CITY-WIDE DRAINAGE MASTER PLAN FOR FISH CREEK Y# 0881

City of Grand Prairie

July 2012

Project No. 11006.00

RPS Espey

RESOLUTION NO. 4571-2012

A RESOLUTION APPROVING THE CITY OF GRAND PRAIRIE'S CITY-WIDE DRAINAGE MASTER PLAN FOR FISH CREEK.

WHEREAS, the "City-Wide Drainage Master Plan for Fish Creek" (the Plan) is about providing comprehensive, updated technical data for the management of the Fish Creek watershed; and

WHEREAS, the Plan addresses existing flooding, erosion, and sedimentation problems within the watershed and provides planning alternatives and design concepts to help alleviate potential flood damages; and

WHEREAS, the Plan provides the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements to help minimize existing and potential flood damages within the Fish Creek watershed; and

WHEREAS, any revisions to the floodplain and the floodways identified in these studies shall also include ultimate development conditions and shall be for the whole creek as determined in these studies and not for portions of it to ensure that there are no downstream adverse effects; required submittals to FEMA shall be for the whole creek (as determined in these studies) and not for portions of it; and

WHEREAS, the recommendations of this report shall be incorporated for all future development as well as CIP budget considerations;

NOW THEREFORE, BE IT RESOLVED, BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS:

SECTION 1. THAT the City of Grand Prairie, Texas, having developed the "City-Wide Drainage Master Plan for Fish Creek" to cost-effectively manage flood or storm waters within budgeting constraints, approves and adopts the "City-Wide Drainage Master Plan for Fish Creek" thereby setting the standard for future drainage master plans, addressing existing flooding problems and providing planning recommendation, alternatives and design concepts for future development, to include CIP as well as possible developer participation projects.

PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF GRAND PRAIRIE, TEXAS, ON THIS THE 21ST DAY OF AUGUST, 2012.

APPROVED:

Charles England, Mayor

ATTEST:

City Secretary

APPROVED AS TO FORM:

City Attorney

Grand Prairie
T E X A S

CITY-WIDE DRAINAGE MASTER PLAN
FOR FISH CREEK
(Y #0881)

Prepared for:
Public Works Engineering Department
City of Grand Prairie
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Project No. 11006
July 2012

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EXECUTIVE SUMMARY

The fundamental objective of this Fish Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed historically for the Fish Creek watershed as well as to address existing flooding, erosion, and sedimentation within the basin. This updating incorporated current watershed conditions inclusive of channel conditions, additional structures, new improvements, etc., and additional data reflected in approved and pending Letters of Map Revision (LOMRs). Future watershed conditions are also projected, particularly the fully developed watershed conditions and planned transportation improvements now being implemented. This study included the collection of baseline information, review of environmental constraints, and the identification of flood/drainage problem areas. Hydrologic and hydraulic modeling was performed to refine the understanding of flood impacts from which alternatives were developed and analyzed to reduce these impacts. This report also provides a planning analysis and design concepts for the mitigation of these risks. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements and help minimize existing and potential flood damages within the Fish Creek watershed.

The Fish Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie to a point where it discharges into Mountain Creek Lake. The watershed is characterized by a mix of industrial, commercial, and residential use with the City of Arlington's area approaching build-out while the City of Grand Prairie's area is experiencing continuing fill-in growth. The Fish Creek Basin has a drainage area of 28.2 square miles and has two major tributaries: North Fish (Prairie) Creek and Kirby Creek, as well as twelve minor tributaries.

The Fish Creek watershed is located south of Warrior Trail and north of Joe Pool Lake. Drainage generally travels from west to east from an area in Arlington west of SH360, north and south of Interstate 20, traveling eastward under the interstate and SH360 to Mountain Creek Lake on the east side of the City of Grand Prairie.

This study recommends two flood mitigation projects and two stream stability projects. Only one of the flood mitigation projects involves flooding of residences or businesses the remaining flood mitigation project is designed to alleviate roadway flooding at a culvert. The stream stability projects are intended to minimize erosion that is developing as a result of urbanization of the watershed.

The project priorities are shown in the table below. Project receiving a ranking of 3 or less in Step 1 of the ranking process are considered short term priorities, while projects receiving ranking of 4 or higher are considered long term priorities. There are four projects with a ranking of 2, making them short term priority, and seven long term priority projects.

