Lower Guadalupe Feasibility Study (Guadalupe and Blanco Rivers), TX

Integrated Draft Feasibility Report and Environmental Impact Assessment

December 2019

US Army Corps of Engineers®
Fort Worth District

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EXECUTIVE SUMMARY

Lower Guadalupe River Flood Risk Management Study
Feasibility Closeout Report

Study Information

This report documents the results of a feasibility study conducted as an interim response to the Guadalupe and San Antonio Rivers and Tributaries, Texas, resolution adopted by the Committee on Transportation and Infrastructure, U.S. House of Representatives, in House Resolution docket 2547 dated 11 March 1998.

The purpose of the study was to determine how to effectively address the flood risk in the Lower Guadalupe Blanco River Basin. The study used previous reports completed by Halff and Associates at the request of the Guadalupe-Blanco River Authority (GBRA), the non-Federal Sponsor (NFS). Those Halff studies identified 11 damage centers, and potential solutions to the 4 damage centers with the greatest flood risk.

Problems and Opportunities

The identified problems in the study area are:

1. Periodic flash flooding poses a risk to human health and safety, especially on the uncontrolled Blanco and San Marcos Rivers
2. Routine flooding damages buildings, property, and infrastructure

The identified opportunities in the study area are:

1. Increase flood risk awareness
2. Improve local planning regarding future development

Objectives, Constraints, and Planning Criteria

The study specific objectives for the study from the year 2028 to 2078 for the focused damage centers of Lower Guadalupe River Basin are:

1. Reduce flood risks to human health and safety
2. Reduce flood damages to buildings, and property

The study specific constraints are:

1. Minimize impacts to the recharge of the Edwards Aquifer and coordinate any impacts with the Texas Commission on Environmental Quality (TCEQ)
2. Avoid reducing flows from the aquifer, altering cave systems, or decreasing surface water quality at the Edwards Aquifer-fed Comal and San Marcos Springs
3. Minimize impacts to Nesting Habitat for the endangered Golden Cheeked Warbler
4. Minimize negative impacts to cultural resources

The planning criteria used for decisions was based on how well an alternative plan 1) accounts for all the required work in order to meet project objectives and projected benefits (Completeness); 2) achieves the planning objectives (Effectiveness); 3) complies with laws, regulation, and public policy (Acceptability); and 4) achieves the planning objectives in relation to costs (Efficiency).

Effectiveness measured reduced risk to human health and safety and reduced flood damages. Reduced risk was measured by the number of structures no longer at risk of the 0.01 Annual Exceedance Probability (AEP) floodplain. Flood damages reduced were determined by the reduction in expected annual damages.

Considered Solutions
Structural measures were considered, evaluated, and screened as part of the planning process. The measures, a description, and screening are shown in Table ES-1.

Table ES-1: Structural Measures Considered and Screening

Measure	Description	Screening
Detention Basin	6 ft thick Roller Compacted Concrete layer covering compacted earth	The PDT determined that this management measure should be retained for further plan formulation as they have a large regional impact by reducing flood risk.
Channelization	Excavation of channel to increase depth/width	This measure was kept for further evaluation as the PDT determined that channelization would be able to address flood risk in the immediate vicinity.
Floodwalls	No higher than 6 feet above grade. These measures can be placed around a single structure or a small group of structures.	Preliminary economic numbers determined that floodwalls are not economically justified and were removed from further consideration.
Levees/Berms	Berms would be constructed of compacted earthen fill with a 10 foot wide top and 0-4 feet above the surrounding terrain. Side slopes would be protected with turf matting or other suitable materials.	This measure was removed from further consideration as a stand-alone measure due to real estate costs and hydraulic considerations. A smaller feature remained possible if combined with channelization and was kept for further evaluation.

Non-structural measures were considered, evaluated, and screened as part of the planning process. The measures, a description, and screening are shown in Table ES-2.

Table ES-2: Non-Structural Measures Considered and Screening

Measure	Description	Screening
Wet Floodproofing	This technique consists of reconfiguring a structure to not be damaged by flood waters.	This measure is generally not applicable to large flood depths and high velocity flows and so was removed from further consideration. Further it is applied to basements.
Dry Floodproofing	This technique consists of waterproofing the structure.	This measure was removed from further consideration because dry floodproofing is not suitable for anticipated depth of flooding
Structure Elevation	This technique lifts an existing structure to an elevation which is at least equal to or greater than the 1 percent annual chance flood elevation.	This measure was removed from further consideration as the structures best suited for elevation that were damaged in the recent flooding either were not rebuilt or raised by the owner
Acquisition	This technique consists of buying the structure and the land. The structure is either demolished or is sold to others and relocated to a site external to the floodplain. The land is often used for recreation or for ecosystem restoration.	Damages do not begin until the 4 percent Annual Chance Exceedance (ACE) event. Significant damages occur at the 1 percent ACE. Given that a large number of structures receive damages at less than frequent events, the cost of acquiring and relocating those properties would overshadow the annual benefits
Flood Warning System	This technique relies upon stream gage, rain gages, and hydrologic computer modeling to determine the impacts of flooding for areas of potential flood risk.	This management measure was retained for further consideration. Local governments in basin are currently implementing flood forecast and warning systems
Flood Emergency Preparedness Plans (FEPP)	The FEPP should incorporate the community's response to flooding, location of evacuation centers, primary evacuation routes, and post flood recovery processes.	This management measure was retained for further evaluation. Local sponsors are required to develop FEPPs as part of their responsibilities during Planning, Engineering, and Design (PED) and to implement them within one year of construction completion.
Canyon Lake Storage Reallocation	Reallocation of storage from the conservation pool to the flood storage pool.	Canyon Lake Dam is a medium risk dam and the conservation pool is unavailable for reallocation. This leaves no pool to reallocate to the flood pool should the risk at some future point be considered acceptable.

In San Marcos a combination of a small levee and channelization was fully analyzed. It was determined to have a favorable benefit-cost ratio. However, the City of San Marcos has moved forward on implementing this with HUD funding and it is now part of the Future Without Project condition for the area.

Tentatively Selected Plan

All the evaluated alternatives produced did not produce enough benefits to justify the costs. Therefore, the Tentatively Selected Plan (TSP) is the No Action Alternative, or future without project condition. The Bear Creek Detention was the alternative with the highest potential for justification so the cost benefit analysis is shown below.

Table ES-3: Bear Creek Detention Benefit-Cost Analysis

Alternative	First Costs	Average Annual Benefits	Average Annual Costs	Net Benefits	BCR
No Action Alternative	0	0	0	0	0
Bear Creek Detention (25 percent Confidence)	70,283	679	2,799	-2,120	0.24
Bear Creek Detention (50 percent Confidence)	70,283	1,363	2,799	-1,436	0.49
Bear Creek Detention (75 percent Confidence)	70,283	2,295	2,799	-504	0.82

The actions of the local governments has reduced and will continue to reduce the health and safety risks in the area through further development of emergency action plans, zoning and building restrictions, and advanced warning systems. Although the NAA does not provide the additional flood risk reduction and life safety benefits as found in the BCDD alternative.

Study Products

The study has provided the local communities with new hydrologic analysis, hydraulic modeling and floodplain mapping of their flood hazard areas. It gave the local communities the technical information needed to regulate development and to update their FEMA floodplain maps for the National Flood Insurance Program. Local communities have used the information provided by the Corps to update their emergency action plans and to improve their flood warning system with the installation of new stream gages. This will help the communities be better prepared for future

flooding events. The study achieved its goal in providing an accurate informational picture of the current flood risk management status for the area.

The actions of the local governments, such as new stream gauges, emergency action plans, zoning and building restrictions, and advanced warning systems has reduced and will continue to reduce the health and safety risks in the area. The No Action Alternative does not provide the flood risk reduction and life safety benefits provided by the BCDD alternative.

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Table of Contents

Tables

Figures

Acronym List

AAHUs	Average Annual Habitat Units
APHIS	Animal and Plant Health Inspection Services
AEP	Annual Exceedance Probability
AOU	American Ornithologists' Union
BCR	Benefit Cost Ratio
BMPs	Best Management Practices
BP	Before Present
CAA	Clean Air Act
cfs	Cubic Feet Per Second
DSHS	Department of State Health Services
DNL	Day-Night Average Sound Level
EAA	Edwards Aquifer Authority
EAD	Expected Annual Damages
E.O.	Executive Order
ER	Engineering Regulation
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FEPP	Flood Emergency Preparedness Plans
FFPA	Farmland Protection Policy Act
FRM	Flood Risk Management
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
GCWA	Golden-cheeked Warbler
GBRA	Guadalupe – Blanco River Authority
GRP	Gross Regional Product
HUD	Housing and Urban Development
IPaC	Information for Planning and Consultation
LERRDs	Lands, Easements, Rights-of-way, Relocations, and Disposal Areas
MAMP	Monitoring and Adaptive Management Plan
MOA	Memorandum of Agreement
mph	Miles per Hour
NAA	No Action Alternative
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NFS	Non-Federal Sponsor
NOAA	National Oceanographic Atmospheric Administration
NPDES	National Pollutant Discharge Elimination
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
OSE	Other Social Effects
OSUM	Ohio State University at Marion

PA	Programmatic Agreement
PED	Planning, Engineering, and Design
RED	Regional Economic Development
SHPO	State Historic Preservation Officer
T&E	Threatened and Endangered
TCEQ	Texas Commission on Environmental Quality
THC	Texas Historic Commission
TPWD	Texas Parks and Wildlife Department
TSWQS	Texas Surface Water Quality Standards
TWDB	Texas Water Development Board
TXNDD	Texas Natural Diversity Database
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGCRP	US Global Change Research Program
VOC	Volatile Organic Compounds
WRDA	Water Resource Development Act

1.0 Introduction

1.1 Project and Study Authorization

The Lower Guadalupe Flood Risk Management (FRM) Study is conducted as an interim response to the Guadalupe and San Antonio Rivers and Tributaries, Texas, resolution adopted by the Committee on Transportation and Infrastructure, U.S. House of Representatives, in House Resolution docket 2547 dated 11 March 1998, which reads as follows:

> "*Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the report of the Chief of Engineers on the Guadalupe and San Antonio Rivers, Texas, published as House Document 344, 83rd Congress, 2nd Session, and other pertinent reports, with a view to determining whether any modifications to the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of flood control, environmental restoration and protection, water quality, water supply, and allied purposes on the Guadalupe and San Antonio Rivers in Texas*."

1.2 Purpose and Need

The Guadalupe River Basin has recurring flooding, with six major flood events in the last 10 years. A renewed emphasis came after the Memorial Day weekend 2015, the Lower Guadalupe and Blanco River Basins experienced record rainfalls and flooding. The estimated damages were in excess of $32 million and 12 lives were lost. A second flood event occurred in October 2015 flooding over 1,000 structures in San Marcos on the Blanco River.

1.2.1 Flooding History

Since 1913, the study area has experienced 28 (Table 1) major flood events, 14 of which affected the majority of the Lower Guadalupe River Basin. The most significant floods occurred in 1998, 2002, and 2015, with two occurring in 2015. The most recent flood event occurred in August 2017, with the most severe occurring in October 1998 and May 2015 on the Guadalupe and Blanco respectively. More details on the flood history are in Appendix A.

Table 1: Major Historical Flood Events

Date of Flood	Observed Peak Flow (cfs)		
	Guadalupe River above Comal River at New Braunfels	Blanco River at Wimberley	Guadalupe River at Victoria
Jul-1932	95,200	-	-
Jun-1935	101,000	-	38,500
Jul-1936	-	-	179,000
Sep-1936	52,800	-	-
Sep-1952	72,900	95,000	-
Apr-1957	26,900	62,600	35,300
Feb-1958	-	-	58,300
May-1958	47,900	96,400	-
Oct-1959	35,700	40,100	-
Jun-1961	-	-	55,800
Sep-1967	-	-	70,000
May-1972	92,600	-	58,500
Sep-1981	-	-	105,000
***Jun-1987**	-	-	83,400
Dec-1991	-	32,900	61,500
Oct-1998	90,000	88,500	466,000
Nov-2001	-	108,000	-
Jul-2002	73,200	82,500	71,700
Nov-2002	-	-	58,500
Nov-2004	17,000	34,000	102,000
Mar-2007	-	36,900	-
Jun-2010	69,000	-	-
Oct-2013	25,500	75,800	-
May-2015	-	175,000	49,100
Oct-2015	39,000	71,000	-
Aug-2017	-	-	86,500

*Canyon Lake Dam and Reservoir completed construction in 1964

1.2.2 Federal Interest

There are 11 urban to semi-urban areas focused on with an estimated 2,200 structures (residences or businesses) within the 0.01 Annual Exceedance Probability (AEP) floodplain (more commonly known as the 100 year floodplain), whose structures and content are valued at over $250 million. Also over the last 10 years, approximately 12 lives were lost. These deaths occurred when a house in Wimberley was swept of its piers during the May 2015 flood.

1.3 Study Area

The study area is comprised of the portions of the Guadalupe and Blanco River Basins in Texas that are under the stewardship of the Guadalupe – Blanco River Authority (GBRA). The study area includes the Guadalupe River from Canyon Lake Dam downstream to Victoria (the Lower Guadalupe River Basin), Texas, the San Marcos River from the headwaters, the San Marcos Springs, to its confluence with the Guadalupe River near Gonzales, Texas, and the Blanco River from the confluence with the San Marcos River upstream to its headwaters, as shown in Figure 1.

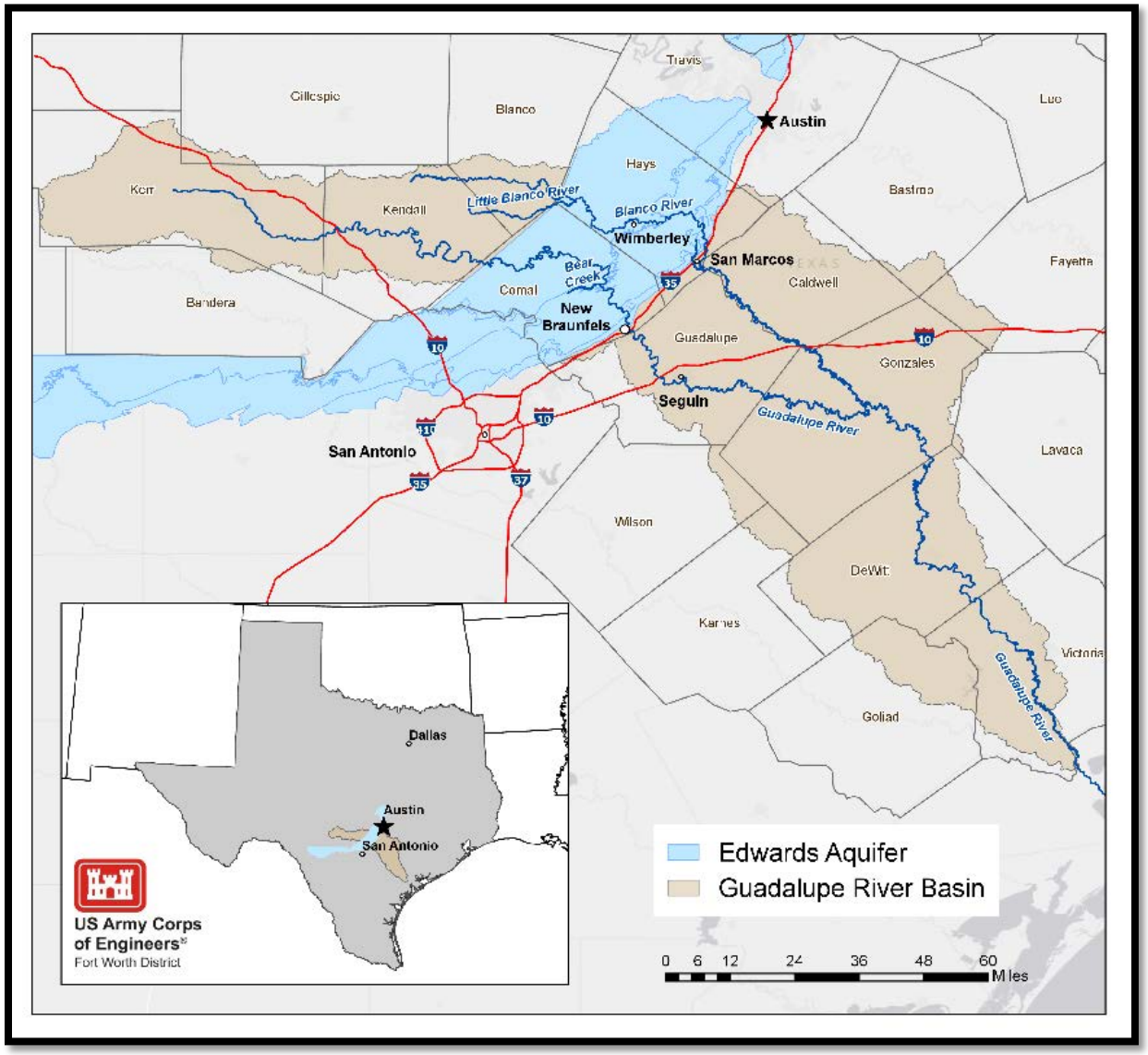


Figure 1: Lower Guadalupe River FRM Study Area

The Guadalupe River Basin is about 6,700 square miles. While the study area covers only the approximately 5,300 square miles of the 0.02 AEP floodplain, it drains all or major portions of 8 Texas counties (Comal, Blanco, Guadalupe, Hays, Caldwell,

Gonzales, DeWitt, and Victoria). Three large urban areas lie within the study area including San Marcos, New Braunfels, and Victoria. Two Interstate Highways, I-35 and I-10, traverse the northern portion of the study area. The I-35 corridor has seen substantial residential and commercial development. The study area's population is estimated at 397,000, or approximately 71 percent of the total population of the 7 counties.

1.3.1 Non-Federal Sponsors

The Non-Federal Sponsor (NFS) for this study is the GBRA.

1.3.2 Damage Centers

Within the study area there are 11 developed areas that were considered damage centers (Figure 2): Woodcreek, Wimberley, Kyle, San Marcos, Lockhart, Luling, New Braunfels, Seguin, Gonzales, Cuero, and Victoria. Due to their geographic proximity and hydraulic connectivity Seguin and New Braunfels were treated as a single center.

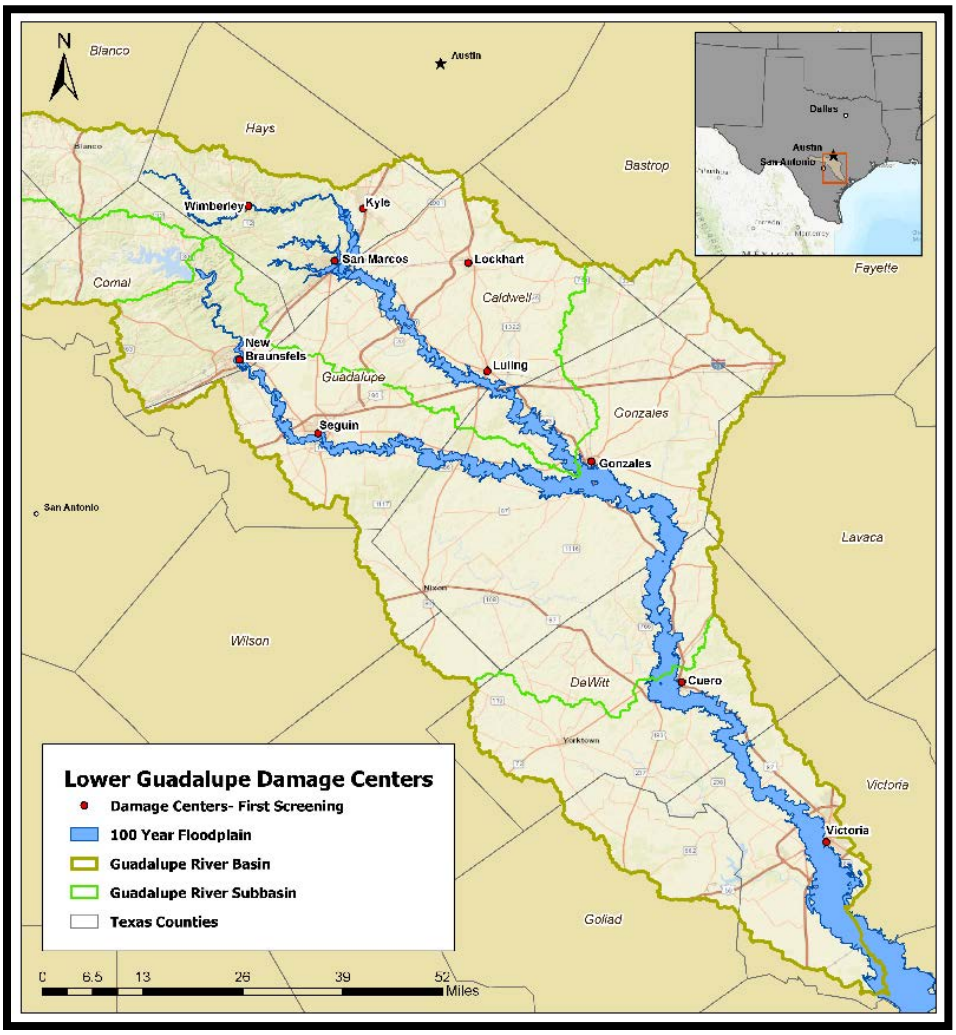


Figure 2: Damage Centers

The damage centers were analyzed to determine the number of structures in the floodplain and their total value (Table 2). These values were used to determine which areas had the largest flood risk and, since they coincided with the previous loss of life, they would be the main focus of the study.

Table 2: Damage Center Structure Count and Values

Damage Center	Est. Number of Structures	Percent of Structures	Est. Total Value of Structures	Percent of Total Value
City of Victoria	522	23 percent	$50,000,000	20 percent
Cities of Seguin and New Braunfels	420	19 percent	$56,000,000	22 percent
City of Wimberley	198	9 percent	$45,000,000	18 percent

City of San Marcos	363	16 percent	$45,000,000	18 percent
City of Gonzales	320	14 percent	$23,000,000	9 percent
City of Cuero	264	12 percent	$15,000,000	6 percent
City of Kyle	73	3 percent	$11,000,000	4 percent
City of Woodcreek	23	1 percent	$5,000,000	2 percent
City of Lockhart	34	2 percent	$4,000,000	2 percent
City of Luling	13	1 percent	$1,000,000	0 percent
Total	2,230	100 percent	$253,000,000	100 percent

1.3.2.1 Screening of Damage Centers

The damage centers were screened and four damage centers (Victoria, Wimberley, San Marcos, and New Braunfels) were identified as having the greatest potential for a Federal project, even though all damage centers could have the potential for small projects. Therefore, the damage centers focused on in this study were Victoria, New Braunfels and Seguin, Wimberley, and San Marcos. More details on screening damage centers can be found in the Appendix H.

According to Section 308 of Water Resource Development Act (WRDA) 1990, that the flood damage benefits from structures within the 0.01 AEP floodplain at the time of their construction, can only be used to justify a federal project if they come from events greater than the 0.01 AEP event. Most of the damages in Victoria's 0.01 AEP floodplain are from structures built after 1992; therefore those benefits could be subject to WEDA 1990. Without determining which damages were allowable, the damages in Victoria were too small to justify a large Federal project. Therefore, Victoria was also screened from further study.

1.4 Related Documents

1.4.1 2007. Espey Consultants, Inc. San Marcos Flood Protection Plan.

This document is a Flood Protection Plan for the City of San Marcos, Texas. The purpose of the project was to develop comprehensive hydrologic and hydraulic models of watersheds within and upstream of the City of San Marcos to develop flood protection alternatives (both structural and non-structural). The study included the watersheds of Blanco River, San Marcos River, Bypass Creek, and others. It evaluated the watershed as a system independent of political boundaries. Major elements of the San Marcos Flood Protection Plan included comprehensive hydrologic and hydraulic analysis, flood mitigation recommendations, and preliminary phasing and implementation recommendations to implement the flood mitigation alternatives.

1.4.2 2008. Federal Emergency Management Agency. Flood Protection Project, Comal County, Texas, FEMA-1257-DR-TX / FEMA-1606-DR-TX.

The project analyzed the proposed impacts of reducing flooding levels on downstream waters, especially on Dry Comal Creek and the Guadalupe River, near New Braunfels. The Proposed Action constructed a Flood Retention Structure on an unnamed tributary of Dry Comal Creek, approximately 1 mile north of I-35, described in Section 1.5.3 .

1.4.3 2014. USACE Fort Worth District. San Marco River Section 206 Detailed Project Report and Integrated Environmental Assessment.

The purpose of this study is to identify potential aquatic ecosystem restoration alternatives for the San Marcos River. The National Ecosystem Restoration (NER) Plan would improve the riparian corridors' ability to function as a filter of storm water runoff and substantially reduce the input of sediments in the river. Concurrently, the removal of sediments and invasive species from approximately 3.5 miles of river channel would restore native substrates and local hydraulics. Both the Texas Parks and Wildlife Department (TPWD) and US Fish and Wildlife Service (USFWS) are supportive of this Section 206 project.

1.4.4 2015. Lower Guadalupe River Basin Guadalupe-Blanco River Authority Interim Feasibility Study

The purpose of this study was to establish a baseline condition and to complete a preliminary assessment of flood risk management alternatives. The information and analysis done during the investigation served as a base for the current study effort. The work was divided into multiple phases and the reports are included in Appendix A.

1.5 Other Projects in Study Area

1.5.1 Canyon Lake Reservoir

Canyon Lake Reservoir is an existing Corps reservoir that was authorized by the Rivers and Harbors Act of 1945, PL 79-14, as modified by the Flood Control Act of 1954, PL 83-780. Canyon Lake is located in Comal County, Texas 12 miles northwest of New Braunfels, Texas, on the Guadalupe River. The project consists of a rolled earth-fill

dam (6,830 feet long by 224 feet high); an uncontrolled spillway (1,260 feet wide in the saddle); and, one 10-foot diameter conduit controlled by two slide gates (5-foot, 8-inch by 10-foot) completed in 1964. The flood control storage is 354,600 acre-feet. Eight recreation areas comprise 1,544 acres. Visitation totaled 2,296,223 visitor hours in 2011. The GBRA is the sponsor for water supply storage and hydropower.

1.5.2 Spring Lake Aquatic Ecosystem Restoration, San Marcos, Texas.

This project restored valuable aquatic and floodplain habitats throughout the Spring Lake area, which were degraded by the construction, operation, and existence of the now-closed Aquarena Springs Center, the surrounding golf course, and other urban developments. The restoration project helped restore and protect sensitive habitat for multiple federally listed species. Construction was complete in 2014.

1.5.3 Dry Comal Creek Flood Retarding Structure, Krueger Canyon, New Braunfels, Texas.

Construction of this dry detention dam was prompted by the 1998 flood that resulted in the loss of 29 people and more than $1 billion in damages (Section 6.1.2 - *2008. Federal Emergency Management Agency. Flood Protection Project, Comal County, Texas*). The facility can hold up 2,878.6 ac-ft of water with continuous, but limited, flows through a 5' x 6' culvert. Construction costs were $19.2 million, with the City of New Braunfels, Texas, sharing $1.5 million of the cost. $12 million came from federal grants. Krueger Canyon dam was completed in 2013.

1.6 National Environmental Policy Act Considerations

Environmental conditions evaluated during the FRM study included aquatic, biological, cultural, economic, and social resources. Resources of concern in relation to this study centered on life and property safety. In addition, threatened and endangered (T&E) species, particularly the golden-cheeked warbler (*Setophaga chrysoparia*), cultural resources, and ground water resources like the Edwards Aquifer were accounted for during plan formulation and evaluation. See Section 2.0 and Section 5.0 of this report, as well as the Appendix C, for details on other resources evaluated.

2.0 Affected Environment (Existing Condition) and No Action Alternative (Future Without Project Condition)

The affected environment or existing condition is a baseline from which all of the future conditions are built, and is made up of the natural and physical environment as well as the relationship of people with the environment. The future without project condition, also known as the No Action Alternative (NAA), is the anticipated future for a given resource if no Federal action is implemented. The NAA serves as the baseline against which all action alternatives effects are measured. The 50 year period of analysis for this study begins in 2028 to allow for Congressional approval and appropriations as well as engineering and design prior to construction; therefore, the planning horizon for this study is 2028-2078. In general few changes for most resources are expected with the

NAA. Flash flooding and urban sprawl are expected to continue throughout the I-35 corridor. More detail for each resource is available in Section 5.0 regarding the NAA.

The focused study area is comprised of three sub-areas that will be the focus of Section 2.0 ; Guadalupe River from just below Canyon Dam downstream to Seguin, Texas, Bear Creek from FM 2722 down to its confluence with the Guadalupe River, and the San Marcos area from just below Cummings Dam, southeast of San Marcos, on the San Marcos River upstream approximately two and a half river miles near the City of San Marcos' Wastewater Treatment Plant. The San Marcos area also includes a one half mile reach of the Blanco River upstream of the San Marcos River and Blanco River confluence. Figure 3 shows the location of the study areas.

