Water Resources Technical Report

North Houston Highway Improvement Project
From US 59/I-69 at Spur 527 to I-45 at Beltway 8 North
CSJ 0912-00-146

Prepared by: TxDOT Houston District
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The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried-out by TxDOT pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated December 9, 2019, and executed by FHWA and TxDOT.

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1.0 Introduction

The Texas Department of Transportation (TxDOT) proposes to construct improvements to Interstate Highway 45 (I-45) in the northern portion of the City of Houston. The proposed project, referred to as the North Houston Highway Improvement Project (NHHIP), begins at the interchange of I-45 and Beltway 8 North and continues south along I-45 to Downtown Houston where it terminates at the interchange of U.S. Highway (US) 59/I-69 and Spur 527 south of Downtown Houston. The project area also includes portions of I-10 and US 59/I-69 near Downtown Houston. The project area is composed of three study segments, Segments 1 through 3 (*Exhibit 1*).

This Water Resources Technical Report supports the Final Environmental Impact Statement (Final EIS) that evaluates the social, economic, and environmental impacts potentially resulting from the Preferred Alternative for the proposed project.

2.0 Project Description

2.1 Existing Facility

2.1.1 Segment 1: I-45 from Beltway 8 North to north of I-610 (North Loop)

I-45 within this segment consists of eight general purpose lanes (i.e., mainlanes; four lanes in each direction), four frontage road lanes (two lanes in each direction), and a reversible high occupancy vehicle (HOV) lane in the middle, all within a variable right-of-way (ROW) width of 250 to 300 feet. The existing posted speed limit along the general purpose lanes and reversible HOV lane is 60 miles per hour (mph). The existing posted speed limit for the frontage roads is 45 mph. The length of Segment 1 is approximately 8.8 miles, and the area of the existing ROW is approximately 349 acres.

2.1.2 Segment 2: I-45 from north of I-610 (North Loop) to I-10

I-45 within this segment primarily consists of eight at-grade general purpose lanes (four lanes in each direction), six frontage road lanes (three lanes in each direction), and a reversible HOV lane in the middle, all within a variable ROW width of 300 to 325 feet. Segment 2 also includes a depressed section that consists of eight general purpose lanes (four lanes in each direction) and a reversible HOV lane in the middle, all below grade, within a 245-foot ROW. The six frontage road lanes associated with the depressed section (three lanes in each direction) are located at-grade. The existing posted speed limit is 60 mph along the general purpose lanes, 55 mph along the reversible HOV lane, and 40 mph along the frontage road lanes. The I-45 and I-610 frontage roads are discontinuous at the I-45/I-610 interchange. The length of Segment 2 is approximately 4.5 miles, and the area of the existing ROW is approximately 220 acres.

2.1.3 Segment 3: Downtown Loop System (I-45, US 59/I-69, and I-10)

The Downtown Loop System consists of three interstate highways that create a loop around Downtown Houston. I-45 forms the western and southern boundaries of the loop and is known locally as the Pierce Elevated because it partially follows the alignment of Pierce Street. I-10 forms the northern boundary of the loop, and US 59/I-69 forms the eastern boundary of the loop. The loop includes three major interchanges: I-45 and I-10, I-10 and US 59/I-69, and US 59/I-69 and I-45. The interchange of US 59/I-69 and Spur 527 is located south of Downtown Houston.

I-45 along the west side of Downtown Houston consists of six elevated general purpose lanes (three lanes in each direction) within an existing ROW width of 205 feet. I-45 along the south side of Downtown Houston (the Pierce Elevated) consists of six elevated general purpose lanes (three lanes in each direction). I-10 north of Downtown Houston, between I-45 and US 59/I-69, consists of 10 general purpose lanes (five lanes in each direction) within an existing ROW width of 420 feet. US 59/I-69 along the east side of Downtown Houston consists of six general purpose lanes (three lanes in each direction) within an existing ROW width of 225 feet. Generally, local streets serve as one-way frontage roads within Segment 3, except near the I-10 and US 59/I-69 interchange, where the frontage roads are discontinuous. The length of Segment 3, which includes the Downtown Loop System, is approximately 13.1 miles, and the existing ROW area is approximately 638 acres.

2.2 Proposed Facility

The Preferred Alternative for the proposed project is described below, by study segment. The Preferred Alternative includes changes to the Recommended Alternative (for each segment) presented and evaluated in the Draft Environmental Impact Statement. Section 2.0 of the Final EIS discusses the design changes, including proposed storm water detention areas.

2.2.1 Segment 1: I-45 from Beltway 8 North to north of I-610 (North Loop)

The Preferred Alternative would widen the existing I-45 primarily on the west side of the roadway to accommodate four managed express (MaX) lanes. The proposed typical section would include eight to ten general purpose lanes (four to five lanes in each direction), four MaX lanes (two lanes in each direction), and four to six frontage road lanes (two to three lanes in each direction).The general purpose lanes and MaX lanes would be at-grade except at major cross streets, where they would be elevated over the intersecting streets. Approximately 200 to 225 feet of new ROW would be required, mostly to the west of the existing I-45. New ROW would be required to the east of the existing I-45 ROW at intersections with major streets and between Crosstimbers Street and I-610. The new ROW would include several proposed storm water detention areas west of I-45. Approximately 246 acres of new ROW would be required, and the project length would be approximately 8.8 miles.

2.2.2 Segment 2: I-45 from north of I-610 (North Loop) to I-10 (including the interchange with I-610)

The Preferred Alternative would widen the existing I-45 to accommodate four MaX lanes. Within the at-grade section of I-45, the proposed typical section would include eight general purpose lanes (four lanes in each direction), four MaX lanes (two lanes in each direction), and four frontage road lanes (two lanes in each direction), all at-grade. I-45 would be depressed from north of Cottage Street to Norma Street, a distance of approximately 1,800 feet. Within the depressed section of I-45, the proposed typical section would include eight below-grade general purpose lanes (four lanes in each direction) and four below-grade MaX lanes (two lanes in each direction), while the four frontage road lanes (two lanes in each direction) would be at-grade. The proposed I-45 and I-610 frontage roads would be continuous through the I-45/I-610 interchange. New ROW would be required from both the east and west sides of the existing I-45. The new ROW would include proposed storm water detention areas on the east side of I-45, south of Patton Street. Approximately 44 acres of new ROW would be required, and the project length, including interchange improvements, would be approximately 4.5 miles.

The Preferred Alternative provides a structural “cap” over a portion of the depressed lanes of I-45 from north of Cottage Street to south of N. Main Street. Future use of the structural cap area for another purpose would require additional development and funding by entities other than TxDOT.

2.2.3 Segment 3: Downtown Loop System (I-45, US 59/I-69, and I-10)

The Preferred Alternative would reroute I-45 to be parallel with US 59/I-69 on the east side of Downtown Houston. The existing elevated I-45 roadway along the west and south sides of Downtown would be removed and relocated to be parallel to I-10 on the north side of Downtown and parallel to US 59/I-69 on the east side of Downtown. Access to the west side of Downtown would be provided via “Downtown Connectors,” which would provide access to and from various Downtown streets. To improve safety and traffic flow in the north and east portions of Segment 3, both I-10 and US 59/I 69 would be realigned to eliminate the current roadway curvature. I-45 and US 59/I-69 would be depressed along a portion of the alignment east of Downtown. South of the George R. Brown Convention Center, I-45 would begin to elevate to the interchange of I-45 and US 59/I-69 southeast of Downtown, while US 59/I-69 would remain depressed as it continues southwest toward Spur 527.

The four proposed I-45 MaX lanes in Segments 1 and 2 would terminate/begin in Segment 3 at Milam Street/Travis Street, respectively. I-10 express lanes (two lanes in each direction) would be located generally in the center of the general purpose lanes within the proposed parallel alignment of I-10 and I-45 on the north side of Downtown. The I-10 express lanes would vary between being elevated and at-grade.

New ROW to the east of the existing US 59/I-69 along the east side of Downtown would be required to accommodate the proposed realigned I-45. The existing Hamilton Street would be realigned to be adjacent to US 59/I-69 to serve as a southbound access road, and the existing St. Emanuel Street would serve as a northbound access road. The project ROW would include areas to be developed as storm water detention. Approximately 160 acres of new ROW would be required, the majority of which would be for the I-10 and

US 59/I-69 realignments and to construct the proposed I-45 lanes adjacent to US 59/I-69 along the east side of Downtown. The project length, including interchange improvements, would be approximately 11.9 miles. The length of the proposed project does not include existing roadways that would be removed: I-45 (Pierce Elevated) along the south side of Downtown, and sections of I-10 and US 59/I-69 where the roadways would be straightened.