Project Priorities

City Wide Drainage Master Plan

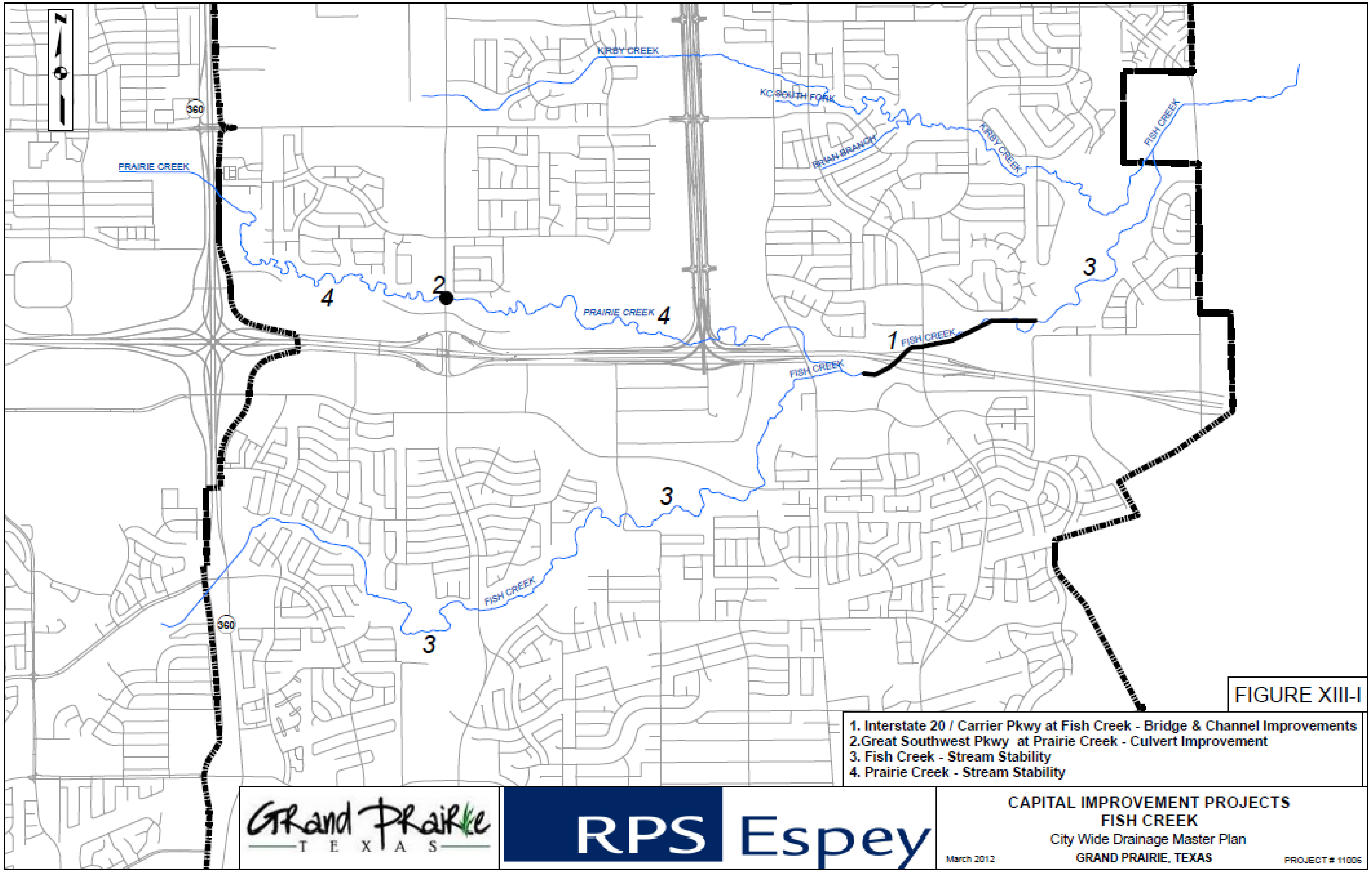
Fish Creek

	Capital Improvement Project Alternative	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property Structures [7]		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
			# Structures	Cost	1st Factor [1]	Type	Roadway Flood Event Protection	Roadway % Citizens Protected [3]	Roadway % Citizens Impacted [4]	Roadway # Citizens Impacted [5]	Cost to Benefit Roadway # Citizens Impacted [6]	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank [8]	Ultimate Q_{100}	Sorting [9]	Rank [10]
1	IH-20/Carrier at Fish Creek	Super-Size/Long-Term	10	$28,842,000	10	HWY	2	15%	85%	66200	$435.68	2	$2,000,000	1	13	1	26,347		1
2	GSW Pkwy at Prairie Creek	Medium/Long-Term	0	$570,000	4	P4D	10	50%	50%	3900	$146.15	1	$0	20	25	2	10,589		2
3	Fish Creek Stream Stability Projects	Small/Short-Term	0	$356,430	3	N/A	N/A	N/A	N/A	N/A	N/A	3	$0	20	26	3			3
4	North Fish (Prairie) Creek Stream Stability Projects	Medium/Long-Term	0	$727,910	4	N/A	N/A	N/A	N/A	N/A	N/A	3	$0	20	27	4			4

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
6 Cost of CIP divided by Roadway # Citizens Impacted
7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6

Additional Notes:
a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)
b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

Project Location Map



I. INTRODUCTION

A. Acknowledgements

Espey Consultants, Inc., dba RPS Espey, has completed the *Fish Creek City-Wide Drainage Master Plan* for establishing an understanding of this watershed, the potential impacts during flood events, and the viability of improvements to reduce these impacts. The resources required to address this effort included not just site specific information gathered during the study but additionally resource materials provided by the City of Grand Prairie Staff and from prior studies of the drainage basin that had material effects on the outcome of the plan. Additionally, the value of the final plan was significantly enhanced with the review of plan elements as they were developed by the City of Grand Prairie management. These added resources and the access to the individuals offering input have served to provide greater confidence in the reliability of the final *Fish Creek City-Wide Drainage Master Plan* findings. Thus, the staff of RPS Espey, associated with the project, appreciates the contributions from each of the resources and recognizes that there are many individuals who will go unnamed in recognizing the key contributors to the success of the project. However, RPS Espey gratefully acknowledges the key contributions made by the individuals listed below for their participative support with the *Fish Creek City-Wide Drainage Master Plan* project.

Romin Khavari, P.E., CFM, City Engineer
Gabe Johnson, P.E., CFM, Floodplain Administrator
Chris Agnew, P.E., Storm Drainage Engineer

B. Purpose of Study

This study is in compliance with the requirements set forth in the "City-Wide Drainage Master Plan Road Map." The fundamental objective of this Fish Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed historically for the Fish Creek watershed as well as to address existing flooding, erosion, and sedimentation within the basin. This updating incorporated current watershed conditions inclusive of channel conditions, additional structures, new improvements, etc., and additional data reflected in approved and pending Letters of Map Revision (LOMRs). Future watershed conditions are also projected, particularly the fully developed watershed conditions and planned transportation improvements now being implemented. This study included the collection of baseline information, review of environmental constraints, and the identification of flood/drainage problem areas. Hydrologic and hydraulic modeling was performed to refine the understanding of flood impacts from which alternatives were developed and analyzed to reduce these impacts. This report also provides a planning analysis and design concepts for the mitigation of these risks. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements and help minimize existing and potential flood damages within the Fish Creek watershed.

Specific objectives of the City-Wide Drainage Master Plan for Fish Creek for the
City of Grand Prairie, Texas, includes:

1. Collect and compile data from the Hydrologic Model developed as a part of the Flood Protection Plan (FPP) previously developed by RPS Espey (EC) for the City and incorporate this information into the Drainage Master Plan. This includes the HEC-HMS model which encompasses the existing conditions 2YR, 5YR, 10YR, 25YR, 50YR, 100YR, & 500YR storms and the ultimate condition 100YR event.

2. Collect and compile data from the Hydraulic Model developed as a part of the Flood Protection Plan (FPP) previously developed by EC for the City and incorporate this information into the Drainage Master Plan. This includes the HEC-RAS model which encompasses the existing conditions 2YR, 5YR, 10YR, 25YR, 50YR, 100YR, & 500YR storms and the ultimate condition 100YR event.

3. Develop concept plans and alternatives for reducing or eliminating flooding. The alternatives should take into consideration non-structural as well as structural mitigation.

4. Perform a detailed Geomorphologic study of the basin to assess stream bed and bank stability. Identify areas of excessive erosion and develop mitigation alternatives.

5. Utilize the City's existing database, aerial photographs and field reconnaissance to provide a description of dams, levees, and detention ponds in the Fish drainage basin.

6. Perform an assessment of drainage outfalls and prepare recommendations for maintenance utilizing the City's existing data.

7. Prepare cost estimates for proposed projects, evaluate and prioritize in accordance with the procedures set forth in the City-Wide Drainage Master Plan Roadmap.

C. City Ordinances and Development Requirements

As part of this City-Wide Drainage Master Plan study, the City Drainage Design Manual and existing development requirements were reviewed to determine their adequacy to prevent future flooding issues. The Fish Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie to a point where it discharges into Mountain Creek Lake. The watershed is characterized by a mix of industrial, commercial, and residential use. Within the City of Grand Prairie, the basin is experiencing fill-in growth. Proper drainage requirements and responsible development of the watershed will help prevent future flood damage and unnecessary capital improvement costs.

The City of Grand Prairie is especially progressive in their storm water management program. The City's Drainage Design Manual was updated as recently as October of 2010 and is intended to "…protect the general health, safety, and welfare of the public by reducing flooding potential, controlling excessive runoff, minimizing erosion and siltation problems, and eliminating damage to public facilities resulting from uncontrolled storm water runoff."

Articles 14 and 15 of the Unified Development Code, included in the City's Drainage Design Manual, contain the City ordinances for Drainage and Floodplain Management, respectively. Requirements include the elevation of new construction a minimum of one foot above the ultimate 100-year floodplain or two feet above the existing conditions floodplain, whichever is higher. Construction of detention basins is required when downstream facilities are not adequately sized to convey a design storm based on current City criteria for hydraulic capacity. Post project peak flows are not allowed to exceed the existing conditions peak flows unless sufficient downstream capacity above existing discharge conditions is available. When required, detention facilities are to be designed such that peak discharges or velocities are not increased when compared to pre-project conditions for the 2-, 10- and 100-year floods. The City ordinances allow for responsible development of the watershed such that flood risks to future structures can be minimized. The ordinances also allow for protection of existing structures so that future development will not increase the flooding hazard in areas that do not have the capacity to convey increased flood discharges. Upon review of the City's Drainage Design Manual and existing development requirements, it has been determined that the requirements in combination with the technical data provided in this report are adequate to properly manage the watershed going forward.

D. Watershed Description

The Fish Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie to a point where it discharges into Mountain Creek Lake. The Fish Creek Basin has a drainage area of 28.2 square miles and has two major tributaries: North Fish (Prairie) Creek and Kirby Creek, as well as twelve minor tributaries.

The Fish Creek watershed is located south of Warrior Trail and north of Joe Pool Lake. Drainage generally travels from west to east from an area in Arlington west of SH360, north and south of Interstate 20, traveling eastward under the interstate and SH360 to Mountain Creek Lake on the east side of the City of Grand Prairie.