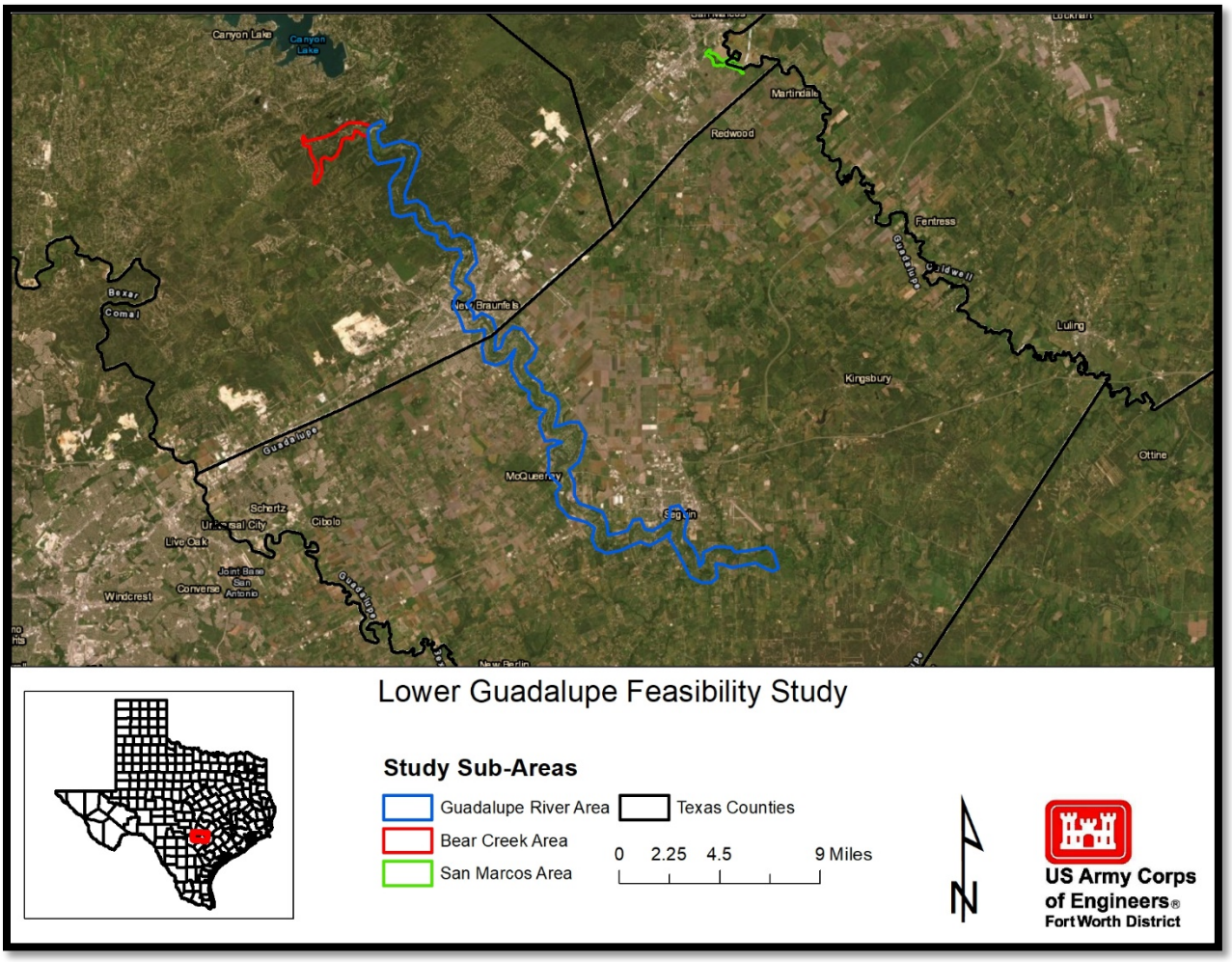


Figure 3: Lower Guadalupe Study Sub-Areas.

Conditions described in this section summarize the technical evaluations both the resources for National Environmental Policy Act (NEPA) and those that drive the National Economic Development (NED). When not discussed separately it is assumed the existing conditions for a resource for each area is similar. While all NEPA resources

are significant to various institutions, this section discusses only those resources that would be directly or indirectly impacted by the proposed alternatives. Details on both the existing condition and NAA are detailed in the following sections.

2.1 Climate

The study area is in central Texas which has a temperate warm, subtropical, and humid climate. It is characterized by hot summers and mild winters, with occasional extreme cold temperatures in winter months for a short duration. The climate of New Braunfels has similar temperatures and precipitation to the rest of the study area (Figure 4). The average low and high temperatures for New Braunfels, are 38 ° Fahrenheit (F) in January and 95°F in August (U.S Climate Data, 2019) respectively.

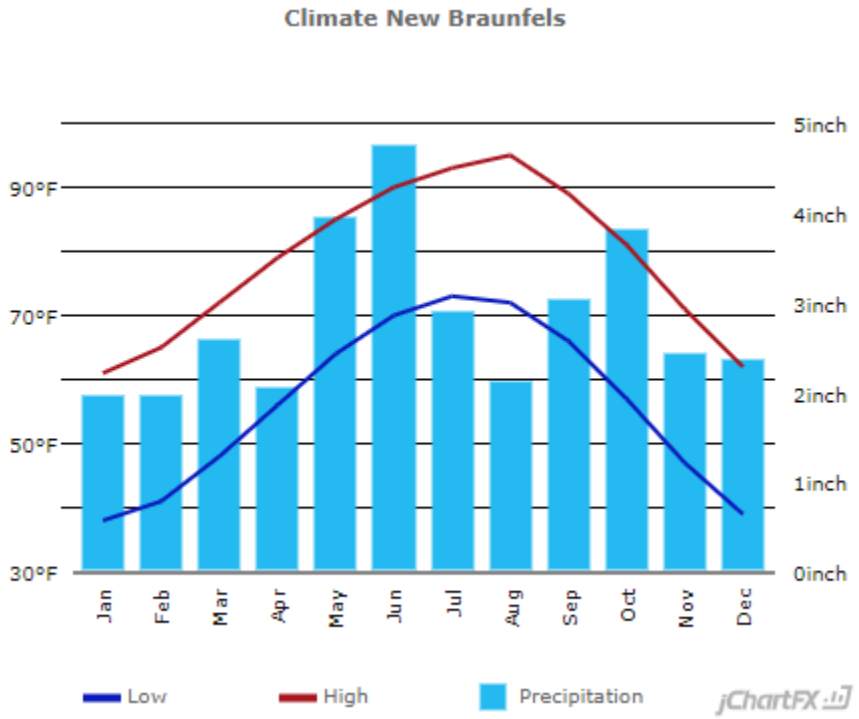


Figure 4: Average Monthly Temperature and Precipitation for New Braunfels, Texas.

Annual precipitation for New Braunfels averages 33.98 inches per year (U.S Climate Data, 2019). The area has experienced up to 18.74 inches of rain in a single month (National Oceanic and Atmospheric Administration [NOAA], 2019B) with wettest being during late spring and early fall. The highest rainfall events typically occurring in May and June then again in September and October. This area experiences extreme droughts and flooding. Snow rarely falls and is an insignificant source of moisture. Relative humidity ranges from 1 percent to 83 percent with the driest period around December and January, with the most humid period in June (Cedar Lake Ventures Inc, 2019).

The prevailing surface winds are southerly with the winter months being more northerly. In a typical year, wind speeds vary from 0 to 17 miles per hour (mph) with spring and winter being the windiest times of the year. There is no anticipated change from the existing condition to the NAA.

2.1.1 Climate Change

The U.S. Global Change Research Program (USGCRP) looks at potential impacts of climate change globally, nationally, regionally, and by resource (e.g., water resources, ecosystems, human health). The Lower Guadalupe study area is within the Southern Great Plains region of analysis. Over the last few decades, the Southern Great Plains have seen an increase of higher temperatures, as well as an overall increase in total precipitation. Within this region, there was a 1.5°F increase in average temperatures from the 1960's to the year 2000 (USGCRP, 2014). In 2018, the 4th Annual Climate Assessment noted climate change in the Southern Great Plains is expected to lead to an increase in average temperatures. The USGCRP study also states that frequency, duration, and intensity of extreme heat events and a reduction in extreme cold events is also expected.

2.2 Air Quality

National Ambient Air Quality Standards (NAAQS) have been established by the USEPA, Office of Air Quality Planning and Standards (OAQPS), for six criteria pollutants that have been deemed to potentially impact human health and the environment. These include: 1) carbon monoxide (CO); 2) lead (Pb); 3) nitrogen dioxide (NO2); 4) ozone (O3); 5) particulate matter <10 microns (PM10); and 6) sulfur dioxide (SO2). Ground level or "bad" O3 is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC (TCEQ, 2018C).

On November 30, 1993 the USEPA published a Conformity Rule requiring all Federal actions to conform to appropriate State Implementation Plans that were established to improve ambient air quality. At this time, the Conformity Rule only applies to Federal actions in non-attainment areas. A non-attainment area is an area which does not meet one or more of the NAAQS for the criteria pollutants designated in the Clean Air Act (CAA).

2.2.1 Guadalupe River and Bear Creek

The geographical region surrounding the Guadalupe River and Bear Creek is located within the State Implementation Plan for the San Antonio area (Bexar, Comal, Guadalupe, and Wilson Counties) (TCEQ, 2019A). Air quality attainment status was accessed on September 14, 2018 for the San Antonio area which showed all pollutants are in attainment status except for the pending designation for the 2015 standard for Ozone (0.070 ppm). The region meets the National Air Quality Standards for the criteria pollutants designated in the CAA, except for Bexar County. Bexar County is listed as

having marginal non-attainment for the 2015 standard for Ozone (0.070 ppm). Consequently, a conformity determination may be required if any construction activities are proposed in Bexar County. The attainment deadline for Bexar County is listed as 2021. As such, it is assumed that attainment will be reached in the NAA.

2.2.2 San Marcos

The geographical region surrounding the San Marcos River is located within the State Implementation Plan for the Austin area (Hays, Caldwell, Bastrop, Travis and Williamson Counties) (TCEQ, 2019A). Air quality attainment status was accessed on March 22, 2019 for the Austin area which showed all pollutants in attainment status. The region meets the National Air Quality Standards for the criteria pollutants designated in the CAA. Consequently, a conformity determination is not required. There is no anticipated change from the existing condition to the NAA.

2.3 Topography, Geology, and Soils

2.3.1 Topography

2.3.1.1 Guadalupe River

The study area lies within the Edwards Plateau and Blackland Belt Provinces and flows through the Balcones Fault. The land upstream of New Braunfels along the Guadalupe River exhibits extensive hills, canyons, shallows soils. Downstream of New Braunfels the landscape transitions to flatter terrain with deeper soils.

2.3.1.2 Bear Creek

Bear Creek lies within the Edwards Plateau topographic province of Texas. The region, locally known as the “Hill Country,” is a geographically young plateau with moderate to steep hills. Land forms surrounding the area feature steep canyons and generally rugged topography. Any relative flat areas has been turned into pastures and farmlands. Hills and valleys in the Edwards Plateau are generally characterized by dense oak-juniper forests. Over the past few years, new residential developments have appeared near the headwaters of Bear Creek.

2.3.1.3 San Marcos

The San Marcos River lies on the northern outer edge of the Blackland Belt topographic province of Texas. The region is characterized by rolling planes that are increasingly turning from once abundant farm fields into residential and industrial centers. Only the lands along and within the creeks and rivers have not converted to agriculture and urbanization purposes. The river channels are well defined in undeveloped areas with narrow corridors of mixed riparian forest and scrub shrub understories bracketing the banks. The meandering nature of the narrow rivers and creeks form tear drop peninsulas that are scarred by past changes in the river morphology.

2.3.2 Geology

2.3.2.1 Guadalupe River

The Guadalupe River flows through the Pleistocene-Holocene Terrace near Canyon Lake Dam then proceeds to flow through Early Cretaceous/Glen Rose Limestone, Early Cretaceous/Edwards Limestone, Late Cretaceous/Buda Limestone, Early Cretaceous/Edwards Limestone, and Pleistocene-Holocene Terrace in its course to New Braunfels. Upon reaching New Braunfels the river continues to flow through the Pleistocene-Holocene Terrace until just above Seguin where it flows through the Quaternary/Alluvium to the southern end of Seguin, Texas (Texas Master Naturalist, 2019).

2.3.2.2 Bear Creek

The geology of Bear Creek can be summarized as layers of limestone, marl, shale and dolomite. The limestone that underlies Bear Creek originated in the Cretaceous Era and developed over millions of years. The Trinity Group of rock strata that underlies the area consists of the Glen Rose formation, which is then divided into an upper member and lower member. The upper member is about 400 feet thick and consists of alternating thin beds of limestone, marl, and shale with some dolomite. The lower member consists of about 200 feet of alternating limestones, marls, and shales overlying about 100 feet of massive, fossiliferous limestone.

2.3.2.3 San Marcos

The San Marcos River lies within a geologic region known as the Balcones fault zone, which consists of numerous fault zones, cross faults, grabens, horsts, step faults, en echelon faults and similar features. The area bedrock is characterized by being composed of limestones, dolomites, marls, chalk and calcareous clays. This difference in erosion resistance results in escarpments, generally called Balcones Escarpment. East of the escarpment the soil cover is thick and forms prime agricultural soil and west of the scarp the soils are thin and rocky and are primarily ranches and agricultural land (Grimshaw and Woodruff, 1976).

2.3.3 Soils

As required by Section 1541(b) of the Farmland Protection Policy Act (FPPA) of 1980 and 1995, 7 U.S.C. 4202(b), federal and state agencies, as well as projects funded with federal funds, are required to (a) use the criteria to identify and take into account the adverse effects of their programs on the preservation of farmland, (b) consider alternative actions, as appropriate, that could lessen adverse effects, and (c) ensure that their programs, to the extent practicable, are compatible with state and units of local government and private programs and policies to protect farmland. Sunev silty clay loam, with 0 to 1 percent and of 1 to 3 percent slopes soils are the only soils in the project area that are considered to be of state importance for farmlands.

2.3.3.1 Guadalupe River

The Guadalupe River is characterized by two distinct soil areas, Edwards Plateau and Blackland Prairie Soils. With the Edwards Plateau Soils occurring north of New Braunfels and Blackland Prairie Soils occurring within the city and going on south through the remainder of the study area. The difference between these two soil areas is

that the Edwards upland soils occurs in shallow light colored layers, and on top of limestone; while the Blackland Soils are thick regardless topographic position and have the same dark-gray to black colors (Texas Almanac, 2019). Furthermore, within the valleys the Edwards soils are at their thickest with the least amount of stones and at their darkest color, brown.

While the map of the entire Guadalupe River area is too coarse to visually display all soil types. Table 3 shows the Prime and other important Farmlands that are common downstream of New Braunfels.

Table 3: Soil & Surface Types within the Guadalupe River Area

Map Unit Symbol	Soil Type	Farmland Status
AnB	Anhalt clay, 1 to 3 percent slopes	All areas are prime farmland
BtG	Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes	Not prime farmland
CrD	Comfort-Rock outcrop complex, 1 to 8 percent slopes	Not prime farmland
ErG	Eckrant-Rock outcrop association, 8 to 30 percent slopes	Not prime farmland
RUD	Rumple-Comfort association, 1 to 8 percent slopes	Not prime farmland
SuB	Sunev clay loam, 1 to 3 percent slopes	State important

2.3.3.2 Bear Creek

Bear Creek is characterized by valley bottoms containing up to 55 feet of alluvial overburden with the uplands thinly mantled with soil or have rocky outcroppings devoid of soil. The predominant soil series within Bear Creek is the Eckrant-Rock outcrop association. The Eckrant soil makes up 65 percent of the association, forms 0.1-12 inches thick surface layers, is normally found on well drained sloping areas, made up of weathered limestone material, and is not a prime farmland soil. The rock outcrop makes up 27 percent of the association, forms 0-80 inches thick surface layers, and is normally found on sloping areas. While well drained, the limestone bedrock is also not considered a prime farmland soil. The NRCS Web Soil Survey (2018) reports 7 soil types occurring within the Bear Creek area. Table 4 shows the acreage and farmland status associated with each soil & surface type in the area. Figure 5 shows the location of each soil and surface type.

Table 4: Total Acres of Soil & Surface Types within Bear Creek Area

Map Unit Symbol	Soil Type	Number of Acres	Farmland Status
BtG	Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes	400.1	Not prime farmland
CrD	Comfort-Rock outcrop complex, 1 to 8 percent slopes	129.5	Not prime farmland
ErG	Eckrant-Rock outcrop association, 8 to 30 percent slopes	465.1	Not prime farmland
Or	Orif soils, moist, 0 to 3 percent slopes, frequently flooded	0.8	Not prime farmland
RUD	Rumple-Comfort association, 1 to 8 percent slopes	150.1	Not prime farmland
SuA	Sunev silty clay loam, 0 to 1 percent slopes	13.8	State important
SuB	Sunev clay loam, 1 to 3 percent slopes	71.6	State important
Water	Water	5.7	Not prime farmland
Total		1,236.7	

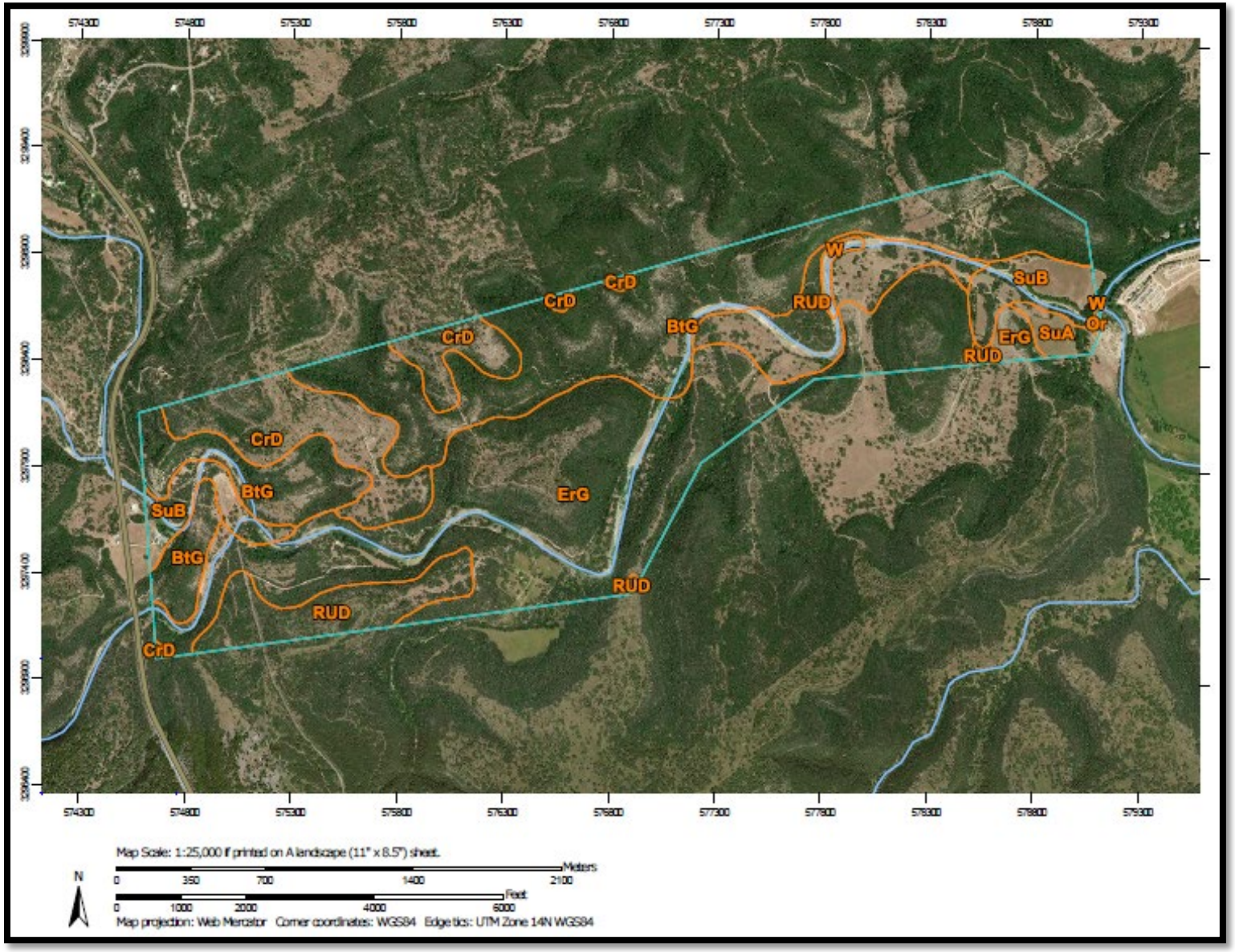
2.3.3.3 San Marcos

The predominant soil series within the San Marcos are is the Oakalla silty clay loam. The soil forms 0.1-80 inches thick surface layers, is normally found on floodplains with 0 to 2 percent slopes, that is frequently flooded soil well drained, is a loamy alluvium derived from limestone, and is not a prime farmland soil. The Natural Resource Conservation Service (NRCS) Web Soil Survey (2019) reports 7 soil types occurring within the San Marcos area. Table 5 shows the acreage and farmland status associated with each soil & surface type in the area. Figure 6 shows the location of each soil and surface type.

Table 5: Total Acres of Soil & Surface Types within the San Marcos River

Map Unit Symbol	Soil Type	Number of Acres	Farmland Status
FeF4	Ferris clay, 5 to 20 percent slopes, severely, eroded	8.3	Not Prime Farmland
HeD3	Heiden clay, 5 to 8 percent slopes, eroded	0.4	Not Prime Farmland
HoB	Houston Black clay, 1 to 3 percent slopes	1.2	Prime Farmland
LeB	Lewisville silty clay, 1 to 3 percent slopes	11.8	Prime Farmland
Oa	Oakalla silty clay loam, 0 to 1 percent slopes, rarely flooded	1.4	Prime Farmland
Ok	Oakalla silty clay loam, 0 to 2 percent slopes, frequently flooded	83.7	Not Prime Farmland
Pt	Pits	29.1	Not Prime Farmland
SuA	Sunev silty clay loam, 0 to 1 percent slopes	0.5	State Important
W	Water	16.5	Not Prime Farmland
	Total	152.9	

The prime farmland soils are as follows: Lewisville silty clay, 0 to 1 percent and 1 to 3 percent slopes; Houston Black clay, 1 to 3 percent slopes; and the Oakalla silty clay loam, 0 to 1 percent slopes, rarely flooded. There is only 1 soil of statewide importance and that is the Sunev silty clay loam, 0 to 1 percent slopes.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Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

Figure 5: Soil Map of Bear Creek

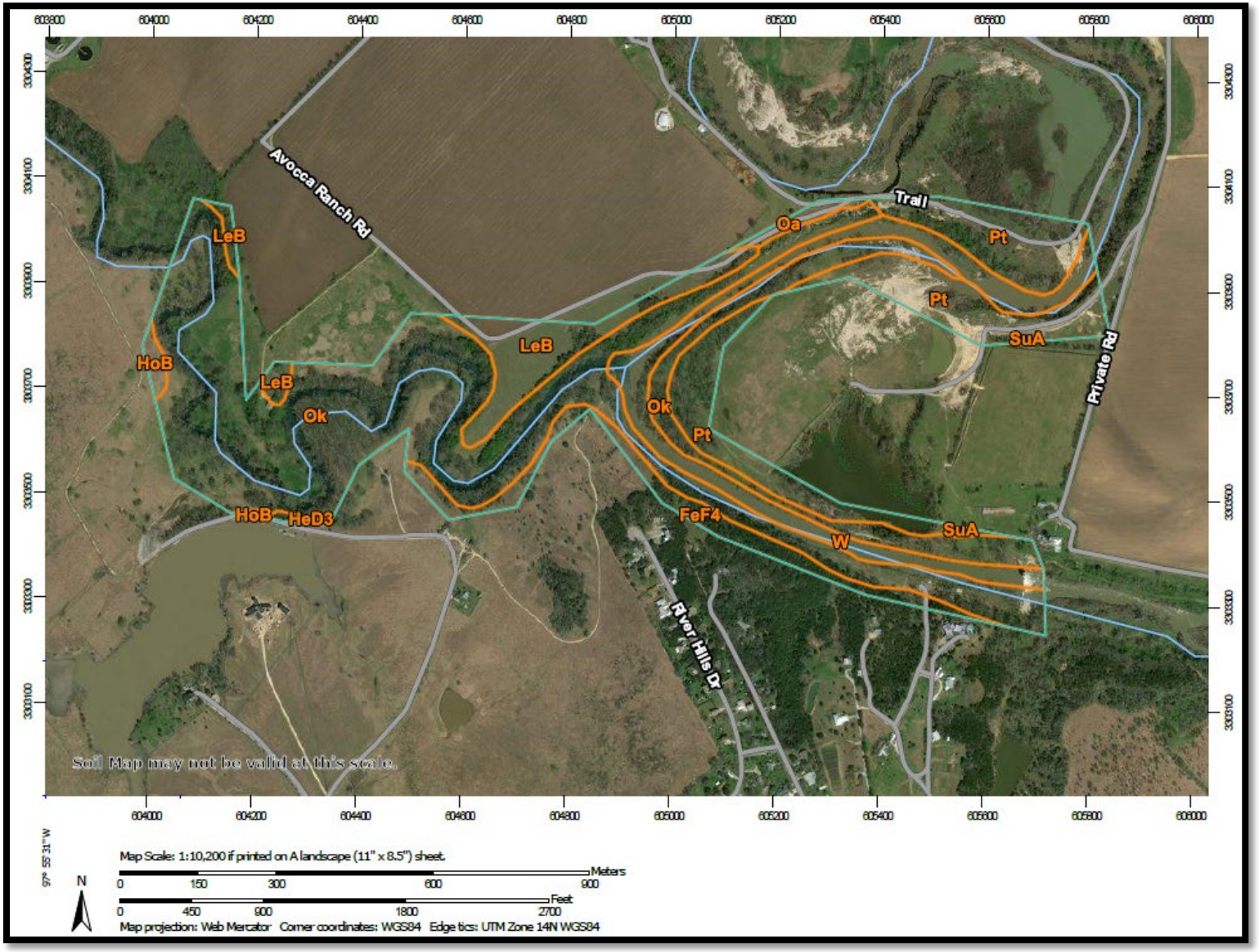

Figure 6: Soil Map of San Marcos

2.4 Land Use

2.4.1 Guadalupe River

The Guadalupe River is bracketed by a mixture of land uses. Residential and industrial areas are dominant near the larger cities and gradually transition to agriculture and mixed forested land cover in more remote regions. Forested areas are primarily north of New Braunfels and agricultural areas south of the city with the river is mostly paralleled by a thin strip of mixed riparian forest and agricultural lands.

2.4.2 Bear Creek

Bear Creek lies within a rural portion of Comal County with steep hills, dense oak-juniper forests, and limited pastures and farmlands due to topography. The few non-forested areas are typically used for homes or pastures and farms scattered out in individual patches. There are a few private homes located throughout the rural countryside. While Bear Creek meets the Guadalupe River a few miles downstream, an outdoor recreation hotspot in Texas, Bear Creek generally lacks public access points, parks, and trails. As such, recreation facilities are virtually non-existent.

2.4.3 San Marcos

Downstream of the City of San Marcos, the San Marcos and Blanco Rivers are primarily surrounded by flatland checkered pastures, farms and sparse residential neighborhoods. Narrow bands of mix riparian forest and scrub shrub line the river at various buffering distances.

2.5 Water Resources

2.5.1 Hydrology

2.5.1.1 Lower Guadalupe River

The Guadalupe River Basin is located in south Texas, stretching from its headwaters, which are approximately 65 miles northwest of San Antonio, to its confluence with San Antonio Bay, which is 30 miles southeast of Victoria, Texas. The Lower Guadalupe River basin has a drainage area of approximately 4,530 square miles between Canyon Dam and the confluence of the Guadalupe and San Antonio Rivers. From its source, the Guadalupe River flows in an easterly direction for a distance of approximately 184 miles to the Balcones Escarpment near the city of New Braunfels. From there, the river turns southeasterly and flows 280 miles to San Antonio Bay, an estuary of the Gulf of Mexico.

Canyon Dam, which is the only major flood control reservoir in the basin, is located on the Guadalupe River 12 miles northwest of New Braunfels, Texas. Six hydropower dams are located on the Guadalupe River downstream of New Braunfels. These hydropower dams are operated by the Guadalupe-Blanco River Authority and do not contain any significant flood storage.

The Lower Guadalupe River watershed was modeled, under contract with Halff, to determine the existing conditions standard frequency flows for use in determination of potential damage centers within the watershed. A new basin-wide hydrologic model was developed in HEC-HMS. Historical storms occurring in October 1998, July 2002, November 2004 were used in the calibration of the Lower Guadalupe basin-wide HEC-HMS model.

As part of the Lower Guadalupe Feasibility Study, a gage analysis was performed for all discharge gages within the Lower Guadalupe River basin with sufficient period of record using standard Bulletin 17B methodologies. The following six gages were used to develop frequency flows for the Guadalupe River: the Guadalupe River above the Comal River at New Braunfels, the Guadalupe River at New Braunfels, the Guadalupe River at Gonzales, the Guadalupe River below Cuero, and the Guadalupe River at Victoria. The “Guadalupe at Sattler” gage is highly affected by Canyon Dam outflows and was not a good candidate for Bulletin 17B analysis. Therefore, a set of Canyon Dam outflows for the different frequencies was provided by the Water Management Section of the Fort Worth District USACE.

The Guadalupe River gage analysis results were used to interpolate the set of frequency flows to be used in the final hydraulic modeling. The basin-wide HEC-HMS model was used to proportion peak flows between the gages. The final adopted frequency flows for the Lower Guadalupe were taken as a combination of the statistical gage analyses and the HEC-HMS model results. A full listing of the final adopted frequency flows for the Lower Guadalupe River, and additional details on the basin-wide hydrology, can be found in in Appendix A.

2.5.1.1 Bear Creek

Bear Creek is a tributary of the Guadalupe River with about 16.7 square miles of drainage area. Its confluence with the Guadalupe River is located about 9 river miles downstream of Canyon Dam and about 15 river miles upstream of New Braunfels, Texas. It is the largest tributary upstream of the New Braunfels damage center that is not regulated by a dam. The steep topography of the Bear Creek watershed results in high velocities and flash flooding. The hydrology of Bear Creek was determined by the Lower Guadalupe River HEC-HMS model, as described in the preceding section. Additional hydrology information can be found in Appendix A.

2.5.1.2 San Marcos

After completion of the Lower Guadalupe River basin-wide hydrology, the hydrology for the Blanco and San Marcos River basin was updated to include additional calibrations for the May and October 2015 flood events and to add additional detail near the cities of Wimberley and San Marcos. This hydrology was updated as part of a separate study for FEMA (InFRM, 2016).