The Preferred Alternative provides a structural "cap" over the proposed depressed lanes of I-45 and US 59/I-69 from approximately Commerce Street to Lamar Street. Future use of the structural cap area for another purpose would require additional development and funding by entities other than TxDOT.

3.0 Waters of the United States, including Wetlands

A separate technical report has been prepared that describes the waters of the United States, including wetlands, identified within the project area. The report is included as Appendix K of the NHHIP Final EIS.

4.0 Surface Water

The TCEQ has developed surface water quality standards that apply to all surface waters in the state of Texas (Texas Administrative Code Title 30, Chapter 307). These standards were last amended in June 2010 and represent rules designed to establish goals for water quality throughout the state. However, during the following triennial review, the TCEQ revised and adopted the 2014 standards and submitted the package to the U.S. Environmental Protection Agency (EPA). This means that the 2014 standards are in effect for non-federal programs, unless specifically disapproved by the EPA while the entire package is under review. The standards provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the established goals for water quality.

The surface waters in the state have been individually defined and assigned a unique identification number. The major surface waters of the state are grouped by the Texas Commission on Environmental Quality (TCEQ) into 25 basins, with each basin being assigned a number. The waters are further separated into segments, with each segment having relatively homogeneous chemical, physical, and hydrological characteristics. A water segment provides a basic unit for assigning site-specific water quality standards based on designated uses for implementing a watershed-based approach to water quality management programs. Segments are identified as classified or unclassified. Classified segments include most rivers and their major tributaries, major reservoirs, bays, estuaries, and the Gulf of Mexico. Classified segments refer to water bodies that have designated uses defined in the TCEQ's Texas Surface Water Quality Standards (TSWQS) and are protected by general or site-specific water quality criteria and screening levels. Unclassified segments are usually the smaller water bodies and tributaries where data may be lacking or is not available, and where designated uses are not defined in the TSWQS. The state presumes a high aquatic life use designation for unclassified waters, and these are protected by the general standards and screening levels corresponding to that use designation until data is available or generated through a Use Attainability Analysis study or other assessment investigation.

Unique identification numbers are typically four digits, with the initial two digits representing the basin within which the segment is located. For example, the proposed project area is located in Basin 10, the San Jacinto River Basin. Therefore, segments in the San Jacinto River Basin begin with 10. The second two digits represent a specific segment of the San Jacinto River system. These specific segments are numbered sequentially beginning with 01 and increasing numerically as needed. For example, the segment of the San Jacinto River system named Houston Ship Channel/Buffalo Bayou Tidal, with designated upstream and downstream limits, is identified as segment 1007, and the segment named Buffalo Bayou Tidal, having designated upstream and downstream limits that do not overlap other named segments, is identified as segment 1013. Some tributaries flowing into a river are not classified, but rather are unclassified waters that may need to be reviewed for the assignment of site-specific water quality standards. Such unclassified waters are assigned a letter after the unique identification number. For example, the segment named Little White Oak Bayou, which flows into Buffalo Bayou, is identified as segment 1013A.

The TCEQ assigns each water body in the state a category designation from 1 to 5. The higher the category number, the higher the level of effort that is required to manage the water quality. Category 1 water bodies meet

all designated uses and require only routine monitoring and preventive action. Category 5 waters require TCEQ action to restore water quality. A water body is considered impaired if its designated use(s) is affected by a pollutant or condition of concern and the water quality standards are not met. Water bodies assigned to Category 4 or 5 are considered by the TCEQ to be impaired waters.

The TCEQ is required under Section 303(d) of the Clean Water Act (CWA) to identify water bodies that do not meet, or are not expected to meet, applicable water quality standards for their designated uses. Some of the streams in Basin 10 are located in heavily urbanized areas and receive treated domestic and industrial wastewater, and agricultural and urban runoff. In compliance with Section 303(d) of the CWA, the TCEQ identifies water bodies in the state that do not meet the TSWQS**.** The compiled listing of these water bodies is known as the 303(d) List. Category 5 waters comprise the 303(d) List.

Within the boundaries of the project area, there are six surface waters, including bayous and other tributaries. The surface water segments within the project area are listed in *Table 4-1*.

Table 4-1: Texas Surface Water Quality Water Segments within the Project Area

Water Segment	Name and Location	Project Segment(s) within which the Surface Water Occurs	Category	Designated Uses
1006D	Halls Bayou (unclassified water body): From Greens Bayou confluence upstream to Frick Rd.	1	4	Aquatic Life Use, Recreation Use, General Use
1007	Houston Ship Channel/Buffalo Bayou Tidal: From point immediately upstream of Greens Bayou to point 100 meters upstream of US 59, including tidal portion of tributaries	3	5	Aquatic Life Use, Fish Consumption Use, General Use
1013	Buffalo Bayou Tidal: From point 100 meters upstream of US 59 to point 400 meters upstream of Shepherd Dr., including the tidal portion of tributaries	3	4	Aquatic Life Use, Recreation Use, General Use
1013A	Little White Oak Bayou (unclassified water body): From White Oak Bayou confluence to Yale St.	1, 2	5	Aquatic Life Use, Recreation Use, General Use
1016C	Unnamed Tributary of Greens Bayou (unclassified water body): From the confluence with Greens Bayou, east of Aldine Westfield Road, to the Hardy Toll Road	1	4	Aquatic Life Use, Recreation Use, General Use
1017	White Oak Bayou Above Tidal: From point immediately upstream of confluence of Little White Oak Bayou to point 3 kilometers (1.9 miles) upstream of FM 1960	3	4	Aquatic Life Use, Recreation Use, General Use

Source: TCEQ Texas 303(d) List 2014

Segments 1007 and 1013A are Category 5 waters, and are included in the TCEQ 303(d) List and the TCEQ Water Quality Index (WQI). Segments 1006D, 1013, 1016C, and 1017are listed in TCEQ's WQI as Category 4 waters. Category 4 waters are defined as impaired waters for which Total Maximum Daily Loads (TMDLs) have already

been adopted, or for which other management strategies are underway to improve water quality. The TCEQ prioritizes water bodies on the 303(d) List to schedule development of a TMDL. A TMDL is a technical analysis that determines maximum loadings of a pollutant of concern that a water body can receive and still meet water quality standards. A TMDL allocates the allowable loading to different point and non-point pollutant sources in a watershed (TCEQ 2014a). The TCEQ reviews the standards for one or more parameters before a management strategy is selected, including the possible revision of the water quality standards (TCEQ 2014b). Water quality concerns for the six water segments in the project area for the years 2002 through 2014 are presented in *Table 4-2*.

Table 4-2: Texas Water Quality Assessment Results for Potentially Affected Water Bodies (2002-2014): Water Quality Assessment/303(d) List Details by Year

Year	Seg ID	Segment Name	Impairment(s)
2002	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Polychlorinated biphenyls (PCBs) in fish tissue; dioxin in catfish and crab tissue; pesticides in fish tissue
	1013	Buffalo Bayou Tidal	Bacteria; copper (chronic) in water
	1013A	Little White Oak Bayou (unclassified water body)	Bacteria; depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria
2004	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	PCBs in fish tissue; chlordane in fish tissue; dieldrin in fish tissue; dioxin in catfish and crab tissue; heptachlor epoxide in fish tissue
	1013	Buffalo Bayou Tidal	Bacteria
	1013A	Little White Oak Bayou (unclassified water body)	Bacteria; depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria
2006	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Dioxin in edible tissue; PCBs in edible tissue; bacteria; toxicity in sediment
	1013	Buffalo Bayou Tidal	Bacteria
	1013A	Little White Oak Bayou (unclassified water body)	Bacteria; depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria
2008	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Dioxin in edible tissue; PCBs in edible tissue; bacteria; toxicity in sediment