1. Major Streams and Tributaries

A hydrologic and hydraulic analysis of the Fish Creek basin was performed as part of the FEMA FY10 Risk MAP Project in which the City of Grand Prairie was a cooperating Technical Partner. The hydrologic analysis of Fish Creek encompassed 28.2 square mile drainage basin, of which 13.5 square miles are located within the city limits of Grand Prairie. Fish Creek has two major tributaries: Prairie Creek and Kirby Creek, ten minor tributaries: Lively Branch, Brian Branch, South Kirby Creek, Vernoy Branch, Dechman Branch, Rodger’s Branch, Willis Branch, Martin Branch, Knox Branch, and Garden Branch.

Table I-1: Study Streams

Stream Name	Downstream Limit	Upstream Limit	Study Method	Hydrologic Model Used	Hydraulic Model Used	Length (mi)
Fish Creek	Confluence with Mountain Creek	Approximately 1600’ upstream of Matthew Road	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	7.89
Brian Branch	Confluence with Kirby Creek	Upstream end of concrete lined channel	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	0.48
Garden Branch	Confluence with Fish Creek	Just downstream of Camp Wisdom Road	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	1.39
Kirby Creek	Confluence with Fish Creek	Trader’s Village	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	4.4
North Fork of Fish Creek	Confluence with Fish Creek	Approximately 2200’ upstream of SH360	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	5.07
South Fork of Kirby Creek	Confluence with Kirby Creek	Robinson Road	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	0.26
Willis Branch	Confluence with Fish Creek	Approximately 260 feet downstream of Great Southwest Parkway	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	1.4
					Total Length	**20.9**

2. Unique Attributes of the Watershed

Fish Creek crosses all of the major north-south transportation routes within the City, which includes Beltline Road, Carrier Parkway, State Highway 161, Great Southwest Parkway, and State Highway 360. Fish Creek also crosses Interstate 20. There are a total of thirty-one bridges and/or culverts in Fish Creek and its studied tributaries.

E. Principal Flooding Problems

1. Drainage Complaint Database

The Drainage Complaint Database has four hundred twenty (420) entries for the Fish Creek Basin. This represents approximately eighteen percent (18%) of all the entries in the database. The complaints are categorized as follows: fifty-eight (58) erosion, fifty-six (56) property flooding, fourteen (14) street flooding and twenty (20) structure flooding.

2. Hot Spot Locations

a. Blacksmith Court (along south side of Beacon Branch)
b. Paladium Drive and Forest Trail (along north side of Prairie Creek)
c. Tiber River Lane (along north side of Prairie Creek)
d. Bent Tree Trail and Winter Crest Road
e. Darbytown Road
f. Lindsey Lane & Stephen Street
g. Newport Street (west of Carrier)
h. Meadows Drive & Summerfield Lane (west of Robinson Road)
i. Santa Anna (east of Corn Valley)
j. Along Corn Valley Road (north of Kirby Creek)
k. Glendale Street & Elm Drive (east of Corn Valley)
l. Pinoak Street & Crossland Boulevard (east of Robinson Road)
m. Ridgewood Street (south of Kirby Drive)
n. Green Hollow Drive
o. Silver Meadow Lane & Brevito Drive (west of Beltline Road)
p. Bluegrass Street (along Fish Creek, west of Beltline Road)
q. IH-20 along Fish Creek (between Robinson Road & Carrier Parkway)

F. Pertinent Study and Technical Data Related to Watershed Prior to Fish Creek Drainage Master Plan Preparation

1. Existing Data

a. <u>FEMA FY10 Risk MAP Project–Halff Associates, Espey Consultants Inc., AECOM, O'Brien Engineering Inc. (October 2011)</u>

The City of Grand Prairie as a Cooperating Technical Partner (CTP) with the Federal Emergency Management Agency (FEMA) prepared updated hydrologic models, hydraulic models and floodplain mapping for four major watersheds in the City, Cedar Creek, Cottonwood Creek, Fish Creek and Johnson Creek. The Risk Map Project also included Garden Branch and Willis Branch which are sub-watersheds of the Fish Creek Basin. Relevant information from that study has been included this report.

b. <u>Kirby Creek, Letter of Map Revision (LOMR), Halff Associates (January 2010)</u>

Halff Associates prepared a Hydrologic and Hydraulic model for Kirby Creek, South Fork of Kirby Creek and Brian Branch. This study incorporated the airport detention pond as well as the improvements to the Pardue and Smith properties located upstream of Robinson Road on Kirby Creek.

c. Cottonwood and Fish Creek Flood Protection Plan – Espey Consultants Inc.(January2011)
The Cottonwood and Fish Creeks Flood Protection Plan is an engineering analysis of the flooding risks facing both Cottonwood and Fish Creek Basins, as well as a planning analysis of mitigation of these flooding risks. This project was funded by the Texas Water Development Board (TWDB) and the City of Grand Prairie. This project developed comprehensive hydrologic and hydraulic models for both watersheds within and upstream of the City of Grand Prairie to be utilized in developing flood protection alternatives (both structural and non-structural) within the City of Grand Prairie.

d. Watershed Technical Report – Freese & Nichols (February 2005)
This report is part of the City of Grand Prairie Comprehensive Plan. Updated land use plans were incorporated into the existing and ultimate conditions hydrologic models and new discharges were input into “best available” hydraulic models to produce a new 100-YR ultimate floodplain. Many structures were overtopped and detention was recommended to reduce peak flows for the smaller frequencies, although this had a minor impact on the 100-yr frequency.

e. Garden Branch Watershed Study – Halff Associates (March 2003)
H&H study using existing land use and existing land use with proposed Lake Parks West Phase I Development upstream of Camp Wisdom Road.

f. Technical Support Data Notebook (TSDN) – Tarrant County, Texas Phase 1 – North Fork Fish Creek (Prairie Creek) – Halff Associates (Sept. 2005)

g. Hydraulic Study for Bardin Road Bridge at Fish Creek – Halff Associates (July 2002)

h. LOMR for Fish Creek at Bardin Road Bridge – Halff Associates

i. Kirby Creek Watershed & Erosion Master Plan – Halff Associates (January 2005)

j. Capital Improvement Study Along Kirby, Prairie, and Fish Creek (April 2006)
The purpose of this study was to identify flood prone areas and analyze potential relief measures along Kirby Creek, Prairie Creek, and Fish Creek. Detention and channel/structure improvements are recommended.

k. Erosion Master Plan Study for Willis Branch (November 2006)
The purpose of this study was to develop hydrologic and hydraulic models, identify channel stability and erosion problems, and recommend alternative channel improvements to help alleviate existing and potential future flood and erosion damages.

l. Hydrologic & Hydraulic Study for Fish Creek – NUDALLAS to HEC-HMS Conversion and HEC-2 to HEC-RAS Conversion – Halff Associates (March 2002)

m. Fish Creek, North Fork Fish Creek (Prairie), and Kirby Creek Drainage Master Plan – Halff Associates (May 1990)

II. THE HYDROLOGIC STUDIES

A. General

The Fish Creek Basin has a drainage area of 28.2 square miles. Fish Creek has two major tributaries: Prairie Creek and Kirby Creek, twelve minor tributaries: Lively Branch, Brian Branch, South Kirby Creek, Vernoy Branch, Dechman Branch, Rodger's Branch, Willis Branch, Martin Branch, Knox Branch, Garden Branch and two unnamed tributaries in Arlington. The hydrologic analysis included the evaluation of the existing conditions 50%, 20%, 10%, 4%, 2%, and 1% (2-, 5-, 10-, 25-, 50- and 100-year, respectively) annual chance storm events as well as the ultimate condition 1% annual chance storm event. Version 3.4 of the HEC-HMS computer program developed by the Hydrologic Engineering Center of the U. S. Army Corps of Engineers (USACE) was used in the hydrologic analysis to estimate peak flow rates and storm hydrographs for each reach.