To better define the hydrology of the San Marcos River Basin, additional subbasin breaks were added to the original basin-wide HEC-HMS model. The total number of subbasins was increased from 19 to 47. Additional subbasins were added in two areas: the Blanco River and Sink Creek. These areas were selected for additional detail due to their locations just

upstream of the developed areas of Wimberley and San Marcos. The San Marcos River HEC-HMS model used the same methods and data sources for initial parameters as the Lower Guadalupe basin-wide HEC-HMS model. Detailed routing data was added to the HEC-HMS model for the associated new river reaches and for other reaches where detailed hydraulic modeling was available.

After building the HEC-HMS model, the InFRM team calibrated the model to verify it was accurately simulating the response of the watershed to a range of observed flood events. A total of eight recent storm events were used to fine tune the model, including the May 2015 and October 2015 flood events, which caused extensive damage in San Marcos, Texas. The final model results accurately simulated the expected response of the watershed, as it reproduced the timing, shape, and magnitudes of the observed floods very well. Existing conditions frequency flow values were then calculated in HEC-HMS by applying frequency rainfall depths to the final watershed model.

2.5.2 Hydraulics

2.5.2.1 Hydraulics for the Guadalupe, Blanco and San Marcos Rivers

New hydraulic models were developed in HEC-RAS for the Guadalupe, San Marcos, and Blanco Rivers. Hydraulic analyses were developed for approximately 450 miles of stream including about 270 miles of detailed study that required field surveys to be incorporated into the hydraulic models, 50 miles of limited detail study without surveys, and 130 miles of incorporated existing detailed models from FEMA's Map Mod program in Comal, Guadalupe, and Victoria Counties.

The Guadalupe River was studied for 296 river miles with surveyed sections and structures from Canyon Dam downstream to the Victoria/Calhoun County Boundary near the Town of Tivoli, TX. The Blanco River was studied in limited detail for 47.8 miles without surveyed sections and structures from the Blanco/Hays County line to its confluence with the San Marcos River near the City of San Marcos. The San Marcos River was studied for 76.9 miles with surveyed sections and structures from its confluence with the Blanco River near the City of San Marcos downstream to its confluence with the Guadalupe River near the City of Gonzales.

Storm and high water mark data was obtained through coordination with the local sponsor for use in calibration of the models. The models were reasonably calibrated to USGS gage rating curves and recorded gage heights for historic flood events and any established high water marks. Existing high water mark elevations were available on the Guadalupe, San Marcos and Blanco Rivers for the 1998 flood event.

The frequency discharges from the hydrologic analysis were run through the models in steady flow analysis to compute water surface elevations for the standard frequency flood events (the 50 percent, 20 percent, 10 percent, 4 percent, 2 percent, 1 percent, 0.4 percent, and 0.2 percent annual chance exceedance events). The only exception to this steady state methodology was in the area of the City of San Marcos.

2.5.2.2 2D Hydraulic Modeling in the City of San Marcos

The Blanco River is the primary source of flooding for the City of San Marcos, which is located at the confluence of the Blanco River with the San Marcos River. The San Marcos River above San Marcos has a drainage area of only 50 square miles and is a spring fed stream that is largely controlled by NRCS flood detention structures. The Blanco River, on the other hand, is 436 square miles and flows through narrow canyons and steep stream beds until it approaches the City of San Marcos. Near San Marcos, the valley widens and the stream bed flattens. Rapidly rising floodwaters from the Blanco River tend to spread out when they reach San Marcos, flowing in multiple directions through city neighborhoods and over the drainage divides into the neighboring watersheds. As a result, the city experiences substantial flood damages when the Blanco River exceeds its banks, most recently in May and October of 2015.
For water surface elevations in the City of San Marcos, an existing InfoWorks ICM 2-Dimensional (2D) model of the floodplain in the City of San Marcos was used. This model was developed by Halff under a contract with the Guadalupe-Blanco River Authority (GBRA) unrelated to the feasibility study. The 2D hydraulic analysis of the confluence and overflow areas was developed to better model the complex multi-directional flow patterns occurring in the overflow area that were observed in the 2015 flood events.
The 1D hydraulic models of the Blanco and San Marcos Rivers were truncated to represent the 1D portions of those rivers while a 2D overland mesh was formed using the Hays County 2008 LiDAR, which allowed the flow to travel in multiple directions between mesh points. The result was a 1D /2D coupled model in ICM. The 2D model was calibrated to the observed high water marks, flood photos, and known damages from the May flood event in San Marcos.
After calibration, the frequency flow hydrographs from the InFRM San Marcos HEC-HMS model were applied to the upstream boundaries of the 2D InfoWorks model. The frequency storm events analyzed included the 50 percent, 20 percent, 10 percent, 4 percent, 2 percent, 1 percent, 0.4 percent, and 0.2 percent annual chance exceedance (ACE) events. For the 10 percent ACE and smaller storm events, there was no ponding in the areas of interest. For the 4 percent ACE and larger storm events, water from the Blanco River spilled outside of the banks downstream of the Highway 80 bridge, inundating the Blanco Gardens area. The large storm events such as the 1 percent ACE and higher show more inundation upstream of Highway 80 and begin to flood the apartment complexes located along the Blanco River.
Additional detail on the hydraulic modeling can be found in Appendix A.

2.5.3 Groundwater

Three major aquifers (Carrizo, Edwards, and Trinity) lie beneath the Lower Guadalupe Feasibility Study Area. Figure 7 shows the extent of each major aquifer as it relates to the study sub-areas.

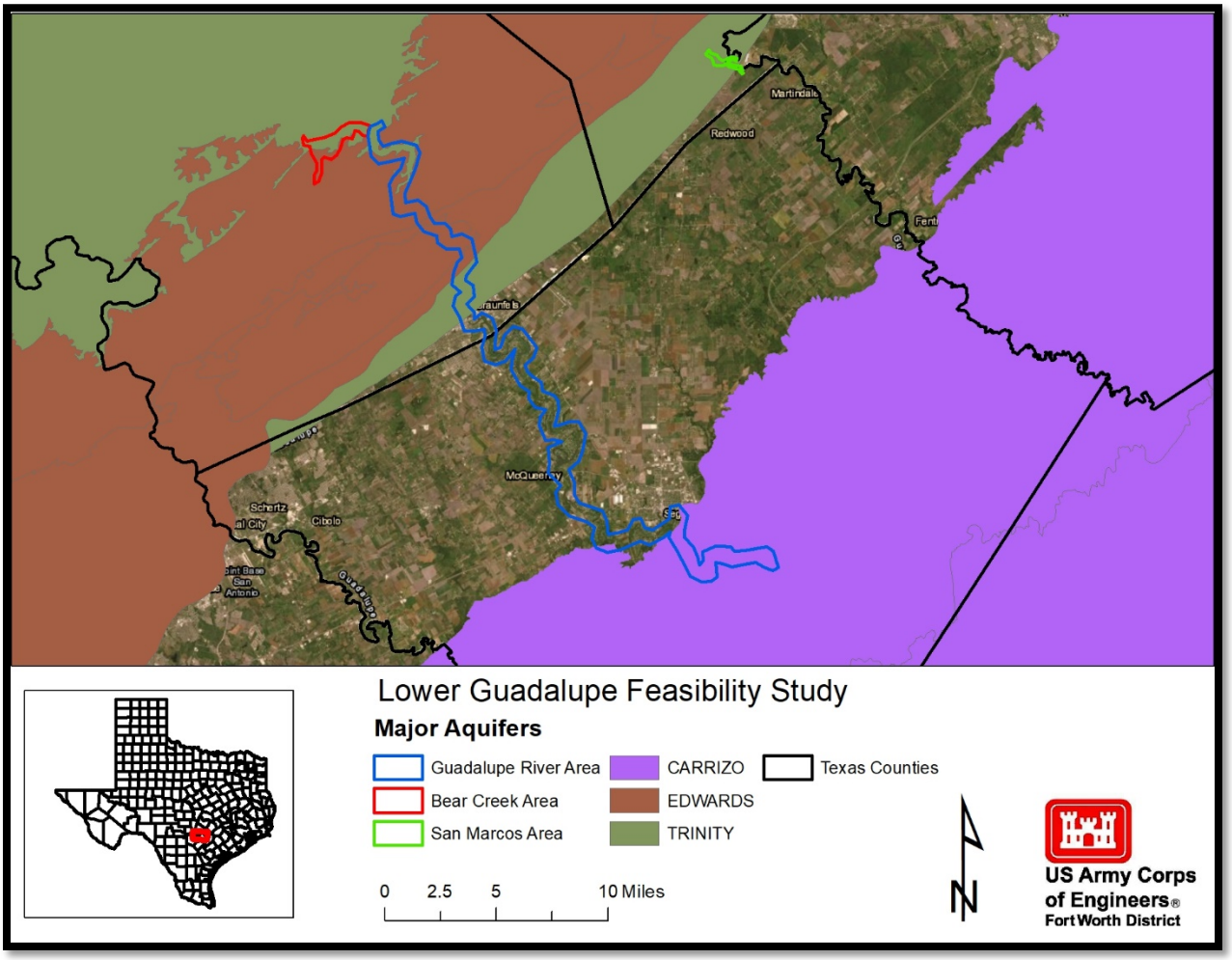

Figure 7: Major Aquifers in the Lower Guadalupe Study Area.

2.5.3.1 Guadalupe River

The Lower Guadalupe Feasibility Study Area groundwater consists of the Edwards Aquifer and the various independent underground caves with water. Within the study area, the aquifer runs from Canyon Lake Dam to the area just above New Braunfels. The Edwards Aquifer within the study area consists of contributing, recharge, and transition zones (see Figure 8). The Edwards Aquifer recharge zone is a fault zone aquifer. The average annual recharge from 1934 to 2010 was approximately 718,000 acre-feet (EAA 2013). Since 1980, as a result of increased pumping, there has been greater fluctuation of spring flow with increased time required for recovery, even during a period that recorded the two highest levels of aquifer recharge (1992 and 1987). The majority of the recharge occurs when surface water intersects the permeable formation

and goes underground; the remaining recharge occurs when precipitation falls directly on the outcrop. However, rainfall is highly variable, so recharge amounts vary widely from year to year.

The contributing zone starts at the northernmost limit and runs to the area just north of River Chase Drive in New Braunfels, the recharge zone continues on from the southern limit of the contributing zone and runs downs south to Gruene Road in Gruene, Texas, and the transition zone continues on from the southern limit of the recharge zone and runs down south to East Nacogdoches Road in New Braunfels.

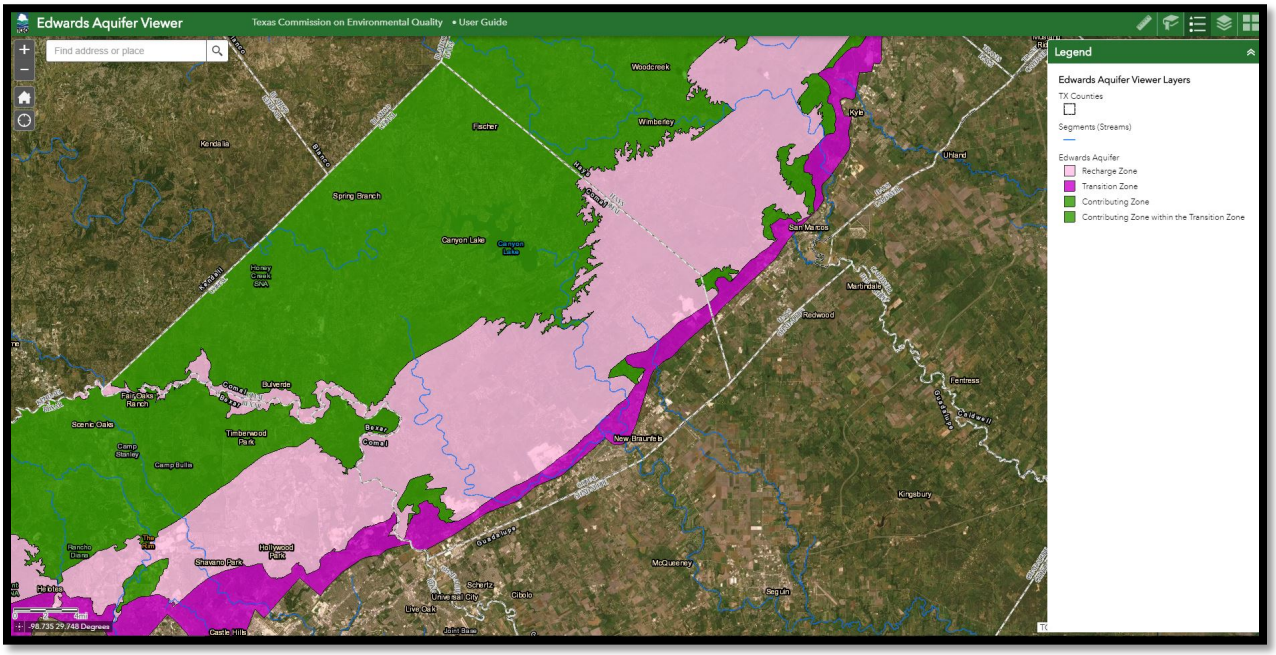

Figure 8: Edwards Aquifer in the Lower Guadalupe Study.

The Edwards Aquifer was the first aquifer designated as a sole-source aquifer in 1975 and is the main source of water for the City of San Antonio, and much of central Texas. It supplies water for approximately 1.7 million people (Edwards Aquifer Authority [EAA] 2013). The Edwards Aquifer is approximately 180 miles long and underlies 10 counties in central Texas. It is primarily composed of limestone. The EAA has an active program to educate the public on water conservation and also operates several active groundwater recharge sites. The San Antonio River Authority also has a number of flood-control structures that effectively recharge the aquifer (Texas Almananc 2019).

Conservation districts are promoting more-efficient irrigation techniques, and market-based, voluntary transfers of unused agricultural water rights to municipal uses are more common.

2.5.3.2 Bear Creek

Bear Creek lies within the contributing zone of the Edwards Aquifer, although the drainage lies on the northern fringe of the recharge zone. Water flowing through Bear

Creek reaches the Edwards Aquifer recharge zone downstream below the Guadalupe River confluence. Figure 9 shows the boundary between the contributing and recharge zones near Bear Creek.

2.5.3.3 San Marcos River

The San Marcos area lies immediately to the south of the Edwards Aquifer, above the Trinity Aquifer. The springs that provide water to the area are rain fed with outflows fluctuating based on rainfall and human consumption.

Figure 9: Edwards Aquifer Contributing and Recharge Zones near Bear Creek

2.5.4 Water Quality

Texas Commission on Environmental Quality (TCEQ) sets and implements standards for surface water quality to improve and maintain the quality of water in the state based on various beneficial use categories for the water body. The Texas Integrated Report of Surface Water Quality, which is a requirement of the Federal Clean Water Act Sections 305(b) and 303(d), evaluates the quality of surface waters in Texas and identifies those that do not meet uses and criteria defined in the Texas Surface Water Quality Standards (TSWQS). The Texas Integrated Report describes the status of Texas' surface waters based on historical data and assigns waterways to various categories depending on the extent to which they attain the TSWQS.

2.5.4.1 Guadalupe River

Existing water quality within the Guadalupe River is largely affected by Canyon Lake. Additionally inputs include natural springs, rainfall, and associated storm water flows originating from residential, industrial and agricultural properties near rivers, creeks, and tributaries.

The Draft 2018 Texas Integrated Report - Texas 303(d) List (TCEQ 2019B) does not identify any segment within the Guadalupe River from below Canyon Lake Dam down to Seguin, Texas as being impaired or exceeding TSWQS.

As of July 2019, no fish consumption advisories have been issued for the Guadalupe River by Texas Department of State Health Services (DSHS) (DSHS 2019).

As a result of the passage of Texas Senate Bill 1 (SB1) in 1997, water planning in Texas became the domain of regional planning groups rather than the Texas Water Development Board (TWDB). As a part of the planning process, each regional planning group may include recommendations for the designation of ecologically unique river and stream segments in their adopted regional water plan

The Guadalupe River, from the confluence of the Comal River in Comal County upstream to the Kendall/Kerr County line (excluding Canyon Lake), has been designated as a significant stream segment by the Texas Water Development Board for its contribution to the Edwards Aquifer, riparian conservation, high water quality and aesthetics, as well as overall high use (TPWD 2019).

2.5.4.2 Bear Creek

The Draft 2018 Texas Integrated Report - Texas 303(d) List (TCEQ, 2019B) does not identify any segment within Bear Creek area as impaired or exceeding TSWQS.

As of July 2019, no fish consumption advisories have been issued for Bear Creek by DSHS (DSHS, 2019).

Bear Creek watershed is fed by rainfall and by two spring flows (Heitmuller et al. 2003). Few urban areas and many farms have allowed for generally clear water flows into Guadalupe River outside of flood events. With little urban development in the Bear Creek watershed, it can be assumed that these waters are of good to excellent quality for aquatic life use.

2.5.4.3 San Marcos

Existing water quality within the San Marcos area is affected by the Edwards Aquifer outflow as well as rainfall, and associated storm water flows originating from residential, industrial and agricultural properties in around the San Marcos area. Downstream of the City of San Marcos, agriculture run-off becomes more influential as the area serves as a transition zone between residential and industrial to agriculture areas.

The Draft 2018 Texas Integrated Report - Texas 303(d) List (TCEQ 2019B) does not identify any segment within the San Marcos area as impaired or exceeding TSWQS.

As of July 2019, no fish consumption advisories have been issued for the San Marcos area by DSHS (DSHS 2019).

The San Marcos River, from the confluence with the Guadalupe River in Gonzales County upstream to a point 0.7 mile downstream of I-35 in Hays County, has also been designated as a significant stream segment by the Texas Water Development Board for its contribution to riparian conservation, and threatened or endangered species/unique communities (TPWD 2019).

2.5.5 Wetlands

Waters of the United States are defined within the Clean Water Act (CWA), and jurisdiction is addressed by the USACE and United States Environmental Protection Agency (USEPA). Wetlands are a subset of the waters of the United States that may be subject to regulation under Section 404 of the CWA (40 CFR 230.3). Wetlands are those areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

The National Wetlands Inventory (NWI) established by U.S. Fish and Wildlife Service (USFWS) was used to identify wetland types in the study area, as described in section below. During site visits with USFWS and TPWD staff in the late summer of 2017, various physical, geological, and biological data were collected to help describe habitat and habitat quality, see Appendix C2. While access was limited to public areas, a combination of site visits, NWI data, and aerial imagery was used to map general habitat types, including wetlands to better describe existing conditions.

2.5.5.1 Guadalupe River

Wetlands along the Guadalupe River typically form near river and creek beds, or other areas with low topographic relief, or adjacent to rivers in the form of oxbows and small ponds. Because of the steep topography of the Edwards Plateau, wetlands within the topographic province are rare. Wetlands are more common east of I-35 in the study area within the Blackland Belt topographic province which consists of flatter land that allows for more wetlands to occur. Appendix C2 provides more detail regarding acreage and quality of aquatic habitat along the Guadalupe River.

2.5.5.2 Bear Creek

Bear Creek lies within the Edwards Plateau topographic province, which makes wetlands rarer than those found in the neighboring Blackland Belt. Wetlands still exist in Bear Creek, but are concentrated in areas of low topographic relief near the creek channel. Appendix C2 provides more detail regarding acreage and quality of aquatic habitat along Bear Creek.

2.5.5.3 San Marcos

The San Marcos area transitions from heavy urban use along the western edge to agriculture and pockets of prairie. Many of the flatlands near the rivers been converted from wetland and riparian habitat to farms or small housing communities. Remaining wetlands are largely constricted to the river channel, side channel ponds, and remnant

oxbows immediately adjacent to rivers. Appendix C2 provides more detail regarding acreage and quality of aquatic habitat in the San Marcos area.

2.6 Biological Resources

2.6.1 Vegetation

Vegetation varies across the study area. From the Edwards Plateau canyons and narrow drainages to the flat fertile prairies, general vegetation communities can be described by which ecoregion the area sits in. Figure 10 shows where each area lies within the ecoregions of Texas. Appendix C2 provides more detail and regarding acreage and habitat quality of terrestrial habitat for all areas described below.

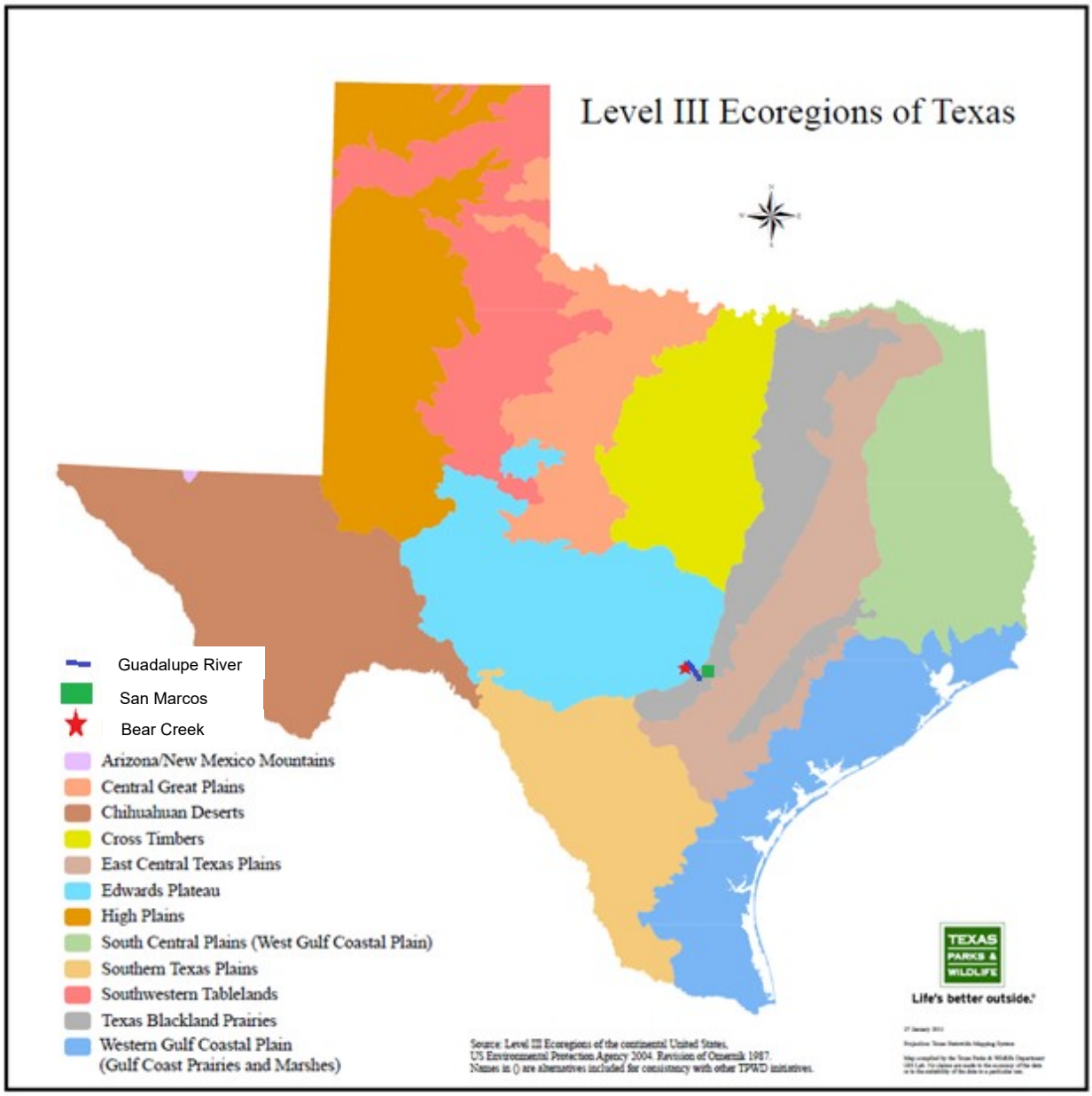

Figure 10: Ecoregions within the State of Texas and the Lower Guadalupe Feasibility Study Area.

2.6.1.1 Guadalupe River

The Guadalupe River lies within the Edwards Plateau and Texas Blackland Prairies ecoregions. The greater Guadalupe River area can be generally described by two different habitat types split by the I-35 corridor. The vegetative composition of these two ecoregions are discussed in more detail for vegetative descriptions for Bear Creek and San Marcos sections. Dense oak-juniper woodlands dominate the areas above New Braunfels, west of I-35 and similar to that of Bear Creek. The drastic transition to a mix of riparian scrub shrub lined rivers and creeks with mixed riparian forests, gradually fading to grasslands and heavy agriculture use occurs east of I-35, which closely resembles vegetation communities in the San Marcos area.

2.6.1.2 Bear Creek

Bear Creek lies within the Edwards Plateau ecoregion as seen in the figure above. It is a land of many springs, stony hills, and steep canyons. The region is home to a host of rare plants and animals found nowhere else on earth. Soils are usually shallow with a variety of surface texture underlain by limestone. Though open grasslands and savannahs were more common in pre-settlement times than they are today, the Edwards Plateau is characterized by grasslands, oak-juniper woodlands, and plateau live oak and mesquite savannah. Figure 11 shows the distribution of habitat in Bear Creek.

The Guadalupe River Valley bottomlands support a restricted hardwood forest of various species including pecan (*Carya illinoinensis*), hackberry (*Celtis spp.*), live oak (*Quercus virginiana*), Texas oak (*Quercus buckleyi*), elm (*Ulmus spp*.), bald cypress (*Taxodium distichum*), and Texas black walnut (*Juglan microcarpa*). Slopes and uplands support live oak, some post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*), Texas ash (*Fraximus texensis*), Texas persimmon (*Diospyros texana*), Texas sophora (*Sophora affinis*), and Ashe juniper (*Juniperus ashei*). Climax grasses consist of switchgrass (*Panicum virgatum*), several species of bluestem (*Andropogon sp.*), gramas (*Bouteloua* sp.), and lovegrass (*Eragrostis sp.*), curly mesquite (*Hilaria belangeri*), buffalo grass (*Bouteloua dactyloides*), and Indiangrass (*Sorgastrum nutans*). Common upland and hillside vegetation include yucca (*Yucca spp.*) and prickly pear (*Opuntia engelmanni*). Disturbed upland sites contain numerous species of forbs, vines, and shrubs that are intermixed with noxious and/or invasive species such as ragweed (*Ambrosia spec.*), cocklebur (*Xanthium spec.*), annual broomweed (*Amphiachyris dracunculoides*), bloodweed (*Ambrosia trifida*), and Johnson grass (*Sorghum halepense*).

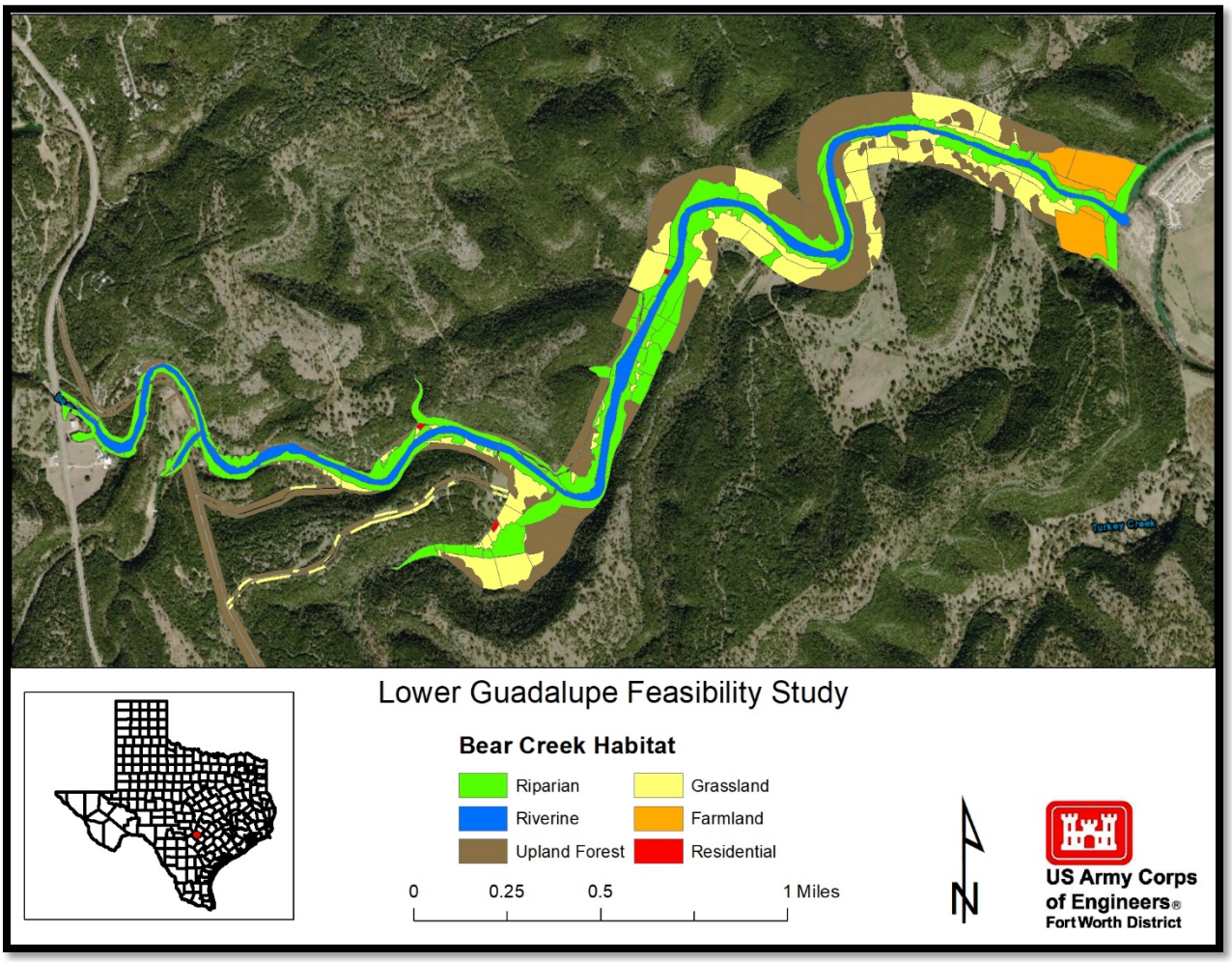

Figure 11: Existing Bear Creek Habitat

2.6.1.3 San Marcos

San Marcos area lies within the Texas Blackland Prairies ecological region in central Texas. The largest section of the ecoregion is mostly south to north trending, starting at San Antonio and nearly reaching the Oklahoma border north and northeast of Dallas. The other part of the Texas Blackland Prairies trends southwest to northeast, starting at about 55 miles southeast of San Antonio. This smaller, more southeastern located part of the ecoregion is commonly called the Fayette Prairie. The entire Texas Blackland Prairies ecoregion covers approximately 19,500 square miles.