Year	Seg ID	Segment Name	Impairment(s)
	1013	Buffalo Bayou Tidal	Bacteria
	1013A	Little White Oak Bayou (unclassified water body)	Bacteria; depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria
2010	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Dioxin in edible tissue; PCBs in edible tissue; bacteria; toxicity in sediment
	1013	Buffalo Bayou Tidal	Not listed
	1013A	Little White Oak Bayou (unclassified water body)	Depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Not listed
2012	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Dioxin in edible tissue; PCBs in edible tissue; bacteria; toxicity in sediment
	1013	Buffalo Bayou Tidal	Bacteria
	1013A	Little White Oak Bayou (unclassified water body)	Depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria
2014	1006D	Halls Bayou (unclassified water body)	Bacteria
	1007	Houston Ship Channel/Buffalo Bayou Tidal	Dioxin in edible tissue; PCBs in edible tissue; bacteria; toxicity in sediment
	1013	Buffalo Bayou Tidal	Bacteria
	1013A	Little White Oak Bayou (unclassified water body)	Depressed dissolved oxygen
	1016C	Unnamed Tributary of Greens Bayou (unclassified water body)	Bacteria
	1017	White Oak Bayou Above Tidal	Bacteria

Source: TCEQ Texas 303(d) Lists 2002-2014

4.1 Short-term Water Quality Impacts

The Texas Pollutant Discharge Elimination System (TPDES) program implements the federal National Pollutant Discharge Elimination System program. TCEQ administers storm water permits for construction projects disturbing at least one acre within the state. The proposed project would disturb more than one acre of land, thereby requiring the preparation of a Storm Water Pollution Prevention Plan (SW3P). In addition, because the proposed project would disturb more than five acres, a Notice of Intent (NOI) for coverage under the TPDES

Construction General Permit (CGP) would also be required. Once construction has been completed, a Notice of Termination would be filed per permit requirements. Lastly, in accordance with Section 402 of the CWA, where storm water runoff would discharge to a Municipal Separate Storm Sewer System (MS4), the MS4 permittee would be notified of the construction activity.

As noted, a SW3P would be developed for the proposed project in accordance with TxDOT policies, and measures would be implemented to prevent or correct erosion that may develop during construction. Guidance documents, such as TxDOT's *Storm Water Management Guidelines for Construction Activities*, discuss temporary erosion control measures to be implemented to minimize impacts to water quality during construction (TxDOT 2002). Temporary and permanent erosion control practices from TxDOT's *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges* (TxDOT 2014) would be implemented for the proposed project. The practices would be in place prior to and during the construction period and would be maintained throughout construction of the proposed project.

Temporary soil erosion and sedimentation controls may include the use of silt fencing, temporary berms, inlet protection barriers, hay bales, seeding or sodding of bare areas, or other suitable means of containment. Temporary erosion control structures would be installed where appropriate before construction begins and would be maintained throughout construction of the proposed project. During construction, the amount of cleared or non-vegetated soil would be restricted to minimize additional erosion and sedimentation. When construction is completed, disturbed areas would be restored according to TxDOT specifications. Mitigation for the impacts mentioned above would include TxDOT best management practices (BMPs) that have been designed to limit water quality degradation from construction activities. Contractors would take appropriate measures to prevent or minimize and control hazardous material spills in construction assembly areas. Removal and disposal of waste materials by the contractors would be in compliance with applicable federal and state guidelines and laws.

4.2 Long-term Water Quality Impacts

Long-term operational effects on surface water quality would include changes in the volume of rainfall runoff and constituents carried in the runoff. Generally, runoff would contain sediment or pollutants in quantities that could impact water quality. For example, runoff from paved surfaces would carry particulate matter from tire wear and oils and greases from vehicles, and would be expected to include urban litter, such as paper and plastic materials. There is also the possibility of collisions on any roadway, regardless of operating characteristics and traffic volumes. Collisions can contribute to pollutants being conveyed in storm water runoff, as a minimal amount of spilled chemicals would run off or be flushed into adjacent drainageways.

Construction of the proposed project would result in an increase in the overall area of impervious cover, which would result in minor increases in localized runoff contributed by the proposed project compared to existing conditions. Storm water runoff from the proposed project would likely have little adverse effect on area receiving waters, as the project area is in a highly urbanized part of the City of Houston, and proposed detention facilities would collect storm water runoff from the project area before it enters receiving waters. The proposed detention facilities would promote the settling of suspended solids that may, for some constituents in storm water runoff, lead to reduced pollutant concentrations. A reduction in the volume of pollutants would result in a reduced pollutant load potentially being conveyed with storm water runoff into receiving waters.

Construction, operation, and maintenance activities associated with the proposed project would not adversely impact water quality in the proposed project area. BMPs implemented during construction and operation would reduce the introduction of pollutants into receiving waters. Construction of the proposed project would not result in contamination to or adverse effect on a public water supply, as potable water sources are typically obtained from underground aquifers or surface water sources located outside the project area.

During the review and evaluation of the proposed project, TxDOT will coordinate with TCEQ regarding potential impacts to impaired water bodies that are located within the proposed project area that could be impacted by the construction and operation of the project.

4.3 No Build Alternative Impacts

The No Build Alternative would have no impacts to existing surface water quality conditions. The No Build Alternative would maintain current conditions for detention areas, protection measures, and BMPs that reduce impacts to existing water resources and water quality. Storm water runoff would continue to flow into receiving waters within and near the project area.

5.0 Groundwater

The major aquifer in the Houston area is known as the Gulf Coast Aquifer and consists of complexly interbedded clays, silts, sands, and gravels of Cenozoic age, which are hydrologically connected to form a large, leaky, artesian aquifer system. The Gulf Coast Aquifer parallels the coastline and increases in thickness in the direction of the Gulf of Mexico. This aquifer system is comprised of four major components, and several recognized water-producing formations. The Chicot Aquifer, which is the upper component of the Gulf Coast Aquifer system, consists of the Willis Sand, the Bentley and Montgomery Formations, the Beaumont Clay, and overlying alluvial deposits. The Lissie Formation is considered by some to be equivalent in age to the Montgomery and Bentley Formations. The Burkeville Clay lies beneath the Evangeline Aquifer and separates it from the Jasper Aquifer. The Gulf Coast Aquifer is not designated as a sole-source aquifer by the state, and the project is not located in a protected aquifer recharge or discharge zone. A description of these aquifer systems and stratigraphic information included below in *Table 5-1* (TWDB 2006).

Table 5-1: Description of Gulf Coast Aquifer System Components

Hydrologic Unit	Maximum Thickness in Houston Area (feet)	Geologic Formation (oldest to youngest)	Composition	Water-bearing Properties*
Chicot Aquifer	480	Willis Sand, Bentley and Montgomery Formations (aka Lissie Formation), Beaumont Clay, and Holocene Alluvium	Gravel, sand, silt, and clay. Sand constitutes about 50 percent of the aquifer. Gravel, very minor.	Large yields of fresh water possible in areas with high rates of transmissivity within interconnected sand units
Evangeline Aquifer	1,900	Goliad Sand	Sand, gravel, silt, and clay. Gravel very minor. Sand constitutes about 30 to 50 percent of the unit.	Large yields of fresh water possible in areas with high rates of transmissivity within interconnected sand units
Burkeville Confining System	450	Upper part of Fleming Formation/Lagarto Clay	Clay, silt, and sand. Sand constitutes from less than 10 to 20 percent of the unit.	Would not transmit fresh water, as the unit is a confining layer (aquitard or aquiclude)
Jasper Aquifer	2,400	Oakville Sandstone, Fleming Formation	Sand, silt, and clay. Sand constitutes from 30 to 40 percent of the unit (fresh to slightly saline water).	Small to medium yields of fresh water possible in areas with relatively thicker and more transmissive sand units

Hydrologic Unit	Maximum Thickness in Houston Area (feet)	Geologic Formation (oldest to youngest)	Composition	Water-bearing Properties*
Catahoula Confining System		Frio Clay, Anahuac and Catahoula Tuff or Sandstone	Clay, sand, and silt	Would not easily transmit fresh water, as the unit is a confining layer (aquitard or aquiclude)

*Small = less than 100 gallons per minute (gpm); Moderate = 100 – 1,000 gpm; Large = more than 1,000 gpm
Source: Table adapted from Texas Water Development Board Report 72 (TWDB 1968) and *Aquifers of the Gulf Coast of Texas* (TWDB 2006)

The regional Gulf Coast Aquifer system is recharged by the infiltration of precipitation that falls on topographically elevated aquifer outcrop areas, farther to the north and west of the Houston area. Groundwater in the recharge area is normally under unconfined, water-table conditions, and is most susceptible to contamination. Some water-bearing formations dip below the surface and are covered by other formations (TWDB 2011).