B. Watersheds

The Fish Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie to a point where it discharges into Mountain Creek Lake. The watershed is characterized by a mix of industrial, commercial, and residential use. The Fish Creek Basin is experiencing continuing fill-in growth. **Figure II-1** is a detailed map of the watershed and its sub-basins.

C. Land Use

An existing conditions land use map (City of Grand Prairie GIS and City of Arlington GIS) was analyzed in conjunction with 2004 color-infrared imagery in GIS to estimate existing conditions impervious cover percentages. The hydrologic model utilized percent impervious cover values calculated for each watershed sub-basin. The Existing Land Use Map is included as **Figure II-2**.

The ultimate development conditions (fully-developed conditions) analysis included modifications to the impervious cover percentages to represent full development. For the purposes of this analysis, full development was assumed to be equivalent to the estimated level by the year 2030 for City of Grand Prairie, and 2025 for City of Arlington (as per their respective future land use studies). The Ultimate Land Use Map is included as **Figure II-3**.

D. Impervious Coverage

The hydrologic model for existing conditions utilized percent impervious cover values calculated for each watershed sub-basin based on the weighted land use in each area. The impervious covers for each land use type are shown on **Table II-1**.

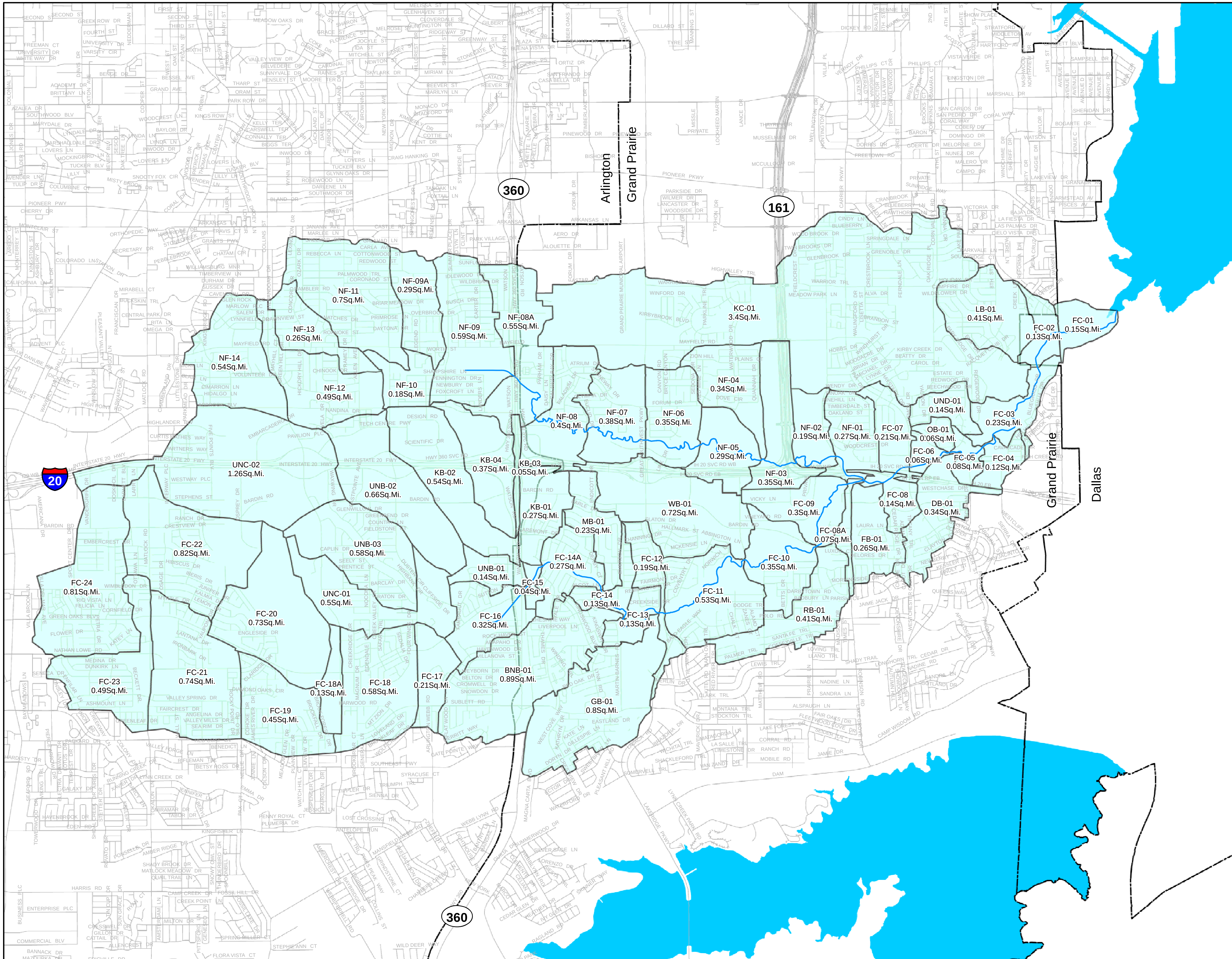


Figure II-1

Watersheds Fish Creek

KEY TO FEATURES

- Stream Centerline
- Drainage Areas
- City _Limits
- Streets
- Lakes

0 2,000 4,000 8,000

Scale in Feet

N S E W

RPS Espey

Grand Prairie TEXAS

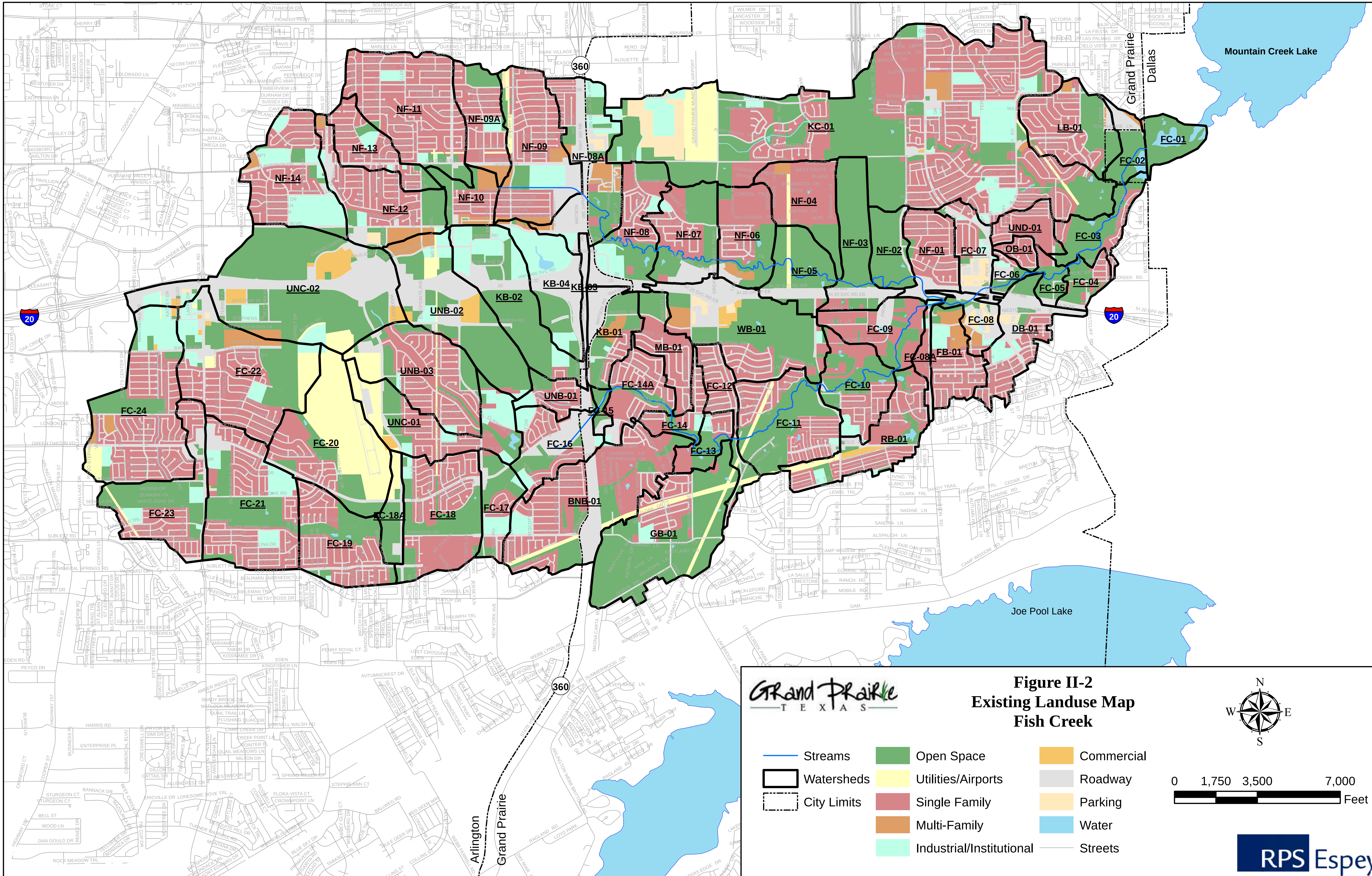


Figure II-2
Existing Landuse Map
Fish Creek

Table II-1: Impervious Cover

Description	Land Use Code	Percent Impervious Cover
Airports	144	35%
Expanded Parking	308	90%
Flood Control	181	6%
Hotel/Motel	124	95%
Industrial	131	90%
Institutional	123	40%
Mobile Homes	113	20%
Multi-family	112	70%
Office	121	95%
Parks	171	6%
Retail	122	95%
Roadway	142	35%
Runway	146	100%
Single Family	111	38%
Utilities	143	60%
Vacant	300	0%
Water	500	100%

The impervious cover for each sub-area is modified to reflect the projected land use based on the datasets provided by the City of Grand Prairie and the City of Arlington. Land use impervious cover percentages were taken from City of Grand Prairie Drainage Design Manual (December 2010). For land use types that are not mentioned in the manual, values are estimated based on previous studies and engineering judgment.

E. Soil Types

The study area is located in the Blackland Prairie physiographic subprovince of the Gulf Coastal Plain. The Blackland Prairie is underlain by Cretaceous age sandstone (Woodbine Formation), limestone (Austin Chalk Formation) and shale (Eagle Ford Formation). The surface soils consist of silty clay, clay, and clay loam soils mapped as the Altoga, Ferris, Frio, Lewisville, Navo and the Wilson by the Natural Resources Conservation Service (NRCS). The Altoga, Navo and Wilson soils are classified as clay (CL) soils. The Ferris soils are classified as fat clay (CH). The Frio and Lewisville soils are classified as CL to CH soils. The various soils found in the watershed and their respective hydraulic types are shown in **Table II-2**.

Table II-2: Watershed Soil Classification

SSURGO Database Classification	Hydrologic Soil Type
Altoga silty clay, 5 to 12 percent slopes, eroded	C
Axtell fine sandy loam, 1 to 3 percent slopes	D
Axtell fine sandy loam, 2 to 5 percent slopes, eroded	D
Branyon clay, 0 to 1 percent slopes	D
