASSES.

Brief Map Unit Description

Fannin County, Texas

Map unit: CrC2 - Crockett loam, 2 to 5 percent slopes, eroded

Description category: AGR

Map Unit CrC2, Component CROCKETT is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

THE CROCKETT SERIES CONSISTS OF DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL TO STRONGLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN ALKALINE MARINE CLAYS INTERBEDDED WITH LOAMY MATERIAL. TYPICALLY, THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM ABOUT 8 INCHES THICK. CLAY SUBSOIL EXTENDS TO ABOUT 57 INCHES AND IS MOTTLED REDDISH AND BROWNISH IN THE UPPER PART AND OLIVE, YELLOW, BROWN AND GRAY IN THE LOWER PART. MATERIAL BELOW IS MOTTLED YELLOW AND BROWN LOAM AND CONTAINS CARBONATE MASSES.

Map unit: CtC - Crosstell fine sandy loam, 2 to 5 percent slopes

Description category: AGR

Map Unit CtC, Component CROSSTELL is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE CROSSTELL SERIES CONSISTS OF DEEP, WELL DRAINED, NEARLY LEVEL TO STRONGLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN STRATIFIED ACID CLAYS AND SHALES. IN A REPRESENTATIVE PROFILE THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM ABOUT 6 INCHES THICK. THE SUBSOIL IS CLAY TO A DEPTH OF ABOUT 46 INCHES AND IS REDDISH YELLOW AND YELLOWISH RED IN THE UPPER PART AND MOTTLED REDDISH BROWN, PALE OLIVE AND OLIVE YELLOW IN THE LOWER PART. THIS IS UNDERLAIN BY STRATIFIED CLAY AND SHALE.

Brief Map Unit Description

Fannin County, Texas

Map unit: CtD2 - Crosstell fine sandy loam, 5 to 12 percent slopes, erod ed

Description category: AGR

Map Unit CtD2, Component CROSSTELL is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

8B - SLOPING TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes greater than 5 percent; low natural fertility, seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium production potential.

Description category: RNG

TIGHT SANDY LOAM PE 52-64 SITE - Sandy loam surfaces, clayey subsoils over shale or sandstone. Vegetation is a post oak, blackjack savannah with hackberry, bumelia, greenbrier, little and big bluestems, sideoats grama, indiangrass, switchgrass, purpletop, dropseeds, lovegrass, gayfeather, sensitivebrier, lespedezas, western indigo tickclovers, neptunia, and bundleflower.

Description category: SOI

THE CROSSTELL SERIES CONSISTS OF DEEP, WELL DRAINED, NEARLY LEVEL TO STRONGLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN STRATIFIED ACID CLAYS AND SHALES. IN A REPRESENTATIVE PROFILE THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM ABOUT 6 INCHES THICK. THE SUBSOIL IS CLAY TO A DEPTH OF ABOUT 46 INCHES AND IS REDDISH YELLOW AND YELLOWISH RED IN THE UPPER PART AND MOTTLED REDDISH BROWN, PALE OLIVE AND OLIVE YELLOW IN THE LOWER PART. THIS IS UNDERLAIN BY STRATIFIED CLAY AND SHALE.

Map unit: DaC - Dalco clay, 3 to 5 percent slopes

Description category: AGR

Map Unit DaC, Component DALCO is 24 - 40 inches thick. Permeability is VERY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE DALCO SERIES CONSISTS OF MODERATELY DEEP, MODERATELY WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS ON UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAY CLAY. THE NEXT LOWER LAYER IS BLACK CLAY ABOUT 17 INCHES THICK. THIS IS UNDERLAIN BY DARK GRAY CLAY TO A DEPTH OF 35 INCHES. THE MATERIAL FROM 35 INCHES TO SEVERAL FEET IS WHITE, PLATY CHALK.

Brief Map Unit Description

Fannin County, Texas

Map unit: De - Dela loam, occasionally flooded

Description category: AGR

Map Unit De, Component DELA is 80 - inches thick. Permeability is MODERATELY RAPID and available water holding capacity is MODERATE. A water table when present is 3.0 - 5 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

2B - LOAMY ACIDIC BOTTOMLAND - Deep and very deep, strongly to very strongly acid bottomlands with loamy surfaces; may overflow; medium natural fertility; moderate to very high water holding capacity with good plant-soil-moisture relationship; high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL TO MODERATELY WELL DRAINED, MODERATELY RAPIDLY PERMEABLE SOILS ON FLOOD PLAINS. TYPICALLY, THE SURFACE LAYER IS DARK GRAYISH BROWN FINE SANDY LOAM. THE NEXT LAYER IS BROWN FINE SANDY LOAM AND THE UNDERLYING MATERIAL IS STRATIFIED YELLOWISH, BROWN, LIGHT YELLOWISH BROWN, PALE BROWN AND VERY PALE BROWN VERY FINE SANDY LOAM AND LOAMY FINE SAND.

Description category: WSG

2w8 - Seasonal wetness may cause moderate equipment limitations and plant competition. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include water oak, red oak, yaupon, American beautyberry, and Alabama supplejack. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, virginia wildrye, switchgrass, and beaked panicum. Stocking rates depend on canopy density and range from 6-60 acres per animal unit.

Map unit: Df - Dela loam, frequently flooded

Description category: AGR

Map Unit Df, Component DELA is 80 - inches thick. Permeability is MODERATELY RAPID and available water holding capacity is MODERATE. A water table when present is 3.0 - 5 feet. The soil has a capability subclass of 5W dryland and NONE irrigated.

Description category: PHG

2B - LOAMY ACIDIC BOTTOMLAND - Deep and very deep, strongly to very strongly acid bottomlands with loamy surfaces; may overflow; medium natural fertility; moderate to very high water holding capacity with good plant-soil-moisture relationship; high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL TO MODERATELY WELL DRAINED, MODERATELY RAPIDLY PERMEABLE SOILS ON FLOOD PLAINS. TYPICALLY, THE SURFACE LAYER IS DARK GRAYISH BROWN FINE SANDY LOAM. THE NEXT LAYER IS BROWN FINE SANDY LOAM AND THE UNDERLYING MATERIAL IS STRATIFIED YELLOWISH, BROWN, LIGHT YELLOWISH BROWN, PALE BROWN AND VERY PALE BROWN VERY FINE SANDY LOAM AND LOAMY FINE SAND.

Description category: WSG

2w8 - Seasonal wetness may cause moderate equipment limitations and plant competition. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include water oak, red oak, yaupon, American beautyberry, and Alabama supplejack. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, virginia wildrye, switchgrass, and beaked panicum. Stocking rates depend on canopy density and range from 6-60 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: DgA - Derly silt loam, 0 to 1 percent slopes

Description category: AGR

Map Unit DgA, Component DERLY is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is +0.5 - 1 feet. The soil has a capability subclass of 4W dryland and NONE irrigated.

Description category: PHG

8E2 - WET UPLAND - Deep and very deep, wet, loamy uplands with possible depressed or ponded areas or seasonal water table; poorly to very poorly drained; tight subsoils; medium natural fertility; Very high to high water holding capacity but poor plant-soil-moisture relationship; medium production potential.

Description category: SOI

THE DERLY SERIES CONSISTS OF VERY DEEP, POORLY DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL SOILS ON PLEISTOCENE TERRACES WITH UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE HORIZON IS GRAYISH BROWN SILT LOAM ABOUT 3 INCHES THICK AND LIGHT BROWNISH GRAY SILT LOAM ABUT 5 INCHES THICK THAT TONGUES INTO LIGHT BROWNISH GRAY CLAY LOAM SUBSOIL. LOWER HORIZONS ARE GRAYISH BROWN AND LIGHT BROWNISH GRAY CLAY LOAM.

Description category: WSG

4w6 - Wet conditions may cause severe equipment limitations and seedling mortality. Important commercial tree species include sweetgum, water oak, willow oak, and green ash. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 70. The yield from an unmanaged stand of sweetgum over a 50-year period is approximately 50 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and yaupon. High value grasses and forbs used by livestock include switchcane, wildrye, longleaf uniola, and sedge. Stocking rates depend on canopy density and range from 10-80 acres per animal unit.

Map unit: DrA - Derly-Raino complex, 0 to 1 percent slopes

Description category: AGR

Map Unit DrA, Component RAINO is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is 2.0 - 3.5 feet. The soil has a capability subclass of 3S dryland and NONE irrigated.

Map Unit DrA, Component DERLY is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is +0.5 - 1 feet. The soil has a capability subclass of 4W dryland and NONE irrigated.

Description category: PHG

8E2 - WET UPLAND - Deep and very deep, wet, loamy uplands with possible depressed or ponded areas or seasonal water table; poorly to very poorly drained; tight subsoils; medium natural fertility; Very high to high water holding capacity but poor plant-soil-moisture relationship; medium production potential.

Description category: SOI

THE RAINO SERIES CONSISTS OF VERY DEEP MODERATELY WELL-DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS ON TERRACES FORMED IN LOAMY AND CLAYEY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK YELLOWISH-BROWN LOAM ABOUT 5 INCHES THICK. THE SUBSOIL TO 35 INCHES IS STRONG BROWN LOAM AND CONTAINS ABOUT 20 PERCENT OF UNCOATED SAND AND SILT. BELOW 35 INCHES AND TO A DEPTH OF 70 INCHES THE SOIL IS MOTTLED RED, BROWNISH GRAY AND GRAY CLAY.

THE DERLY SERIES CONSISTS OF VERY DEEP, POORLY DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL SOILS ON PLEISTOCENE TERRACES WITH UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE HORIZON IS GRAYISH BROWN SILT LOAM ABOUT 3 INCHES THICK AND LIGHT BROWNISH GRAY SILT LOAM ABUT 5 INCHES THICK THAT TONGUES INTO LIGHT BROWNISH GRAY CLAY LOAM SUBSOIL. LOWER HORIZONS ARE GRAYISH BROWN AND LIGHT BROWNISH GRAY CLAY LOAM.

Brief Map Unit Description

Fannin County, Texas

Map unit: DrA - Derly-Raino complex, 0 to 1 percent slopes

Description category: WSG

4w6 - Wet conditions may cause severe equipment limitations and seedling mortality. Important commercial tree species include sweetgum, water oak, willow oak, and green ash. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 70. The yield from an unmanaged stand of sweetgum over a 50-year period is approximately 50 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and yaupon. High value grasses and forbs used by livestock include switchcane, wildrye, longleaf uniola, and sedge. Stocking rates depend on canopy density and range from 10-80 acres per animal unit.

Map unit: Eb - Elbon silty clay loam, frequently flooded

Description category: AGR

Map Unit Eb, Component ELBON is >60 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is 2.5 - 3.5 feet. The soil has a capability subclass of 5W dryland and NONE irrigated.

Description category: PHG

1C - FRIABLE CLAYEY BOTTOMLAND - Deep and very deep, friable clayey bottomlands; friable when moist, somewhat sticky when wet; may overflow; high natural fertility; very high to high water holding capacity and good plant-soil-moisture relationship; high production potential.

Description category: SOI

THE ELBON SERIES CONSISTS OF VERY DEEP MODERATELY WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS OF BOTTOMLANDS. THE SOIL FORMED IN LOAMY CALCAREOUS ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAYISH BROWN SILTY CLAY LOAM ABOUT 21 INCHES THICK. THE UNDERLYING MATERIAL IS WEAKLY TO PROMINENTLY STRATIFIED WITH VARYING TEXTURES AND IS VERY DARK GRAYISH BROWN OR DARK GRAYISH BROWN WITH COMMON BROWN AND GRAYISH BROWN MOTTLES.

Map unit: EsD2 - Ellis clay, 5 to 12 percent slopes, eroded

Description category: AGR

Map Unit EsD2, Component ELLIS is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

7B1 - SLOPING HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes greater than 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline on lower layers; medium to high natural fertility; seasonally wet or droughty; Very high to high water holding capacity but poor to fair plant-soil-moisture relationship; medium production potential.

Description category: RNG

ERODED BLACKLAND PE 44-64 SITE - Deep, sloping, eroded, clay soils. Climax vegetation includes big and little bluestem, indiangrass switchgrass, wildrye, meadow dropseed, texas wintergrass, silver bluestem engelmanndaisy maximilian sunflower gayfeather blacksamson, bundleflower sensitivebrier neptunia prairieclovers, scurfpea, buttonsnakeroot, and groundplum. Sparse woody inhabitants occur.

Brief Map Unit Description

Fannin County, Texas

Map unit: EsD2 - Ellis clay, 5 to 12 percent slopes, eroded

Description category: SOI

THE ELLIS SERIES CONSISTS OF VERY DEEP, WELL DRAINED, GENTLY SLOPING TO MODERATELY STEEP SOILS ON UPLANDS. THE SOIL FORMED IN WEAKLY CONSOLIDATED SHALES. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH-BROWN CLAY ABOUT 4 INCHES THICK. THE NEXT LAYER IS OLIVE, OLIVE YELLOW, AND GRAY CLAY ABOUT 26 INCHES THICK. BELOW THIS IS WEAKLY CONSOLIDATED SHALE WITH CLAY TEXTURE.

Map unit: FaA - Fairlie clay, 0 to 1 percent slopes

Description category: AGR

Map Unit FaA, Component FAIRLIE is 40 - 60 inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 2S dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE FAIRLIE SERIES CONSISTS OF DEEP, MODERATELY WELL-DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS ON UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS SILTY CLAY LOAM THAT IS VERY DARK GRAY IN THE UPPER PART AND BLACK IN THE LOWER PART. THE NEXT LAYER, FROM 24 TO 35 INCHES, IS A VERY DARK GRAY SILTY CLAY. THE NEXT LAYER, FROM 35 TO 54 INCHES, IS A DARK GRAY CLAY. BELOW 54 INCHES IS WHITE PLATY CHALK.