In the project area, the Gulf Coast Aquifer is a confined aquifer and the location of the recharge area is controlled by the presence and location of the Beaumont Clay. The northern part of the project area (Segment 1) is the outcrop or recharge area of the Chicot Aquifer, the location of the Willis Sand and Lissie Formation. There is little to no Gulf Coast Aquifer recharge occurring in the area of Segments 1 or 2 (USGS 1996a). Pumping from the Gulf Coast Aquifer between 1985 and 2000 ranged from around 1 million to 1.3 million acre-feet per year. Water-level declines of up to 350 feet in Fort Bend, Galveston, Harris, Jasper, and Wharton counties have led to land-surface subsidence (USGS 2004; USGS 1996b). Since the establishment of the Harris-Galveston Subsidence District in 1975, groundwater use has decreased in an effort to address land subsidence. Surface water use has increased and is planned to continue to provide needed water supplies in the Houston area, although groundwater will continue to supply water for irrigation, public water needs, and industrial uses. However, large groundwater withdrawals in Harris County and adjacent areas have reduced the artesian pressure of the Gulf Coast Aquifer to cause water from clay beds in permeable zones to flow into sands. As the water flows out of the compressible clays, they become irreversibly compacted, causing permanent land surface subsidence. This subsidence has increased the risk of flood damage to residential and commercial properties and has activated faults that have caused structural damage in the Houston area. The natural, regional groundwater flow system in the Houston area has been profoundly altered by decades of substantial withdrawals of water from the Gulf Coast Aquifer. Large regional cones of depression have developed in the permeable areas of the Chicot and Evangeline aquifers (USGS 1996a). The shallow groundwater table in the study area generally ranges from 10 to 30 feet below the ground level surface. The estimated total recharge to the saturated zone in the project area is about six inches per year, since some percentage of the total aquifer recharge discharges locally to streams, creeks, ditches, seeps, or canals. Potential impacts to shallow groundwater of the upper Gulf Coast Aquifer system could result from activities associated with the construction and operation of the proposed project. Construction-related impacts could include actions that occur during excavation, grading or trenching that could expose soils and shallow groundwater, and potentially result in impacts to groundwater or surface water quality; footing excavations for pier foundations resulting in or possibly encountering groundwater contamination; potential surface water impacts from excavation and dewatering operations, concrete pouring, and washout activities; management and application of chemical products; construction activities that may affect shallow aquifer recharge or discharge areas; and the potential for accidental spills from construction equipment and from material storage. Additional construction-related impacts may be associated with the demolition and replacement of existing bridges, roads, and road base, which may include discharges of waste material, accidental spills, and the discharge or generation of impacted soils that could result in impacts to surface water or shallow groundwater in recharge areas.

The TCEQ administers the TPDES, and a TPDES Construction General Permit would be required to manage the discharge of storm water from the proposed project construction area. TxDOT has been issued TPDES General

Permit Number TXR150000 by the TCEQ related to storm water discharges associated with construction activities.

Construction work would include dredging, dewatering, concrete pouring, welding, painting and paint removal, and other activities that have the potential to impact water quality. Preventing these impacts may be difficult due to complex site conditions, with limited space and several constraints. However, controls in the SW3P would be used to minimize water quality effects to the maximum extent practicable. The SW3P would have a plan for responding to and managing accidental spills during construction, a plan for the management of chemical and/or hazardous materials used during construction, a plan for management and performance of all construction activities conducted over water to minimize the potential for accidental releases, a plan for the management of excavation activities to minimize or eliminate the potential for groundwater contamination resulting from such activities, and a plan for the management and disposal of all pumped water and excavated or dredged materials. The SW3P would also address overall management of the project, such as BMPs for concrete pouring, the application of concrete curing compounds, material storage, equipment fueling, concrete washout, and stockpiles. The transport of materials and equipment use would also be covered.

The SW3P would describe erosion control measures to be implemented by the contractors and BMPs to be implemented to control and prevent, to the maximum extent practicable, the discharge of pollutants to surface waters and groundwater. Erosion control measures may include, but not be limited to, the installation of silt fences on cut slopes, around drainage inlets, and any drainage path; placement of hay bales, and/or mulching; erosion control blankets; and hydro-seeding. Roadway, bridge, and facility demolition work may also occur and may require a separate and specific SW3P to address planned demolition activities, including structures that may have asbestos-containing materials or lead-based paint. The SW3P would address specific dismantling activities and BMPs to be implemented to minimize the discharge of pollutants associated with these activities. Similar to the SW3P prepared for the construction of new roadway and bridge structures, this SW3P would have a plan for managing and responding to accidental spills and discharges of waste material.

The proposed project could include the construction of drilled shafts during bridge or other support structure construction. These excavation activities would increase the potential of encountering hazardous material contamination during construction. Additional subsurface environmental investigations would be required to determine whether possible contamination might be encountered during construction. If the presence of hazardous constituents were to be confirmed, appropriate soils and/or groundwater management plans for activities within these areas would be developed.

Impacts on groundwater quality from the proposed project would be related to storm water discharges from both construction and operation. During construction, spills would be mainly limited to fuels (i.e., petrochemicals) and lubricants used for construction equipment. Impacts to groundwater quality because of surface spills would be minimized by the implementation of spill prevention measures. The project area is in a highly urbanized portion of the City of Houston; therefore, much of the area is composed of impervious cover (e.g., streets and roadways, driveways, parking areas, residential and commercial buildings, etc.). There is little opportunity for undeveloped land to absorb and filter precipitation and storm water runoff to recharge groundwater resources. Rather, the majority of storm water runoff in the project area is directed to storm water management facilities to be conveyed to area receiving waters.

During construction, appropriate measures would be implemented to prevent, minimize, and/or control hazardous materials spills in construction assembly areas. Removal and disposal of materials by the contractors would be conducted in accordance with applicable federal and state regulations and laws so as not to degrade groundwater quality. As stated previously, storm water control measures and BMPs would be implemented such that construction and operation of the proposed project would have minimal, if any, impact to regional groundwater resources.

5.1 No Build Alternative Impacts

The No-Build Alternative would have no direct impacts to groundwater resources within the area of the proposed project.

6.0 Public Drinking Water Systems

The state's Source Water Protection Program (SWPP) is a community-based, voluntary pollution prevention program that helps public water systems (PWSs) protect their drinking water sources. The program was created by the 1986 Safe Drinking Water Act Amendments and the expansion of the Wellhead Protection Program. The Safe Drinking Water Act emphasizes groundwater and wellhead programs to protect source waters. The Wellhead Protection Program sets in place public health protection measures to ensure safe drinking water for citizens served by public drinking water supplies. A PWS provides potable water for the public's use. A system must be a certain size to be considered public. It must have at least 15 service connections or serve at least 25 individuals for at least 60 days annually (TCEQ 2014c). These water systems are classified as either Community Water systems that serve the same people year-round (e.g., in homes or businesses), Non-Transient Non-Community Water systems that serve the same people, but not year-round (e.g., schools that have their own water system), or Transient Non-Community Water systems (systems that do not consistently serve the same people). All public water supply systems are eligible to participate in the program, which establishes procedures and criteria for identifying the boundaries of areas that constitute the sources of water used by PWSs. The program also defines procedures for identifying potential sources of contaminants within the same areas, and provides for the development and implementation of plans for managing potential contaminant sources to prevent contamination.

The TCEQ's Water Utility Database was searched for information pertaining to PWSs located in the proposed project area. There are 669 active community water utilities in Harris County (TCEQ 2016). These utilities include municipalities, private corporations, and district ownership. There are 1,220 active PWSs in Harris County (TCEQ 2016).

The Texas Water Development Board's (TWDB) groundwater database was searched for water wells located within the project area. A total of six registered water wells documented in the database were identified as being in the project area (*Table 6-1*). Identified wells in the area are found within the Chicot, Evangeline, and Gulf Coast aquifers. Primary uses listed for the wells include commercial, domestic, industrial, public supply, and unused (TWDB 2016). Of the six water wells, two wells are listed as being used for public water supply. Wells occurring within the project area that would be unavoidably impacted by the proposed project would be plugged by the project contractor during construction according to TCEQ regulations to eliminate the potential for impacts to groundwater resources.