The land cover of the Texas Blackland Prairies at the beginning of the 19th century was predominately tallgrass prairie, with forest found primarily along stream courses and some uplands. The common grass and forb species include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardi*), yellow Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), tall dropseed (*Sporobulus compositus*), asters (*Aster spp.*), prairie bluet (*Stenaria nigricans*), prairie clovers (*Dalea spp.*), and coneflowers (*Echinacea spp.*).

Bottomland hardwoods forest are not as prevalent, but where they occur common species include bur oak (*Quercus macrocarpa*), Shumard oak (*Quercus shumardii*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), green ash (*Fraxinus pennsylvanica*), pecan (*Carya illinoinensis*), cedar elm (*Ulmus crassifolia*), American elm (*Ulmus americana*), Winged elm (*Ulmus alata*), sweetgum (*Liquidambar styraciflua*), sugar hackberry (*Celtis laevigata*), and eastern cottonwood (*Populus deltoides*). Slopes and upland forests support mesquites (*Prosopis laevigata*) and several cedars and junipers (*Juniperus spp.*), and have become more prevalent due to the absence of regular fires. Figure 12 shows the distribution of habitat in the San Marcos area.

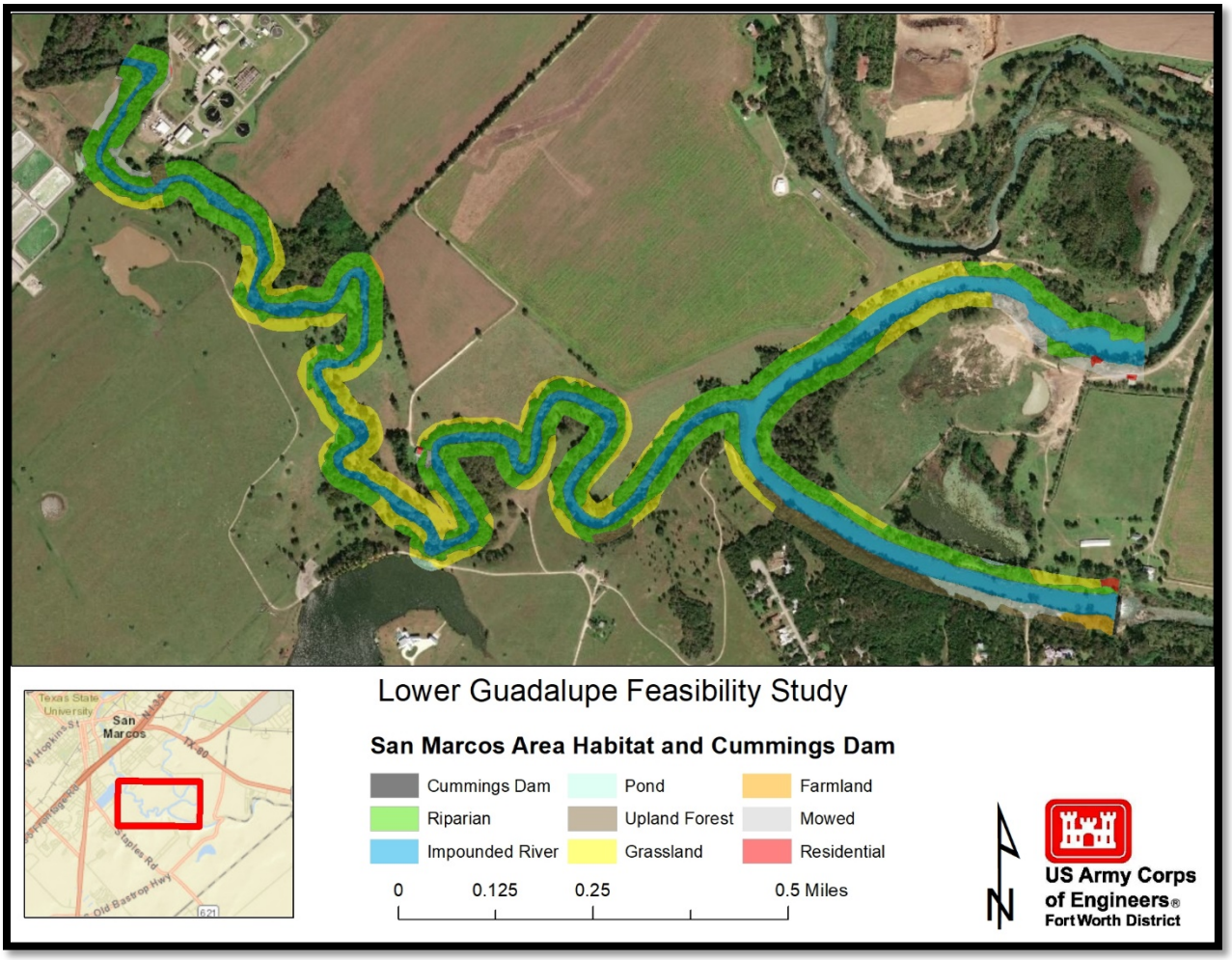

Figure 12: Existing San Marcos Habitat

Vegetation within the San Marcos refers to areas immediately adjacent to and within the rivers and creeks. Because the area is subject to varying degrees of river flow including flooding, the grasses and shrubs are periodically inundated and recolonized. This results in a mixed under- and overstory riparian forest community. The sudden changes of the meandering river and can quickly erode and wash away vegetation during

flooding, this is evident in the isolated bands of old growth trees along the river banks. The influence of flooding and local development has shaped the scrub shrub shorelines with mixed riparian forest corridors.

2.6.2 Fisheries and Wildlife Resources

2.6.2.1 Guadalupe River

The Guadalupe River provides for a wide mixture of freshwater based habitats for fish and wildlife; the evidence of this can be found in the diversity of fish, crustaceans, mussels, insects, birds, mammals, and reptiles that can be found within it and on adjacent lands. Fish species found in the Guadalupe River include largemouth bass *(Micropterus salmoides)*, white bass *(Morone chrysops)*, striped bass *(Morone saxatilis)*, channel catfish *(Ictalurus punctatus)*, blue catfish *(Ictalurus furcatus)*, and flathead catfish *(Pylodictis olivaris*). Annual stockings of rainbow trout (*Oncorhynchus mykiss)* also occur downstream of Canyon Dam.

2.6.2.2 Bear Creek

Bear Creek provides habitat for small fish, crustaceans, aquatic invertebrates, amphibians, and other wildlife species. The spring fed low water flow conditions and numerous low water dams, provide refuge and foraging habitat even during the hot Texas summers. Within Bear Creek small finger size fish like red shiner (*Cyprinella lutrensis*) and fathead minnow (*Pimephales promelas*) are likely to be more prevalent while larger football size fish like largemouth bass (*Micropterus salmoides*) and channel catfish (*Ictalurus punctatus*) are more likely to occur in numbers downstream in the Guadalupe River. The relative inaccessibility for human foot traffic and kayaking, as well as a lack of urbanization in the area help to create an area that species are rarely disturbed as compared to other areas within Comal County.

Bear Creek is home to various warblers, upland birds, migratory birds, and birds of prey. Other wildlife includes squirrels (*Sciurus* spp.), common raccoons (*Procyon lotor*), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), porcupines (*Erethizon dorsatum*), and skunks (Mephitidae).

An important vegetation type within Bear Creek is the oak-juniper woodlands. Mature stands of Ashe juniper and mixed oak forest provide important nesting areas for the golden-cheeked warbler (*Dendrioca chryoparia*), a federally-listed endangered neotropical bird.

2.6.2.3 San Marcos

The San Marcos area fish and wildlife success is greatly dependent on rainfall and freshwater consumption. Therefore, the area provides intermittent habitat for fish and wildlife species. When the rivers are flowing, they provide pristine water conditions and availability of habitat in the rivers provide for great conditions for a diversity of fish, crustaceans and mussels to thrive. Otherwise ponding can occur resulting in pools that if not replenished with water would starve out whatever is caught within them. What vegetation is available for both rivers can be found directly alongside and within the rivers. The meandering nature of the rivers create tear drop peninsulas that provide

prime isolated habitats for birds. And when the rivers are flowing high these peninsulas serve as refuges for animals.

The San Marcos area is home to various migratory songbirds, waterfowl and birds of prey. The typical animals found are squirrels (*Sciurus* spp.), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), porcupines (*Erethizon dorsatum)* and skunks (*Mephitidae*). Common fish species include catfish, bass, crappie, and sunfish.

2.6.3 Federally Threatened and Endangered Species

The purpose of the Endangered Species Act is to provide protection for Endangered and Threatened Species. Protection is not limited to the species itself but also to the ecosystems upon which they depend on for survival. USFWS is the primary agency responsible for implementing the Endangered Species Act, and is responsible for birds and other terrestrial and freshwater species. USFWS responsibilities under the Endangered Species Act include (1) the identification of threatened and endangered species; (2) the identification of critical habitats for listed species; (3) implementation of research on, and recovery efforts for, these species; and (4) consultation with other Federal agencies concerning measures to avoid harm to listed species.

An endangered species is a species officially recognized by USFWS as being in danger of extinction throughout all or a significant portion of its range. A threatened species is a species likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Proposed species are those that have been formally submitted to Congress for official listing as threatened or endangered. Species may be considered eligible for listing as endangered or threatened when any of the five following criteria occur: (1) current/imminent destruction, modification, or curtailment of their habitat or range; (2) overuse of the species for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or human-induced factors affecting their continued existence.

In addition, USFWS has identified species that are candidates for listing as a result of identified threats to their continued existence. The candidate designation includes species for which USFWS has sufficient information to support proposals to list as endangered or threatened under the Endangered Species Act. Until the species has gone through the entire review process it will not be listed as either endangered or threatened. Although not afforded protection by the Endangered Species Act, candidate species may be protected under other Federal or state laws.

The USFWS's Information for Planning and Consultation (IPaC) database (2019A, 2019B, and 2019C) lists the threatened and endangered species that may occur within the project area (see USFWS Species List in Appendix C3).

2.6.3.1 Federally Listed Threatened and Endangered Species Occurrence within Guadalupe River, Bear Creek, and San Marcos Area.

Based on the habitat requirements of listed species, the likelihood of listed species occurring within the study's action areas was evaluated based on existing habitat conditions and species distribution during informal consultation with USFWS and TPWD. Two species have the potential to occur in the project areas and are discussed in the sections below.

2.6.3.2 Species and Habitat Descriptions

Descriptions of species with the potential to occur within the study's action areas are provided below. For more information regarding all species listed in the study area, see Appendix C3.

2.6.3.2.1 Golden-cheeked Warbler

Golden-cheeked warbler habitat consists of old-growth and mature growth Ashe juniper-oak woodlands in rocky terrain (NatureServe, 2018D). Within the U.S, the species can only be found with the Edwards Plateau Ecoregion. It is a migratory species that spends its winters in Honduras and Guatemala. The species is a small yellow-and-black songbird that preys on insects. There have been numerous sightings of the species in the surrounding areas of the project area. Golden-cheeked warbler (GCWA) habitat was mapped throughout the GCWA range in Texas and categorized based on whether the patch of habitat was lost, gained, or remained over the course of several years (Duarte et al. 2013). GCWA habitat within the Bear Creek area is shown in Figure 13.

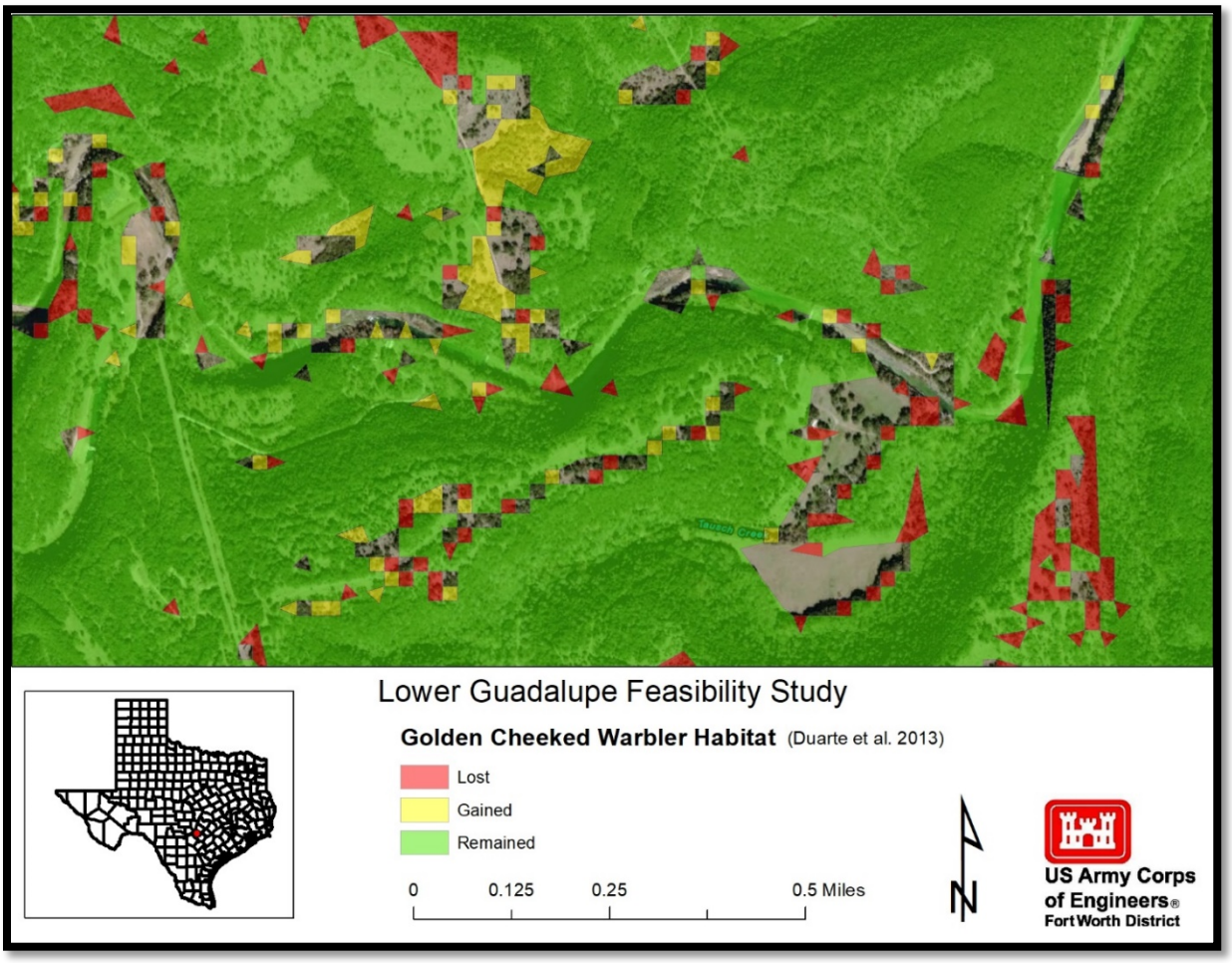

Figure 13: Golden-cheeked Warbler Habitat along Bear Creek

2.6.3.2.2 Texas Wild-rice

When Texas wild-rice (*Zizania texana*) was first described in 1933, it was found in abundance in the San Marcos River and Spring Lake, as well as in contiguous irrigation ditches (Terrell et al., 1978; Silveus, 1933). Following its discovery, abundance of Texas wild-rice declined substantially. In 1978, Texas wild-rice was listed as Federally endangered due to habitat degradation and competition with non-native species.

Spring flow is critical for growth and survival of Texas wild-rice (Saunders et al., 2001). Texas wild-rice relies on CO2 as its inorganic carbon source for photosynthesis rather than the more commonly available bicarbonate used by most other aquatic plants (Seal and Ellis, 1997). Water from the Edwards Aquifer contains relatively high levels of dissolved CO2 due to the calcium carbonate makeup of the region's karstic geology, and springflows transport the dissolved gas-enriched water downstream.

The current distribution of Texas wild-rice extends from the upper reaches of the San Marcos River to just upstream of the wastewater treatment plant in San Marcos. The heaviest concentration occurs in Spring Lake and on upstream side of the associated

dam. The most recent range wide estimate of Texas wild-rice coverage is 39,417 square feet from September 2011 (Bio-West 2012, and USFWS 2013A). Data indicate that while the total areal coverage of Texas wild-rice has generally increased in recent years, the distribution of the species has contracted (Poole, 2002). Texas wild-rice is now only found in the upper 3.5 miles of the San Marcos River, including Spring Lake. All examples of Texas wild-rice now found in Spring Lake are the result of reintroduction efforts (USFWS, 1996).

Increased sedimentation, water depth and turbidity, and a decrease in current velocities have contributed to a loss of habitat for Texas wild-rice throughout the lower portions of its historic range (Poole and Bowles, 1999). While water depth and current velocity are primarily dependent on the rate of spring flow into the San Marcos River, dams and other modifications have substantially altered local conditions of depth and current velocity. The impacts of increased sedimentation and turbidity on Texas wild-rice are largely a result of urbanization within the contributing watershed. Other threats to Texas wild-rice include direct damage to plants and substrates as a result of recreation and herbivory by waterfowl.

When a species is proposed for listing as endangered or threatened under the Endangered Species Act, the USFWS must consider whether there are areas of habitat believed to be essential to the species' conservation. Those areas may be proposed for designation as critical habitat.

Within the San Marcos area, critical habitat has been designated for Texas Wild-rice from the confluence of the San Marcos and Blanco Rivers upstream to Spring Lake.

2.6.3.3 Texas Natural Diversity Database

2.6.3.3.1 Guadalupe River

The Texas Natural Diversity Database (TXNDD), administered by TPWD, manages and disseminates occurrence of information on rare species, natural communities, and animal aggregations in Texas to help guide project planning efforts. An official request via email was made on March 22, 2019 and USACE received the information from TPWD on April 1, 2019. USACE Biologists requested information for the Sattler USGS quadrangle within Guadalupe River portion of the Lower Guadalupe River Study Area.

In the information that TXNDD provided, there were sixteen rare or unique species that occur within the Guadalupe River and nearby areas but no communities listed. Within this there is: one mammal, western spotted skunk (*Spilogale gracilis*); five species of fish, Texas shiner (*Notropis amabilis)*, Guadalupe darter (*Percina apristis*), Guadalupe bass (Micropterus treculii), fountain darter (*Etheostoma fonticola*), plateau shiner (*Cyprinella lepida*); one salamander, Blanco River Springs salamander (*Eurycea pterophila)*; six species of plants, Warnock's coral-root (*Hexalectris warnockii*), narrowleaf brickell-bush (*Brickellia oblongifolia*), buckley's fluffgrass (*Tridens buckleyanus*), bracted twistflower (*Streptanthus bracteatus*), Texas amorpha (*Amorpha roemeriana*), Lindheimer's tickseed (*Desmodium lindheimeri*); two species of mussels,

golden orb (*Quadrula aurea*), Guadalupe orb (*Cyclonaias necki*); and one snail, flattened cavesnail (*Phreatodrobia micra*).

2.6.3.3.2 Bear Creek

An official request via email was made on October 16, 2018 and USACE received the information from TPWD on October 26, 2018. USACE Biologists requested information for the Sattler USGS quadrangle within the project area.

In the information that TXNDD provided, there were not any rare or unique species nor natural communities that occur within the Bear Creek. However, there are areas within a 5 mile radius of Bear Creek that TXNDD identified as to containing rare and unique species, such as: narrowleaf brickellbush (*Brickellia eupatorioides var. gracillima*), Texas Amorpha (*Amorpha roemeriana*), Guadalupe Darter (*Percina apristis*), Linheimer's tickseed (*Desmodium lindheimeri*), Blanco River Springs Salamander (*Eurycea pterophila*), Buckley's fluffgrass (*Buckley tridens*), A Bathynellid (*Texanobathynella bowmani*), hill county wild-mercury (*Argythamnia aphoroides*), Texas Shiner (*Notropis amabilis*), Bracted Twistflower (*Streptanthus bracteatus*) and Warnock's coral-root (*Hexalectris warnockii*), and western spotted skunk (*Spilogale gracilis*).

2.6.3.3.3 San Marcos

An official request via email was made on March 14, 2019 and USACE received the information from TPWD on March 22, 2019. USACE Biologists requested information regarding any unique species or community occurrences for the San Marcos South USGS quadrangle which includes the San Marcos area. In the information that TXNDD provided, the Guadalupe Darter (*Percina apristis*), was detected and may occur in the region.

On 31 December, 2010, Guadalupe Darter was detected at a location within the San Marcos area as well with numerous previous sightings. The ideal habitat for this species is rocky/gravely runs of permanent rivers and streams (NatureServe, 2018G; and Texas State University-San Marcos, 2017).

Within a five mile radius of the San Marcos area, the TXNDD identified other rare and unique species, and natural communities such as: headwater catfish (*Ictalurus lupus*), heller's marbleseed (*Onosmodium helleri*), Texas wild-rice (*Zizania texana*), Guadalupe bass (*Micropterus treculii*), ironcolor shiner (*Notropis chalybaeus*), Texas blind salamander (*Eaurycea rathbuni*), hill county wild-mercury (*Argythamnia aphoroides*), and Texas Shiner (*Notropis amabilis*).

2.6.4 Invasive Species

2.6.4.1 Guadalupe River and Bear Creek

An invasive species is defined as a plant or animal that is non-native (or native nuisance) to an ecosystem and whose introduction causes, or is likely to cause, economic and/or environmental harm, or harm to human health. Invasive species can thrive in areas beyond their normal range of dispersal. These species are characteristically adaptable, aggressive, and have high reproductive capacity. Their vigor, along with a lack of natural enemies or controls, often leads to outbreak populations with some level of negative effects on native plants, animals, and ecosystem functions and are often associated with disturbed ecosystems and human activities.

Table 6 lists many of the invasive and exotic species that are currently exist or have been found at Canyon Lake. For this report, an assumption has been made that if an invasive species is found within Canyon Lake then it could be found within the Bear Creek and the Guadalupe River as well. Canyon Lake is about 3 miles north of Bear Creek and drains directly into a shared waterway, the Guadalupe River.

Invasive species with potential to occur in Bear Creek and the Guadalupe River include house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), and the zebra mussel (*Dreissena polymorpha*). Zebra mussels were recently detected in Canyon Lake. The low water dams and lack of boat traffic may slow down the spread of zebra mussels into the Bear Creek. Although native, brown-headed cowbirds (*Molothrus ater*) have become problematic due to their expanding range associated with agriculture and human development. The lack of urban landscaping in the immediate area may also limit the spread of many common landscaping plants from colonizing the area.

Table 6: Invasive Species Found in Guadalupe River

Habitat	Common Names	Scientific Name
Plant		
Terrestrial	Tree of heaven	*Ailanthus altissima*
Terrestrial	Yellow star thistle	*Centaurea solstitialis*
Terrestrial	Chinaberry tree	*Melia azedarach*
Terrestrial	Chinese tallow tree	*Triadica sebifera*
Terrestrial	Castor beans	*Ricinus communis*
Terrestrial	King Ranch bluestem	*Bothriochloa ischaemum*
Terrestrial	Ashe juniper	*Juniperus ashei*
Terrestrial	Willow baccharis	*Baccharis salicina*
Animal		
Terrestrial	Feral hog	*Sus scrofa*
Terrestrial	Feral cat	*Felis catus*
Aquatic	Zebra mussel	*Dreissena polymorpha*
Aquatic	Armored Catfish	*Hypotomus plecostomus*
Birds		
Terrestrial	Eurasion sparrow	*Passer montanus*
Terrestrial	European starling	*Sturnus vulgaris*
Insect		
Terrestrial	Fire ants	*Solenopsis invicta*

Source USACE (2015)

2.6.4.2 San Marcos

Table 7 lists many of the invasive and exotic species found within the San Marcos area. Other species are currently being researched for their invasive characteristics, while there may be debate on whether other species should be considered invasive.

Table 7: Invasive Species Found in San Marcos Area

Habitat	Common Names	Scientific Name	Prevalence
Plant			
Aquatic	Giant Reed	*Arundo donax*	Minor
Aquatic	Hydrilla	*Hydrilla verticillata*	Moderate
Aquatic	Dwarf Hygrophila	*Hygrophila polysperma*	Minor
Animal			
Aquatic	Nutria	*Myocastor coypus*	Minor
Aquatic	Zebra Mussel	*Dreissena polymorpha*	Neighboring Threat
Terrestrial	Feral Cat	*Felis catus*	Minor
Aquatic	Bighead Carp	*Hypophthalmichthys nobilis*	Minor
Aquatic	Armored Catfish	*Hypotomus plecostomus*	Minor
Aquatic	Grass Carp	*Ctenopharyngodon idella*	Minor
Birds			
Terrestrial	House Sparrow	*Passer domesticus*	Minor
Terrestrial	European Starling	*Sturnus vulgaris*	Minor
Terrestrial	Brown-headed Cowbird	*Molothrus ater*	Minor
Insect			
Terrestrial	Fire Ant	*Solenopsis invicta*	Major

Other invasive species posing a constant threat to natural communities include several species of introduced fish (including released baitfish and “aquarium dumping”), and mollusks including zebra mussels (*Dreissena polymorpha*). The neighboring waters of the San Marcos area have reported zebra mussels, therefore an assumption has been made that within the foreseeable future that this species may be found within the area. Although native, cowbirds (*Molothrus ater*) have become problematic due to their expanding range associated with agriculture and human development. The close proximity to urban landscaping has led to many common landscape plants becoming aggressive colonizers throughout the state.

2.7 Cultural Resources

The earliest well-defined cultural horizon in central Texas is the Clovis tradition, beginning approximately 11,500 years before present (BP). However, a growing body of data suggests humans were dispersed across North America as early as 13,000 to 15,000 BP, and that they may have revisited sites and established longer term settlement much earlier than previously thought (Collins 1989; Miller et al. 2013). Within 3 miles of the project study area, the Spring Lake site at San Marcos Springs contains a rich and continuous archaeological record, confirming that the region has been continuously inhabited from 13,000 BP to the present day.

Data gathered from the Texas Historical Commission (THC) Atlas Database, U.S. Geological Survey, Natural Resource Conservation Service Soil Survey, Google Earth aerial imagery, peer-reviewed literature, and information provided by local historical

societies have been used to identify previously recorded historic properties within the study area, as well as the potential for unknown significant cultural resources. Results of this research, including the regional cultural chronology and a discussion of known significant resources, are provided in Appendix D. Previously recorded surveys and cultural resources located within 1 mile (1.61 km) of the study area are summarized below.

2.7.1 Bear Creek

No systematic cultural resources surveys have been undertaken in the vicinity of Bear Creek. One previously archaeology recorded site, 41CM32 is located within 1 mile (1.61 km) of Bear Creek. The site was recorded in 1963 and is described as having a dense concentration of flint. A National Register of Historic Places (NRHP) eligibility determination has not been made for 41CM32.

2.7.2 San Marcos

Five area surveys and five linear cultural resources surveys have been conducted between 1981 and 2006 within 1 mile (1.61 km) of the study area along the San Marcos River. Each of these efforts has resulted in the discovery of pre-contact and historic era archeological resources. Thirty-four previously recorded archaeology sites and three historical markers are located within the San Marcos portion of the study area. Of these, three sites have been determined eligible for listing in the NRHP, nine have been determined ineligible, and twenty-two have undetermined eligibility. For a complete list of previously recorded cultural resources within the study area, see Appendix D.

2.8 Social and Economic Resources

2.8.1 Noise

Noise is generally described as unwanted sound, which can be based either on objective effects (i.e., hearing loss, damage to structures, *etc*.) or subjective judgments (e.g., community annoyance). The threshold of human hearing is approximately 0 dB, and the threshold of discomfort or pain is around 120 decibel (dB). Long-term noise levels are computed over a 24-hour period and adjusted for nighttime annoyances to produce the day-night average sound level (DNL). A DNL of 65 dB is the level most commonly used for noise planning purposes and represents a compromise between community impact and the need for activities like construction.

Table 8: Common Noise Emitters and Associated Decibel Readings

Noise Emitter	Decibel Reading
Quiet residential area	40
Freeway traffic	70
Car horn	110
Power lawn mower	65-95
Tractor	90
Chain saw	120

Center for Hearing and Communication (2018).

2.8.1.1 Guadalupe River

Noise generation within the Lower Guadalupe River can come from a variety of sources like vehicular traffic, boating, residential, industry, stereos, and large crowds. Because of the high tourism to the area, noise can intensify during the spring and summer time especially within New Braunfels area. The nature of surrounding topography and geology has an impact on how sound travels, in that sounds generated can be either amplified or muffled depending on local land features.

2.8.1.2 Bear Creek

Noise within Bear Creek is limited to the nearby country roads as well as to the few houses that dot the country side and the associated landscaping activities. Other than the various hunting seasons, noise does not intensify for any part of the year.

2.8.1.3 San Marcos

Noise within the San Marcos area is limited to the water rushing over Cummings Dam, nearby county and residential roads as well as to the few houses that dot the country side and the associated landscaping activities. Noise within the area intensifies within the area when crops are planted and harvested, as well as on the weekends and during summer time from the increase of kayakers that utilize the rivers within the area.