Map unit: FdB - Fairlie-Dalco complex, 1 to 3 percent slopes

Description category: AGR

Map Unit FdB, Component DALCO is 24 - 40 inches thick. Permeability is VERY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Map Unit FdB, Component FAIRLIE is 40 - 60 inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: FdB - Fairlie-Dalco complex, 1 to 3 percent slopes

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE FAIRLIE SERIES CONSISTS OF DEEP, MODERATELY WELL-DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS ON UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS SILTY CLAY LOAM THAT IS VERY DARK GRAY IN THE UPPER PART AND BLACK IN THE LOWER PART. THE NEXT LAYER, FROM 24 TO 35 INCHES, IS A VERY DARK GRAY SILTY CLAY. THE NEXT LAYER, FROM 35 TO 54 INCHES, IS A DARK GRAY CLAY. BELOW 54 INCHES IS WHITE PLATY CHALK.

THE DALCO SERIES CONSISTS OF MODERATELY DEEP, MODERATELY WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING SOILS ON UPLANDS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAY CLAY. THE NEXT LOWER LAYER IS BLACK CLAY ABOUT 17 INCHES THICK. THIS IS UNDERLAIN BY DARK GRAY CLAY TO A DEPTH OF 35 INCHES. THE MATERIAL FROM 35 INCHES TO SEVERAL FEET IS WHITE, PLATY CHALK.

Map unit: FeD2 - Ferris clay, 5 to 12 percent slopes, eroded

Description category: AGR

Map Unit FeD2, Component FERRIS is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

7B2 - SLOPING HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes greater than 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; medium to high natural fertility; seasonally wet or droughty; very high to high water holding capacity but poor to fair plant-soil-moisture relationship; medium production potential.

Description category: RNG

ERODED BLACKLAND PE 44-64 SITE - Deep, sloping, eroded, clay soils. Climax vegetation includes big and little bluestem, indiangrass switchgrass, wildrye, meadow dropseed, texas wintergrass, silver bluestem engelmanndaisy maximilian sunflower gayfeather blacksamson, bundleflower sensitivebrier neptunia prairieclovers, scurfpea, buttonsnakeroot, and groundplum. Sparse woody inhabitants occur.

Description category: SOI

THE FERRIS SERIES CONSISTS OF SOILS THAT ARE DEEP TO WEATHERED SHALE. THEY ARE WELL DRAINED, VERY SLOWLY PERMEABLE, GENTLY SLOPING TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN WEAKLY CONSOLIDATED CALCAREOUS MARINE SHALES AND CLAYS. IN A REPRESENTATIVE PROFILE, THE SURFACE IS OLIVE CLAY ABOUT 8 INCHES THICK. THE SUBSOIL IS PALE OLIVE CLAY ABOUT 32 INCHES THICK. THE SUBSTRATUM IS WEAKLY CONSOLIDATED SHALE THAT HAS CLAY TEXTURE.

Map unit: FhB - Freestone-Hicota complex, 0 to 2 percent slopes

Description category: AGR

Map Unit FhB, Component HICOTA is >60 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water table when present is 3.0 - 5 feet. The soil has a capability subclass of 2S dryland and NONE irrigated.

Map Unit FhB, Component FREESTONE is >60 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water

Map unit: FhB - Freestone-Hicota complex, 0 to 2 percent slopes

Description category: AGR

table when present is 2.0 - 3.5 feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, MODERATELY WELL DRAINED, SLOWLY PERMEABLE SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO GENTLY SLOPING STREAM TERRACES. THE SOIL FORMED IN ACID AND ALKALINE CLAYEY SEDIMENTS. THESE SOILS HAVE BROWN FINE SANDY LOAM UPPER LAYERS ABOUT 11 INCHES THICK OVER YELLOWISH BROWN SANDY CLAY LOAM AND CLAY LOAM UPPER SUBSOILS THAT CONTAIN ABOUT 10 PERCENT ALBIC MATERIALS. THE LOWER SUBSOIL IS MOTTLED GRAY, RED AND YELLOWISH BROWN CLAY.

THE HICOTA SERIES CONSISTS OF DEEP, WELL DRAINED, NEARLY LEVEL TO GENTLY SLOPING MOUNDY SOILS ON OLD TERRACES.THE SOIL FORMED IN OLD LOAMY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY FINE SANDY LOAM THAT IS BROWN IN THE UPPER PART AND LIGHT YELLOWISH BROWN IN THE LOWER PART. THE UPPER SUBSOIL IS YELLOWISH BROWN LOAM AND CLAY LOAM THAT CONTAINS TONGUES OF MATERIAL FROM ABOVE. THE LOWER PART IS MOTTLED GRAY AND LIGHT BROWNISH GRAY CLAY LOAM AND CLAY.

Description category: WSG

3w8 - Seasonally wet periods may cause moderate equipment limitations, seedling mortality, and plant competition. Important commercial tree species include loblolly pine, shortleaf pine, water oak, and sweetgum. These soils are suited for pine and hardwoods, and the site index for loblolly pine, water oak, and sweetgum is 80. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 230 board feet (Doyle rule) or 120 for sweetgum per acre per year. Native species important to wildlife include water oak, green ash, yaupon, and Alabama supplejack. High value grasses and forbs used by livestock include pinehill bluestemr, beaked panicum, longleaf uniola, wildrye, switchcane, and switchgrass. Stocking rate depend on canopy density and range from 6-50 acres per animal unit.

Map unit: Fr - Frioton silty clay loam, occasionally flooded

Description category: AGR

Map Unit Fr, Component FRIOTON is 80 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

1C - FRIABLE CLAYEY BOTTOMLAND - Deep and very deep, friable clayey bottomlands; friable when moist, somewhat sticky when wet; may overflow; high natural fertility; very high to high water holding capacity and good plant-soil-moisture relationship; high production potential.

Description category: RNG

LOAMY BOTTOMLAND PE 52-64 SITE - Flood plains of alluvial soils. Vegetation includes indiangrass; little, sand, or big bluestem; switchgrass, wildryes, texas wintergrass, vine-mesquite, falseswitchgrass, meadow dropseed, western wheatgrass, sideoats grama, ragweeds, engelmanndaisy, heath aster, maximilian sunflower, gauras, elm, hackberry, bumelia, soapberry, grapes, cottonwood, and ash.

Map unit: Fr - Frioton silty clay loam, occasionally flooded

Description category: SOI

THESE ARE VERY DEEP, WELL-DRAINED, MODERATELY SLOWLY PERMEABLE SOILS ON FLOODS PLAINS. TYPICALLY, THE SURFACE LAYER IS VERY DARK BROWN SILTY CLAY LOAM ABOUT 24 INCHES THICK. BELOW THE SURFACE LAYER AND TO A DEPTH OF 37 INCHES IS VERY DARK GRAY SILTY CLAY LOAM. THE NEXT LAYER TO A DEPTH OF 62 INCHES IS VERY DARK GRAY SILTY CLAY LOAM.

Map unit: HeB - Heiden clay, 1 to 3 percent slopes

Description category: AGR

Map Unit HeB, Component HEIDEN is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE HEIDEN SERIES CONSISTS OF VERY DEEP, WELL DRAINED, CALCAREOUS, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN CALCAREOUS CLAYEY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN CLAY ABOUT 18 INCHES THICK. THE SUBSOIL FROM 18 TO A DEPTH OF 58 INCHES IS DARK GRAYISH BROWN AND OLIVE GRAY CLAY WITH OLIVE MOTTLES. THE LOWER LAYER FROM 58 TO 70 INCHES IS MOTTLED OLIVE AND YELLOW CLAY AND WEAKLY CONSOLIDATED SHALE.

Map unit: HfC2 - Heiden-Ferris complex, 2 to 6 percent slopes, eroded

Description category: AGR

Map Unit HfC2, Component HEIDEN is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Map Unit HfC2, Component FERRIS is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Map unit: HfC2 - Heiden-Ferris complex, 2 to 6 percent slopes, eroded

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

ERODED BLACKLAND PE 44-64 SITE - Deep, sloping, eroded, clay soils. Climax vegetation includes big and little bluestem, indiangrass switchgrass, wildrye, meadow dropseed, texas wintergrass, silver bluestem engelmanndaisy maximilian sunflower gayfeather blacksamson, bundleflower sensitivebrier neptunia prairieclovers, scurfpea, buttonsnakeroot, and groundplum. Sparse woody inhabitants occur.

Description category: SOI

THE FERRIS SERIES CONSISTS OF SOILS THAT ARE DEEP TO WEATHERED SHALE. THEY ARE WELL DRAINED, VERY SLOWLY PERMEABLE, GENTLY SLOPING TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN WEAKLY CONSOLIDATED CALCAREOUS MARINE SHALES AND CLAYS. IN A REPRESENTATIVE PROFILE, THE SURFACE IS OLIVE CLAY ABOUT 8 INCHES THICK. THE SUBSOIL IS PALE OLIVE CLAY ABOUT 32 INCHES THICK. THE SUBSTRATUM IS WEAKLY CONSOLIDATED SHALE THAT HAS CLAY TEXTURE.

THE HEIDEN SERIES CONSISTS OF VERY DEEP, WELL DRAINED, CALCAREOUS, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN CALCAREOUS CLAYEY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN CLAY ABOUT 18 INCHES THICK. THE SUBSOIL FROM 18 TO A DEPTH OF 58 INCHES IS DARK GRAYISH BROWN AND OLIVE GRAY CLAY WITH OLIVE MOTTLES. THE LOWER LAYER FROM 58 TO 70 INCHES IS MOTTLED OLIVE AND YELLOW CLAY AND WEAKLY CONSOLIDATED SHALE.

Map unit: Hm - Hopco silt loam, occasionally flooded

Description category: AGR

Map Unit Hm, Component HOPCO is >60 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is 2.0 - 4 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

2B - LOAMY ACIDIC BOTTOMLAND - Deep and very deep, strongly to very strongly acid bottomlands with loamy surfaces; may overflow; medium natural fertility; moderate to very high water holding capacity with good plant-soil-moisture relationship; high production potential.

Description category: SOI

THE HOPCO SERIES CONSISTS OF VERY DEEP, SOMEWHAT POORLY-DRAINED NEARLY LEVEL SOILS OF BOTTOMLANDS. THE SOIL FORMED IN STRATIFIED ALLUVIAL SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS A VERY DARK GRAYISH-BROWN SILTY CLAY LOAM, ABOUT 16 INCHES THICK. THE NEXT LAYER, ABOUT 44 INCHES THICK, IS A VERY DARK GRAY SILTY CLAY LOAM AND CLAY LOAM THAT IS MOTTLED IN THE LOWER PART. THE UNDERLYING MATERIAL IS OLIVE BROWN CLAY LOAM THAT IS MOTTLED WITH OLIVE YELLOW.

Description category: WSG

2w6 - Clayey texture and seasonal wetness will cause severe equipment limitations and seedling mortality. Important commercial trees include willow oak, water oak, green ash, and sweetgum. These soils are suited for hardwoods, and the site index for water oak and sweetgum is 90. The yield from unmanaged stand of water oak over a 50-year period is approximately 236 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and blackgum. Grasses and forbs important for livestock include switchgrass, beaked panicum, switch cane, wildrye and sedges. Stocking rates depend on canopy density and range from 6-50 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: Hn - Hopco silt loam, frequently flooded

Description category: AGR

Map Unit Hn, Component HOPCO is >60 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is 2.0 - 4 feet. The soil has a capability subclass of 5W dryland and NONE irrigated.

Description category: PHG

2B - LOAMY ACIDIC BOTTOMLAND - Deep and very deep, strongly to very strongly acid bottomlands with loamy surfaces; may overflow; medium natural fertility; moderate to very high water holding capacity with good plant-soil-moisture relationship; high production potential.

Description category: SOI

THE HOPCO SERIES CONSISTS OF VERY DEEP, SOMEWHAT POORLY-DRAINED NEARLY LEVEL SOILS OF BOTTOMLANDS. THE SOIL FORMED IN STRATIFIED ALLUVIAL SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS A VERY DARK GRAYISH-BROWN SILTY CLAY LOAM, ABOUT 16 INCHES THICK. THE NEXT LAYER, ABOUT 44 INCHES THICK, IS A VERY DARK GRAY SILTY CLAY LOAM AND CLAY LOAM THAT IS MOTTLED IN THE LOWER PART. THE UNDERLYING MATERIAL IS OLIVE BROWN CLAY LOAM THAT IS MOTTLED WITH OLIVE YELLOW.

Description category: WSG

2w6 - Clayey texture and seasonal wetness will cause severe equipment limitations and seedling mortality. Important commercial trees include willow oak, water oak, green ash, and sweetgum. These soils are suited for hardwoods, and the site index for water oak and sweetgum is 90. The yield from unmanaged stand of water oak over a 50-year period is approximately 236 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and blackgum. Grasses and forbs important for livestock include switchgrass, beaked panicum, switch cane, wildrye and sedges. Stocking rates depend on canopy density and range from 6-50 acres per animal unit.

Map unit: HoB - Houston Black clay, 1 to 3 percent slopes

Description category: AGR

Map Unit HoB, Component HOUSTON BLACK is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

7A2 - HEAVY CLAYEY UPLAND (CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is moderately alkaline throughout; high natural fertility; seasonally wet or droughty; KVery high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE HOUSTON BLACK SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL TO GENTLY SLOPING SOILS OF UPLANDS. THE SOIL FORMED IN CALCAREOUS MARINE CLAYS AND MARLS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAY CLAY ABOUT 24 INCHES THICK. BELOW 24 INCHES AND TO DEPTHS OF MORE THAN 80 INCHES THE SOIL IS CLAY THAT GRADES FROM DARK GRAY TO GRAYISH BROWN AS DEPTH INCREASES.

Brief Map Unit Description

Fannin County, Texas

Map unit: HwC - Howe-Whitewright complex, 3 to 5 percent slopes

Description category: AGR

Map Unit HwC, Component HOWE is 20 - 40 inches thick. Permeability is MODERATE and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Map Unit HwC, Component WHITEWRIGHT is 10 - 20 inches thick. Permeability is MODERATE and available water holding capacity is VERY LOW. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

13A - SHALLOW CLAYEY - Very shallow and shallow clayey uplands less than 20 inches thick; medium natural fertility; droughty very low to low water holding capacity with poor plant-soil-moisture relationship; low production potential.

Description category: RNG

CHALKY RIDGE PE 44-64 SITE - Shallow, loamy soils. Climax vegetation is little bluestem, indiangrass, big bluestem, sideoats grama, and tall dropseeds; with forbs such as engelmanndaisy, maximilian sunflower, gayfeathers, and bundleflowers. Hackberry, elm, live oak, and osageorange are sparsely present.

