GeoTech Appendix B
Integrated Planning and Design Analysis and Environmental Assessment
Waco Metropolitan Area Regional Sewerage System Treatment Plant
Waco and McLennan County, Texas
Brazos River
Section 14 Emergency Streambank and Shoreline Protection

May 2021

US Army Corps
of Engineers®
Fort Worth District

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1 Introduction

The Wastewater Treatment Plant (WWTP) located on the banks of the Brazos River has experienced bank erosion over a period of at least 25 years and is gradually encroaching the WWTP to an untenable high-risk condition. The rate of erosion has not been studied but documented in surveys of the slope conducted between 1995 and 2015. Protection of the slope from further erosion landward is necessary and this feasibility study has been authorized under Section 14 of the Flood Control Act of 1946; Public Law (PL) 79-526 as amended. Under Sec 14 the U.S. Army Corps of Engineers (USACE) is authorized to plan, design, and construct small flood control projects.

This project study area along the Brazos River bank in the area adjacent to the Waco WWTP is shown in Figure 1 below and alternative solutions for the mitigation and reduction of further erosion from increasing the risk level for the water treatment plant and the associated utilities forms the scope of this feasibility study.

Figure 1. Project Location

2 Study Area

The Waco WWTP study area is located southeast of the city center of Waco, Texas on the Brazos River. The Waco Metropolitan Area Sewer System (WMARSS) Regional

Wastewater Treatment Plant (RWTP) and the City of Robinson's Water Supply Intake are impacted by the slope erosion. The area that requires slope stabilization is shown in Figure 2 below. This is an approximately 1,300 feet of the riverbank. Though there are no structures in this stretch that are functional parts of the WWTP, there are utilities, power lines, access roads and the intake structure for the City of Robinson that would be impacted by the slope instability.

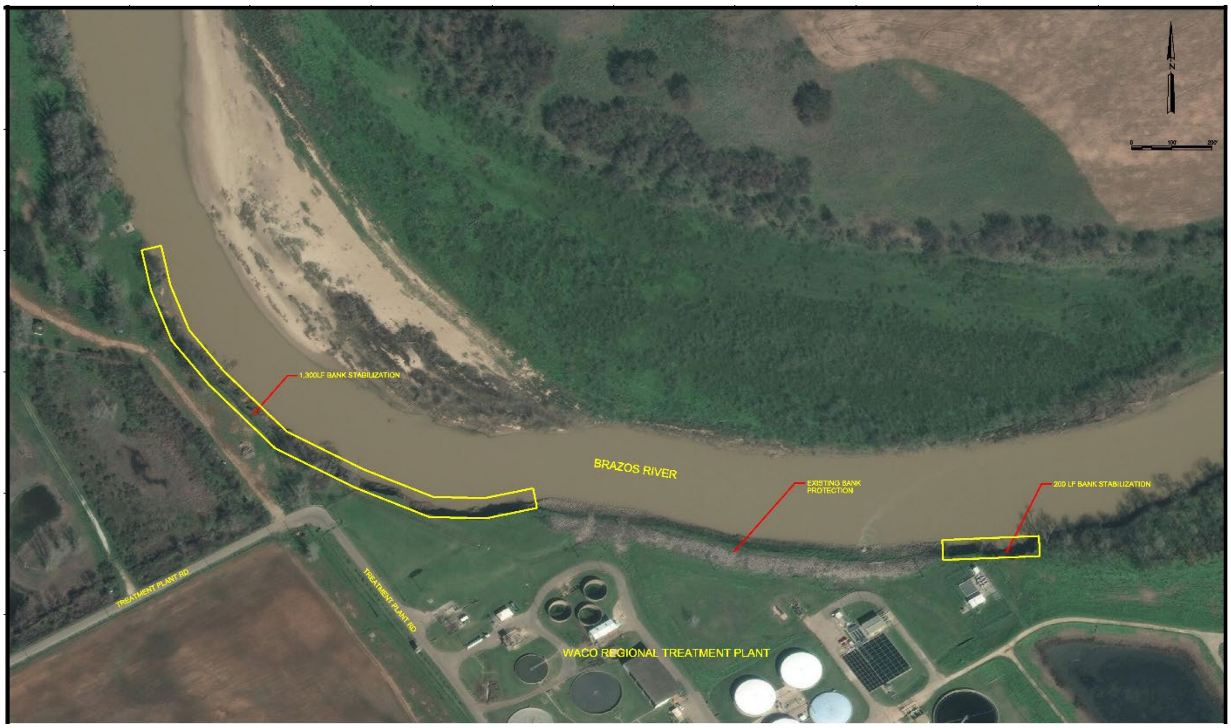


Figure 2. Project Location and Study Area.

No detailed studies of the slope are available other than a survey of the slope conducted at periodic intervals between 1995 and 2015. This information provided by the WWTP is included in Appendix 1.

3 Alternatives Proposed for Slope Stabilization

Three different alternatives were assessed, in addition to the no-action alternative, also known as the Future without Project (FWOP) condition.

3.1 No-Action Alternative

If the "No-Action" is the selected alternative, the riverbank erosion is likely to continue and further erode landward. Eventually the functioning of the WWTP will be impacted with loss of structures positioned close to the slope. As the rate of erosion varies with the differing site conditions and given the unpredictability of 100-year storms occurring more frequently, it is impossible to determine a time frame under which the slope repair will become an emergency action. That the slope will continue to erode is evident from the current near-vertical configuration of the slope as shown in the photograph below in Figure 3 taken during a site visit on 20 February 2020.

Figure 3 Slope geometry as of 20 February 2020

3.2 Alternative 1 - Longitudinal Peaked Stone Dike and Tie Back

Alternative 1 consists of a stone toe dike placed longitudinally and parallel at the toe for a length of approximately 1,300-feet. This dike would be placed upstream and downstream of the existing riprap section as shown in Figure 2 above. The downstream section is about 300 feet long and the upstream section would be about 1,300 feet long. The exposed embankment would be planted with native vegetation. This alternative would require approximately 31,200 cubic yards of riprap material into the river channel, 26,200 cubic yards of fill material to dress up bank and 9,400 square yards of native vegetation. Native vegetation would be planted on approximately 4,500 square yards on the embankment. These figures are approximate and would be refined from the civil design drawings and the quantities calculated.