2.8.2 Aesthetics

2.8.2.1 Guadalupe River

The visual resources of a study area refer to those components of the environment perceived through the visual sense only, while aesthetic resources specifically refers to beauty in both form and appearance. Due to the intensity of adjacent land uses, these resources are also informed by the biological, land use, and recreation sections of this document. The visual and aesthetic character of the Guadalupe River has been substantially changed due to farming and urban & industrial development, which have limited the undeveloped aesthetics to the northern portion of the river. The area is comprised of hilly areas overlain with an oak-juniper forest, while the area south of New Braunfels consists of pastures, farms, urban and industrial development. Notable visual and aesthetic features within the river, include the clear transparent aquamarine waters, views of Canyon Lake Dam, and views from Cypress Bend Park, Landa Park, and Camp Comal.

2.8.2.2 Bear Creek

The Bear Creek can best described by the clear transparent aquamarine blue water that flows through the steep hilly terrain. The hills are covered by greens and browns from the thick coat of oak-juniper forests. In some areas the creeks expose the white, grays, and blacks of the limestone bedrock that is unique to the region.

2.8.2.3 San Marcos

The San Marcos area can be best described by the clear-aquamarine blue waters. These banks are lined with scrub shrub vegetation and mixed riparian forests that provide a dramatic backdrop to the highly aesthetic flowing river. These colors stand in contrast to one another when paired to the vast pale yellows and lime greens from the farmlands and pastures that stand against the trees.

2.8.3 Transportation

2.8.3.1 Guadalupe River

The Guadalupe River has numerous rail and vehicular roads crossing and running parallel to it. The major roads that cross it are: SH-337, I-35, I-10, SH-90, FM-46, and FM-123. There is no commercial shipping within the river.

2.8.3.2 Bear Creek

Transportation in the Bear Creek area is limited to local county and private roads with FM-2722 lying on the western edge of the study area.

2.8.3.3 San Marcos

San Marcos area transportation infrastructure is limited to local city, county, and private roads with FM-80 lying just north east of the impact area. The Blanco and San Marcos Rivers are not used for transportation of goods and people but rather more so for recreation.

2.8.4 Utilities

2.8.4.1 Guadalupe River

The communities along the Guadalupe River are serviced by a wide range of utility connections, with the greatest complexity focused in and around residential areas while rural private homes and industrial facilities are limited to a few. The residential areas and nearby industrial facilities are further characterized by being serviced by an established and maintained system of drainage, electrical, freshwater and sewage treatment facilities. The rural homes and industrial facilities are characterized by individual above ground power lines that feed directly into them as well by their own individual septic and water well systems. Electricity generation within the area comes from the hydropower produced by Canyon Lake Dam, wind power from the nearby wind farms, and electricity produced from the various coal and natural gas power plants within the area.

2.8.4.2 Bear Creek

Bear Creek is characterized by individual above ground power lines that feed directly into the few private homes. These homes are then characterized by being serviced by their own individual septic and water well systems.

2.8.4.3 San Marcos

The San Marcos area is characterized by individual above ground power lines that feed into the rural private home and industrial facilities as well as the one housing

community. These homes and industrial facilities are also characterized by a mixed use of septic, city water and sewage.

2.8.5 Recreation

2.8.5.1 Guadalupe River

The Guadalupe River offers numerous recreational opportunities ranging from boating, kayaking, tubing, fishing, birding, hiking, hunting, bicycling and off-roading. The tubing and kayaking conditions within New Braunfels is a major tourist attraction to the area bringing in thousands of people across the state to experience it.

2.8.5.2 Bear Creek

Bear Creek has minimal public access points, no public lands, no hiking and biking trails adjacent to the river, and is mostly surrounded by private property. With numerous small low water dams, aquatic recreational activities likely include swimming, fishing, paddling, and wildlife viewing.

2.8.5.3 San Marcos

The San Marcos area has sizable public access and boat ramps for the public to launch a kayak and float tube from. Access points are mostly located upstream within the City of San Marcos along both the San Marcos River and Blanco River. The two rivers are tube and kayak friendly, however low water dams present a challenge to cross of varying difficulty. Fishing may occur from kayaks, or small boats and from private property along the river banks. Popular game fish are bass, panfish, and catfish. Birding and wildlife viewing may also occur from the river and along the banks.

2.8.6 Economics

The major employment sector in the study area is the service sector. With the exception of Wimberly, approximately 14 percent of the employment in each of the areas was in retail trade. Wimberly, consistent with higher education levels, has almost 18 percent of its population in the professional, scientific and management sector and 19 percent in the arts, entertainment, recreation and food services sector. Other major industries include health care and manufacturing. For more detail on economics refer to Appendix B.

2.8.6.1 Socio-Economics

Both the counties of Comal and Hays, as well as the cities of New Braunfels and Wimberly have median household incomes greater than the state, with Comal County overall having the greatest median income of $73,655. Seguin, with $41,250, and San Marcos, with $24,748 had lower median incomes than the State and the remainder of the geographic areas.

Both Sequin and San Marcos had higher percentages of families below the poverty level, each with almost 18 percent of families. This compares to the approximately 12 percent for the state overall. The percent was almost half in the other areas, ranging

from 6 percent in Wimberly to 9 percent in for Hays County overall. The population is shown in Table 9.

Table 9: Population Projections 2010-2050

Geographic Area	Year				
	2010	2020	2030	2040	2050
Texas	25,145,561	29,677,668	34,894,452	40,686,496	47,342,105
Comal County	108,472	147,330	204,873	282,548	389,584
Guadalupe County	131,533	170,266	221,356	280,644	351,776
Hays County	157,330	234,896	347,120	509,975	746,149
Source: Texas State Demographer, https://demographics.texas/gov					

2.8.6.2 Demographics

The racial composition of New Braunfels is 61 percent white, 2 percent Black, 34 percent Hispanic 1 percent Asian and 1 percent two or more races. This is similar to Comal County, with 69 percent white, 2 percent Black, 27 percent Hispanic, 1 percent Asian, and 1 percent two or more races. Seguin has a higher percentage of Hispanics, with 54 percent, followed by white, with 36 percent, Black, 8 percent, and Asian 2 percent. In the Blanco River damage centers, San Marcos is 49 percent white, 5 percent Black, 42 percent Hispanic, 2 percent Asian and 2 percent two or more races and Wimberly is 85 percent white, 13 percent Hispanic and 1 percent each for other and two or more races. Hays County is 55 percent white, 3 percent Black, 38 percent Hispanic, 1 percent Asian and 2 percent two or more races. By comparison, the racial makeup of the State is 42 percent white, 12 percent Black, 39 percent Hispanic, 4 percent Asian and 2 percent two or more races.

2.8.7 Health and Safety

Health and safety in the Guadalupe River Basin is affected by numerous factors. Recreation on the Guadalupe River, San Marcos, and Blanco Rivers includes tubing, canoeing, and other water based recreation as well as recreation alongside the rivers. Since 1998, approximately 27 lives have been lost within the basin. Approximately 13 of those deaths occurred when vehicles entered high water, 12 were lost when a house was swept off its piers, and the remaining 2 deaths are attributed to flood waters restricting emergency access to a residence that was not flooded.

The counties and cities recognized that flooding causes significant risk to life and safety. In response they have worked with the USGS and four new stream gauges have been installed in the watershed headwaters. One gauge was installed on Bear Creek and the other three were installed on the Blanco River upstream of the Wimberley gauge. Further, the counties have developed flood response plans that are practiced on a routine basis, with the last occurring in Hays County in June 2019. Flood warning systems have been implemented in Hays and Comal counties, where the hydrology is flashiest.

2.8.7.1 Guadalupe River

There are numerous forms of recreation within and alongside the Guadalupe River. The river has numerous roads that cross and run parallel within the floodplain. There is a long history of properties being destroyed and human life lost from flooding, such as the 2002 Flood where there was over 30 inches of rain recorded within 8 days. For further information on past flooding in the area please refer to Appendix A.

2.8.7.2 Blanco River

There are numerous forms of recreation within and alongside the Blanco River. The Memorial Day flood of 2015 had several homes swept off their piers, with one resulting in 12 deaths.

2.9 Hazardous, Toxic, and Radioactive Waste

In order to complete a feasibility level HTRW evaluation for the proposed Lower Guadalupe River project, a records search was conducted following the rules and guidance of ER 1165-2-132: HTRW Guidance for Civil Works Projects, and ASTM E1527-13: Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process. In the records review, files, maps and other documents that provide environmental information about the project area are obtained and reviewed. To complete the records review, USACE reviewed publicly available databases and sources, using the proposed footprints of the project, along with an approximate 1 mile search distance for each of the sources. The records search revealed no potential HTRW sites within the 1 mile radius.

Although not considered HTRW, the records search also covered water wells, oil and gas wells, pipeline, and other potentially hazardous features. The search did reveal the presence of a private water well in the proposed footprint of the Bear Creek Detention. This aspect of the project may require coordination with the landowner before project implementation. Refer to the Appendix E for details of the HTRW evaluation.

3.0 Plan Formulation

3.1 Problems, Opportunities, Objectives, and Constraints

Based on the existing conditions and the NAA, study specific problems, opportunities, objectives, and constraints were developed. These problems, opportunities, objectives, and constraints would be assessed inside the study area unless otherwise indicated.

3.1.1 Problems

The problems identified in the study area are:

1. Periodic flash flooding poses a risk to human health and safety, especially on the uncontrolled Blanco and San Marcos Rivers
2. Routine flooding damages buildings, property, and infrastructure

3.1.2 Opportunities

The opportunities identified in the study area are:

1. Increase flood risk awareness
2. Improve local planning regarding future development

3.1.3 Objectives

Objectives are used to assess the how well an alternative addresses the significant problems and opportunities. The Federal Objective for all flood risk management projects is to contribute to the National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to National environmental statutes and applicable Executive Orders, and following other Federal planning requirements.

The study specific objectives for the study from the year 2028 to 2078 for the focused damage centers of Lower Guadalupe River Basin are:

1. Reduce flood risks to human health and safety
2. Reduce flood damages to buildings, property

3.1.4 Constraints

The study specific constraints are:

1. Minimize impacts to the recharge of the Edwards Aquifer and coordinate any impacts with the Texas Commission on Environmental Quality (TCEQ)
2. Avoid reducing flows from the aquifer, altering cave systems, or decreasing surface water quality at the Edwards Aquifer-fed Comal and San Marcos Springs
3. Minimize impacts to nesting habitat for the endangered golden-cheeked warbler
4. Minimize negative impacts to cultural resources

3.2 Management Measures

Management Measures are actions that can be taken in general, or at a specific location, in order to achieve the stated study objectives. The initial array of management measures included both structural and non-structural measures. Structural measures modify the extents and depths of floodplains in order to reduce flood risk. Non-structural measures do not change the extents or depths of the floodplain, but change the effects flooding has on structures or people’s health and safety.

3.2.1 Structural Measures

Structural measures were considered, evaluated, and screened as part of the planning process. The measures, a description, and screening are shown in Table 10. More detail on the screening of the measures is in Appendix H.

Table 10: Structural Measures Considered and Screening

Measure	Description	Screening
Detention Basin	6 ft thick Roller Compacted Concrete layer covering compacted earth	The PDT determined that this management measure should be retained for further plan formulation as they have a large regional impact by reducing flood risk.
Channelization	Excavation of existing channel to increase depth/width	This measure was kept for further evaluation as the PDT determined that channelization would be able to address flood risk in the immediate vicinity.
Floodwalls	No higher than 6 feet above grade. These measures can be placed around a single structure or a small group of structures.	Preliminary economic numbers determined that floodwalls are not economically justified and were removed from further consideration.
Levees/Berms	Berms would be constructed of compacted earthen fill with a 10 foot wide top and 0-4 feet above the surrounding terrain. Side slopes would be protected with turf matting or other suitable materials.	This measure was removed from further consideration as a stand-alone measure due to real estate costs and hydraulic considerations. A smaller feature remained possible if combined with channelization and was kept for further evaluation.

3.2.2 Non-Structural Measures

Non-structural measures were considered, evaluated, and screened as part of the planning process. The measures, a description, and screening are shown in Table 11. More detail on the screening of the measures is in Appendix H.

Table 11: Non-Structural Measures Considered and Screening

Measure	Description	Screening
Wet Floodproofing	This technique consists of reconfiguring a structure to not be damaged by flood waters.	This measure is generally not applicable to large flood depths and high velocity flows and so was removed from further consideration. Further it is applied to basements.
Dry Floodproofing	This technique consists of waterproofing the structure.	This measure was removed from further consideration because dry floodproofing is not suitable for anticipated depth of flooding
Structure Elevation	This technique lifts an existing structure to an elevation which is at least equal to or greater than the 1 percent annual chance flood elevation.	This measure was removed from further consideration as the structures best suited for elevation that were damaged in the recent flooding either were not rebuilt or raised on their own
Acquisition	This technique consists of buying the structure and the land. The structure is either demolished or is sold to others and relocated to a site external to the floodplain. The land is often used for recreation or for ecosystem restoration.	Damages do not begin until the 4 percent Annual Chance Exceedance (ACE) event. Significant damages occur at the 1 percent ACE. Given that a large number of structures receive damages at less than frequent events, the cost of acquiring and relocating those properties would overshadow the annual benefits.
Flood Warning System	This technique relies upon stream gage, rain gages, and hydrologic computer modeling to determine the impacts of flooding for areas of potential flood risk.	This management measure was retained for further consideration. Local governments in basin are currently implementing flood forecast and warning systems
Flood Emergency Preparedness Plans (FEPP)	The FEPP should incorporate the community's response to flooding, location of evacuation centers, primary evacuation routes, and post flood recovery processes.	This management measure was retained for further evaluation. Local sponsors are required to develop FEPPs as part of their responsibilities during Planning, Engineering, and Design (PED) and to implement them within one year of construction completion.
Canyon Lake Storage Reallocation	Reallocation of storage from the conservation pool to the flood storage pool.	Canyon Lake Dam is a medium risk dam and the conservation pool is unavailable for reallocation. This leaves no pool to reallocate to the flood pool should the risk at some future point be considered acceptable.

3.3 Initial Alternatives Array

A brief description of the evaluated alternatives are provided below, for more detail on an alternative see Appendix A, F, I, and J.

3.3.1 Blanco River Detention Blanco 2

The dam would extend across the Blanco River in tree covered ranch land with some open pasture. Chimney Valley Road (County Road 407), an asphalt paved road extends through the center of the proposed dam site 2 and crosses the Blanco River near the proposed dam site. County Road 407 extends northwest along the south side of the Blanco River through the inundated flood zone for approximately 2 miles. Approximately 1.5 miles upstream from the proposed dam site County road 407 crosses the Blanco River at a low water crossing & culvert. Cox Road (County Road 406), an asphalt paved road runs through the inundation flood zone from Ranch Road 165 south along the west side of the Blanco River for approximately 1.8 miles. County Road 406 crosses the Blanco River at a low water crossing & culvert at approximately 1 mile south of Ranch Road 165. Existing power and fiber optic lines that run along County Roads 407 and 406 will need to be terminated and removed or abandoned in place, or relocate to remain in service. There is an abandoned 12-inch petroleum line that runs along County Road 407. Three options were studied for the Blanco 2 site. Determined from H&H analysis, the maximum dam heights of 60, 65, and 73 feet were evaluated.

3.3.2 Blanco River Detention Hays 2

The dam would be located near the Hays/Comal/Blanco County Line. The Dam site extends across the Blanco River in tree covered ranch land with some open pasture. The dam crosses an unpaved dirt road. The unpaved road extends through the river at an unpaved low water crossing. The inundated flood zone covers tree covered ranch land with unpaved ranch roads extending throughout the area. One of the ranch roads at the far northwest end of the flood zone has an existing concrete low water crossing extending across the river. Existing utilities in the area were not verified due to the site being on private property. Utility services located within the inundation area will be terminated, abandoned, and/or rerouted.

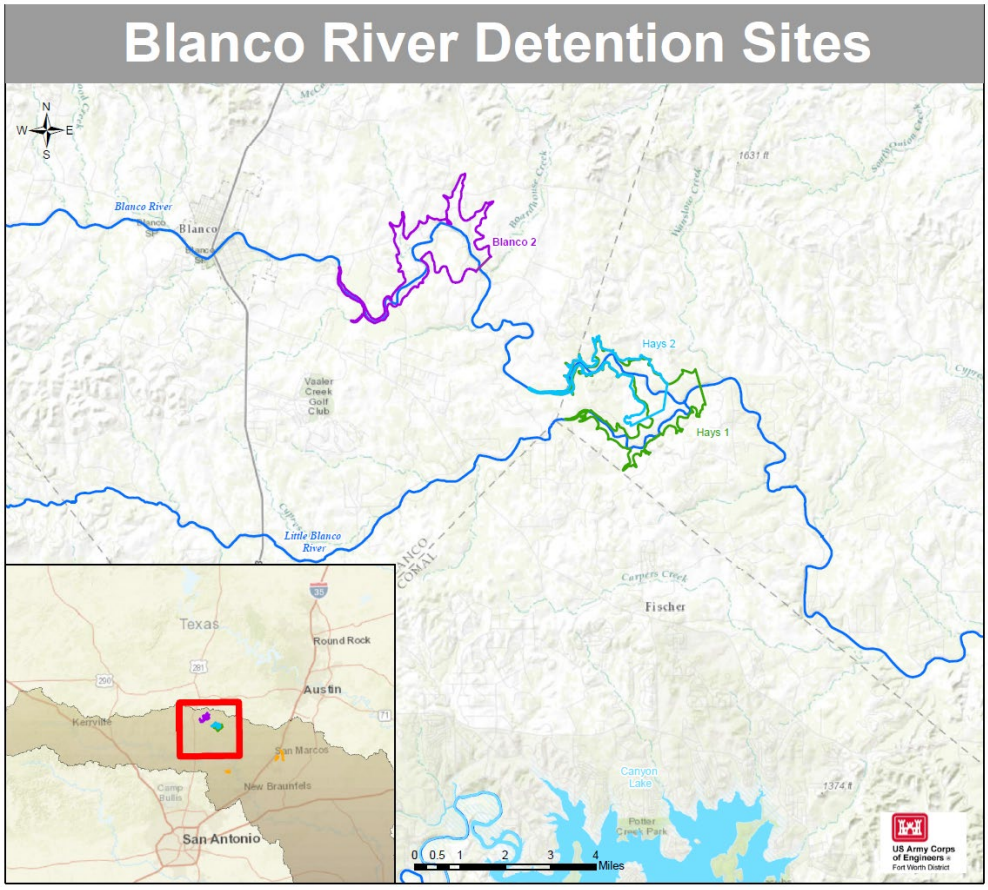

Figure 14: Blanco 2 and Hays 2 Detention Areas Map

3.3.3 Blanco River Bank Improvement

This alternative includes the combination of the Blanco Gardens berm and a diversion channel from Old Martindale Road to the San Marcos River. This alternative only provides flood mitigation benefits for the Blanco Gardens neighborhood. This alternative raises the topography of the western Blanco River bank from Highway 80 to Old Martindale Road. This elevation of the bank reduces the overflow from the Blanco River into the Blanco Gardens neighborhood. The berm is simulated at the 2 percent ACE existing condition Blanco River water surface elevations protecting the neighborhood from the more frequent storm events. Reduction of overflow into the neighborhood increases flows in the Blanco River causing a slight increase in the water surface. The diversion from near Old Martindale Road to the San Marcos River is used to mitigate that rise. The diversion consists of a 300-foot wide, 10-feet deep channel in the below figure. Additionally this alignment significantly reduces the required property acquisition because the majority of the land along this alignment is owned by the City of San Marcos. The proposed channel will require each of the crossing structures to be constructed as bridges that span the channel. The bridges were not included in the hydraulic modeling as it was assumed the bridges would be designed to generate minimal head loss.

3.3.4 Blanco River Bypass Channel

Channelization of Bypass Creek would occur from the Blanco River overflow near IH-35 and rerouting the channel to the confluence with the San Marcos River, shown in Figure 15. The increased capacity of Bypass Creek and its bypass will receive additional overflow from the Blanco River into the improved channel while avoiding heavily populated areas. This alternative reroutes Bypass Creek between Airport Highway and Highway 80 creating a shorter channel with less crossings, development, and constraints. Two conceptual channel options were investigated: 1) 125-foot, 20-feet deep channel and 2) 200-ft, 20-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires lowering the topography between the Blanco River and Bypass Creek and construction of bridges. The Blanco Garden Berm is part of this alternative.

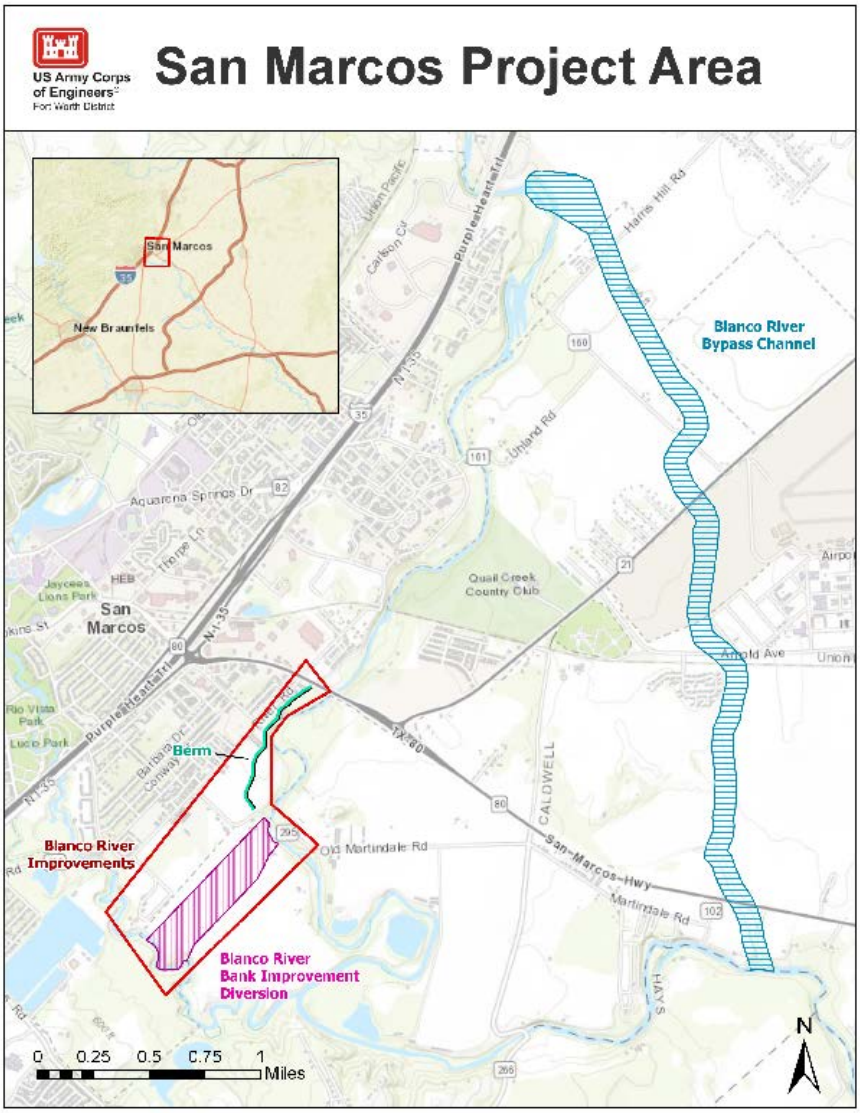

Figure 15: Blanco River Improvements Map

3.3.5 Bear Creek Detention

The Bear Creek Dam is located 1.5 miles east of Farm to Market Road 2722 and Bear Creek Trail. The dam is a 75 feet high, extends across Bear Creek in tree covered canyon lands with a culvert to convey normal flows. At the northwest end of the inundated flood area, Bear Creek Trail extends from north to south across the inundated flood zone and across a tributary to the creek. Bear Creek Trail extends from FM 2722 southeast through tree-covered canyons for approximately 1.76 miles then southwest for approximately 0.67 miles to FM 2722. Bear Creek Trail will need to be closed to traffic during flood events. Oso Arroyo road, an unpaved gravel road, runs through the inundation footprint for approximately 1.2 miles, continuing through the dam footprint. There are three lower water crossings along Oso Arroyo road.

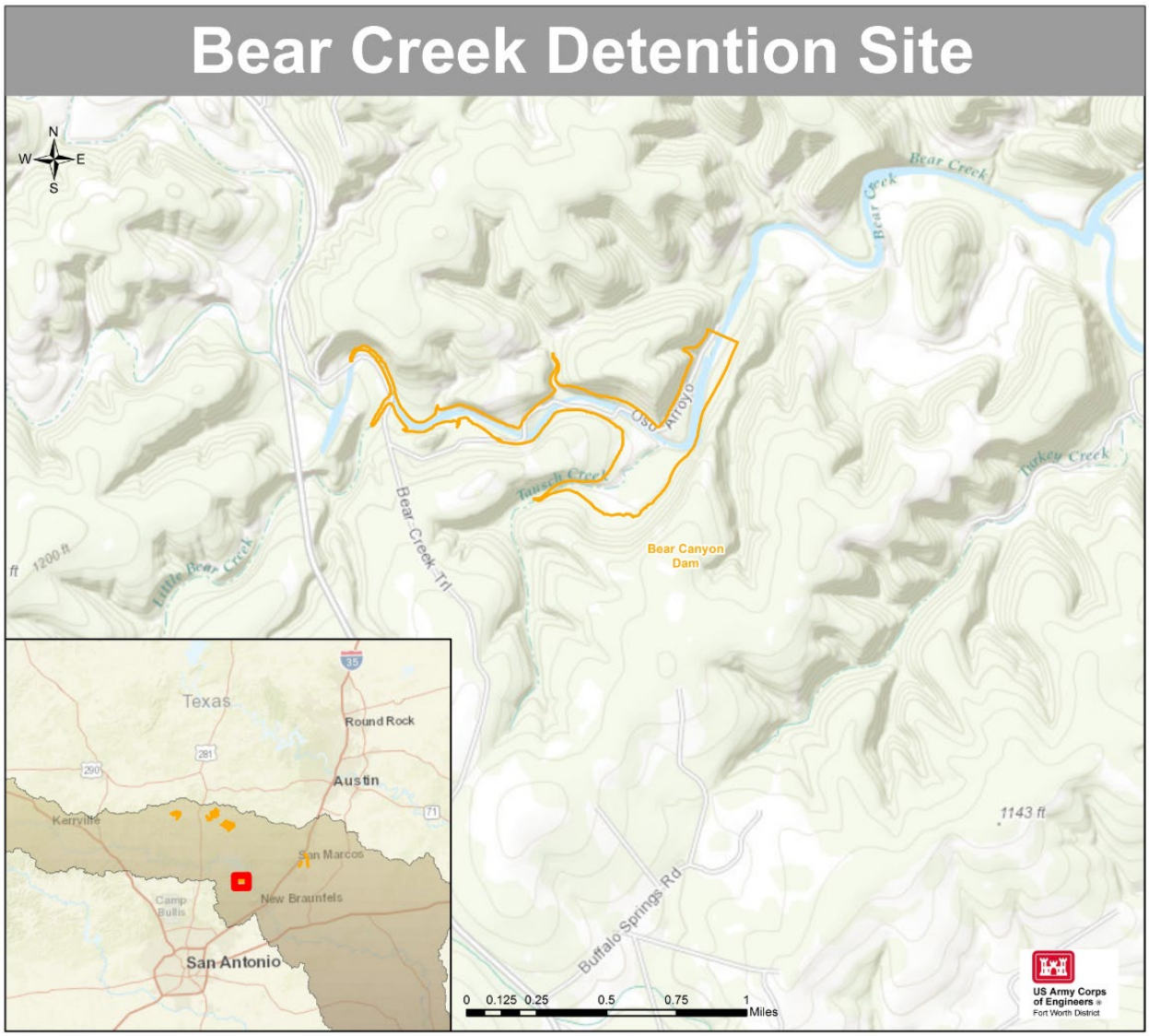

Figure 16: Bear Creek Detention Map

3.3.6 Evaluation and Comparison of Initial Alternative Array

Based on previous studies, performed by Halff and Associates, it was determined that the Hays 2 detention area would not be cost effective. The benefits of Blanco 2 were similar with an anticipated lower cost. For more detail see the Halff reports in Appendix A.

3.4 Final Array of Alternatives

The final array of alternatives included the Blanco River Detentions, Blanco River Bypass Channel, and Bear Creek Detention as described in previous sections.

3.5 Evaluation and Comparison of Final Alternative Array

Alternatives were screened and compared based on how well an alternative plan 1) accounts for all the required work in order to meet project objectives and projected benefits (Completeness); 2) achieves the planning objectives (Effectiveness); 3) complies with laws, regulation, and public policy (Acceptability); and 4) achieves the planning objectives in relation to costs (Efficiency).

3.5.1 Completeness

The alternatives in the final array would achieve the benefits described below independently. For all alternatives, this included determining mitigation of impacts to cultural and natural resources.

3.5.2 Effectiveness

3.5.2.1 Reduce Flood Risk to Human Health and Safety

Reduced risk to human health and safety was evaluated through the number of structures no longer at risk of the 0.01 AEP flood event.

Table 12: Alternatives 0.01 AEP floodplain changes

Alternative	Structures no longer at risk of the 0.01 AEP flood event
No Action Alternative	0
Blanco River Detention	131
Blanco River Bypass Channel	0
Bear Creek Detention	159

3.5.2.2 Reduce Flood Damages to Buildings, Property, and Infrastructure

Flood damages reduced were determined by evaluating the Expected Annual Damages (EAD) and comparing those with the NAA (Table 13). The reduced flood damages are weighted average over the 50 year planning horizon and reported as an annual rate. The areas of protections have no connectivity the EAD was evaluated for each area independently. The details on how these damages were developed are in Appendix B.

Table 13: Reduced Flood Damages (Oct 2017, $1,000)

Alternative	Without Project Expected Annual Damages	With Project Expected Annual Damages	Damages Reduced
Blanco River Detention (60 foot height)	4,332	3,341	991
Blanco River Detention (65 foot height)	4,332	3,136	1,196
Blanco River Detention (73 foot height)	4,332	2,998	1,334

Blanco River Bypass Channel	4,332	2,616	1,716
Bear Creek Detention	14,048	12,436	1,612

3.5.3 Acceptability

All of the alternatives in the final array complied with laws, regulations, and public policy. This effort includes, as required by regulation, a qualitative assessment of climate change for the area, as well as a qualitative assessment on how climate change will affect the resiliency of the recommended action. The qualitative climate change analysis shows no impact on the evaluated alternatives nor a change in resiliency from one alternative to the other. Further, as shown in Section 7.0 , the Tentatively Selected Plan is in compliance with environmental laws and public policy.

