APPENDIX D
CIVIL AND STRUCTURAL DESIGN

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APPENDIX D
Civil and Structural Design

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1.0 GENERAL INFORMATION AND EXISTING CONDITIONS

1.1 General Information and Layout of Appendix

The purpose of this appendix is to provide feasibility level engineering information in support plan formulation for the Water Resources Development Act (WRDA) 2007 Section 5141 of the City's Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) as well as several local features in a "Comprehensive Analysis." The focus of this appendix is on existing and future-without project conditions, plan formulation and evaluation, the findings of the Comprehensive Analysis, and the final determination of the Modified Dallas Floodway Project (to implement under Section 5141 of WRDA 2007). Civil drawings are provided at the end of this appendix.

An evaluation was completed to determine whether the various projects in the BVP and IDP were technically sound. The first evaluation was conducted on the City of Dallas' BVP and IDP Plans with respect to the technical soundness of each feature and its compatibility with neighboring features within the Dallas Floodway, Section 2. This evaluation included a National Economic Development (NED) Analysis of various probable failure modes to determine a flood risk management (FRM) plan, then a study of the various BVP features, and finally a discussion on the proposed IDP features. Each feature is discussed in detail within the report and is followed by a determination of technical soundness. See Section 2.1 for the definition of technical soundness used within the context of this report.

Following an evaluation of the City's BVP and IDP, a Comprehensive Analysis was conducted to determine the compatibility of the BVP, IDP and local features within the Dallas Floodway Levee System, see Section 3. The currently known set of local features was determined based on information provided in design submittals to USACE. A key local feature evaluated was the Trinity Parkway. Two designs were developed for the BVP regarding the Trinity Parkway; one assuming the Trinity Parkway in the future condition, and one without the Trinity Parkway in the future condition. These two designs were the plans evaluated in the Environmental Impact Statement (EIS) completed for the BVP and IDP. The Trinity Parkway runs along the riverside toe of the East Levee and directly impacts a large portion of the BVP and IDP. Reviews pertaining to a Section 408 are included after discussions of each local feature in Section 3.0. It is important to note, the Comprehensive Analysis modeled features from a hydrologic and hydraulic perspective collectively and not on an individual basis. Civil and Structural design reviewed the projects from a technical perspective on an individual basis, and will continue to analyze at an individual level under the Corps Section 408 review process and future Planning Engineering and Design (PED) phase of the Recommended Plan for the MDFP.

During the evaluation of the City's BVP and IDP and the Comprehensive Analysis, a Recommended Plan for the Modified Dallas Floodway Project (MDFP) was determined based on two project objectives: FRM and environmental restoration. Recreation features of the BVP were found to be beyond the USACE mission for recreation; therefore, construction of recreation features was not included in the MDFP. A subset of the City's BVP and IDP was recommended for inclusion into the federal plan as authorized by WRDA 2007. The MDFP, and its features are described in Section 4. The features included in the MDFP satisfy the project objectives and will be cost-shared between the Federal Government and the local sponsor, the City of Dallas.

1.2 Existing Conditions

The existing Dallas Floodway Levee System, authorized in 1945, extends along the Trinity River upstream from the Atchison, Topeka, and Santa Fe (AT&SF) Railroad Bridge at Trinity River Mile (RM)

497.37, to the confluence of the West and Elm Forks at RM 505.50, thence upstream along the West Fork for approximately 2.2 miles and upstream along the Elm Fork approximately 4 miles. Of the 22.6 miles of levees within this reach, the East Levee is 11.7 miles in length and the West Levee is 10.9 miles in length. The existing Dallas Floodway Levee System includes the levees, river channel, 6 pumping plants, 18 sump storage ponds, 7 pressure storm sewers, and 3 gravity sluices. Several different surveys have been used in the preparation of this report. A topographic survey (with two foot interval contours) from 1991 covers the entire Floodway area. A one-foot contour interval topographic survey that was performed in 2003 covers the downstream portion of the levees and documents the levee modifications performed by the City of Dallas in the early 1990s. A bathymetric survey of the Trinity River channel was performed in 2004. A survey of the low beam elevations on many of the bridges that cross the Floodway was performed in 2003. Older surveys were based on a datum of NAVD 1929 and more recent surveys are based on a datum of NAVD 1988. However, elevation differences between these two datum are on the order of a few hundredths of a foot within the project area and are considered insignificant relative to the accuracy of the surveys themselves. Therefore, differences in datum are not considered to be a concern with regard to the accuracy of the results of this study. The most current survey of the Dallas Floodway was a LIDAR survey completed by HNTB in 2009. This information is available but not discussed in this report at this time. The purpose of maintaining the old survey information for continued evaluation is to create and maintain an established baseline across all disciplines. An updated survey with more detailed information on the interior of the Dallas Floodway System will be created and utilized before future stages of design.

Construction of the existing Dallas Floodway Levee System was completed in 1959. The distance between the levees varies between approximately 2,000 feet to 2,600 feet. The levees are approximately 30 feet high with slopes that vary. The levee system will be discussed providing information for the current existing condition, the 1950s design and as-built condition of the levees. The stationing discussed in the narrative and shown on figures or maps translate forward from the initial 1950s design of both levees. See Figures D-1 through D-8 for aerial photography maps with levee and river stationing displayed.

1.2.1 Original Condition - 1950s Design

1.2.1.1 Slopes

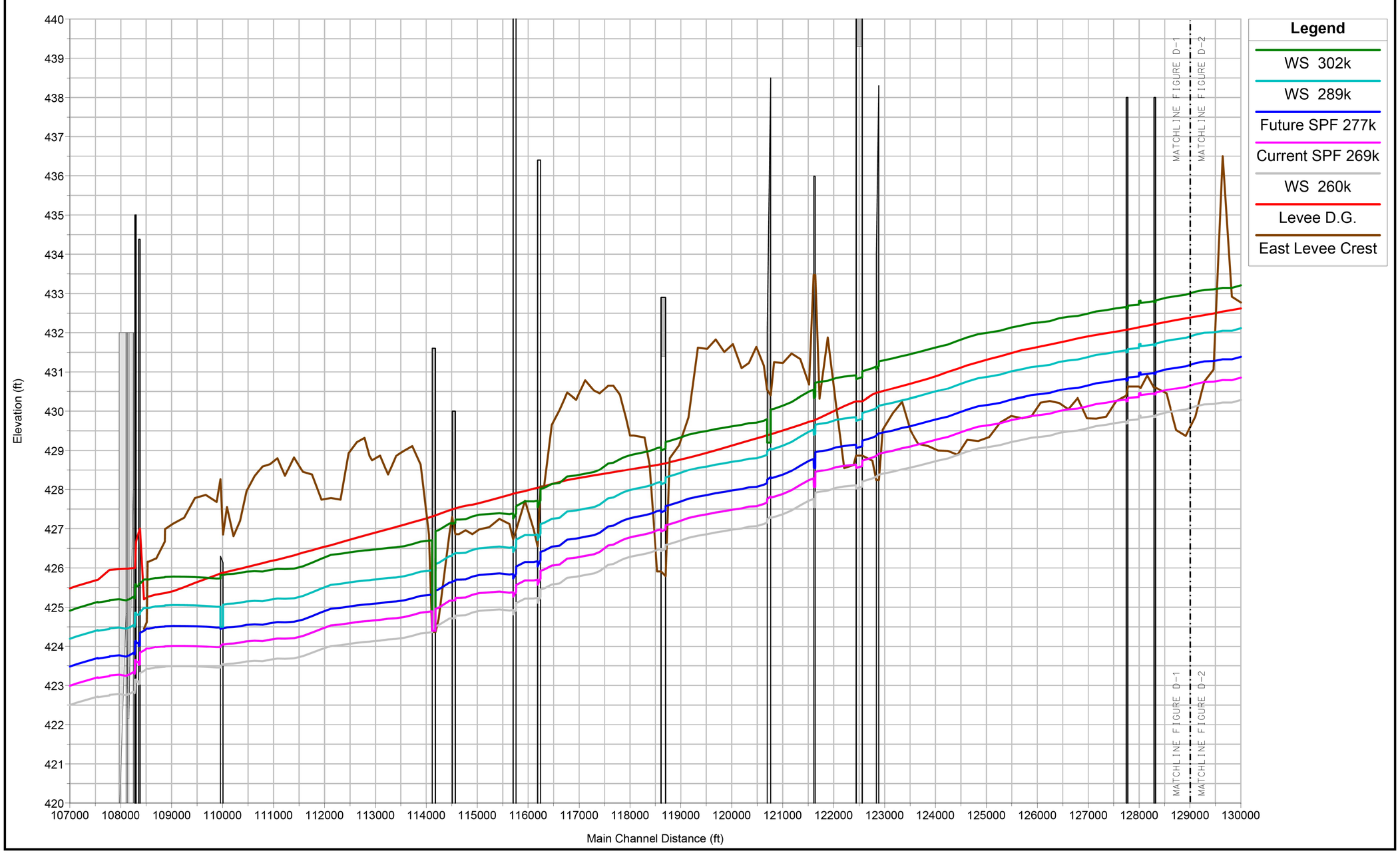
According to the as-built plans, the original construction of the East Levee consisted of a 3:1 (horizontal: vertical) slope for the river side of the levees. The protected or land side of the levees were constructed of mainly of 3.5:1 slopes. The only exception found was that the slopes of the East Levee land side were varied slightly to 3:1 at station 305+00 and also from station 387+00 to station 405+00. As-built plans for the West Levee show that the levee was constructed with a 3:1 slope on both the land side and the river side. There was only one location where the slope was slightly lessened to a 3.5:1 slope. This was shown on the landside of the West Levee near station 322+11.