3.3 Alternative 2 - Stone Riprap Toe Protection

Alternative 2 replicates the same amount of toe protection as in Alternative 1 but extends farther towards the river. The existing bank should be dressed up by placing fill material at a slope of 2H:1V. An 18-inch thick stone riprap layer will be placed along the toe of the dressed up bank with a 9-inch layer of bedding stone placed over a geotechnical filter fabric and extend to the top of bank to provide erosion protection to the toe of the bank from river scour. The stone riprap will be anchored at top with a 3-foot dep and 3-foot wide anchor trench and keyed at the toe of bank the with 3-foot deep and 10-foot wide key trench. This alternative would require approximately 26,200 cubic yards of fill material to dress up bank, 9,660 cubic yards of riprap material, 17,740 square yards of geotextile filter fabric and 4,410 cubic yards of bedding material into the river channel.

3.4 Alternative 3 - Toe Protection with Bend-way Weirs

Alternative 3 consists of constructing bend-way weirs to channel the river flow away from the slope in addition to placing longitudinal slope protection along the bank placed in the form of a trapezoidal bank protection. The weirs would be spaced every 100 feet and would extend out toward the centerline of the riverbed 38 feet from the crest of longitudinal stone toe dike. The weirs are angled upstream approximately 10 to 15 degrees from the radius of the bend to direct flow away from the bank toward the center of the riverbed. The total length of the slope protection would be approximately 1,300-feet section upstream of existing riprap and 300 feet section downstream of existing riprap at the WWTP property. This alternative would require approximately 32,500 cubic yards of riprap material into the river channel, 26,200 cubic yards of fill material to dress up bank and 9,400 square yards of native vegetation.

4 Baseline Conditions

The study area is located on the right (west) bank of Brazos River at one of its U-shaped bends just upstream of the Waco WWTP. The left bank shows evidence of sedimentation, while the right bank suffers erosion. The study site is located about 12 river miles downstream of Waco Dam. This description of the baseline provides the background for reference to evaluate the alternative plans.

4.1 Geology of the area

The study area is a part of the Edwards Plateau to the west and the Blackland Prairie to the east. The City of Waco and the surrounding areas are located within western sector of the Balcones Fault Zone which extends to the South Bosque River, generally recognized as the base of the Bosque Escarpment. The Balcones Fault Zone trends generally north-south and is a set of complex system of faults. The Balcones Zone is about five to ten miles wide generally with the dip and the downthrow towards the southeast. The fault zone is generally considered inactive. Balcones fault is generally considered inactive.

4.2 Site Specific conditions

The Geologic Map include in Appendix 2 shows the major formations encountered in the study area consist of alluvial soils (Qal) overlying the bedrock of Cretaceous age consisting of the Ozan Formation (Ko). The Ozan formation is described as clay, marly clay with silt-sized quartz and calcite fragments. In-situ condition of the clay and marly clay is described as clay-shale commonly encountered in this area and being primarily montmorinollitic clays, tend to be expansive.

The soils at the study site can generally be referred to as alluvial soils consisting of gravel, sandy silts, and clays. The slope configuration seen in Figure 3 is a generalized approximation of the soil profile within the upper 20 feet of the existing surface. The site elevation as seen from USGS topographic map is 380 feet NAVD.

4.3 Soil Survey

Alluvial soils vary in composition depending on their depositional history. The soil identified on the right riverbanks is predominantly Westwood silty loam (Wd) soils. This is in contrast with the left bank, which is predominantly Gaddy loamy fine sand (Ga). It is classified in the soil survey report as CL, ML, SM or SP-SM. This is a silty clayey soil which is moderately to highly plastic. The eroded slope currently stays at a steeper slope despite continuous erosion over the years. The soils seen at the upper one-third of the slope are nearly vertical, while the lower two-thirds represent the soils that have slid down the slope and provide a low margin of safety against a circular arc failure. However, once the soil slides down the slope, it is erodible and hence the slope failure keeps progressing landward on the right bank.

If the slope failure progress further upland, the soils encountered are represented by more clayey soils classified as CL, CL-ML or CH, which is listed as Westwood silty clay loam. These soils are less susceptible to erosion as compared to Gaddy loam fine sand.

4.4 Ground Water

Due to the rains in the few days prior to the site visit on 20 February 2020 the site was wet and some areas north of the WWTP site were waterlogged. The rain had not caused any new slope failure. Normal ground water table would be expected to be controlled by the hydraulic gradient towards the river and hence the water table observed during the site visit should be interpreted as perched water table condition. The water-logged area is also identified as a fresh water emerging wetland according to the environmental engineering evaluation of the study site, as noted in the National Wetland Inventory of the U.S. Fish and Wildlife Service.

5 Future Without Project Conditions

The engineering consequences of not taking any action are deemed catastrophic since eventually the soil erosion would intrude into the functional areas of the Waco WWTP. The rate of erosion has not been studied, nor any geotechnical studies conducted, and hence it is not possible to estimate the rate of progressive failure of the slope. In fact, a tension crack observed on the land side of the slope is an indication that future slope failure is likely if not imminent.

A swale behind a berm at the top of the slope (about 3 feet high) appears to be a likely weak spot where the progression of the slope failure may occur in the future. This swale can be seen in Figure 3 in the foregoing section.

5.2 Alternatives Considered

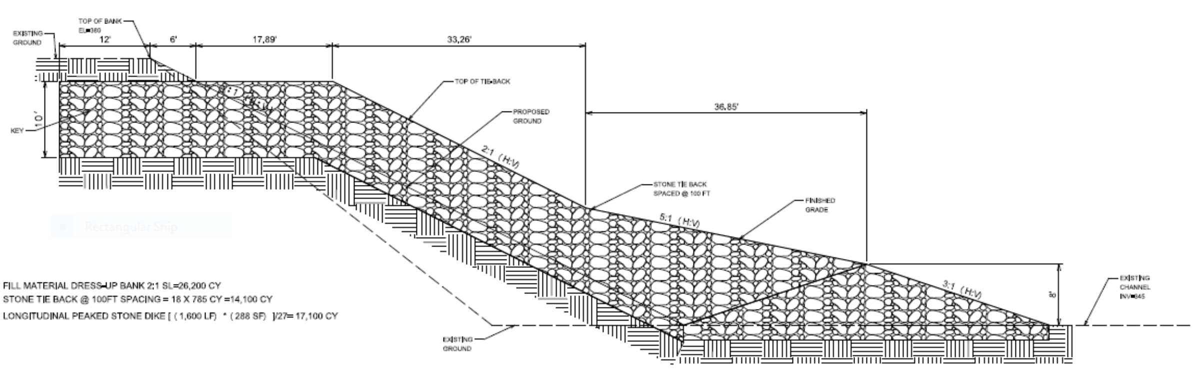
This feasibility considered three potential alternatives to the no action alternative as described below.