Table 6-1: Water Wells Within the Proposed NHHIP Right-of-Way

Water Well Primary Use	Segment 1	Segment 2	Segment 3
Commercial	1	0	0
Domestic	1	0	0
Industrial	1	0	0
Public Supply	2	0	0
Unused	1	0	0
Total	6	0	0

6.1 No Build Alternative Impacts

The No Build Alternative would have no impacts on existing public drinking water systems. The No Build Alternative would maintain current conditions relative to the suppliers and distributors of water for public consumption in the general project area.

7.0 Floodplains

Based on comments received during the Draft EIS public comment period, changes were made to the design and the proposed new ROW of the Preferred Alternative. In addition, after the adoption of the Atlas 14 rainfall data in development regulations in Harris County, the City of Houston and Harris County Flood Control District (HCFCD) now require that all projects within the effective floodplain provide floodplain mitigation based on the effective 500-year floodplain (see Section 7.1). Consequently, floodplains were reassessed for the Preferred Alternative alignment.

Portions of the proposed project would traverse areas that are designated by the Federal Emergency Management Agency (FEMA) as special flood hazard areas (i.e., regulatory floodways, 100-year floodplains, and 500-year floodplains). The following FEMA Flood Insurance Rate Maps (FIRMs) were reviewed for the project area (the effective dates of the maps are shown in parentheses): 48201C0460M (10/16/2013), 48201C0470L (6/18/2007), 48201C0660M (6/9/2014), 48201C0680L (6/18/2007), 48201C0670M (6/9/2014), 48201C0690N (1/6/2017), 48201C0860L (6/18/2007), and 48201C0880M (1/6/2017) (FEMA 2019). The FIRMs indicate that approximately 70 percent of the project area is outside the 100-year floodplain, or other flood hazard areas as determined by FEMA (see *Waters of the United States Technical Report*). In 2018, NOAA released revised precipitation-frequency data for Texas, termed "Atlas 14" data. The data included in Atlas 14 updates rainfall depth information that had been used since the 1960s, and included data in Texas through December 2017, which incorporates rainfall from Hurricane Harvey. It is estimated that the future Atlas 14 one-percent (100-year) floodplain can be estimated by using the current published 0.2 percent (500-year) floodplain (HCFCD 2019). As of July 2019, the Atlas 14 rainfall data must be used when designing and constructing drainage features as part of development in Harris County. The remapping of the floodplains within Harris County based on Atlas 14 data is ongoing at the time this report was prepared.

Areas adjacent to Brays Bayou, Buffalo Bayou, a tributary of Greens Bayou, Halls Bayou, Little White Oak Bayou, and White Oak Bayou are mapped as being within the effective 100-year and 500-year floodplains as mapped by FEMA. Table 7-1 presents the approximate acreages of the pre-Atlas 14 500-year FEMA floodplain within the existing and proposed new ROW for each segment of the Preferred Alternative, based on the assumption that the current effective 500-year floodplain approximates the Atlas 14 100-year floodplain.

Table 7-1: Pre-Atlas 14 500-Year Floodplain Acreage within NHHIP Existing and Preferred Alternative Rights-of-Way

		Floodplain Acres (approximate)
Segment 1	Existing ROW	141
	Proposed New ROW	148
Segment 2	Existing ROW	138
	Proposed New ROW	16
Segment 3	Existing ROW	179
	Proposed New ROW	45

7.1 Impacts of the Preferred Alternative

TxDOT has performed a preliminary drainage study for the proposed project, detailed drainage studies for Segments 2 and 3 of the proposed project, and will perform a detailed drainage study for Segment 1. The drainage studies will be used to determine the appropriate locations and sizes of detention basins, bridges, culverts, or other drainage structures that would be required to mitigate risks incurred by construction of the

proposed project. Federal, state, and local authorities will have the opportunity to review the drainage studies to verify that appropriate measures have been proposed such that the project would not increase the flood risk to adjacent properties. Bridges, culverts, and cross-drainage structures will be designed to FHWA and TxDOT standards for design events up to the 100-year storm event. The studies will also confirm that the project would not adversely impact existing floodplain conditions within the vicinity of the project for extreme events, (i.e., storm events in excess of a 100-year storm event). BMPs, such as the construction of detention facilities, would be incorporated into the final design of the proposed project to offset increased flows from areas of impervious surface. Construction of the proposed project would comply with county and local floodplain guidelines and policies. The floodplain acreages listed in Table 7-1 and discussed in the following sections are subject to change as updated floodplain mapping occurs. As noted in Section 7, Atlas 14 data is currently required to be used in project design, and TxDOT is using the updated precipitation-frequency estimates when designing new construction projects. The acreages in Sections 7.1.1 through 7.1.3 are based on the estimated Atlas 14 100-year floodplain (effective 500-year floodplain) within the existing and proposed project ROW.

7.1.1 Segment 1: I-45 from Beltway 8 to I-610

Approximately 141 acres of 500-year floodplains as currently mapped by FEMA, which approximates the Atlas 14 100-year floodplain, occur within the existing I-45 ROW for Segment 1.

Approximately 148 acres of 500-year floodplains as currently mapped by FEMA (pre-Atlas 14) occur within the new ROW of the Preferred Alternative. The waterbodies and acreage of floodplains include the following:

- Tributary of Greens Bayou: 0.02 acre
- Halls Bayou: 34.05 acres
- Little White Oak Bayou: 114.09 acres

Drainage Improvements

TxDOT prepared a preliminary drainage study that included all segments of the NHHIP project area (AECOM 2018). To be conservative, a preliminary mitigation assessment was completed for the project alternative that would have the most additional pavement. The following summarizes the preliminary drainage analysis findings for Segment 1:

Preliminary Detention Assessment

- Potential area needed for detention: approximately 36.0 acres.
- Majority of preliminary detention sites were located in parcels identified to be partially acquired by the future roadway ROW.

Preliminary Profile Analysis

Recommended mainlane profile adjustments to bring mainlanes up to a 100-year level of service:

- I-45 crossing of Halls Bayou - minor adjustments to the mainlane roadway profile approaching the bridge crossing.
- I-45 between West Little York and HB&T Railroad - minor adjustments to the mainlane roadway profile in the vicinity of West Little York Road, Parker Road, Tidwell Road, Airline Drive, and Crosstimbers Street.
- These adjustments are not anticipated to impact ROW needs or result in significant design changes.

Preliminary Floodplain Analysis

- Each alternative results in net fill within the floodplain.
- It is anticipated that the required floodplain fill mitigation could be provided for in an oversized detention facility along the east bank of Little White Oak Bayou north of Crosstimbers Street.

Preliminary Conveyance Analysis

- Based on the preliminary analysis, no mitigation measures were recommended in regard to floodway conveyance within Segment 1.
- Conveyance considerations were not anticipated to impact ROW needs or result in significant roadway/bridge design changes.

The preliminary drainage study for the NHHIP (October 2018) did not utilize the Atlas 14 data. TxDOT will prepare a detailed drainage study using the Atlas 14 data for Segment 1 during detailed design. The analyses conducted during detailed design will be based on drainage design criteria in effect at the time of the study. The study will include evaluation of detention, floodplain fill, floodway conveyance, and mitigation for all impacts, and will be based on the detailed design of the roadway and drainage system. A detailed hydraulic analysis will be completed to determine the appropriate configuration of the storm sewer system. Detention basin locations will be further refined based on the project ROW needs and property availability at the time of the design.

7.1.2 Segment 2: I-45 from I-610 to I-10

Approximately 138 acres of 500-year floodplains as currently mapped by FEMA, which approximates the Atlas 14 100-year floodplain, occur within the existing I-45 ROW for Segment 2.