Burleson clay, 0 to 1 percent slopes	D
Burleson clay, 1 to 3 percent slopes	D
Crockett fine sandy loam, 0 to 1 percent slopes	D
Crockett fine sandy loam, 1 to 3 percent slopes	D
Crockett fine sandy loam, 2 to 5 percent slopes, eroded	D
Ferris-Heiden complex, 5 to 12 percent slopes	D
Frio silty clay, occasionally flooded	B
Heiden clay, 1 to 3 percent slopes	D
Heiden clay, 2 to 5 percent slopes, eroded	D
Houston Black clay, 1 to 3 percent slopes	D
Houston Black-Urban land complex, 0 to 4 percent slopes	D
Lewisville silty clay, 1 to 3 percent slopes	B
Lewisville silty clay, 3 to 5 percent slopes	B
Lewisville-Urban land complex, 0 to 4 percent slopes	B
Mabank fine sandy loam, 0 to 1 percent slopes	D
Normangee clay loam, 1 to 3 percent slopes	D
Ovan clay, frequently flooded	D
Silawa fine sandy loam, 1 to 3 percent slopes	B
Silawa fine sandy loam, 2 to 8 percent slopes, eroded	B
Silawa fine sandy loam, 3 to 8 percent slopes	B
Smithville loam	B
Sunev clay loam, 1 to 3 percent slopes	B
Sunev clay loam, 3 to 8 percent slopes	B
Trinity clay, frequently flooded	D
Trinity clay, occasionally flooded	D
Wilson clay loam, 0 to 1 percent slopes	D
Wilson clay loam, 1 to 3 percent slopes	D

F. Loss Rates

The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), has developed a rainfall-runoff index called the runoff curve number (CN) which takes into account such factors as soil characteristics, land use/land condition, and antecedent soil moisture to derive a generalized rainfall-runoff relationship for a given area. A description of these components and the equations for calculating runoff depth from rainfall are provided below.

The NRCS classifies soils into four hydrologic soil groups: A, B, C, and D which indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff potential (group D).

Digital soil data is available from the Texas Natural Resource Information System (TNRIS) post-processed from the US Department of Agriculture Soil Survey Geographic (SSURGO) database into the Texas statewide mapping system. **Figure II-4** shows the soils map for the study area.

The NRCS provides runoff curve numbers for three Antecedent Moisture Conditions (AMC): I, II and III. AMC I represents dry soil conditions, and AMC III represents saturated soil conditions. AMC II is normally considered to be the average soil condition; however, studies have indicated that the average condition ranges from AMC I in West Texas to between AMC II and III for east Texas. Runoff curve numbers vary from 0 to 100, with the smaller values representing soils with lower runoff potential and the larger values representing soils with higher runoff potential. This study assumes an AMC II to represent average conditions.

Curve numbers were evaluated independently of impervious cover (i.e., these curve numbers reflect fair condition open spaces) for this analysis. A composite CN is computed based on area weighting of each hydrologic soil group within each sub-area. Impervious cover values are entered separately from CN values into the HEC-HMS model. The assumed CN values are shown in **Table II-3**. A table describing the weighted CN values for each sub-area is included in **Section IV-A** of this report. HEC-HMS computes 100 percent runoff from impervious areas, while runoff from pervious areas is computed using the selected CN value and the following equations:

$$Q = (P - 0.2 \times S)^2 / (P + 0.8 \times S) \qquad \text{Equation 1}$$

And

$$CN = 1000 / (10 + S) \qquad \text{Equation 2}$$

Where:

- Q = depth of runoff (in),
- P = depth of precipitation (in),
- S = potential maximum retention after runoff begins (in), and
- CN = runoff curve number.