1.2.1.2 Levee Height

The as-built (design grade) elevations for both the East and West Levees (including the Elm and West Fork Levees) are shown as compared to existing elevations and various flows' water surface elevations in Figures D-1 through D-6. These profiles were determined using HEC-RAS models. Their creation as well as the correlation between flow volume and water surface elevation is discussed further in the Hydraulics and Hydrology Appendix (Appendix A of this report) in Section 6. Sections 2.2.2 and 2.2.3 describe the further utilization of Figures D-1 through D-6.

Dallas Floodway ATSF Bridge Removed

Trinity River Main Stem



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DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-1
EAST LEVEE PROFILE 1

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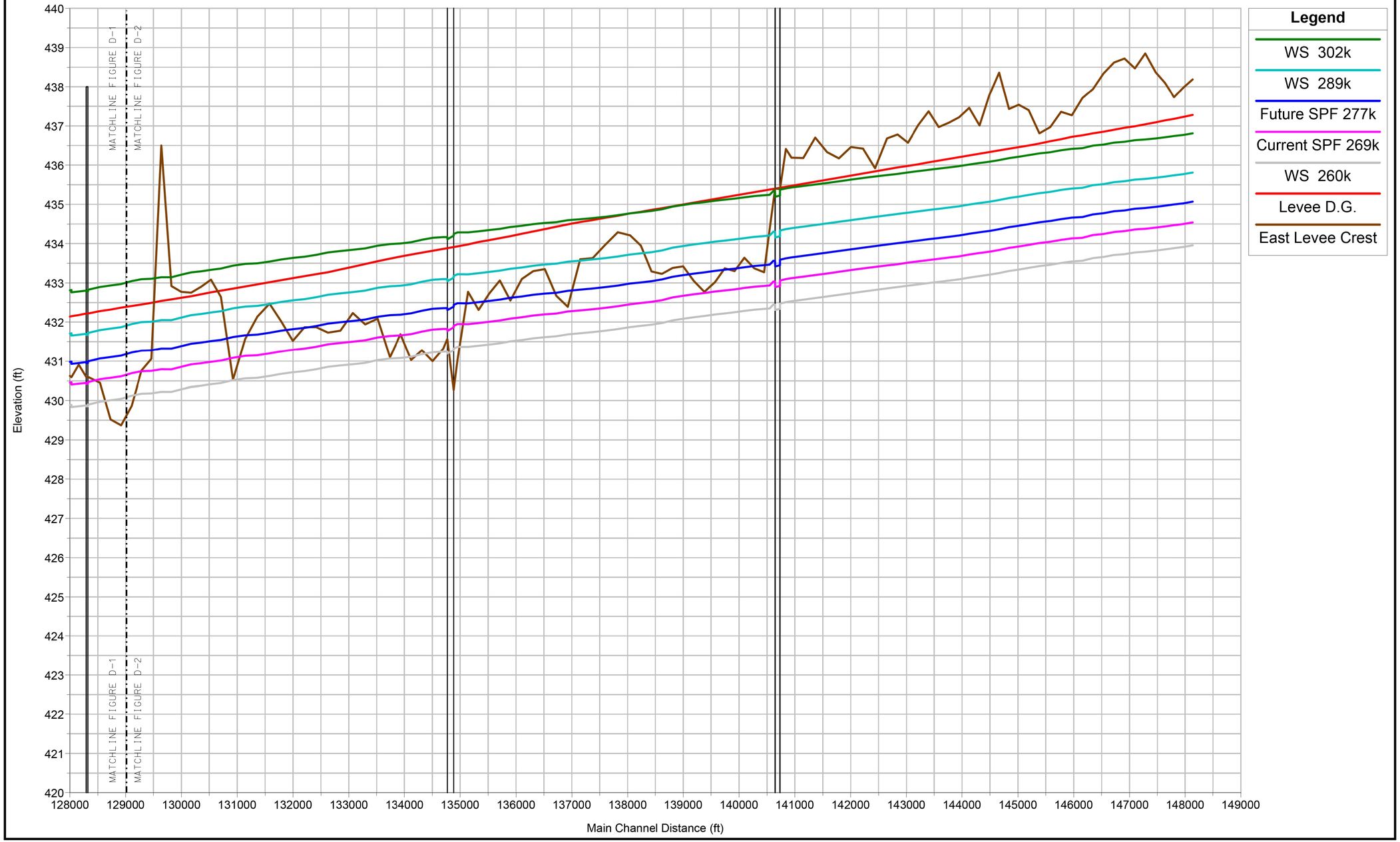
Trinity River Main Stem



Legend

- WS 302k
- WS 289k
- Future SPF 277k
- Current SPF 269k
- WS 260k
- Levee D.G.
- East Levee Crest

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DALLAS, TEXAS

FIGURE D-2
EAST LEVEE PROFILE II

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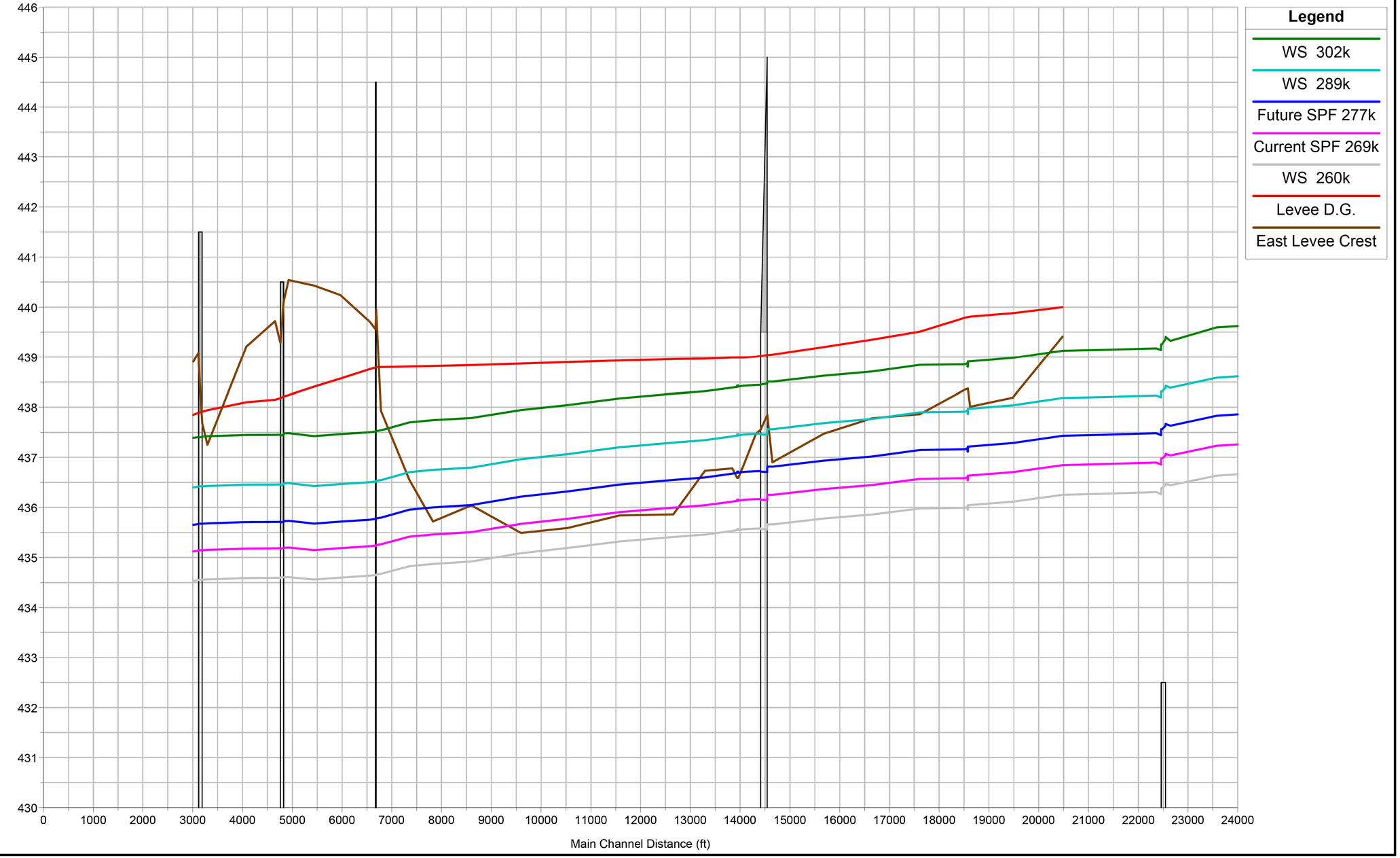
Elm Fork Trinity River