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THE HOWE SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, GENTLY SLOPING TO STRONGLY SLOPING SOILS ON UPLANDS. THE SOIL FORMED IN MARINE CHALK AND MARL. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH-BROWN SILTY CLAY LOAM, ABOUT 7 INCHES THICK. THE NEXT LAYER IS LIGHT GRAY SILTY CLAY LOAM, 8 INCHES THICK. THE NEXT LOWER LAYER IS VERY PALE BROWN SILTY CLAY LOAM, 11 INCHES THICK. BELOW 26 INCHES IS WHITE WEAKLY-CEMENTED CHALK.

THE WHITEWRIGHT SERIES CONSISTS OF SHALLOW, WELL DRAINED, MODERATELY PERMEABLE SOILS OF UPLANDS. THEY FORMED IN CHALK AND MARL. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS LIGHT BROWNISH-GRAY SILTY CLAY LOAM, ABOUT 5 INCHES THICK. THE NEXT LAYER IS VERY PALE BROWN SILTY CLAY LOAM, ABOUT 11 INCHES THICK. THE SUBSTRATUM BELOW 16 INCHES IS WHITE MARINE CHALK INTERBEDDED WITH THIN STRATA OF OLIVE YELLOW SILTY CLAY LOAM.

Map unit: IvA - Ivanhoe silt loam, 0 to 1 percent slopes

Description category: AGR

Map Unit IvA, Component IVANHOE is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is 0.5 - 1.5 feet. The soil has a capability subclass of 3W dryland and NONE irrigated.

Description category: PHG

8A - TIGHT LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and dense subsoils; slopes 0 to 5 percent; low natural fertility; seasonally wet or droughty; medium water holding capacity but poor to fair plant-soil-moisture relationship; medium to high production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: IvA - Ivanhoe silt loam, 0 to 1 percent slopes

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

THE IVANHOE SERIES CONSISTS OF VERY DEEP, SOMEWHAT POORLY DRAINED, NEARLY LEVEL SOILS ON HIGH RIVER TERRACES. THE SOIL FORMED IN CLAYEY ALLUVIAL SEDIMENTS. IN A REPRESENTATIVE PROFILE THE SURFACE LAYER IS BROWN SILT LOAM 13 INCHES THICK, THE BA HORIZON IS VERY DARK GRAYISH BROWN SILTY CLAY LOAM 4 INCHES THICK, THE SUBSOIL IS VERY DARK GRAYISH BROWN CLAY 34 INCHES THICK THAT HAS REDDISH MOTTLES IN THE UPPER PART, THE BC HORIZON IS GRAYISH BROWN CLAY.

Map unit: KaA - Karma loam, 0 to 2 percent slopes

Description category: AGR

Map Unit KaA, Component KARMA is 80 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE LOAMY SOILS ON TERRACES. TYPICALLY, THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM. THE UPPER SUBSOIL LAYER IS RED CLAY LOAM, THE MIDDLE SUBSOIL LAYER IS YELLOWISH RED CLAY LOAM AND THE LOWER SUBSOIL LAYER IS YELLOWISH RED FINE SANDY LOAM.

Description category: WSG

3o1 - No significant management problems are caused by soil characteristics. Important commercial tree species include loblolly pine and shortleaf pine. These soils are suited for pine, and the site index for loblolly pine is 80. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 230 board feet (Doyle rule) per acre per year. Native species important to wildlife include red oak, white oak, American beautyberry, and yaupon. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, longleaf uniola, indiangrass, and beaked panicum. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Map unit: KaD2 - Karma loam, 5 to 12 percent slopes, eroded

Description category: AGR

Map Unit KaD2, Component KARMA is 80 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: KaD2 - Karma loam, 5 to 12 percent slopes, eroded

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE LOAMY SOILS ON TERRACES. TYPICALLY, THE SURFACE LAYER IS DARK BROWN FINE SANDY LOAM. THE UPPER SUBSOIL LAYER IS RED CLAY LOAM, THE MIDDLE SUBSOIL LAYER IS YELLOWISH RED CLAY LOAM AND THE LOWER SUBSOIL LAYER IS YELLOWISH RED FINE SANDY LOAM.

Description category: WSG

3o1 - No significant management problems are caused by soil characteristics. Important commercial tree species include loblolly pine and shortleaf pine. These soils are suited for pine, and the site index for loblolly pine is 80. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 230 board feet (Doyle rule) per acre per year. Native species important to wildlife include red oak, white oak, American beautyberry, and yaupon. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, longleaf uniola, indiangrass, and beaked panicum. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Map unit: KoD - Konawa fine sandy loam, 5 to 8 percent slopes

Description category: AGR

Map Unit KoD, Component KONAWA is 80 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

SANDY LOAM PE 52-64 SITE - Deep, sandy loam soils. Climax vegetation is a post oak, blackjack oak savannah, with associated woody plants and big and little bluestem, indiangrass, purpletop, switchgrass, beaked panicum, longleaf uniola, lespedezas, tickclovers, snoutbeans, tephrosia, butterflypea, partridge pea, bundleflower, and sensitivebrier.

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE SOILS ON STREAM TERRACES. TYPICALLY, THE SURFACE LAYER IS BROWN FINE SANDY LOAM. THE SUBSURFACE LAYER IS LIGHT REDDISH BROWN FINE SANDY LOAM. THE SUBSOIL IS RED SANDY CLAY LOAM AND FINE SANDY LOAM.

Map unit: LaD - Lamar clay loam, 5 to 8 percent slopes

Description category: AGR

Map Unit LaD, Component LAMAR is >60 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

7D - SLOPING FRIABLE CLAYEY UPLAND - Moderately deep to very deep friable clayey uplands with slopes greater than 5 percent; friable when moist, somewhat sticky when wet; high natural fertility; medium to high water holding capacity and fair to good plant-soil-moisture relationship; medium production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: LaD - Lamar clay loam, 5 to 8 percent slopes

Description category: RNG

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THE LAMAR SERIES CONSISTS OF VERY DEEP, WELL DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN CALCAREOUS LOAMY MARINE SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH BROWN CLAY LOAM ABOUT 4 INCHES THICK. THE UNDERLYING MATERIAL IS LIGHT YELLOWISH BROWN GRADING TO OLIVE YELLOW CLAY LOAM. THE LOWER PART IS BROWNISH YELLOW CLAY LOAM WITH MANY SOFT CARBONATE MASSES.

Map unit: LcA - Larton loamy fine sand, 0 to 2 percent slopes

Description category: AGR

Map Unit LcA, Component LARTON is 80 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

9A - SANDY UPLAND - Deep and very deep, sandy uplands with clayey or loamy subsoils within 40 inches; low natural fertility; low to medium water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE SOILS ON TERRACES. TYPICALLY, THE SURFACE AND SUBSURFACE LAYERS ARE BROWN LOAMY FINE SAND. THE UPPER SUBSOIL LAYERS ARE RED AND OR YELLOWISH RED FINE SANDY LOAM. THE LOWER SUBSOIL LAYER IS DOMINANTLY YELLOWISH RED SANDY CLAY LOAM.

Description category: WSG

3s2 - Sandy texture may cause moderate equipment limitations and seedling mortality. Important commercial tree species include loblolly pine, shortleaf pine, and longleaf pine. These soils are suited for pines, and the site index for loblolly pine is 80. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 230 board feet (Doyle rule) per acre per year. Native species important to wildlife include post oak, dogwood, and yaupon. High value grasses and forbs used by livestock include pinehill bluestem, little bluestem, longleaf uniola, and indiangrass. Stocking rates depend on canopy density and range from 8-40 acres per animal unit.

Map unit: LeB - Leson clay, 1 to 3 percent slopes

Description category: AGR

Map Unit LeB, Component LESON is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

7A1 - HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline in the lower layers; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Map unit: LeB - Leson clay, 1 to 3 percent slopes

Description category: RNG

BLACKLAND PE 44-64 SITE - Deep, fertile, clay soils. Climax vegetation is little bluestem, big bluestem, indiangrass, and switchgrass; with maximilian sunflower, engelmanndaisy, button snakeroot, bundleflowers, prairieclover, prairieparsley, indianplantain, and gayfeather. Live oak may dot the landscape.

Description category: SOI

THE LESON SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL TO GENTLY SLOPING SOILS ON UPLANDS. THE SOIL FORMED IN WEAKLY CONSOLIDATED MARINE SHALES AND CLAYS. IN A REPRESENTATIVE PROFILE, THE SURFACE IS BLACK CLAY ABOUT 10 INCHES THICK. THE SUBSOIL FROM 10 TO 60 INCHES IS CLAY AND IS DARK GRAY IN. THE UPPER PART AND PALE OLIVE IN THE LOWER PART. THE SUBSTRATUM FROM 60 TO MORE THAN 80 INCHES IS OLIVE GRAY WEAKLY CONSOLIDATED SHALE THAT HAS CLAY TEXTURE.

Map unit: LvB - Lewisville silty clay, 1 to 3 percent slopes

Description category: AGR

Map Unit LvB, Component LEWISVILLE is >60 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

7C - FRIABLE CLAYEY UPLAND - Moderately deep to very deep friable clayey uplands with slopes 0 to 5 percent; friable when moist; somewhat sticky when wet; high natural fertility; medium to high water holding capacity and fair to good plant-soil-moisture relationship; high production potential.

Description category: RNG

CLAY LOAM PE 44-64 SITE - Deep, fertile, loamy soils. Climax vegetation includes big and little bluestem, indiangrass, switchgrass, wildrye, and sideoats grama; with maximilian sunflower, engelmanndaisy, penstemon, gayfeather, sundrops, and other forbs. Pecan, hackberry, elm, oaks, bumelia, and sumac are sparse inhabitants.

Description category: SOI

THESE ARE VERY DEEP WELL DRAINED, MODERATELY PERMEABLE CALCAREOUS SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO STRONGLY SLOPING STREAM TERRACES. THE SOIL FORMED IN CALCAREOUS LOAMY ALLUVIAL SEDIMENTS. THESE SOILS HAVE DARK GRAYISH BROWN FRIABLE SILTY CLAY UPPER LAYERS ABOUT 16 INCHES THICK OVER SILTY CLAY LOWER LAYERS THAT ARE GRAYISH BROWN IN THE UPPER PART AND PALE BROWN IN THE LOWER PART. BUT ARE DOMINANTLY ABOUT 2 TO 6 PERCENT.

Map unit: MoD2 - Morse clay, 5 to 12 percent slopes, eroded

Description category: AGR

Map Unit MoD2, Component MORSE is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Brief Map Unit Description

Fannin County, Texas

Map unit: MoD2 - Morse clay, 5 to 12 percent slopes, eroded

Description category: PHG

7B1 - SLOPING HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes greater than 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline on lower layers; medium to high natural fertility; seasonally wet or droughty; Very high to high water holding capacity but poor to fair plant-soil-moisture relationship; medium production potential.

Description category: SOI

THE MORSE SERIES CONSISTS OF WELL DRAINED, VERY SLOWLY PERMEABLE SOILS. THEY HAVE A VERY DARK GRAY CLAY SURFACE AND A YELLOWISH RED CLAY UNDERLYING MATERIAL. LIME CONCRETIONS ARE COMMON IN THE UNDERLYING MATERIAL AND IN PLACES EXTEND TO THE SURFACE. THESE SOILS DEVELOPED IN ALKALINE CLAYS.

Description category: WSG

6c9 - Clayey texture may cause severe equipment limitations and seedling mortality when wet. Erosion increases with slope. Important commercial tree species include loblolly pine, shortleaf pine, and red oak. These soils are suited for pines and hardwoods, and the site index for loblolly pine is 50. The yield from an unmanaged stand may be too low for commercial production. Native species important to wildlife include post oak, red oak, ash, and American beautyberry. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, and longleaf uniola. Stocking rates depend on canopy density and range from 10-60 acres per animal unit.

Map unit: Mu - Muldrow clay loam, rarely flooded

Description category: AGR

Map Unit Mu, Component MULDROW is 80 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is 0 - 2 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

1A - HEAVY CLAYEY BOTTOMLAND - Deep and very deep, somewhat poorly to well drained, heavy bottomlands; may overflow; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; high production potential.

Description category: SOI

THESE ARE VERY DEEP, SOMEWHAT POORLY DRAINED, VERY SLOWLY PERMEABLE SOILS ON LOW TERRACES. TYPICALLY, THE SURFACE LAYER IS VERY DARK GRAYISH BROWN SILTY CLAY LOAM. THE UPPER PART OF THE SUBSOIL IS VERY DARK GRAY SILTY CLAY AND THE LOWER PART IS DARK GRAYISH BROWN SILTY CLAY. SLOPES RANGE FROM 0 TO 1 PERCENT.

Description category: WSG

2w6 - Clayey texture and seasonal wetness will cause severe equipment limitations and seedling mortality. Important commercial trees include willow oak, water oak, green ash, and sweetgum. These soils are suited for hardwoods, and the site index for water oak and sweetgum is 90. The yield from unmanaged stand of water oak over a 50-year period is approximately 236 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and blackgum. Grasses and forbs important for livestock include switchgrass, beaked panicum, switch cane, wildrye and sedges. Stocking rates depend on canopy density and range from 6-50 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: NoB - Normangee clay loam, 1 to 3 percent slopes

Description category: AGR

Map Unit NoB, Component NORMANGEE is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

7H - TIGHT CLAYEY UPLAND - Deep and very deep, tight clayey or clay loam uplands; dense clayey subsoils; slopes 0 to 5 percent; medium natural fertility; medium water holding capacity but poor plant-soil-moisture relationship; seasonally wet or droughty; medium to high production potential.

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

NORMANGEE SOILS ARE DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO MODERATELY SLOPING UPLANDS. THE SOIL FORMED IN ALKALINE CLAYS AND SHALES. IN REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN CLAY LOAM ABOUT 7 INCHES THICK OVER A CLAY SUBSOIL THAT IS BROWN MOTTLED WITH YELLOWISH AND REDDISH BROWN IN THE UPPER PART AND LIGHT YELLOWISH BROWN MOTTLED WITH YELLOWISH BROWN AND OLIVE YELLOW IN THE LOWER PART.