1. Longitudinal Peaked Stone Dike and Tie Back
2. Stone Rip/rap Toe Protection
3. Longitudinal Peaked Stone Toe Protection with Bendway Weirs

These alternatives are considered with a view of mitigating the No-action alternative with resources for a 50-year life cycle, which is considered the designated life of the proposed project.

Alternative 1 Longitudinal Peaked Stone Dike and Tie Back

This is illustrated in the figure below:

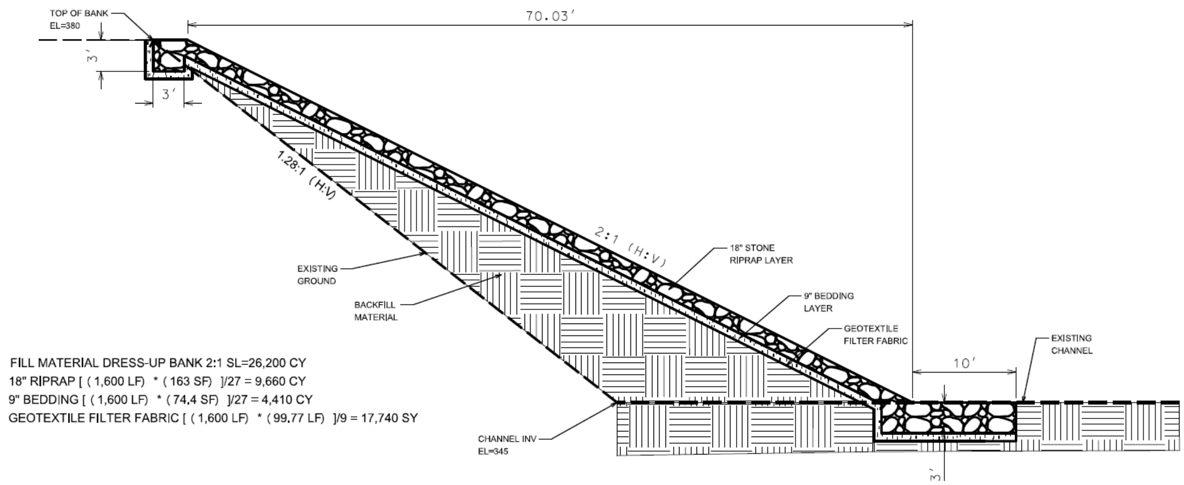


ALTERNATIVE 1

LONGITUDINAL PEAKED STONE DIKE AND TIE BACK

Alternative 2 Stone riprap toe protection:

This is illustrated in the figure below:

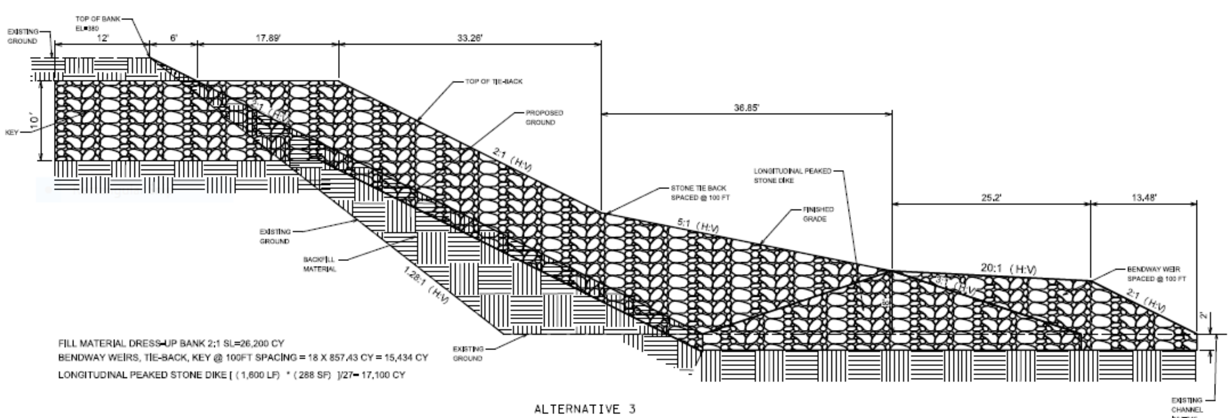


ALTERNATIVE 2

STONE RIPRAP TOE PROTECTION

Alternative 3: Longitudinal Peaked Stone Toe Protection with Bendway Weirs

This is illustrated in the figure below:



ALTERNATIVE 3

LONGITUDINAL PEAKED STONE TOE PROTECTION
WITH BENDWAY WEIRS

In all three alternatives, the size of the stones used in the riprap would be 18” as estimated based on the assumed velocity of 10 feet/sec under recently recorded high flow conditions. Based on the data from a gage station (USGS -8096500) located just upstream of the study area the flow conditions were assumed to at a high of 30,000 cubic feet per second (cfs.) at a gage height of 22 feet. The physical location of the above gage is Latitude 31°32'09", Longitude -97°04'23" (NAD 29). The study site, more specifically, the slope failure is centered at Latitude 31°31'11", Longitude -97°04'03" about 1.33 river miles downstream of the gage station.

6 Conclusion

The proposed alternatives have been considered and evaluated on basis of environmental, civil, cost, and geotechnical considerations. After evaluation of the comparative merits and demerits of the alternatives considered above, a tentative plan would be selected for further study and in-depth and evaluation. The final selection would also be influenced by the Sponsor’s participation and public hearing, apart from the funding availability. Other issues such as a contractor’s staging area, haul route and quantities of riprap and fill material are addressed in more detail in the Civil Engineering Appendix.

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GEOTECHICAL APPENDIX 1

Survey of slope configuration from 1995 to 2015

FLOOD NOTE:

ALL OF THE AREA IS LOCATED WITHIN AN AREA HAVING A DESIGNATION OF ZONE "A" (SHADED) DESCRIBED AS "NO BASE FLOOD ELEVATIONS DETERMINED". ACCORDING TO FLOOD INSURANCE RATE MAP NUMBER 48309C0390C, DATED SEPTEMBER 26, 2008, IN MCLENNAN COUNTY, STATE OF TEXAS.

NOTES:

1. The bearings shown hereon are grid bearings and are based on GPS observations, and the Texas State Plane Coordinate System, Central Zone (4203), North American Datum of 1983. An average combined scale factor of 0.99991357386 was utilized for this project or local area. All distances and areas shown are based on "Surface Coordinates". To obtain Grid Coordinates or Grid Distances, multiply by the above referenced average combined scale factor.
2. No utilities were located, the utilities lines shown hereon are based on the City of Waco GIS maps.
3. Property lines are approximate, a Boundary Survey was not performed.