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DALLAS, TEXAS

FIGURE D-3
ELM FORK LEVEE PROFILE

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Dallas Floodway ATSF Bridge Removed

Trinity River Main Stem

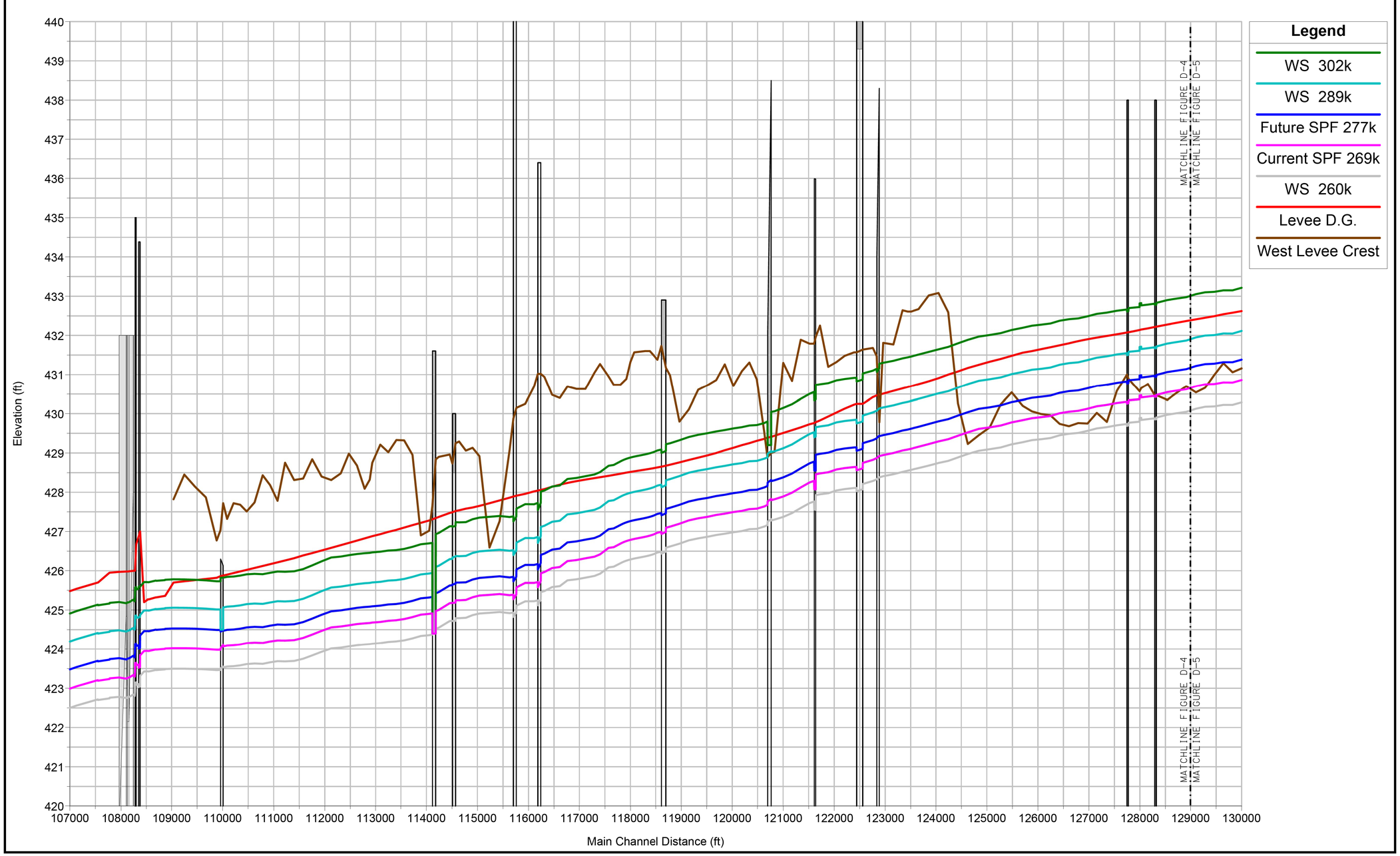

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FIGURE D-4
WEST LEVEE PROFILE I

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Dallas Floodway ATSF Bridge Removed

Trinity River Main Stem

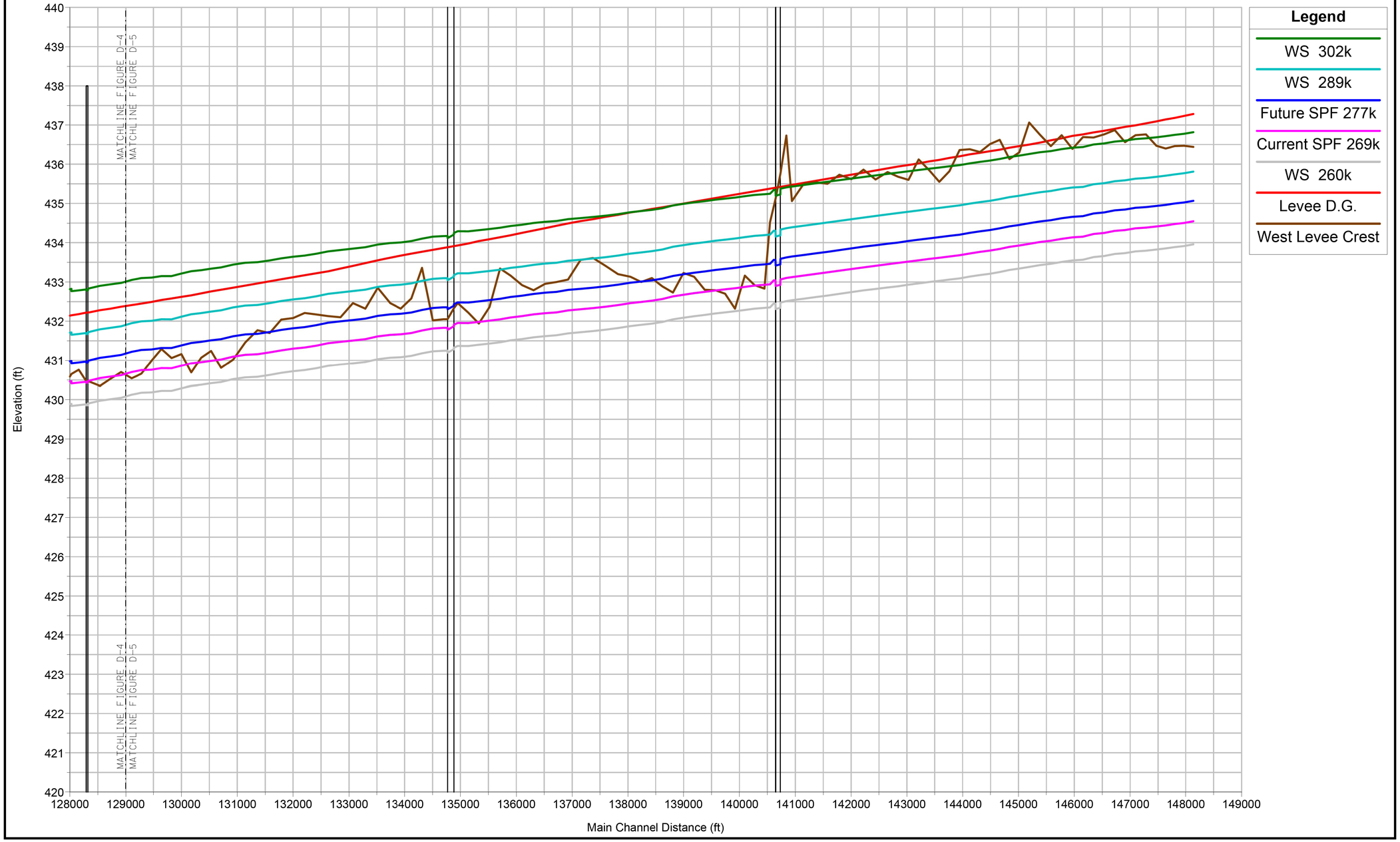

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FIGURE D-5
WEST LEVEE PROFILE II