Map unit: NoC2 - Normangee clay loam, 2 to 5 percent slopes, eroded

Description category: AGR

Map Unit NoC2, Component NORMANGEE is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

7H - TIGHT CLAYEY UPLAND - Deep and very deep, tight clayey or clay loam uplands; dense clayey subsoils; slopes 0 to 5 percent; medium natural fertility; medium water holding capacity but poor plant-soil-moisture relationship; seasonally wet or droughty; medium to high production potential.

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

NORMANGEE SOILS ARE DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO MODERATELY SLOPING UPLANDS. THE SOIL FORMED IN ALKALINE CLAYS AND SHALES. IN REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN CLAY LOAM ABOUT 7 INCHES THICK OVER A CLAY SUBSOIL THAT IS BROWN MOTTLED WITH YELLOWISH AND REDDISH BROWN IN THE UPPER PART AND LIGHT YELLOWISH BROWN MOTTLED WITH YELLOWISH BROWN AND OLIVE YELLOW IN THE LOWER PART.

Brief Map Unit Description

Fannin County, Texas

Map unit: Nw - Norwood silt loam, rarely flooded

Description category: AGR

Map Unit Nw, Component NORWOOD is >60 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 1 dryland and 1 irrigated.

Description category: PHG

2A - LOAMY BOTTOMLAND - Deep and very deep, loamy bottomlands with friable loamy subsoils; may overflow; medium natural fertility; medium to high water holding capacity with good plant- soil-moisture relationship; high production potential.

Description category: SOI

THE NORWOOD SERIES CONSISTS OF VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE NEARLY LEVEL TO SLOPING SOILS OF BOTTOMLANDS. THE SOIL FORMED IN CALCAREOUS LOAMY ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS SILT LOAM ABOUT 13 INCHES THICK AND IS BROWN IN THE UPPER PART AND REDDISH BROWN IN THE LOWER PART. THE NEXT LAYER IS LIGHT REDDISH BROWN SILT LOAM 24 INCHES THICK. THE SUBSTRATUM BELOW 37 INCHES IS REDDISH YELLOW STRATIFIED VERY FINE SANDY LOAM AND SILT LOAM.

Description category: WSG

2o4 - No significant management problems are caused by soil characteristics. Important commercial tree species include water oak, green ash, willow oak, and sweetgum. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 90. The yield from an unmanaged stand over a 50-year period is approximately 210 board feet (Doyle rule) for sweetgum, per acre per year. Native species important to wildlife include water oak, willow oak, Alabama supplejack, yaupon, and American beautyberry. High value grasses and forbs used by livestock include switchgrass, longleaf uniola, pinehill bluestem, and virginia wildrye. Stocking rates depend on canopy density and range from 8-40 acres per animal unit.

Map unit: OkA - Okay loam, 0 to 1 percent slopes

Description category: AGR

Map Unit OkA, Component OKAY is 80 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 1 dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY PERMEABLE SOILS ON TERRACES. TYPICALLY, THE SURFACE LAYER IS DARK BROWN LOAM. THE NEXT LAYER IS DARK BROWN LOAM. THE SUBSOIL IS REDDISH BROWN CLAY LOAM AND LOAM.

Description category: WSG

3o1 - No significant management problems are caused by soil characteristics. Important commercial tree species include loblolly pine and shortleaf pine. These soils are suited for pine, and the site index for loblolly pine is 80. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 230 board feet (Doyle rule) per acre per year. Native species important to wildlife include red oak, white oak, American beautyberry, and yaupon. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, longleaf uniola, indiangrass, and beaked panicum. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: Om - Oklared-Kiomatia complex, occasionally flooded

Description category: AGR

Map Unit Om, Component KIOMATIA is >60 - inches thick. Permeability is MODERATE and available water holding capacity is LOW. A water table when present is 3.5 - 5 feet. The soil has a capability subclass of 3S dryland and NONE irrigated.

Map Unit Om, Component OKLARED is 80 - inches thick. Permeability is MODERATELY RAPID and available water holding capacity is HIGH. A water table when present is 3.5 - 5 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

2A - LOAMY BOTTOMLAND - Deep and very deep, loamy bottomlands with friable loamy subsoils; may overflow; medium natural fertility; medium to high water holding capacity with good plant- soil-moisture relationship; high production potential.

Description category: SOI

THESE ARE VERY DEEP, WELL DRAINED, MODERATELY RAPIDLY PERMEABLE SOILS ON FLOOD PLAINS. TYPICALLY THE SURFACE LAYER IS YELLOWISH RED FINE SANDY LOAM. THE UNDERLYING MATERIALS ARE REDDISH YELLOW, REDDISH BROWN, AND YELLOWISH RED VERY FINE FINE SANDY LOAM, FINE SANDY LOAM AND SILT LOAM THAT ARE STRATIFIED.

THE KIOMATIA SERIES CONSISTS OF VERY DEEP, WELL DRAINED, RAPIDLY PERMEABLE, NEARLY LEVEL TO GENTLY SLOPING SOILS OF BOTTOMLANDS. THE SOIL FORMED IN CALCAREOUS SANDY ALLUVIUM. IN A REPRESENTATIVE PROFILE THE SURFACE LAYER IS BROWN LOAMY FINE SAND ABOUT 4 INCHES THICK. THE UNDERLYING MATERIAL IS STRATIFIED FINE SAND, VERY FINE SANDY LOAM, AND FINE SANDY LOAM.

Description category: WSG

2o4 - No significant management problems are caused by soil characteristics. Important commercial tree species include water oak, green ash, willow oak, and sweetgum. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 90. The yield from an unmanaged stand over a 50-year period is approximately 210 board feet (Doyle rule) for sweetgum, per acre per year. Native species important to wildlife include water oak, willow oak, Alabama supplejack, yaupon, and American beautyberry. High value grasses and forbs used by livestock include switchgrass, longleaf uniola, pinehill bluestem, and virginia wildrye. Stocking rates depend on canopy density and range from 8-40 acres per animal unit.

Map unit: Or - Orthents, loamy

Description category: AGR

Map Unit Or, Component ORTHENTS is >60 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 2C dryland and 1 irrigated.

Description category: PHG

OSI - On site investigation needed for Pasture and Hayland interpretations.

Description category: SOI

USTORTHENTS, LOAMY CONSISTS OF VERY DEEP SOILS THAT HAVE BEEN DRASTICALLY CUT BY HEAVY MACHINERY DURING LAND LEVELING. THE SOIL CONSISTS OF LOWER SUBSOILS AND SUBSTRATA THAT ARE CULTIVATED AND IRRIGATED.

Brief Map Unit Description

Fannin County, Texas

Map unit: PoC - Porum loam, 2 to 5 percent slopes

Description category: AGR

Map Unit PoC, Component PORUM is 80 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water table when present is 2.0 - 3 feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, MODERATELY WELL DRAINED, SLOWLY PERMEABLE SOILS ON HIGH TERRACES. TYPICALLY, THEY HAVE DARK GRAYISH BROWN FINE SANDY LOAM SURFACE LAYER, BROWN FINE SANDY LOAM SUBSURFACE LAYER, STRONG BROWN LOAM UPPER SUBSOIL, YELLOWISH RED SILTY CLAY LOAM MIDDLE SUBSOIL AND STRONG BROWN CLAY LOAM LOWER SUBSOIL.

Description category: WSG

4c2 - Clayey texture may cause moderate equipment limitations during wet periods, and erosion may increase with slope. Important commercial tree species include loblolly pine and shortleaf pine. These soils are suited for pines, and the site index for loblolly pine is 70. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 130 board feet (Doyle rule) per acre per year. Native species important to wildlife include red oak, post oak, and American beautyberry. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, and longleaf uniola. Stocking rates depend on canopy density and range from 6-40 acres per animal unit.

Map unit: PoD - Porum loam, 5 to 12 percent slopes

Description category: AGR

Map Unit PoD, Component PORUM is 80 - inches thick. Permeability is SLOW and available water holding capacity is HIGH. A water table when present is 2.0 - 3 feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THESE ARE VERY DEEP, MODERATELY WELL DRAINED, SLOWLY PERMEABLE SOILS ON HIGH TERRACES. TYPICALLY, THEY HAVE DARK GRAYISH BROWN FINE SANDY LOAM SURFACE LAYER, BROWN FINE SANDY LOAM SUBSURFACE LAYER, STRONG BROWN LOAM UPPER SUBSOIL, YELLOWISH RED SILTY CLAY LOAM MIDDLE SUBSOIL AND STRONG BROWN CLAY LOAM LOWER SUBSOIL.

Brief Map Unit Description

Fannin County, Texas

Map unit: PoD - Porum loam, 5 to 12 percent slopes

Description category: WSG

4c2 - Clayey texture may cause moderate equipment limitations during wet periods, and erosion may increase with slope. Important commercial tree species include loblolly pine and shortleaf pine. These soils are suited for pines, and the site index for loblolly pine is 70. The yield from an unmanaged stand of loblolly pine over a 50-year period is approximately 130 board feet (Doyle rule) per acre per year. Native species important to wildlife include red oak, post oak, and American beautyberry. High value grasses and forbs used by livestock include pinehill bluestem, big bluestem, and longleaf uniola. Stocking rates depend on canopy density and range from 6-40 acres per animal unit.

Map unit: Re - Redlake clay, rarely flooded

Description category: AGR

Map Unit Re, Component REDLAKE is 80 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 3W dryland and NONE irrigated.

Description category: PHG

1A - HEAVY CLAYEY BOTTOMLAND - Deep and very deep, somewhat poorly to well drained, heavy bottomlands; may overflow; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; high production potential.

Description category: SOI

THESE ARE VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE SOILS ON FLOOD PLAINS. TYPICALLY, THE SURFACE IS DARK REDDISH BROWN CLAY. THE SUBSOIL IS REDDISH BROWN CLAY. THE UNDERLYING MATERIAL IS YELLOWISH RED CLAY LOAM.

Description category: WSG

3w6 - Equipment limitations and seedling mortality will be severe during wet periods. Important commercial tree species include water oak, willow oak, green ash, and sweetgum. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 80. The yield from an unmanaged stand of sweetgum over a 50-year period is approximately 120 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and Alabama supplejack. High value grasses and forbs used by livestock include switchgrass, beaked panicum, wildrye, switchcane, and sedges. Stocking rates depend on canopy density and range from 6-50 acres per animal unit.

Map unit: Se - Severn silt loam, rarely flooded

Description category: AGR

Map Unit Se, Component SEVERN is 80 - inches thick. Permeability is MODERATELY RAPID and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 1 dryland and NONE irrigated.

Description category: PHG

2A - LOAMY BOTTOMLAND - Deep and very deep, loamy bottomlands with friable loamy subsoils; may overflow; medium natural fertility; medium to high water holding capacity with good plant- soil-moisture relationship; high production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: Se - Severn silt loam, rarely flooded

Description category: SOI

THESE ARE VERY DEEP, WELL-DRAINED, MODERATELY RAPIDLY PERMEABLE SOILS ON FLOODPLAINS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS REDDISH-BROWN, VERY FINE SANDY LOAM TO A DEPTH OF 10 INCHES. THE UNDERLYING MATERIAL IS REDDISH-BROWN, VERY FINE SANDY LOAM, THAT IS STRATIFIED WITH THIN STRATA OF LOAM, SILT LOAM, AND LOAMY FINE SAND.

Description category: WSG

2o4 - No significant management problems are caused by soil characteristics. Important commercial tree species include water oak, green ash, willow oak, and sweetgum. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 90. The yield from an unmanaged stand over a 50-year period is approximately 210 board feet (Doyle rule) for sweetgum, per acre per year. Native species important to wildlife include water oak, willow oak, Alabama supplejack, yaupon, and American beautyberry. High value grasses and forbs used by livestock include switchgrass, longleaf uniola, pinehill bluestem, and virginia wildrye. Stocking rates depend on canopy density and range from 8-40 acres per animal unit.

Map unit: ShB - Stephen silty clay, 1 to 3 percent slopes

Description category: AGR

Map Unit ShB, Component STEPHEN is 7 - 20 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is VERY LOW. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

13A - SHALLOW CLAYEY - Very shallow and shallow clayey uplands less than 20 inches thick; medium natural fertility; droughty very low to low water holding capacity with poor plant-soil-moisture relationship; low production potential.

Description category: RNG

CHALKY RIDGE PE 44-64 SITE - Shallow, loamy soils. Climax vegetation is little bluestem, indiangrass, big bluestem, sideoats grama, and tall dropseeds; with forbs such as engelmanndaisy, maximilian sunflower, gayfeathers, and bundleflowers. Hackberry, elm, live oak, and osageorange are sparsely present.

Description category: SOI

THE STEPHEN SERIES CONSISTS OF GENTLY SLOPING TO SLOPING, SHALLOW SOILS OF THE UPLANDS. THE SOIL FORMED IN INTER- BEDDED MARL AND CHALKY LIMESTONE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK BROWN SILTY CLAY ABOUT 8 INCHES THICK. THE NEXT 4 INCH LAYER CONSISTS OF ABOUT 65 PERCENT CHALK FRAGMENTS AND 35 PERCENT DARK BROWN SILTY CLAY. THE SUBSTRATA BELOW 12 INCHES IS PLATY CHALK.

Map unit: SrC - Stephen-Rock outcrop complex, 2 to 5 percent slopes

Description category: AGR

Map Unit SrC, Component STEPHEN is 7 - 20 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is VERY LOW. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

13A - SHALLOW CLAYEY - Very shallow and shallow clayey uplands less than 20 inches thick; medium natural fertility; droughty very low to low water holding capacity with poor plant-soil-moisture relationship; low production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: SrC - Stephen-Rock outcrop complex, 2 to 5 percent slopes

Description category: RNG

CHALKY RIDGE PE 44-64 SITE - Shallow, loamy soils. Climax vegetation is little bluestem, indiangrass, big bluestem, sideoats grama, and tall dropseeds; with forbs such as engelmanndaisy, maximilian sunflower, gayfeathers, and bundleflowers. Hackberry, elm, live oak, and osageorange are sparsely present.