APPENDIX 1 SLOPE SURVEYS
(Provided by Waco WWTP)

REV	DATE	BY	DESCRIPTION

PRELIMINARY SET
FOR REVIEW ONLY

0 25 50 100 (IN FEET)

PROJECT: CWAC1801020
DESIGNED: CPY
DRAWN: CPY
CHECKED: CPY

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TEXAS REGISTERED ENGINEERING FIRM
F-1741

CITY OF WACO
TOPOGRAPHIC SURVEY WMARSS PLANT
COMPARISON OF 2019 GROUND SURVEY VERSUS 1995 AERIAL IMAGE

SHEET
OF SHEETS

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GEOTECHICAL APPENDIX 2

Geology of the Area

APPENDIX 2 USGS GEOLOGICAL MAP

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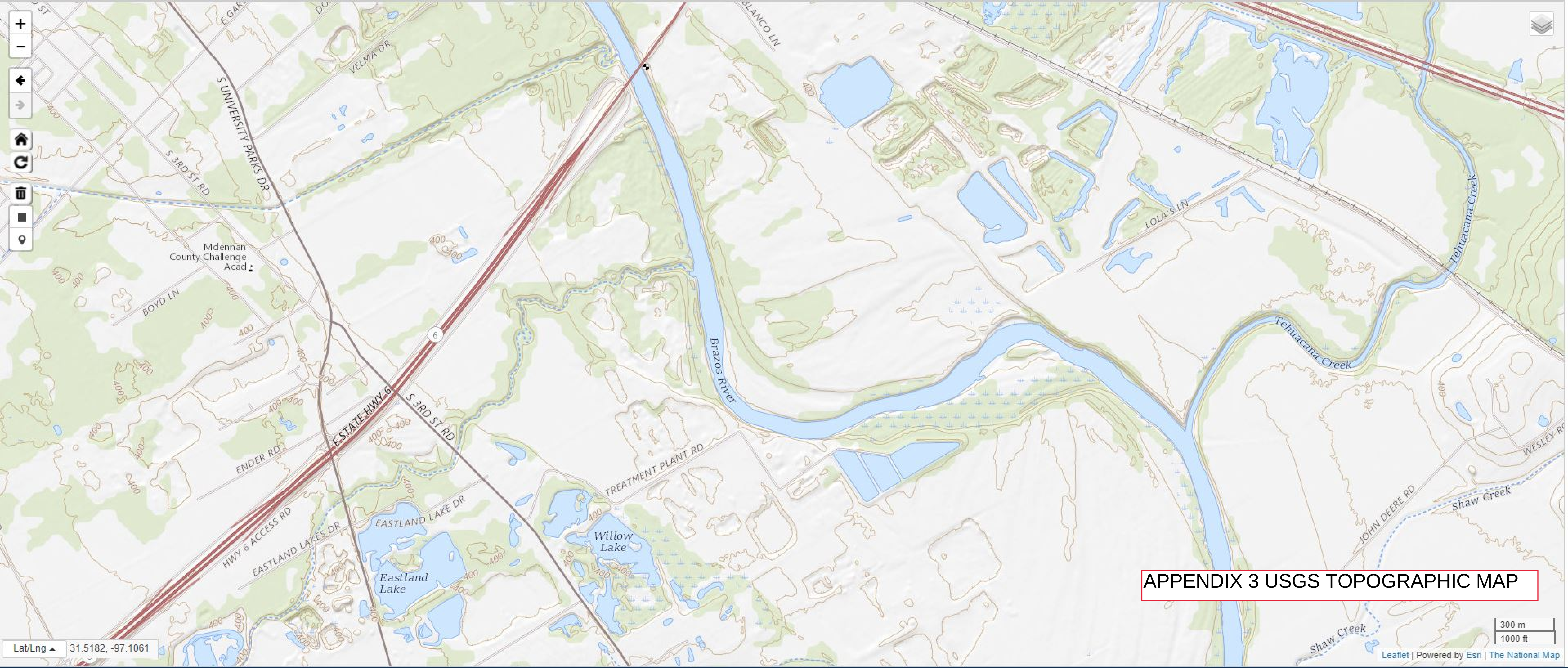
GEOTECHICAL APPENDIX 3

USGS Topographic Map

APPENDIX 3 USGS TOPOGRAPHIC MAP



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GEOTECHICAL APPENDIX 4

Soil Survey Report

APPENDIX 4

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

McLennan County, Texas

Waco RWWTP Soils Report

September 24, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map

Map Scale: 1:13,300 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: McLennan County, Texas
Survey Area Data: Version 19, Jun 11, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 4, 2016—Jun 15, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ga	Gaddy loamy fine sand, frequently flooded	34.2	4.4%
Pg	Pits, gravel	27.9	3.6%
Sh	Ships clay, 0 to 1 percent slopes, rarely flooded	50.7	6.5%
To	Tinn clay, 0 to 1 percent slopes, frequently flooded	43.8	5.6%
W	Water	49.0	6.3%
Wd	Weswood silt loam, rarely flooded	154.9	19.9%
We	Weswood silty clay loam, rarely flooded	133.0	17.1%
Ya	Yahola loam, rarely flooded	131.7	16.9%
Yg	Yahola-Gaddy complex, occasionally flooded	153.6	19.7%
Totals for Area of Interest		**778.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

McLennan County, Texas

Ga—Gaddy loamy fine sand, frequently flooded

Map Unit Setting

National map unit symbol: df3m
Elevation: 700 to 1,500 feet
Mean annual precipitation: 26 to 38 inches
Mean annual air temperature: 57 to 63 degrees F
Frost-free period: 200 to 230 days
Farmland classification: Not prime farmland

Map Unit Composition

Gaddy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gaddy

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 8 inches: loamy fine sand
H2 - 8 to 20 inches: loamy fine sand
H3 - 20 to 80 inches: fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: FrequentNone
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A
Ecological site: R087AY010TX - Sandy Bottomland
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 12 percent
Hydric soil rating: No

Unnamed, hydric

Percent of map unit: 3 percent
Landform: Depressions on flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Pg—Pits, gravel

Map Unit Setting

National map unit symbol: df49
Elevation: 20 to 8,750 feet
Mean annual precipitation: 9 to 56 inches
Mean annual air temperature: 54 to 73 degrees F
Frost-free period: 180 to 350 days
Farmland classification: Not prime farmland

