Analysis of Historical Data

for the

Joe Pool Lake Watershed Characterization Project

October 2019

Trinity River Authority of Texas

On the cover:
Looking downstream at a historical data collection site on Low Branch at the Holland Road crossing.

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for the

Joe Pool Lake Watershed Characterization Project

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Investigating Entities

The Trinity River Authority of Texas

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List of Acronyms

AU	Assessment Unit
BMP	best management practice
BOD5	5-day biochemical oxygen demand
BSR	Basin Summary Report
CCN	Certificate of Convenience and Necessity
Cl^-	chloride
CRP	Clean Rivers Program
DO	dissolved oxygen
DOQQ	Digital Orthogonal Quarter Quadrangle
DFW	Dallas-Fort Worth metropolitan area
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FWS	U.S. Fish & Wildlife Service
GIS	geographic information system
GLO	General Land Office
JPLWPP	Joe Pool Lake Watershed Protection Plan
LDC	load duration curve
LULC	land use/land cover
MSL	mean sea level
NAIP	National Aerial Imagery Program
NASS	National Agricultural Statistics Service
NH_3	ammonia
NHD	National Hydrography Dataset
NO_2^-	nitrite
NO_3^-	nitrate
NCTCOG	North Central Texas Council of Governments
NRCS	U.S. Department of Agriculture - Natural Resource Conservation Service
NWS	National Weather Service
OP	orthophosphate
OSSF	on-site sewage facility
POR	period of record
RUAA	Recreational Use Attainability analysis
RRC	Texas Railroad Commission
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SO_4^{-2}	sulfate
SWCD	Soil & Water Conservation District
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TKN	total Kjeldahl nitrogen
TNRIS	Texas Natural Resource Information System
TOP	Texas Orthoimagery Program
TP	total phosphorous
TPWD	Texas Parks and Wildlife Service

TRA	Trinity River Authority of Texas
TSS	total suspended solids
TSSWCB	Texas State Soil & Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
TWDB	Texas Water Development Board
TXDOT	Texas Department of Transportation
USDOT	U.S. Department of Transportation
USGS	U.S. Geological Survey
WPP	watershed protection plan
WWTF	wastewater treatment facilities

1.0 Introduction

1.1 Project Overview and Objectives

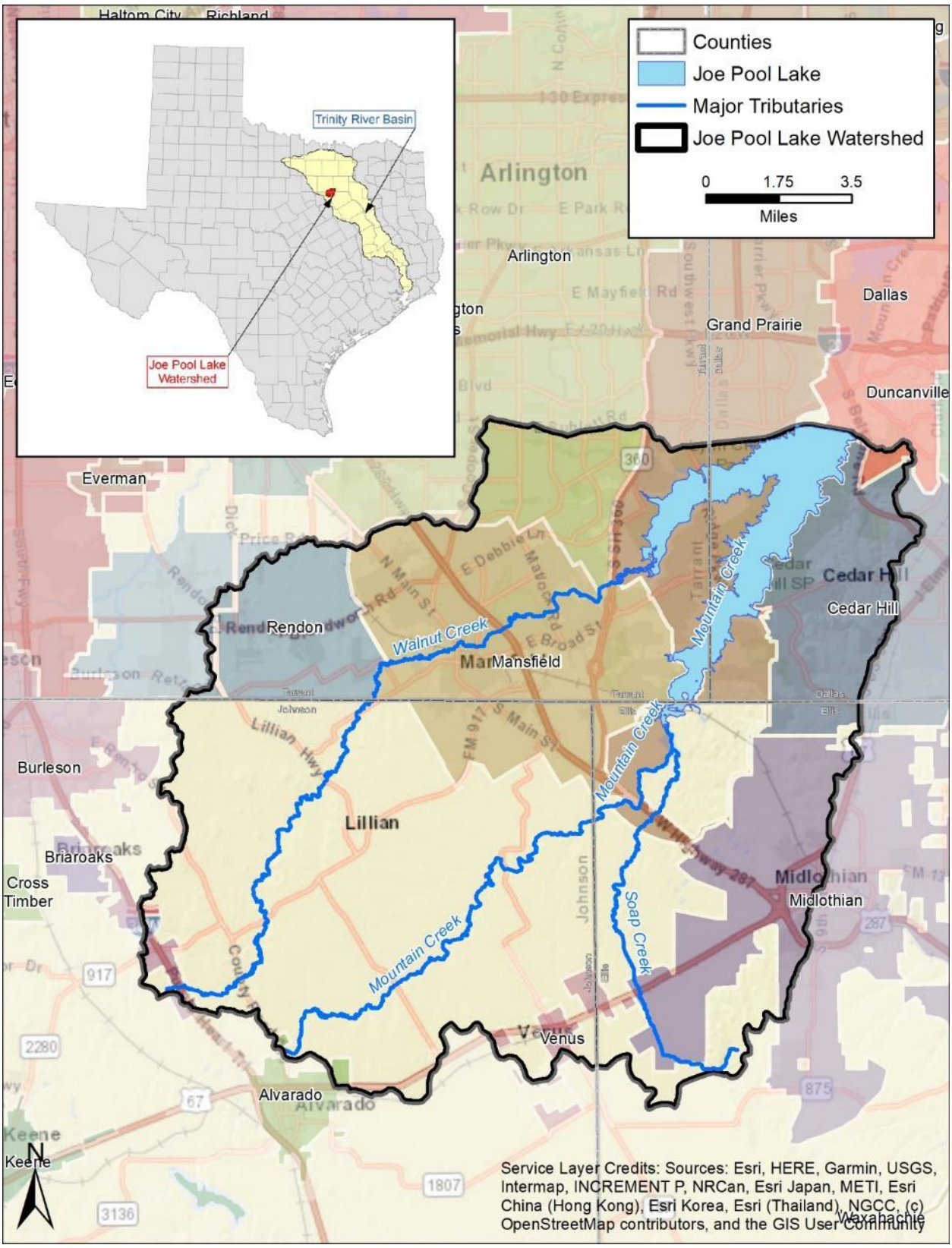
This analysis of historical data was performed as part of an effort to restore water quality within Walnut Creek, which is a tributary of Joe Pool Lake (JPL). The effort has further goals of protecting water quality in Joe Pool Lake, along with its other tributaries, Soap Creek and Mountain Creek. This analysis will support the development of the Joe Pool Lake Watershed Protection Plan (JPLWPP) by assessing existing water quality data in the watershed and analyzing it within the context of various watershed characteristics (e.g., climate, land use, land cover, geology, ecology) to ascertain current and historical conditions, as well as any trends in this data.

Due to Walnut Creek's classification as an impaired waterbody due to elevated levels of bacteria, there will be an emphasis on that constituent throughout the report. However, several other constituents of interest have also been identified through historical data review and stakeholder interaction. These include several nutrients, as well as other in-stream parameters that may indicate concerns for one or more designated uses of Joe Pool Lake and other waterbodies within its contributing watershed. Quality-assured data retrieved from the Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring Information System (SWQMIS) database will be processed with the use of statistical and geospatial analyses to evaluate temporal/spatial trends and relationships. Specific analyses to be run will include:

1) Regression of *Escherichia coli* (*E. coli*) concentrations with/against other water quality constituents as well as flow (or a surrogate such as precipitation);
2) Evaluation of occurrences of high *E. coli* values and other constituents of interest spatially within the watershed via geographic information systems (GIS) analysis to determine likely sources or subwatersheds for further evaluation; and
3) Plotting data spatially to identify temporal trends.

In pursuit of the overall watershed protection plan (WPP) goals outlined above, the analyses conducted using the results of this historical data report will be used to achieve several objectives, which include:

1) Developing a dataset to support modeling and assessment activities for quantifying pollutant loadings to the lake, especially for those constituents of interest where water quality standards are not being met;
2) Performing the modeling and assessment activities necessary to identify potential pollutant sources and quantifying the loadings of the constituents of interest for all segments;
3) Providing watershed stakeholders with the tools needed to take a proactive approach to watershed protection by engaging them through public outreach and education efforts; and
4) Utilizing stakeholder recommendations and expert technical knowledge within the watershed to develop a WPP that describes specific best management practices (BMPs) intended to reduce pollutant loadings and achieve target reductions for the watershed.



Basemap: ESRI World Streetmap.

Figure 1. Location of the Joe Pool Lake watershed.

1.2 Review of the Watershed and Impairments

The JPL watershed is formed by two major sub-watersheds, Walnut Creek to the west, and Mountain Creek to the east. Walnut Creek's headwaters are located south of the town of Burleson, draining to the northeast. Mountain Creek's headwaters are located north of Alvarado, draining northward to meet Walnut Creek to form Joe Pool Lake. The watershed spans four counties, occupying the adjoining corners of Dallas, Ellis, Johnson, and Tarrant counties (Figure 1). Urban and suburban areas dominate the northern end of the watershed, along with some areas industrial and municipal complexes. The east side of the lake is home to a state park and is thus less developed, although some housing subdivisions are scattered though the area. Land use trends more towards agricultural use in the southern extent, with the exception of some large industrial complexes inside the Midlothian city limits on the southeast perimeter of the watershed. During peak use, JPL currently serves as a drinking water source for up to 40,000 people, primarily serving the community of Midlothian. When demand is high, Midlothian may also provide water to the communities of Venus, Rockett, Mountain Peak, Sardis, and parts of southern Grand Prairie.

Walnut Creek is one of Joe Pool Lake's two main tributaries, listed on TCEQ's *2016 Texas Water Quality Inventory-303(d) List* (TCEQ, 2019a) as impaired for bacteria (first listed in 2006). The Mountain Creek arm of Joe Pool Lake itself was listed on TCEQ's *2014 Water Quality Inventory—Water Bodies with Concerns for Use Attainment and Screening Levels* (TCEQ, 2015b) for nitrate. However, since the onset of this project, the Mountain Creek arm has since been removed, according to the *2016 Water Quality Inventory—Water Bodies with Concerns for Use Attainment and Screening Levels* (TCEQ, 2019b)

2.0 Data Inventory

2.1 Geographic and Spatial Data

Data from a wide variety of sources will be used to characterize the JPL watershed and support the development of the WPP. Data related to water quality/quantity, potential point sources, land use/land cover, soils/geology, and climate were identified, with relevant datasets compiled. In addition to watershed characterization, the datasets listed in Table 1 will be used to characterize potential pollutant sources throughout the watershed, to be analyzed using one or several watershed models or other related analysis tools. More information about this analysis is provided in Section 8.3.

Table 1. Geospatial data sources used for source assessment analysis

Geospatial Data Type	Source	Date(s)	Analysis and/or Processing	Data Use
Aerial imagery	National Aerial Imagery Program (NAIP), Texas Orthoimagery Program (TOP)	2018, 1996	Mosaic and clip raster files to watershed	Determine ground conditions of watershed
Topographic maps (1:24,000 scale)	U.S. Geological Survey (USGS)	1996	Isolate DOQQs situated inside/tangent to watershed boundary	Characterize watershed, reference for hydrologic features
Detailed streets and highways	Environmental Systems Research Institute (ESRI)	2016	None	Public outreach component, orient map viewers to watershed extents
City boundaries	Texas Dept. of Transportation (TXDOT)	2014	Clip features to watershed boundary	Public outreach component
County boundaries	TXDOT	2014	Clip features to watershed boundary	Public outreach component
Joe Pool Lake Watershed	National Hydrography Dataset (NHD)	2009	Aggregate of HUC 12 subwatersheds upstream of the Joe Pool Lake dam and outlet structure, additional hand-delineation to correct for addition of lake	Clipping boundary for isolating other data sources
Census data	U.S. Census Bureau	2010	Distribute population density characteristics appropriately to watershed	Determine population characteristics, base data for several *E.coli* loading components
911 address structures points	North Central Texas Council of Governments (NCTCOG)	2015	Clip source points to watershed boundary	Determine location, density of structures
SWQM stations	Trinity River Authority (TRA), TCEQ	Varies (2012)	Relate to surface water quality data sampling results	Document locations of surface water quality monitoring stations
County Soils Maps	Natural Resource Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO)	2014	Identify areas that may prove problematic for modeling and/or pollutant transport	Characterize watershed, watershed delineation
General Soils Maps	NRCS State Soil Geographic Database (STATSGO)	1997	Identify areas that may prove problematic for modeling and/or pollutant transport	Characterize watershed, watershed delineation

Geospatial Data Type	Source	Date(s)	Analysis and/or Processing	Data Use
National Land Cover Database (NLCD)	Texas Natural Resource Information System (TNRIS)	2016	Clip database to watershed boundary, identify areas that may prove problematic for modeling and/or pollutant transport	Determine land use/land cover in watershed, watershed delineation
LULC field verification points	TRA	2019-2020	Compare to NLCD data	Determine accuracy of NLCD data
Soil/Water Conservation District (SWCD) boundaries	Texas State Soil & Water Conservation Board (TSSWCB)	2014	Isolate Dalworth/Johnson SWCDs	Public outreach strategy
List of steering committee member locations	TRA	2020	Gather geographic information at stakeholder meetings, personal communication, email	Determine distribution of committee member locations to ensure adequate watershed representation
Recreational Use Attainability Analysis (RUAA) sampling locations	TCEQ	2011 (Walnut Creek)	Generalize sampling location results to applicable extents within watershed	Determine extent of recreational use in watershed for bacteria standards applicability
Digital Elevation Models (DEMs)	USGS	2015	Mosaic and clip raster files to watershed mask, process to develop stream network.	Watershed delineation
Weather data	National Weather Service (NWS)	2008-2019	Isolate precipitation, evaporation, and temperature data; isolate for time period dictated by modeling constraints	Watershed delineation
Hydrology - existing lakes and reservoirs	NHD	2009	Ground truth feature margins for accuracy	Watershed delineation
Hydrology – streams	NHD	2009	Clip NHD features to watershed boundary	Watershed delineation
Named streams	NHD	2009	Generalize NHD data for streams, isolate named streams to new layer	Public outreach – use for general information maps
TCEQ stream segments	TCEQ	2016	Clip features to watershed boundary	Watershed delineation
TCEQ assessment units (AUs)	TCEQ	2016	Clip features to watershed boundary	Watershed delineation
Aquifers – major and minor	Texas Water Development Board (TWDB)	2006	None	Public outreach component

Geospatial Data Type	Source	Date(s)	Analysis and/or Processing	Data Use
New TCEQ surface water quality monitoring stations	TRA/TCEQ	Created through project	Identify new/existing station locations at strategic points along stream path	Watershed delineation
Floodplain data	National Flood Hazard Layer – Federal Emergency Management Agency (FEMA)	2015	Compare and adjust land use/land cover (LULC) maps as appropriate	Used to update LULC maps as necessary, public outreach component
Oil & natural gas wells, pipelines, leases	Railroad Commission (RRC) of Texas; Texas General Land Office (GLO)	Varies	Clip features to watershed boundary	Locate and determine density of oil/natural gas wells for potential pollutant point source identification
Public water system wells & surface water intakes	TCEQ	2016	Append well constituent tables to spatial network of wells	Determine if wells may be subject to pollution from nearby sources
Bridge locations	National Bridge Inventory, U.S Dept. of Transportation (USDOT)	2012	Append bridge location data to well information tables, apply to watershed	Component of approximating *E. coli* loading rate from avian sources
Municipal solid waste (MSW) sites/landfills	TCEQ	2007	Verify activity & history of sites clipped to watershed	Potential pollutant point source identification
Solid waste sites/landfills/ illegal dump site field verification	TRA	Created through project	Compare to MSW/landfill database points, add points for illegal dump sites found in watershed	Determine accuracy of municipal solid waste sites/landfills data, identify other dump site point sources
Water control structures database	NRCS/TRA	Created through project	Comparison and integration of TRA and NRCS records	Identify and verify significant impoundments in watershed
Superfund sites	TCEQ	2015	Clip database to watershed boundary	Potential pollutant point source identification
Petroleum storage tanks	TCEQ	2014	Clip database to watershed boundary	Potential pollutant point source identification
Permitted industrial/ hazardous waste sites	TCEQ	n/a	Clip database to watershed boundary	Locate sites for potential pollutant point source identification
Concentrated Animal Feeding Operations (CAFOs)	TCEQ	n/a	Clip database to watershed boundary – **none in watershed**	Locate sites for potential pollutant point source identification
Cattle – population density	USGS National Agricultural Statistics Service (NASS)	2016	Clip database to watershed boundary	*E. Coli* load calculation

Geospatial Data Type	Source	Date(s)	Analysis and/or Processing	Data Use
Sheep – population density	USGS NASS	2015	Clip database to watershed boundary	*E. Coli* load calculation
Goats – population density	USGS NASS	2015	Clip database to watershed boundary	*E. Coli* load calculation
Horses – population density	USGS NASS	2012	Clip database to watershed boundary	*E. Coli* load calculation
Deer – population density	Texas Parks & Wildlife Department (TPWD) deer density study (Lockwood 2007)	2007	Clip database to watershed boundary	*E. Coli* load calculation
Waterfowl – population density	Stakeholder input, using other WPP data as benchmarks	Created through project	Bias to riparian buffers, other areas of interest identified by stakeholders	*E. Coli* load calculation
Other avian – population density	Stakeholder input, using other WPP data as benchmarks	Created through project	Bias to bridge crossings, other areas of interest identified by stakeholders	*E. Coli* load calculation
Feral Hogs – population density	Stakeholder input, using peer-reviewed literature and other WPP data as benchmarks	Created through project	Bias to riparian buffers, other areas of interest identified by stakeholders	*E. Coli* load calculation
Wastewater treatment facilities (WWTFs)	TCEQ	2016	Clip to watershed boundary, verify operational state	*E. Coli* load calculation
Certificates of Convenience and Necessity (CCNs)	Public Utility Commission of Texas (PUC)	2014	Clip to watershed, verify extents	*E. Coli* load calculation
On-site sewage facilities (OSSFs)	Census Bureau	2010	census data, total households – CCNs = total households w/OSSFs	*E. Coli* load calculation
Domestic dogs	Census Bureau and stakeholder input	2010	Census data, households *0.8 = dogs	*E. Coli* load calculation

Note: Metadata that contains the Federal Geographic Data Committee (FGDC) minimum documentation requirements will be created for any acquired spatial data manipulated through data analysis and/or processing.

2.2 Other Studies and Reports

The proposed project seeks to build upon several past and ongoing initiatives in the watershed with water quality improvement components. These projects will be supported and/or progressed by developing an effective WPP. This WPP is expected to identify and provide the groundwork for implementation of strategies to address the current water quality issues of bacteria in Walnut Creek, along with other potential constituents of interest identified by stakeholders during the project and sampling activities. The watershed stakeholders have

demonstrated a long-term commitment towards this goal and have asked TRA to work with them to produce such a WPP. The JPLWPP will not only provide specific direction towards meeting current challenges, but will also provide a holistic framework for protecting water quality as the watershed develops.

2.2.1 Joe Pool Lake Customer Reports

TRA, in association with its member cities, collects additional water quality monitoring data, though this data is not submitted for inclusion in the SWQMIS database. This monitoring is paid for directly by the cities of Cedar Hill, Duncanville, Grand Prairie, and Midlothian, all of whom have water supply interests in the lake. The goal of this monitoring, is similar to that of the Clean Rivers Program (CRP), with the intent to assess, monitor, and protect the many uses of water in Joe Pool Lake, including water supply, aquatic life support, and recreation. TRA compiles this data each year and produces annual reports for the participating cities. Every fifth year, a comprehensive report is prepared, with the latest version, published in 2017, focused on the 2013-2016 period, but including data from as far back as 1997 for examination of long-term trends. This report will summarize the findings of both the 2013-2016 comprehensive report (TRA, 2017), as well as the 2017 annual report (TRA, 2018b).

2.2.2 *E. coli* in Sediments – CRP Special Report

There is local interest in understanding factors that influence bacteria levels in the water column. There are many sources in scientific literature that indicate that sediments can be a significant reservoir of bacteria in waterbodies. However, most studies have focused on swimming beaches of reservoirs and coastal areas; little work has been conducted on flowing/eroding systems. To more fully understand bacterial impairment issues in the streams of the Trinity River Basin, a study is currently being conducted to identify the extent to which bacteria in sediments may affect water column concentrations. The initial phase of this project focuses on sediment and water column E. coli enumeration. Joe Pool Lake's two primary tributaries (Mountain and Walnut Creeks) are included in the study (TRA, 2019).

2.2.3 CRP Biological Monitoring – Walnut Creek

Each year, TRA conducts Aquatic Life Monitoring in one or more streams. In 2017, this form of monitoring was conducted on Walnut Creek at Katherine Rose Park in Mansfield (TRA, 2018a). This monitoring consists of an assessment of the benthic macroinvertebrate and fish populations as well as the available habitat in and around the stream for up to a 500-meter reach in wadable streams. This information is used to determine if aquatic life uses are being supported.

3.0 Data Review Methods

3.1 TCEQ Water Quality Standards

TCEQ is responsible for establishing numeric and narrative goals for water quality in the state of Texas. These goals are described in TCEQ's Texas Surface Water Quality Standards (TSWQS) and are approved by the U.S. Environmental Protection Agency (EPA). These standards are codified in the Texas Administrative Code (TAC), Title 30, Chapter 307, hereto referred to as TAC 307 (TCEQ, 2018) and are used by TCEQ regulatory programs to establish reasonable methods of assessing water bodies of the state with the intent of implementing targeted strategies aimed at specific water quality goals. Site-specific water quality criteria for Joe Pool Lake (Segment 0838) and its unclassified tributaries (Segments 0838A through 0838F), as defined in TAC 307, are presented in Table 2. Known deviations from these criteria are noted below the table, although others may exist. For additional information about the collection, preservation, and laboratory analysis of samples collected for these parameters, please consult TCEQ's *Surface Water Quality Monitoring (SWQM) Procedures Manual, Volume 1: Physical and Chemical Monitoring Methods* (TCEQ, 2012).

Table 2. Site-specific water quality criteria for the Joe Pool Lake watershed.

Parameter	Segment ID	
	0838	0838A-F
Cl^- (mg/L)	100	100
SO_4^{2-} (mg/L)	250	-
TDS (mg/L)	500	300
DO (mg/L) 24-hr minimum	3.0	1.5[a]
DO (mg/L) 24-hr average	5.0	2.0[a]
pH range	6.5-9.0	6.5-9.0
E. coli (#/100ml) geomean	126	126[b]
Temperature (°F; °C)	95; 35	95; 35

(a) Tributaries 0838B and 0838C use a DO 24-hr minimum and average of 2.0 mg/L and 3.0 mg/L, respectively.

(b) Walnut Creek (0838C) is designated for Primary Contact 2 with an E. coli geomean criteria of 630 MPN/100 mL)

3.2 Nutrient Screening Levels and Reference Criteria

Currently, no numeric criteria exist for nutrients in streams in the state of Texas. Numeric criteria for chlorophyll-a have been approved by EPA for 75 reservoirs in the state; however, Joe Pool Lake is not one of these reservoirs. In such situations where no water quality standards exist or are in the process of being developed, controls such as narrative criteria and antidegradation considerations are often used. Despite this lack of narrative criteria, TCEQ continues to screen for parameters such as nitrogen, phosphorus, and chlorophyll-a as preliminary indicators in waterbodies of possible concern for 303(d) impairments. To support this effort, nutrient screening levels and reference conditions are often used to compare a waterbody to reference values at a local, regional, or national level. Table 3 provides screening values from various sources. The Texas Nutrient Screening Levels are based on statistical analyses of SWQM monitoring data (TCEQ, 2015a) and the EPA Reference Criteria are regional values based on data from reservoirs and streams within specific ecoregion units and subunits (USEPA, 2000a, 2000b). It is worth noting that these Reference Criteria differ from the Texas Nutrient Screening Levels in that EPA developed the Reference Criteria using conditions that are indicative of minimally impacted (or in some cases, pristine) waterbodies, attainment of which would result in protection of all designated uses within those specific units and subunits. As such, Reference Criteria thresholds are much lower than those for state screening levels, and surpassing them may not necessarily indicate a concern, as is the case with the state thresholds. Where state screening levels or national reference criteria were non-existent, other sources were used. In particular, other sources were used as a reference for screening values of nitrite (NO_2^-) (Mesner & Geiger, 2010).

Table 3. Texas Nutrient Screening Levels and EPA Nutrient Reference Criteria.

Parameter		TCEQ Screening Levels		EPA Reference Criteria				Other Sources
		Lake/Reservoir	Stream	Lake/Reservoir		Stream		
TKN	(mg/L)	-	-	0.38[a]	0.41[b]	0.3[a]	0.4[b]	
NO_2^-	(mg/L)	-	-	-	-	-	-	0.02[c]
NO_3^-	(mg/L)	0.37	1.95	-	-	-	-	
$NO_2^-+NO_3^-$	(mg/L)	-	-	0.017[a]	0.01[b]	0.125[a]	0.078[b]	
TP	(mg/L)	0.20	0.69	0.02[a]	0.019[b]	0.037[a]	0.038[b]	
OP[d]	(mg/L)	0.05	0.37	-	-	-	-	
Chlorophyll a[e]	(µg/L)	26.7	14.1	5.18[a]	2.875[b]	0.93[a]	1.238[b]	

(a) Reference conditions for aggregate Ecoregion IX waterbodies, upper 25th percentile of data from all seasons, 1990-1999.

(b) Reference conditions for level III Ecoregion 29 waterbodies, upper 25th percentile of data from all seasons.

(c) For nitrite, concentrations above 0.02 mg/L (ppm) usually indicate polluted waters (Mesner, N., J. Geiger. 2010. Understanding Your Watershed: Nitrogen. Utah State University, Water Quality Extension.

(d) OP is no longer used for TCEQ screening purposes, as of the 2014 Texas Integrated Report.

(e) Chlorophyll a, as measured by Spectrophotometric method with acid correction.