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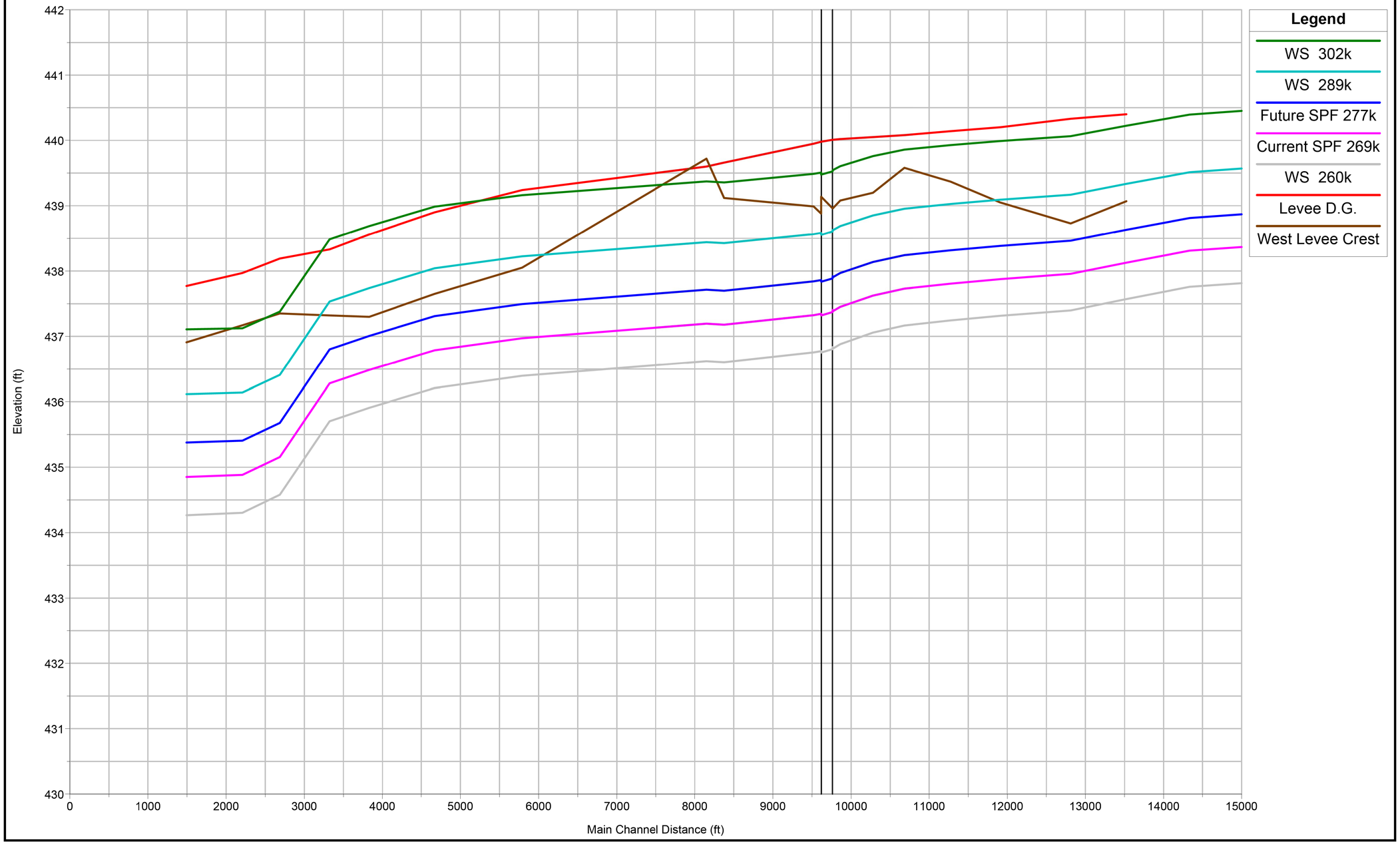
Dallas Floodway ATSF Bridge Removed

West Fork Trinity River



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Submitted by: DAVID G. BROWN, P.E. CHIEF, CIVIL SECTION

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DALLAS FLOODWAY LEVEE STUDY
DALLAS, TEXAS

FIGURE D-6
WEST FORK LEVEE PROFILE

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1.2.2 Current Existing Condition (based on 2003 survey data)

The top of the existing levees are approximately 16 feet wide and are topped with an access road made of crushed limestone. Interior drainage on the land side of the levees is accommodated by a system of sumps and pump stations. Within this study area, numerous highway and railroad bridges cross the Floodway. A 1,334 linear foot concrete floodwall completes the downstream end of the East Levee and is located just upstream of DART Railway Bridge. This floodwall provides a tie-back to high ground for the existing earthen levee. The floodwall originally had four stop-log structures, two of which have been removed and replaced with earthen fill.

1.2.2.1 Slopes

For both the East and West Levee located upstream of the Inwood Road/N. Hampton Road Bridge (station 292+00 for the East Levee and station 252+00 for the West Levee), the slopes vary slightly from 3:1 to 3.5:1. From the Inwood Road/N Hampton Road Bridge downstream to the Sylvan Road Bridge (station 225+00 for the East Levee and station 185+00 for the West Levee), the slopes are indicated to vary between 3:1 to 3.4:1. From the Sylvan Bridge downstream to the IH-30 Bridge (station 120+00 for the East Levee and station 105+00 for the West Levee), the slopes begin to lessen. Slopes start around 3.3:1 vertical and vary to nearly 4:1 as the levees approach IH-30. The slope of the East Levee slightly steepens to 3.7:1 beginning approximately 620-feet north of the IH-30 Bridge. Between the IH-30 Bridge and the Jefferson Boulevard (station 96+00 for the east levee and station 66+00 for the West Levee) bridge, the East Levee begins with a slope of 3:1. The slope gently tapers to a 4:1 but then steepens again to nearly 3:1 as it approaches the Houston and Jefferson bridges. These two bridges are located near station 100+00 of the East Levee and station 68+77 for the West Levee. The West Levee starts out at a steeper 2.8:l, flattens out to a 4:1 slope, and then steepens again to 3.5:1 as it approaches the Jefferson Blvd Bridge. Continuing from the Jefferson Blvd Bridge, both levees have slopes that vary from 3.7:1 to 4:1. Throughout the Floodway, the surface data indicated that steeper slopes near 2.5:1 exist along the maintenance access roads traversing the levee slopes.

1.2.3 Roads & Bridges

Beginning at the downstream end of the Floodway and preceding upstream, the bridges shown in Figure D-7 cross the Floodway and/or Levees. The low beam and deck elevations are shown in comparison to the 277, 000 cfs flow both with and without the AT&SF Railroad Bridge removal in Table D-1. The partial removal of the AT&SF Railroad Bridge on the far downstream end of the Floodway is one of the FRM options being looked at to reduce the overall risk and water surface elevation of the Floodway. See Sections 2.2.1.2 and 2.3.2 for more information. Bridges highlighted in green are in stages of being replaced by other entities and the shown information is based on the existing bridge. The completion of the proposed project features is not necessarily predicated on the construction and completion of the new bridges. The gray row in the East Levee bridge descriptions designates the beginning of the Elm Fork Levee. The gray row in the West Levee bridge descriptions indicates the start of the West Fork Levee.