Map Unit Composition

Pits: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pits

Setting

Down-slope shape: Concave
Across-slope shape: Concave

Typical profile

H1 - 0 to 80 inches: variable

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 10 percent
Hydric soil rating: No

Sh—Ships clay, 0 to 1 percent slopes, rarely flooded

Map Unit Setting

National map unit symbol: 2y0tx
Elevation: 140 to 480 feet
Mean annual precipitation: 33 to 46 inches
Mean annual air temperature: 63 to 68 degrees F
Frost-free period: 240 to 257 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ships and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ships

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Microfeatures of landform position: Circular gilgai
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Clayey alluvium derived from calcareous shale

Typical profile

Ap - 0 to 14 inches: clay
Bss - 14 to 54 inches: clay
Bkss - 54 to 80 inches: clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: NoneRare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 9.0
Available water capacity: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: D
Ecological site: R086AY013TX - Clayey Bottomland

Hydric soil rating: No

Minor Components

Weswood

Percent of map unit: 7 percent
Landform: Flood plains
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Highbank

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Yahola

Percent of map unit: 2 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Roetex, hydric

Percent of map unit: 2 percent
Landform: Closed depressions on flood plains
Landform position (three-dimensional): Tread
Microfeatures of landform position: Circular gilgai
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R086AY013TX - Clayey Bottomland
Hydric soil rating: Yes

To—Tinn clay, 0 to 1 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2vtgr
Elevation: 330 to 750 feet
Mean annual precipitation: 35 to 47 inches
Mean annual air temperature: 63 to 68 degrees F
Frost-free period: 226 to 263 days
Farmland classification: Not prime farmland

Map Unit Composition

Tinn and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tinn

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Microfeatures of landform position: Circular gilgai
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Calcareous clayey alluvium

Typical profile

A - 0 to 17 inches: clay
Bss - 17 to 57 inches: clay
Bkssy - 57 to 80 inches: clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: FrequentNone
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: D
Ecological site: R086AY013TX - Clayey Bottomland
Hydric soil rating: No

Minor Components

Whitesboro

Percent of map unit: 10 percent
Landform: Flood plains
Microfeatures of landform position: Circular gilgai
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Gladewater

Percent of map unit: 5 percent

Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R086AY013TX - Clayey Bottomland
Hydric soil rating: Yes

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Wd—Weswood silt loam, rarely flooded

Map Unit Setting

National map unit symbol: df4v
Elevation: 200 to 800 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 220 to 280 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Weswood and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Weswood

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium of holocene age derived from mixed sources

Typical profile

H1 - 0 to 6 inches: silt loam
H2 - 6 to 60 inches: silt loam
H3 - 60 to 80 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: RareNone

Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 7.0
Available water capacity: High (about 9.6 inches)

Interpretive groups
Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Minor Components

Unnamed
Percent of map unit: 14 percent
Hydric soil rating: No

Unnamed, hydric
Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

We—Weswood silty clay loam, rarely flooded

Map Unit Setting
National map unit symbol: df4w
Elevation: 200 to 800 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 220 to 280 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Weswood and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Weswood

Setting
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium of holocene age derived from mixed sources

Typical profile
H1 - 0 to 8 inches: silty clay loam
H2 - 8 to 60 inches: silt loam
H3 - 60 to 80 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: RareNone
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 7.0
Available water capacity: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Ecological site: R086AY012TX - Loamy Bottomland
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 12 percent
Hydric soil rating: No

Unnamed, hydric

Percent of map unit: 3 percent
Landform: Depressions
Hydric soil rating: Yes

Ya—Yahola loam, rarely flooded

Map Unit Setting

National map unit symbol: df4y
Elevation: 200 to 450 feet
Mean annual precipitation: 32 to 40 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 190 to 230 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Yahola and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Yahola

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

H1 - 0 to 12 inches: loam
H2 - 12 to 28 inches: very fine sandy loam
H3 - 28 to 40 inches: fine sandy loam
H4 - 40 to 56 inches: loam
H5 - 56 to 80 inches: fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A
Ecological site: R087AY011TX - Loamy Bottomland
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 15 percent
Hydric soil rating: No

Yg—Yahola-Gaddy complex, occasionally flooded

Map Unit Setting

National map unit symbol: df4z
Elevation: 200 to 1,500 feet
Mean annual precipitation: 26 to 40 inches
Mean annual air temperature: 57 to 70 degrees F
Frost-free period: 190 to 230 days

Farmland classification: Not prime farmland

Map Unit Composition

Yahola and similar soils: 65 percent
Gaddy and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Yahola

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Typical profile

H1 - 0 to 10 inches: very fine sandy loam
H2 - 10 to 42 inches: very fine sandy loam
H4 - 42 to 56 inches: loam
H5 - 56 to 80 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: OccasionalNone
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: A
Ecological site: R087AY011TX - Loamy Bottomland
Hydric soil rating: No

Description of Gaddy

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 8 inches: loamy fine sand
H2 - 8 to 20 inches: loamy fine sand
H3 - 20 to 80 inches: fine sand

Properties and qualities

Slope: 0 to 2 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: OccasionalNone
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: R087AY011TX - Loamy Bottomland
Hydric soil rating: No

Minor Components

Unnamed

Percent of map unit: 10 percent
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

AOI Inventory

This folder contains a collection of tabular reports that present a variety of soil information. Included are various map unit description reports, special soil interpretation reports, and data summary reports.

Map Unit Description (Brief) (Map Unit Description)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the selected area. The component descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the associated soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas (components) for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

The "Map Unit Description (Brief)" report gives a brief, general description of the soil components that occur in a map unit. Descriptions of nonsoil (miscellaneous areas) and minor map unit components may or may not be included. This description is written by the local soil scientists responsible for the respective soil survey area data. A more detailed description can be generated by the "Map Unit Description" report.

Additional information about the map units described in this report is available in other Soil Data Mart reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the Soil Data Mart reports define some of the properties included in the map unit descriptions.

Report—Map Unit Description (Brief) (Map Unit Description)

McLennan County, Texas

Map Unit: Ga—Gaddy loamy fine sand, frequently flooded

Description Category: PHG

3A - SANDY BOTTOMLAND - Deep and very deep, sandy bottomlands; may overflow; low natural fertility; low to moderate water holding capacity with good plant-soil-moisture relationship; medium production potential.

Description Category: RNG

Sandy Bottomland 28-40" PZ - Deep, sandy, alluvial sediments. Climax vegetation is a savannah of oak, elm, ash, sycamore, cottonwood, and black willow trees; with woody understory and switchgrass, indiangrass, bluestem, purpletop, virginia wildrye, sedges, uniolas, tickclover, snoutbean, wildbeans, ironweed, and white crownbeard.