3.3 Description of Assessments

3.3.1 TCEQ 2016 Texas Integrated Report

The TCEQ 2016 Texas Integrated Report covers a seven-year assessment period from December 1, 2007 to November 30, 2014. In cases where additional data was needed to make an informed assessment, data from an additional three-year segment beginning December 1, 2005 were used. The methods used for this assessment are described in the TCEQ's 2014 *Guidance for Assessing and Reporting Surface Water Quality in Texas* (TCEQ, 2015a).

Findings of the Integrated Report are classified as Fully Supporting, No Concern, Use Concern, Screening Level Concern, and Not Supporting. To simplify data presentation in this report, the Use Concern and Screening Level Concern classifications were combined into a single "Concern" category. Use Concern findings are given for assessments against designated use standards for water quality parameters such as dissolved oxygen (DO) and *E. coli*. Use Concerns can apply to datasets with limited data where the threshold number of exceedances are met or to datasets with adequate data where there are less than the threshold number of exceedances required for a Not Supporting finding. Screening Level Concerns apply to General Use parameters, such as nutrients and chlorophyll-a, as well as a few other parameters for other designated uses. These parameters have screening levels rather than standards.

3.3.2 TRA In-house Assessment

As part of the 2015 Basin Summary Report (BSR) (TRA, 2015), TRA conducted an in-house assessment using the most recent available and complete data. This includes data collected between December 1, 2008 and November 30, 2013. Data were compared to standards and screening levels in a manner similar to TCEQ methods. A trends analysis was included with the assessment, which may provide information on emerging issues that may not be readily apparent in the results of the TCEQ Integrated Report or the other reports when reviewed separately.

3.3.3 TRA Joe Pool Lake Customer Water Quality Reports

As noted in Section 2.2.1, TRA prepares annual reports for the customer cities of Joe Pool Lake, with a more comprehensive report prepared on a 5-year cycle. The 2013-2016 report will be the primary focus within this document (TRA, 2017), but analyses conducted as part of the 2017 annual report (TRA, 2018b) will be briefly explored.

3.4 Data Collection

Data represented in this report prior to 2012 was collected and submitted to TCEQ under the SWQMIS program, generated either by TRA staff or through TRA's partners within the Clean Rivers Program (CRP). Data collected after that date was still collected under the sampling protocols dictated in SWQM Procedures Manual (TCEQ, 2012), but was not submitted to TCEQ for inclusion in the SWQMIS database. Use of this data will be noted in futures sections, as appropriate, as a caveat.

3.5 Water Quality Trends

Trend analyses were conducted as part of the TRA BSR In-house Assessment (TRA, 2015) and the Joe Pool Lake Customer Reports (TRA, 2017, 2018b). Trend analyses were conducted on all datasets determined to be adequately normal. Those datasets that passed significance testing were determined to have trends that warranted further discussion and investigation. The methods used for data preparation and trend analysis are discussed in detail in the 2015 BSR (TRA 2015). Please consult the corresponding reports for additional information regarding normality, significance, and trends.

4.0 Watershed Characteristics

4.1 General Information

The Joe Pool Lake watershed extends from its headwaters near the cities of Burleson in Johnson County and southern Midlothian in Ellis County to the Joe Pool Lake dam in Dallas County. The watershed consists of several TCEQ-monitored segments, including Joe Pool Lake (0838), a classified segment, and six unclassified segments: Mountain Creek (0838A), Sugar Creek (0838B), Walnut Creek (0838C), Soap Creek (0838D), Hollings Branch (0838E), and an unnamed tributary (0838F), known locally as Low Branch.

4.2 Climate

Mean annual daily temperature from the National Weather Service database for the Dallas/Fort Worth Metroplex (https://www.weather.gov/fwd/dfwclimo) is 66.2°F for the entire period of record (POR) between 1981 and 2010. Temperatures are generally lowest in January and highest in August, with POR daily annual averages of 45.9 °F and 85.6 °F, respectively.

The mean annual precipitation for the Dallas/Fort Worth Metropolitan area is 36.14 inches for the entire POR between 1981 and 2010. The lowest yearly total came in 1921, with only 17.9 inches, with the highest yearly total occurring in 2015, when prolonged storms brought 62.61 inches of rain, along with historic flooding.

4.3 Geology

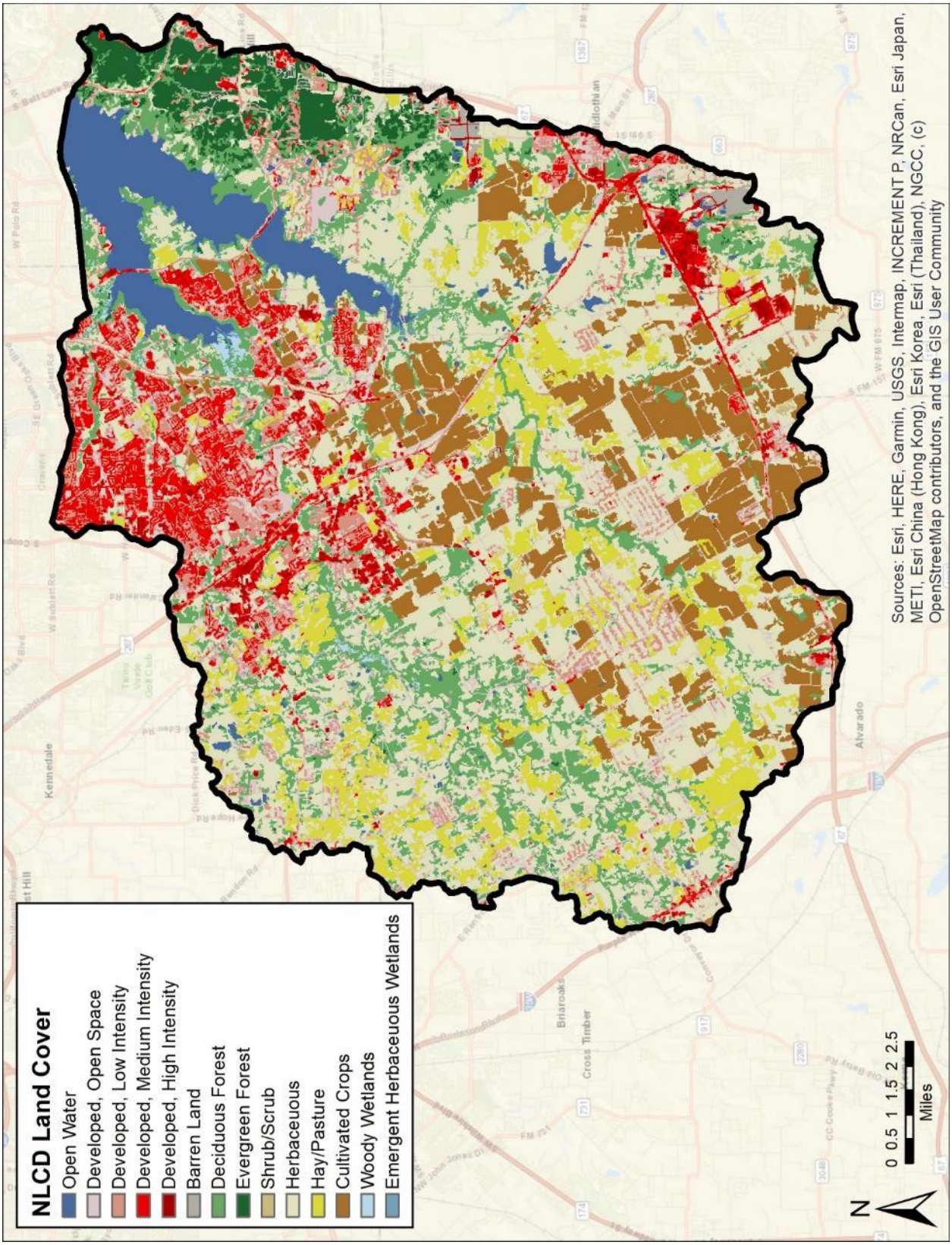
The Joe Pool Lake watershed is generally located within the Grand Prairie physiographic province according to the Physiographic Map of Texas(BEG, 1996). The majority of the watershed is underlain by units from the Austin Chalk, Eagle Ford (undivided), and Woodbine groups, with some fluviatile terrace deposits and alluvial floodplain deposits in areas underlying or near larger waterbodies.

4.4 Soils

Soils in the vicinity of the lake are composed mainly of fine sandy loams and silty clays. Some of the more common upland soil groups in the watershed include Crosstell fine sandy loams, Heiden clays, Houston black clays, and Rader fine sandy loams. Several hydric soils occupy the bottom land areas of the watershed, with Trinity clays, Tinn clays, and Pulexas fine sandy loams being most common. A complete soils list and map are provided in Appendix A.

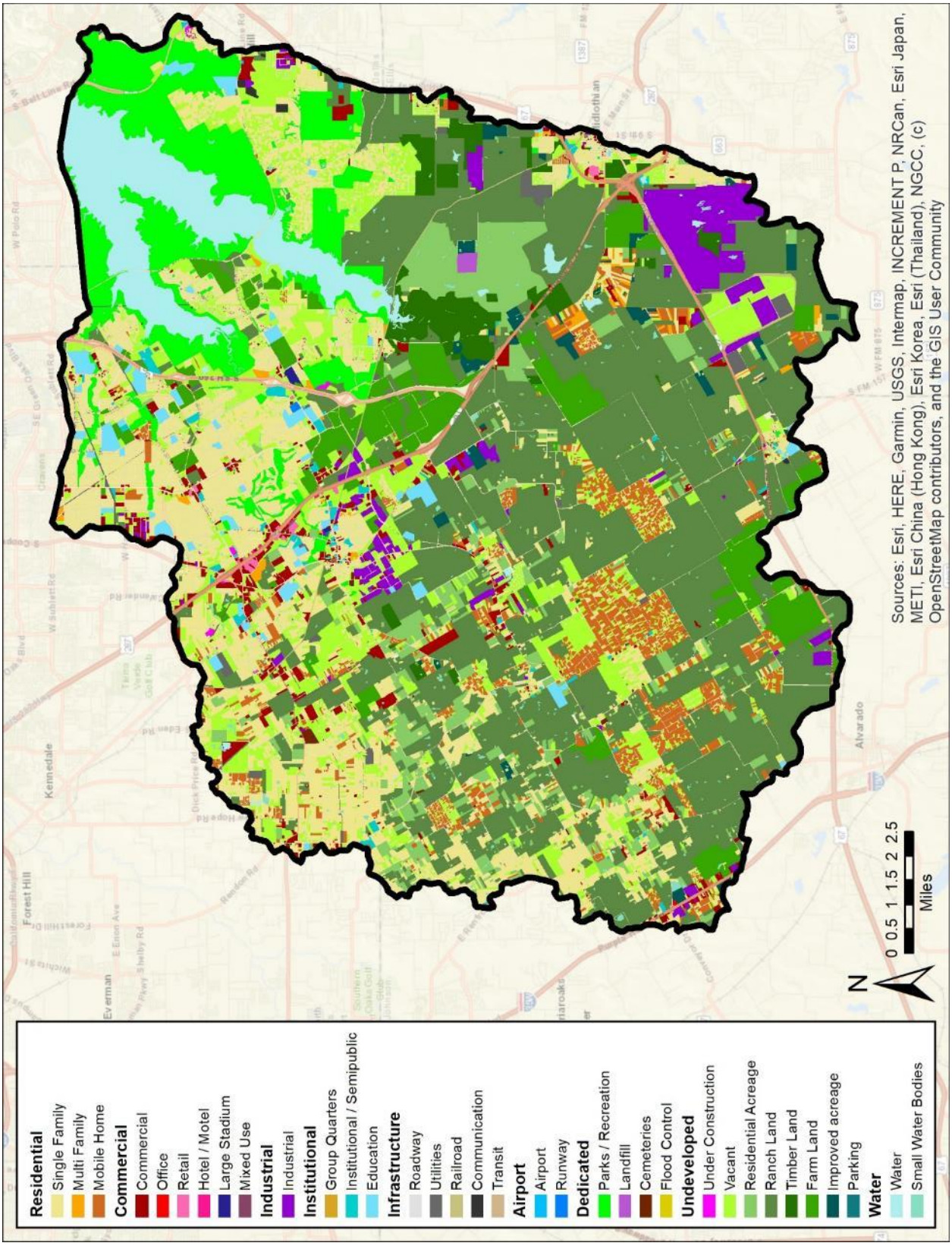
4.5 Land Use and Land Cover

The northern-central and southeastern portions of the subwatershed surrounding the lake are urbanized, while the upstream, southwestern portions of the subwatershed have remained generally rural, dominated by herbaceous cover, with some pastureland and row-crop agriculture. Much of the area east of the lake remains forested, due to the existence of Cedar Hill State Park. Major population centers include the City of Midlothian and the communities of the southwest Dallas-Fort Worth (DFW) Metroplex, which includes portions of Mansfield, Arlington, Grand Prairie, and Cedar Hill. These population centers compose the majority of the developed land in the area, which is shown at as red areas in Figure 2. Land use within the watershed from 2013 is depicted in Figure 3, which relates a use category (residential, industrial, undeveloped, etc.) to the land cover information. The urban centers previously mentioned are characterized by a high percentage of single-family homes, but a significant percentage of industrial complexes appear in the vicinity of Midlothian, with smaller examples near the center of the watershed. Outside of these urbanized areas, ranch land is dominant, with pockets of farm land and undeveloped open lots being typical. The majority of the state park area to the west of the lake is categorized accordingly as parks/recreation land.



Data source: Multi-Resolution Land Characteristics Consortium; Basemap: ESRI World Streetmap.

Figure 2. 2015 NLCD land cover classes in the Joe Pool Lake watershed.



Data source: NCTCOG; Basemap: ESRI World Streetmap.

Figure 3. 2013 NCTCOG land use classifications in the Joe Pool Lake watershed.

4.6 Ecology

The watershed is shared between the Texas Blackland Prairie and Cross Timbers ecoregions. The southwestern extent of the watershed is in the Eastern Cross Timbers ecoregion (29b). Here, post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) are common overstory trees, with minor representation from species like black hickory (*Carya texana*), plateau live oak (*Quercus fusiformis*), eastern redcedar (*Juniperus virginiana*), and various sumac species (*Rhus* spp.). with native grasses such as bluestem (*Schizachyrium* spp.), yellow Indiangrass (*Sorghastrum nutans*), and tall dropseed (*Sporobolus asper*) in the understory and within prairie inclusions. In disturbed areas, honey mesquite (*Prosopis glandulosa*) and prickly pear (*Opuntia* spp.) are common.

The eastern extent of the watershed is within the Northern Blackland prairie ecoregion (32a). The area was once dominated by tallgrass prairie species in upland areas, but extensive urbanization has occurred in this ecoregion. In undisturbed areas, this includes big bluestem (*Andropogon gerardii*), yellow Indiangrass, little bluestem (*Schizachyrium scoparium*), and tall dropseed. The remaining forested areas include woody species such as oak (*Quercus macrocarpa, Quercus shumardii*), ash (*Fraxinus* spp.), sugar hackberry (*Celtis laevigata*) elm (*Ulmus* spp.), pecan (*Carya illinoensis*), and eastern cottonwood (*Populus* deltoides) are common (Griffith 2007).

Although no instances of critical habitat occur within the watershed for any federally-listed threatened and endangered species, a U.S. Fish and Wildlife Service (FWS) Information, Planning, and Consultation (IPaC) report indicated the possible presence of several threatened and endangered species that may occur intermittently throughout the watershed. Of note were several endangered avian species, including the Golden-cheeked Warbler (*Dendroica chrysoparia*), Least Tern (*Sterna antillarum*), Piping Plover (*Charadrius melodus*), and Red Knot (*Calidris canutus rufa)*. The list also included one species of clam, the Texas Fawnsfoot (*Truncilla macrodon*), which is currently listed as a Candidate species. The full IPaC report is provided in Appendix B.

In most cases, state lists of threatened and endangered species are more robust, given the increased specificity for critical populations and habitats afforded by the smaller scope of study inherent to state boundaries. As a result of this refined scope, additional avian and mollusk species appear within the state list produced by the TPWD is provided in Appendix C. The state list also includes several fish, mammal, reptilian, and plant species, which are not shown in the Federal list.

5.0 Reservoir Characteristics

5.1 General Information

Named after Congressman Joe Pool of Oak Cliff, the lake is operated by the Trinity River Authority for conservation, flood control, recreation, and water supply purposes Originally designated as Lakeview Reservoir, the lake is formed by a rolled earthen dam structure, with its spillway elevation of 536 ft above mean sea level (MSL). Construction on the dam was completed in December 1985, and the lake was filled by January 1989. (Dallas Times Herald, 1989).

Several recreational areas utilize a significant portion of the 64 miles of lakeshore provided by the reservoir. The largest of these is Cedar Hill State Park, which encompasses much of the eastern lakeshore of the Mountain Creek arm. Pleasant Valley Park exists just south of the State Park. Loyd Park and Lynn Creek Park are located on the lake's northwestern shores on the Walnut Creek arm, while Estes Park can be found between the two arms of the lake (Dallas Times Herald, 1989).

5.2 Hydraulics

Joe Pool Lake receives 100% of its yield from natural tributaries, draining an area of approximately 232 square miles. These incoming flows are comprised of stormwater runoff, as well as treated wastewater effluent from two WWTFs and several smaller domestic sewage discharges within the watershed (Table 4). Databases

maintained by USEPA did not identify any discharges of cooling water, mining effluent, or concentrated animal feeding operation effluent in the watershed.

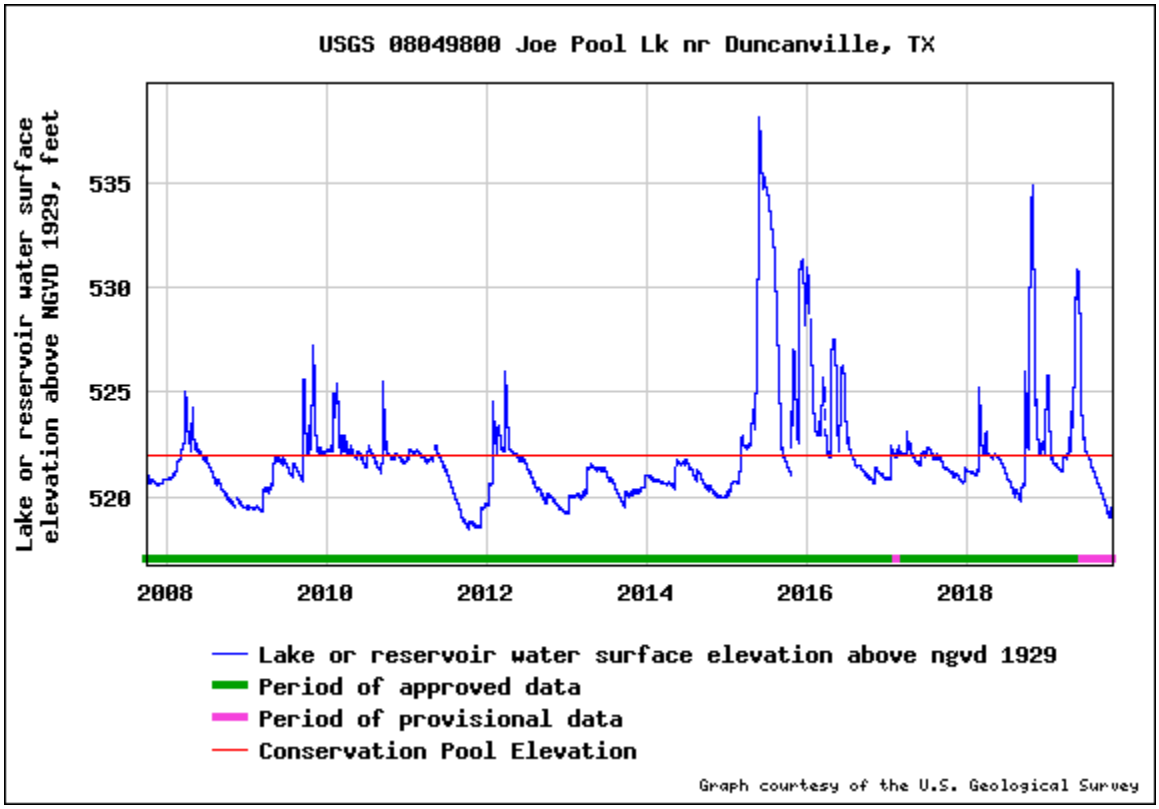
Table 4. Discharges in the Joe Pool Lake watershed, by type and count.

County	Domestic Sewage <1 MGD	Wastewater Dischargers >1 MGD	Total
Ellis	2	2	4
Johnson	5		5
Tarrant	1		1
Total	**8**	**2**	**10**

No discharge permits for cooling water, concentrated animal feeding operations, or mining exist in the watershed.

Withdrawals in the lake for public water supply purposes are currently limited to the City of Midlothian's activities. Midlothian withdraws anywhere from 1 MGD during winter months, up to 9 MGD during peak demand in the summer. Summer withdrawals by the City may also include sales of the water to other communities, including southern Grand Prairie, Venus, Mountain Peak, and Sardis to supplement their water supplies during peak demand. Midlothian withdraws their water from an intake structure in the southern extent of the Mountain Creek arm of the lake. The TRA has a separate structure to the north, located off the shoreline of Cedar Hill State Park. This structure is currently inactive. Likewise, several other entities have interests in developing the water resources of the lake, but have yet to tap into those resources.

The normal conservation pool level of 522 MSL (red line in Figure 4) creates an impoundment of 7,400 acres (USACE, n.d.), with a maximum depth of 75 ft. Joe Pool Lake has a conservation storage capacity of 176,900 acre-feet. Historical lake elevations from 2007 to 2019 are provided in Figure 4 below.

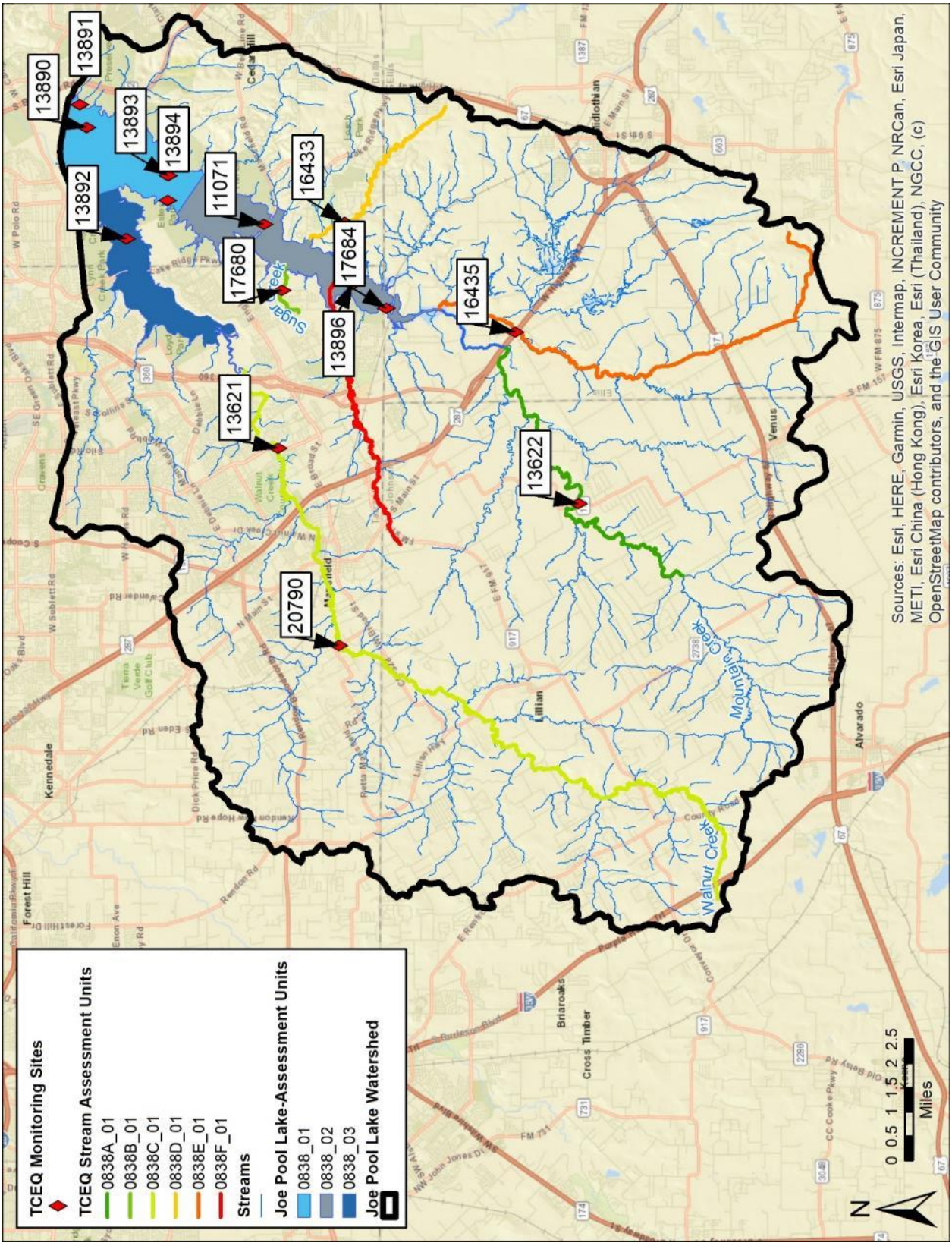


Data source: USGS.

Figure 4. Daily Observed Water Surface Elevation in Joe Pool Lake, 2007-2019.

5.3 Water Quality Monitoring Data

The lake is composed of 3 assessment units (AUs) that are analyzed for water quality, as part of TCEQ's SWQMIS. These assessment units and their location descriptions are listed in Table 5 below, as well as in all other use assessment results tables that follow. Each assessment unit contains one or more SWQMIS monitoring station, from which data is analyzed to evaluate the unit's use assessment. The locations of these monitoring stations, as well as the locations of the assessment units, are provided in Figure 5. It is important to note that while information from each unit's station is listed separately in the reporting database, the lake is evaluated as a whole segment, compounding data from all 3 assessment units for analysis. Stream segments are evaluated separate from one another, but likewise may be composed of data from several monitoring stations. All stream segments discussed in this report are composed of a single AU.