Description category: SOI

THE STEPHEN SERIES CONSISTS OF GENTLY SLOPING TO SLOPING, SHALLOW SOILS OF THE UPLANDS. THE SOIL FORMED IN INTER- BEDDED MARL AND CHALKY LIMESTONE. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK BROWN SILTY CLAY ABOUT 8 INCHES THICK. THE NEXT 4 INCH LAYER CONSISTS OF ABOUT 65 PERCENT CHALK FRAGMENTS AND 35 PERCENT DARK BROWN SILTY CLAY. THE SUBSTRATA BELOW 12 INCHES IS PLATY CHALK.

Map unit: SvB - Stephenville fine sandy loam, 1 to 3 percent slopes

Description category: AGR

Map Unit SvB, Component STEPHENVILLE is 20 - 40 inches thick. Permeability is MODERATELY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

SANDY LOAM PE 52-64 SITE - Deep, sandy loam soils. Climax vegetation is a post oak, blackjack oak savannah, with associated woody plants and big and little bluestem, indiangrass, purpletop, switchgrass, beaked panicum, longleaf uniola, lespedezas, tickclovers, snoutbeans, tephrosia, butterflypea, partridge pea, bundleflower, and sensitivebrier.

Description category: SOI

THESE ARE MODERATELY DEEP, WELL DRAINED, MODERATELY PERMEABLE SOILS ON UPLAND. TYPICALLY, THE SURFACE LAYER IS BROWN FINE SANDY LOAM. THE SUBSURFACE LAYER IS LIGHT BROWN FINE SANDY LOAM. THE UPPER PART OF THE SUBSOIL IS YELLOWISH RED SANDY CLAY LOAM AND THE LOWER PART IS RED SANDY CLAY LOAM. THE UNDERLYING MATERIAL IS LIGHT RED SANDSTONE.

Map unit: Tc - Tinn clay, occasionally flooded

Description category: AGR

Map Unit Tc, Component TINN is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

1A - HEAVY CLAYEY BOTTOMLAND - Deep and very deep, somewhat poorly to well drained, heavy bottomlands; may overflow; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; high production potential.

Brief Map Unit Description

Fannin County, Texas

Map unit: Tc - Tinn clay, occasionally flooded

Description category: SOI

THE TINN SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, CALCAREOUS SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO VERY GENTLY SLOPING BOTTOMLANDS. THE SOIL FORMED IN CLAYEY ALLUVIUM. THESE SOILS ARE CALCAREOUS AND CLAYEY THROUGHOUT. THEY ARE BLACK OR VERY DARK GRAY IN THE UPPER PART AND DARK GRAY OR GRAY MOTTLED WITH OLIVE AND YELLOW IN THE LOWER PART. THE SOILS ARE COMMONLY FLOODED UNLESS PROTECTED.

Description category: WSG

4w6 - Wet conditions may cause severe equipment limitations and seedling mortality. Important commercial tree species include sweetgum, water oak, willow oak, and green ash. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 70. The yield from an unmanaged stand of sweetgum over a 50-year period is approximately 50 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and yaupon. High value grasses and forbs used by livestock include switchcane, wildrye, longleaf uniola, and sedge. Stocking rates depend on canopy density and range from 10-80 acres per animal unit.

Map unit: Tf - Tinn clay, frequently flooded

Description category: AGR

Map Unit Tf, Component TINN is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 5W dryland and NONE irrigated.

Description category: PHG

1A - HEAVY CLAYEY BOTTOMLAND - Deep and very deep, somewhat poorly to well drained, heavy bottomlands; may overflow; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; high production potential.

Description category: SOI

THE TINN SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, CALCAREOUS SOILS. THESE SOILS OCCUPY NEARLY LEVEL TO VERY GENTLY SLOPING BOTTOMLANDS. THE SOIL FORMED IN CLAYEY ALLUVIUM. THESE SOILS ARE CALCAREOUS AND CLAYEY THROUGHOUT. THEY ARE BLACK OR VERY DARK GRAY IN THE UPPER PART AND DARK GRAY OR GRAY MOTTLED WITH OLIVE AND YELLOW IN THE LOWER PART. THE SOILS ARE COMMONLY FLOODED UNLESS PROTECTED.

Description category: WSG

4w6 - Wet conditions may cause severe equipment limitations and seedling mortality. Important commercial tree species include sweetgum, water oak, willow oak, and green ash. These soils are suited for hardwoods, and the site index for sweetgum and water oak is 70. The yield from an unmanaged stand of sweetgum over a 50-year period is approximately 50 board feet (Doyle rule) per acre per year. Native species important to wildlife include water oak, willow oak, green ash, and yaupon. High value grasses and forbs used by livestock include switchcane, wildrye, longleaf uniola, and sedge. Stocking rates depend on canopy density and range from 10-80 acres per animal unit.

Map unit: VtC - Vertel clay, 2 to 5 precent slopes

Description category: AGR

Map Unit VtC, Component VERTEL is 24 - 40 inches thick. Permeability is VERY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Brief Map Unit Description

Fannin County, Texas

Map unit: VtC - Vertel clay, 2 to 5 precent slopes

Description category: PHG

7A1 - HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline in the lower layers; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

ERODED BLACKLAND PE 44-64 SITE - Deep, sloping, eroded, clay soils. Climax vegetation includes big and little bluestem, indiangrass switchgrass, wildrye, meadow dropseed, texas wintergrass, silver bluestem engelmanndaisy maximilian sunflower gayfeather blacksamson, bundleflower sensitivebrier neptunia prairieclovers, scurfpea, buttonsnakeroot, and groundplum. Sparse woody inhabitants occur.

Description category: SOI

THE VERTEL SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, VERY SLOWLY PERMEABLE, GENTLY SLOPING TO STEEP SOILS OF UPLANDS. THE SOIL FORMED IN SHALES. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH BROWN CLAY ABOUT 6 INCHES THICK. THE NEXT LAYER IS ABOUT 27 INCHES THICK AND IS GRAYISH BROWN CLAY WITH YELLOWISH BROWN MOTTLES. BELOW 33 INCHES IS DARK GRAY YELLOWISH BROWN, YELLOW AND YELLOWISH RED SHALE,

Map unit: VtD - Vertel clay, 5 to 8 percent slopes

Description category: AGR

Map Unit VtD, Component VERTEL is 24 - 40 inches thick. Permeability is VERY SLOW and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

7A1 - HEAVY CLAYEY UPLAND (NON-CALCAREOUS) - Deep and very deep heavy clayey uplands with slopes of 0 to 5 percent; dense clayey subsoils; reaction is slightly acid to moderately alkaline in the surface and mildly to moderately alkaline in the lower layers; high natural fertility; seasonally wet or droughty; very high to high water holding capacity but fair plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

ERODED BLACKLAND PE 44-64 SITE - Deep, sloping, eroded, clay soils. Climax vegetation includes big and little bluestem, indiangrass switchgrass, wildrye, meadow dropseed, texas wintergrass, silver bluestem engelmanndaisy maximilian sunflower gayfeather blacksamson, bundleflower sensitivebrier neptunia prairieclovers, scurfpea, buttonsnakeroot, and groundplum. Sparse woody inhabitants occur.

Description category: SOI

THE VERTEL SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, VERY SLOWLY PERMEABLE, GENTLY SLOPING TO STEEP SOILS OF UPLANDS. THE SOIL FORMED IN SHALES. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH BROWN CLAY ABOUT 6 INCHES THICK. THE NEXT LAYER IS ABOUT 27 INCHES THICK AND IS GRAYISH BROWN CLAY WITH YELLOWISH BROWN MOTTLES. BELOW 33 INCHES IS DARK GRAY YELLOWISH BROWN, YELLOW AND YELLOWISH RED SHALE,

Map unit: WaA - Waskom silt loam, 0 to 1 percent slopes

Description category: AGR

Map Unit WaA, Component WASKOM is >60 - inches thick. Permeability is MODERATELY SLOW and available water holding capacity is HIGH. A water table when present is 1.5 - 2.5 feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Brief Map Unit Description

Fannin County, Texas

Map unit: WaA - Waskom silt loam, 0 to 1 percent slopes

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THE WASKOM SERIES CONSISTS OF VERY DEEP, MODERATELY WELL-DRAINED, NEARLY LEVEL SOILS ON OLD STREAM TERRACES. THE SOIL FORMED IN LOAMY ALLUVIAL SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAYISH-BROWN LOAM, ABOUT 15 INCNES THICK. THE UPPER SUBSOIL IS DARK BROWN CLAY LOAM, ABOUT 17 INCHES THICK. THE NEXT LAYER, TO 80 INCHES OR MORE, MOTTLED YELLOWISH-BROWN, GRAYISH-BROWN, AND STRONG BROWN SANDY CLAY LOAM.

Description category: WSG

2w8 - Seasonal wetness may cause moderate equipment limitations and plant competition. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include water oak, red oak, yaupon, American beautyberry, and Alabama supplejack. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, virginia wildrye, switchgrass, and beaked panicum. Stocking rates depend on canopy density and range from 6-60 acres per animal unit.

Map unit: WhB - Whakana very fine sandy loam, 1 to 3 percent slopes

Description category: AGR

Map Unit WhB, Component WHAKANA is >60 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 2E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THE WHAKANA SERIES CONSISTS OF VERY DEEP, WELL DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN ACID, LOAMY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS A BROWN LOAM 14 INCHES THICK. THE UPPER PART OF THE SUBSOIL IS A CLAY LOAM AND YELLOWISH RED IN THE UPPER 10 INCHES AND BROWN IN THE NEXT 10 INCHES. THE NEXT LAYER IS A LOAM. THE UPPER 12 INCHES IS DARK RED; THE LOWER 17 INCHES IS RED. THE NEXT LAYER TO 80 INCHES IS YELLOWISH RED SANDY CLAY LOAM.

Description category: WSG

2o7 - Soil characteristics do not cause significant management problems. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include red oak, American beautyberry, Alabama supplejack, yaupon, and ash. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, big bluestem, beaked panicum, and little bluestem. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Brief Map Unit Description

Fannin County, Texas

Map unit: WhC - Whakana very fine sandy loam, 3 to 5 percent slopes

Description category: AGR

Map Unit WhC, Component WHAKANA is >60 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3E dryland and NONE irrigated.

Description category: PHG

8C - LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes 0 to 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THE WHAKANA SERIES CONSISTS OF VERY DEEP, WELL DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN ACID, LOAMY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS A BROWN LOAM 14 INCHES THICK. THE UPPER PART OF THE SUBSOIL IS A CLAY LOAM AND YELLOWISH RED IN THE UPPER 10 INCHES AND BROWN IN THE NEXT 10 INCHES. THE NEXT LAYER IS A LOAM. THE UPPER 12 INCHES IS DARK RED; THE LOWER 17 INCHES IS RED. THE NEXT LAYER TO 80 INCHES IS YELLOWISH RED SANDY CLAY LOAM.

Description category: WSG

2o7 - Soil characteristics do not cause significant management problems. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include red oak, American beautyberry, Alabama supplejack, yaupon, and ash. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, big bluestem, beaked panicum, and little bluestem. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Map unit: WhD - Whakana very fine sandy loam, 5 to 12 percent slopes

Description category: AGR

Map Unit WhD, Component WHAKANA is >60 - inches thick. Permeability is MODERATE and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 4E dryland and NONE irrigated.

Description category: PHG

8D - SLOPING LOAMY UPLAND - Moderately deep to very deep uplands with loamy surfaces and friable loamy subsoils; slopes greater than 8 percent; medium natural fertility; medium to high water holding capacity with good plant-soil-moisture relationship; medium to high production potential.

Description category: SOI

THE WHAKANA SERIES CONSISTS OF VERY DEEP, WELL DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS OF UPLANDS. THE SOIL FORMED IN ACID, LOAMY SEDIMENTS. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS A BROWN LOAM 14 INCHES THICK. THE UPPER PART OF THE SUBSOIL IS A CLAY LOAM AND YELLOWISH RED IN THE UPPER 10 INCHES AND BROWN IN THE NEXT 10 INCHES. THE NEXT LAYER IS A LOAM. THE UPPER 12 INCHES IS DARK RED; THE LOWER 17 INCHES IS RED. THE NEXT LAYER TO 80 INCHES IS YELLOWISH RED SANDY CLAY LOAM.

Brief Map Unit Description

Fannin County, Texas

Map unit: WhD - Whakana very fine sandy loam, 5 to 12 percent slopes

Description category: WSG

2o7 - Soil characteristics do not cause significant management problems. Important commercial tree species include loblolly pine, shortleaf pine, sweetgum, and red oak. These soils are suited for pine and hardwoods, and the site index for loblolly pine and sweetgum is 90. The yield from an unmanaged stand over a 50-year period is approximately 330 board feet (Doyle rule) for loblolly pine, or 210 for sweetgum per acre per year. Native species important to wildlife include red oak, American beautyberry, Alabama supplejack, yaupon, and ash. High value grasses and forbs used by livestock include pinehill bluestem, longleaf uniola, big bluestem, beaked panicum, and little bluestem. Stocking rates depend on canopy density and range from 8-50 acres per animal unit.

Map unit: Ws - Whitesboro loam, occasionally flooded

Description category: AGR

Map Unit Ws, Component WHITESBORO is >60 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 2W dryland and NONE irrigated.

Description category: PHG

2A - LOAMY BOTTOMLAND - Deep and very deep, loamy bottomlands with friable loamy subsoils; may overflow; medium natural fertility; medium to high water holding capacity with good plant- soil-moisture relationship; high production potential.

Description category: RNG

LOAMY BOTTOMLAND PE 52-64 SITE - Flood plains of alluvial soils. Vegetation includes indiangrass; little, sand, or big bluestem; switchgrass, wildryes, texas wintergrass, vine-mesquite, falseswitchgrass, meadow dropseed, western wheatgrass, sideoats grama, ragweeds, engelmanndaisy, heath aster, maximilian sunflower, gauras, elm, hackberry, bumelia, soapberry, grapes, cottonwood, and ash.

Description category: SOI

THE WHITESBORO SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, MODERATELY PERMEABLE NEARLY LEVEL SOILS OF FLOOD PLAINS. THE SOIL FORMED IN LOAMY ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN LOAM, 19 INCHES THICK. THE NEXT LAYER IS DARK GRAYISH-BROWN SANEDY CLAY LOAM 18 INCHES THICK. THE NEXT 12 INCHES IS BROWN CLAY LOAM WITH GRAY AND REDDISH-BROWN MOTTLES. BELOW 39 INCHES IS MOTTLED GRAY AND REDDISH-YELLOW SANDY CLAY LOAM.