Map Unit: Sh—Ships clay, 0 to 1 percent slopes, rarely flooded

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: RNG

Clayey Bottomland 32-40" PZ - Deep, clay, bottomland soils supporting savannah of oak, elm, hackberry, and ash; with understory of grape, greenbrier, honeysuckle, and hawthorn. Virginia wildrye, switchgrass, eastern gamagrass, and beaked panicum occur with blood ragweed, ironweed, white crownbeard, and spiny aster.

Map Unit: To—Tinn clay, 0 to 1 percent slopes, frequently flooded

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: RNG

Clayey Bottomland 28-40" PZ - Deep, clay, bottomland soils supporting savannah of oak, elm, hackberry, and ash; with understory of grape, greenbrier, honeysuckle, and hawthorn. Virginia wildrye, switchgrass, eastern gamagrass, and beaked panicum occur with blood ragweed, ironweed, white crownbeard, and spiny aster.

Map Unit: Wd—Weswood silt loam, rarely flooded

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 28-40" PZ - Deep, loamy, bottomland soils. Climax vegetation is a savannah of pecan, oaks, hackberry; with understory of hawthorns, greenbrier, grape, peppervine, honeysuckle; and virginia wildrye, switchgrass, eastern gamagrass, switchcane, beaked panicum, indiangrass, ironweed, blood ragweed, and white crownbeard.

Map Unit: We—Weswood silty clay loam, rarely flooded

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 28-40" PZ - Deep, loamy, bottomland soils. Climax vegetation is a savannah of pecan, oaks, hackberry; with understory of hawthorns, greenbrier, grape, peppervine, honeysuckle; and virginia wildrye, switchgrass, eastern gamagrass, switchcane, beaked panicum, indiangrass, ironweed, blood ragweed, and white crownbeard.

Map Unit: Ya—Yahola loam, rarely flooded

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 30-38" PZ - Deep, fertile, clay loam and loam, bottomland soils. Climax vegetation includes eastern gamagrass, switchgrass, little bluestem, virginia wildrye, blood ragweed, hairy ruellia, hairy tubetongue, aster, maximilian sunflower, and white crownbeard; with pecan, elm, cypress, oak, and ash.

Map Unit: Yg—Yahola-Gaddy complex, occasionally flooded

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 30-38" PZ - Deep, fertile, clay loam and loam, bottomland soils. Climax vegetation includes eastern gamagrass, switchgrass, little bluestem, virginia wildrye, blood ragweed, hairy ruellia, hairy tubetongue, aster, maximilian sunflower, and white crownbeard; with pecan, elm, cypress, oak, and ash.

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties (Map Unit Description)

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Chemical Soil Properties–McLennan County, Texas								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
Ga—Gaddy loamy fine sand, frequently flooded								
Gaddy	0-8	4.0-10	—	7.4-8.4	0-2	0	0	0
	8-20	4.0-10	—	7.9-8.4	1-5	0	0	0
	20-80	4.0-10	—	7.9-8.4	1-5	0	0	0
Pg—Pits, gravel								
Pits	0-80	—	—	4.5-8.4	0	0	0.0-8.0	0
Sh—Ships clay, 0 to 1 percent slopes, rarely flooded								
Ships	0-14	29-46	—	7.6-8.4	5-15	0	0.0-2.0	0-2
	14-54	30-47	—	7.6-8.4	5-15	0	0.0-2.0	2-7
	54-80	22-31	—	7.6-8.4	1-15	0	0.0-2.0	2-9
To—Tinn clay, 0 to 1 percent slopes, frequently flooded								
Tinn	0-17	33-44	—	7.4-8.4	2-10	0	0.0-2.0	0
	17-57	31-42	—	7.4-8.4	10-20	0	0.0-2.0	0
	57-80	27-41	—	7.4-8.4	10-25	0-2	0.0-2.0	0-2
W—Water								
Water	—	—	—	—	—	—	—	—
Wd—Weswood silt loam, rarely flooded								
Weswood	0-6	10-25	—	7.4-8.4	5-15	0	0.0-2.0	0-1
	6-60	10-25	—	7.4-8.4	5-15	0	0.0-2.0	0-1
	60-80	15-35	—	7.4-8.4	5-15	0	0.0-2.0	0-7

Chemical Soil Properties–McLennan County, Texas								
Map symbol and soil name	**Depth**	**Cation-exchange capacity**	**Effective cation-exchange capacity**	**Soil reaction**	**Calcium carbonate**	**Gypsum**	**Salinity**	**Sodium adsorption ratio**
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
We—Weswood silty clay loam, rarely flooded								
Weswood	0-8	10-25	—	7.4-8.4	5-15	0	0.0-2.0	0-1
	8-60	10-25	—	7.4-8.4	5-15	0	0.0-2.0	0-1
	60-80	15-35	—	7.4-8.4	5-15	0	0.0-2.0	0-7
Ya—Yahola loam, rarely flooded								
Yahola	0-12	4.0-8.0	—	7.4-8.4	5-10	0	0	0
	12-28	3.0-7.0	—	7.9-8.4	5-10	0	0	0
	28-40	3.0-7.0	—	7.9-8.4	5-10	0	0	0
	40-56	3.0-7.0	—	7.9-8.4	5-10	0	0	0
	56-80	3.0-7.0	—	7.9-8.4	5-10	0	0	0
Yg—Yahola-Gaddy complex, occasionally flooded								
Yahola	0-10	3.0-7.0	—	7.4-8.4	5-10	0	0	0
	10-42	3.0-7.0	—	7.9-8.4	5-10	0	0	0
	42-56	3.0-7.0	—	7.9-8.4	5-10	0	0	0
	56-80	3.0-7.0	—	7.9-8.4	5-10	0	0	0
Gaddy	0-8	4.0-10	—	7.4-8.4	0-2	0	0	0
	8-20	4.0-10	—	7.9-8.4	1-5	0	0	0
	20-80	4.0-10	—	7.9-8.4	1-5	0	0	0

Soil Erosion

This folder contains a collection of tabular reports that present soil erosion factors and groupings. The reports (tables) include all selected map units and components for each map unit. Soil erosion factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

Conservation Planning (Soil Erosion)

This report provides those soil attributes for the conservation plan for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. It provides the soil description along with the slope, runoff, T Factor, WEI, WEG, Erosion class, Drainage class, Land Capability Classification, and the engineering Hydrologic Group and the erosion factors Kf, the representative percentage of fragments, sand, silt, and clay in the mineral surface horizon. Missing surface data may indicate the presence of an organic surface layer. Further information on these factors can be found in the National Soil Survey Handbook section 618 found at the url http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054223#00 .