Basemap: ESRI World Streetmap.

Figure 5. Water quality monitoring stations, hydrography, and Lake Assessment Units.

5.3.1 Aquatic Life Use Assessments

Adequate aquatic life use data was only available for assessment unit 0838_02 (Table 5). The water quality parameter associated with aquatic life assessments is DO. The available data showed that the segment was fully supporting aquatic life uses.

Table 5. Aquatic life use assessment results for Joe Pool Lake.

Waterbody	AU	2016 TCEQ Report
Joe Pool Lake: Lowermost portion of reservoir adjacent to the dam	0838_01	Not Assessed (No Data)
Joe Pool Lake: Mountain Creek arm	0838_02	Fully Supporting
Joe Pool Lake: Walnut Creek arm	0838_03	Not Assessed (No Data)

5.3.2 Contact Recreation Use Assessments

Adequate recreational use data was only available for assessment unit 0838_02. The water quality parameter associated with this assessment is *E. coli.* This segment was found to have no concern based on the TCEQ 2016 Integrated Report (Table 6).

Table 6. Contact recreation use assessment results for Joe Pool Lake.

Waterbody	AU	2016 TCEQ Report
Joe Pool Lake: Lowermost portion of reservoir adjacent to the dam	0838_01	Not Assessed (No Data)
Joe Pool Lake: Mountain Creek arm	0838_02	No Concern
Joe Pool Lake: Walnut Creek arm	0838_03	Not Assessed (No Data)

5.3.3 General Use Assessments

Adequate general use data was available for assessment units 0838_01 and 0838_02. The water quality parameters associated with this assessment are temperature, pH, dissolved solids, and several nutrients. Both assessment units were found to be fully supportive of general uses (Table 7).

Table 7. General use assessment results for Joe Pool Lake.

Waterbody	AU	2016 TCEQ Report
Joe Pool Lake: Lowermost portion of reservoir adjacent to the dam	0838_01	Fully Supporting
Joe Pool Lake: Mountain Creek arm	0838_02	Fully Supporting
Joe Pool Lake: Walnut Creek arm	0838_03	Not Assessed (No Data)

5.3.4 Fish Consumption Use Assessments

Adequate fish consumption use data was unavailable for all assessment units within Joe Pool Lake (Table 8). As such, no support assessment for the fish consumption use can be made at this time.

Table 8. Fish consumption use assessment results for Joe Pool Lake.

Waterbody	AU	2016 TCEQ Report
Joe Pool Lake: Lowermost portion of reservoir adjacent to the dam	0838_01	Not Assessed (Inadequate Data)
Joe Pool Lake: Mountain Creek arm	0838_02	Not Assessed (Inadequate Data)
Joe Pool Lake: Walnut Creek arm	0838_03	Not Assessed (Inadequate Data)

5.3.5 Public Water Supply Use Assessments

Adequate public water supply use data was unavailable for all assessment units within Joe Pool Lake (Table 9). As such, no support assessment for public water supply use can be made at this time.

Table 9. Public water supply use assessment results for Joe Pool Lake.

Waterbody	AU	2016 TCEQ Report
Joe Pool Lake: Lowermost portion of reservoir adjacent to the dam	0838_01	Not Assessed (No Data)
Joe Pool Lake: Mountain Creek arm	0838_02	Not Assessed (No Data)
Joe Pool Lake: Walnut Creek arm	0838_03	Not Assessed (No Data)

6.0 Stream Characteristics

6.1 Flow

Flow data for Walnut Creek is tracked continuously by a USGS gaging station at the Walnut Creek bridge on Matlock Rd (USGS Gage #08049700), with data back to July 2007. Mountain Creek is also gaged (USGS Gage #08049580), with data back to 1987. Other flow data exist at other stations throughout the watershed within SWQMIS that will be used to supplement the USGS dataset, where appropriate.

6.2 Water Quality Monitoring Data

Six stream AUs in the Joe Pool Lake watershed have been monitored by TCEQ through 2012. With the exception of Walnut Creek, all AUs contain a single station used for use attainment analyses. It is important to note that data taken at sites 13621 and 13622 are sampled where the previously-mentioned USGS gages are located for Walnut and Mountain Creeks, respectively. Data in SWQMIS is available from 1997 to 2012.

6.2.1 Aquatic Life Use Assessments

Adequate aquatic life use data was available for all assessment units aside from 0838A (Table 10). As with Joe Pool Lake, DO was the water quality parameter used in the assessment. The available data showed that all AUs with available data fully supported aquatic life uses.

Table 10. Aquatic life use assessment results for unclassified segments.

Waterbody	AU	2016 TCEQ Report
Entire segment	0838A_01	Not Assessed (No Data)
Entire segment	0838B_01	Fully Supporting
From the confluence with Joe Pool Lake up to the headwaters at Spring Street in Burleson	0838C_01	Fully Supporting
Hollings Branch from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 500 m downstream of US 67 in Midlothian	0838D_01	Fully Supporting
Soap Creek from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 6.6 km (3.98 miles) upstream of US 67 in Midlothian	0838E_01	Fully Supporting
Intermittent stream from the confluence with Mountain Creek south of Mansfield upstream to the headwaters approximately 2.0 km upstream of FM 157 in Mansfield	0838F_01	No Concern

6.2.2 Contact Recreation Use Assessments

This segment was found to be not supportive of contact recreation uses due to elevated *E. coli* geometric means (Table 11). Current standards for *E. coli* are 399 MPN/100 mL for a single grab sample and 126 MPN/100 mL for

the geometric mean of samples over time. Data from the 2016 Integrated Report suggest that 0838C was only slightly out of compliance, reporting at 126.62 MPN/100 mL, just barely above the quality criteria of 126 MPN/100 mL. As discussed above, elevated *E. coli* and stream flow values typically occur in tandem due to nonpoint source inputs of incoming stormwater runoff from the surrounding watershed. A residential subdivision with a golf course is located immediately upstream of the sampling station, but is wooded along the channel. Further upstream, this wooded riparian zone continues through rural areas. The *E. coli* impairment is therefore assumed to be caused either by wildlife or pet waste. Failing septic systems from further upstream are also suspect.

Table 11. Contact recreation use assessment results for unclassified segments.

Waterbody	AU	2016 TCEQ Report
Entire segment	0838A_01	Not Assessed (No Data)
Entire segment	0838B_01	Fully Supporting
From the confluence with Joe Pool Lake up to the headwaters at Spring Street in Burleson	0838C_01	Not Supporting
Hollings Branch from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 500 m downstream of US 67 in Midlothian	0838D_01	Fully Supporting
Soap Creek from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 6.6 km (3.98 miles) upstream of US 67 in Midlothian	0838E_01	Fully Supporting
Intermittent stream from the confluence with Mountain Creek south of Mansfield upstream to the headwaters approximately 2.0 km upstream of FM 157 in Mansfield	0838F_01	No Concern

6.2.3 General Use Assessments

Adequate data for general use determinations was unavailable for all assessment units within Joe Pool Lake tributaries (Table 12).

Table 12. General use assessment results for unclassified segments.

Waterbody	AU	2016 TCEQ Report
Entire segment	0838A_01	Not Assessed (No Data)
Entire segment	0838B_01	Not Assessed (No Data)
From the confluence with Joe Pool Lake up to the headwaters at Spring Street in Burleson	0838C_01	Not Assessed (No Data)
Hollings Branch from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 500 m downstream of US 67 in Midlothian	0838D_01	Not Assessed (No Data)
Soap Creek from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 6.6 km (3.98 miles) upstream of US 67 in Midlothian	0838E_01	Not Assessed (No Data)
Intermittent stream from the confluence with Mountain Creek south of Mansfield upstream to the headwaters approximately 2.0 km upstream of FM 157 in Mansfield	0838F_01	Not Assessed (No Data)

6.2.4 Fish Consumption Use Assessments

For the TCEQ Integrated Report, Adequate fish consumption data were available for the assessment unit 0838A and 0838D, as reviewed under the TCEQ Integrated Report. The available data showed that these segments were all fully supporting aquatic life uses (Table 13).

Table 13. Fish consumption use assessment results for unclassified segments.

Waterbody	AU	2016 TCEQ Report
Entire segment	0838A_01	Not Assessed (No Data)
Entire segment	0838B_01	Fully Supporting
From the confluence with Joe Pool Lake up to the headwaters at Spring Street in Burleson	0838C_01	Not Assessed (No Data)
Hollings Branch from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 500 m downstream of US 67 in Midlothian	0838D_01	No Concern
Soap Creek from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 6.6 km (3.98 miles) upstream of US 67 in Midlothian	0838E_01	Not Assessed (No Data)
Intermittent stream from the confluence with Mountain Creek south of Mansfield upstream to the headwaters approximately 2.0 km upstream of FM 157 in Mansfield	0838F_01	Not Assessed (No Data)

6.2.5 Public Water Supply Use Assessments

Typically, streams are not used for public water supplies. However, since these segments are tributaries to a water supply reservoir, it may prove beneficial to continue monitoring public water supply use parameters and compare them to those from the lake (Table 10), in the event that any trends or predictive variables develop.

Table 14. Public water supply use assessment results for unclassified segments.

Waterbody	AU	2016 TCEQ Report
Entire segment	0838A_01	Not Assessed (No Data)
Entire segment	0838B_01	Not Assessed (No Data)
From the confluence with Joe Pool Lake up to the headwaters at Spring Street in Burleson	0838C_01	Not Assessed (No Data)
Hollings Branch from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 500 m downstream of US 67 in Midlothian	0838D_01	Not Assessed (No Data)
Soap Creek from the confluence of the Mountain Creek arm of Joe Pool Lake upstream to the headwater 6.6 km (3.98 miles) upstream of US 67 in Midlothian	0838E_01	Not Assessed (No Data)
Intermittent stream from the confluence with Mountain Creek south of Mansfield upstream to the headwaters approximately 2.0 km upstream of FM 157 in Mansfield	0838F_01	Not Assessed (No Data)

7.0 Trend Analysis

There were 32 significant trends identified for this segment as summarized in Table 15. Four sites were analyzed for responses for trends, 0838_2 for the lake, and 0838B, C, and E for tributaries. For additional detail on trend methods, please see the Data Review Methodology section in the 2015 BSR (TRA, 2015).

Additional years of data were included in the trend analysis undertaken in the 2013-2016 Joe Pool Lake Water Quality Report, using data from various parameters taken as far back as 1997. The results of these analyses are provided in Table 16. Do recall that portions of datasets used to produce these trend analyses may not have been submitted to TCEQ for inclusion in the SWQMIS database, but were still collected using proper SWQM collection procedures (TRA, 2017). In the graph, increasing trends are noted in orange, with decreasing trends noted in green.

7.1 Trends in Joe Pool Lake

To supplement the summary provided in Table 15, Table 17 is provided for a detailed analysis of the significant trends within Joe Pool Lake. Overall, trends in this segment have R^2 values equal to/less than 0.2. Secchi depth appears to be the lone constituent of interest with respect to increasing trends, while it would appear that pH is slowly decreasing.

The long-term trend analysis in Table 16 revealed that statistically significant increasing trends exist in Joe Pool Lake for DO, total suspended solids (TSS), and chlorophyll-a. However, decreases were observed for long-term trends of pH, nitrate/nitrite, ortho-phosphate, and hardness.

Table 15. Trend analysis results summary for Joe Pool Lake (0838) and its tributaries (0838A-0838E).

Assessment Unit		Flow			Secchi Depth			Water Temp			pH			Sp Cond			*E. coli*			TDS			Chloride		
Seg_AU	Site	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W
0838_02	17684						UP						DN												
0838B_01	17680					UP	UP							DN		DN	DN	DN		DN		DN			
0838C_01	13621		DN				DN																DN	DN	DN
0838E_01	16435									UP															

Assessment Unit		SO4			BOD5			NH3			NO3			TKN			TP			Hardness		
Seg_AU	Site	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W	A	S	W
0838_02	17684																					
0838B_01	17680	DN		DN					UP			DN		DN	DN	DN				DN	DN	
0838C_01	13621					UP											UP	UP	UP	DN	DN	DN
0838E_01	16435																					

Trends Key

A-All Months

S-Summer/Growing Season (May-October)

W-Winter/Dormant Season (November-April)

UP Increasing Trends

DN Decreasing Trends

Table 16. Long-term trends (1997-2016) in the main body of Joe Pool Lake and in its tributaries.

Site	Parameter	MEAN	MAXIMUM	MINIMUM	DATA #	Trend of Test (p=0.05)
Main Body	TEMPERATURE, WATER DEG C	20.19	33.59	6.08	618	No Trend
	OXYGEN, DISSOLVED mg/L	8.33	16.49	ND	598	Increasing
	PH s.u.	8.16	10.53	5.16	615	Decreasing
	TSS mg/L	7.84	42.00	ND	239	Increasing
	NO2 + NO3 mg/l	0.16	0.98	ND	270	Decreasing
	NH3 mg/L	0.03	0.19	ND	266	Decreasing
	TKN mg/L	0.48	1.40	ND	266	No Trend
	TP mg/L	0.03	0.94	ND	265	No Trend
	HARDNESS mg/L	159.28	316.00	ND	540	Decreasing
	E. COLI MPN/100 mL	18.48	649.00	ND	102	No Trend
	CHLOROPHYLL-A ug/L	6.82	27.00	ND	222	Increasing
	OP mg/L	ND	0.10	ND	269	Decreasing
Tributary	HARDNESS mg/L	339.85	777.00	66.00	392	No Trend
	E. COLI MPN/100 mL	964.91	41100.00	2.00	98	Decreasing
	TDS mg/L	670.36	2260.00	169.00	391	No Trend

Table 17. Detailed trend analysis results for Joe Pool Lake (0838).

Segment	Station	Parameter	Season	R^2	Slope	P	Std Dev	T	Skewness /SES	Kurtosis/ SEK	N	Mean	Max	Q75	Median	Q25	Min	IQR	Min Date	Max Date
0838_02	17684	Secchi	Winter	0.2	0.2	0.04	0.09	2.23	0.94	0.3	22	0.13	0.34	0.15	0.1	0.08	0.04	0.07	11/15/2004	4/22/2008
0838_02	17684	pH	Winter	0.16	-0.09	0.04	0.04	-2.17	0.36	-0.47	27	8.03	8.6	8.2	8	7.9	7.5	0.3	12/15/2003	4/22/2008

Table 18. Detailed Trend Analysis Result for three Joe Pool Lake tributaries (0838B, 0838C, and 0838E).

Segment	Station	Parameter	Season	R^2	Slope	P	Std Dev	T	Skewness /SES	Kurtosis/ SEK	N	Mean	Max	Q75	Median	Q25	Min	IQR	Min Date	Max Date
0838B_01	17680	Secchi Depth	Summer	0.31	0.04	0	0.01	5.02	-1.25	-2.32	58	0.41	0.6	0.6	0.46	0.21	0.02	0.39	5/24/2004	10/30/2013
0838B_01	17680	Secchi Depth	Winter	0.22	0.03	0	0.01	3.71	1.28	-1.33	51	0.34	0.76	0.52	0.34	0.19	0.08	0.33	11/15/2004	11/19/2013
0838B_01	17680	Sp Cond	POR	0.15	-0.05	0	0.01	-4.51	0.06	1.01	##	717.85	1590	790	659	536	214	254	12/15/2003	11/19/2013
0838B_01	17680	Sp Cond	Winter	0.22	-0.07	0	0.02	-4.06	-0.13	0.26	59	761.98	1590	990	678	537	214	453	12/15/2003	11/19/2013
0838B_01	17680	NH3	Summer	0.33	0.01	0.01	0	3	0.88	-0.45	20	0.08	0.17	0.11	0.07	0.04	0	0.07	5/24/2004	8/20/2013
0838B_01	17680	NO3	Summer	0.43	-0.26	0	0.07	-3.49	0.73	-0.28	18	0.22	1.45	0.23	0.1	0.03	0.03	0.21	5/24/2004	8/20/2013
0838B_01	17680	TKN	POR	0.2	-0.08	0.01	0.03	-2.93	1.1	0.77	36	0.73	2.3	0.9	0.6	0.49	0.22	0.41	2/23/2004	11/19/2013
0838B_01	17680	TKN	Summer	0.26	-0.08	0.03	0.03	-2.43	1.27	0.64	19	0.85	2.3	0.95	0.69	0.6	0.3	0.35	5/24/2004	8/20/2013
0838B_01	17680	TKN	Winter	0.19	-0.04	0.08	0.02	-1.88	1.87	0.88	17	0.6	1.3	0.6	0.6	0.4	0.22	0.2	2/23/2004	11/19/2013
0838B_01	17680	Hardness	POR	0.13	-0.03	0.03	0.01	-2.29	0.14	1.03	37	133.78	272	148	132	120	74	28	2/23/2004	11/19/2013
0838B_01	17680	Hardness	Summer	0.28	-5.29	0.03	2.18	-2.42	0.17	-1.15	17	116.76	164	140	120	88	74	52	5/24/2004	8/20/2013
0838B_01	17680	SO4	POR	0.14	-0.05	0.03	0.02	-2.34	0.31	1.38	37	166.68	420	191	146.1	124	54	67	2/23/2004	11/19/2013
0838B_01	17680	SO4	Winter	0.19	-8.48	0.07	4.32	-1.96	1.74	0.88	18	165.29	306	195	153	128	77.3	67	2/23/2004	11/19/2013
0838B_01	17680	E. coli	POR	0.12	-0.22	0	0.05	-3.99	0.88	-0.83	##	264.68	2800	160	52	17	0.5	143	12/15/2003	11/19/2013
0838B_01	17680	E. coli	Summer	0.27	-0.33	0	0.07	-4.58	1.3	-0.87	59	303.97	2600	160	46	17	2	143	5/24/2004	10/30/2013
0838B_01	17680	TDS	POR	0.15	-0.05	0	0.01	-4.58	-0.33	1.28	##	468.5	1034	514	422.58	355.6	139	158.5	12/15/2003	11/19/2013
0838B_01	17680	TDS	Winter	0.24	-0.07	0	0.02	-4.22	-0.3	0.78	59	502.42	1034	643.5	444.41	358.2	139	285.4	12/15/2003	11/19/2013
0838C_01	13621	Air Temp	Summer	0.11	-1.51	0.05	0.75	-2	-0.36	0.08	33	25.44	38	28.5	25	23	11	5.5	5/24/2004	10/21/2008
0838C_01	13621	Flow	Summer	0.26	-0.47	0.09	0.25	-1.87	-0.53	-0.67	16	7.15	73	6.6	0.45	0.01	0	6.6	6/15/2004	9/18/2012
0838C_01	13621	Secchi Depth	Winter	0.13	-0.06	0.08	0.03	-1.82	-0.93	-1.17	24	0.4	0.6	0.6	0.45	0.25	0.08	0.35	11/15/2004	11/18/2008
0838C_01	13621	BOD5	Summer	0.21	0.23	0.06	0.11	2.03	1.81	-0.22	17	2.02	7	3	1	1	1	2	5/24/2004	8/19/2008
0838C_01	13621	TKN	Summer	0.27	0.2	0.07	0.1	2.01	1.2	1.57	13	0.73	1.9	0.7	0.6	0.6	0.3	0.1	5/24/2004	5/20/2008
0838C_01	13621	TP	POR	0.45	0.8	0	0.19	4.31	-0.41	-1.4	25	0.1	0.62	0.13	0.06	0.01	0.01	0.13	2/23/2004	11/18/2008
0838C_01	13621	TP	Summer	0.42	0.78	0.02	0.29	2.67	-0.33	-0.7	12	0.13	0.62	0.17	0.06	0.02	0.01	0.15	5/24/2004	8/19/2008
0838C_01	13621	TP	Winter	0.52	0.04	0.01	0.01	3.48	1.12	-0.55	13	0.08	0.23	0.11	0.04	0.01	0.01	0.11	2/23/2004	11/18/2008
0838C_01	13621	Hardness	POR	0.3	-69.4	0	18.5	-3.76	-0.68	-0.95	35	432.46	730	564	458	290	112	274	1/22/2004	11/18/2008
0838C_01	13621	Hardness	Summer	0.34	-82.7	0.01	29.7	-2.78	-0.87	-0.79	17	440.94	700	576	470	308	120	268	5/24/2004	8/19/2008
0838C_01	13621	Hardness	Winter	0.27	-58.9	0.03	24.1	-2.44	-0.04	-0.27	18	424.44	730	516	449	290	112	226	1/22/2004	11/18/2008
0838C_01	13621	Chloride	POR	0.22	-8.53	0	2.81	-3.03	-0.94	-0.95	35	65.89	104	86	67	44.9	14.7	41.1	1/22/2004	11/18/2008
0838C_01	13621	Chloride	Summer	0.22	-9.05	0.06	4.45	-2.03	-1.36	-0.18	17	66.04	100	83	72.6	47	14.7	36	5/24/2004	8/19/2008
0838C_01	13621	Chloride	Winter	0.22	-8.12	0.05	3.8	-2.13	0.03	-1.08	18	65.74	104	86	63	43	23	43	1/22/2004	11/18/2008
0838E_01	16435	Water Temp	Winter	0.12	1.15	0.09	0.65	1.78	0.2	-0.93	25	13.41	21.1	16.6	12.8	11	6	5.6	1/13/2009	4/23/2013

7.2 Trends in Joe Pool Lake Tributaries

Table 18 provides a detailed analysis of the significant trends within the Joe Pool Lake tributaries. Most trends within the unclassified segments are decreasing and do not present a concern There are increasing trends for both Secchi depth and ammonia (NH3) in 0838B, while Biochemical Oxygen Demand (BOD5) and total phosphorus (TP) are on the increase in 0838C.

The trends for the period of record have an R^2 of 0.32 with shallow slopes, although trends are only present in the summer months. However, trends across all time periods exist for TP in 0838C and have R^2 values greater than 0.42. The correlation coefficient for TP and stream flow is 0.88, indicating
that TP is being washed into the stream during rain events.

For total dissolved solids (TDS), the average of all the data in this assessment unit is very close to the 300 mg/L standard at 283 mg/L. For this reason, continued monitoring of TDS in the stream will be conducted to determine if the source of high TDS levels are natural or anthropogenic. Of the remaining trends with R^2 values greater than 0.4, three are decreasing trends for nutrients including ammonia and total Kjeldahl nitrogen (TKN) and one is a decreasing trend for pH. Decreases in nutrient trends are of no concern, given that the watershed is expected to continue urbanizing.

8.0 Source Identification Analysis

Segment 0838C is currently listed on the 2016 Texas 303(d) list for a recreation use impairment due to bacteria, i.e., elevated concentrations of *E. coli*. The objective of this section is to describe the planned modeling approach for identifying the sources of pollution that contribute to this impairment, and developing pollutant load reduction targets required to gain attainment for the recreation use. The following subsections will describe the suite of source identification strategies that will be used in the watershed.

8.1 Baseline Watershed Monitoring

Source identification will involve 15 sampling locations spatially representative of the Joe Pool Lake watershed, along with 5 locations in the lake itself. Sites will be positioned to identify contributions from major tributaries and suspected areas of pollutant loading. Sampling will include 12 total events at 14 stations, including six bi-monthly routine events and six flow-biased events. One flow-biased event is expected to occur in the two-month period between each routine event. Once complete, this monitoring effort is expected to provide spatial specificity to potential areas of high influence, providing a “bracketing” effect with which we can discern whether one particular type of land use, tributary, or geographic area is contributing a greater pollutant load than others.

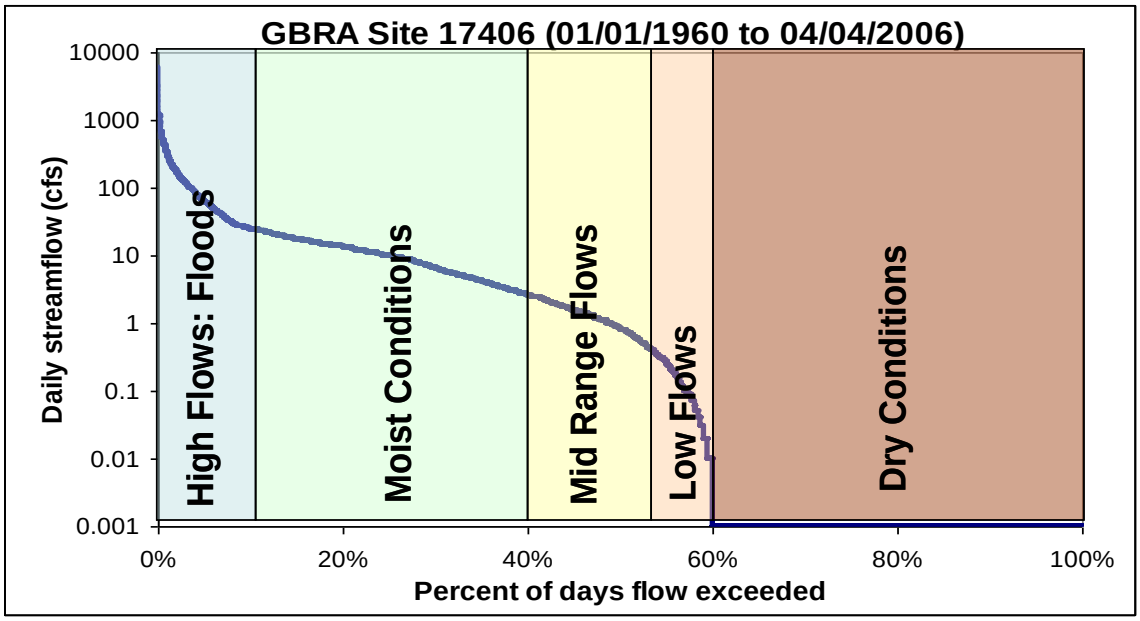
The remaining six sites will only be sampled during high flow situations, as they are located in more remote, ephemeral areas. The goal of this monitoring subset is to characterize the pollutant loads from dryer, upland areas when they are flushed during heavier rainfall events.