Map unit: Wt - Whitesboro loam, frequently flooded

Description category: AGR

Map Unit Wt, Component WHITESBORO is >60 - inches thick. Permeability is MODERATE and available water holding capacity is HIGH. A water table when present is >6 - feet. The soil has a capability subclass of 5W dryland and NONE irrigated.

Description category: PHG

2A - LOAMY BOTTOMLAND - Deep and very deep, loamy bottomlands with friable loamy subsoils; may overflow; medium natural fertility; medium to high water holding capacity with good plant- soil-moisture relationship; high production potential.

Description category: RNG

LOAMY BOTTOMLAND PE 52-64 SITE - Flood plains of alluvial soils. Vegetation includes indiangrass; little, sand, or big bluestem; switchgrass, wildryes, texas wintergrass, vine-mesquite, falseswitchgrass, meadow dropseed, western wheatgrass, sideoats grama, ragweeds, engelmanndaisy, heath aster, maximilian sunflower, gauras, elm, hackberry, bumelia, soapberry, grapes, cottonwood, and ash.

Brief Map Unit Description

Fannin County, Texas

Map unit: Wt - Whitesboro loam, frequently flooded

Description category: SOI

THE WHITESBORO SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, MODERATELY PERMEABLE NEARLY LEVEL SOILS OF FLOOD PLAINS. THE SOIL FORMED IN LOAMY ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS DARK GRAYISH BROWN LOAM, 19 INCHES THICK. THE NEXT LAYER IS DARK GRAYISH-BROWN SANEDY CLAY LOAM 18 INCHES THICK. THE NEXT 12 INCHES IS BROWN CLAY LOAM WITH GRAY AND REDDISH-BROWN MOTTLES. BELOW 39 INCHES IS MOTTLED GRAY AND REDDISH-YELLOW SANDY CLAY LOAM.

Map unit: WwD2 - Whitewright-Howe complex, 5 to 12 percent slopes, eroded

Description category: AGR

Map Unit WwD2, Component HOWE is 20 - 40 inches thick. Permeability is MODERATE and available water holding capacity is LOW. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Map Unit WwD2, Component WHITEWRIGHT is 10 - 20 inches thick. Permeability is MODERATE and available water holding capacity is VERY LOW. A water table when present is >6 - feet. The soil has a capability subclass of 6E dryland and NONE irrigated.

Description category: PHG

13A - SHALLOW CLAYEY - Very shallow and shallow clayey uplands less than 20 inches thick; medium natural fertility; droughty very low to low water holding capacity with poor plant-soil-moisture relationship; low production potential.

Description category: RNG

CHALKY RIDGE PE 44-64 SITE - Shallow, loamy soils. Climax vegetation is little bluestem, indiangrass, big bluestem, sideoats grama, and tall dropseeds; with forbs such as engelmanndaisy, maximilian sunflower, gayfeathers, and bundleflowers. Hackberry, elm, live oak, and osageorange are sparsely present.

Description category: SOI

THE WHITEWRIGHT SERIES CONSISTS OF SHALLOW, WELL DRAINED, MODERATELY PERMEABLE SOILS OF UPLANDS. THEY FORMED IN CHALK AND MARL. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS LIGHT BROWNISH-GRAY SILTY CLAY LOAM, ABOUT 5 INCHES THICK. THE NEXT LAYER IS VERY PALE BROWN SILTY CLAY LOAM, ABOUT 11 INCHES THICK. THE SUBSTRATUM BELOW 16 INCHES IS WHITE MARINE CHALK INTERBEDDED WITH THIN STRATA OF OLIVE YELLOW SILTY CLAY LOAM.

THE HOWE SERIES CONSISTS OF MODERATELY DEEP, WELL DRAINED, GENTLY SLOPING TO STRONGLY SLOPING SOILS ON UPLANDS. THE SOIL FORMED IN MARINE CHALK AND MARL. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS GRAYISH-BROWN SILTY CLAY LOAM, ABOUT 7 INCHES THICK. THE NEXT LAYER IS LIGHT GRAY SILTY CLAY LOAM, 8 INCHES THICK. THE NEXT LOWER LAYER IS VERY PALE BROWN SILTY CLAY LOAM, 11 INCHES THICK. BELOW 26 INCHES IS WHITE WEAKLY-CEMENTED CHALK.

Map unit: WzA - Wilson silt loam, 0 to 1 percent slopes

Description category: AGR

Map Unit WzA, Component WILSON is >60 - inches thick. Permeability is VERY SLOW and available water holding capacity is MODERATE. A water table when present is >6 - feet. The soil has a capability subclass of 3W dryland and NONE irrigated.

Brief Map Unit Description

Fannin County, Texas

Map unit: WzA - Wilson silt loam, 0 to 1 percent slopes

Description category: PHG

8E1 - SLIGHTLY WET UPLAND - Deep and very deep, loamy uplands; wet during cool seasons; somewhat poorly drained; mainly tight subsoils; medium natural fertility; Very high to high water holding capacity with fair to good plant-soil-moisture relationship; medium to high production potential.

Description category: RNG

CLAYPAN PRAIRIE PE 44-64 SITE - Deep, loamy soils. Climax vegetation includes little bluestem, indiangrass, big bluestem, switchgrass, dropseeds, wildrye, silver bluestem, and texas wintergrass; with engelmanndaisy, maximilian sunflower, prairieparsley, indianplantain, bundleflower, neptunia, sensitivebrier, and scurfpea. Mesquite invades aggressively.

Description category: SOI

THE WILSON SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, VERY SLOWLY PERMEABLE, NEARLY LEVEL TO GENTLY SLOPING SOILS ON TERRACES. THE SOIL FORMED IN ALKALINE CLAYEY ALLUVIUM. IN A REPRESENTATIVE PROFILE, THE SURFACE LAYER IS VERY DARK GRAY SILT LOAM ABOUT 5 INCHES THICK. THE SUBSOIL IS SILTY CLAY THAT IS VERY DARK GRAY IN THE UPPER PART AND GRAYISH BROWN IN THE LOWER PART. BELOW 65 INCHES THE SOIL IS OLIVE GRAY SILTY CLAY.

Table 1. Identification of soil samples from 2006 data collection.

RESEARCH SOIL ANALYSIS		
Lab #	**Sample ID #**	**Extended Sample ID's**
R4608	1	Davis Creek Bed-near FM 1550
R4609	2	Brushy Creek Bed- close to confluence of Brushy and Pots Creeks
R4610	3	Pickle Creek Bed
R4611	4	Upstream reaches of North Sulfur River-bedrock outcrop. This is chips of that bedrock to determine if this mat'l is erodible.
R4612	5	This is from the 2nd bedrock shelf we found, material from the banks of the river. Upstream reaches of North Sulfur River-bedrock outcrop.
R4613	6	This sample is from the banks of that tributary, near the location marked as "Willow Grove Cemetery" on the USGS quads. Tributary to North Sulfur River, flowing into river from the south.
R4614	7	This sample is from the bed of that tributary, near the location marked as "Willow Grove Cemetery" on the USGS quads. Tributary to North Sulfur River, flowing into river from the south.
R4615	8	Long Creek Bed-near confluence with North Sulphur River
R4616	9	Long Creek Banks-near confluence with North Sulphur River
R4617	10	Most upstream point we reached on the North Sulphur River, from the toe of the bank- all mud because of standing water of unknown depth
R4618	11	From 1st bedrock outcrop/shelf/waterfall (looked 20' tall). Rock very hard, we broke these pieces off with a hammer
R4619	12	Davis Creek banks-near FM 1550
R4620	13	North Sulphur River upstream of Allen Creek at the first bridge we ever visited. This sample is from the bank where an unnamed tributary enters
R4621	14	North Sulphur River upstream end-from the bed of the river just downstream of the first bedrock outcrop/shelf/waterfall.

Table 2. Sediment Size Distribution for Sand and Gravel Fractions (Percent Finer by Weight).

Sediment Size Distribution for Sand and Gravel Fractions (Percent Finer by Weight).											
Sample ID	**0.0625**	**0.25**	**0.5**	**0.6**	**0.71**	**1.0**	**1.18**	**1.7**	**2.0**	**4.0**	**8.0**
1	0	45.583	52.750	60.250	64.500	71.417	73.000	77.708	80.167	93.167	100.000
2	0	17.400	20.400	21.800	23.267	30.600	36.267	53.067	61.067	87.000	100.000
3	0	16.280	19.680	23.040	26.040	34.360	39.120	54.440	63.000	88.920	100.000
4	0	0.000	5.175	7.153	8.529	12.270	13.956	20.333	24.481	43.671	100.000
5	0	77.429	80.500	82.214	83.071	86.071	88.571	92.643	94.071	98.857	100.000
6	0	92.368	94.105	94.737	94.947	96.000	96.526	97.632	98.053	100.000	100.000
7	0	51.263	55.158	57.474	59.737	64.842	67.421	74.421	78.737	90.474	100.000
8	0	49.684	55.053	58.789	62.368	70.263	72.684	78.947	82.526	94.789	100.000
9	0	70.821	74.143	75.500	76.643	78.786	79.536	81.679	83.000	91.607	100.000
10	0	81.467	90.800	93.400	95.067	96.600	97.133	97.733	98.467	100.000	100.000
11	0	22.673	28.224	30.408	31.571	35.000	36.878	43.673	47.347	69.245	100.000
12	0	77.120	86.640	90.480	93.520	98.240	98.720	99.560	99.800	100.000	100.000
13	0	52.960	62.360	64.840	66.440	69.880	71.600	76.240	78.400	87.560	100.000
14	0	68.185	72.222	73.778	75.296	79.000	80.296	84.778	86.593	93.333	100.000

Table 3. Sediment Size Distribution All Size Fractions (Percent Finer by Weight).

Sediment Size Distribution for All Size Fractions (Percent Finer by Weight).														
Sample ID	**0.0002**	**0.004**	**0.0625**	**0.25**	**0.5**	**0.6**	**0.71**	**1.0**	**1.18**	**1.7**	**2.0**	**4.0**	**8.0**
1	0	55	76.000	86.940	88.660	90.460	91.480	93.140	93.520	94.650	95.240	98.360	100.0
2	0	50	70.000	75.220	76.120	76.540	76.980	79.180	80.880	85.920	88.320	96.100	100.0
3	0	58	75.000	79.070	79.920	80.760	81.510	83.590	84.780	88.610	90.750	97.230	100.0
4	0	28	48.000	48.000	50.670	51.690	52.400	54.330	55.200	58.490	60.630	70.530	100.0
5	0	64	86.000	96.840	97.270	97.510	97.630	98.050	98.400	98.970	99.170	99.840	100.0
6	0	54	81.000	98.550	98.880	99.000	99.040	99.240	99.340	99.550	99.630	100.000	100.0
7	0	53	81.000	90.740	91.480	91.920	92.350	93.320	93.810	95.140	95.960	98.190	100.0
8	0	63	81.000	90.440	91.460	92.170	92.850	94.350	94.810	96.000	96.680	99.010	100.0
9	0	50	72.000	91.830	92.760	93.140	93.460	94.060	94.270	94.870	95.240	97.650	100.0
10	0	46	70.000	94.440	97.240	98.020	98.520	98.980	99.140	99.320	99.540	100.000	100.0
11	0	33	51.000	62.110	64.830	65.900	66.470	68.150	69.070	72.400	74.200	84.930	100.0
12	0	44	75.000	94.280	96.660	97.620	98.380	99.560	99.680	99.890	99.950	100.000	100.0
13	0	58	75.000	88.240	90.590	91.210	91.610	92.470	92.900	94.060	94.600	96.890	100.0
14	0	56	73.000	91.410	92.500	92.920	93.330	94.330	94.680	95.890	96.380	98.200	100.0

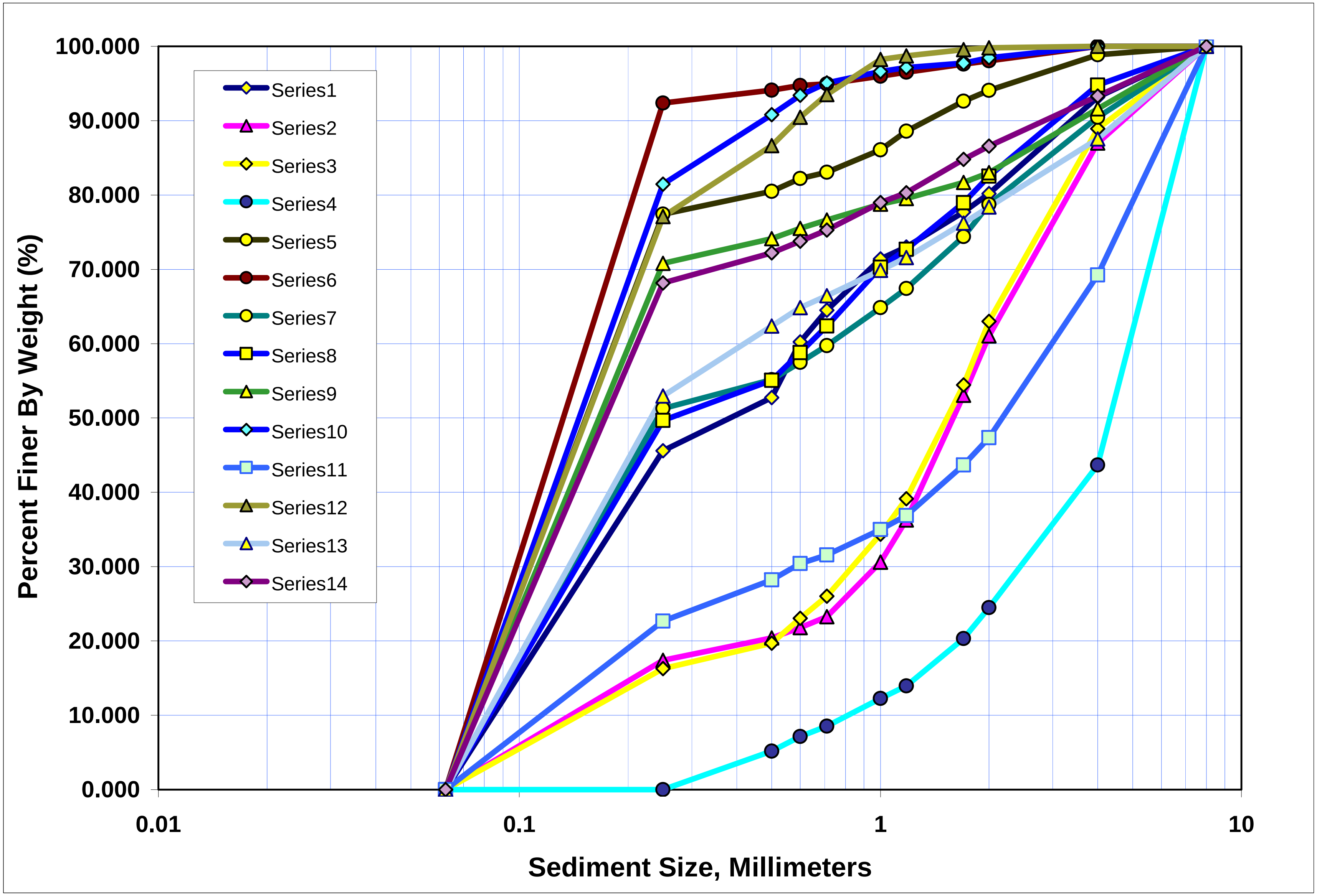

Figure 1. Sediment size distribution curves for the sediment samples collected in May 2006 (Sand and Gravel Fractions).