Soil properties and interpretations for conservation planning. The surface mineral horizon properties are displayed. Organic surface horizons are not displayed.

Conservation Planning–McLennan County, Texas																		
Map symbol and soil name	Pct. of map unit	Slope RV	USLE Slope Length ft.	Runoff	T Factor	WEI	WEG	Erosion	Drainage	NIRR LCC	Hydrologic Group	Surface						
												Depths in.	Kf Factor	Frag-ments RV	Sand RV	Silt RV	Clay RV
Ga—Gaddy loamy fine sand, frequently flooded																	
Gaddy	85	1.0	200	Negligible	5	134	2	—	Somewhat excessively drained	5w	A	0 - 7	.15	1	83	6	10
Pg—Pits, gravel																	
Pits	90	48.0	49	—	—	0	8	—	Well drained	8s	D	0 - 79	—	—	—	—	—
Sh—Ships clay, 0 to 1 percent slopes, rarely flooded																	
Ships	85	0.5	98	High	5	86	4	Class 1	Moderately well drained	3s	D	0 - 14	.17	0	1	31	68
To—Tinn clay, 0 to 1 percent slopes, frequently flooded																	
Tinn	85	0.5	98	High	5	86	4	None - deposition	Moderately well drained	5w	D	0 - 16	.24	1	22	28	50
Wd—Weswood silt loam, rarely flooded																	
Weswood	85	0.5	98	Negligible	5	86	4L	—	Well drained	—	B	0 - 5	.43	1	13	69	17
We—Weswood silty clay loam, rarely flooded																	
Weswood	85	0.5	98	Negligible	5	86	4L	—	Well drained	—	B	0 - 7	.37	1	6	62	31
Ya—Yahola loam, rarely flooded																	
Yahola	85	0.5	98	Negligible	5	86	4L	—	Well drained	2e	A	0 - 11	.32	—	44	41	14

Conservation Planning–McLennan County, Texas																	
Map symbol and soil name	**Pct. of map unit**	**Slope RV**	**USLE Slope Length ft.**	**Runoff**	**T Fact or**	**WEI**	**WEG**	**Erosion**	**Drainage**	**NIRR LCC**	**Hydro logic Group**	**Surface**					
												Depths in.	**Kf Fact or**	**Frag- ments RV**	**Sand RV**	**Silt RV**	**Clay RV**
Yg—Yahola-Gaddy complex, occasionally flooded																	
Yahola	65	1.0	200	Very low	5	86	3	—	Well drained	2w	A	0 - 9	.37	2	62	24	14
Gaddy	25	1.0	200	Negligible	5	134	2	—	Somewhat excessively drained	4s	A	0 - 7	.15	1	83	6	10

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties (Soil Physical Properties)

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–McLennan County, Texas

Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
Ga—Gaddy loamy fine sand, frequently flooded														
Gaddy	85	A	0-8	Loamy fine sand	SM, SP-SM	A-2-4, A-3	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-20- 35	0-7 -14	NP
			8-20	Loamy fine sand	CL, ML, SM, SP-SM	A-2, A-3, A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-48- 90	0-20 -40	NP-9-18
			20-80	Fine sand	CL, ML, SM, SP-SM	A-2, A-3, A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-48- 90	0-20 -40	NP-9-18
Pg—Pits, gravel														
Pits	90	D	0-80	Variable	—	—	—	—	—	—	—	—	0-7 -14	—
Sh—Ships clay, 0 to 1 percent slopes, rarely flooded														
Ships	85	D	0-14	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	100-100-100	98-100-100	95-100-100	92-99-100	55-67-69	28-40-42
			14-54	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	100-100-100	98-100-100	94-100-100	91-99-100	56-65-68	30-38-40
			54-80	Silty clay, clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	100-100-100	98-100-100	93-100-100	89-99-100	49-61-66	27-34-37

Engineering Properties–McLennan County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
To—Tinn clay, 0 to 1 percent slopes, frequently flooded														
Tinn	85	D	0-17	Clay	CH	A-7, A-7-6	0- 0- 0	0- 0- 0	100-100-100	96-98-100	84-91-100	73-79-91	61-66-76	37-41-49
			17-57	Silty clay, clay	CH	A-7, A-7-6	0- 0- 0	0- 0- 0	100-100-100	96-98-100	81-91-100	70-79-91	58-66-76	35-41-49
			57-80	Silty clay, clay	CH	A-7, A-7-6	0- 0- 0	0- 0- 0	100-100-100	92-96-100	78-89-100	67-78-91	58-66-76	35-41-49
Wd—Weswood silt loam, rarely flooded														
Weswood	85	B	0-6	Silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	90-95-100	65-80-95	20-28-35	5-12-18
			6-60	Very fine sandy loam, silty clay loam, silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	95-98-100	70-84-98	20-30-40	5-14-22
			60-80	Silty clay loam, silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	95-98-100	75-88-100	40-50-60	22-31-40
We—Weswood silty clay loam, rarely flooded														
Weswood	85	B	0-8	Silty clay loam	CL	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	95-98-100	75-87-98	20-30-40	9-16-22
			8-60	Very fine sandy loam, silty clay loam, silt loam	CL, CL-ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	95-98-100	70-84-98	20-30-40	5-14-22
			60-80	Silty clay loam, silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	95-98-100	75-88-100	40-50-60	22-31-40

Engineering Properties–McLennan County, Texas															
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
Ya—Yahola loam, rarely flooded														
Yahola	85	A	0-12	Loam	CL, CL-ML, ML	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	95-98-100	65-75-85	0-16 -31	NP-5-10
			12-28	Fine sandy loam, loam, very fine sandy loam	CL, ML, SC, SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	36-61-85	0-15 -30	NP-5-10
			28-40	Fine sandy loam	CL, ML, SC, SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	15-50-85	0-15 -30	NP-5-10
			40-56	Loam	CL, ML, SC, SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	15-50-85	0-15 -30	NP-5-10
			56-80	Fine sandy loam	CL, ML, SC, SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	15-50-85	0-15 -30	NP-5-10