8.2 Flow and Load Duration Curves

Once completed, the flow and *E. coli* datasets can then be used to build flow duration curves and load duration curves to further evaluate the contaminant sources. First, all flow values are aggregated and ranked from lowest to highest. This data is then graphically depicted to show the general flow regime, complete with the percentage of time that the water body is expected to be dry, as well as its response to storm flows (Figure 6).

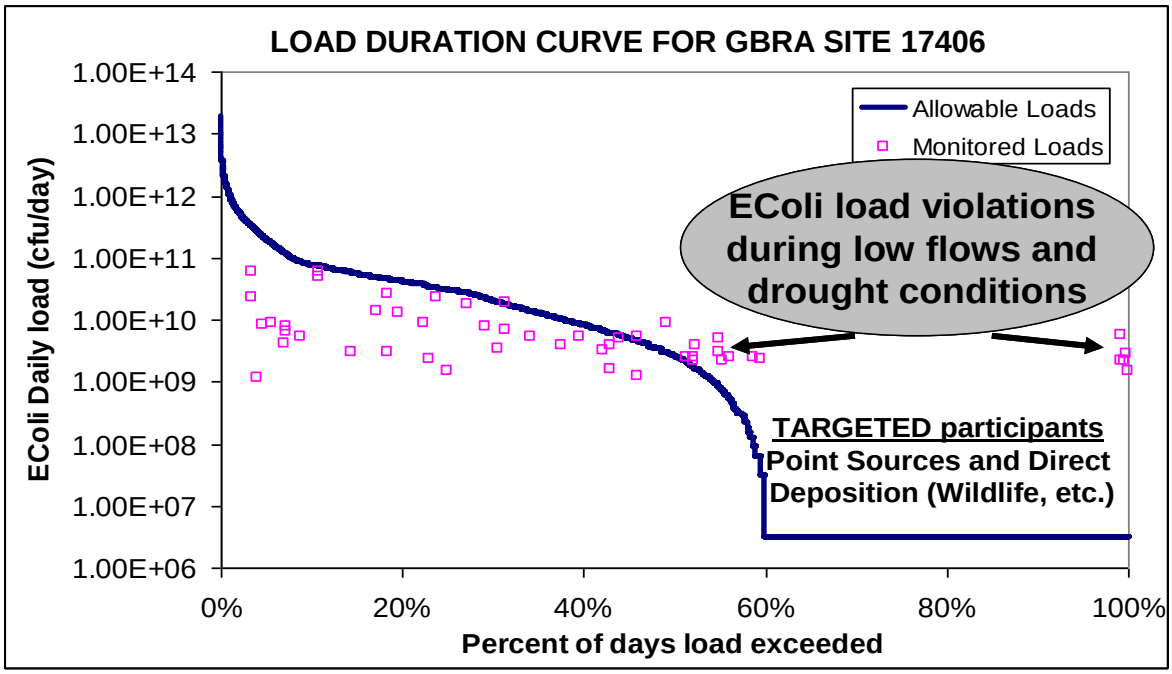
The flow duration curve can then be used to develop a load duration curve (LDC) for a specific pollutant of interest, given that there is pollutant concentration data that complements the flow data. Figure 7 depicts an

example LDC based on the FDC shown in Figure 6. The first step in the process is to apply the pollutant's allowable limit concentration to all available flow values to produce the allowable load limit curve. In the case of bacteria, this value is 126 MPN/100 mL (blue line in Figure 7). Then, the baseline monitoring data values for *E. coli* (also in MPN/100 mL) are also multiplied by their associated flow values to get loads for each data point (pink squares in Figure 7).



Source: Flow Duration Curve (FDC) for streamflow conditions at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX.

Figure 6. Flow duration curve example from Plum Creek watershed (log scale Y-axis).



Source: Load Duration Curve for E. coli at GBRA monitoring station 17406 on Plum Creek, near Uhland, TX.

Figure 7. Load duration curve example from Plum Creek watershed (log scale Y-axis).

This can be developed further by performing regression analysis on the monitored data points, as depicted in Figure 8. Here, the allowable load limit is depicted in red, while the regression line for the data points is depicted

in blue. For each of the different flow regimes (High Flows, Moist Conditions, Mid-range Flows, etc.), a load reduction estimate can be calculated. Achieving these reductions will become the primary targets for success once the WPP moves into the implementation stage.

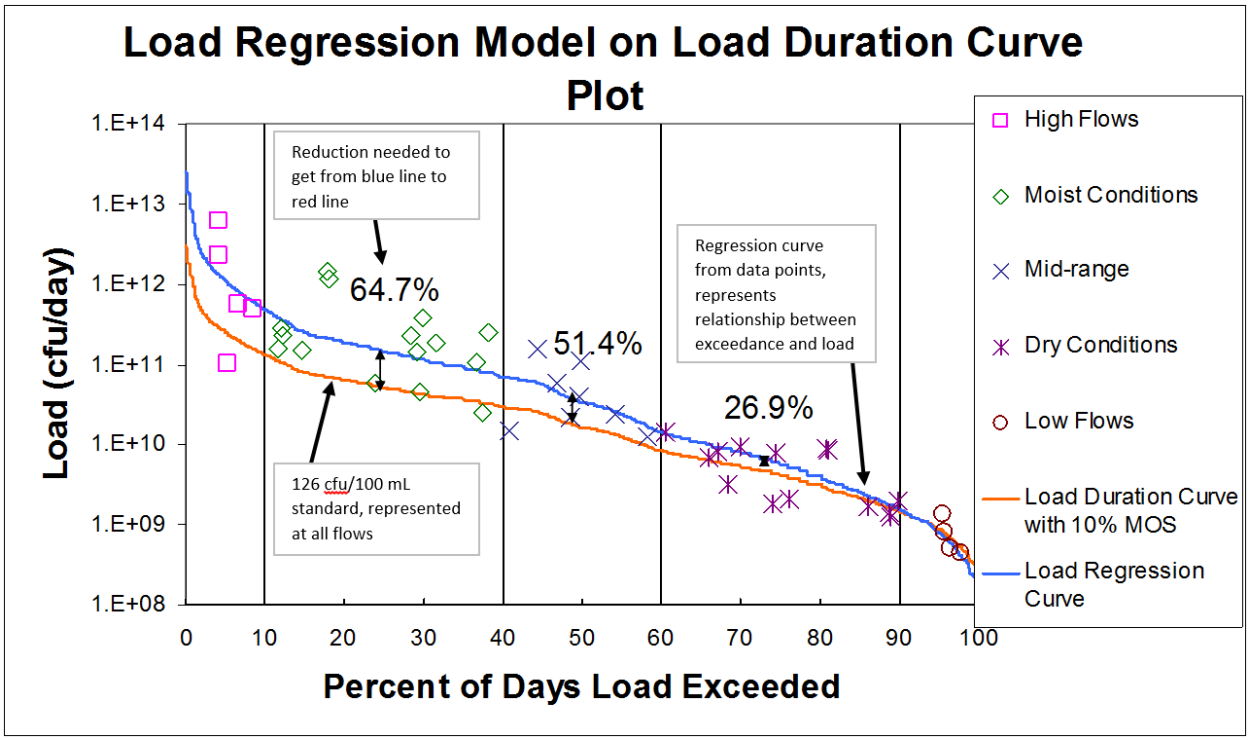


Figure 8. Load duration curve example for E. coli, with flow condition breakdowns and load reduction estimates (log scale Y-axis).

However, it is worth noting that some of these reductions, specifically those within the "High Flows" range, may not be achievable due to feasibility of applying management measures to storm flows that fall within the extreme range. It is therefore customary to focus efforts on the load reductions identified at the lower flow conditions, where it becomes easier to separate potential point source contributors from nonpoint source contributors. In most cases, if a water body exhibits high pollutant loads on the extreme right of the graph where low flows are represented (Figure 9), it is highly likely that this may be attributable to a point source, such as a malfunctioning WWTF or leaking/failing wastewater infrastructure somewhere in the watershed. These types of contributions can typically be easily addressed, and are worth investigating early on in the process. Conversely, if pollutant loads tend towards the middle of the graph, it is likely that they are attributed to stormwater runoff during periods of normal or moderate rainfall. While typically not as easily addressed as point sources, load reductions in these areas may also be targeted for watershed pollutant load reductions through BMP recommendations.

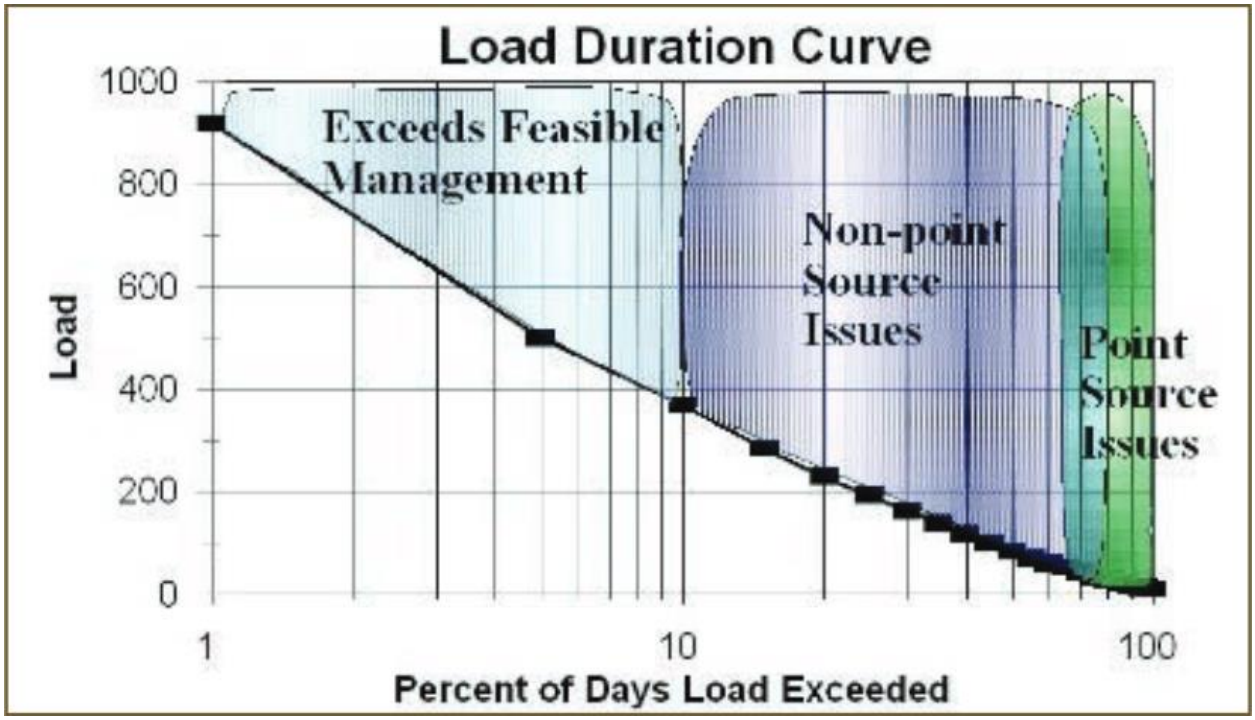


Figure 9. Regions of likely pollutant sources along load duration curve (normal scale Y-axis, log scale X-axis).

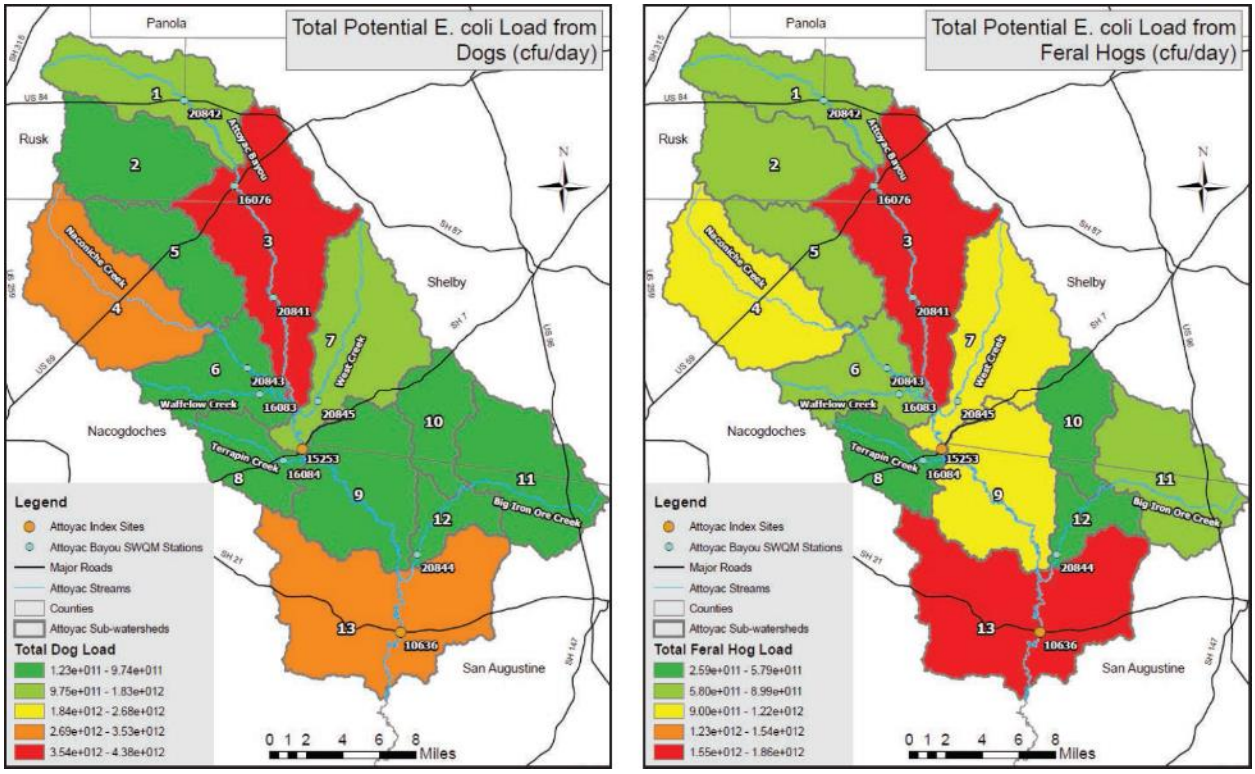
8.3 Load Calculation and Modeling Analyses

8.3.1 SELECT Pollutant Load Calculation Tool

Through baseline monitoring and the associated LDC analysis, it is possible to begin forming an understanding of where areas contributing high pollutant loads may be situated in the watershed, as well as whether those contributions may be from point or nonpoint sources. However, this only provides a basic spatial location of the potential sources and a general understanding of their origin. To further identify the extent of a certain source type's likely contribution to the bacteria load in a specific subwatershed, the Spatially Explicit Load Enrichment Calculation Tool (SELECT) analysis can be conducted for any number of potential bacteria source types, including urban/municipal runoff, agricultural runoff, failing septic systems, wildlife, and even invasive species.

SELECT first uses spatial data for land use and/or land cover data to determine where representatives from a particular contributing source might be located, and then uses watershed boundaries, soils data, topography, and stream network information to further determine suitability and range. In the example provided in Figure 10, it was expected that the majority of dogs would be found in close proximity to human populations, while it was expected that feral hogs would stay within suitable habitat found within riparian bands near rivers, on cropland, or within the vicinity of other water sources, so the spatial analysis incorporated these limitations.

Then, an estimated population density is applied to these suitable areas. Population density data can come in the form of census estimates for humans, literature values from published resource agency materials, or in some cases, anecdotal evidence from watershed stakeholders. In the example provided in Figure 10, statewide estimates for feral hog population were first applied to the watershed, then anecdotal evidence from watershed stakeholders was used to verify and adjust the statewide estimates. For dogs, an average value of dogs per household was applied to local human population estimates, and that estimated population was then concentrated around areas with higher human population densities to simulate the expected loading conditions.



Source: Attoyac Bayou Watershed Protection Plan.

Figure 10. Visual output examples from SELECT analysis for separate estimated populations of dogs (left) and feral hogs (right).

Finally, literature values for *E. coli* production from these sources are applied to the estimated population so that a potential *E. coli* load can be calculated for each subwatershed in the analysis. This yields visual output that can be color-coded to show the severity of the load's potential contribution to the watershed, which can be used to pinpoint areas where management measures would provide the most cost-to-benefit ratio. In the case of the feral hog analysis in Figure 10, funding used for hog control BMPs would be best utilized in subwatersheds 3 and 13, where contributions are expected to be significant. Conversely, potential *E. coli* contributions from feral hogs are low in 8, 10, and 12 so it would be best to focus control efforts elsewhere.

Although SELECT can provide users with valuable information for pollutant source location and quantification, there are some caveats which must be publicized to stakeholders about its use. The load calculations that are output from the model, even if based on the best available science and information, are still predicted *E. coli* loadings that are effectively "worst-case scenarios." This is because SELECT is not currently capable of accounting for the natural processes that occur in the watershed, such as natural bacterial decay, breakdown by sunlight, permeation to groundwater, etc. that influence bacteria die-off as the load makes its way to a water body. As such, the total load predicted from a subwatershed by SELECT is not expected to reach the creek, and thus, represents a potential loading. SELECT is currently incapable of making adjustments needed to provide a real-world, delivered loading to the creek. Despite this shortcoming, both stakeholders and technical advisory staff agree that this analysis method, coupled with the LDC analysis covered in Section 8.2, is the most cost-effective means of source identification and analysis available for the watershed.

8.3.2 SWAT Modeling Exercises

The Soil and Water Assessment Tool (SWAT) watershed modeling program will also be used to quantify pollutant loads in the watershed. While they may both shed some light on the topic of pollutant loading, the SWAT model differs from the SELECT analysis in several important aspects. The primary difference concerns the type of data

used by the two tools, with SELECT principally relying on anecdotal and estimated data based on human/animal populations, whereas SWAT relies on collected data for flow, discrete, field-collected water pollutant concentrations, and many smaller variables that can be adjusted by the user to accurately approximate watershed characteristics, like evapotranspiration rates and antecedent soil moisture conditions. Then, the two tools will then use the water, soil, and topographic characteristics of the watershed to provide the user with two sources of data with which to make decisions about watershed pollutant management. SWAT is currently the preferred model of choice for this project, but may be substituted with a more suitable alternative, should the need arise.

9.0 Conclusions

In addition to the impairments listed for Segment 0838C in the *2016 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)* (TCEQ, 2019b), the 2013-2016 Joe Pool Lake Customer Report (TRA, 2017)provides an overall summary of the potential issues facing the watershed:

When reviewing the 1997-2012 water quality data as a whole:

- Increasing trends of both algal and atrazine concentrations in the reservoir and
- E. coli, total dissolved solids, atrazine and sulfate, in excess of standards in tributaries.

When focusing on the more recent data analyzed annually between 2013 and 2015, the following concerns were noted in respective annual reports:

- TDS concentrations exceed standards on a regular basis at tributary sites;
- E. coli, nitrate/nitrite, and sulfate samples occasionally exceeded standards at tributary sites;
- Chlorophyll-a and TSS demonstrate an increasing trend at site A3 (Mountain Creek arm); and
- One Giardia cyst was detected in the sample collected at intake site I1 (Lakeview Intake) on 9/2/2015.

An attempt to re-evaluate using data from 2013 to 2016 was attempted to focus on more comparable, recent data. However, the extreme weather (both drought and excessive rains) of those years complicates trend analyses over such a short time period.

The WPP effort will also endeavor to address other stakeholder concerns with respect to water quality as identified during public meetings and other outreach campaigns. As these concerns are identified and investigated through continued contact with stakeholders and studied in the watershed, additional historical data analysis may be needed, which will continue past the submission of this report. Application of and adherence to this adaptive approach will result in a more thorough and applicable set of solutions for managing water quality issues and concerns within the Joe Pool Lake watershed.

9.1 Joe Pool Lake (Segment 0838)

While there are no immediate needs for addressing water quality impairments in Joe Pool Lake, concerns for maintaining water quality have been made known by stakeholders who would like to see continued nutrient and sediment management addressed in the WPP. These concerns are related to nitrate inputs and algal growth and decay (as indicated by chlorophyll-a). Overall trends for both parameters are currently decreasing in the lake, and the management measures recommended in the WPP will hopefully continue to add to these decreases, or at the very least, stall any future increases. These management measures may be targeted to areas with direct drainage to the lake, or by extension within larger tributaries such as Mountain, Soap, and Walnut Creeks, which may be contributing a significant portion of the nutrient load itself.

While certainly important, lake protection strategies for the listed water quality concerns are two of many outcomes identified thus far in the stakeholder process. The Lake Arlington Master Plan (Malcolm Pirnie 2011) also identified several aesthetic and community wellness-based outcomes that are expected to be incorporated

into the Joe Pool Lake WPP. These include trash and litter control efforts, lakefront property renovations, and other efforts that are expected to also provide some level of bacteria and/or nutrient load reductions as well. As stakeholder outcomes develop around the lake, further historical data analysis will be conducted to adapt to and address stakeholder needs. Accompanying updates to this report will be made if/when those needs arise.

9.2 Walnut Creek (Segment 0838C)

The primary focus within Walnut Creek is the bacteria impairment. Along with the data collected through this effort, stakeholder input and expert technical advice will be used to provide the base on which management efforts to address the impairment will be built. The end goal will be improving water quality in Walnut Creek, and by extension, protecting the water quality downstream in Joe Pool Lake.

As with the lake, there are several additional stakeholder concerns that are expected to be addressed in the WPP. These include similar concerns for floatable and deposited trash and debris, along with erosion control measures and nutrient controls. The BMPs identified to address these additional concerns are expected to provide some level of bacteria and/or nutrient load reductions in addition to their primary purposes.

10.0 References

BEG. (1996). *Physiographic Map of Texas*. Bureau of Economic Geology, Austin, TX. Available at:<http://www.beg.utexas.edu/UTopia/images/pagesizemaps/physiography.pdf>. Accessed 11 November 2016.

Dallas Times Herald. (1989). *Handbook of Texas Online: Joe Pool Lake*. Texas State Historical Association, Austin, TX. Available at: < http://www.tshaonline.org/handbook/online/articles/roj06>. Accessed 22 Oct 2019.

Mesner, N., & Geiger, J. (2010). *Understanding Your Watershed: Nitrogen.* Understanding Your Watershed Fact Sheet Series. Utah State Water Quality Extension, Logan, UT. Available at: <http://extension.usu.edu/htm/publications/publication=12770&custom=1>. Accessed 18 July 2016.

TCEQ. (2012). *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods.* Retrieved from https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg415/rg-415.pdf

TCEQ. (2015a). *2014 Guidance for Assessing and Reporting Surface Water Quality in Texas*. Retrieved from https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_guidance.pdf

TCEQ. (2015b). *2014 Texas Integrated Report - Water Bodies with Concerns for Use Attainment and Screening Levels.* Texas Commission on Environmental Quality, Austin, TX. Available at: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_concerns.pdf>. Accessed 14 June 2016.

TCEQ. (2018). *Texas Surface Water Quality Standards*. Texas Administrative Code (TAC), Title 30, Chapter 307. Date of last revision: 1 March 2018.

TCEQ. (2019a). *2016 Texas Integrated Report - Texas 303(d) List (Category 5)*. Texas Commission on Environmental Quality, Austin, TX. Available at: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/16txir/2016_303d.pdf>. Accessed 16 August 2019.

TCEQ. (2019b). *2016 Texas Integrated Report Water Bodies with Concerns for Use Attainment and Screening Levels*. Texas Commission on Environmental Quality, Austin, TX. Available at: <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/16txir/2016_concerns.pdf>. Accessed 16 August 2019.

TRA. (2015). *TRA Clean Rivers Program 2015 Basin Summary Report.* Arlington, TX: Trinity River Authority. 460 pp. Available at:< http://serv.trinityra.org/reports/BasinSummaryReports/Final2015TRABSR.pdf>. Accessed 4 August 2016.

TRA. (2017). *Joe Pool Lake Water Quality Report, 2013-2016*. Trinity River Authority of Texas, Arlington, TX.

TRA. (2018a). *2018 Basin Highlights Report*. Trinity River Authority of Texas, Arlington, TX. Available at: <http://serv.trinityra.org/reports/BasinSummaryReports/2018BasinHighlightsReport.pdf>. Accessed 17 September 2019.

TRA. (2018b). *Joe Pool Lake Water Quality Monitoring Summary: January 2017 - February 2018*. Trinity River Authority of Texas, Arlington, TX.

TRA. (2019). *Sediment E. coli, Phase I: Colony Enumeration and Sediment Habitat Preferences*. Trinity River Authority of Texas, Arlington, TX.

USACE. (n.d.). *Development of Joe Pool Lake*. Fort Worth, TX. U.S. Army Corps of Engineers. Available at: <http://www.swf-wc.usace.army.mil/joepool/Information/History.asp>. Accessed 22 Oct 2019.