Table D-1. Bridge Low Beam and Deck Elevation Relative to 277K cfs Flow with and without AT&SF Railroad Bridge Removal

East Levee								
Bridge Name	*277K Water Surface Elev. (feet)*	*277K WSE (With AT&SF Bridge Removal) (feet)*	*Low Beam Elev. (feet)*	*Bridge Deck Elev. (feet)*	*Low Beam Freeboard (feet)*	*Low Beam Freeboard (With AT&SF Removal) (feet)*	*Bridge Deck Freeboard (feet)*	*Bridge Deck Freeboard (With AT&SF Removal) (feet)*
Dallas Area Rapid Transit (DART)	425.00	424.35	431.00		6.00	6.65		
Corinth	425.45	424.46	424.00	429.00	-1.45	-0.46	3.55	4.54
IH-35 (Northbound) (R.L. Thornton Freeway)	426.38	425.43	423.00	428.20	-3.38	-2.43	1.82	2.77
IH-35 (Southbound) (R.L. Thornton Freeway)	426.63	425.70	424.11	428.30	-2.52	-1.59	1.67	2.60
Jefferson	426.93	426.04	430.95	436.20	4.02	4.91	9.27	10.16
Houston	427.30	426.41	430.10	438.70	2.80	3.69	11.40	12.29
IH-30 Exit	428.27	427.47	426.54	431.50	-1.73	-0.93	3.23	4.03
IH-30 (Eastbound)	428.37	427.58	427.29	432.70	-1.08	-0.29	4.33	5.12
IH-30 (Westbound)	428.37	427.58	428.40	433.10	0.03	0.82	4.73	5.52
IH-30 Entrance	428.37	427.58	427.50	432.30	-0.87	-0.08	3.93	4.72
Commerce	429.03	428.28	428.54	432.20	-0.49	0.26	3.17	3.92
U.P. R.R.	429.60	428.96	428.61	436.00	-0.99	-0.35	6.40	7.04
Margaret Hunt Hill	429.87	429.25	436.27		6.40	7.02		
Continental	430.04	429.43	429.20	434.30	-0.84	-0.23	4.26	4.87
Sylvan (old)	431.51	431.00	427.52		-3.99	-3.48		
Hampton/Inwood	432.88	432.44	438.84	445.35	5.96	6.40	12.47	12.91
Westmoreland	433.98	433.59	435.71	442.00	1.73	2.12	8.02	8.41
Shady Grove/ E. Irving Blvd	435.98	435.67	436.94	441.00	0.96	1.27	5.02	5.33
SH-356	436.03	435.73	434.31	438.90	-1.72	-1.42	2.87	3.17
DART Trinity Rail Express (C.R.I.& PAC.) RR (old bridge)	436.09	435.78	440.68	444.50	4.59	4.90	8.41	8.72
DART Trinity Rail Express C.R.I.& PAC. RR (new bridge)	436.09	435.78	438.44		2.35	2.66		
SH-183	437.04	436.77	437.67	442.00	0.63	0.90	4.96	5.23

West Levee								
Bridge Name	*277K Water Surface Elev. (feet)*	*277K WSE (With AT&SF Bridge Removal) (feet)*	*Low Beam Elev. (feet)*	*Bridge Deck Elev. (feet)*	*Low Beam Freeboard (feet)*	*Low Beam Freeboard (With AT&SF Removal) (feet)*	*Bridge Deck Freeboard (feet)*	*Bridge Deck Freeboard (With AT&SF Removal) (feet)*
Corinth	425.45	424.46	424.37		-1.08	-0.09		
IH-35 (Northbound) (R.L. Thornton Freeway)	426.38	425.43	424.13		-2.25	-1.30		
IH-35 (Southbound) (R.L. Thornton Freeway)	426.63	425.70	425.01		-1.62	-0.69		
Jefferson	426.93	426.04	431.42	437.30	4.49	5.38	10.37	11.26
Zang Blvd	427.04	426.15	444.91	450.00	17.87	18.76	22.96	23.85
Houston	427.30	426.41	418.50	424.47	-8.80	-7.91	-2.83	-1.94
IH-30 (Eastbound)	428.37	427.58	428.89	433.20	0.52	1.31	4.83	5.62
IH-30 (Westbound)	428.37	427.58	428.89	433.00	0.52	1.31	4.63	5.42
Commerce	429.03	428.28	430.15	432.50	1.12	1.87	3.47	4.22
U.P. R.R.	429.60	428.96	430.22	435.50	0.62	1.26	5.90	6.54
Margaret Hunt Hill	429.87	429.25	434.22		4.35	4.97		
Continental	430.04	429.43	430.00	434.30	-0.04	0.57	4.26	4.87
Sylvan (old)	431.51	430.86	429.52		-1.99	-1.34		
Hampton/Inwood	432.88	432.44	439.23	445.21	6.35	6.79	12.33	12.77
Westmoreland	433.98	433.59	436.04	441.50	2.06	2.45	7.52	7.91
Loop 12	438.15	437.85	441.22	448.00	3.07	3.37	9.85	10.15
Singleton	438.74	438.46	440.00	444.10	1.26	1.54	5.36	5.64

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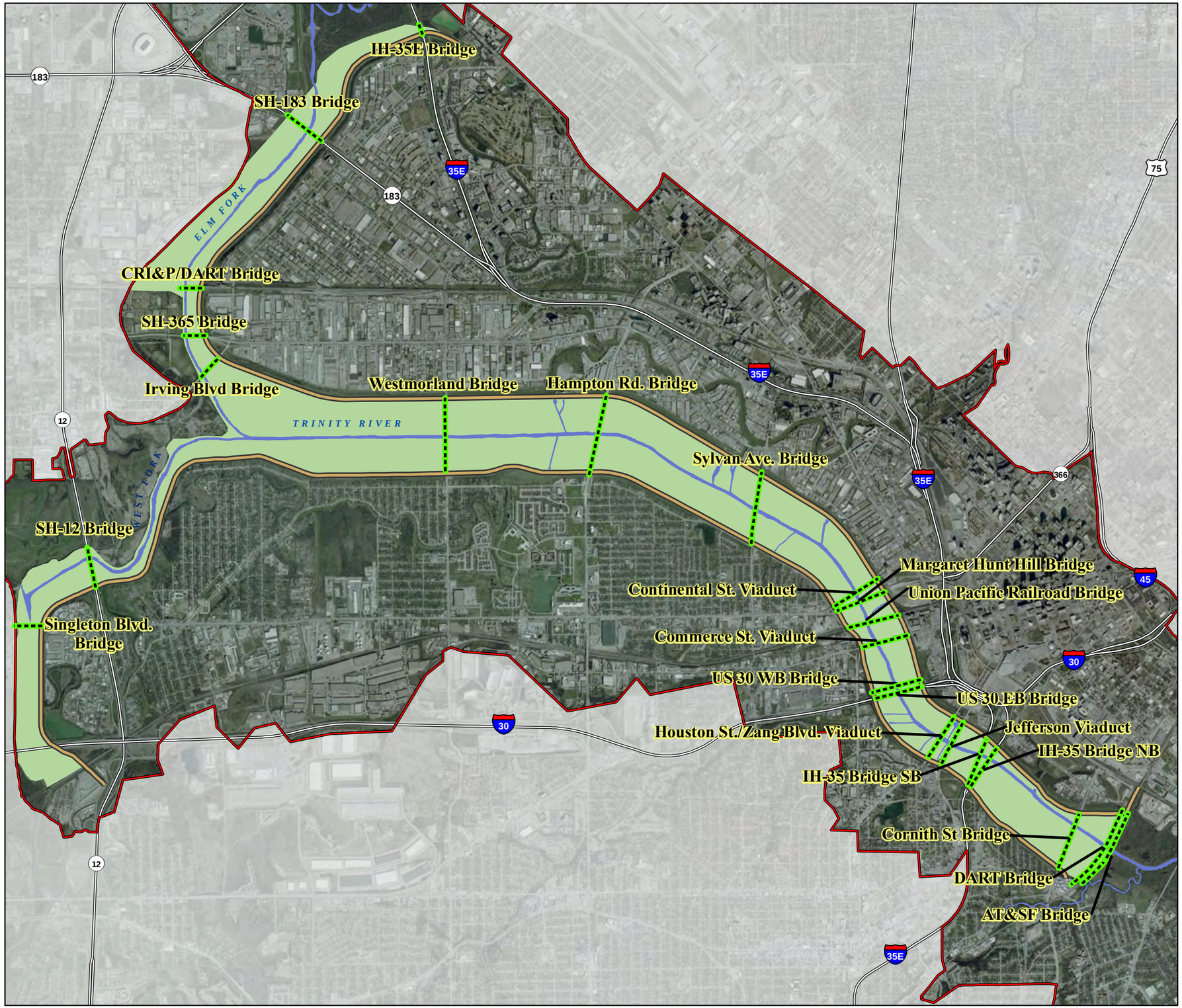
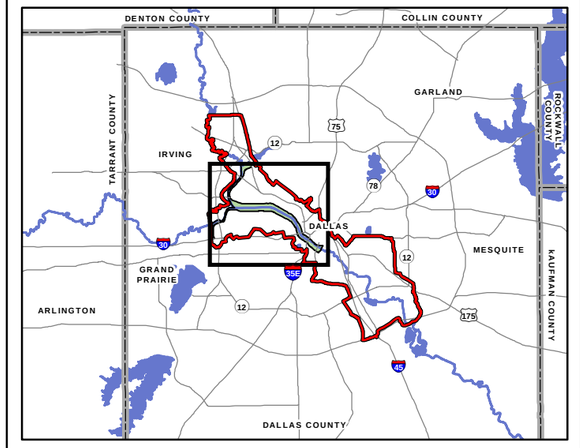
Figure D-7
Bridges Crossing the Dallas Floodway