Approximately 16 acres of 500-year floodplains as currently mapped by FEMA (pre-Atlas 14) occur within the new ROW of the Preferred Alternative. The waterbody and floodplain acreage in Segment 2 is:

- Little White Oak Bayou: 16.37 acres

Drainage Improvements

In March 2020, a drainage study was completed for Segment 2 and the portion of Segment 3 of the NHHIP project area that includes Little White Oak Bayou, White Oak Bayou, and Buffalo Bayou watersheds (CivilTech Engineering, Inc. 2020). TxDOT coordinated closely with the HCFCD and the City of Houston regarding previously identified and/or potential future drainage improvements projects within the limits of Segments 2 and 3. These project elements were considered as part of the floodplain impact analysis. The following summarizes the recommendations, which are subject to change during detailed project design:

Drainage Crossings

Replace four (4) major drainage crossings under I-45 and I-610 as listed below:

- Little White Oak Bayou at Cavalcade Street: Replace 3 – 15' x 16' box culverts with bridge over open channel
- Tributary to Little White Oak Bayou at I-45: Replace 1 - 10' x 10' box culvert with 3 – 10'x 10' box culverts
- Little White Oak Bayou at Patton Street: Replace 3 – 15' x 16' box culverts with bridges over open channel
- Little White Oak Bayou at I-610 (I-45 & I-610 Interchange): Replace 3 – 15' x 16' box culverts with bridges over open channel

Storm Drain Systems

The preliminary sizing of the proposed storm sewer systems was performed for the following roadways:

- I-45 Northbound and Southbound Mainlanes, Max Lanes and Frontage Roads
- I-610 Eastbound and Westbound Mainlanes and Frontage Roads

Preliminary storm sewer plan and profiles are provided in the drainage study. The preliminary design did not include inlets or storm drain laterals for the mainlanes storm sewer trunkline, and drainage system components (bridge deck drains, piping, etc.) were not included for bridges, direct connectors and ramps. These will be determined during detailed design.

Pump Station Facility

The I-45 Segment 2 proposed depressed section of highway between North Main Street and Melwood Street would be serviced by one (1) pump station facility located southwest of the I-45 and North Main interchange, at the corner of W. Norma Street and Houston Avenue, on the west side of I-45. The pump station was designed to handle the 100-year storm event (Atlas 14). The pump station will have multiple pumps.

Roadway Mitigation Facilities (Detention Basins)

Two detention basins located within the I-45 and I-610 interchange within the proposed ROW were preliminarily designed to mitigate the increased runoff from the proposed highways and for hydraulic system changes due to the proposed storm drainage improvements for NHHIP Segment 2. Three additional basins would provide for impacts to floodplain storage.

Floodplain Mitigation

The floodplain mitigation volume required to compensate for the proposed fill within the floodplain for Segment 2 would be provided in two detention basins on the east side of I-45, south of Patton Street The floodplain mitigation volume includes the loss of floodplain volume within the depressed section in Segment 2.

Based on the mitigation analysis presented in the study, the proposed roadway and storm drainage improvements for NHHIP Segment 2 would not adversely impact existing conditions for storm events up to and including the 100-year storm (Atlas 14) and the 500-year storm (Pre-Atlas 14).

7.1.3 Segment 3: Downtown Loop System

Approximately 179 acres of 500-year floodplains as currently mapped by FEMA, which approximates the Atlas 14 100-year floodplain, occur within the existing I-45 ROW for Segment 3.

Approximately 45 acres of 500-year floodplains as currently mapped by FEMA (pre-Atlas 14) occur within the new ROW of the Preferred Alternative. The waterbodies and acreages of floodplain include the following:

- Little White Oak Bayou: 0.0 acres (there is no proposed ROW in the Little White Oak Bayou floodplain)
- White Oak Bayou: 25.98 acres
- Buffalo Bayou: 19.39 acres
- Brays Bayou: 0.0 acres (there is no proposed ROW in the Brays Bayou floodplain)

Drainage Improvements

The drainage study completed for Segment 2 included a portion of the Segment 3 project area, including evaluation of potential impacts to Little White Oak, White Oak, and Buffalo Bayou floodplains (see Section 7.1.2). In addition, five separate drainage studies were completed for various sections of Segment 3 that evaluated existing drainage conditions and proposed drainage improvements such that the Segment 3 project would not adversely impact existing conditions for storm events up to and including the 100-year storm event.

Depressed sections of the proposed project will be designed to handle extreme weather events with rainfall levels similar to the region's three most recent flood events: Memorial Day (2015), Tax Day (2016), and Hurricane Harvey (2017). Additionally, the project will be designed to meet and/or exceed the most recent guidelines set by the HCFCD. In some cases, there may be water over the roadway during an extreme rainfall event, but the road is designed to still be passable. This will be achieved through a pumped drainage system that will collect rainwater falling inside the depressed sections and discharge it to an adjacent detention basin or receiving channel. For example, the rainwater that falls within the depressed section along US 59/I-69 between Main Street and Alabama Street would be conveyed to a detention facility where it would be held and then discharged at a controlled rate to Brays Bayou. The detention facilities will be sized to accommodate extreme rain events so that the water pumped out of the depressed sections does not overwhelm the receiving bayous. To further protect the depressed sections, the entrance points to these areas would be constructed above the new 500-year water surface elevation such that adjacent floodwaters do not enter the depressed

sections and overwhelm the pumps. The pump stations for the depressed sections of highway will be designed with backup pumps and backup generators to reduce the likelihood of a pump system failure. TxDOT is currently exploring the development of an alert system that will close access to depressed sections of the highways in the event of a pump failure.

Drainage Crossings

Replace four (4) major bridge crossings of waterways:

- I-45 bridge crossing of Buffalo Bayou
- I-45 bridge crossing of White Oak Bayou
- I-10/I-45 bridge crossing of White Oak Bayou
- US 59/I-69 bridge crossing of Buffalo Bayou

Roadway Mitigation Facilities (Detention Basins)

Seven detention basins located within the Segment 3 proposed ROW were preliminarily designed to mitigate the increased runoff from the proposed highways and for hydraulic system changes due to the proposed storm drainage improvements.

Floodplain Mitigation

The floodplain mitigation volume required to compensate for the proposed fill within the floodplain for Segment 3 would be provided in three detention basins that would be located along Buffalo Bayou and White Oak Bayou. The floodplain mitigation volume includes the loss of floodplain volume within the depressed sections in Segments 3.

Based on the mitigation analysis presented in the Segment 3 drainage studies, the proposed roadway and storm drainage improvements for NHHIP Segment 3 would not adversely impact existing conditions for storm events up to and including the 100-year storm (Atlas 14) and the 500-year storm (Pre-Atlas 14).

7.1.4 Segments 1, 2 & 3: Floodplain Impact Analysis

The March 2020 Segment 2 drainage study (CivilTech Engineering Inc. 2020) included a floodplain impact analysis on the three (3) major drainage systems: Little White Oak Bayou, White Oak Bayou, and Buffalo Bayou for Segment 2 and the sections of Segment 3 that are impacted by White Oak Bayou and Buffalo Bayou. The purpose of the floodplain analysis was to evaluate the impact from the proposed NHHIP on existing floodplains and determine the appropriate mitigation required in order for the NHHIP project to have no adverse impacts on existing conditions.

The floodplain impact analysis shows the proposed drainage improvements along Segment 2 and Segment 3, which include drainage crossing improvements and addition of detention basins, results in a lowering of the 500-year Pre-Atlas 14 water surface elevations compared to existing conditions. The proposed Segment 2 and Segment 3 NHHIP improvements would not adversely impact existing conditions for storm events up to and include the 500-year pre-Atlas 14 storm events. In addition, the proposed NHHIP drainage improvements would enhance the resiliency of the roadway project and the adjacent areas.

This project is subject to and will comply with Executive Order 11988 on Floodplain Management. TxDOT adheres to this Executive Order through the procedures and policies in its Hydraulic Design Manual. Design of this project will be conducted in accordance with the department's Hydraulic Design Manual. The design and constructions of Segments 1, 2 and 3 of the NHHIP will not increase the base flood elevation and will not result in a "significant encroachment" as defined by FHWA's rules implementing Executive Order 11988 at 23 CFR 650.105(q). TxDOT will coordinate with the City of Houston Department of Public Works and Engineering, and the HCFCD as needed, relative to regulatory floodplains and floodplain management during the design and evaluation of the proposed project.

7.2 No Build Alternative Impacts

The No Build Alternative would result in no new roadway construction within, or encroachment on, flood hazard areas mapped in the project area. Therefore, the No Build Alternative would have no direct impacts on flood hazard areas. However, in the vicinity of the project area, but outside the existing I-45 ROW, land use changes and construction activities could alter areas of impervious cover, thereby affecting surface drainage patterns and the volume of storm water runoff, which may potentially impact FEMA-mapped floodplains. Potential floodplain impacts would be regulated by the City of Houston, in cooperation with HCFCD.