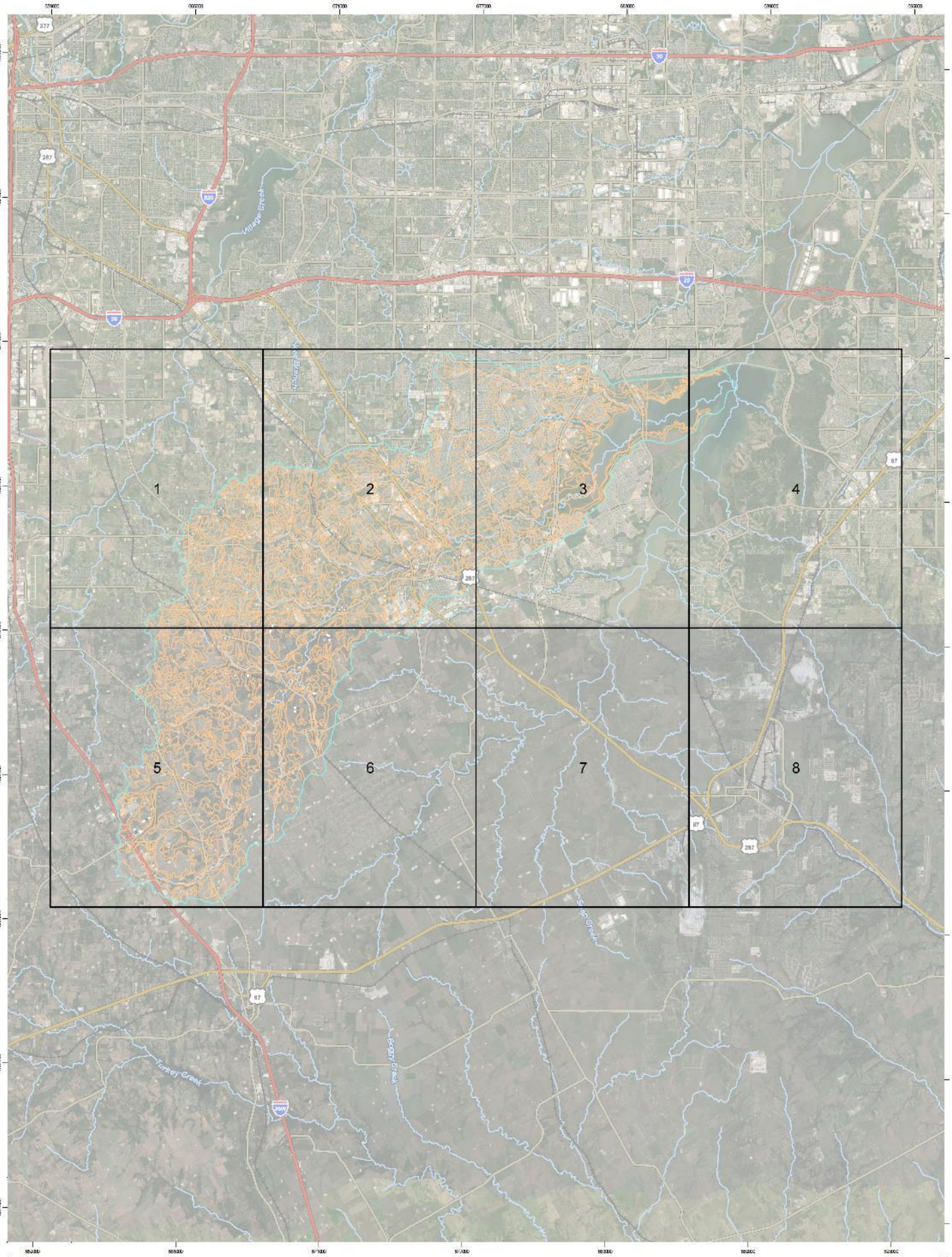
USEPA. (2000a). *Ambient Water Quality Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX.* EPA 822-B-00-011. Washington, DC: U.S. Environmental Protection Agency. 99 pp. Available at: <https://www.epa.gov/sites/production/files/documents/lakes9.pdf>. Accessed 24 June 2016.

USEPA. (2000b). *Ambient Water Quality Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Nutrient Ecoregion IX.* https://doi.org/EPA 822-B-00-019

Appendix A

NRCS Soils Surveys for the Joe Pool Lake Watershed

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Index Sheet



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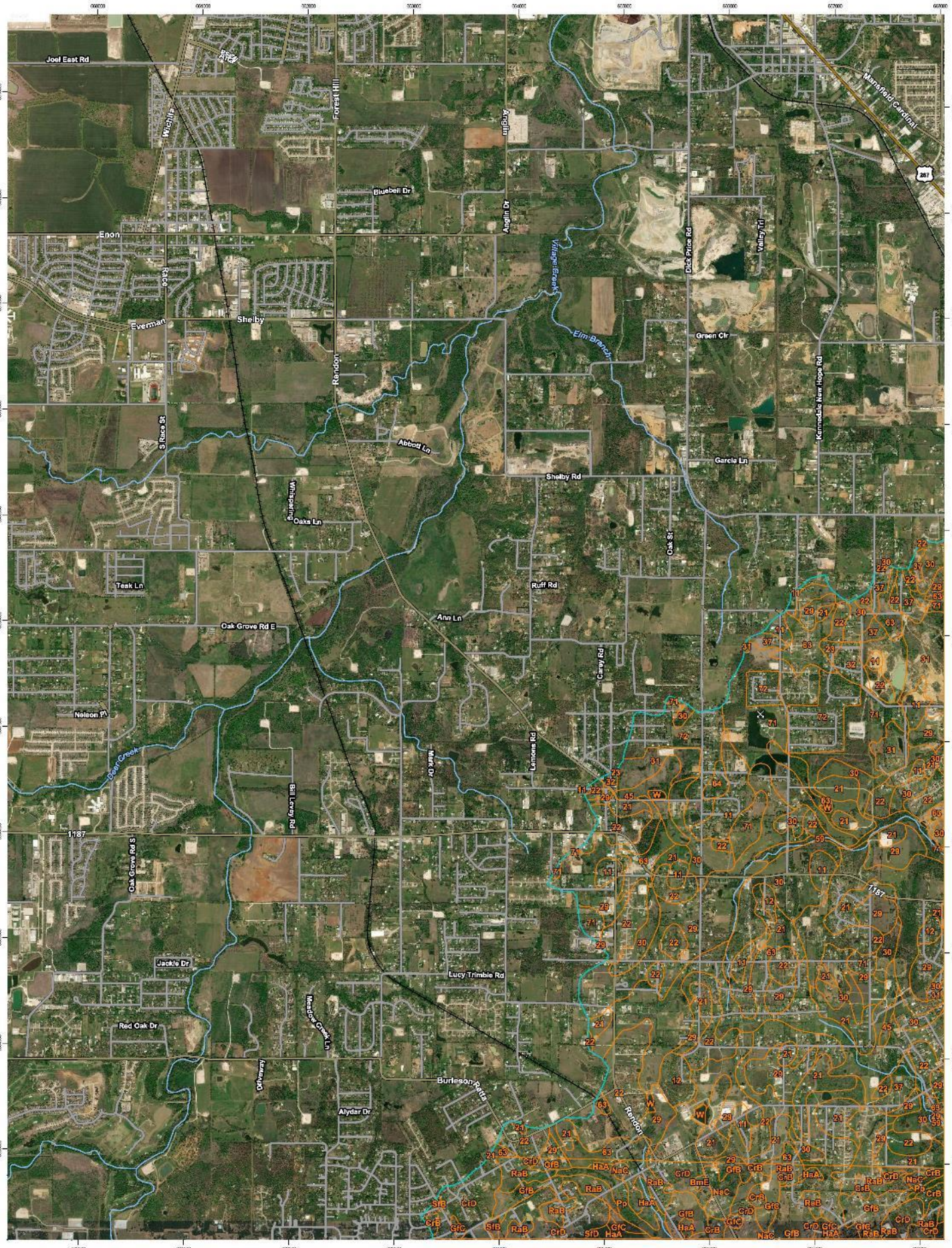
Meters: 0 1000 2000 4000 6000

Feet: 0 5000 10000 20000 30000

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

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 1 of 8



Joins sheet 5

Map Scale: 1:24,000 if printed on C portrait (17" x 22") sheet.

Meters: 0 300 700 1400 2100

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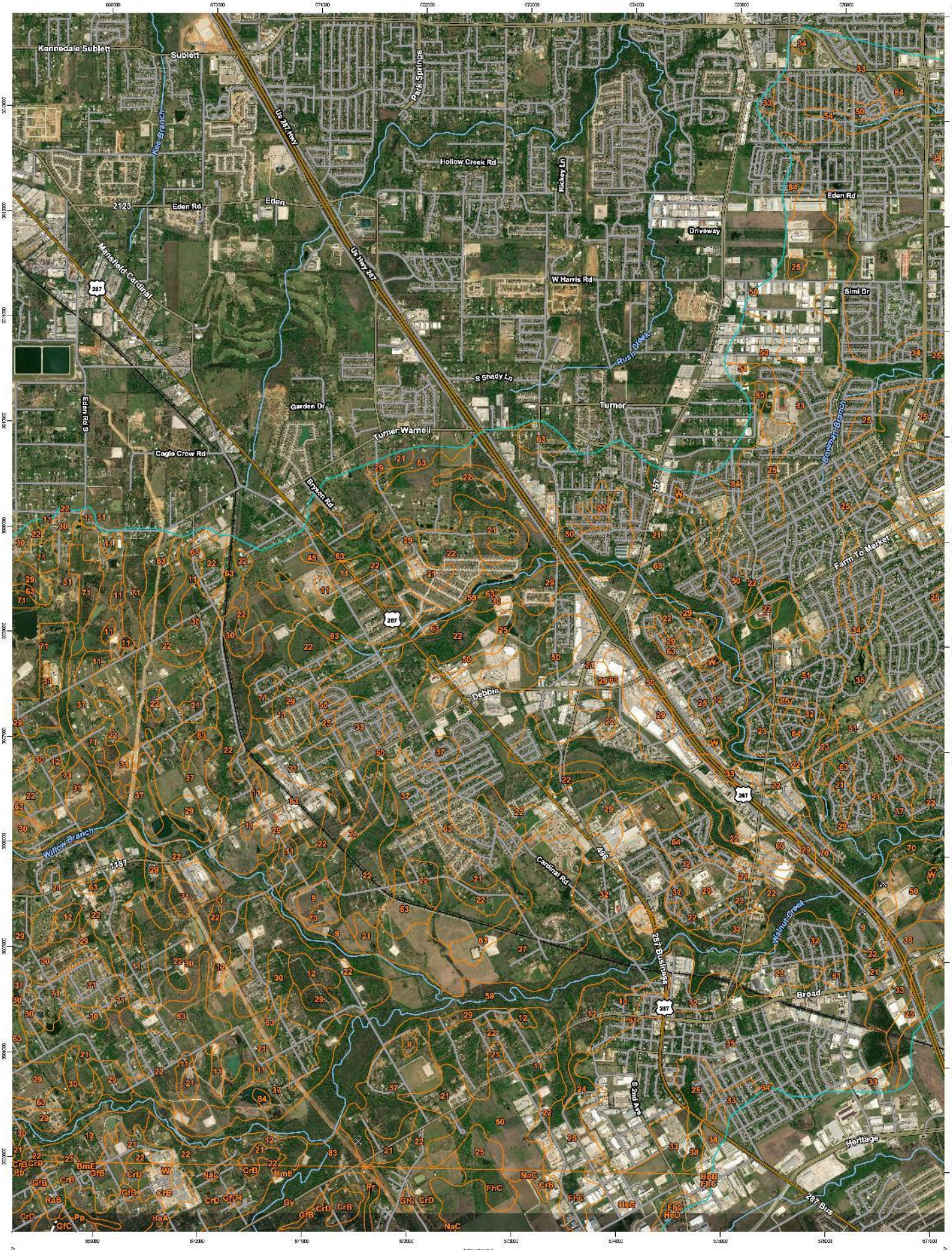
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 2 of 8



Map Scale: 1:24,000 if printed on C portrait (17" x 22") sheet.
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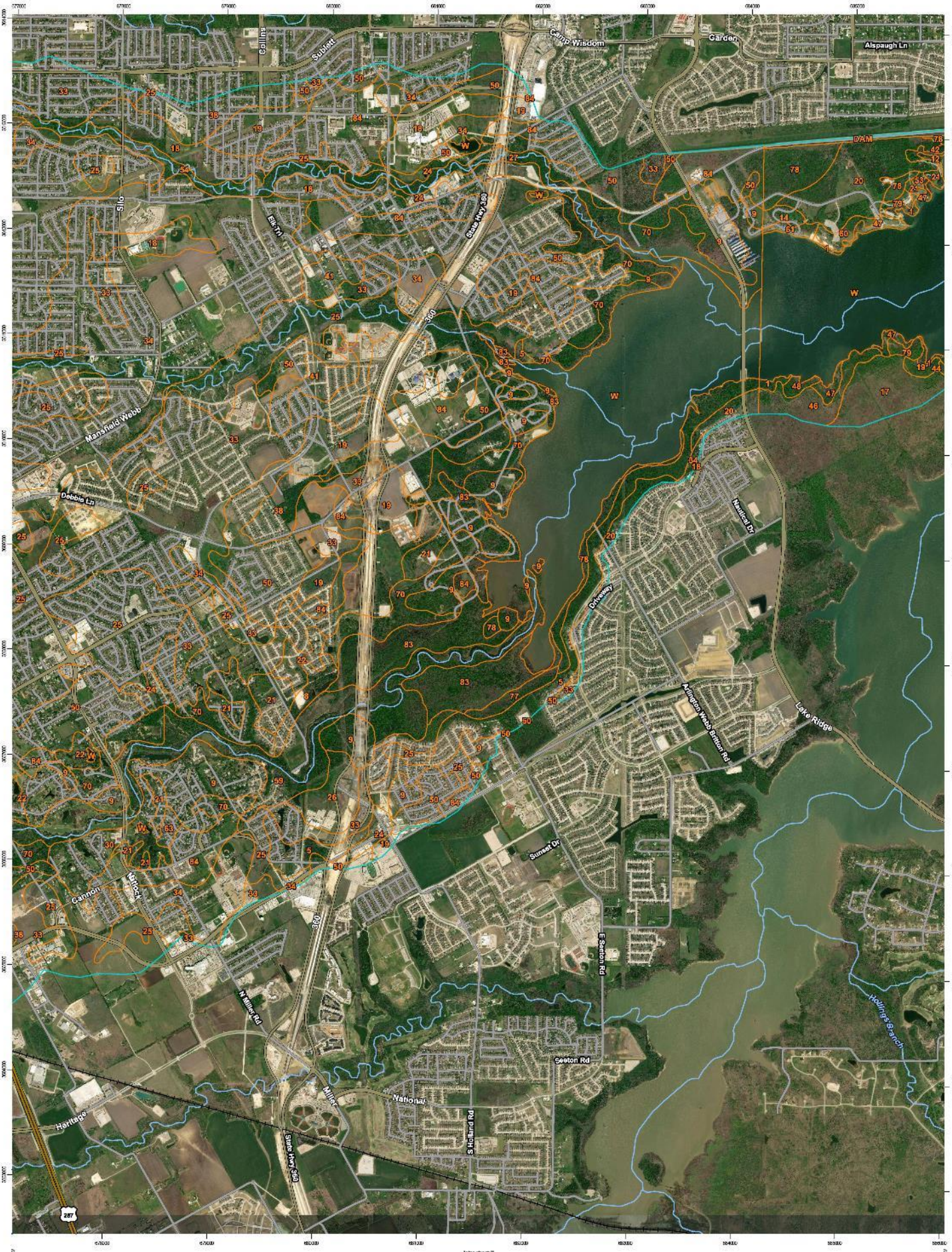
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 3 of 8



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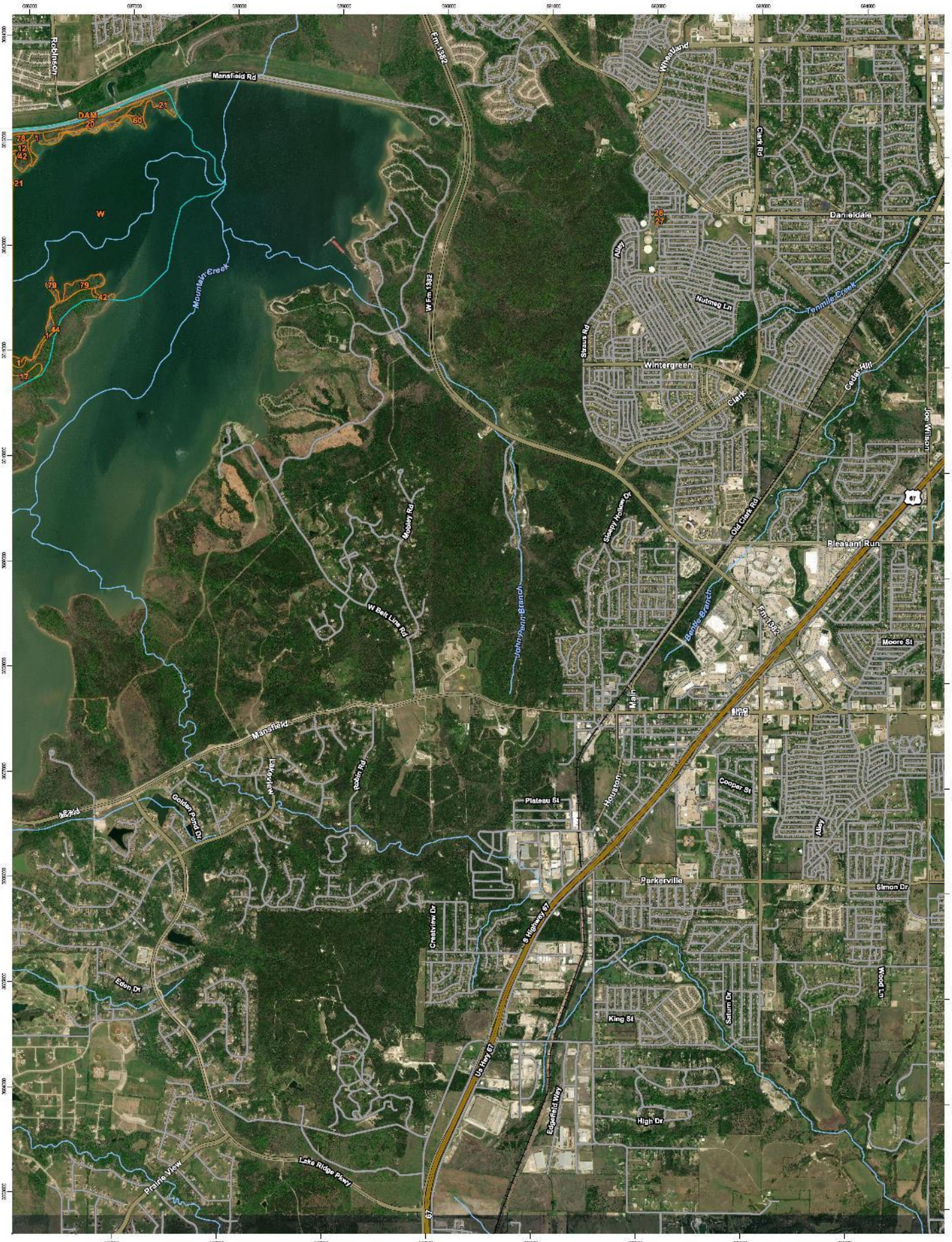
Meters
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 4 of 8



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Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

9/24/2019
Page 5 of 15

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 5 of 8
Table sheet 1

Map Scale: 1:24,000 if printed on C portrait (17" x 22") sheet.
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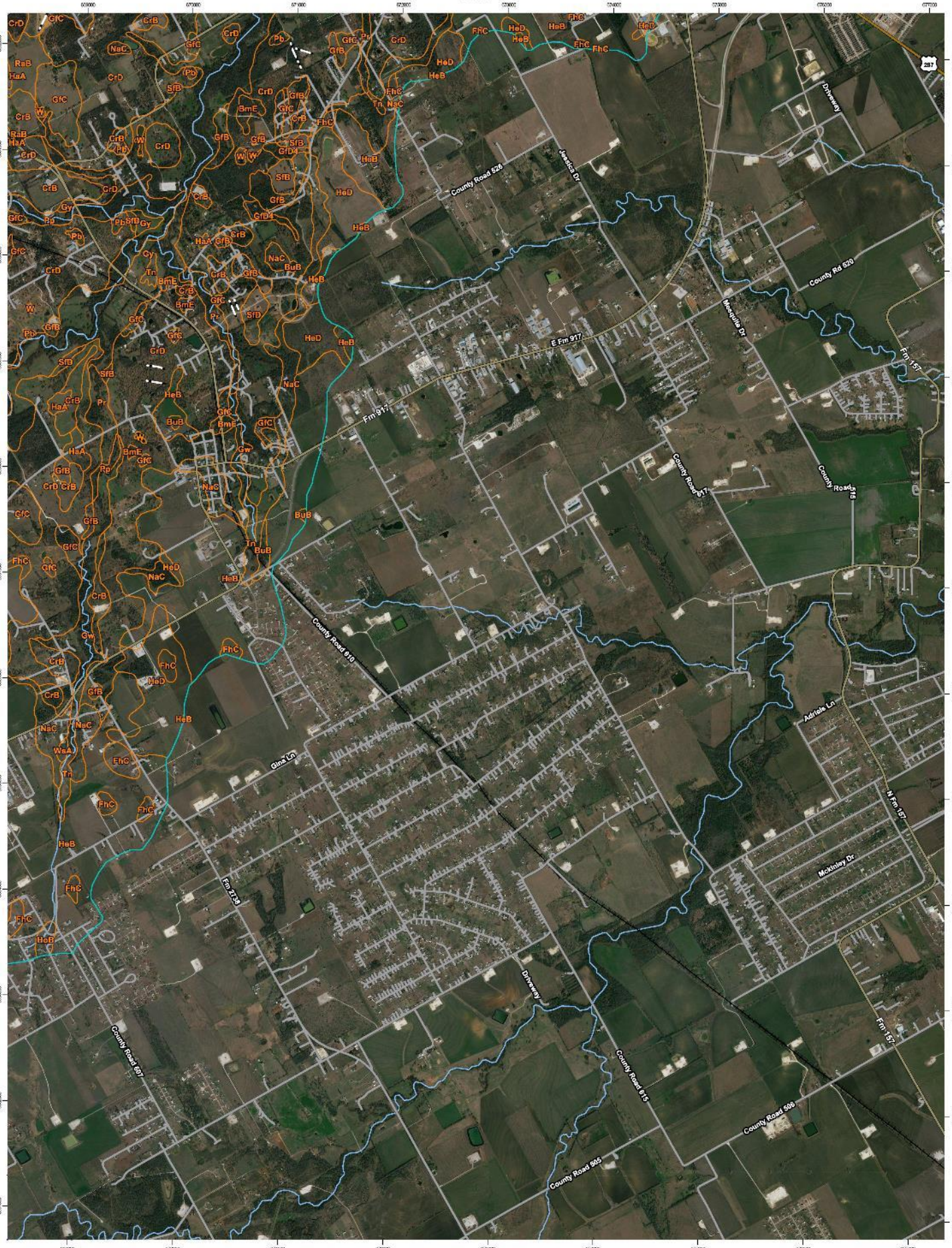
Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location



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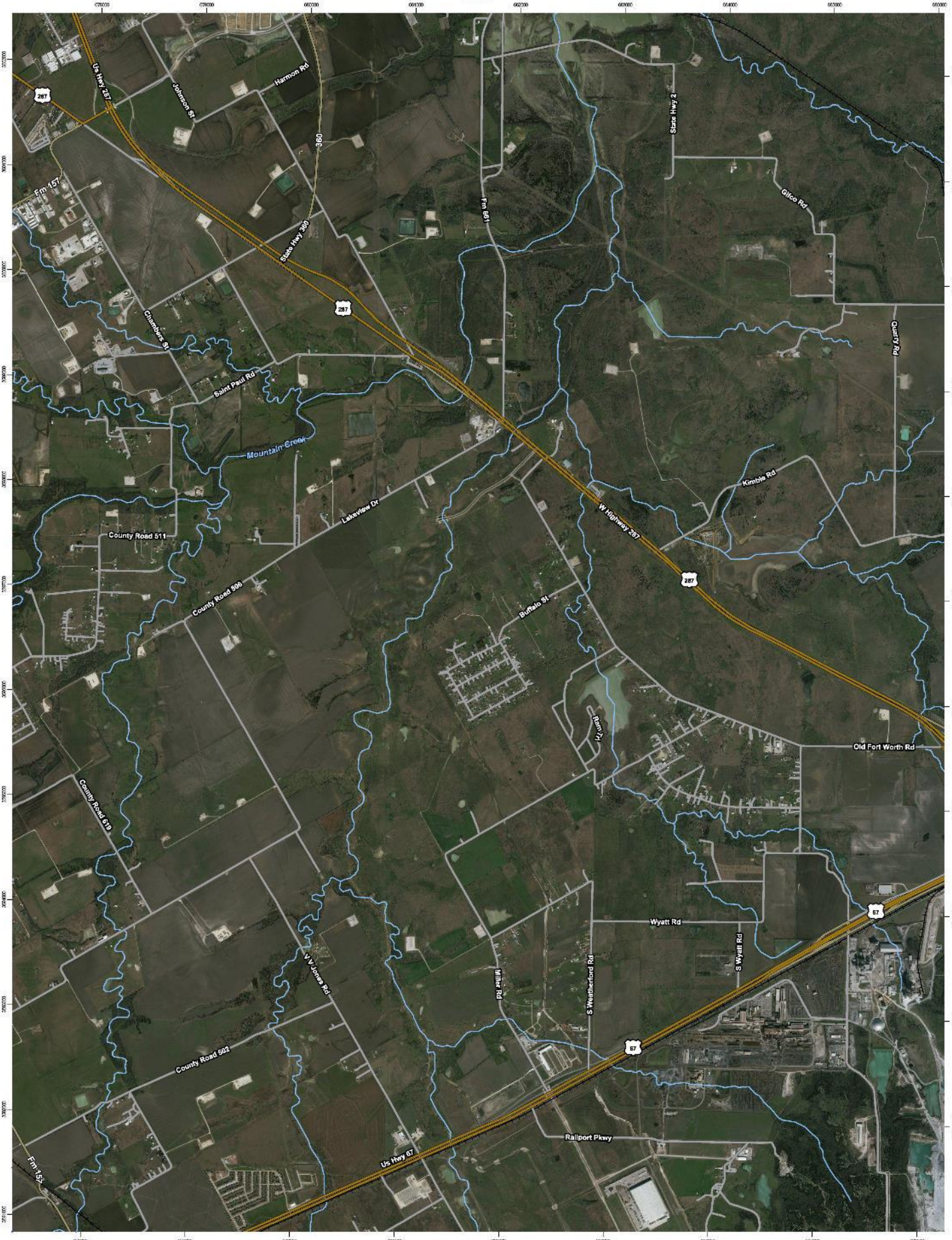
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Walnut Creek Arm)
Map sheet 7 of 8
Table sheet 3