Engineering Properties–McLennan County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
Yg—Yahola-Gaddy complex, occasionally flooded														
Yahola	65	A	0-10	Fine sandy loam, very fine sandy loam	CL-ML, ML, SC-SM, SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	36-48-60	0-13 -26	NP-4 -7
			10-42	Fine sandy loam, loam, very fine sandy loam	CL, ML, SC, SM	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	36-61-85	0-15 -30	NP-5 -10
			42-56	Loam	CL, ML, SC, SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	15-50-85	0-15 -30	NP-5 -10
			56-80	Fine sandy loam	CL, ML, SC, SM	A-2, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	15-50-85	0-15 -30	NP-5 -10
Gaddy	25	A	0-8	Loamy fine sand	SM, SP-SM	A-2-4, A-3	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-20- 35	0-7 -14	NP
			8-20	Loamy fine sand	CL, ML, SM, SP-SM	A-2, A-3, A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-48- 90	0-20 -40	NP-9 -18
			20-80	Fine sand	CL, ML, SM, SP-SM	A-2, A-3, A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	98-99-100	80-90-100	5-48- 90	0-20 -40	NP-9 -18

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Integrated Planning and Design Analysis and Environmental Assessment

Waco Metropolitan Area Regional Sewerage System Treatment Plant Waco and McLennan County, Texas

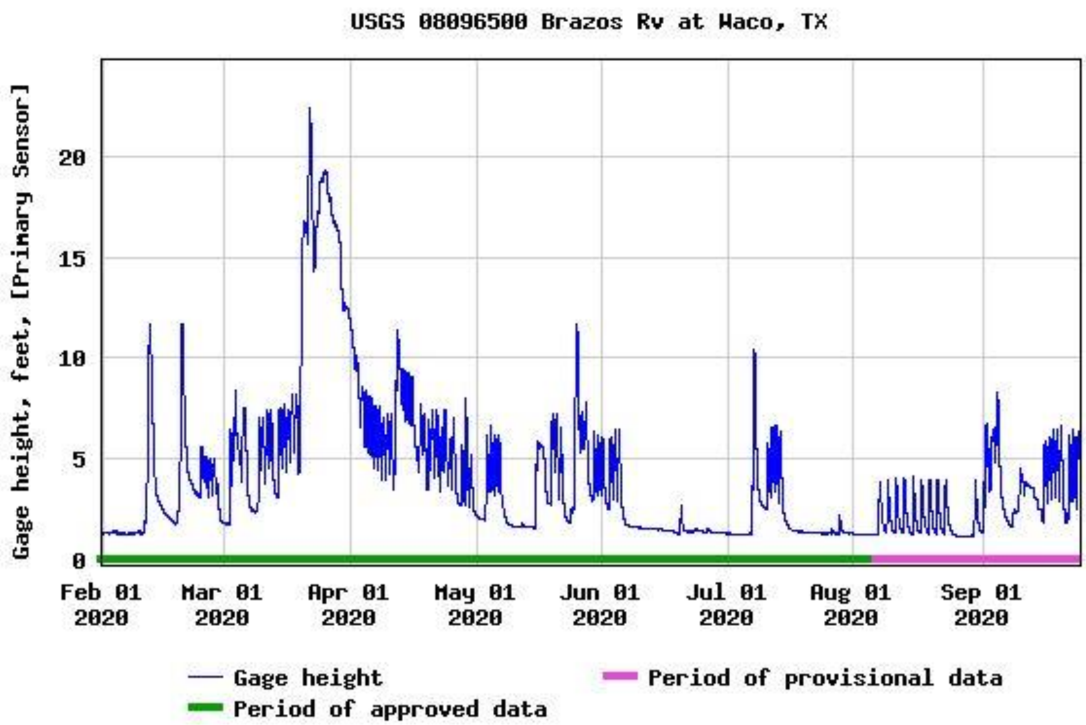
Brazos River

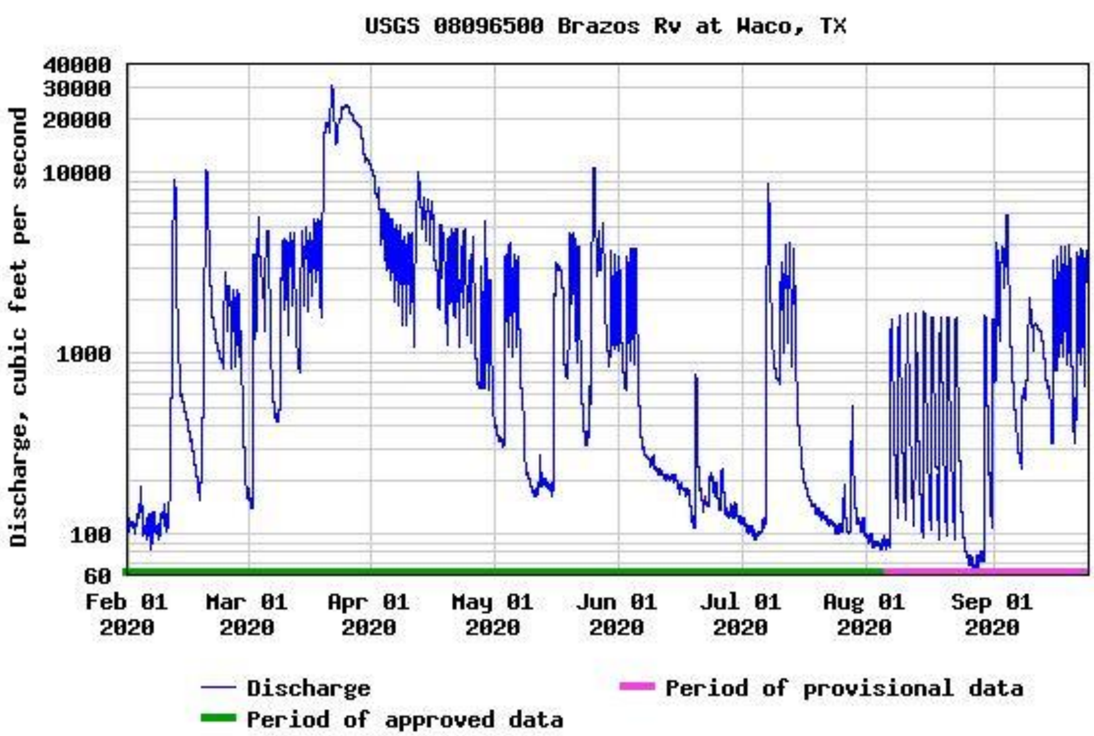
Section 14 Emergency Streambank and Shoreline Protection

GEOTECHICAL APPENDIX 5

Brazos River Stream Flow Data

Appendix 5 Brazos River Data





Steam Flow and Gage Height Records at Brazos River Gage Station upstream of Waco WWTP