8.0 Municipal Separate Storm Sewer Systems

Water quality impacts from development can be minimized through the implementation of a SW3P in compliance with TPDES requirements and a MS4 in conjunction with City of Houston improvements. Polluted storm water runoff is often transported to MS4s and ultimately discharged into local rivers and streams without treatment. EPA's storm water Phase II Rule establishes a MS4 storm water management program that is intended to improve the nation's waterways by reducing the quantity of pollutants that storm water collects and carries into storm sewer systems during storm events. Common pollutants include oil and grease from roadways, pesticides from lawns, sediment from construction sites, and carelessly discarded trash, such as cigarette butts, paper wrappers, and plastic bottles. When deposited into nearby waterways through MS4 discharges, these pollutants can impair the waterways, thereby discouraging recreational use of the resource, contaminating drinking water supplies, and interfering with habitat for fish, other aquatic organisms, and wildlife.

The proposed project is located within the City of Houston's MS4 boundary. TxDOT would coordinate with the City of Houston regarding construction of the proposed project within the MS4 boundary.

8.1 No Build Alternative Impacts

The No Build Alternative would have no impacts on the City of Houston's MS4. Storm water discharges from the current I-45 roadway into the City of Houston's MS4 would be similar to existing conditions under the No Build Alternative.

9.0 Coastal Zone Management Plan

The Coastal Zone Management Act of 1972 (as amended in 1996) provides for the preservation, protection, development, restoration, and enhancement (where feasible) of coastal zones in the United States. In Texas, the General Land Office is designated as the lead agency that coordinates the development and implementation of the Texas Coastal Management Plan. The Coastal Coordination Advisory Committee assists in administering the program and adopting uniform goals and policies to guide decision making by all entities that regulate or manage the use of natural resources within the Texas coastal area.

The boundary of the Texas Coastal Management Zone was delineated in accordance with the requirements of the Coastal Zone Management Act, federal program development and approval regulations, and the Texas Coastal Coordination Act. Requirements dictate that a state's coastal zone boundaries include four elements: an inland boundary, a seaward boundary, interstate boundaries, and federal land excluded from the boundary.

As illustrated in *Exhibit 2*, the southern portion of the project area is within the coastal zone area.

The General Land Office typically requires Coastal Consistency determinations for projects located in the coastal zone. The proposed project is expected to require permit authorization under Section 10 of the Rivers and Harbors Act and/or Section 404 of the CWA for impacts to waters of the United States. Formal coordination with the General Land Office would be required to ensure consistency with the Texas Coastal Management Program, as a portion of the proposed project associated with the tidal waters of Buffalo Bayou is within the mapped Texas Coastal Management Zone. Additionally, a bridge permit or permit amendment from the U.S. Coast Guard would be required for the proposed project's crossing(s) of the tidally-influenced Buffalo Bayou.

TxDOT will coordinate with the General Land Office regarding Texas Coastal Management Program consistency certification, as the proposed project is expected to require permit authorization from the USACE for unavoidable

impacts to jurisdictional waters of the United States regulated under Section 404 of the CWA and/or Section 10 of the Rivers and Harbors Act.

9.1 No Build Alternative Impacts

The No Build Alternative would have no impacts on the Texas Coastal Management Zone. The current roadways and bridge structures occurring within the coastal zone would remain in place, thus no coordination with the General Land Office would be required relative to a coastal consistency determination.

10.0 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (as amended on October 11, 1996) directs that all federal agencies proposing actions that would impact essential fish habitat consult with the National Marine Fisheries Service regarding potential adverse impacts. Although Halls Bayou, Buffalo Bayou, Little White Oak Bayou, and White Oak Bayou traverse the project area, according to the TCEQ's stream segments for the state of Texas, only Buffalo Bayou and the lower portion of White Oak Bayou are identified as tidal waters. Otherwise, the water courses in the project area are not tidally influenced.

The National Oceanic and Atmospheric Administration (NOAA) Essential Fish Habitat mapper was reviewed to determine if the proposed project area is within an area of NOAA-designated Essential Fish Habitat. No Habitat Areas of Particular Concern (HAPC) or Essential Fish Habitat Areas (EFHA) protected from fishing were identified in the project area.

10.1 No Build Alternative Impacts

The No Build Alternative would have no impacts to EFHA. Even though the tidally-influenced portions of Buffalo Bayou and White Oak Bayou are not identified as protected areas, the No Build Alternative would maintain current conditions within these water courses.

11.0 Bibliography

AECOM. 2018. North Houston Highway Improvement Project – Preliminary Drainage Study (CSJ: 0912-00-146), Harris County, Texas. AECOM Technical Services, Inc. October 2018.

CivilTech Engineering, Inc. 2020. Drainage Study for North Houston Highway Improvement Project (NHHIP) Segment 2, Harris County, Texas. Limits: I-45 From Carl Street to Houston Belt and Terminal RR, I-610 From North Main Street to Irvington Blvd. CivilTech Engineering, Inc. March 2020

Federal Emergency Management Agency (FEMA). 2000. Section 60.3 of *National Flood Insurance Program (NFIP) Regulations: Floodplain Management Criteria.* Accessed January 2018.

Federal Emergency Management Agency (FEMA). 2019. FEMA Flood Insurance Rate Maps (FIRM) for Map Numbers 48201C0460M, 48201C0470L, 48201C0660M, 48201C0680L, 48201C0670M, 48201C0690N, 48201C0860L and 48201C0880M. FEMA Flood Map Service Center. http://msc.fema.gov/portal. Accessed October 2019.

Harris County Flood Control District (HCFCD). 2019. Interim Guidelines and Criteria for Atlas 14 Implementation. July 2019. https://www.hcfcd.org/Portals/62/Downloads/ATLAS%2014/Atlas_14_RVSD_070319.pdf?ver=2019-07-10-104201-167&timestamp=1582480495877. Accessed February 23, 2020.

Texas Commission on Environmental Quality (TCEQ). 2014a. Texas 303(d) List (November 19, 2015) <https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/14txir/2014_303d.pdf>. Accessed January 2018.

_____. 2014b. Eight Total Maximum Daily Loads for Indicator Bacteria in Buffalo and Whiteoak Bayous and Tributaries. <https://ofmpub.epa.gov/waters10/attains_impaired_waters.show_tmdl_document?p_tmdl_doc_blobs_id=72799>. Accessed January 2018.

_____. 2014c. Am I a "Public Water System"? <https://www.tceq.texas.gov/drinkingwater/pws.html> Accessed January 2018

_____. 2016. Texas Safe Drinking Water Information System. <http://dww2.tceq.texas.gov/DWW/>. Accessed January 2018.

Texas Department of Transportation (TxDOT). 2002. TxDOT's Storm Water Management Guidelines for Construction Activities. July 2002. Accessed January 2018.

_____. 2014. TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges. November 1, 2014. Accessed January 2018.

Texas Water Development Board (TWDB). 1968. Report 72: Ground-water Resources of Liberty County, Texas. < http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R72/Report72.asp>. Accessed January 2018.

_____.2006. Report 365: Aquifers of the Gulf Coast of Texas. <http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R365/Report365.asp>. Accessed January 2018.

_____. 2011. Report 380: Aquifers of Texas. < http://www.twdb.texas.gov/publications/ reports/numbered_reports/doc/R380_AquifersofTexas.pdf?d=34743.685000000005>. Accessed January 2018.

_____. 2016. Geographical Information Systems Data. Well Locations from TWDB Groundwater Database (GWDB). <http://www.twdb.texas.gov/ mapping/gisdata.asp>. Accessed January 2018.