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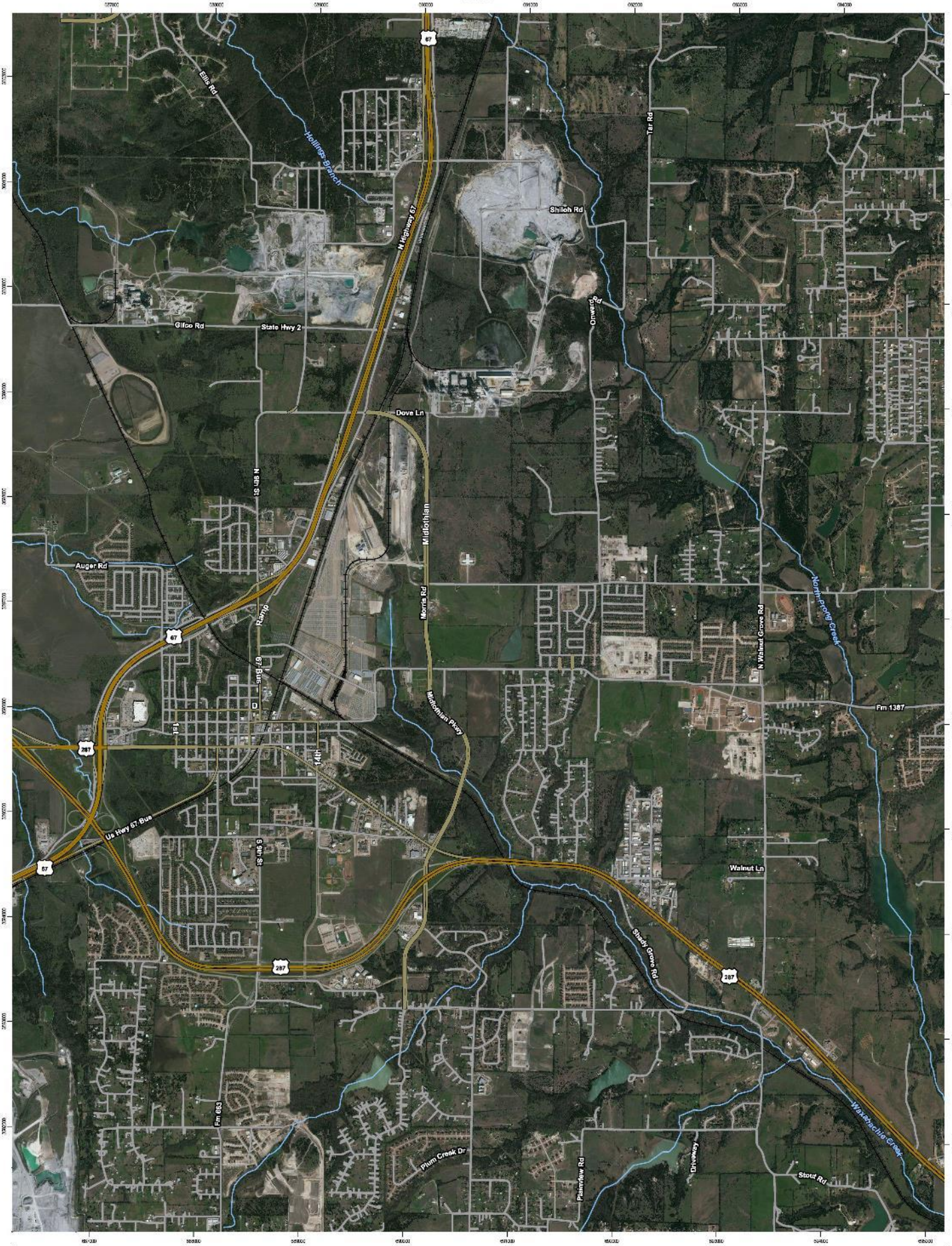
Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

9/24/2019
Page 8 of 15



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Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

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 1:20,000.

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: Dallas County, Texas
Survey Area Data: Version 16, Sep 14, 2018

Soil Survey Area: Johnson County, Texas
Survey Area Data: Version 15, Sep 14, 2018

Soil Survey Area: Tarrant County, Texas
Survey Area Data: Version 16, Sep 16, 2018

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Aug 8, 2013—Dec 13, 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
1	Altoga silty clay, 5 to 12 percent slopes, eroded	36.7	0.1%
12	Axtell fine sandy loam, 2 to 5 percent slopes, moderately eroded	6.0	0.0%
14	Bastsil fine sandy loam, 0 to 2 percent slopes	15.3	0.0%
17	Branyon clay, 0 to 1 percent slopes	116.3	0.2%
19	Burleson clay, 1 to 3 percent slopes	10.5	0.0%
20	Crockett fine sandy loam, 0 to 1 percent slopes	178.7	0.3%
21	Crockett fine sandy loam, 1 to 3 percent slopes	22.8	0.0%
26	Eddy clay loam, 1 to 3 percent slopes	0.0	0.0%
27	Eddy clay loam, 3 to 8 percent slopes	0.0	0.0%
42	Heiden clay, 2 to 5 percent slopes, eroded	12.2	0.0%
44	Houston Black clay, 1 to 3 percent slopes	29.8	0.1%
46	Lewisville silty clay, 1 to 3 percent slopes	62.1	0.1%
47	Lewisville silty clay, 3 to 5 percent slopes, eroded	35.8	0.1%
48	Lewisville silty clay, 5 to 8 percent slopes	9.7	0.0%
53	Normangee clay loam, 1 to 3 percent slopes	3.0	0.0%
60	Silawa fine sandy loam, 1 to 3 percent slopes	22.6	0.0%
61	Silawa fine sandy loam, 3 to 8 percent slopes	12.5	0.0%
78	Wilson clay loam, 0 to 1 percent slopes	88.6	0.2%
79	Wilson clay loam, 1 to 3 percent slopes	32.2	0.1%
DAM	Dams	32.0	0.1%
W	Water	1,219.5	2.2%
Subtotals for Soil Survey Area		**1,946.3**	**3.5%**
Totals for Area of Interest		**55,260.8**	**100.0%**

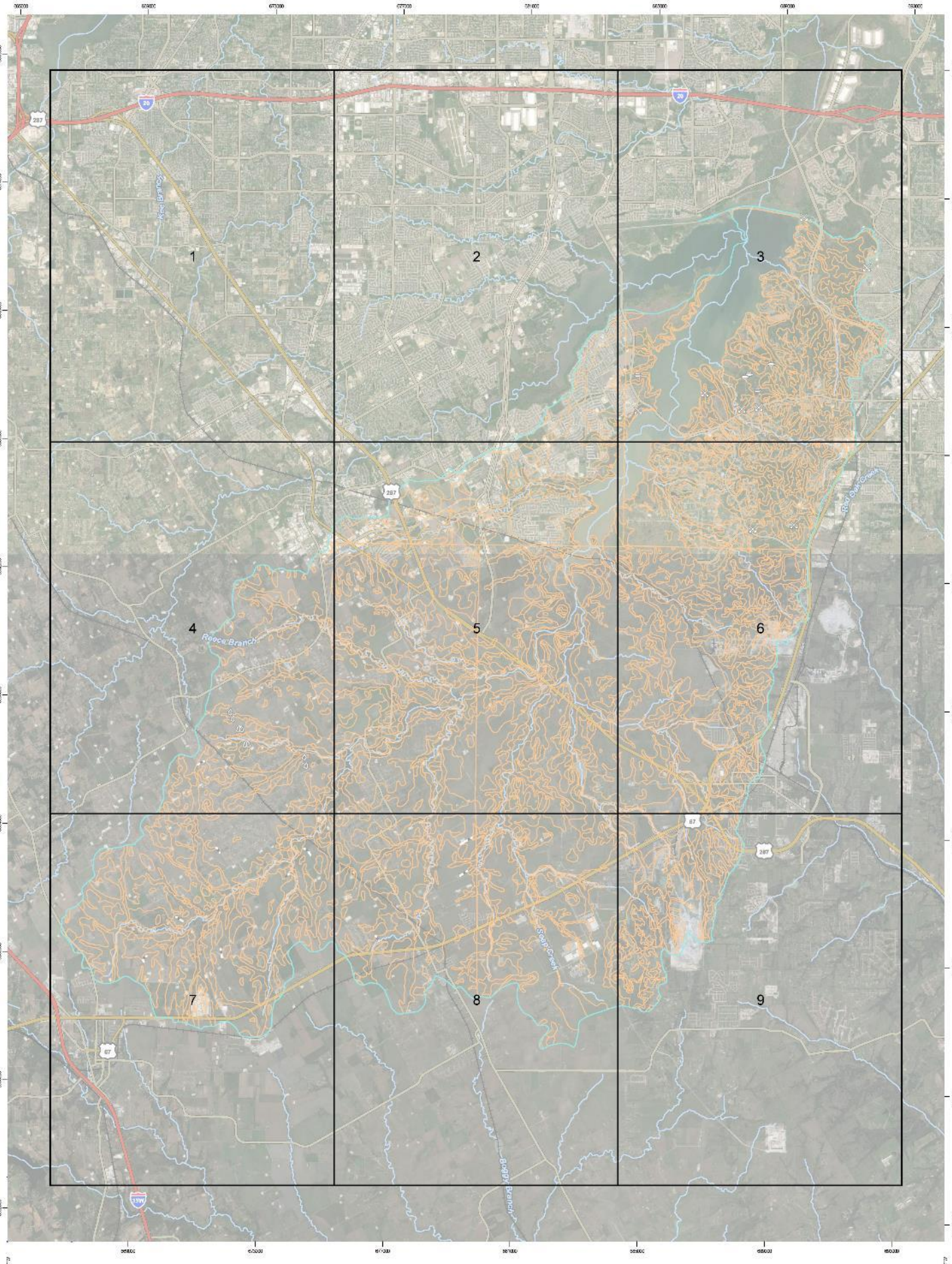
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BmE	Birome-Rayex complex, 5 to 20 percent slopes	273.6	0.5%
BuB	Burleson clay, 1 to 3 percent slopes	16.7	0.0%
CrB	Crosstell fine sandy loam, 1 to 3 percent slopes	2,434.4	4.4%
CrD	Crosstell fine sandy loam, 3 to 8 percent slopes	8,204.6	14.8%
FhC	Ferris-Heiden complex, 2 to 5 percent slopes	715.6	1.3%
GaB	Gasil loamy fine sand, 0 to 5 percent slopes	0.8	0.0%
GfB	Gasil fine sandy loam, 1 to 3 percent slopes	925.7	1.7%
GfC	Gasil fine sandy loam, 3 to 8 percent slopes	943.4	1.7%
GfD4	Gasil fine sandy loam, 1 to 8 percent slopes, severely eroded	69.2	0.1%
Gw	Gowen clay loam, occasionally flooded	407.8	0.7%
Gy	Gowen clay loam, frequently flooded	644.0	1.2%
HaA	Hassee fine sandy loam, 0 to 1 percent slopes	191.4	0.3%
HeB	Heiden clay, 1 to 3 percent slopes	3,108.2	5.6%
HeD	Heiden clay, 3 to 8 percent slopes	616.6	1.1%
HoB	Houston Black clay, 1 to 3 percent slopes	22.5	0.0%
NaC	Navo clay loam, 2 to 5 percent slopes	581.6	1.1%
Pb	Pits, 0 to 45 percent slopes	20.7	0.0%
Pp	Pulexas fine sandy loam, frequently flooded	549.9	1.0%
Pr	Pursley clay loam, frequently flooded	221.7	0.4%
RaB	Rader fine sandy loam, 0 to 3 percent slopes	1,458.4	2.6%
SaB	Sanger clay, 1 to 3 percent slopes	3.4	0.0%
SfB	Silstid loamy fine sand, 1 to 3 percent slopes	152.2	0.3%
SfD	Silstid loamy fine sand, 3 to 8 percent slopes	245.0	0.4%
Tn	Tinn clay, 0 to 1 percent slopes, frequently flooded	47.3	0.1%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
W	Water	61.3	0.1%
WsA	Wilson silty clay loam, 0 to 1 percent slopes	4.1	0.0%
Subtotals for Soil Survey Area		**21,919.8**	**39.7%**
Totals for Area of Interest		**55,260.8**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5	Altoga silty clay loam, 5 to 12 percent slopes	274.4	0.5%
8	Arents, loamy	46.1	0.1%
9	Bastsil fine sandy loam, 0 to 3 percent slopes	548.9	1.0%
11	Birome fine sandy loam, 1 to 5 percent slopes	400.2	0.7%
12	Birome-Aubrey-Rayex complex, 5 to 15 percent slopes	332.7	0.6%
13	Birome-Aubrey-Urban land complex, 5 to 15 percent slopes	28.9	0.1%
18	Branyon clay, 0 to 1 percent slopes	308.0	0.6%
19	Burleson clay, 0 to 1 percent slopes	302.9	0.5%
20	Chatt silty clay, 1 to 3 percent slopes	73.0	0.1%
21	Crosstell fine sandy loam, 1 to 3 percent slopes	3,034.0	5.5%
22	Crosstell fine sandy loam, 3 to 8 percent slopes	3,218.4	5.8%
23	Crosstell-Urban land complex, 1 to 5 percent slopes	121.8	0.2%
24	Ferris clay, 5 to 12 percent slopes, eroded	176.5	0.3%
25	Ferris-Heiden complex, 2 to 5 percent slopes	1,346.2	2.4%
26	Frio silty clay, 0 to 1 percent slopes, occasionally flooded	75.6	0.1%
27	Frio silty clay, frequently flooded	93.3	0.2%
29	Gasil fine sandy loam, 1 to 3 percent slopes	1,323.5	2.4%
30	Gasil fine sandy loam, 3 to 8 percent slopes	1,005.8	1.8%
31	Gasil sandy clay loam, graded, 1 to 5 percent slopes	448.2	0.8%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
32	Gasil-Urban land complex, 1 to 8 percent slopes	284.5	0.5%
33	Heiden clay, 1 to 3 percent slopes	3,857.4	7.0%
34	Houston Black clay, 1 to 3 percent slopes	1,655.1	3.0%
35	Houston Black-Urban land complex, 1 to 4 percent slopes	758.9	1.4%
37	Konsil fine sandy loam, 1 to 5 percent slopes	963.9	1.7%
38	Leson clay, 1 to 3 percent slopes	216.5	0.4%
41	Lott silty clay, 1 to 3 percent slopes	121.3	0.2%
45	Mabank fine sandy loam, 0 to 1 percent slopes	50.3	0.1%
50	Navo clay loam, 1 to 3 percent slopes	2,547.4	4.6%
51	Navo-Urban land complex, 1 to 3 percent slopes	168.2	0.3%
54	Ovan clay, frequently flooded	138.7	0.3%
59	Pulexas fine sandy loam, frequently flooded	1,564.8	2.8%
63	Rader fine sandy loam, 0 to 3 percent slopes	1,771.7	3.2%
64	Rader-Urban land complex, 0 to 3 percent slopes	80.8	0.1%
70	Silawa fine sandy loam, 3 to 8 percent slopes	759.3	1.4%
71	Silstid loamy fine sand, 1 to 5 percent slopes	809.8	1.5%
72	Silstid-Urban land complex, 1 to 5 percent slopes	222.5	0.4%
77	Sunev clay loam, cool, 1 to 3 percent slopes	25.7	0.0%
78	Sunev clay loam, 3 to 8 percent slopes	42.9	0.1%
83	Whitesboro loam, frequently flooded	316.7	0.6%
84	Wilson clay loam, 0 to 2 percent slopes	882.3	1.6%
85	Wilson-Urban land complex, 0 to 2 percent slopes	9.9	0.0%
W	Water	987.6	1.8%
Subtotals for Soil Survey Area		**31,394.6**	**56.8%**
Totals for Area of Interest		**55,260.8**	**100.0%**

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Index Sheet



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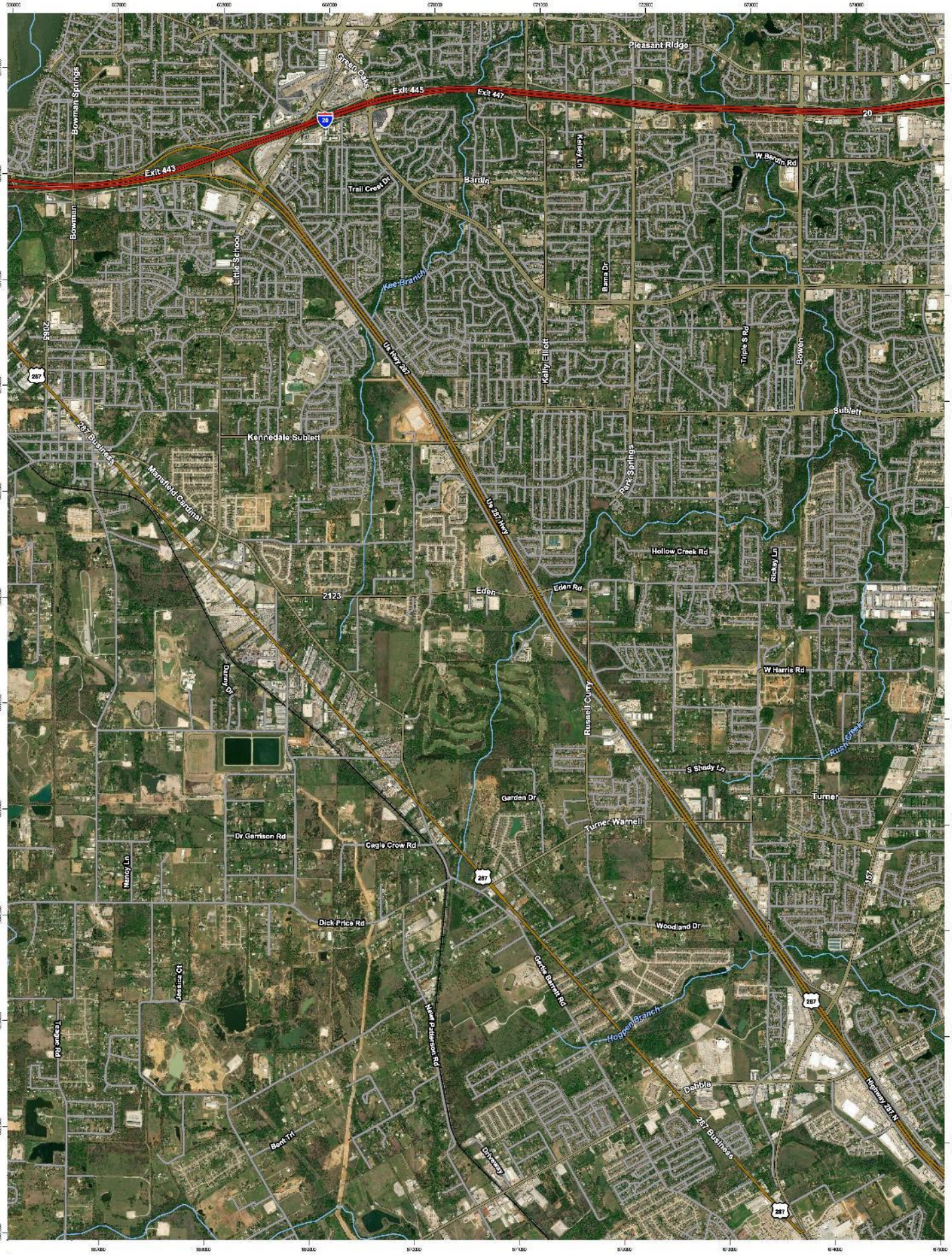

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Feet: 0 1000 2000 4000 6000

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

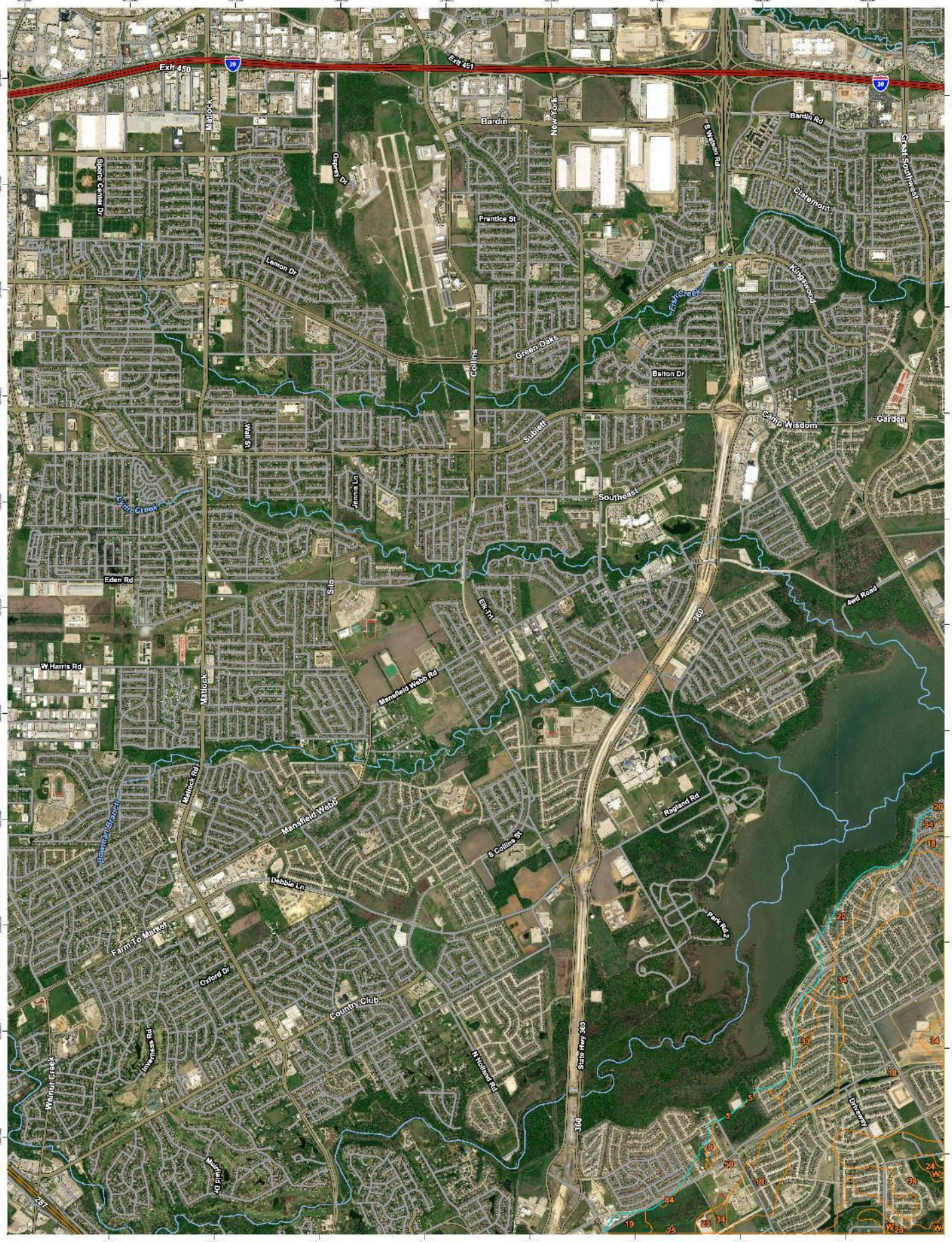
Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

9/24/2019
Page 2 of 16

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet 2 of 9



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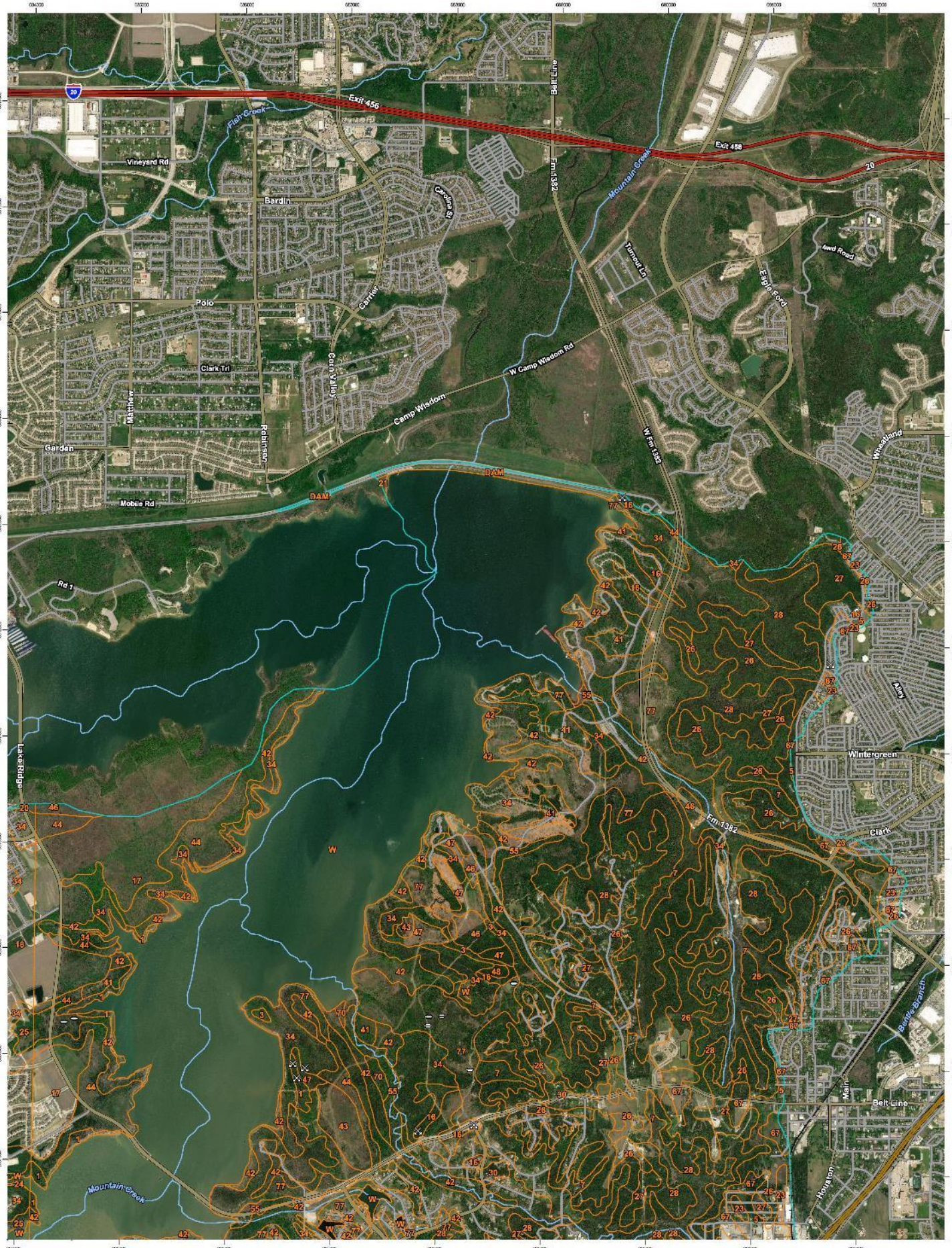
Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location