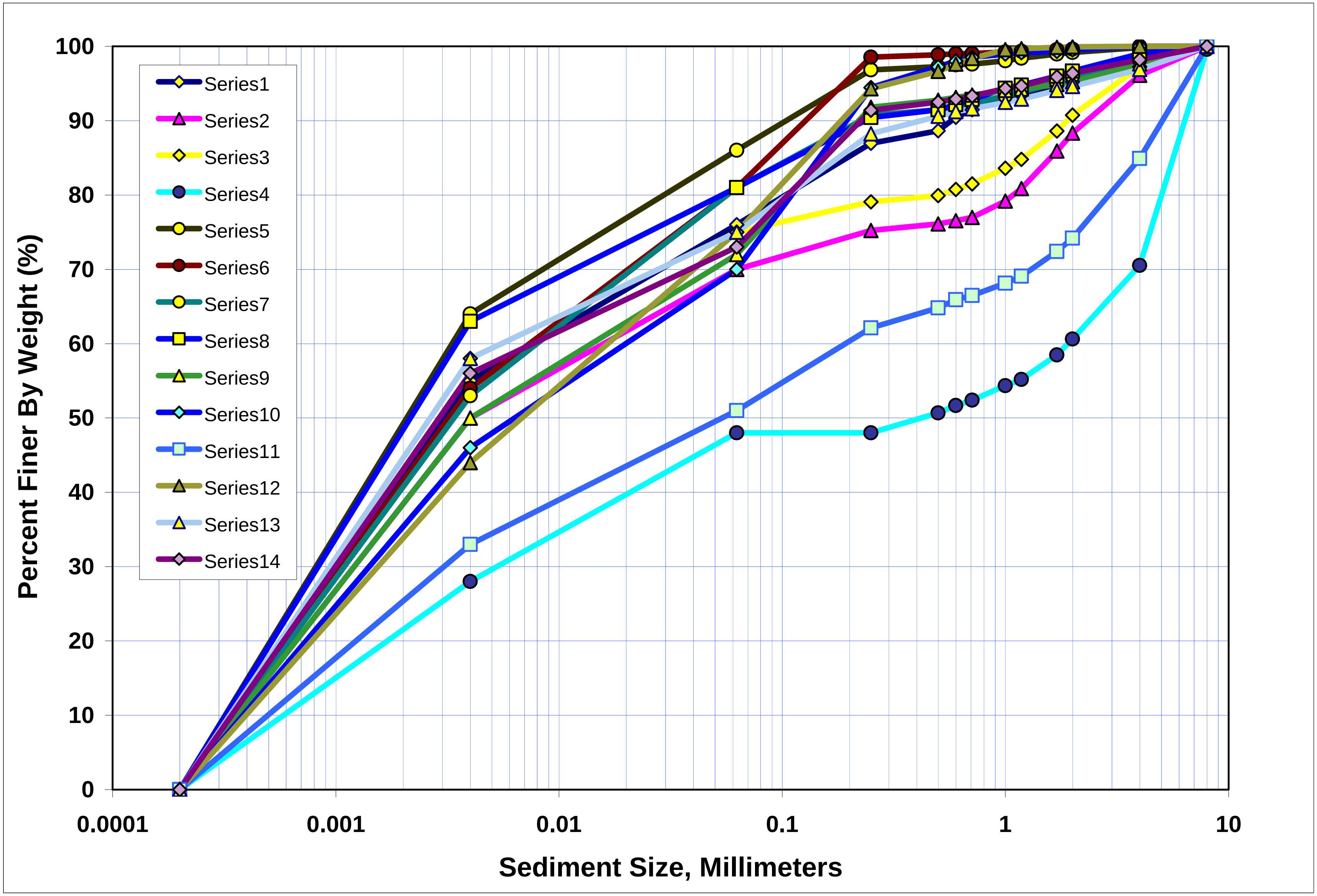

Figure 2. Sediment size distribution curves for the sediment samples collected in May 2006 (All Size Fractions).

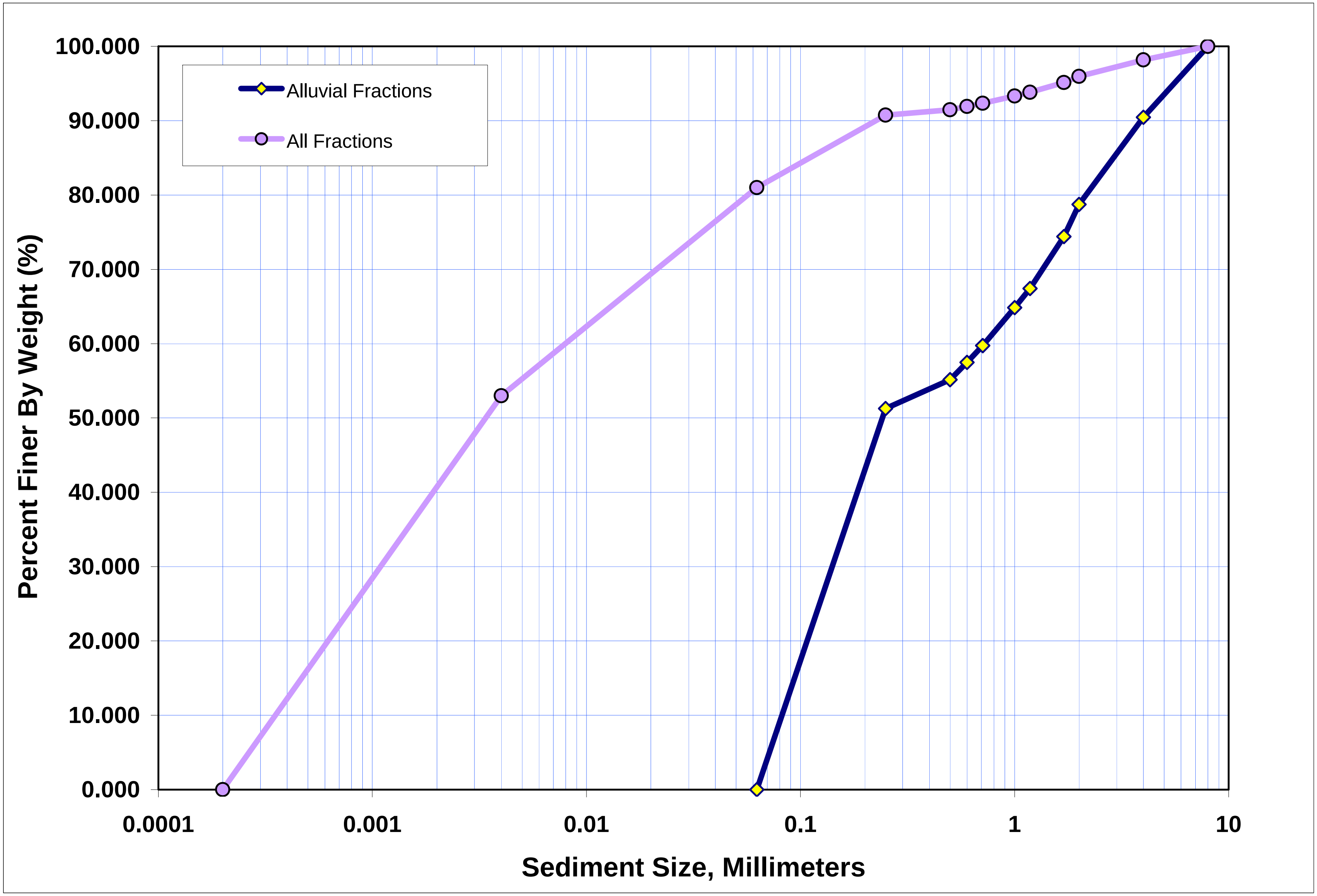

Figure 3. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 7).

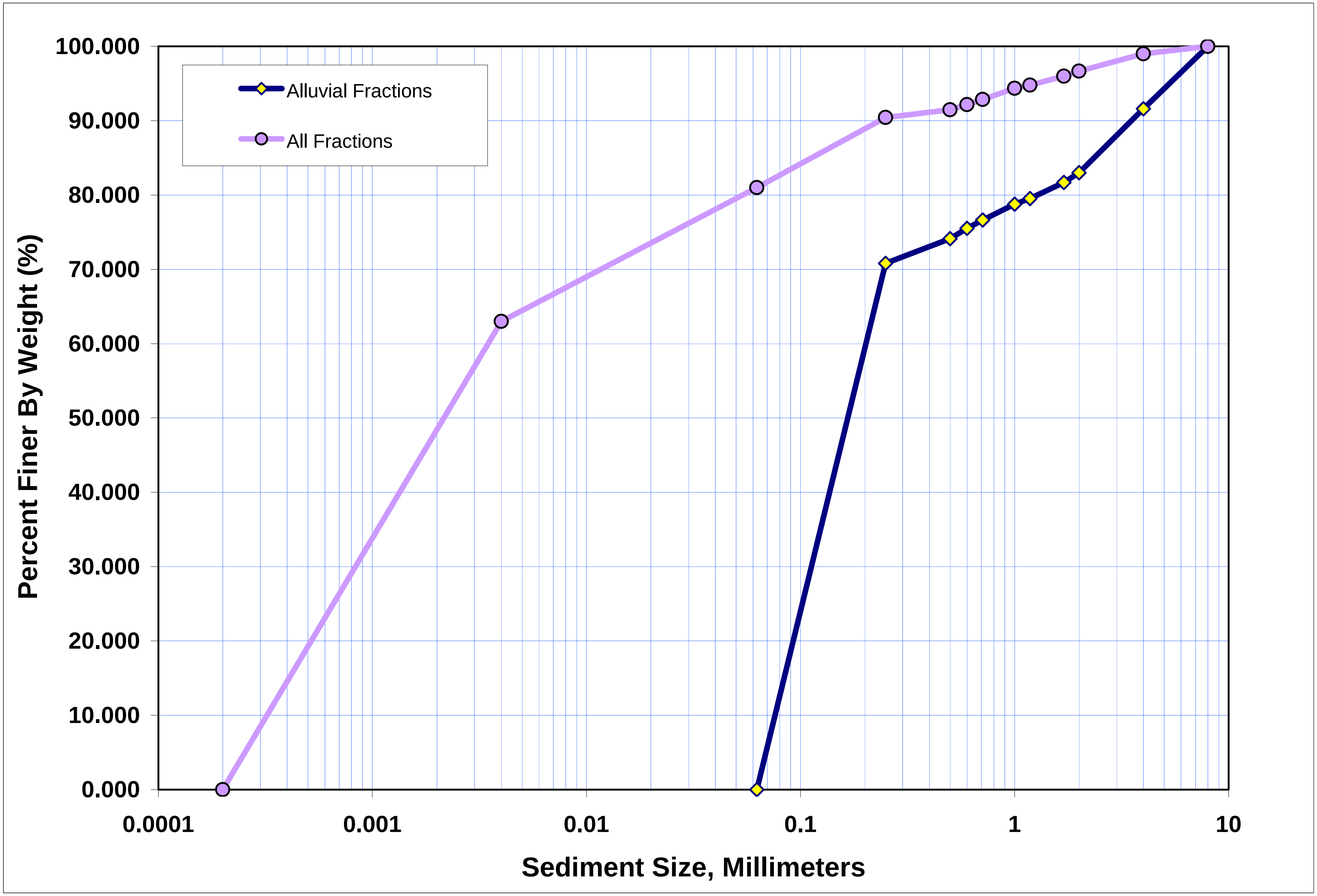

Figure 4. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 8).