Table II-3: NRCS Curve Number Assumption

Group	AMC I	AMC II	AMC III
A	21	39	59
B	41	61	78
C	55	74	88
D	63	80	91

Key Assumption: Undeveloped grassland or range land.
Reference: National Engineering Handbook 4 (NEH-4)

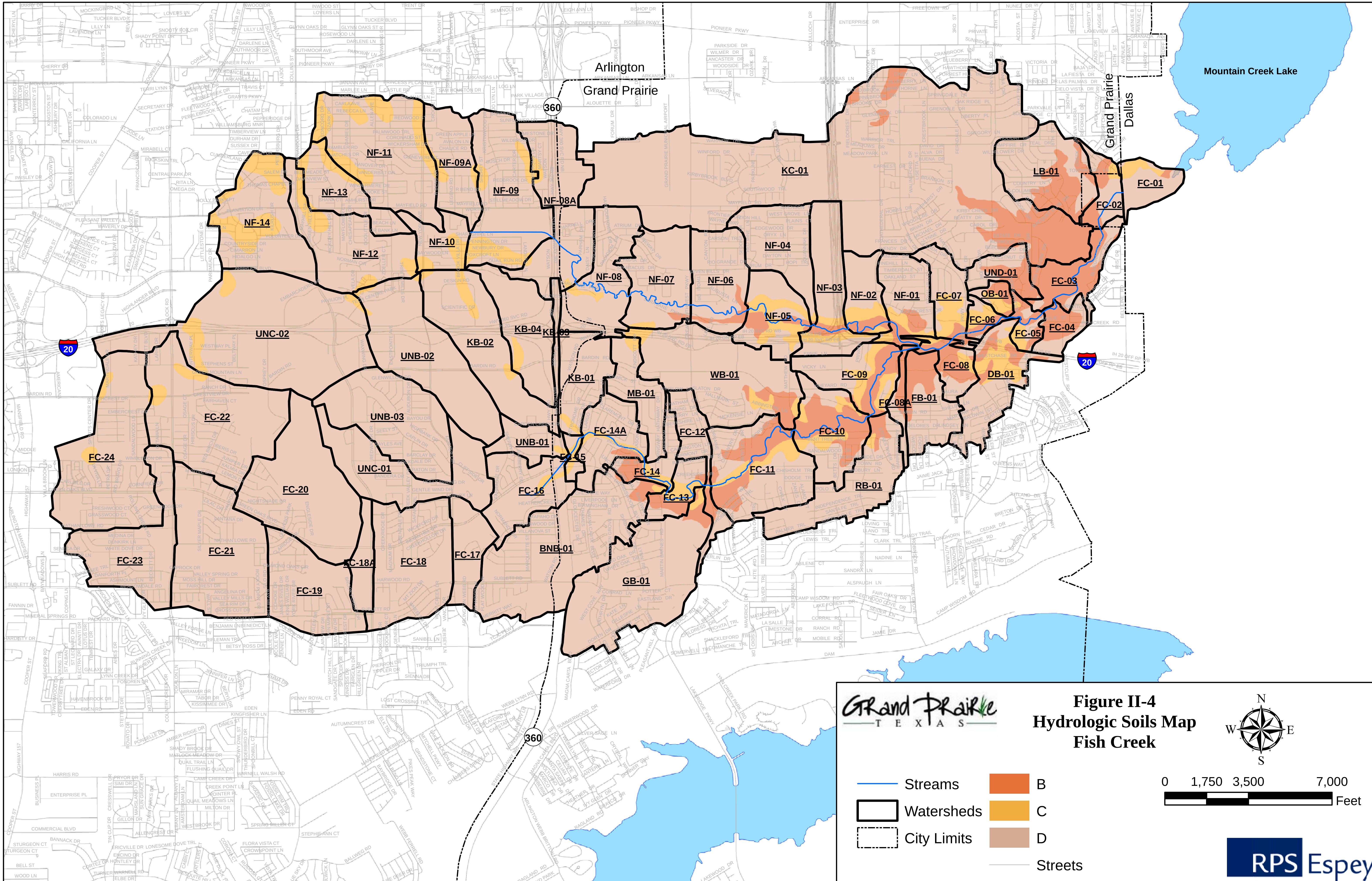


Figure II-4
Hydrologic Soils Map
Fish Creek
Grand Prairie TEXAS
Streams
Watersheds
City Limits
B
C
D
Streets
0 1,750 3,500 7,000
Feet
N
S
E
W
RPS Espey
Arlington
Grand Prairie
Dallas
Mountain Creek Lake
360
20
KC-01
LB-01
FC-01
FC-02
FC-03
FC-04
FC-05
FC-06
FC-07
FC-08
FC-08A
FC-09
FC-10
FC-11
FC-12
FC-13
FC-14
FC-14A
FC-15
FC-16
FC-17
FC-18
FC-18A
FC-19
FC-20
FC-21
FC-22
FC-23
FC-24
UND-01
OB-01
DB-01
FB-01
RB-01
NF-01
NF-02
NF-03
NF-04
NF-05
NF-06
NF-07
NF-08
NF-08A
NF-09
NF-09A
NF-10
NF-11
NF-12
NF-13
NF-14
KB-01
KB-02
KB-03
KB-04
MB-01
WB-01
UNB-01
UNB-02
UNB-03
UNC-01
UNC-02
BNB-01
GB-01

G. Synthetic Unit Hydrograph Methods

1. Background

A rainfall-runoff transformation is required to convert excess rainfall (total rainfall minus infiltration losses) into runoff from a particular sub-basin. The NRCS unit hydrograph option in HEC-HMS was used in this analysis to generate runoff hydrographs for each defined sub-basin within the studied watersheds. The unit hydrograph method represents a hydrograph for one unit (one inch) of direct runoff, which is standard engineering practice.

The dimensionless unit hydrograph developed by the NRCS (see **Figure II-5**) was developed by Victor Mockus and presented in *National Engineering Handbook, Section 4, Hydrology*. The dimensionless unit hydrograph has its ordinate values expressed in a dimensionless ratio, of discharge relative to peak discharge, q/qp, and its abscissa values as time relative to time to peak, t/Tp. This unit hydrograph has a point of inflection approximately 1.7 times the time to peak (Tp), and the time-to-peak 0.2 of the time-of-base (Tb).

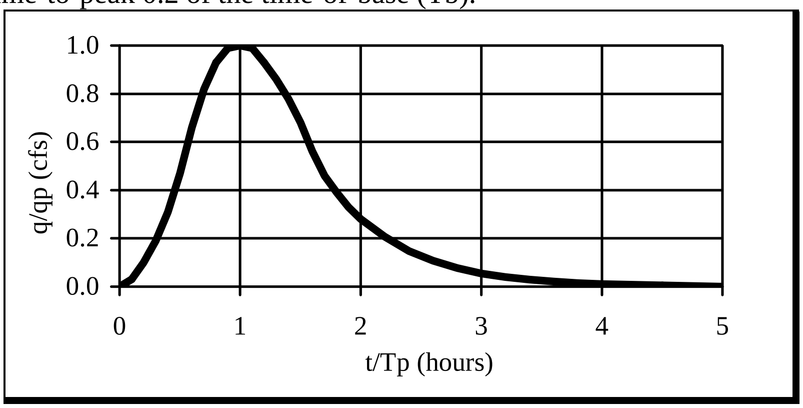


Figure II-5: NRCS Unit Graph

In HEC-HMS, input data for this method consists of a single input parameter, T_{LAG}, which is equal to the time (hours) between the center of mass of excess rainfall and the peak of the unit hydrograph (NRCS 1985). In other words, there is a delay in time after a rain event begins before the runoff reaches it maximum peak. This delay is known as lag. The lag is determined based on the time of concentration, as discussed in **Section II.G.2**.

The time to peak is computed using the following equation:

$$T_{PEAK} = \Delta t/2 + T_{LAG} \qquad \text{Equation 3}$$

Where:

T_{PEAK} = time to peak of the unit graph (hours),
Δt = computation interval or duration of unit excess (hours), and
T_{LAG} = watershed lag (hours).

The peak flow rate of the unit graph is computed using the following equation:

$$qp = 484A/T_{PEAK} \qquad \text{Equation 4}$$

Where:

qp = peak flow rate of the unit graph (cubic feet per second [cfs] / inch) and
A = watershed area (square miles).
484 = peak rate factor (dimensionless)

Note: The peak rate factor of 484 has been known to vary from 600 in steep terrain to 300 in very flat, swampy terrain. The 484 value is standard engineering practice and is used in this analysis.