3.5.4 Efficiency

3.5.4.1 Average Annual Costs and Benefits

The developed costs include the required land acquisition, construction, design, and implementation of the proposed mitigation. The costs are amortized out over the 50 year planning horizon. Costs are also found in Appendix J and annualization of the costs is shown in Appendix B. Average annual net benefits are the benefits after subtracting the average annual cost. The benefits are represented by the average annual damages reduced by an alternative.

Table 14: Alternative Cost Analysis (Oct 2017, $1,000, 2.875% interest rate)

Alternative	First Costs	O&M Costs	Average Annual Costs	Average Annual Benefits	Net Benefits
No Action Alternative	0	0	0	0	0
Blanco River Detention (60 foot height)	53,443	300	2,334	1,227	-1,107
Blanco River Detention (65 foot height)	60,638	300	2,609	1,342	-1,266
Blanco River Detention (73 foot height)	73,014	300	3,079	1,570	-1,509
Blanco River Bypass Channel	52,503	300	2,299	1,967	-331
Bear Creek Detention	21,774	300	1,129	1,620	483

3.6 Plan Selection

After determining that Bear Creek was the only economically justified alternative, additional analysis was done. That analysis revealed that the location of the Bear Creek Detention had a high likelihood of that it is sitting on karst terrane, which is limestone with contiguous cavities. Avoiding seepage caused failures from the cavities require additional foundation work. This would be done in the form of grouting and cutoff walls. The dam would be roller compacted concrete (RCC) to ensure that overtopping does not cause failure. A newly constructed earthen dam with on top would have increased voids beneath the RCC layer. These updates in the design increased the costs of the Bear Creek detention, but would have been required for all the detention structures evaluated.

The new costs for Bear Creek are shown below. Cost uncertainty is included in the costs as contingency based on an abbreviated risk analysis, which result in an estimated first cost of $70,293,000 with $27,000 O&M costs. The average annual costs, benefits, net benefits, and benefit cost ratio (BCR) are shown in Table 15.

Table 15: Net Benefits of Bear Creek Detention ($1,000, Oct 2018, 2.75% interest rate)

Alternative	Average Annual Benefits	Average Annual Costs	Net Benefits	BCR
Bear Creek Detention	1,620	2,799	-1,152	0.58

With no economically justified alternative the tentatively selected plan (TSP) is the NAA.

4.0 Tentatively Selected Plan

The NED plan is the NAA, which is also the TSP.

4.1 Risk and Uncertainty

4.1.1.1 Benefit and Cost Uncertainty

Cost uncertainty is included in the average annual costs as contingency based on an abbreviated risk analysis, which result in an estimated first cost of $70,283,000 with $27,000 O&M costs. The benefits could vary based on natural variability. This was captured by analyzing the net benefits using the 25, 50, and 75 percent confidence bounds. The results of that analysis are shown in Table 16, which includes the resulting Benefit-Cost Ratios (BCR).

Table 16: Net Benefit Uncertainty Analysis ($1,000, Oct 2018, 2.75% interest rate)

Alternative	First Costs	Average Annual Benefits	Average Annual Costs	Net Benefits	BCR
No Action Alternative	0	0	0	0	0
Bear Creek Detention (25 percent Confidence)	70,283	679	2,799	-2,120	0.24
Bear Creek Detention (50 percent Confidence)	70,283	1,363	2,799	-1,436	0.49
Bear Creek Detention (75 percent Confidence)	70,283	2,295	2,799	-504	0.82

5.0 Environmental Consequences

Numerous alternatives were formulated, including structural and non-structural alternatives such as buyouts, wet and dry flood proofing, as well as other dry detentions and by pass channels to reduce flood risk and damages. The initial and final array of alternatives were screened and analyzed, ultimately identifying the No Action Alternative, also referred to as NAA or TSP, as the only alternative economically justifiable. As such, Sections 5.0 , 6.0 only analyzed the “No Action” alternative and the Bear Creek Detention Dam (BCDD) alternative.

The “No Action” alternative serves as a baseline against which alternatives can be evaluated. The Tentative Selected Plan consists of no Federal action taking place as a result of this study while the BCDD alternative entails building a detention dam on Bear Creek that would hold back water only during a flood event but allow for normal water

flow through large culverts running the length of the dam along the creek bed. Additional drawings and specifications regarding the detention dam can be found in Appendix I.

Refer to Section 3.0 for detailed descriptions and figures of the geographic extent of the BCDD. The “No Action” alternative is also referred to as the Future without Project Conditions and presumes no management measure would be taken to address the planning objectives. The discussion of each resource considers the direct and indirect effects of construction and operations related to the Tentative Selected Plan and the BCDD alternative.

The identification of potential impacts includes consideration of both the context and the degree of the impact. When feasible, distinctions are made between short- and long-term impacts; negligible and significant impacts; and negative and positive impacts. A negligible impact may have an inconsequential effect or be unlikely to occur; whereas a significant impact would have more pronounced or severe consequences, generally adverse. If the current condition of a resource would be improved or an undesirable impact would be lessened, the impact is considered beneficial.

5.1.1 Significance Criteria and Impact Characterization Scale

In accordance with CEQ regulations and implementing guidance, impacts are evaluated in terms of their significance. The term “significant,” as defined in 40 CFR 1508.27, part of the CEQ regulations for implementing NEPA, requires consideration of both context and intensity. Context means that the significance of an action must be analyzed in several settings, such as society as a whole (human, national); the affected region; the affected interests; and the locality. Significance varies with the setting of the Tentative Selected Plan. For instance, in the case of a site-specific action, significance would usually depend on the effects on the locale rather than on the world as a whole.

Intensity refers to the severity of impact with regard to the above ratings (minor through significant). Factors contributing to the evaluation of the intensity of an impact include, but are not limited to, the following:

- The balance of beneficial and adverse impacts, in a situation where an action has both;
- The degree to which the action affects public health or safety;
- The unique characteristics of the geographic area where the action is proposed, such as proximity to parklands, historic or cultural resources, wetlands, prime farmlands, wild and scenic rivers, and ecologically critical areas;
- The degree to which the effects on the quality of the human environment are likely to be controversial;
- The degree to which the effects of the action on the quality of the human environment are likely to be highly uncertain or involve unique or unknown risks;
- The degree to which the action might establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration;
- Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to

anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action “temporary” or by breaking it down into small component parts;
- The degree to which the action might adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the NRHP or might cause loss or destruction of significant scientific, cultural, or historic resources;
- The degree to which the action might adversely affect an endangered or threatened species or habitat that has been determined to be critical under the environmental site assessment of 1973;, and;
- Whether the action threatens a violation of Federal, state, or local law or requirements imposed for the protection of the environment.

Impacts are characterized by their relative magnitude. Adverse or beneficial impacts that are significant are the highest levels of impacts. Conversely, negligible negative or negligible positive effects are the lowest level of impacts. In this document, nine descriptions are used to characterize the level of impacts. In order of degree of increasing impact they are:

- Significant Negative Effect
- Moderate Negative Effect
- Minor Negative Effect
- Negligible Negative Effect
- No Impact or Negligible Effect
- Negligible Positive Effect
- Minor Positive Effect
- Moderate Positive Effect
- Significant Positive Effect

5.2 Climate

5.2.1 No Action Alternative

Climate change is expected to further amplify the severity of extreme events such as drought and heavy rainfall throughout the southwest for the NAA as described in Section 2.1.

5.2.2 Bear Creek Detention Dam

The construction of the BCDD, and associated mitigation construction activity would result in temporary increase of air pollution in the immediate surrounding area. These emissions could contribute to climate change, although, impacts would be negligible as total construction time is expected to be less than two years.

5.3 Air Quality

5.3.1 No Action Alternative

Air quality across the study area is not anticipated to change from the existing condition to the NAA. While urban sprawl along the I-35 corridor in the study area will continue to

contribute to adverse air quality, these impacts are expected to be limited by advances in construction methods and materials, more fuel efficient cars, as well as local, state, and Federal air quality management measures.

5.3.2 Bear Creek Detention Dam

The building of the proposed BCDD, and associated mitigation measures would have short-term, minor, adverse impacts on air quality for the Guadalupe River, Bear Creek, and San Marcos areas. The increase of construction activity would result in temporary increase of air pollution in the immediate surrounding area as total construction time is expected to be less than two years. All counties with proposed measures (Comal, Guadalupe, and Hays) are in attainment status for all pollutants and no conformity determination would be required.

The planting of up to 25 acres of riparian forest along the Guadalupe River would have long-term benefits to air quality as the trees would absorb atmospheric carbon, although this beneficial impact would be negligible due to the small acreage.

The temporary increase of construction activity is not anticipated to impact San Antonio nor Austin Areas air quality attainment status.

5.4 Topography, Geology, and Soils

5.4.1 No Action Alternative

The NAA does not involve any activities that would contribute to changes in existing or future without project conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on topography, geology, and soils within the Guadalupe River, Bear Creek, or San Marcos areas. Development is likely to continue to transform natural areas into pockets of residential developments and other urban and agriculture uses. These actions can have adverse impact on soils through farming practices and the placement of non-permeable surfaces like roads and concrete for buildings. Adverse impacts to geology and topography could occur as well from development but would be expected to occur less frequently and at lower intensity due to the effort needed to alter these resources on the landscape.

5.4.2 Bear Creek Detention Dam

5.4.2.1 Guadalupe River

The Guadalupe River geology and soils would receive minor, long-term benefits from the reduction in flash floods, swift flows, and erosional forces that the proposed BCDD would help to alleviate. The planting of up to 25 acres of riparian forest along the Guadalupe River would also help stabilize and buffer upland soils from larger flood events.

Minimal adverse impacts to Prime Farmland would be expected from the riparian mitigation plantings. All efforts will be made to avoid and minimize the conversion of active agriculture lands. Riparian plantings would likely occur along the banks of the

Guadalupe River between New Braunfels and the Guadalupe-Gonzales County. While these areas exhibit numerous active farms, riparian plantings would be focused adjacent to the river where farming is limited due to reoccurring flood events. The NRCS would need to be coordinated with under the Farmland Protection Policy Act. The AD-1006 form would be completed by USACEW to disclose the impact to farmlands converted to riparian habitat.

5.4.2.2 Bear Creek

The small nature of the dam and the placement in a steep canyon would have moderate, permanent negative impacts on topography as the detention dam would essentially turn the area into a box canyon configuration. Any drilling and excavation conducted would be confined to the footprint of the dam and associated aprons and stilling basins. Placement of the dam and associated future flooding would not impact Prime farmland soils. Within the footprint of the dam there are no known karst or unique geological features, although the possibility exists of discovering these features during construction. The BCCD would reduce the impact of flash floods and swift flows downstream. This reduction in swift water would help to reduce erosion downstream, providing minor benefits to the river geomorphology and soils within the area.

During flooding events, some vegetation may die due to inundation and destabilize soils. Although the maximum inundation duration post-flood event for the BCDD is less than 30 hours. Vegetation mortality is expected to be minimal, between flooding the area would naturally re-vegetate from nearby and in-ground seed bank sources.

5.4.2.3 San Marcos

The removal of the Cummings Dam would have negligible to minor, long-term, beneficial impacts on topography, geology, and soils within the San Marcos area. The beneficial impacts comes from the restoration of a more natural sediment and water regime in the San Marcos and Blanco Rivers. The lower water surface profile may cause temporary bank sloughing that would naturally stabilize and re-vegetate, further stabilizing river banks from future floods.

5.5 Land Use

5.5.1 No Action Alternative

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on land use within the study area. Local development is likely to continue to spread from the heavily populated I-35 corridor areas into adjacent rural areas. As such, continued urban development is expected to spread into undeveloped areas across all regions in the study area converting natural areas and/or agriculture lands into mixed land uses.

5.5.2 Bear Creek Detention Dam

5.5.2.1 Guadalupe River

The building of the proposed BCDD would have negligible to minor impacts on land use along the Guadalupe River. The purpose of the detention dam is to help alleviate flooding to communities along the Guadalupe River. Appendix A describes impacts to water elevations during various flood stages. The result of the reduced flooding for these communities is that it may promote development along the floodplain. However, Federal, state, and local laws and regulations are expected to limit development along waterways in the region.

5.5.2.2 Bear Creek

The building of the proposed Bear Creek Detention Dam would have moderate, adverse impacts on land use within the project area. While the area is remote and contains mostly natural areas, some residential use exists within and adjacent to the detention area. The land needed for the BCDD and the detention area, approximately 135 acres, would be purchased in fee, with all other standing structures removed, for the use of flood risk reduction. Between flooding, the land would continue to be managed for the benefit of natural communities. Appendix G provides more detail regarding the land acquisition needs and processes. Lands downstream of the dam may become more desirable to be developed into residential areas from the significant increase of flood protection that they would receive. Federal, state, and local development law and regulations regarding building in floodplains is expected to help limit further development along Bear Creek.

5.5.2.3 San Marcos

The removal Cummings Dam would have no to negligible impacts on land use within the San Marcos. Current users and uses of other area rivers would continue into the future as flows from Spring Lake and the Blanco River would allow recreation to continue. Existing Federal, state, and local law and regulations that govern construction in waterways would still apply.

5.6 Water Resources

For more detailed information and maps regarding water resources, see Appendix C2. General information is provided below.

5.6.1 No Action Alternative - Guadalupe River

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on water resources within and along the Guadalupe River. However, the areas within the floodplain would continue to be impacted by flood flows in the future as they do today. As urban development continues more water would continue to enter the Guadalupe River, potentially increasing flood damages.

5.6.2 No Action Alternative - Bear Creek

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on water resources within the Bear Creek.

5.6.3 No Action Alternative - San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on water resources within the San Marcos area. The continued presence of Cummings Dam would: impede river flow and maintain an un-natural lake environment upstream; reduce downstream continuous hydrology connectivity as the dam is unpassable for aquatic organisms, and may allow for the temporary pooling of contaminants and/or nutrients upstream until flooding flushes the upstream area.

5.6.4 Bear Creek Detention Dam

5.6.4.1 Guadalupe River and Bear Creek

The TSP would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on water resources in the Guadalupe River. The majority of daily flows in the Guadalupe River are controlled by Canyon Lake Dam. The BCDD would negligibly reduce floodplain connectivity due to the generally steep river banks along the river.

The TSP would have short-term, minor, adverse impacts on water quality during flood events. As water is pooled upstream of the BCDD and subsequently released, the water downstream would likely be more turbid from agitation of flowing through the culvert and stilling basin. Temporary increases in suspended debris may also occur as upland areas are drained towards the end of flood events. Minor, long-term benefits to ground water recharge may occur with the operation of the BCDD. While the BCDD would not detain water for an extended period of time, any voids or geological features that may exist in the area would allow for ground water recharge. The dam would allow for more water to flow into Edwards Aquifer by slowing down the amount of flood waters that flow into the recharge zone of the Guadalupe River, therefor giving the aquifer that much more time to absorb it which means that the Guadalupe River would receive minor long-term beneficial impacts.

The design of the proposed BCDD allows for the continued passage of normal flows of water downstream of the dam through the 10 ft. by 12ft. culverts placed at riverbed level. It is anticipated that the building of the dam would result in the permanent removal of 1.3 acres of riverine habitat. Short-term, adverse impacts may also occur to Bear Creek during construction as equipment would need to cross Bear Creek at an existing low water crossing. Figure 17 shows the general footprints of the BCDD and associated construction activities. Temporary improvements may be needed to this crossing to allow for safe movements of equipment and construction personnel. All

avoidance measures, BMPs, and TCEQ regulations will be followed in relation to water crossings to avoid and minimize impacts during construction.

The high quality riverine habitat within Bear Creek would be mitigated for by the removal of Cummings Dam to restore riverine hydrology and habitat function to approximately 34 acres of riverine habitat upstream. This mitigation effort is expected to reduce the impacts of the BCDD to less than significant for water resources in the study area. For more information regarding the modeled efforts related to the BCDD and riverine habitat, see Appendix C2.

Had the BCDD alternative been selected, a 404(b)(1) analysis would have been prepared and submitted to TCEQ for review in order to receive the appropriate water quality permits.

Appendices A and I contain further metrics, maps, and design figures regarding the BCDD function, operation, and footprint.

5.6.4.2 San Marcos

The removal of Cummings Dam would offset the aquatic impacts associated with the BCDD. Cummings Dam restricts river reach connectivity, and impounds the San Marcos and Blanco Rivers. This impoundment creates an un-natural lake environment that promotes non-native species, and suppresses native species, including federally endangered species like Texas Wild-rice. Texas Wild-rice thrives in the flowing spring fed waters upstream of Cummings Dam. However, the distribution downstream, including designated critical habitat for Texas Wild-rice, appears to be limited by the inundation footprint of Cummings Dam. By removing Cummings Dam, not only does it offset the aquatic impacts of the BCDD, but it also restores the natural hydrology within the San Marcos River which in turn may provide for the expansion of Texas Wild-rice downstream towards the confluence with the Blanco River. Additionally, the upstream river reaches of the dam would be slightly shallower, with increase river flows. This allows for additional ancillary benefits, although likely negligible, to water quality and flood risk.

For additional details regarding the mitigation plan selection, see Appendix C3

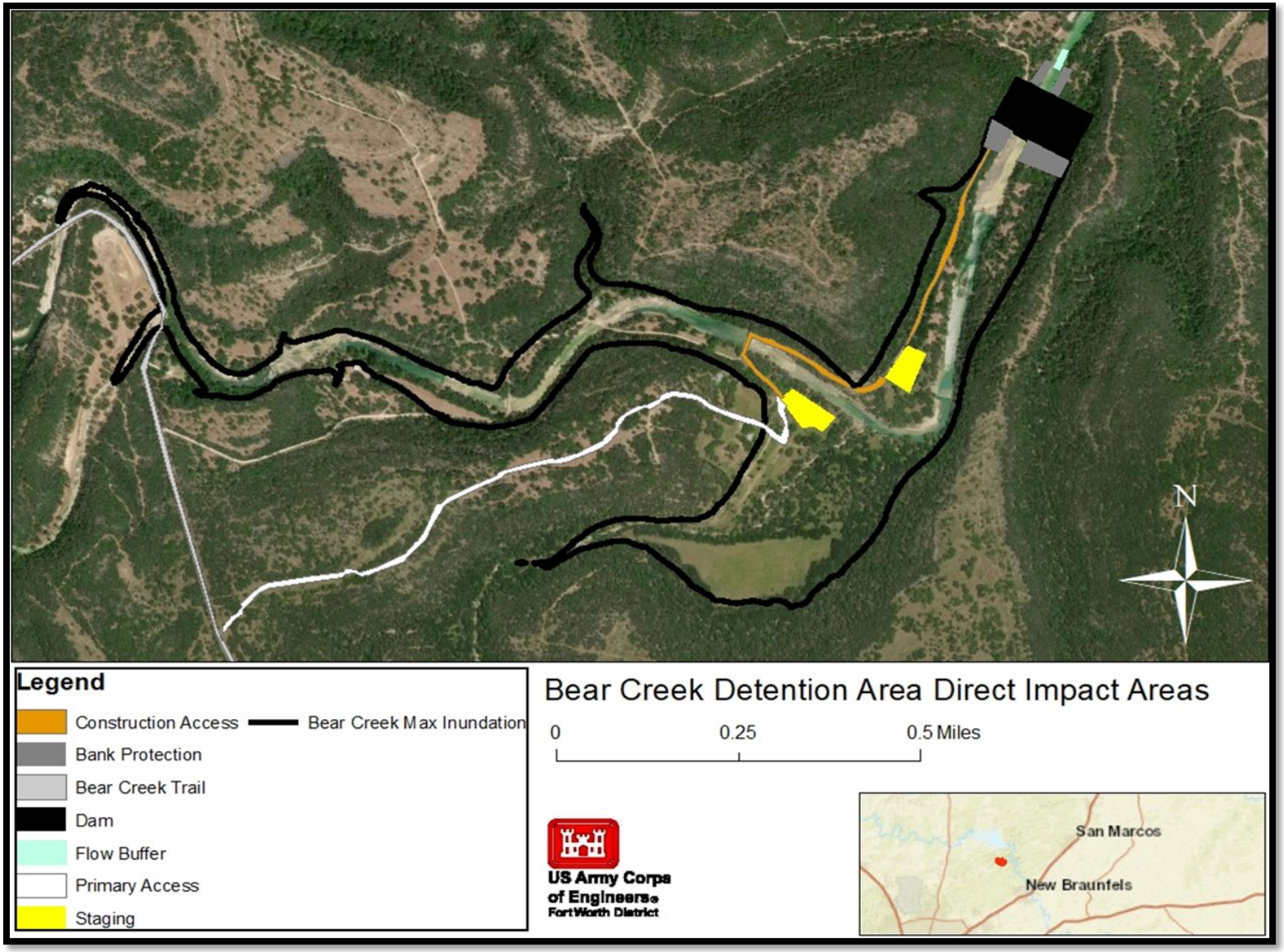

Figure 17: Bear Creek Detention Project Area (Direct Impact Areas)

5.7 Biological Resources

For more detailed information and maps regarding biological resources, see Appendix C2. General information is provided below.

5.7.1 Vegetation

5.7.1.1 No Action Alternative

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on vegetation, and vegetation within and along the Guadalupe River and Bear Creek.

Aquatic vegetation, in particular Texas Wild-rice, will still be largely influenced by the impoundment of rivers by the Cummings Dam within the San Marcos area.

5.7.2 Bear Creek Detention Dam

The BCDD would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on vegetation in the Guadalupe River. The majority of daily flows in the Guadalupe River are controlled by Canyon Lake Dam. The BCDD would negligibly reduce floodplain connectivity due to the generally steep river banks along the river. Vegetation along the Guadalupe River is expected to remain in the same condition as in the NAA.

The building of the BCDD would have long-term, negligible to minor, negative impacts on natural resources within the detention area. The building of the dam would permanently remove 1.3 acres of river, 7.3 acres of riparian forest, 3.2 acres of upland forest habitat, and 3.9 acres of grassland. Downstream of the BCDD, habitat models show a 10 percent loss of riparian forest habitat quality along Bear Creek due to restriction of flood flows down to the 1-2 year flows. Appendix C2 contains additional descriptions of habitat quality loss.

To reduce impacts to vegetation to less than significant, vegetation within the BCDD area will be managed for the benefit of natural resources. In addition, the planting of 25 acres of riparian forest along the Guadalupe River, and potential for expansion of Texas Wild-rice with the removal of Cummings Dam would offset impacts to vegetation loss associated with the construction and operation of BCDD.

Section 5.7.2 contains figures and tables showing the extent and time periods of flooding in the detention area. Because flooding would represent a relatively small period in the life span of the BCDD, and the remainder of the time the area would be managed for natural resource benefit, moderate beneficial impacts would also be realized as this area would be protected from future impacts of urban development. As such, the tradeoff between infrequent flooding, and long-term conservation of the

natural resources within detention area plus the associated mitigation measures would yield overall negligible to minor long-term benefits to vegetation.

5.7.3 Fish and Wildlife Resources

5.7.3.1 No Action Alternative – Guadalupe River and Bear Creek

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on fish and wildlife resources within and along the Guadalupe River or Bear Creek.

5.7.3.2 No Action Alternative - San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on vegetation, and fisheries and wildlife resources within the San Marcos area. The exception to this is that the continual presence of Cummings Dam would continue to: stop movement of aquatic life up and down of the area; slowdown of the movement of mammals and reptiles; alter and disrupt habitats within and along the San Marcos and Blanco Rivers by artificially changing and preventing them from becoming the more desired natural condition.

5.7.4 Bear Creek Detention Dam

5.7.4.1.1 Guadalupe River

The BCDD would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on natural resources for the Guadalupe River. The relative small size of the detention area for the proposed BCDD as compared to the much larger Guadalupe River makes for whatever loss of natural resources negligible.

5.7.4.1.2 Bear Creek

The building of the BCDD would have long-term, negligible to minor, negative impacts on natural resources within the detention area as outside of infrequent flooding, the area would serve as a pseudo-conservation area. The building of the dam, however, would permanently remove 1.3 acres of river, 7.3 acres of riparian forest, 3.2 acres of upland forest habitat, and 3.9 acres of grassland. Downstream of the BCDD, habitat models show a 10 percent loss of riparian forest habitat quality along Bear Creek due to restriction of flood flows down to the 1-2 year flows. Appendix C2 contains additional descriptions of habitat quality loss.

The operation of the BCDD would also increase mortality for terrestrial wildlife not capable of escaping rising flood waters. Species with low mobility and burrowing tendencies like snakes, lizards, armadillos, insects, and others may not be able to escape during flood events. Figure 18 shows the inundation levels, elevation, for various flood events. Table 17 shows elevation, volume, how long each inundation pool would take to drain back to normal creek levels following flood events. Areas inundated

by the 2 year detention pool mostly include the existing riverbed. Minimal upland habitat is flooded with this most frequent flood event. Minor adverse impacts area expected from wildlife mortality due to flooding. As the flood event becomes less frequent the footprint and depth of flooding increase. Most of the inundation is limited to the riverbed except for a low laying area near the last river bend before the BCDD. As such, this area likely experiences some level of inundation in the NAA during flood events with associated adverse impacts to wildlife communities. The increased inundation periods and elevations with BCDD would have reoccurring, moderate adverse impacts to wildlife mortality. However, because flooding would represent a relatively small period in the life span of the BCDD, and the remainder of the time the area would be managed for fish and wildlife benefit, moderate beneficial impacts would also be realized as this area would be protected from future impacts of urban development. The tradeoff between infrequent flooding, and long-term conservation of the natural resources within detention area plus the associated mitigation measures would yield overall negligible to minor long-term benefits to fish and wildlife resources.

Table 17: Flood Storage Metrics for Bear Creek Detention Dam.

		2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	250-YR	500-YR
Peak Pool Elevation	(ft)	804.72	819.49	826.36	834.1	839.83	845.51	848.1	849.46
Peak Storage Volum	(ac-ft)	320.9	833.9	1236.2	1814.1	2323.9	2912.5	3209.9	3375.6
Pool Duration above Channel Banks (733 ft)	(hrs)	7	8.5	12	16	20	23.5	25	25.5

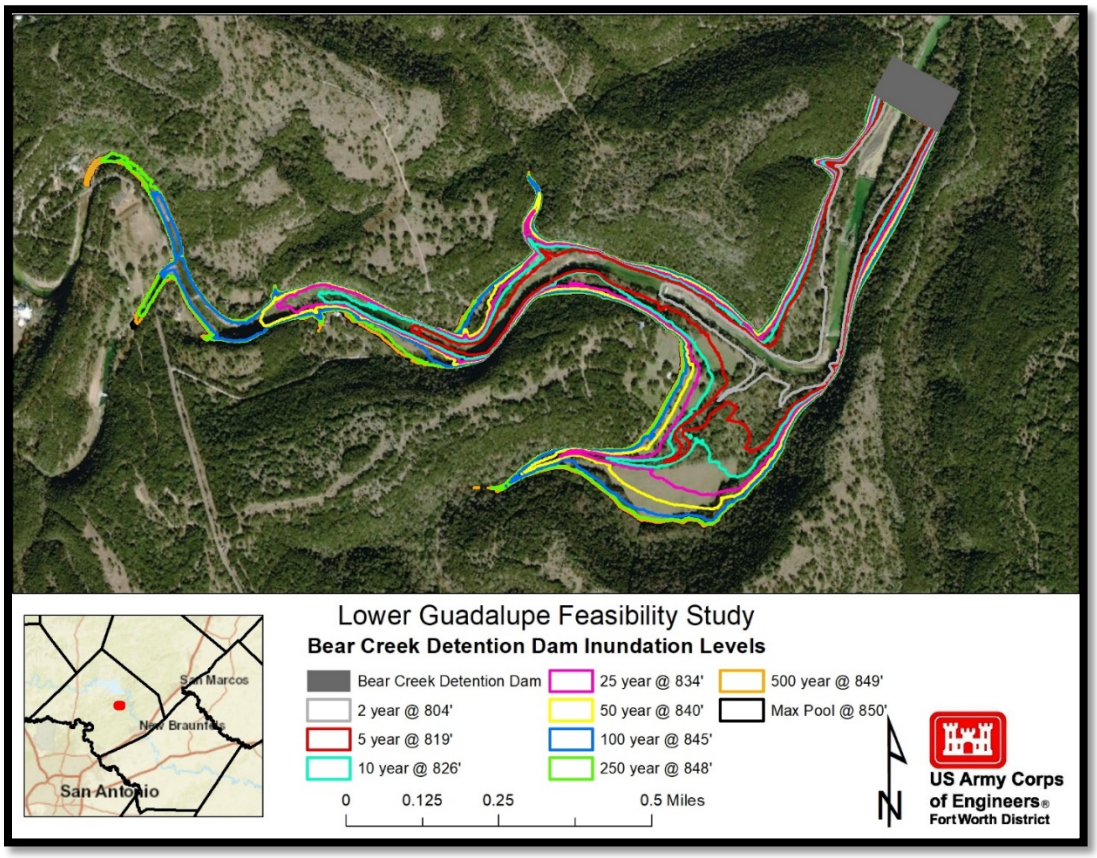

Figure 18: Bear Creek Detention Dam Inundation Levels for Flood Events

5.7.4.1.3 San Marcos

The removal of Cummings Dam would have long-term, major, beneficial, impacts on aquatic natural resources for the San Marcos area. The adverse impacts on aquatic communities including fish, invertebrate, and vegetation from the construction of dams is well known. Cummings Dam maintains an impounded area upstream deeper than what would in occur in natural conditions. This impounded area slows the natural flow allowing sediments to accumulate and reduces light penetration due to depth. As such vegetation species and composition have likely been adversely impacted. The removal of the Cummings Dam will restore of natural, free flowing river and associated movement and life history processes for aquatic life, while promoting native communities within the area. Additional information can be found in Appendix C2 regarding the selection of Cummings Dam to offset aquatic impacts associated with the Bear Creek Detention Dam.