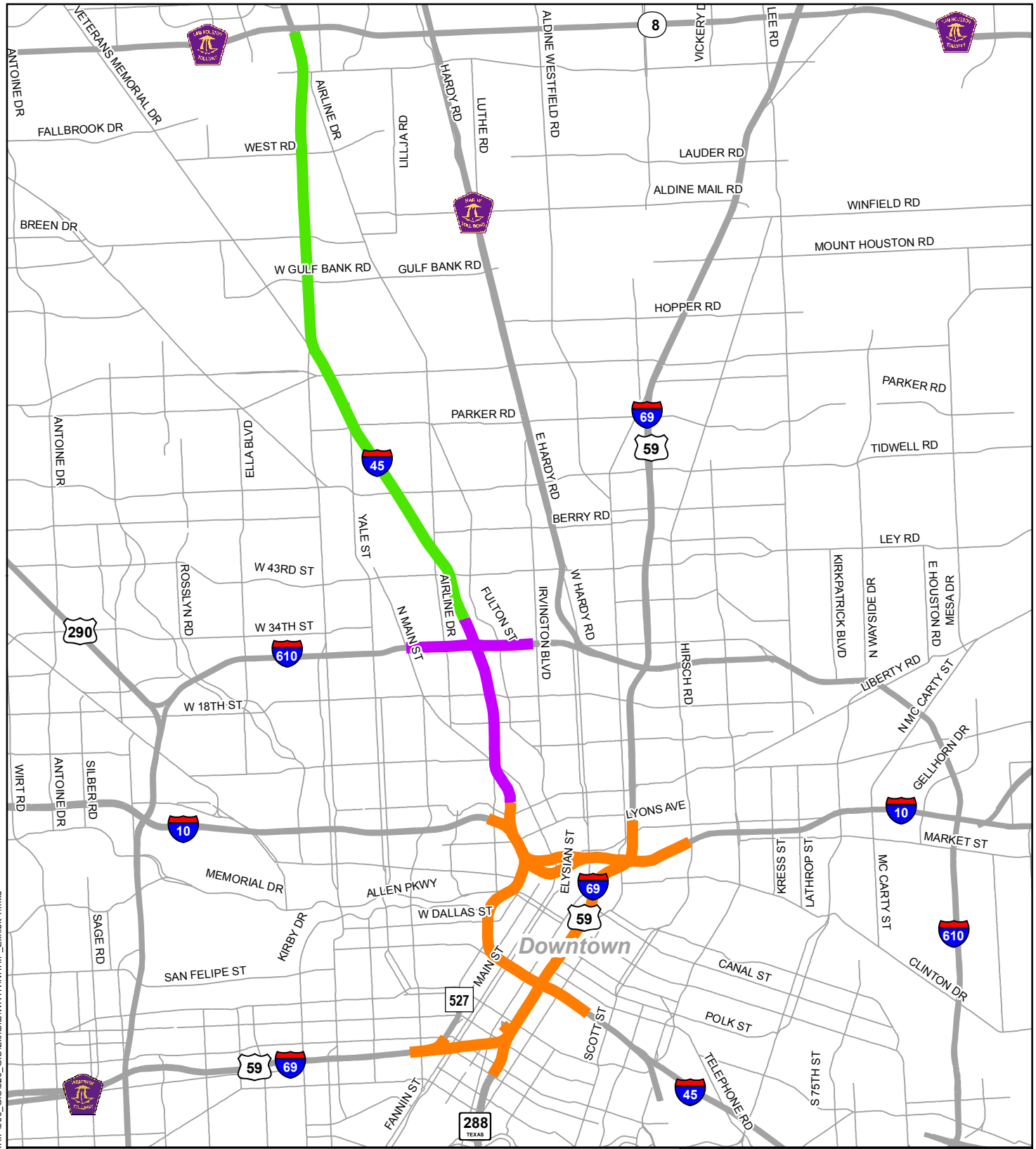
United States Geological Survey (USGS). 1996a. Estimated Depth to the Water Table And Estimated Rate Of Recharge In Outcrops Of The Chicot And Evangeline Aquifers Near Houston, Texas: Water-Resources Investigations Report 96-4018. <https://pubs.usgs.gov/wri/wri96-4018/pdf/wri96-4018.pdf>. Accessed January 2018.

_____. 1996b. Ground Water Atlas of the United States: Oklahoma, Texas; HA 730-E. See esp. Figure 61.

_____. 2004. Hydrogeology and Simulation of GroundWater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer System, Texas. <https://www.twdb.texas.gov/groundwater/models/gam/glfc_n/GLFC_N_Full_Report.pdf>. Accessed January 2018.

Appendix A

Exhibits



Legend

- Segment 1
- Segment 2
- Segment 3

N W E S

0 10,000 20,000 Feet

North Houston Highway Improvement Project

Vicinity Map

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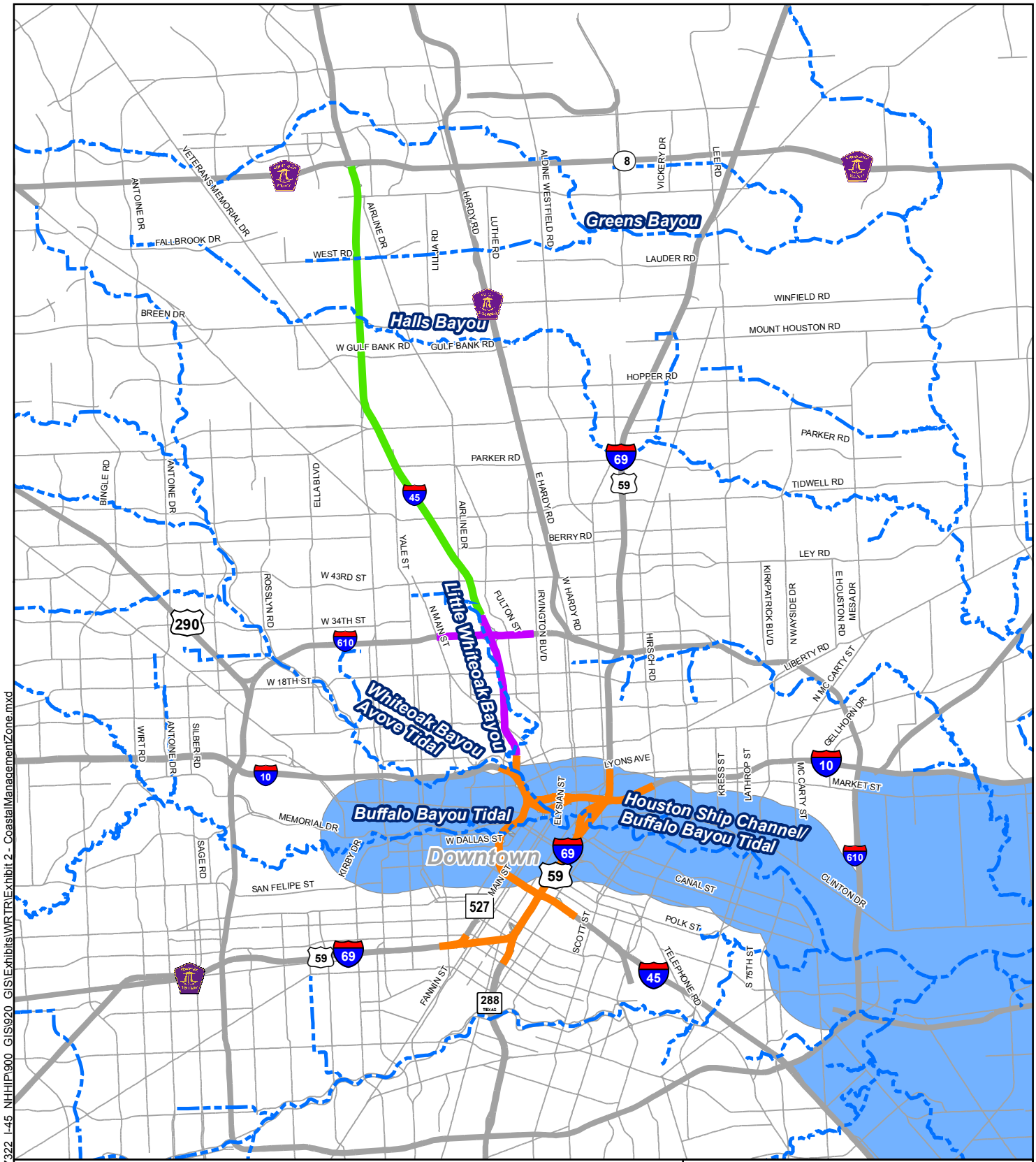
Date: January 2018

Exhibit: 1

Document Path: P:_TRANS\TxDOT\60517322_I-45_NHHIP\900_GIS\920_GIS\Exhibits\WRTR\NHHIP_Exhibit 1.mxd



Source: Texas General Land Office
Coastal Zone Boundary (2015)

N
W E
S

0 13,000 Feet

Legend

- Segment 1
- Segment 2
- Segment 3
- Coastal Zone Area
- TCEQ Impaired Stream Segment

North Houston Highway Improvement Project

Coastal Zone Management Area and TCEQ Impaired Stream Segments

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Exhibit 2

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