2. Time of Concentration

The NRCS method assumes that the lag time of a watershed is 60 percent of the watershed's time of concentration. The time of concentration (Tc) is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed (NRCS, 1985). The time of concentration may be estimated by calculating and summing the travel time for each sub-reach defined by the flow type: sheet flow, shallow concentrated flow, and channelized flow (including roadways, storm sewers, and channels). The methods prescribed in NRCS Technical Release 55 (TR-55) are used to determine the times of concentration for each flow segment in this analysis. Adjustments are made to the time of concentration calculations in the ultimate conditions analysis to reflect faster watershed response times, typically in the uplands of the watershed if development is proposed in these areas. Time of concentration calculations can be found in **Appendix B**, utilizing each typical flow segment presented below.

a. Sheet Flow (≤ 100 feet)

Sheet flow is flow over plane surfaces. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact, of drag over the plane surface and obstacles such as litter, crop ridges, and rocks, and of erosion and transportation of sediment. These n values are for very shallow flow depths of approximately 0.1 feet. Sheet flow normally becomes shallow concentrated flow after no more than approximately 100 feet depending on surface conditions. The *City of Grand Prairie Drainage Design Manual* (December 2010) allows for a maximum sheet flow length of 50 feet in residential areas. The Tc calculations were performed using these guidelines, high resolution aerial photography and engineering judgment. Travel time was computed using the following equation.

$$Tt = (0.007 \times (n \times L)^{0.8}) / (P_2^{0.5} \times s^{0.4}) \qquad \text{Equation 5}$$

Where:

- Tt = travel time (hr),
- n = Manning's roughness coefficient,
- L = flow length (ft),
- P_2 = 2-year, 24-hour rainfall (in), and
- s = slope of hydraulic grade line (land slope, ft/ft).

b. Shallow Concentrated Flow

Sheet flow usually becomes shallow concentrated flow when the depth of flow exceeds 0.1 feet, or flows in a shallow swale or gutter. The average velocity for this flow can be determined from the following figure in which average velocity is a function of watercourse slope and type of channel (TR-55).

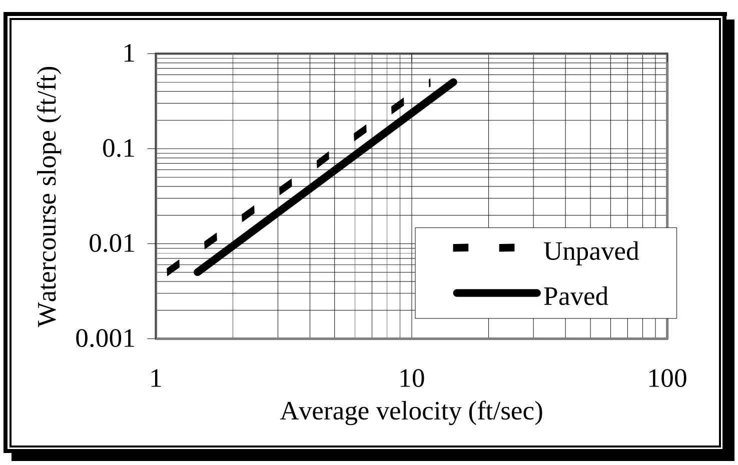


Figure II-6: Average Velocities for Estimating Travel Time in Shallow Concentrated Flow Segments

After determining the average velocity, the following equation is used to compute travel time:

$$Tt = L / (3600 \times V) \qquad \text{Equation 6}$$

Where:
Tt = travel time (hr),
L = flow length (ft),
V = average velocity (ft/sec), and
3,600 = conversion factor from seconds to hours.

c. Channelized Flow
As the depth of concentrated flow increases, the shallow concentrated flow evolves into channelized flow. Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle maps. In the case of this analysis, channel flow either involves flow in man-made storm sewer infrastructure or flow in the natural channel. Manning's equation or water surface profile information (available from HEC-2 or HEC-RAS) can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevations. Both open channel and closed conduit systems can be included.

Manning's equation is:

$$V = 1.49 \times r^{2/3} \times s^{0.5} / n \qquad \text{Equation 7}$$

Where:
V = average velocity (ft/sec),
R = hydraulic radius (ft), equal to flow area divided by wetted perimeter,
S = slope of the hydraulic grade line (channel slope, ft/ft), and
N = Manning's roughness coefficient.

H. Rainfall

The application of a design storm in the HEC-HMS model is used to generate runoff hydrographs and estimate peak flow rates along the watercourse for various storm frequencies. There are three major components to the design storm: depth, duration, and distribution. The precipitation values used in the hydrologic analysis were taken from the *City of Grand Prairie Drainage Design Manual* (December 2010) and are shown in **Table II-4**.

Table II-4: City of Grand Prairie Depth – Duration Rainfall Data

Return Period (years)	Point Rainfall Depths (inches)							
	5-min	15-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
1	0.39	0.76	1.49	1.81	1.99	2.41	2.80	3.21
2	0.49	1.04	1.85	2.22	2.45	2.91	3.45	3.95
5	0.57	1.33	2.45	3.00	3.30	3.90	4.70	5.40
10	0.63	1.36	2.86	3.55	3.85	4.65	5.50	6.40
25	0.73	1.56	3.35	4.15	4.55	5.45	6.50	7.50
50	0.80	1.71	3.82	4.65	5.15	6.20	7.35	8.52
100	0.87	1.87	4.25	5.20	5.70	6.92	8.40	9.55
500	1.00	2.20	5.40	6.60	7.40	8.80	10.50	12.00

Design storm duration is a significant consideration for hydrologic modeling. A check must be performed to ensure that the peak flow of any given event has reached the mouth of the studied basin prior to the end of the rainfall duration. The time of concentration for all watersheds was less than 24 hours; therefore, a 24-hour duration was selected.

A balanced and nested distribution is assumed for this analysis due to its flexibility with regard to storm duration. The distribution is balanced in that the precipitation is centered at half the storm duration. The distribution is nested in that the precipitation depths from the *City of Grand Prairie Drainage Design Manual* (December 2010) are applied in an alternating block format (i.e., the 15-minute depth is applied as the hyetograph peak, the 30-minute depth is applied such that the peak 15-minute block and the adjacent 15-minute block sum to be the 30-minute depth).

I. Flood Routing

Stream routing reaches were modeled using modified Puls data derived from HEC-RAS models developed as part of this study. Modified Puls routing is also called storage routing or level pool routing. It uses conservation of mass and a relationship between storage and discharge to route flow through the stream. The flow through a reach was attenuated by the storage and delayed release of water in the reach. In some of the upper drainage areas, Modified Puls routing data was not available. Muskingum-Cunge routing was used for these locations.

J. Detention and Diversions

The City of Grand Prairie's GIS database indicated twenty-nine (29) possible detention ponds within the Fish Creek Basin. All of these locations were visited to verify the existence and condition of the ponds. There are forty-three (43) ponds designed to provide detention, five (5) small on-channel lakes and ten (10) off-channel lakes. The on-channel lakes were included in the hydrology model as Modified Puls routing data.

There were no diversions identified in the Fish Creek Basin.

III. HYDRAULIC STUDIES

A. Hydraulic Analyses

A hydraulic analysis of the Fish Creek Basin was performed as part of the FEMA FY10 Risk MAP Project. The Fish Creek hydraulic analysis begins at Mountain Creek Lake and extends to the City of Grand Prairie's boundary with Arlington. This project produced three hydraulic models within the Fish Creek Basin, "Fish Creek" which includes North Fish (Prairie) Creek, "Garden Branch" and "Willis Branch." The effective model for Kirby Creek is the 2010 LOMR prepared by Halff Associates.