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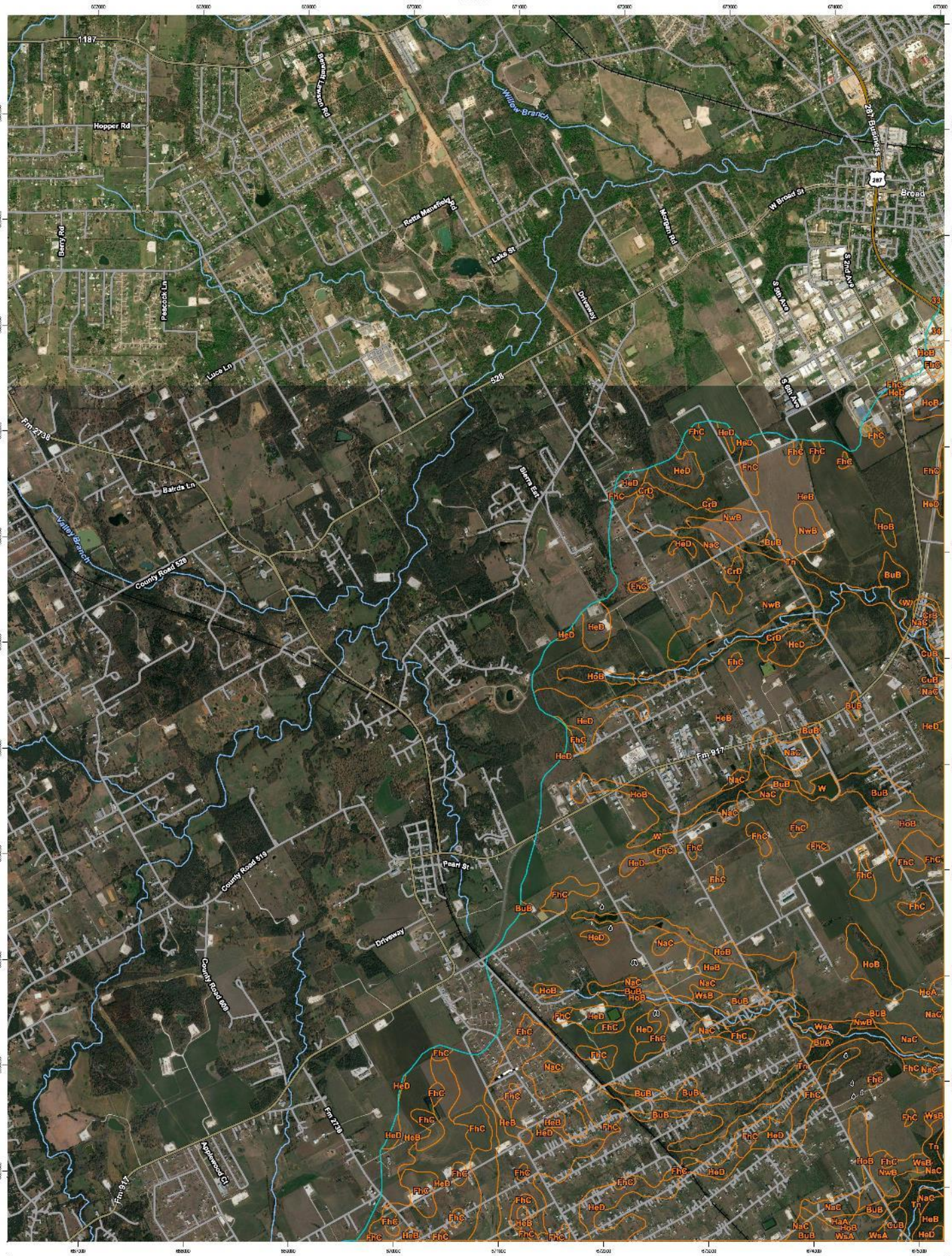
Map Sheet Location

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet 4 of 9



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Meters: 0 300 700 1400 2100

Feet: 0 1000 2000 4000 6000

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Map Sheet Location

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet: 5 of 9
Joins sheet 2

Joins sheet 8

Map Scale: 1:24,000 if printed on C portrait (17" x 22") sheet.

Meters: 0 300 700 1400 2100

Feet: 0 1000 2000 4000 6000

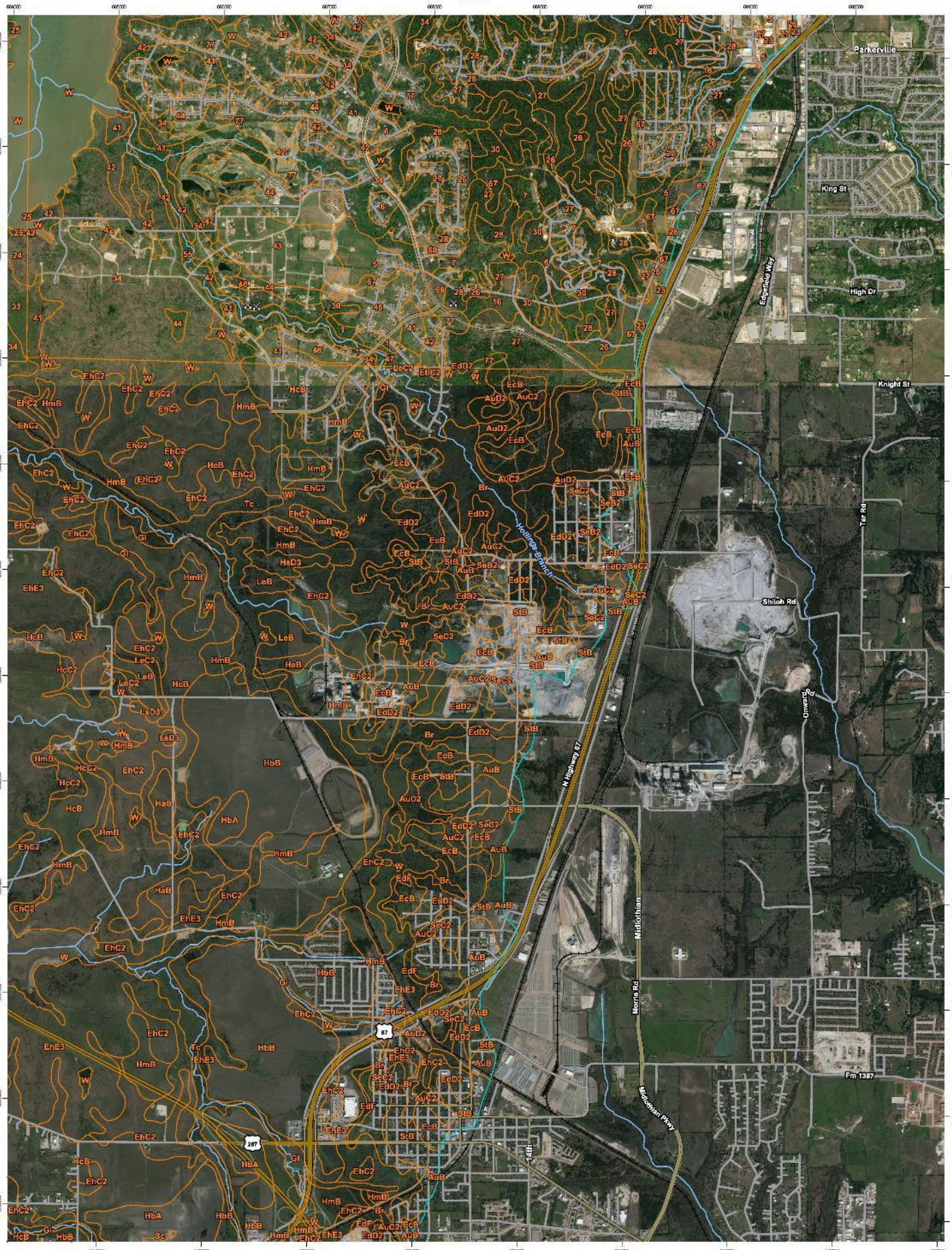
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet 6 of 9
Joins sheet 5



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Feet: 0 1000 2000 4000 6000

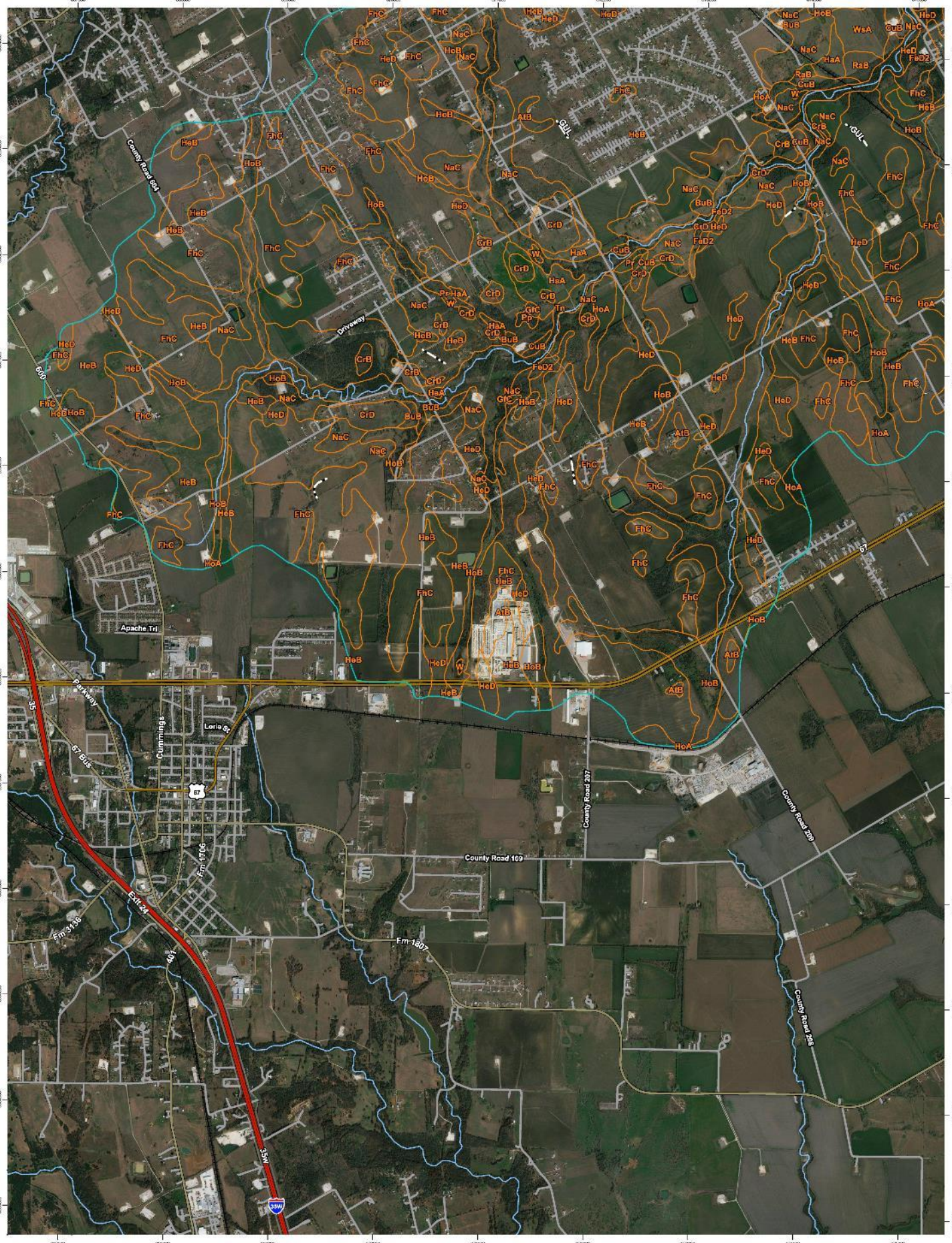
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Sheet Location

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet 7 of 9
Total sheet 4



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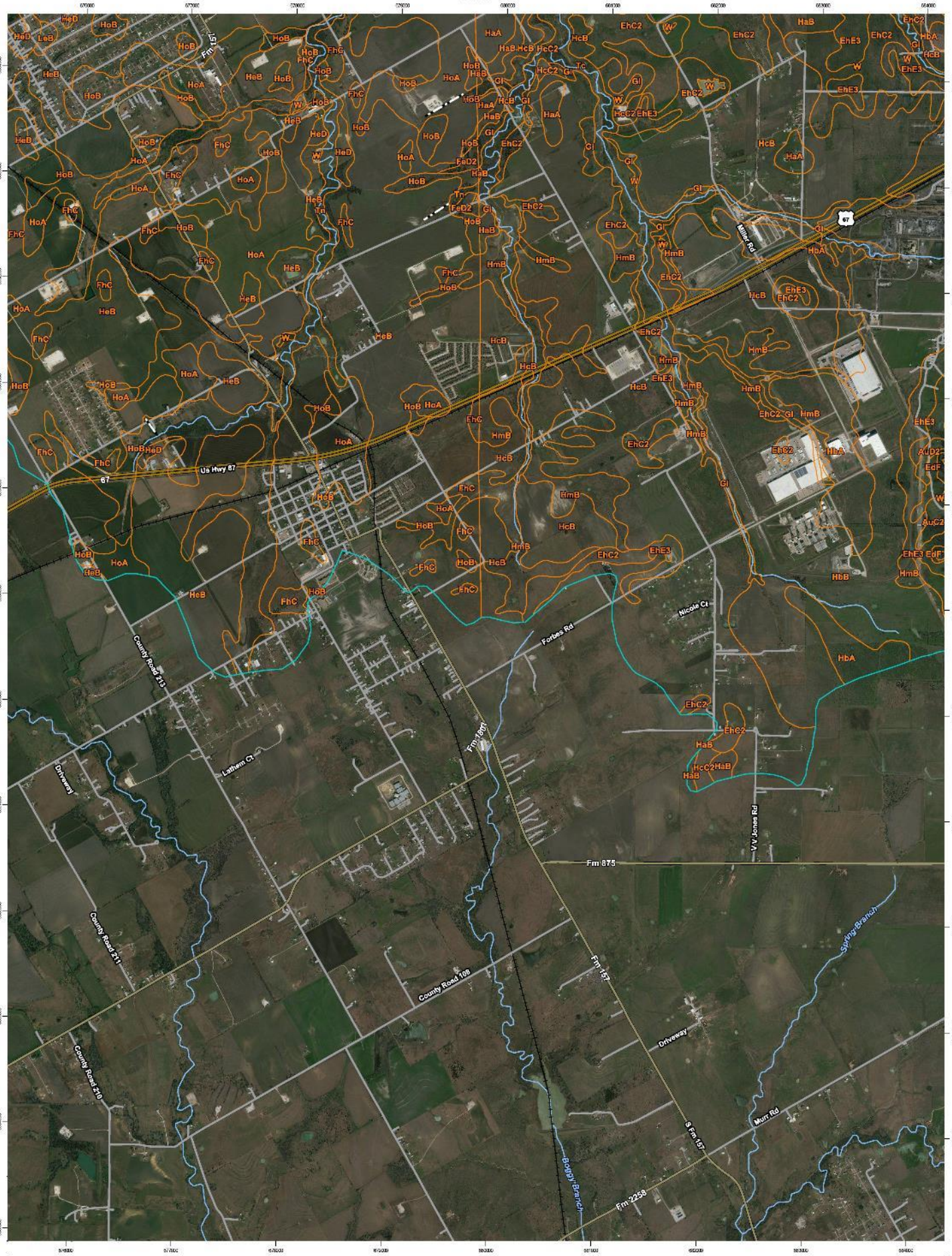
Map Sheet Location

Soil Map—Dallas County, Texas, Ellis County, Texas, Johnson County, Texas, and Tarrant County, Texas
(Joe Pool Lake Watershed - Mountain Creek Arm)
Map sheet 8 of 9
Tile sheet 5



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

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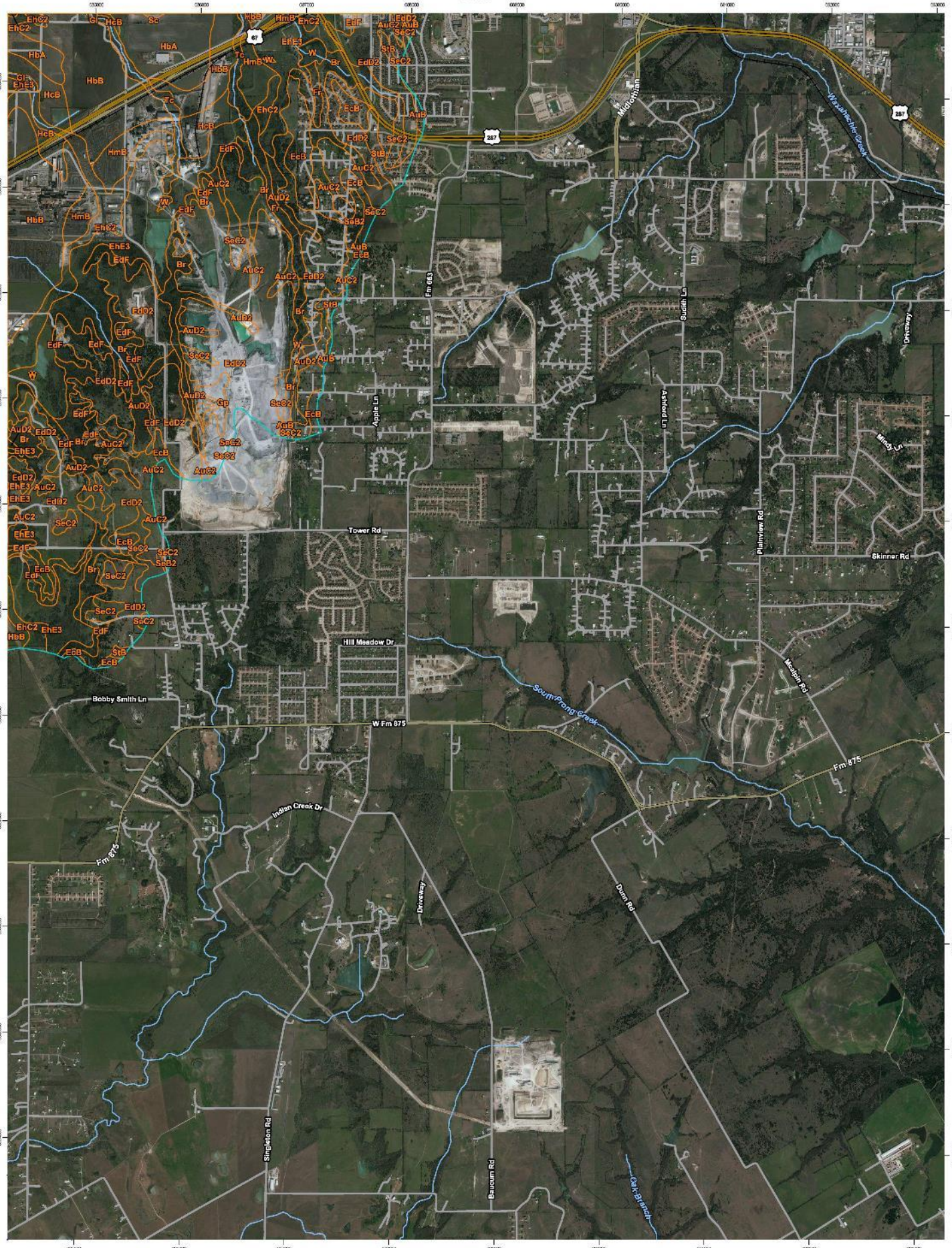

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Natural Resources Conservation Service

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National Cooperative Soil Survey

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MAP LEGEND

Area of Interest (AOI)

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

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

Soil Survey Area: Dallas County, Texas
Survey Area Data: Version 16, Sep 14, 2018

Soil Survey Area: Ellis County, Texas
Survey Area Data: Version 14, Sep 14, 2018

Soil Survey Area: Johnson County, Texas
Survey Area Data: Version 15, Sep 14, 2018

Soil Survey Area: Tarrant County, Texas
Survey Area Data: Version 16, Sep 16, 2018