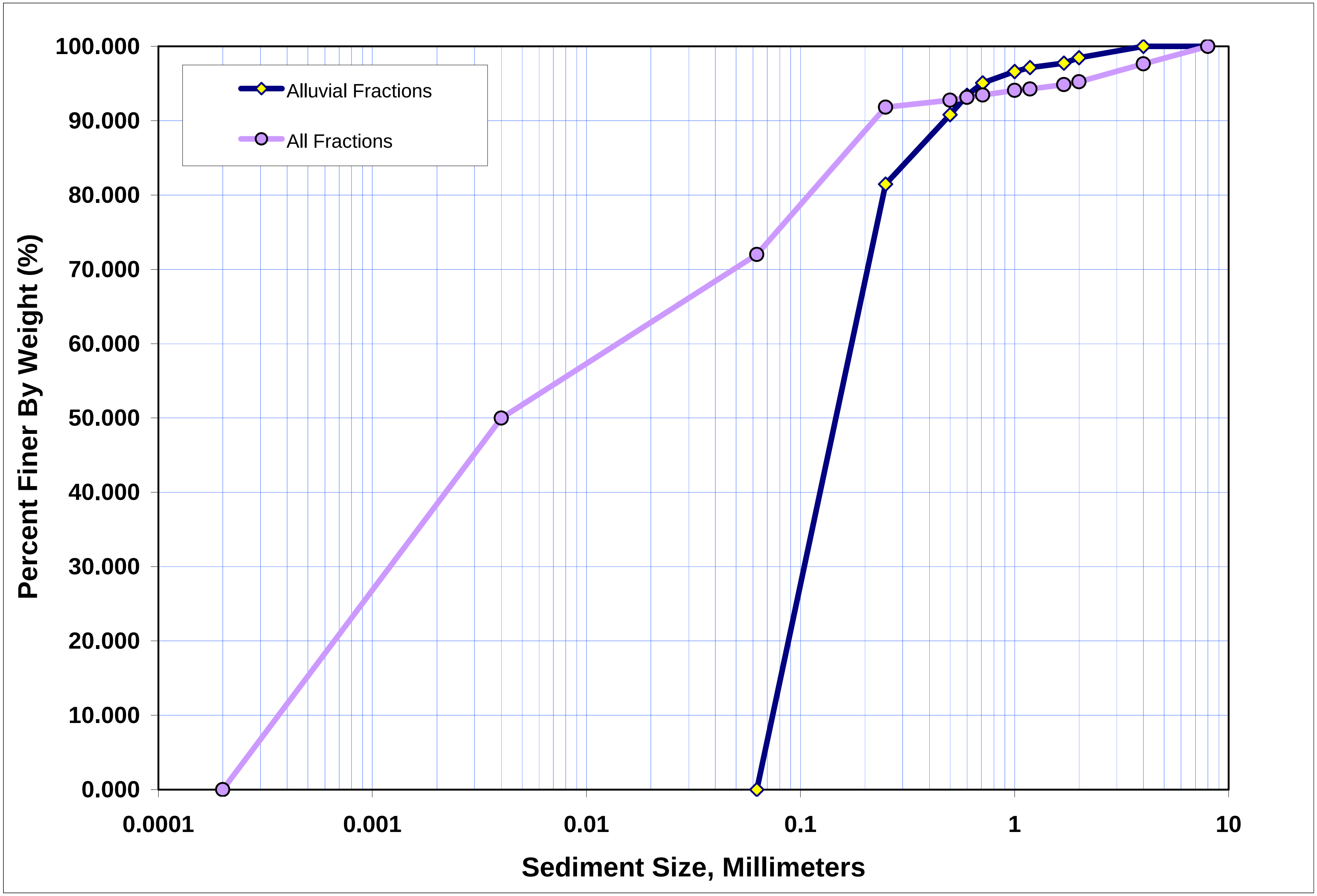

Figure 5. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 9).

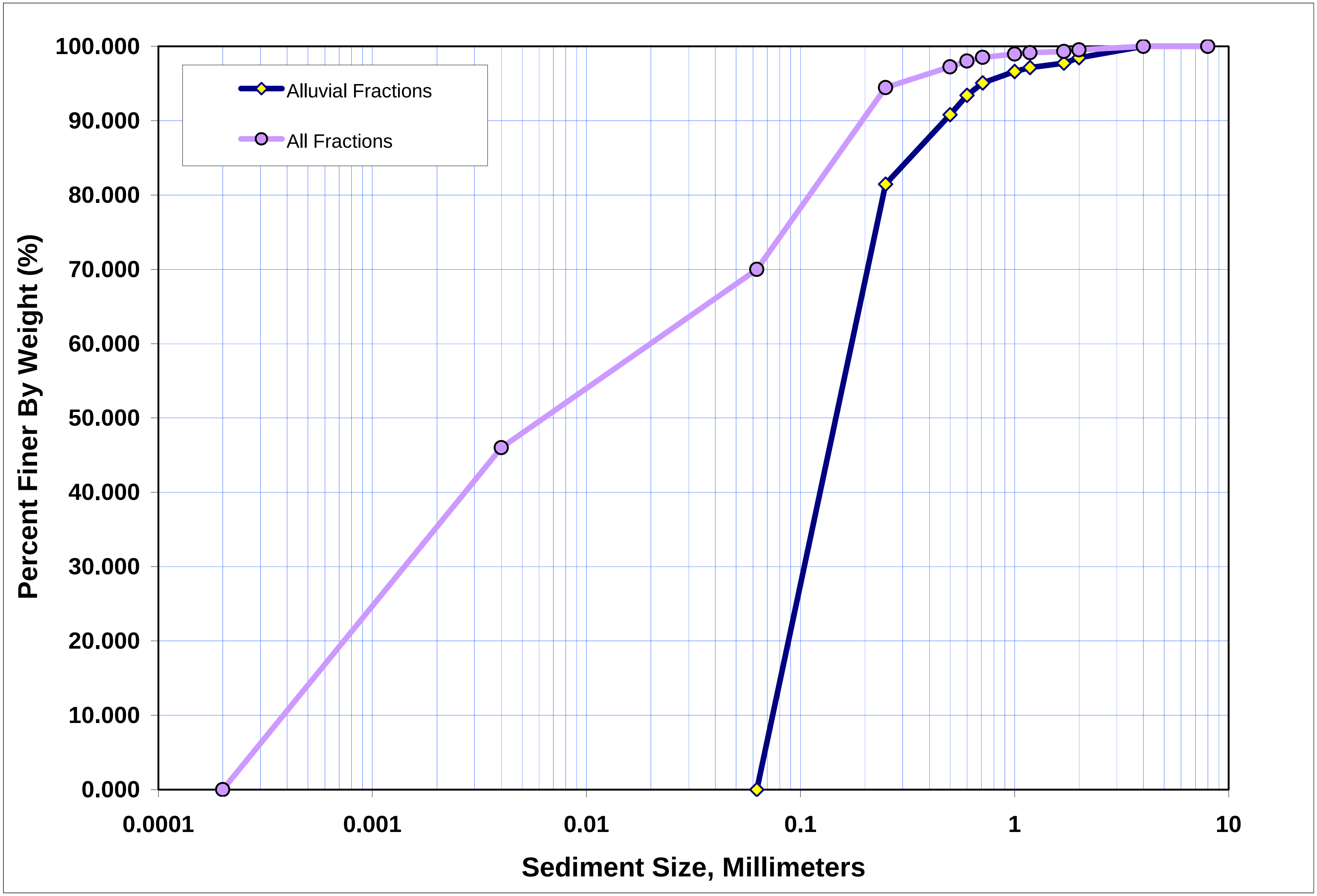

Figure 6. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 10).

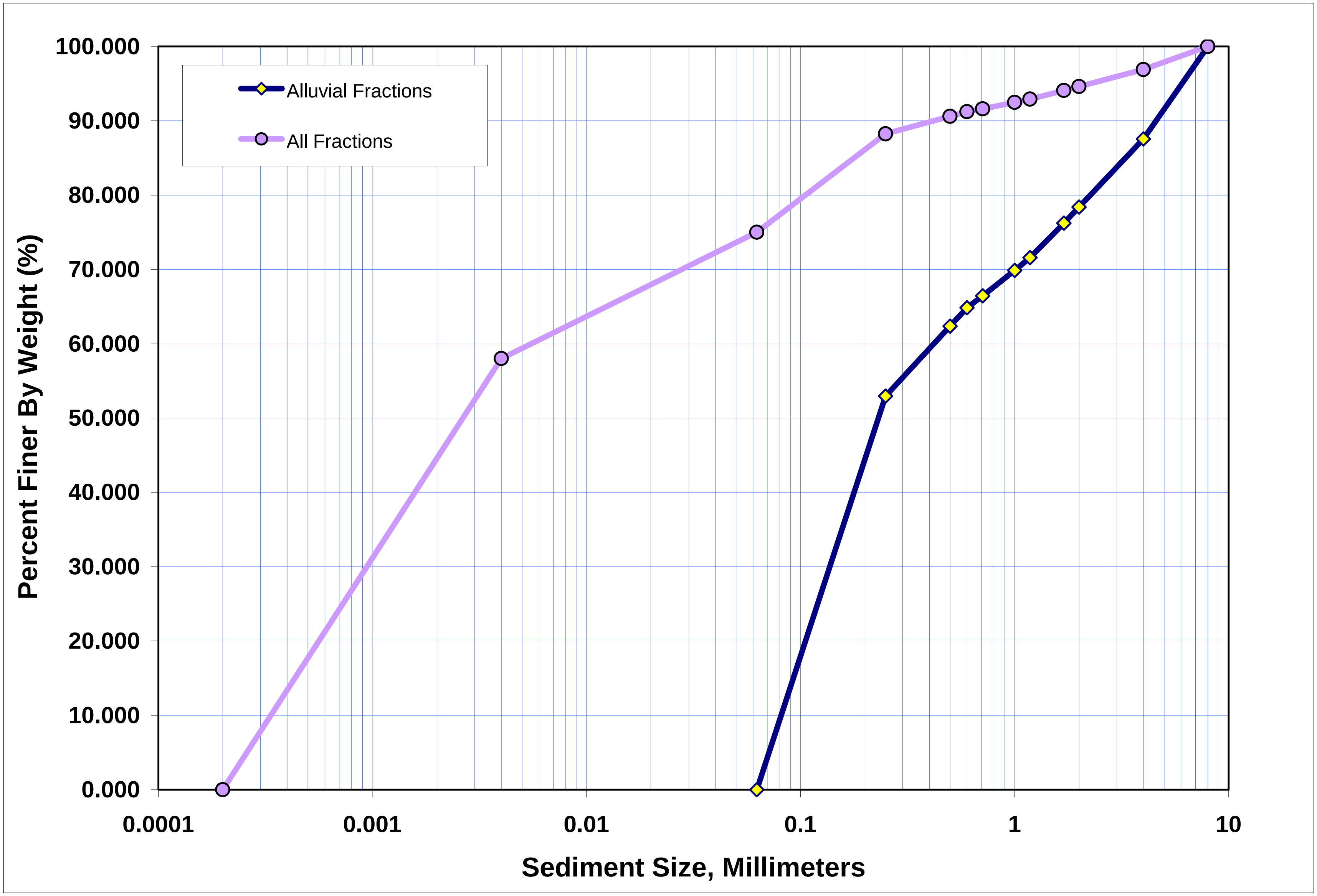

Figure 7. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 13).

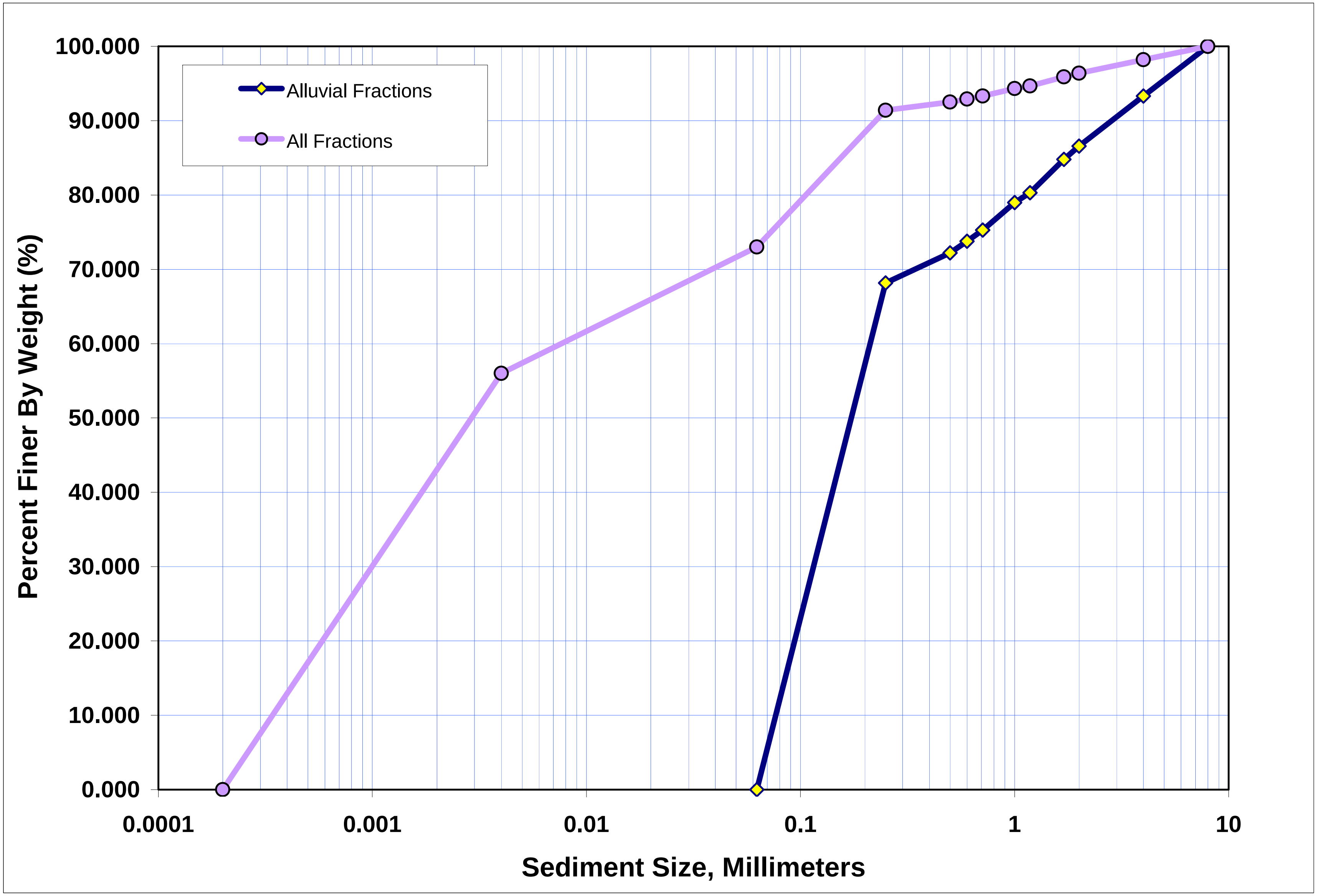

Figure 8. Sediment size distribution curves for the sediment samples collected in May 2006 (Sample 14).