5.7.5 Federally Threatened and Endangered Species

5.7.5.1 No Action Alternative –Guadalupe River and Bear Creek

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on Federally threatened and endangered species within the and along the Guadalupe River and Bear Creek Detention Areas.

5.7.5.2 No Action Alternative - San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on threatened and endangered species within the San Marcos area. The exception to this is that the continual presence of Cummings Dam would likely continue to limit the habitat range of the endangered Texas Wild-rice (*Zizania texana*). The dam likely limits the habitat range by maintaining an impounded area of increasing water depth and lower velocities which in turns prevents the species from occupying areas that it might otherwise occupy within the San Marcos River.

5.7.6 Bear Creek Detention Dam

5.7.6.1.1 Guadalupe River

The reduction of flooding within the Guadalupe River flood zone from the flood waters that the proposed Bear Creek Detention Dam would be able to hold back is not expected to cause short- or long-term, major, moderate, or minor, beneficial, or adverse impacts to any federal listed species.

Golden-cheeked warbler does occur within the vicinity of the Guadalupe River but the reduction in flooding would not impact the habitat for the species, therefore the placement of Bear Creek Detention Dam would not impact the species within the Guadalupe River area. Please refer to the Biological Assessment in Appendix C3 for further explanation.

5.7.6.1.2 Bear Creek

USACE has determined that the construction and operation of the BCDD may affect, and is likely to adversely affect the golden-cheeked warbler. A Biological Assessment would needed and submitted to the USFWS Austin Ecological Services Office as part of a request for formal consultation under the Endangered Species Act. In total, up to approximately 21.3 acres of GCWA habitat would be permanently removed, and an additional 84 acres of GCWA habitat would be temporarily impacted to varying degrees during floods. Comal County, nor any Bear Creek populations are anticipated to suffer from the 21.3 acres loss associated with the BCDD. The placement of a dam in the middle of a fly zone can slow down the overall movement of the GCWAs up and down Bear Creek. The construction of BCDD does entail the creation of new edge habitat, which would provide new routes of entry for predators into the thick forested hills of the area. Predator entry would depend on the species and habitat conditions. The temporary clearing of brush for laydown and borrow sites is occurring at sites with also create edge habitat. Any road expansions would occur in sparsely vegetated areas where practicable.

Construction of the detention dam, including widening of roads, temporary increases in construction and traffic noise, and the temporary laydown and borrow areas would have an indirect, temporary adverse impacts on GCWA. All efforts to complete construction

activities during non-breeding months would have been made. If construction must continue into the breeding season, construction would be continuous so that GCWAs would avoid the area and seek more quiet, less disturbed areas for mating and nesting activities.

To offset adverse impacts to GCWA, the detention area would be purchased in fee and managed for the benefit of GCWA. Any areas previously maintained, farmed, or mowed areas will either be planted or managed for the growth of GCWA habitat. This includes an open field approximately eight acres in size that would provide new habitat for GCWA. In order to fully mitigation the impacts to GCWA, up to 412 acres of existing GCWA habitat in Comal County would be purchased and managed for the benefit of GCWA in perpetuity.

Based on the above discussion permanent, significant, adverse impacts to GCWA would be avoided through mitigation efforts during construction and long-term management of GCWA habitat.

5.7.6.1.3 San Marcos

The removal of Cummings Dam would have a negligible to minor, long-term, beneficial impact on Texas wild-rice. As such, USACE has determined the Cummings Dam removal may affect, but not likely to adversely affect Texas wild-rice and associated critical habitat while providing long-term benefits due to the return of natural river conditions upstream along the San Marcos River. The Biological Assessment would have disclosed specific impacts to Texas wild-rice as well as impact avoidance measures.

The removal of Cummings Dam would help to increase the habitat range of Texas wild-rice by reducing un-natural, constant water depths in areas that are just on the outskirts of its existing habitat range. The downstream expansion of Texas wild-rice would become a moderate, long-term, beneficial impact to the species given its current limited range.

5.7.7 Invasive Species

5.7.7.1 No Action Alternative – Guadalupe River and Bear Creek

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on invasive species within and along the Guadalupe River or Bear Creek.

5.7.7.2 No Action Alternative - San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on invasive species within the San Marcos area. The exception to this is the presence of Cummings Dam would continue to create an artificially disturbed environment within the area that remains highly susceptible invasive species colonization, as compared to a non-dammed area that would have a more natural

environment in which native species would have a higher chance of colonizing and outcompeting invasive species.

5.7.7.3 Bear Creek Detention Dam

5.7.7.3.1 Guadalupe River and Bear Creek

The building of the BCDD and the associated mitigation efforts within the project area would have negligible positive impacts on invasive species within the immediate project area. Invasive species management would occur during construction and as part of the detention dam operations. Beneficial impacts are expected within the detention area as invasive species would be managed long-term. Because of the management is limited to the BCDD there would be no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts in regards to invasive species within to the adjacent Guadalupe River.

5.7.7.3.2 San Marcos

The removal efforts of Cummings Dam and associated mitigation efforts would have minor positive impacts on invasive species within the area. Beneficial impacts would be expected from the area being managed to reduce the invasive species and the that the mere removal of the dam would allow for more natural environment to occur in which native species would have a higher chance of colonizing and outcompeting invasive species.

5.8 Cultural Resources

5.8.1 No Action Alternative

The NAA will not change conditions from the existing condition. The study area will continue to have multiple cultural resources and high potential resource sites.

5.8.2 Bear Creek Detention Dam

Potential impacts to cultural resources at the Bear Creek detention site include disturbance of archaeological material associated with construction of the dam, as well as access routes, construction laydown areas, and borrow material procurement sites. If it is determined that Cummings Dam is eligible for listing in the NRHP, removal of the dam would constitute an adverse effect under Section 106 of the NHPA. Other impacts could include increased erosion upstream of the dam, which may affect previously recorded, as well as unknown archaeological resources. In addition to direct impacts that may be caused by removal of the dam, changes to the viewshed of any historic properties determined to be present may also occur. A programmatic agreement (PA), would be executed to avoid, minimize, and mitigate potential adverse effects in accordance with 36 CFR 800.14.

5.9 Social and Economic Resources

5.9.1 Noise

5.9.1.1 No Action Alternative -Bear Creek, Guadalupe River, and San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on noise within the Bear Creek, Guadalupe River, and San Marcos River.

5.9.1.2 Bear Creek Detention Dam

5.9.1.2.1 Guadalupe River and Bear Creek

The building of the Bear Creek Detention Dam would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on noise for the Guadalupe River and Bear Creek Detention Project.

5.9.1.2.2 San Marcos

The removal of Cummings Dam would have short-term, adverse impacts on noise within the area. Heavy equipment, including excavators and dump trucks would be used to remove and haul away material. Long-term, there would be no change from the NAA outside of a negligible reduction in the amount of noise generated within the area as result of water no longer flowing over Cummings Dam.

5.9.2 Aesthetics

5.9.2.1 No Action Alternative – Guadalupe River, Bear Creek, and San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on aesthetic resources within the Guadalupe River and Bear Creek.

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on aesthetic resources within the San Marcos area. The exception to this is the existence of Cummings Dam which would continue to alter this stretch of the modification area into an unnatural river lake.

5.9.2.2 Bear Creek Detention Dam

5.9.2.2.1 Guadalupe River

The building of BCDD would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on aesthetic resources for the Guadalupe River. The BCDD site is not in visible range from the Guadalupe River due to winding canyon walls. Although the planting of 25 acres of riparian forest would provide minor aesthetic

benefits beyond any agriculture, maintained, or scrub shrub habitat it would replace in addition to the extra wildlife viewing opportunities it would provide.

5.9.2.2.2 Bear Creek

The BCDD would have major, long-term, adverse impacts on aesthetic resources within the Bear Creek. The lack of visibility up and down Bear Creek due to winding canyon walls and virtually no direct line of sight from any public area avoids a significant adverse impact to aesthetics. An estimated two private residences are able to view this area in the NAA.

5.9.2.2.3 San Marcos

The removal of Cummings Dam would have mixed adverse and beneficial impacts based on the receptors perception. The flat calm water immediately upstream of the Cummings Dam along with the associated mill provide a picturesque scene. The removal of the dam would have a permanent, major, adverse impact this aesthetic value. However, for those who prefer natural landscapes sans anthropogenic influences would find the return of flowing river and riffle complexes a permanent, major, and beneficial impact on aesthetic value. The trade-off would likely result in a minor, adverse impact on aesthetics in the area.

5.9.3 Transportation

5.9.3.1 No Action Alternative- Guadalupe River

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on transportation within the Guadalupe River. The exception to this is that the rail and vehicular roads within the pre-project floodplain would still be susceptible to being damaged by the floods, swift flows, and erosional forces that the proposed Bear Creek Detention Dam would help to alleviate.

5.9.3.2 No Action Alternative-Bear Creek and San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on transportation within the Bear Creek Detention Project Area.

5.9.3.3 Bear Creek Detention Dam

5.9.3.3.1 Guadalupe River

The implementation of the Bear Creek Detention Dam would have minor, long-term, beneficial impacts on transportation within the pre-project floodplain of the Guadalupe River. The beneficial impacts comes from the rail and vehicular roads within pre-project floodplain would now have a higher degree of protection from being damaged by floods, swift flows, and erosional forces that the proposed Bear Creek Detention Dam would help to alleviate.

5.9.3.3.2 Bear Creek and San Marcos

The Bear Creek Detention Dam, and associated removal Cummings Dam would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on utilities within Bear Creek, and the San Marcos areas.

5.9.4 Utilities

5.9.4.1 No Action Alternative- Guadalupe River

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on utilities within the Guadalupe River. The exception to this is that the utilities within the pre-project floodplain would still be susceptible to being damaged by the floods, swift flows, and erosional forces that the Bear Creek Detention Dam would help to alleviate.

5.9.4.2 No Action Alternative-Bear Creek and San Marcos

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on utilities within Bear Creek and the San Marcos area.

5.9.4.3 Bear Creek Detention Dam

5.9.4.3.1 Guadalupe River

The implementation of the BCDD would have minor, long-term, beneficial impacts on utilities within the pre-project floodplain of the Guadalupe River. The beneficial impacts comes from the utilities within pre-project floodplain would now have a higher degree of protection from being damaged by floods, swift flows, and erosional forces that the proposed Bear Creek Detention Dam would help to alleviate.

5.9.4.3.2 Bear Creek and San Marcos

The building of the BCDD, and associated removal Cummings Dam would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on utilities within the Bear Creek or San Marcos area.

5.9.5 Recreation

5.9.5.1 No Action Alternative - Guadalupe River, Blanco River, San Marcos River, and Bear Creek

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on recreation within the Guadalupe River, Blanco River, San Marcos River, and Bear Creek.

5.9.5.2 Bear Creek Detention Dam

5.9.5.2.1 Guadalupe River and Bear Creek.

The building of the Bear Creek Detention Dam would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on recreation within the Guadalupe River and Bear Creek Detention Project Area. There wouldn't be any expected impact to recreation within the Bear Creek Detention area because recreation is already limited due to little to no public access. When flooding events to the extent that the proposed Bear Creek Detention Dam would help to alleviate do occur people are not going to be recreating in the Guadalupe River. Those who use the river for recreation would have more time to evacuate the river increasing the safety on the Guadalupe River and Bear Creek.

5.9.5.2.2 San Marcos

The removal of the Cummings Dam would have minor long-term beneficial impacts on recreation within the San Marcos area. An impacts trade off would occur based on the user group. For those who prefer slow, calm waters the removal would adversely impact their kayaking experience. For those who prefer recreating in flowing water, they would perceive the removal of Cummings Dam as a beneficial impact. With the dam removed, both user groups can still recreate in the San Marcos area, plus the Cummings Dam would no longer present a portage hurdle and safety issue. Overall, minor beneficial impact would be realized as the increased ease and safety of transiting up and down the rivers within the area would result from the removal of the dam.

5.9.6 Economics

5.9.6.1 No Action Alternative

The NAA does not involve any activities that would contribute to changes in existing conditions; therefore, no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on the economics within the Guadalupe River, Blanco River, San Marcos River, and Bear Creek.

5.9.6.2 Bear Creek Detention Dam

The building of the Bear Creek Detention Dam, and mitigation measures would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on the economics within the study area.

5.9.7 Health and Safety

5.9.7.1 No Action Alternative

The actions of the local governments has reduced and will continue to reduce the health and safety risks in the area through further development of emergency action plans, zoning and building restrictions, and advanced warning systems. Although the NAA does not provide the additional flood risk reduction and life safety benefits as found in the BCDD alternative.

5.9.7.2 Bear Creek Detention Dam

5.9.7.3 Guadalupe River

The implementation of the Bear Creek Detention Dam would have minor, long-term, beneficial impacts on health and safety within the pre-project floodplain of the Guadalupe River. The beneficial impacts comes from decrease of flooding to the pre-project floodplain. Utilities, roads, and homes would experience flood damages less frequently, and to a lesser extent no longer be impacted from the floodwaters that the proposed dam would help to alleviate. Appendices A and B provide more detail regarding the reduction in flood damages throughout the study area.

5.9.7.4 Bear Creek

The building of the Bear Creek Detention Dam would have no short- or long-term, major, moderate, or minor, beneficial, or adverse impacts on health and safety within the Bear Creek Detention Project Area. Even though there would be a decrease of flooding downstream of the proposed dam location and an increase of flooding upstream it is the low amount of utilities, vehicular traffic, housing, and recreation as well as the complete buyout of flooded lands that leads to this determination.

In response to the Advisory Circular, the United States Army as well as other Federal agencies, signed a Memorandum of Agreement (MOA) with the Federal Aviation Administration (FAA) to address aircraft-wildlife strikes.

The MOA establishes procedures necessary to coordinate the proposed actions more effectively to address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States.

Maps and project descriptions would need to be coordinated with the FAA. The FAA will determine if any elements of the BCDD would increase aviation wildlife strikes at any of the airports in the region.

In accordance with the Advisory Circular, USACE would have coordinated with the FAA and the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture to address potential hazardous wildlife attractants near airports within the vicinity of the BCDD.

5.9.7.5 San Marcos

Impacts to health and safety as a result of the TSP are discussed in Section 5.9.5.2.2.

5.10 Hazardous, Toxic, and Radioactive Waste

5.10.1 No Action Alternative

Any HTRW substances in the study area will most likely stay the same in the NAA. The applicable parts of Hays and Comal County are relatively lightly developed, and heavy industry is unlikely to impact the project areas, especially in the Bear Creek area. The extent to which HTRW sites continue to be created and discovered is impossible to

predict, although currently existing HTRW sites can be expected to be remediated over time.

5.10.2 Bear Creek Detention Dam

None of the areas of interest contain known HTRW. The BCDD project elements should not change the existing condition, although heavy construction as part of the project always has the potential to have limited temporary impacts on the surrounding area. The existence of the BCDD features would have no effect on HTRW in either project area.

The removal of standing structures within the BCDD area would be necessary, any remaining utilities would be disconnected and/or properly disposed of if they posed a threat to the human environment. As such, the BCDD would have no impact on HTRW within the study area

6.0 Cumulative Effects

Potentially, the most severe environmental degradation does not result from the direct effects of any particular action, but from the combination of effects of multiple, independent actions over time. As defined in the CFR, 40 CFR 1508.7 (CEQ Regulations), a cumulative effect is the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." Some authorities contend that most environmental effects can be seen as cumulative because almost all systems have already been modified. Principles of cumulative effects analysis, as described in the CEQ guide Considering Cumulative Effects under NEPA, are:

- Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.
- Cumulative effects are the total effects, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (Federal, non-Federal, or private) has taken the actions.
- Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.
- It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.
- Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.
- Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.
- Cumulative effects may last for many years beyond the life of the action that caused the effects.
- Each affected resource, ecosystem, and human community must be analyzed in terms of the capacity to accommodate additional effects, based on its own time and space parameters.

According to the CEQ regulations a cumulative effect is defined as:

> "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions." (40 CFR §1508.7)

Principles of cumulative effects analysis are described in the CEQ guide "Considering Cumulative Effects under the National Environmental Policy Act." For this analysis, cumulative effects are examined in terms of how the Recommended Action could affect downstream resources through interaction with other past, present, and reasonably foreseeable future actions. CEQ guidance on cumulative effects analysis states:

> "For cumulative effects analysis to help the decision-maker and inform interested parties, it must be limited through scoping to effects that can be evaluated meaningfully. The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties." (40 CFR 1508.7)

The TSP, the No Action Alternative, has no potential for cumulative effects (with past, present, and reasonably foreseeable future projects) on land use, water resources, the socioeconomic environment, biological resources including protected species, and recreation. The cumulative effects assessment is limited to projects reasonably foreseeable through 2025 within the study areas for various resources described in the Section 5. The geographical boundaries for cumulative effects analysis are limited to those areas described in second paragraph of Section 2.

6.1 Past, Present, and Reasonably Foreseeable Projects within the Lower Guadalupe Feasibility Study Area

Section 1.5 above highlights significant previously completed projects within and near the Lower Guadalupe Study area. Canyon Lake and Dam operations largely influence day to day and flood flows in the Guadalupe River throughout the study area. The Spring Lake Aquatic Ecosystem Restoration project continues to provide habitat benefits within the upper reaches of the San Marcos River. The Dry Comal Creek Flood Retarding Structure provides flood relief for areas between the structures down to Dry Comal Creeks confluence with the Guadalupe River. Collectively, these projects have influenced hydrology, hydraulics, flooding, habitat value, and urban development within the region.

The I-35 corridor in Central Texas is one of the fastest growing areas in Texas, and perhaps the Nation. In order to keep pace with urban development, Texas Department of Transportation has several road projects either underway, beginning soon, or planned for construction in the near future. Figure 19 shows current and future roadway

projects in the study area that range from adding lanes to existing roadways, resurfacing roads, to building new roads.

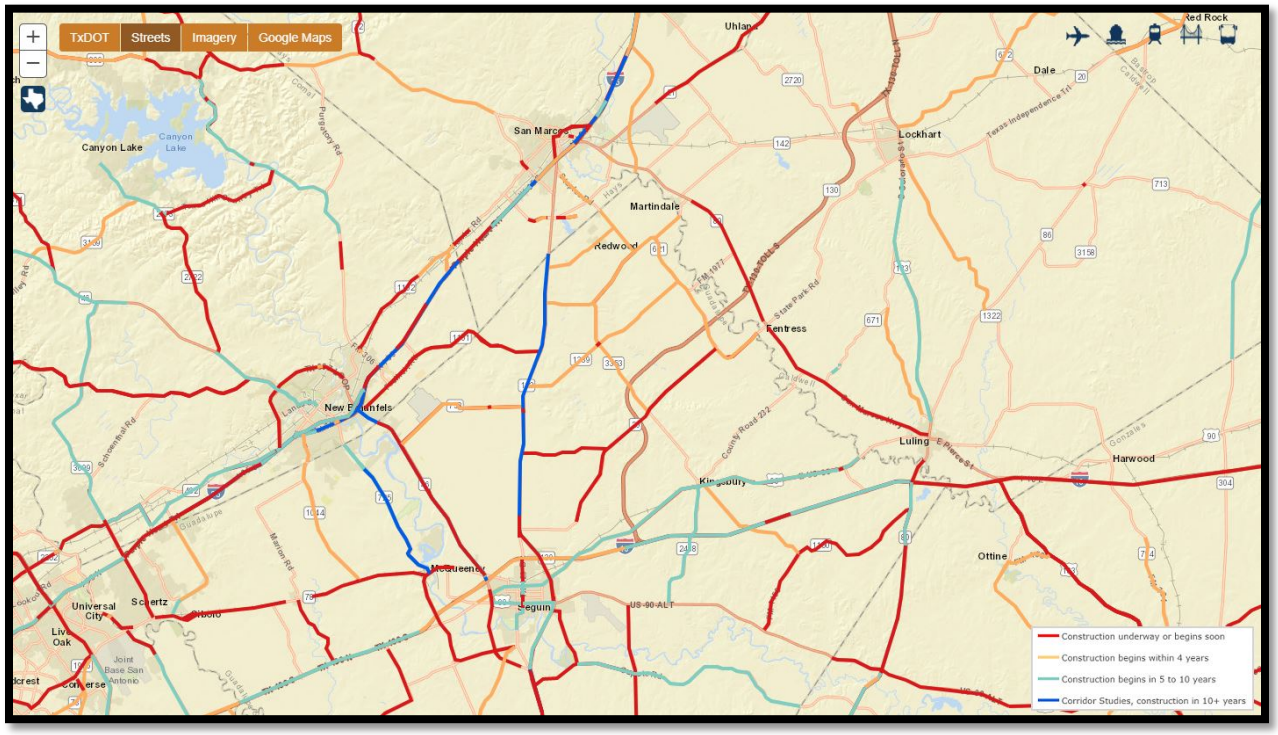

Figure 19: Current and future Texas Department of Transportation roadway projects

Table 18: Summary of Environmental Impacts

Resource	Historic Conditions	Existing Conditions	No Action Alternative	Bear Creek Detention Dam
Climate & Climate Change	Global warming trend beginning in the 1800's. Increase in GHG emissions increasing during the industrial revolution.	Warming trend and GHG emissions are continuing.	There would be temporary, short term, minor impacts due to GHG emissions during construction of the other projects.	Additional temporary, short term, minor impacts due to GHG emissions during construction of the other projects.
Air Quality	General deterioration of air quality due to increases in human populations and industry. Improvements as a result of implementation of legislation.	Improved air quality due to regulations, public outreach, education and improved available and affordable control technology.	There would be temporary, short term, minor impacts due to emissions during construction of the other projects.	Implementing the BCDD would include minor short-term adverse effects on air emissions due to construction activities. Minor additive effects may occur if the projects are constructed simultaneously.
Topography, Geology, and Soils	Conversion of upland and riparian forest and prairie habitat over time to agricultural, transportation and commercial / industrial / and transportation uses.	Continued urban sprawl into natural and undisturbed areas altering topography and converting soil to impervious surfaces like concrete, rooftops, and roads.	No change from existing conditions.	Permanent adverse impacts within the footprint of the dam and areas temporarily disturbed during construction. Impact would be less than significant due to remote location and small footprint. Minor short-term adverse effect on soils if any of the future projects overlap during construction period. Some of the projects may overlap in the period of construction and minor cumulative effects may occur. Negligible adverse impacts from routine mowing, maintenance, and inspection activities.
Land Use	Conversion of upland and riparian forest and prairie habitat over time to agricultural, transportation and commercial / industrial uses. Introduction of recreation activities within the study area with the addition of trails, amenities, parks, look outs, recreational clubs, and entertainment facilities. An increase in non-water based transportation infrastructure in the form of roads, railroads, and bridges.	Ongoing re-development and enhancement of outdoor recreation opportunities and transportation improvements within the study area.	No change from existing conditions.	Permanent adverse impacts within the footprint of the dam and areas temporarily disturbed during construction. Additional adverse impacts would occur within smaller areas converted from residential to flood storage. Impact would be less than significant due to remote location, minimal residential use, and overall small footprint of the BCDD. Undeveloped areas within the detention area would remain undeveloped. Negligible adverse impacts from routine mowing, maintenance, and inspection activities.
Water Resources	Since 1970 the Lower Guadalupe River has been impacted by Canyon Lake Dam. USACE operates and manages the Canyon Lake and Dam.	USACE operates and manages the Canyon Lake and Dam for the purpose of flood control, water supply, hydroelectric power generation, navigation and fish and wildlife. Canyon Lake and Dam largely effect the majority of all water resources in the study area.	No change from existing conditions.	Minor, adverse impacts would occur if water resources are continually lost due to overuse or Clean Water Act rules, regulations, and permitting practices are circumvented.
Biological Resources	Conversion of habitat over time to agricultural, transportation and commercial / industrial uses. Introduction of recreation activities within the study area subsequently adversely impacts biological communities, food webs, and overall quality and abundance in the study area.	Continued loss in abundance of wildlife and habitat within study area due to urban expansion.	No change from existing conditions.	Permanent adverse impacts within the footprint of the dam and areas temporarily disturbed during construction. Impacts would be mitigated to less than significant for Federally listed T&E species as well as terrestrial and aquatic habitat. Negligible adverse impacts from routine mowing, maintenance, and inspection activities.
Cultural Resources	The region has been consistently inhabited by humans for at least 13,000 years. Numerous historic sites and landscapes, which contain	Continued alteration of historic landscapes and impacts to historic properties associated with	No change from existing conditions.	Potential for permanent adverse impacts within the footprint of the dam, areas temporarily disturbed during construction, as well as historic structures impacted during the removal of Cummings Dam.

	irreplaceable evidence of past human lifeways are located throughout the area.	urbanization and commercial land use.		Impacts would be mitigated to less than significant as any resources encountered during surveys would be coordinated with the SHPO and appropriate mitigation actions would be conducted.
Social and Economic Resources	Increasing populations and commercial and residential development in the study area.	Population centers and economic development continue in the study area.	No change from existing conditions.	Beneficial impacts to social and economic resources are expected as the BCDD would reduce downstream flood damages and improve life safety along the Guadalupe River.
Hazardous, Toxic, and Radioactive Waste	Degradation of some areas untreated and uncontrolled discharges, especially in urbanized and/or industrialized areas with improvements as a result of implementation of legislation.	Hazardous materials use and transportation are a regulated activity, thus monitored and permitted only when impacts are minimized and BMPs implemented.	No change from existing conditions.	No impacts to HTRW are expected as the construction footprint is relatively small and no HTRW resources were identified during database searches.

7.0 Environmental Compliance

Table 19 presents the status of compliance with all environmental laws and regulations for the TSP. Additional information regarding specific compliance actions is below.

Table 19: Relationship of Plan to Environmental Protection Statutes and Other Environmental Requirements

Policies	Compliance of Plan
Public Laws	
Archeological and Historic Preservation Act, 1974, as amended	Not Applicable
Archeological Resources Protection Act, 1979, as amended	Not Applicable
Clean Air Act, 1977, as amended*	Not Applicable
Clean Water Act, 1972, as amended*	Not Applicable
Coastal Zone Management Act, 1972, as amended	Not Applicable
Endangered Species Act, 1973, as amended*	Not Applicable
Farmland Protection Policy Act	Not Applicable
Fish and Wildlife Coordination Act, 1958, as amended*	Not Applicable
Magnuson Fisheries Conservation and Management Act	Not Applicable
Migratory Bird Treaty Act, 1918, as amended*	Not Applicable
National Environmental Policy Act, 1969, as amended	Not Applicable
Rivers and Harbors Act, 1899	Not Applicable
Wild and Scenic Rivers Act, as amended	Not Applicable
Native American Graves Protection and Repatriation Act, 1990	Not Applicable
National Historic Preservation Act, 1966, as amended	Not Applicable
Executive Orders	
Environmental Justice (E.O. 12898)*	Not Applicable
Protection of Children (E.O. 13045)	Not Applicable
Flood Plain Management (E.O. 11988)	Not Applicable
Protection of Wetlands (E.O. 11990)	Not Applicable
Invasive Species (E.O. 13112)*	Not Applicable
Migratory Birds (E.O. 13186)*	Not Applicable
Others	
FAA Advisory Circular 150-5200-33*	Not Applicable

7.1.1 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) requires Federal agencies that are impounding, diverting, channelizing, controlling, or modifying the waters of any stream or other body of water to consult with the USFWS and appropriate State fish and game agency to ensure that wildlife conservation receives equal consideration in the

development of such projects. From the initial stages of this study the USFWS, TPWD, and TCEQ have been involved in the planning process.

All agencies provided comments throughout the planning process. USFWS and TPWD biologists participated in the site visits provided input on the models and model projections. These metrics were used to assess existing and future habitat conditions to determine mitigation needs as well as mitigation plans.

The No Action alternative will not disturb natural resources in the study area, no further Fish and Wildlife Coordination Act compliance efforts are required.

Had the study selected the BCDD alternative, a Fish and Wildlife Coordination Act Report describing existing and future without project conditions, future with project conditions, and mitigation projects for the study would have been required. This document would have also provided avoidance and impact minimizing recommendations regarding design, operation, and land management.

7.1.2 Endangered Species Act Coordination

The No Action alternative will have No Effect on any listed species in the study as no ground disturbance will occur from the study, no further Endangered Species Act compliance efforts are required.

Central Texas, particularly the Edwards Plateau, is home to several Federally listed species and unique habitats like karst features and natural springs. Through informal consultation with USFWS Austin Ecological Services and TPWD staff, USACE determined the Bear Creek alternative would have No Effect on all species except for the GCWA and Texas wild-rice. USACE determined the construction and operation of the Bear Detention Dam may affect, and is likely to adversely affect to the golden-cheeked warbler. Therefore, had USACE selected the BCDD alternative, a request for Formal Consultation with USFWS Austin Ecological Services Office would have occurred. To reduce impacts to the GCWA had the BCDD alternative been selected, both onsite conservation measures within the detention area to promote GCWA habitat as well as the purchase of up to 412 acres of GCWA habitat in Comal County would have been required.

USACE has also determine that the removal of Cummings Dam, as part of the aquatic mitigation plan had the BCDD alternative been selected, may affect, but is not likely to adversely affect Texas wild-rice or its critical habitat present in the San Marcos area. The removal of Cummings Dam would have restored natural river flow and water depth throughout the San Marcos area, providing beneficial impacts to Texas wild-rice and its critical habitat.

7.1.3 Clean Air Act

The No Action alternative will have no effect on air quality in the study area as no ground disturbance will occur from the study, no further Clean Air Act compliance efforts are required.
Federal agencies are required by this Act to review all air emissions resulting from federally funded projects or permits to insure conformity with the State Implementation Plans in non-attainment areas.

Both Austin and San Antonio State Implementation Plan areas are currently in attainment for all air emissions within the project areas; therefore, had the TSP been the BCDD alternative, it would be in compliance with the Clean Air Act.