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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
1	Altoga silty clay, 5 to 12 percent slopes, eroded	73.4	0.1%
3	Arents, loamy, hilly, rarely flooded	14.6	0.0%
5	Austin silty clay, 1 to 3 percent slopes	198.3	0.2%
6	Austin silty clay, 2 to 5 percent slopes, eroded	74.8	0.1%
7	Austin-Lewisville complex, 5 to 8 percent slopes, erode d	751.2	0.9%
16	Whitewright loam, 3 to 5 percent slopes	147.9	0.2%
17	Branyon clay, 0 to 1 percent slopes	447.3	0.5%
21	Crockett fine sandy loam, 1 to 3 percent slopes	1.9	0.0%
23	Dalco clay, 1 to 3 percent slopes	48.5	0.1%
26	Eddy clay loam, 1 to 3 percent slopes	1,012.5	1.2%
27	Eddy clay loam, 3 to 8 percent slopes	1,168.3	1.3%
28	Eddy-Whitewright complex, 8 to 20 percent slopes	1,899.0	2.2%
30	Eddy-Stephen complex, 1 to 5 percent slopes	216.3	0.2%
34	Ferris-Heiden complex, 5 to 12 percent slopes	1,810.1	2.1%
41	Heiden clay, 1 to 3 percent slopes	296.6	0.3%
42	Heiden clay, 2 to 5 percent slopes, eroded	1,038.6	1.2%
43	Houston Black clay, 0 to 1 percent slopes	230.3	0.3%
44	Houston Black clay, 1 to 3 percent slopes	654.6	0.7%
46	Lewisville silty clay, 1 to 3 percent slopes	160.6	0.2%
47	Lewisville silty clay, 3 to 5 percent slopes, eroded	116.3	0.1%
48	Lewisville silty clay, 5 to 8 percent slopes	5.8	0.0%
55	Ovan clay, frequently flooded	183.6	0.2%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
67	Stephen silty clay, 1 to 4 percent slopes	272.4	0.3%
68	Stephen silty clay, 3 to 5 percent slopes	46.2	0.1%
70	Sunev clay loam, 1 to 3 percent slopes	14.0	0.0%
77	Vertel clay, 5 to 12 percent slopes	1,669.7	1.9%
DAM	Dams	44.8	0.1%
W	Water	3,544.4	4.0%
Subtotals for Soil Survey Area		**16,142.0**	**18.4%**
Totals for Area of Interest		**87,842.5**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AuB	Austin silty clay, 1 to 3 percent slopes	242.5	0.3%
AuC2	Austin silty clay, 2 to 5 percent slopes, eroded	333.0	0.4%
AuD2	Austin silty clay, 5 to 8 percent slopes, moderately eroded	232.6	0.3%
Br	Broken alluvial land, rarely flooded	538.3	0.6%
DAM	Dams	9.4	0.0%
EcB	Eddy gravelly clay loam, 1 to 3 percent slopes	525.8	0.6%
EdD2	Eddy soils, 3 to 8 percent slopes, eroded	2,405.0	2.7%
EdF	Eddy soils, 8 to 20 percent slopes	246.7	0.3%
EhC2	Ellis and Heiden clay, 3 to 5 percent slopes, eroded	2,687.4	3.1%
EhE3	Ellis and Heiden clays, 5 to 12 percent slopes, severe ly eroded	4,950.7	5.6%
Fl	Bosque loam, rarely flooded	82.9	0.1%
Fr	Frio silty clay, 0 to 1 percent slopes,frequently flooded	47.0	0.1%
Fs	Frio silty clay, 0 to 1 percent slopes, occasionally flooded	27.5	0.0%
Gl	Gullied land	457.4	0.5%
Gp	Gravel pits	25.2	0.0%
HaA	Houston Black clay, 0 to 1 percent slopes	262.8	0.3%
HaB	Houston Black clay, 1 to 3 percent slopes	2,294.7	2.6%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
HbA	Branyon clay, 0 to 1 percent slopes	947.9	1.1%
HbB	Branyon clay, 1 to 3 percent slopes	3,449.4	3.9%
HcB	Heiden clay, 1 to 3 percent slopes	5,054.9	5.8%
HcC2	Heiden clay, 3 to 5 percent slopes, eroded	502.8	0.6%
HcD2	Heiden clay, 5 to 8 percent slopes, eroded	62.5	0.1%
HmB	Heiden and Ellis clays, 1 to 3 percent slopes	1,308.6	1.5%
HsD3	Heiden-Ferris complex, 5 to 8 percent slopes, severely eroded	235.6	0.3%
LeB	Lewisville silty clay, 1 to 3 percent slopes	92.0	0.1%
LeC2	Lewisville silty clay, 3 to 5 percent slopes, eroded	92.7	0.1%
LeD2	Lewisville silty clay, 5 to 8 percent slopes, eroded	42.3	0.0%
LsD3	Altoga soils, 5 to 8 percent slopes, severely eroded	57.9	0.1%
Sc	Slickspots	4.2	0.0%
SeB2	Stephen-Eddy complex, 1 to 3 percent slopes, eroded	47.9	0.1%
SeC2	Stephen-Eddy complex, 2 to 5 percent slopes	289.6	0.3%
StB	Stephen silty clay, 1 to 4 percent slopes	299.0	0.3%
SuE3	Ferris clay, 5 to 12 percent slopes, eroded	27.6	0.0%
Tc	Trinity clay, 0 to 1 percent slopes, frequently flooded	1,699.3	1.9%
To	Trinity clay, 0 to 1 percent slopes, occasionally flooded	375.6	0.4%
W	Water	435.4	0.5%
WsB	Wilson clay loam, 1 to 3 percent slopes	60.8	0.1%
WsB2	Wilson clay loam, 1 to 3 percent slopes, eroded	82.1	0.1%
Subtotals for Soil Survey Area		**30,536.8**	**34.8%**
Totals for Area of Interest		**87,842.5**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AtB	Altoga silty clay, 2 to 5 percent slopes	78.1	0.1%
BuA	Burleson clay, 0 to 1 percent slopes	77.0	0.1%
BuB	Burleson clay, 1 to 3 percent slopes	216.3	0.2%
CrB	Crosstell fine sandy loam, 1 to 3 percent slopes	83.9	0.1%
CrD	Crosstell fine sandy loam, 3 to 8 percent slopes	168.8	0.2%
CuB	Culp clay loam, 0 to 3 percent slopes	203.6	0.2%
FeD2	Ferris clay, 5 to 12 percent slopes, eroded	96.4	0.1%
FhC	Ferris-Heiden complex, 2 to 5 percent slopes	2,911.6	3.3%
Fr	Frio silty clay, 0 to 1 percent slopes, occasionally flooded	22.1	0.0%
GfC	Gasil fine sandy loam, 3 to 8 percent slopes	5.1	0.0%
Gw	Gowen clay loam, occasionally flooded	55.9	0.1%
HaA	Hassee fine sandy loam, 0 to 1 percent slopes	99.1	0.1%
HeB	Heiden clay, 1 to 3 percent slopes	18,847.5	21.5%
HeD	Heiden clay, 3 to 8 percent slopes	1,648.9	1.9%
HoA	Houston Black clay, 0 to 1 percent slopes	1,847.4	2.1%
HoB	Houston Black clay, 1 to 3 percent slopes	3,789.1	4.3%
LeB	Lewisville silty clay, 1 to 3 percent slopes	9.9	0.0%
NaC	Navo clay loam, 2 to 5 percent slopes	1,567.1	1.8%
NwB	Navo-Wilson complex, 0 to 3 percent slopes	299.2	0.3%
Pp	Pulexas fine sandy loam, frequently flooded	5.4	0.0%
Pr	Pursley clay loam, frequently flooded	17.0	0.0%
RaB	Rader fine sandy loam, 0 to 3 percent slopes	25.7	0.0%
Tn	Tinn clay, 0 to 1 percent slopes, frequently flooded	1,793.2	2.0%
W	Water	35.6	0.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
WsA	Wilson silty clay loam, 0 to 1 percent slopes	105.6	0.1%
WsB	Wilson silty clay loam, 1 to 3 percent slopes	28.3	0.0%
Subtotals for Soil Survey Area		**34,038.1**	**38.7%**
Totals for Area of Interest		**87,842.5**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5	Altoga silty clay loam, 5 to 12 percent slopes	0.5	0.0%
9	Bastsil fine sandy loam, 0 to 3 percent slopes	7.4	0.0%
18	Branyon clay, 0 to 1 percent slopes	1,996.3	2.3%
19	Burleson clay, 0 to 1 percent slopes	137.6	0.2%
20	Chatt silty clay, 1 to 3 percent slopes	71.1	0.1%
24	Ferris clay, 5 to 12 percent slopes, eroded	173.6	0.2%
25	Ferris-Heiden complex, 2 to 5 percent slopes	554.3	0.6%
33	Heiden clay, 1 to 3 percent slopes	760.8	0.9%
34	Houston Black clay, 1 to 3 percent slopes	2,370.9	2.7%
35	Houston Black-Urban land complex, 1 to 4 percent slopes	17.0	0.0%
41	Lott silty clay, 1 to 3 percent slopes	8.1	0.0%
50	Navo clay loam, 1 to 3 percent slopes	185.7	0.2%
54	Ovan clay, frequently flooded	219.6	0.3%
78	Sunev clay loam, 3 to 8 percent slopes	17.1	0.0%
84	Wilson clay loam, 0 to 2 percent slopes	1.6	0.0%
W	Water	604.2	0.7%
Subtotals for Soil Survey Area		**7,125.8**	**8.1%**
Totals for Area of Interest		**87,842.5**	**100.0%**

Appendix B

USFWS IPaC Report for the Joe Pool Lake Watershed

IPaC Information for Planning and Consultation **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Texas

Local office

Arlington Ecological Services Field Office

(817) 277-1100
(817) 277-1129

2005 Ne Green Oaks Blvd
Suite 140
Arlington, TX 76006-6247

http://www.fws.gov/southwest/es/arlingtontexas/
http://www.fws.gov/southwest/es/EndangeredSpecies/lists/

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Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

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Birds

NAME	STATUS
Golden-cheeked Warbler (=wood) Dendroica chrysoparia No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/33	Endangered
Least Tern Sterna antillarum No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/8505	Endangered
Piping Plover Charadrius melodus This species only needs to be considered if the following condition applies: • Wind Energy Projects There is **final** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/6039	Threatened
Red Knot Calidris canutus rufa This species only needs to be considered if the following condition applies: • Wind Energy Projects No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/1864	Threatened

Clams

NAME	STATUS
Texas Fawnsfoot Truncilla macrodon No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/8965	Candidate

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)

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Bald Eagle Haliaeetus leucocephalus	Breeds Sep 1 to Jul 31
Buff-breasted Sandpiper Calidris subruficollis This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9488	Breeds elsewhere
Harris's Sparrow Zonotrichia querula This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Lesser Yellowlegs Tringa flavipes This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9679	Breeds elsewhere
Red-headed Woodpecker Melanerpes erythrocephalus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Sep 10
Semipalmated Sandpiper Calidris pusilla This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere

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Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)

A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

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Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

NOT FOR CONSULTATION

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

THERE ARE NO FISH HATCHERIES AT THIS LOCATION.

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

This location overlaps the following wetlands:

The area of this project is too large for IPaC to load all NWI wetlands in the area. The list below may be incomplete. Please contact the local U.S. Fish and Wildlife Service office or visit the NWI map for a full list.

FRESHWATER EMERGENT WETLAND

- PEM1A
- PEM1Ch
- PEM1Ah
- PEM1Fh
- PEM1C
- PEM1Cx
- PEM1Ax

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1A
- PFO1Ch
- PSS1A
- PFO1C
- PSS1/EM1A
- PFO1Ah
- PSS1C
- PSS1Ch
- PSS1Ax

FRESHWATER POND

- PUBFh
- PUBHh
- PUBHx
- PAB4Hh
- PUSCh
- PUBFx
- PUSAh
- PUSCx
- PUBF
- PAB3Hh
- PUSAx
- PAB4Hx
- PUBH
- PAB4Fh

LAKE

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L1UBHh
L1UBHx

A full description for each wetland code can be found at the National Wetlands Inventory website

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

NOT FOR CONSULTATION

Appendix C

TPWD Threatened & Endangered Resources Reports for Dallas, Ellis, Tarrant, and Johnson Counties

Table C-1. State and federal listing status acronyms and their descriptions.

Listing Status	Description
LE or LT	Federally Listed Endangered or Threatened
PE or PT	Federally Proposed Endangered or Threatened
SAE or SAT	Federally Listed Endangered or Threatened by Similarity of Appearance
C	Federal Candidate for Listing
DL or PDL	Federally Delisted or Proposed for Delisting
E or T	State Listed Endangered or Threatened
NT	Not tracked or no longer tracked by the State
“blank”	No regulatory listing status, but considered a "species of greatest conservation need" as defined in the 2012 Texas Conservation Action Plan

Table C-2. Federal and state status of threatened and endangered species potentially within the Joe Pool Lake watershed.

Scientific Name	Common Name	Federal Status	State Status	Description
Amphibians				
Desmognathus conanti	southern dusky salamander			Details unknown.
Anaxyrus woodhousii	Woodhouse's toad			Extremely catholic up to 5000 feet, does very well (except for traffic) in association with man.
Pseudacris streckeri	Strecker's chorus frog			Wooded floodplains and flats, prairies, cultivated fields and marshes. Likes sandy substrates.
Pseudacris fouquettei	cajun chorus frog			Habitat description is not available at this time.
Lithobates areolatus areolatus	southern crawfish frog			The Southern Crawfish Frog can be found in abandoned crawfish holes and small mammal burrows. This species inhabits moist meadows, pasturelands, pine scrub, and river flood plains. This species spends nearly all of its time in burrows and only leaves the burrow area to breed. Although this species can be difficult to detect due to its reclusive nature, the call of breeding males can be heard over great distances. Eggs are laid and larvae develop in temporary water such as flooded fields, ditches, farm ponds and small lakes. Habitat: Shallow water, Herbaceous Wetland, Riparian, Temporary Pool, Cropland/hedgerow, Grassland/herbaceous, Suburban/orchard, Woodland â€“ Conifer.

Scientific Name	Common Name	Federal Status	State Status	Description
Birds				
Plegadis chihi	white-faced ibis		T	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.
Mycteria americana	wood stork		T	Prefers to nest in large tracts of baldcypress (Taxodium distichum) or red mangrove (Rhizophora mangle); forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960
Haliaeetus leucocephalus	bald eagle		T	Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds
Laterallus jamaicensis	black rail	PT		Salt, brackish, and freshwater marshes, pond borders, wet meadows, and grassy swamps; nests in or along edge of marsh, sometimes on damp ground, but usually on mat of previous years dead grasses; nest usually hidden in marsh grass or at base of Salicornia
Grus americana	whooping crane	LE	E	Small ponds, marshes, and flooded grain fields for both roosting and foraging. Potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.
Charadrius melodus	piping plover	LT	T	Beaches, sandflats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Based on the November 30, 1992 Section 6 Job No. 9.1, Piping Plover and Snowy Plover Winter Habitat Status Survey, algal flats appear to be the highest quality habitat. Some of the most important aspects of algal flats are their relative inaccessibility and their continuous availability throughout all tidal conditions. Sand flats often appear to be preferred over algal flats when both are available, but large portions of sand flats along the Texas coast are available only during low-very low tides and are often completely unavailable during extreme high tides or strong north winds. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes. Beaches are rarely used on the southern Texas coast, where bayside habitat is always available, and are abandoned as bayside habitats become available on the central and northern coast. However, beaches are probably a vital habitat along the central and northern coast (i.e. north of Padre Island) during periods of extreme high tides that cover the flats. Optimal site characteristics appear to be large in area, sparsely vegetated, continuously available or in close proximity to secondary habitat, and with limited human disturbance.

Scientific Name	Common Name	Federal Status	State Status	Description
Birds (continued)				
Charadrius montanus	mountain plover			Breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous
Calidris canutus rufa	red knot	LT		Red knots migrate long distances in flocks northward through the contiguous United States mainly April-June, southward July-October. A small plump-bodied, short-necked shorebird that in breeding plumage, typically held from May through August, is a distinctive and unique pottery orange color. Its bill is dark, straight and, relative to other shorebirds, short-to-medium in length. After molting in late summer, this species is in a drab gray-and-white non-breeding plumage, typically held from September through April. In the non-breeding plumage, the knot might be confused with the omnipresent Sanderling. During this plumage, look for the knotâ€™s prominent pale eyebrow and whitish flanks with dark barring. The Red Knot prefers the shoreline of coast and bays and also uses mudflats during rare inland encounters. Primary prey items include coquina clam (Donax spp.) on beaches and dwarf surf clam (Mulinia lateralis) in bays, at least in the Laguna Madre. Wintering Range includes- Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Jefferson, Kennedy, Kleberg, Matagorda, Nueces, San Patricio, and Willacy. Habitat: Primarily seacoasts on tidal flats and beaches, herbaceous wetland, and Tidal flat/shore.
Leucophaeus pipixcan	Franklin's gull			Habitat description is not available at this time.
Sternula antillarum athalassos	interior least tern	LE	E	Sand beaches, flats, bays, inlets, lagoons, islands. Subspecies is listed only when inland (more than 50 mi from a coastline); nests along sand/gravel bars within braided streams, rivers; also on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony
Athene cunicularia hypugaea	western burrowing owl			Open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows
Vireo atricapilla	black-capped vireo		E	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer
Setophaga chrysoparia	golden-cheeked warbler	LE	E	Ashe juniper in mixed stands with various oaks (Quercus spp.). Edges of cedar brakes. Dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests are placed in various trees other than Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees and shrubs; nesting late March-early summer.

Scientific Name	Common Name	Federal Status	State Status	Description
Fishes				
Anguilla rostrata	american eel			Originally found in all river systems from the Red River to the Rio Grande. Aquatic habtiats include large rivers, streams, tributaries, coastal watersheds, estuaries, bays, and oceans. Spawns in Sargasso Sea, larva move to coastal waters, metamorphose, and begin upstream movements. Females tend to move further upstream than males (who are often found in brackish estuaries). American Eel are habitat generalists and may be found in a broad range of habitat conditions including slow- and fast-flowing waters over many substrate types. Extirpation in upstream drainages attributed to reservoirs that impede upstream migration.
Mammals				
Blarina carolinensis	southern short-tailed shrew			Habitat description is not available at this time.
Myotis austroriparius	southeastern myotis bat			Caves are rare in Texas portion of range; buildings, hollow trees are probably important. Historically, lowland pine and hardwood forests with large hollow trees; associated with ecological communities near water. Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures.
Myotis velifer	cave myotis bat			Colonial and cave-dwelling; also roosts in rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (Hirundo pyrrhonota) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore.
Perimyotis subflavus	tricolored bat			Forest, woodland and riparian areas are important. Caves are very important to this species.
Eptesicus fuscus	big brown bat			Any wooded areas or woodlands except south Texas. Riparian areas in west Texas.
Lasiurus borealis	eastern red bat			Found in a variety of habitats in Texas. Usually associated with wooded areas. Found in towns especially during migration.
Lasiurus cinereus	hoary bat			Known from montane and riparian woodland in Trans-Pecos, forests and woods in east and central Texas.
Tadarida brasiliensis	Mexican free-tailed bat			Roosts in buildings in east Texas. Largest maternity roosts are in limestone caves on the Edwards Plateau. Found in all habitats, forest to desert.
Nyctinomops macrotis	big free-tailed bat			Habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore
Sylvilagus aquaticus	swamp rabbit			Habitat description is not available at this time.

Scientific Name	Common Name	Federal Status	State Status	Description
Mammals (continued)				
Ictidomys tridecemlineatus	thirteen-lined ground squirrel			Habitat description is not available at this time.
Cynomys ludovicianus	black-tailed prairie dog			Dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups
Microtus pinetorum	woodland vole			Include grassy marshes, swamp edges, old-field/pine woodland ecotones, tallgrass fields; generally sandy soils.
Ursus americanus	black bear		T	In Chisos, prefers higher elevations where pinyon-oaks predominate; also occasionally sighted in desert scrub of Trans-Pecos (Black Gap Wildlife Management Area) and Edwards Plateau in juniper-oak habitat. For ssp. luteolus, bottomland hardwoods, floodplain forests, upland hardwoods with mixed pine; marsh. Bottomland hardwoods and large tracts of inaccessible forested areas.
Mustela frenata	long-tailed weasel			Includes brushlands, fence rows, upland woods and bottomland hardwoods, forest edges & rocky desert scrub. Usually live close to water.
Neovison vison	mink			Intimately associated with water; coastal swamps & marshes, wooded riparian zones, edges of lakes. Prefer floodplains.
Taxidea taxus	American badger			Habitat description is not available at this time.
Spilogale putorius	eastern spotted skunk			Catholic; open fields prairies, croplands, fence rows, farmyards, forest edges & woodlands. Prefer wooded, brushy areas & tallgrass prairies. S.p. ssp. interrupta found in wooded areas and tallgrass prairies, preferring rocky canyons and outcrops when such sites are available.
Spilogale putorius interrupta	plains spotted skunk			Catholic; open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie
Conepatus leuconotus	western hog-nosed skunk			Habitats include woodlands, grasslands & deserts, to 7200 feet, most common in rugged, rocky canyon country; little is known about the habitat of the ssp. telmalestes
Puma concolor	mountain lion			Rugged mountains & riparian zones.

Scientific Name	Common Name	Federal Status	State Status	Description
Reptiles				
Macrochelys temminckii	alligator snapping turtle		T	Perennial water bodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October
Terrapene carolina	eastern box turtle			Eastern box turtles inhabit forests, fields, forest-brush, and forest-field ecotones. In some areas they move seasonally from fields in spring to forest in summer. They commonly enters pools of shallow water in summer. For shelter, they burrow into loose soil, debris, mud, old stump holes, or under leaf litter. They can successfully hibernate in sites that may experience subfreezing temperatures. In Maryland bottomland forest, some hibernated in pits or depressions in forest floor (usually about 30 cm deep) usually within summer range; individuals tended to hibernate in same area in different years (Stickel 1989). Also attracted to farms, old fields and cut-over woodlands, as well as creek bottoms and dense woodlands. Egg laying sites often are sandy or loamy soils in open areas; females may move from bottomlands to warmer and drier sites to nest. In Maryland, females used the same nesting area in different years (Stickel 1989).
Terrapene ornata	western box turtle			Ornate or western box trutles inhabit prairie grassland, pasture, fields, sandhills, and open woodland. They are essentially terrestrial but sometimes enter slow, shallow streams and creek pools. For shelter, they burrow into soil (e.g., under plants such as yucca) (Converse et al. 2002) or enter burrows made by other species; winter burrow depth was 0.5-1.8 meters in Wisconsin (Doroff and Keith 1990), 7-120 cm (average depth 54 cm) in Nebraska (Converse et al. 2002). Eggs are laid in nests dug in soft well-drained soil in open area (Legler 1960, Converse et al. 2002). Very partial to sandy soil.
Apalone mutica	smooth softshell			Any permanent body of water.Large rivers and streams; in some areas also found in lakes, impoundments, and shallow bogs (Ernst and Barbour 1972). Usually in water with sandy or mud bottom and few aquatic plants. Often basks on sand bars and mudflats at edge of water. Eggs are laid in nests dug in high open sandbars and banks close to water, usually within 90 m of water (Fitch and Plummer 1975).
Alligator mississippiensis	American alligator			Coastal marshes; inland natural rivers, swamps and marshes; manmade impoundments.

Scientific Name	Common Name	Federal Status	State Status	Description
Reptiles (continued)				
Ophisaurus attenuatus	slender glass lizard			Prefers relatively dry microhabitats, usually associated with grassy areas. Habitats include open grassland, prairie, woodland edge, open woodland, oak savannas, longleaf pine flatwoods, scrubby areas, fallow fields, and areas near streams and ponds, often in habitats with sandy soil. This species often appears on roads in spring. During inactivity, it occurs in underground burrows. In Kansas, slender glass lizards were scarce in heavily grazed pastures, increased as grass increased with removal of grazing, and declined as brush and trees replaced grass (Fitch 1989). Eggs are laid underground, under cover, or under grass clumps (Ashton and Ashton 1985); in cavities beneath flat rocks or in abandoned tunnels of small mammals (Scalopus, Microtus) (Fitch 1989).
Phrynosoma cornutum	Texas horned lizard		T	Occurs to 6000 feet, but largely limited below the pinyon-juniper zone on mountains in the Big Bend area. Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September.
Nerodia harteri	Brazos water snake		T	Shallow, fast-flowing water with a rocky or gravelly substrate preferred. Adults can be found in deep water with mud bottoms. Upper Brazos River drainage; riffle specialist, in shallow water with rocky bottom and on rocky portions of banks.
Thamnophis sirtalis	common garter snake			Irrigation canals and riparian-corridor farmlands in west; marshy, flooded pastureland, grassy or brushy borders of permanent bodies of water; coastal salt marshes.
Thamnophis sirtalis annectens	Texas garter snake			Irrigation canals and riparian-corridor farmlands in west; marshy, flooded pastureland, grassy or brushy borders of permanent bodies of water; coastal salt marshes. Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August.
Crotalus horridus	timber (canebrake) rattlesnake		T	Swamps, floodplains, upland pine and deciduous woodland, riparian zones, abandoned farmland. Limestone bluffs, sandy soil or black clay. Prefers dense ground cover, i.e. grapevines, palmetto.
Sistrurus tergeminus	massasauga			Quite common in gently rolling prairie occasionally broken by creek valley or rocky hillside.
Crustaceans				
Caecidotea bilineata	a cave obligate isopod			Habitat description is not available at this time.
Insects				
Bombus pensylvanicus	American bumblebee			Habitat description is not available at this time.
Pogonomyrmex comanche	Comanche harvester ant			Habitat description is not available at this time.
Amblycorypha uhleri	a katydid			Habitat description is not available at this time.

Scientific Name	Common Name	Federal Status	State Status	Description
Insects (continued)				
Arethaea ambulator	No accepted common name			Habitat description is not available at this time.
Neotrichia juani	No accepted common name			Habitat description is not available at this time.
Mollusks				
Lampsilis satura	sandbank pocketbook		T	Small to large rivers with moderate flows and swift current on gravel, gravel-sand, and sand bottoms; east Texas, Sulfur south through San Jacinto River basins; Neches River
Pleurobema riddellii	Louisiana pigtoe		T	Streams and moderate-size rivers, usually flowing water on substrates of mud, sand, and gravel; not generally known from impoundments; Sabine, Neches, and Trinity (historic) River basins
Potamilus amphichaenus	Texas heelsplitter		T	Quiet waters in mud or sand and also in reservoirs. Sabine, Neches, and Trinity River basins
Fusconaia chunii	No accepted common name			Habitat description is not available at this time.
Truncilla macrodon	Texas fawnsfoot	C	T	Little known; possibly rivers and larger streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins
Plants				
Matelea edwardsensis	plateau milkvine			Occurs in various types of juniper-oak and oak-juniper woodlands; Perennial; Flowering March-Oct; Fruiting May-June
Echinacea atrorubens	Topeka purple-coneflower			Occurring mostly in tallgrass prairie of the southern Great Plains, in blackland prairies but also in a variety of other sites like limestone hillsides; Perennial; Flowering Jan-June; Fruiting Jan-May
Liatris glandulosa	glandular gay-feather			Occurs in herbaceous vegetation on limestone outcrops (Carr 2015)
Physaria engelmannii	Engelmann's bladderpod			Grasslands and calcareous rock outcrops in a band along the eastern edge of the Edwards Plateau, ranging as far north as the Red River (Carr 2015).
Cuscuta exaltata	tree dodder			Parasitic on various Quercus, Juglans, Rhus, Vitis, Ulmus, and Diospyros species as well as Acacia berlandieri and other woody plants; Annual; Flowering May-Oct; Fruiting July-Oct
Astragalus reflexus	Texas milk vetch			Grasslands, prairies, and roadsides on calcareous and clay substrates; Annual; Flowering Feb-June; Fruiting April-June
Dalea hallii	Hall's prairie clover			In grasslands on eroded limestone or chalk and in oak scrub on rocky hillsides; Perennial; Flowering May-Sept; Fruiting June-Sept
Pediomelum reverchonii	Reverchon's scurfpea			Mostly in prairies on shallow rocky calcareous substrates and limestone outcrops; Perennial; Flowering Jun-Sept; Fruiting June-July

Scientific Name	Common Name	Federal Status	State Status	Description
Plants (continued)				
Phlox oklahomensis	Oklahoma phlox			Known from a 1958 collection from an oak woodland four miles east of Garland, Texas (Carr 2015).
Agalinis auriculata	earleaf false foxglove			Known in Texas from one late nineteenth century specimen record labeled -Benbrook-; in Oklahoma, degraded prairies, floodplains, fallow fields, and borders of upland sterile woods; in Arkansas, blackland prairie; Annual; Flowering August - October
Agalinis densiflora	Osage Plains false foxglove			Most records are from grasslands on shallow, gravelly, well drained, calcareous soils; Prairies, dry limestone soils; Annual; Flowering Aug-Oct
Yucca necopina	Glen Rose yucca			Grasslands on sandy soils and limestone outcrops; flowering April-June
Carex shinnersii	Shinner's sedge			Occurs in ditches and swales in prairie landscapes (Carr 2015).
Hexalectris nitida	Glass Mountains coral-root			Apparently rare in mixed woodlands in canyons in the mountains of the Brewster County, but encountered with regularity, albeit in small numbers, under Juniperus ashei in woodlands over limestone on the Edwards Plateau, Callahan Divide and Lampasas Cutplain; Perennial; Flowering June-Sept; Fruiting July-Sept
Hexalectris warnockii	Warnock's coral-root			In leaf litter and humus in oak-juniper woodlands on shaded slopes and intermittent, rocky creekbeds in canyons; in the Trans Pecos in oak-pinyon-juniper woodlands in higher mesic canyons (to 2000 m [6550 ft]), primarily on igneous substrates; in Terrell County under Quercus fusiformis mottes on terrraces of spring-fed perennial streams, draining an otherwise rather xeric limestone landscape; on the Callahan Divide (Taylor County), the White Rock Escarpment (Dallas County), and the Edwards Plateau in oak-juniper woodlands on limestone slopes; in Gillespie County on igneous substrates of the Llano Uplift; flowering June-September; individual plants do not usually bloom in successive years

Source: Texas Parks and Wildlife Department.