LEGEND

- Bridges
- Pumping Plant
- Dallas Floodway Levee System Levee
- Freeway
- Study Area
- Dallas Floodway
- Surface Water



0 0.5 1 2 Kilometers

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Sources: City of Dallas 2008a, NCTCOG 2008

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1.2.3.1 Roads and Bridges Assumptions and Preliminary Design Criteria

Water surface elevations are based on the current HEC-RAS steady state model for the 277,000 cubic feet per second flow through the Floodway. The water surface elevations are shown with and without the FRM measure of removing the AT&SF Bridge (See Section 2.2.1.2 and Section 2.3.2). The AT&SF Bridge, as described in Sections 2.2.1.2 and 2.3.2, is one of the potential FRM solutions analyzed in this report. Low beam freeboard refers to the amount of distance between the low beam (the lowest chord elevation of the bridge) and the corresponding water surface elevation. Bridge deck freeboard refers to the difference in elevation between the water surface elevation and the elevation of the bridge deck used by vehicular traffic. A negative number (in red) indicates that the low beam or bridge deck is below the projected water surface elevation. A bridge element with a negative freeboard would be submerged and subject to additional stresses at the specified water surface elevation. At the downstream end of the Levee System, the East Levee turns and extends northeast, parallel to and beneath the DART Bridge for approximately 1,100 feet. The DART Bridge is on a grade which ascends toward the east, so most of the 1,100 feet of levee under the bridge has more clearance than implied by the elevation listed in the table. The IH-35 Roadway crossing of the Elm Fork Levee at the far upstream end of the levee is not displayed in the above table. The roadway is supported by an earthen berm that extends out from the levee towards the river. There is clearance between the water surface elevation at this location and the top of the earthen embankment. Similar circumstances to this occur at the far upstream end of the West Fork Levee with regards to the IH-30 Roadway. The rows highlighted in green are roadways and bridges that are scheduled to be rebuilt at a higher elevation and are not considered issues in further discussion of bridge crossings.

1.2.4 Existing Sumps and Pump Houses

The existing East and West Levees prevent the local storm water runoff from draining directly to the river. The storm water runoff collects in low lying areas on the land side of the levees until it can be pumped into the river, drain through pressure storm sewers, or drain through gravity sluices. A system of sumps areas, pressure storm sewers, and pump houses has been constructed to accommodate the interior drainage. The City of Dallas Trinity River Flood Control District operates and maintains the system, which requires a substantial staff of personnel.

The City utilizes a sophisticated Supervisory Control and Data Acquisition system (SCADA) to help operate and control the pumping plants. The following list summarizes the pump house facilities. Refer to Section 2.6 of this appendix for a more detailed description of the existing interior drainage system. The attached plan set depicts the proposed interior drainage facilities. The IDP proposals are described in Section 2.6.

Able Pump Station

This plant, located on the East Levee downstream of IH-30, contains two pump houses. The old pump house has two 10,000 gallons per minute (gpm) pumps with 85 horsepower (hp) motors each. This facility includes two 4’ x 4’ sluice structures with manually operated sluice gates and flap gates.

Baker Pump Station

This plant, located on the East Levee between Inwood Avenue and Sylvan Avenue, contains four 54,000 gpm pumps. The facility includes four 6’ diameter gravity sluice pipes with four 72 inch diameter hand operated sluice gates and flap gates.

Charlie Pump Station

This plant, located on the West Levee downstream of IH-30, contains two 30,000 gpm pumps with 125 hp motors each. This facility also includes two 4’ x 4’ gravity sluices with two manually operated sluice gates and flap gates.

Delta Pump Station

This plant, located on the West Levee upstream of Inwood Avenue, contains two 30,000 gpm pumps with 125 hp motors each. This facility also includes two 4’ x 4’ gravity sluices with two manually operated sluice gates and flap gates.

Pavaho Pump Station

This plant, located on the West Levee upstream of Continental Street, contains two 30,000 gpm pumps with 250 hp motors each. This facility also includes two 6’ x 8’ gravity sluices with two motor operated sluice gates and flap gates.

Hampton Pump Station

This plant, located on the East Levee upstream of Hampton Avenue, contains four 50,000 gpm pumps with 600 hp motors each. This facility also includes four 42” outside diameter discharge lines.

1.2.5 Existing Utilities

Numerous utilities intersect with the existing Dallas Floodway Levee System. Refer to Figures D-8 to D-22 for depictions of the existing utilities within and adjacent to the Dallas Floodway Levee System. The problems associated with these crossing configurations and the potential solutions are discussed in the following sections of the report. Utilities affected are divided up by the specific feature that requires the modification of the utility.

Utilities are discussed on a per project basis. Therefore, utilities affected by a certain feature are discussed in that section. The same utility may be discussed in multiple sections of the report based on how multiple projects affect the same utility. Cost for utility modification is assigned on a per project basis based on which project affects the utility. Different costs for the same utility may be attributed to multiple projects because of future project phasing.

One utility that is currently under construction in the Dallas Floodway Levee System is the East Bank-West Bank Interceptor. This interceptor is a sanitary sewer line that runs perpendicular to the levees and crosses the Dallas Floodway just downstream from the proposed IH-35E. This sanitary sewer line will become an existing condition prior to much of the construction in the Dallas Floodway. The sanitary sewer line includes a new 78” and 96” line ending at a 40’ diameter terminus near the West Levee. This terminus is referred to as a siphon is some documentation. See Geotechnical Appendix B for more information about this utility.