7.1.4 Clean Water Act

USACE, under direction from Congress, regulates the discharge of dredged and fill material into all waters of the United States, including wetlands. Although USACE does not issue itself permits for construction activities that would affect waters of the United States, USACE must meet the legal requirements of the Act.

The No Action alternative will have no effect on water resources in the study area as no ground disturbance will occur from the study, no further Clean Water Act compliance efforts are required.

Had the BCDD alternative been selected as the TSP, a 404(b)(1) analysis would conducted for the Lower Guadalupe Feasibility Study. Approximately 1.3 acres of riverine habitat loss would occur within the footprint of the Bear Creek Detention Dam. These losses would have been more than offset by the removal of Cummings Dam that would restore riverine function to a reach of the San Marcos River currently impounded.

No net loss of waters of the United States would have occurred with the BCDD. The construction of the Bear Detention Dam would result in a total of approximately 184,835 cubic yards of fill being added to the Bear Creek floodplain. TCEQ would have been provided with a copy of a 404(b)(1) analysis for review as part of the State Water Quality Certification process under Section 401 of the Federal Clean Water Act to ensure the proposed project supports water quality standards.

The construction activities associated with the BCDD that disturb upland areas (land above Section 404 jurisdictional waters) would have been subject to the National Pollutant Discharge Elimination System (NPDES) requirements of Section 402(p) of the Clean Water Act.

In Texas, TCEQ is the permitting authority and administers the NPDES. Operators of construction activities that disturb 5 or greater acres must prepare a Storm Water Pollution Prevention Plan (SWPPP), submit a Notice of Intent to TCEQ, conduct onsite posting and periodic self-inspection, and follow and maintain the requirements of the SWPPP. During construction, the operator shall assure that measures are taken to control erosion, reduce litter and sediment carried offsite (silt fences, hay bales,

sediment retention ponds, litter pick-up, etc.), promptly clean-up accidental spills, utilize BMPs onsite, and stabilize site against erosion before completion.

Commencement of construction at a site regulated under 30 Texas Administrative Code 213 would have applied to the BCDD alternative. As such, construction would not begin until the appropriate Edwards Aquifer Protection Plan had been approved by the TCEQ's Edwards Aquifer Protection Program.

7.1.5 Section 106 of the National Historic Preservation Act

Under the National Historic Preservation Act, federal agencies must “take into account the effects of their undertakings on historic properties” [(36 CFR 800.1(a)].

The No Action alternative will have no effect on historic properties in the study area, no further National Historic Preservation Act compliance efforts are required.

Had the BCDD been selected as the TSP, USACE could not fully determine the effects of the undertaking on historic properties at this time, USACE, Texas State Historic Preservation Officer (SHPO), and the non-federal sponsor would have developed a programmatic agreement (PA) to resolve adverse effects to historic properties.

In accordance with 36 CFR 800.6(1), USACE would have notified the Advisory Council on Historic Preservation of the intent to develop a PA. During the feasibility study, USACE has conducted background research, consulted with the Texas SHPO, and invited five Federally-recognized Native American tribes, including the Kiowa Tribe of Oklahoma, the Apache Tribe of Oklahoma, the Tonkawa Tribe of Oklahoma, the Wichita and Affiliated Tribes, and the Comanche Nation, to consult on the project and to identify participants in the development of the PA had the BCDD been selected as the TSP.

7.1.6 Executive Order 13112 – Invasive Species

EO 13112 recognizes the significant contribution native species make to the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of the invasion of non-native plants and wildlife species in the United States. This EO establishes processes to deal with invasive species and among other items, establishes that Federal agencies “will not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.”

The No Action alternative will have no effect on invasive species in the study area as no ground disturbance will occur from the study, no further EO 13112 compliance efforts are required.

The required operation and maintenance of the Bear Creek Detention Dam, had it been selected as the TSP, and associated mitigation areas by the non-Federal implementation sponsor during long-term management of that area would keep the negative influence of non-native invasive plants at a minimum. The proposed project would be in compliance with EO 13112 by actively monitoring and managing non-native invasive species.

7.1.7 Executive Order 11988 – Floodplain Management

EO 11988 was enacted May 24, 1977, in furtherance of the National Environment Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Star. 975). The purpose of the EO was to avoid, to the extent possible, the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

The order states that each agency shall provide and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. The TSP, inherit as a flood risk management project, would be designed to ensure that the combination of all measures proposed would not result in a decrease in the floodplain capacity and or increase in flood risk to the study area. The TSP would be in compliance with EO 11988.

ER 1165-2-26 sets forth general policy and guidance for USACE implementation of EO 11988, as is pertains to the planning, design, and construction of Civil Works projects. The objective of this EO is to avoid, to the extent possible, long and short-term adverse impacts associated with the occupancy and modification of the base flood plain.

The No Action alternative will have no effect on floodplain management in the study area as no ground disturbance will occur from the study, no further EO 11988 compliance efforts are required.

If BCDD would have been selected as the TSP, due to the nature and authorization of this flood risk management study and the measures' functions, there were no other practical alternatives to locating the proposed project in the base flood plain. The design and operation of each measure will minimize hazard and risk associated with flood and human safety while reducing flood risk and damages in the downstream base flood plain.

While new developments would require the necessary planning and permits to avoid impacts to the environment and the base flood plain.

7.1.8 Executive Order 13186 – Migratory Birds

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act of 1980 demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the USFWS to undertake activities to research and conserve migratory non-game birds. EO 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program.

The No Action alternative will have no effect on migratory birds in the study area as no ground disturbance will occur from the study, no further migratory bird compliance efforts are required.

The BCDD alternative, would have required the permanent conversion of migratory bird habitat to a detention dam. When combined with the mitigation plan would maintain a no net loss in habitat that contributes to the U.S. Fish and Wildlife Service Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations.

7.1.9 Executive Order 12898 – Environmental Justice

EO 12898 “Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations” dated February 11, 1994, requires all Federal agencies to identify and address disproportionately high and adverse effects of its programs, policies, and activities on minority and low-income populations. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.

The No Action alternative will have no effect on Environmental Justice issues in the study area as no ground disturbance will occur from the study, no further EO 12898 compliance efforts are required.

Data was compiled to assess the potential impacts to minority and low-income populations within the study area. Due to almost no occupancy of the lands needed for the BCDD and associated mitigation measures, no Environmental Justice concerns are anticipated.

7.1.10 Executive Order 13045 – Protection of Children

EO 13045 “Protection of Children from Environmental Health Risks” dated April 21, 1997 requires Federal agencies to identify and address the potential to generate disproportionately high environmental health and safety risks to children. This EO was prompted by the recognition that children, still undergoing physiological growth and development, are more sensitive to adverse environmental health and safety risks than adults.

The No Action alternative will have no effect on child safety in the study area as no ground disturbance will occur from the study, no further EO 13045 compliance efforts are required.

If the BCDD alternative had been selected as the TSP, short-term impacts on the protection of children would be expected during construction in urbanized areas with children present. Numerous types of construction equipment such as backhoes, bulldozers, graders, and dump trucks, and other large construction equipment would be used throughout the duration of construction of the TSP. Because construction sites and equipment can be enticing to children, construction activity could create an increased safety risk. However, the BCDD alternative including the mitigation measures, would be constructed in remote areas with very few residential properties in the vicinity of the construction areas.

Out of an abundance of caution, barriers and “No Trespassing” signs would be placed around construction sites to deter children from playing in these areas, and construction vehicles and equipment would be secured when not in use. Since the construction areas are remote and would be flagged or otherwise fenced, issues regarding Protection of Children are not anticipated.

7.1.11 Public and Agency Comments

In 2011, this study was initiated in response to the initial findings of a reconnaissance study authorized by the Guadalupe and San Antonio Rivers and Tributaries, Texas resolution. In 2012, USACE and the non-Federal sponsor hosted a public scoping meeting in Seguin, Texas. No public or agency comments were received. This study was also discussed at various GBRA reoccurring meetings. The 2012 public scoping meeting notice and Fort Worth District fact sheet for the Guadalupe and San Antonio River Basin, Texas studies can be found in Appendix C1.

With the No Action alternative selected as the TSP, no additional public or agency comment periods are required.

Had the BCDD alternative been selected as the TSP, an open house style public information meeting, in conjunction with a 30 day public review period, would have been held to solicit comments. USACE and GBRA staff would have been available to answer questions regarding the study, process, Tentatively Selected Plan, and draft report and EA.

7.2 Study Coordination

Had the BCCD alternative been selected as the TSP, copies of agency coordination letters would have been presented in Appendix C1. Formal and informal coordination would been continued with various federal, state, local agencies and tribes.

7.2.1 Environmental Coordination

TPWD and USFWS have been involved throughout the study process. They participated in initial model selection and use, site visits, impact identification, avoidance and mitigation measure development and provided comments throughout the Lower Guadalupe Feasibility Study process. TCEQ also provided input regarding aquatic mitigation and BMPs to avoid impacts during construction.

7.2.2 Cultural Coordination

During the feasibility study, USACE consulted with the Texas SHPO, and invited five Federally-recognized Native American tribes, including the Kiowa Tribe of Oklahoma, the Apache Tribe of Oklahoma, the Tonkawa Tribe of Oklahoma, the Wichita and Affiliated Tribes, and the Comanche Nation, to consult on the project and to identify participants in the development of the PA had the BCDD been selected as the TSP.

7.3 Mitigation

The No Action alternative, the TSP, will have no effect on natural resources or require any impact avoidance or compensatory mitigation as a result of the study area as no ground disturbance will occur.

The BCDD would have been designed with the smallest practicable footprint to still meet the flood risk reduction goals of the project. All practicable means to avoid or minimize environmental impacts due to construction of the BCDD would have been considered.

The BCDD would feature a culvert at the base of the structure to convey normal flows. This feature would avoid creating an un-natural lake upstream and desiccation of aquatic resources downstream. Also, the detention area would have been purchased in fee and managed for natural resource benefit. Outside of flood events the detention area will serve as a pseudo-preserve for natural communities.

Construction would have occurred outside of GCWA breeding season. If construction were to occur during GCWA breeding season, construction would begin prior to the breeding season and remain constant so that any GCWA in the area would seek alternate suitable breeding grounds.

During construction and maintenance of BCDD and mitigation measures, best management practices would be followed to further minimize impacts to the environment. Measures include but are not limited to designated fueling stations, Storm Water Pollution Prevent Plans, dust abatement, and monitoring for cultural resources

during ground disturbance activities. In addition, mitigation could be required during cultural resource activities.

Engineering Regulation (ER) 1105-2-100 Appendix C directs USACE civil works studies to avoid, minimize, and when necessary, mitigate the unavoidable impacts to significant aquatic habitats. Significant habitats include wetlands, rivers, riparian forest, and bottomland hardwood forest. USACE certified habitat assessments must then be used to quantify functional habitat, and any potential loss, through a unit of measure. This study used Average Annual Habitat Units (AAHUs) and USACE certified Habitat Evaluation Procedures species models to quantify habitat function over the planning horizon. Mitigation requirements and three mitigation plan alternatives were developed and assessed using the same methodology. In accordance with ER 1105-2-100, the least cost mitigation plan was identified for the BCDD alternative. Additional information regarding model selection, site visits, and results can be found in Appendix C2.

In summary, the mitigation plan for BCDD would have included:

- The removal of Cummings Dam on the San Marcos River to offset the permanent loss of 1.14 AAHUs of riverine habitat in Bear Creek from the construction of the Bear Detention Dam.
- Up to 25 acres of riparian forest plantings and management in perpetuity along the Guadalupe River downstream of New Braunfels to offset the permanent loss of 7.18 AAHUs of riparian forest habitat.
- Purchase and manage up to 412 acres of golden-cheeked warbler habitat in Comal County

The Cummings Dam removal would restore 8.29 AAHUs of riverine habitat that is currently impounded by the dam. While it mitigates beyond required 1.14 AAHUs, it does so at no extra cost and remains the most cost effective aquatic mitigation measure.

Opportunities exist to further reduce the environmental mitigation requirements. Initial site visits were conducted from publicly assessable areas. As such conservative estimates in habitat mapping and metric estimations were made, site visits would allow for further refinement of the assumptions used to estimate mitigation requirements.

Appendix C3 contain additional details regarding mitigation planning.

7.4 Monitoring and Adaptive Management

In accordance with ER 1105-2-100 and EC 1105-2-404, a Monitoring and Adaptive Management Plan (MAMP) will be developed for mitigation plans and will be included in the final feasibility report and/or NEPA document.

The TSP, the No Action alternative, requires no mitigation or related MAMP.

Had the BCDD alternative been selected as the TSP, a MAMP would have been developed in consultation with resource agencies and the non-Federal implementation

sponsor to monitor the ecological success for each mitigation measure. Adaptive management of mitigation measures would be limited to only the area of mitigation unless the non-Federal sponsor and the District Commander mutually agree otherwise.

Monitoring of mitigation elements provides information with which to gauge the success of the mitigation. Monitoring, cost-shared for up to five years, includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits.

If during monitoring, a trigger is met indicating an environmental metric is not being satisfied, additional action may be required to ensure mitigation requirements are being satisfied. Adaptive management measures may include supplemental watering of planted trees during droughts, changing of tree species planted to increase tree survivorship, and/or invasive species management.

Appendix C4 contains a draft Monitoring and Adaptive Management Plan and costs.

8.0 Preparers

Table 20: List of Preparers

Discipline	Project Delivery Team Member
Project Management	Andrew Johnston
Planning	Tom Jester
H&H	Bret Higginbotham
H&H	Helena Mosser
Economics	Norman Lewis
Environmental Resources	Brandon Wadlington
Environmental Resources	Justyss Watson
Cultural Resources	Leslie Crippen
Engineering Technical Lead	Efren Martinez
Geotechnical Engineering	RC Kannan
HTRW	David S. Clark
Civil Engineering	Landis Grimmett
Structural Engineering	Jonathan Bennett
Real Estate	Thurman Schweitzer
Cost Engineering	Ninfa Taggart
Office of Counsel	Kathrine Talbot

9.0 Recommendation

I have given consideration to all significant aspects of the public interest. The aspects considered environmental, social, and economic effects; engineering feasibility; and any other elements bearing on the decision. There has been no controversy concerning this study or the proposed project and the NFS and local stakeholders are in support of the proposed action. The plan complies with all seven of the USACE Environmental Operating Principles.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Based on the analysis the No Action Alternative is the Tentatively Selected Plan.

DATE:_____ _____

Kenneth Reed
COL, EN
Commanding

10.0 References

American Ornithologists' Union (AOU). 1983. Check-list of North American Birds, 6th edition. Allen Press, Inc., Lawrence, Kansas. 877 pp.

Bio-West, Inc. 2012. Summary of 2011 sampling efforts related to Edwards Aquifer Authority Variable Flow Study under USFWS permit number TE037155-0. Round Rock, Texas.

Cedar Lake Ventures Inc. 2019. Average Weather in Canyon Lake. Available on the internet at: https://weatherspark.com/y/7105/Average-Weather-in-Canyon-Lake-Texas-United-States-Year-Round

Center for Hearing and Communication (2018). Common environmental noise levels. Available on the internet at: http://chchearing.org/noise/common-environmental-noise-levels/

Comal County Texas. (2017) Dams and Spillways. Available on the internet at: https://www.cceo.org/flood/dams_spillways

Comal County Texas. (2018) Hazard Mitigation Action Plan 2018. Available on the internet at: http://www.co.comal.tx.us/EOC/Comal percent20County percent20HMAP percent20Update percent20- percent206.21.18 percent20- percent206.20.23.pdf

Duarte, A., J. L. R. Jensen, J. S. Hatfield, and F. W. Weckerly. 2013. Spatiotemporal variation in range-wide Golden-cheeked Warbler breeding habitat. Ecosphere 4(12):152. http://dx.doi.org/10.1890/ES13-00229.1

Edwards Aquifer Authority (EAA). 2013. “Edwards Aquifer Authority. About the Aquifer.” Available online: http://www.edwardsaquifer.org/index.php/aquifer_education/discover_the_edwards_aquifer/about_the_aquifer/what_is_the_aquifer/. Last Accessed May 22, 2013.

Emery, W.H.P. 1977. Current status of Texas wild-rice. Southwestern Naturalist 22:393-394.

Grimshaw, Thomas W. and Woodruff, C., “Structural Style in an En Echelon Fault System, Balcones Fault Zone, Central Texas: Geomorphic and Hydrologic Implications,” The Balcones Escarpment, Ed. Abbott, P.L. and Woodruff, C.M., (1986) The Walter Geological Library, University of Texas, Austin, p.71-76.

Groeger, A. W., P. F. Brown, T. E. Tietjen, and T. C. Kelsey. 1997. Water quality of the San Marcos River. *Texas Journal of Science* 49:279-294.

Guyton, W. F. and Associates. 1979. *Geohydrology of Comal, San Marcos, and Hueco springs*. Texas Department of Water Resources, Report 234 Handbook of Texas Online 2012.

Hammontree, S.E., Mabe, J.A., and Kennedy, J.H. 2012. Habitat Requirements of the Golden Orb (*Quadrula aurea*). Final Report for Texas Water Development Board and Texas Parks and Wildlife Department. TWDB Contract Nop. 0904830970.

Heitmuller, F.T., and Reece, B.D., 2003, Data base of historically documented springs and spring flow measurements in Texas: U.S. Geological Survey Open-File Report 03-315

Hillis, D. M., D. A. Chamberlain, T. P. Wilcox, and P. T. Chippindale. 2001. A new species of subterranean blind salamander (Plethodontidae: Hemidactyliini: Eurycea: Typhlomolge) from Austin, Texas, and a systematic revision of central Texas paedomorphic salamanders. Herpetologica 57:266-280.

Horne, F. R. and S. McIntosh. 1979. Factors influencing distribution of mussels in the Blanco River of central Texas. *The Nautilus* 94:119-133.

Howells, R.G., R.W. Neck, and H.D. Murray. 1996. Freshwater Mussels of Texas. Texas Parks and Wildlife Press: Austin, Texas. 218 pp.

Howells, R. G. 2002. *Freshwater mussels (Unionidae) of the pimpleback complex (Quadrula spp.) in Texas.* Texas Parks and Wildlife Management Data Series 197. Austin, Texas.36 pp.

Howells, R. 2006. Statewide freshwater mussel survey. Final report. State Wildlife Grants Program. Texas Parks and Wildlife Department, Austin.

Howells, R. G. 2010. *Texas pimpleback (Quadrula petrina): summary of selected biological and ecological data for Texas*. BioStudies, Kerrville, Texas. 17 pp. Hubbs and Peden 1969.

Karatayev, A. Y., and L. E. Burlakova. 2008. Distributional survey and habitat utilization of freshwater mussels. Texas Water Development Board

Matthews, J.R. and C.J. Moseley (eds.). 1990. The Official World Wildlife Fund Guide to Endangered Species of North America. Volume 1. Plants, Mammals. xxiii + pp 1-560 + 33 pp. appendix + 6 pp. glossary + 16 pp. index. Volume 2. Birds, Reptiles, Amphibians, Fishes, Mussels, Crustaceans, Snails, Insects, and Arachnids. xiii + pp. 561-1180. Beacham Publications, Inc., Washington, D.C

Najvar, P. A. 2001. The effects of diel water quality fluctuations on reproduction and growth in the San Marcos salamander. M.S. thesis, Southwest Texas State University, San Marcos.

NatureServe 2018A. Austin Blind Salamander: Ecology & Life History. Available on the internet at:

http://explorer.natureserve.org/servlet/NatureServe?searchName=eurycea+waterlooensis

NatureServe 2018B. Comal Springs Dryopid Beetle: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Stygoparnus+comalensis

NatureServe 2018C. Comal Springs Riffle Beetle: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Heterelmis+comalensis

NatureServe. 2018D. Golden-cheeked Warbler: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Dendroica+chrysoparia+

NatureServe 2018E. Gray Bracted Twistflower: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Streptanthus+bracteatus

NatureServe 2018F. Peck's Cave Amphipod: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Stygobromus+pecki

NatureServe 2018G. Percina apristis: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Percina+apristis

NatureServe 2018H. Texas Fawnsfoot: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=truncilla+macrodon

NatureServe 2018I. Texas Fatmucket: Ecology & Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Lampsilis+bracteata

NatureServe. 2018J. Whooping Crane: Ecology Life History. Available on the internet at: http://explorer.natureserve.org/servlet/NatureServe?searchName=Grus+americana

National Oceanographic Atmospheric Administration (NOAA) National Weather Service. 2017. ALL-TIME RECORDS FOR SAN ANTONIO AREA. 3/1885-12/2017

TEMPERATURE AND PRECIPITATION RECORDS. Available on the internet at: https://www.weather.gov/media/ewx/climate/ClimateTable-ewx-SanAntonio.pdf

NOAA. National Weather Service. 2019A. October 1998 Flood Event. Available on the internet at: https://www.weather.gov/ewx/wxevent-1998flood

NOAA. National Weather Service. 2019B. Monthly Total Precipitation for CANYON DAM, TX. Available on the internet at: https://w2.weather.gov/climate/xmacis.php?wfo=ewx

Nelson, J. 1993. Population size, distribution, and life history of *Eurycea nana* in the San Marcos River. M.S. Thesis, Southwest TSU, San Marcos, Texas.

Ohio State University at Marion (OSUM). 2011. Texas pimpleback (*Quadrula petrina*) records. Bivalve Database, Division of Molluscs, Museum of Biological Diversity, Department of Evolution, Ecology, and Organismal Biology. The Ohio State University, Columbus. Available online: http://www.biosci.ohio-State.edu/~molluscs/OSUM2

Plantmaps.2019A. Texas Average First Frost Date Map. www.plantmaps.com/interactive-texas-first-date-map.php

Plantmaps.2019B. Texas Average Last Frost Date Map. www.plantmaps.com/interactive-texas-last-date-map.php

Poole, J.M. and D.E. Bowles. l999. Habitat characterization of Texas wild-rice (*Zizania texana* Hitchcock), an endangered aquatic macrophyte from the San Marcos River, TX, USA. *Aquatic Conserv: Mar. Freshwater Ecosystem* 9:291-301.

Poole, J. M. 2002. Historical distribution of Texas wild-rice (*Zizania texana*) from 1989 to 2001. Section 6 Final Report. Albuquerque, N. M.: U. S. Fish and Wildlife Service.

Randklev, C. R., B. Lundeen, and J. H. Kennedy. 2010. Unpublished museum records of rare freshwater mussels in Texas. University of North Texas, Denton.

Saunders, K.S., K.B. Mayes, T.A. Jurgensen, J.F. Trungale, L.J. Kleinsasser, K. Aziz, J.R. Fields, and R.E. Moss. 2001. *An evaluation of spring flows to support the Upper San Marcos River Spring ecosystem, Hays County, Texas*. River Studies Report No. 16. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Seal, U. S. and Ellis, S. (Eds.). 1997. Fountain Darter Working Group. Discussion Notes (Revised). Austin Texas, 19 November. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

Silveus, W.A. 1933. *Texas grasses.* The Clegg Col, San Antonio, Texas. 782 pp.

Texas Almanac. 2019. Soils of Texas. Available on the internet at: https://texasalmanac.com/topics/environment/soils-texas

Texas Commission on Environmental Quality (TCEQ). 2019A. Compliance of San Antonio area counties with the National Ambient Air Quality Standards (NAAQS). Available on the internet at: https://www.tceq.texas.gov/airquality/sip/san/san-status

TCEQ. 2019B. Draft 2018 Texas Integrated Report - Texas 303(d) List. Available on the internet at: https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/16txir/2016_303d.pdf

TCEQ. 2019C. Ozone: The Facts. Available on the internet at: https://www.tceq.texas.gov/airquality/monops/ozonefacts.html

Terrell, E.E., W.H.P. Emery, and H.E. Beatty. 1978. Observations on *Zizania texana* (Texas wild-rice), an endangered species. *Bulletin of the Torrey Botanical Club* 105:50-57.

Texas Almanac. 2019. Aquifers of Texas. Available on the internet at: https://texasalmanac.com/topics/environment/aquifers-texas

Texas Department of Health. 1999. Strom-Related Mortality in Central Texas October 12-31, 1998. Available on the internet at: file:///C:/Users/m2pectsj/Documents/Lower percent20Guadalupe/StormRelatedMortality.pdf

Texas Department of State Health Services (DSHS). 2018. Fish Consumption Advisory Viewer. Available on the internet at: https://dshscpd.maps.arcgis.com/apps/webappviewer/index.html?id=0d443c1940ba4240923a46dfa08f0289

TPWD. 2018A. Barton Springs Salamander (*Eurycea sosorum*). Available on the internet at: https://tpwd.texas.gov/huntwild/wild/species/bartonspringssalamander/

TPWD. 2018B. Fountain Darter (*Etheostoma fonticola*). Available on the internet at: https://tpwd.texas.gov/huntwild/wild/species/fdarter/

TPWD. 2018C. GIS Lab Map Downloads: Map Gallery – Biological: Level III Ecoregions of Texas. Available on the internet at: https://tpwd.texas.gov/landwater/land/maps/gis/map_downloads/map_gallery/bio/

TPWD. 2018D. San Marcos Gambusia (*Gambusia georgei*). Available on the internet at: https://tpwd.texas.gov/huntwild/wild/species/sanmarcosgambusia/

TPWD. 2018E. Texas Blind Salamander (*Eurycea rathbuni*). Available on the internet at: https://tpwd.texas.gov/huntwild/wild/species/blindsal/

Texas Parks and Wildlife Department (TPWD). 2019. Significant Stream Segments. Available on the internet at: https://tpwd.texas.gov/landwater/water/conservation/water_resources/water_quantity/sigsegs/regionl.phtml

Texas State University-San Marcos (2017) Fishes of Texas: Percina apristis-Guadalupe darter. Available on the internet at: http://txstate.fishesoftexas.org/percina percent20apristis.htm

Texas Master Naturalist (2019). Geology of Guadalupe County: Available on the internet at: https://txmn.org/guadalupe/files/2014/01/Guadalupe-County-Geologic-Map.pdf

Tupa, D., W. Davis. 1976. Population dynamics of the San Marcos salamander, *Eurycea nana* Bishop. *The Texas Journal of Science*, 27:179-194.

USACE. 2015. OMBIL Environmental Stewardship Module. USACE, Fort Worth District, Texas.

USACE. 2017. Canyon Lake Master Plan. Available on the internet at https://www.swf.usace.army.mil/Portals/47/docs/Lakes/Canyon/MasterPlan/Canyon_Lake_Master_Plan_Draft_Final.pdf

U.S. Climate Data. 2019. Climate New Braunfels – Texas. Available on the internet at: https://www.usclimatedata.com/climate/new-braunfels/texas/united-states/ustx0950

U.S. Department of Housing and Urban Development (HUD). 1984. 24 CFR Part 51 - Environmental Criteria and Standards Sec. 51.103 Criteria and standards 44 FR 40861, July 12, 1979, as amended at 49 FR 12214, Mar. 29, 1984.

USDA Natural Resources Conservation Service (NRCS). 2018. Custom Soil Resource Report for Comal, and Hays Counties, Texas.

U.S. Environmental Protection Agency (USEPA). 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. USEPA 550/9-74-004, U.S. USEPA, Washington, DC.

USFWS. 1996. San Marcos/Comal/Edwards Aquifer Rare, Threatened, and Endangered Species Contingency Plan. Austin Ecological Field Services Office, Austin, Texas.

USFWS. 2012. Endangered and Threatened Wildlife and Plants: Review of Native Species that are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Descriptions on Progress of Listing Actions. Federal Register 77: 225. November 21, 2012.

USFWS. 2013A. Biological Opinion and letter of concurrence for effects of the Edwards Aquifer Recovery Program Habitat Conservation Plan. United States Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

USFWS. 2013B. 50 CFR Part 17 - Endangered and Threatened Wildlife and Plants; Revised Critical Habitat for the Comal Springs Dryopid Beetle, Comal Springs Riffle Beetle, and Peck's Cave Amphipod- Docket No. FWS–R2–ES–2012–0082; 4500030114. Available on the internet at: https://www.govinfo.gov/content/pkg/FR-2013-10-23/pdf/2013-24168.pdf#page=1

USFWS. 2014. Comal Springs Dryopid Beetle Species Information. Available on the internet at: https://www.fws.gov/southwest/fisheries/documents/species/Comal_Springs_Dryopid_Beetle.pdf

USFWS. 2015. Texas Salamanders. Available on the internet at: https://www.fws.gov/southwest/es/austintexas/ESA_Sp_Salamanders.html

USFWS. 2016. Barton Springs Salamander(*Eurycea sosorum*) Recovery Plan: Amended to include Austin Blind Salamander (*Eurycea waterlooensis*). Initial publication September,2005. Available on the internet at: https://www.fws.gov/southwest/es/Documents/R2ES/BartonSpringsSalamander_RP_with_AustinBlindSalamander_Adendum_Jan2016.pdf

USFWS. 2019A. Lower Guadalupe River Feasibility Study Bear Detention Dam Official Species List. Consultation Code: 02ETAU00-2019-SLI-1442 and Event Code: 02ETAU00-2019-E-02912

USFWS. 2019B. Lower Guadalupe Feasibility Study Cummings Dam Removal Project Area Official Species List. Consultation Code: 02ETAU00-2019-SLI-1444 and Event Code: 02ETAU00-2019-E-02916

USFWS. 2019C. Lower Guadalupe Feasibility Study Cummings Dam Removal Project Area Official Species List. Consultation Code: 02ETAU00-2019-SLI-1443 and Event Code: 02ETAU00-2019-E-02914

USFWS. 2019D. National Wetlands Inventory Surface Waters and Wetlands. Available on the internet at: https://www.fws.gov/wetlands/Data/Mapper.html

U.S. Global Change Research Program (USGCRP). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. Available on the internet at: http://nca2014.globalchange.gov/report

U.S. Global Change Research Program (USGCRP). 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

Vaughan, Jr., J.E. 1986. Population and autecological assessment of Zizania texana Hitchcock (Poaceae) in the San Marcos River. Master's Thesis, Southwest Texas State University (Texas State University – San Marcos).