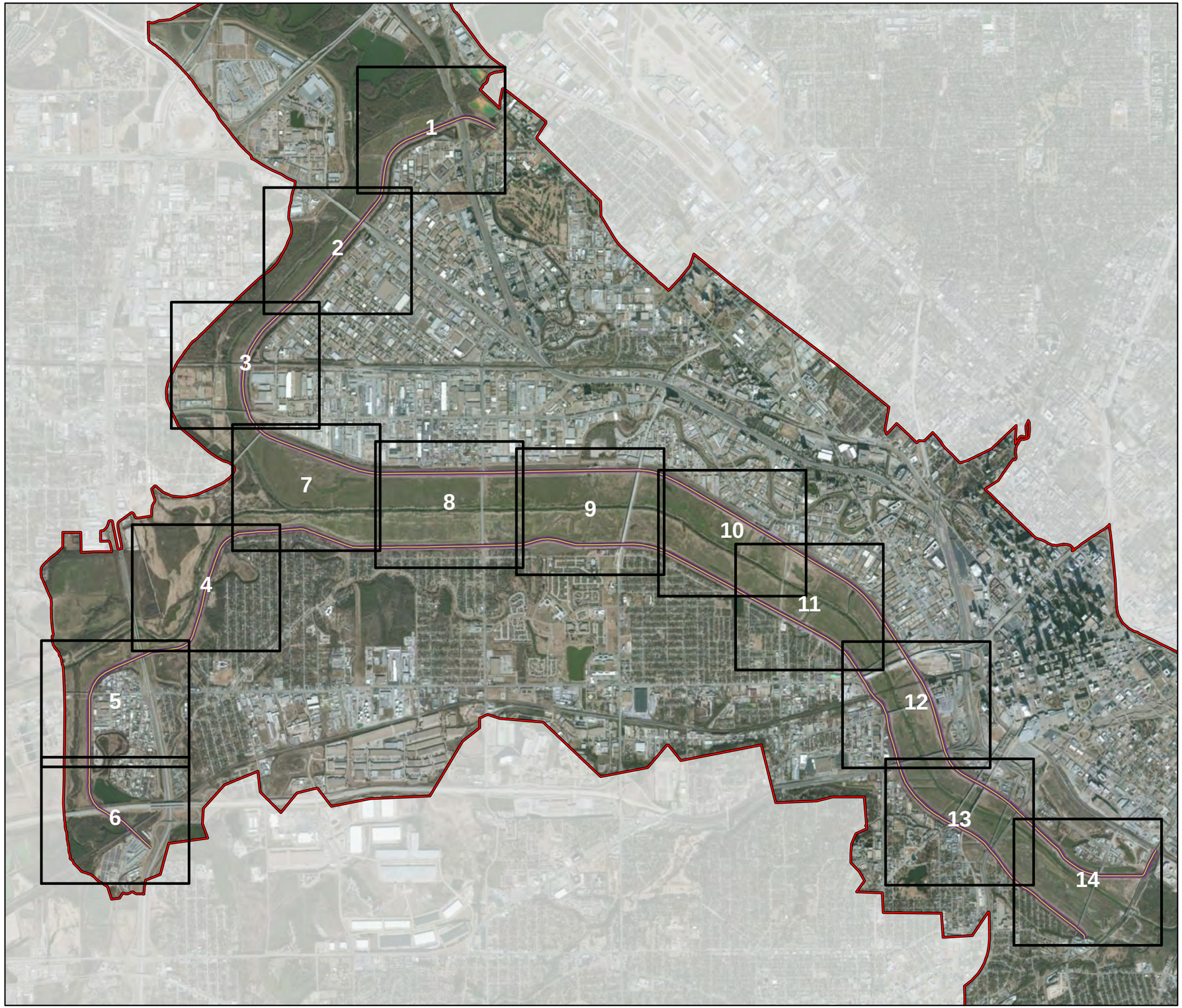
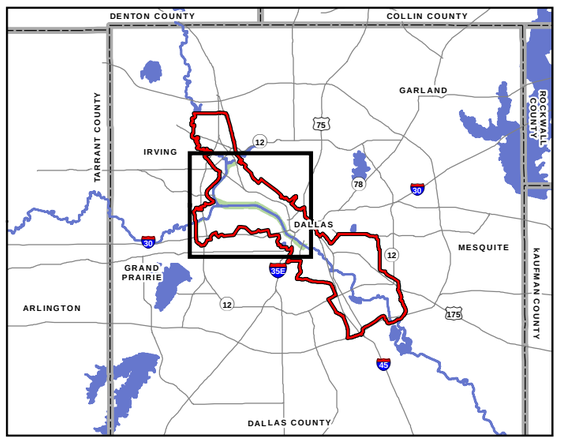


Figure D-8
Key for Detailed Figures Depicting Utilities Located within and Adjacent to the Dallas Floodway Levee System

LEGEND

- Dallas Floodway Levee System Levee Crest
- Dallas Floodway Levee System Levee
- Study Area
- Index

Note: Detailed figures are presented at the end of the utilities section



0 0.5 1
Kilometers
Miles
0 0.5 1

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Source: USACE 2011

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Figure D-9
Utilities Details: Map 1

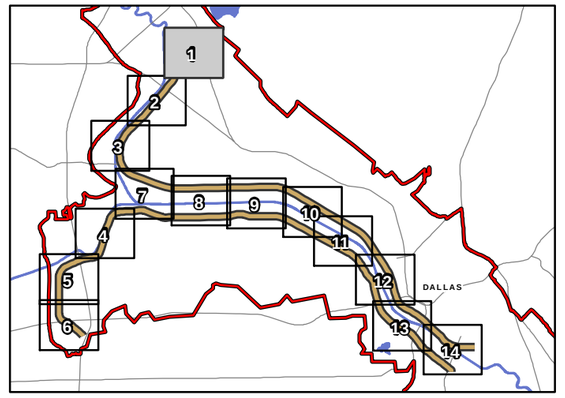
LEGEND

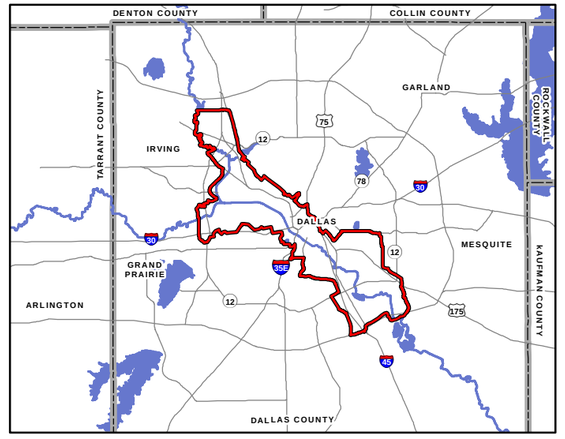
Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
HP	High Pressure
IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater





0 100 200
Meters

Feet
0 250 500

Source: USACE 2011

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Figure D-10
Utilities Details: Map 2

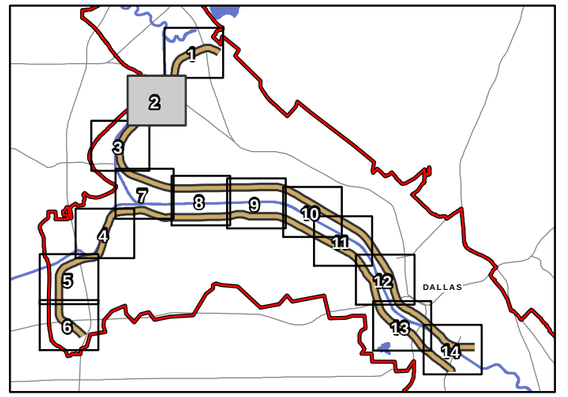
LEGEND

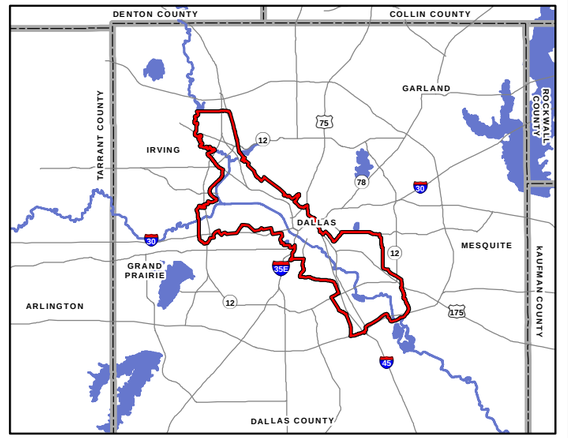
Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
HP	High Pressure
IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater





0 100 200 Meters

0 250 500 Feet

Source: USACE 2011

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Figure D-11
Utilities Details: Map 3

LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
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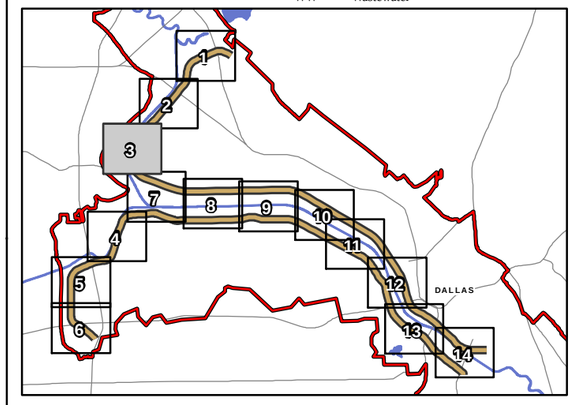
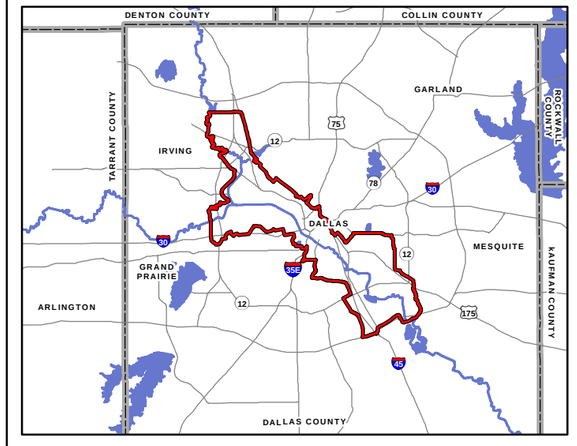
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater





0 100 200 Meters

0 250 500 Feet

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Source: USACE 2011

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Figure D-12
Utilities Details: Map 4

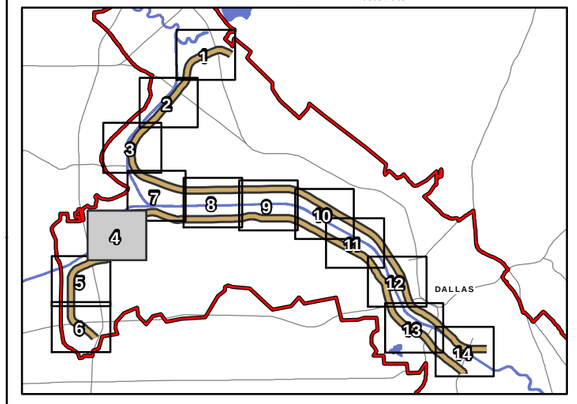
LEGEND

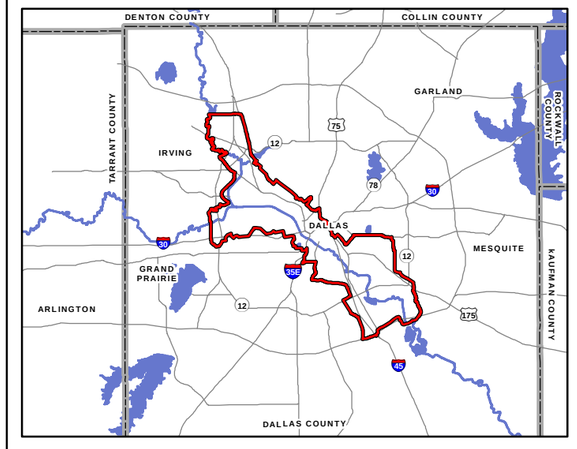
Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

CRI&P	Chicago, Rock Island and Pacific Railroad
Ex.	Existing
HP	High Pressure
IH	Interstate Highway
IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
SFB	Suspended From Bridge
UG	Underground
WW	Wastewater





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0 250 500 Feet

Source: USACE 2011

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Figure D-13
Utilities Details: Map 5

LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

Key

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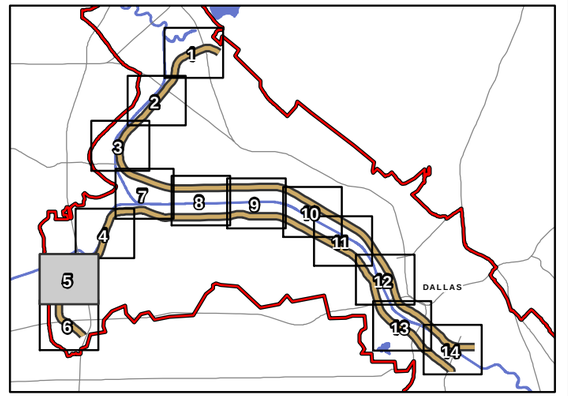
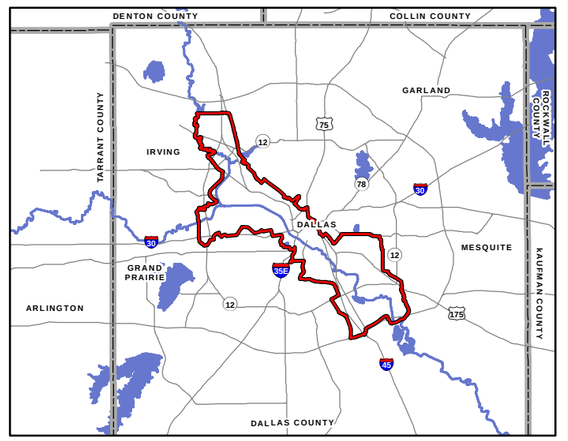
UG	Underground
WW	Wastewater





0 100 200
Meters

Feet
0 250 500

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Source: USACE 2011

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Figure D-14
Utilities Details: Map 6

LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

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IP	Intermediate Pressure
KV	Kilovolt
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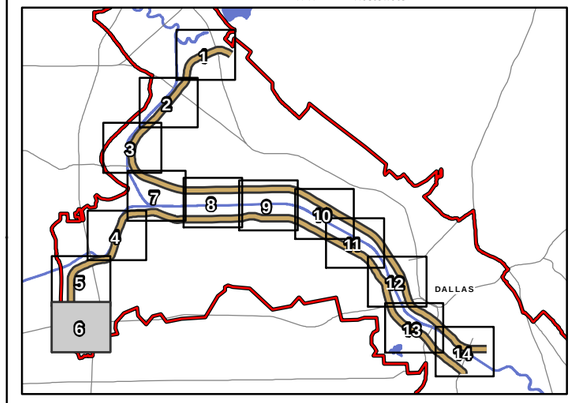

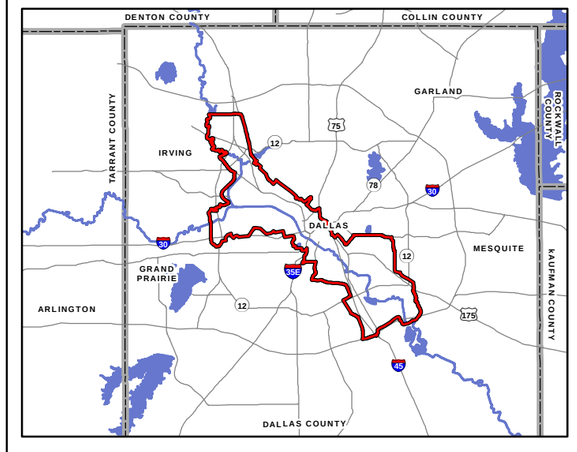

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Source: USACE 2011

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Figure D-15
Utilities Details: Map 7

LEGEND

Utility Lines
- Electrical
- Electrical Substation
- Communication
- Wastewater
- Sewer
- Natural Gas
- Petroluem
- Water
- Abandoned Oil and Gas

- Dallas Floodway Levee System Levee Crest
- Manhole
- Exterior Light
- Power Pole
- Transmission Tower

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IP	Intermediate Pressure
KV	Kilovolt
OH	Overhead
SH	State Highway
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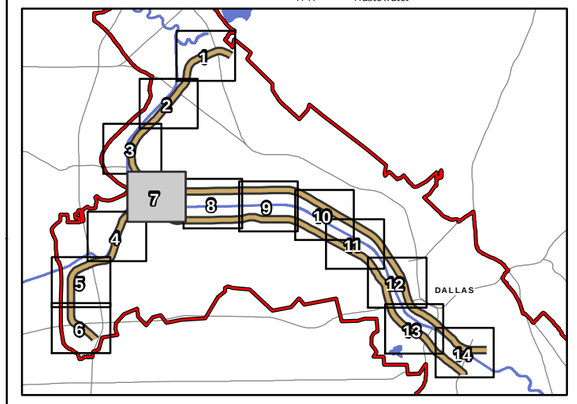
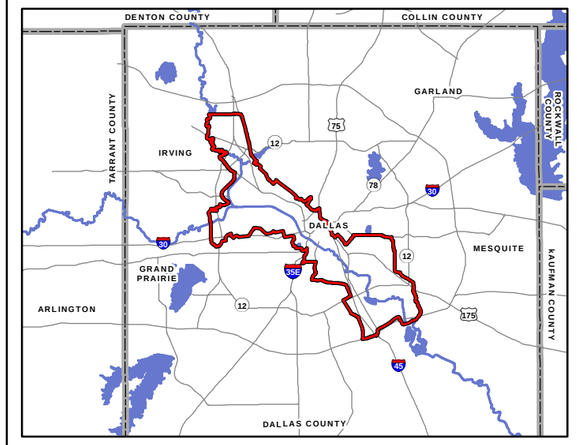
UG	Underground
WW	Wastewater





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Source: USACE 2011

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