1. Fish Creek, FEMA FY10 Risk MAP Project, Espey Consultants, Inc., (October 2011)

Espey Consultants, Inc. prepared a Flood Protection Plan (FPP) for the Cottonwood and Fish Creek Watersheds; as a part of this planning effort, the "Fish Creek" HEC-RAS model was created. The FPP model is a hydraulic analyses which computed the water surface elevations for the 50%, 20%, 10%, 4%, 2%, 1% and 0.2% annual chance (2-, 5-, 10-, 25-, 50-, 100- and 500-year, respectively) existing condition storm events and the ultimate conditions 1% annual chance event. The FEMA FY10 Risk MAP Project modified the FPP model and prepared the necessary supporting documentation required for submission to FEMA.

The hydraulic model for the Fish Creek Basin contains two named creeks, Fish Creek and North Fish Creek, which is also known as Prairie Creek. Fish Creek is divided into two reaches, and North Fish Creek is just one reach. The flows for the various storms and the corresponding cross-section where these flows were applied to the Fish Creek HEC-RAS model are shown in **Section IV-A**.

a. Methodology

The hydraulic model used for this flood study is the U. S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System, version 4.1.1 (HEC-RAS). HEC-GeoRAS was used as a preprocessor to HEC-RAS. HEC-GeoRAS utilizes geographically referenced data sets as well as a three-dimensional terrain model to create the input data files for HEC-RAS.

b. Cross Sections

The floodplain cross sections were placed at representative locations, approximately 500 feet apart along the stream centerline. Model cross sections were placed along the study streams using a digital terrain model created from the Grand Prairie 2009 LiDAR data. Where roads or other structures are encountered, additional cross sections were acquired through additional surveying to meet HEC-RAS data input needs. These detailed cross sections were then used to enhance the channel portions of the cross sections derived from the terrain model. Cross section data was extracted from the digital terrain model using HEC-GeoRAS.

c. Structures

All bridges and culverts along the stream were field surveyed by Marshall Lancaster & Associates, Inc., between January 2009 and April 2009. The inline weirs in McFalls Park and private property upstream of SH 161 were not surveyed.

d. Ineffective and Storage Areas

Ineffective flow areas are added to portions of various cross sections to accurately model any given section's ability to convey flow. Ineffective flow areas are typically modeled by:

i. Applying an ineffective flow area boundary in HEC-RAS with a test elevation that, if exceeded, would offer some level of conveyance;
ii. Applying a permanent ineffective flow area boundary in HEC-RAS, this will permanently prevent that portion of the cross section from conveying flow;
iii. Applying a blocked obstruction boundary in HEC-RAS, this will permanently prevent that portion of the cross section from conveying flow and removes storage capacity of the stream.

Examples of temporary ineffective flow areas include: 1) minor swales parallel to the reach that eventually outfall into the reach; or 2) cross sections immediately upstream or downstream of an in-line structure. Examples of permanent ineffective flow areas include: 1) minor swales parallel to the reach, which do not outfall into the reach; or 2) off-line water quality / detention ponds.

e. Channel Roughness Values

Manning's n-values were estimated based on field inspections, engineering judgment and high resolution aerial photography of stream channels and floodplain areas for the streams in the study area. The n-values for various types of ground cover are listed in **Table III-1** and the ranges of values used in the individual streams are shown in **Table III-2**.

Table III-1: Manning's Roughness Coefficients by Type

Description	Channel "n" Values	Overbank "n" Values
Irregular channel, some pools & shoals	0.04	
Irregular channel, some trees	0.055	
Concrete channels	0.015	
Channel with weeds and brush	0.025	
Tree cover with some open space		0.080
Scattered trees, flow obstructions		0.060
Pasture with high grass		0.035

Table III-2: Summary of Manning's Roughness Coefficients by Stream

Stream Name	Channel "n" Value	Overbank "n" Value
Fish Creek	0.015 - 0.060	0.035 - 0.080
North Fork of Fish Creek	0.015 - 0.060	0.035 - 0.080

f. Split and Diverted Flow

No split or diverted flow analyses were required.

g. Other Model Input

Main Channel and overbank reach lengths were extracted from the digital terrain model using HEC GeoRAS. The other hydraulic parameters used in the analysis of Fish Creek are shown in **Table III-3**.

Table III-3: Hydraulic Parameters

Hydraulic Model Coefficient	Value or Range
Bridge pier drag coefficient, Cd	1.2
Pressure and weir coefficient (submerged inlet and outlet)	0.8
Expansion coefficient for bridges and culverts	0.5
Expansion coefficient for channels	0.3
Contraction coefficient for bridges and culverts	0.3
Contraction coefficient for channels	0.1
Weir coefficient for road decks	2.6 to 3.0
Culvert entrance loss coefficient	0.5
Culvert exit loss coefficient	1

Locations of hydraulic cross-sections for the study are shown on the Floodplain Workmaps included in this report. Floodway models have been developed for the Fish Creek and North Fish Creek. The floodway models were optimized with the maximum encroachment that would not cause a rise of 1-foot or greater at any point along the streams.

2. **Kirby Creek, Letter of Map Revision(LOMR), Halff Associates, (January 2010)**
   Half Associates prepared a Hydrologic and Hydraulic model for Kirby Creek, South Fork of Kirby Creek & Brian Branch for this project. Models were developed for the existing 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual-chance-flood events. These models incorporate the airport detention pond as well as the improvements to the Pardue and Smith properties located upstream of Robinson Road on Kirby Creek

3. **Garden Branch, FEMA FY10 Risk MAP Project, Halff Associates, (October 2011)**
   Halff Associates prepared a Hydraulic model for Garden Branch for the FEMA FY10 Risk MAP Project. Models were developed for the existing 10-, 4-, 2-, 1-, and 0.2-percent annual-chance-flood events. Cross-sections developed from the Grand Prairie 2009 LiDAR data previously discussed. The road crossing at Kingswood Boulevard and Martin Barnes Road as well as six field cross sections were surveyed in June 2011. Channel "n" values ranged from 0.035 to 0.065, with overbank "n" values varying from 0.035 to 0.100. General contraction and expansion values were set at 0.1 and 0.3, respectively; these were increased to 0.3 and 0.5 at each structure's upstream and downstream cross sections.

4. **Willis Branch, FEMA FY10 Risk MAP Project, Halff Associates, (October 2011)**
   Halff Associates prepared a Hydraulic model for Willis Branch for the FEMA FY10 Risk MAP Project. Models were developed for the existing 10-, 4-, 2-, 1-, and 0.2-percent annual-chance-flood events. Cross-sections developed from the Grand Prairie 2009 LiDAR data previously discussed. Seven field cross sections were surveyed in June 2011 as well as the culvert at a private driveway. Channel "n" values ranged from 0.035 to 0.055, with overbank "n" values varying from 0.035 to 0.100. General contraction and expansion values were set at 0.1 and 0.3, respectively; these were increased to 0.3 and 0.5 at the culvert's upstream and downstream cross sections.

A CD-ROM containing copies of all hydraulic computer models and related GIS shapefiles are included in **Appendix G**.

IV. HYDROLOGIC AND HYDRAULIC STUDY RESULTS

A. Hydrologic Study Results

1. Model Input

The HEC-HMS hydrologic model utilizing the NRCS method requires four basic input parameters, basin area, curve number, impervious cover and lag time.

Sub-basins were manually delineated using LiDAR data, in ArcGIS. ArcGIS was then used to measure the areas of each sub-basin.

Soil data from the US Department of Agriculture Soil Survey Geographic (SSURGO) database was imported into the ArcGIS map and the area of each hydrologic soil group in each sub-basin was measured. Each hydrologic soil group was assigned a curve number, and a composite curve number was generated for each sub-basin using the weighted average method. The percentage of each soil type and the weighted average curve number for each Sub-basin are shown in **Table IV-1.**

Table IV-1: Summary of Soil Types & Curve Number

Sub-basin	Total Area (sq. mi.)	Percent of Soil Type				Weighted Curve Number
		%A	%B	%C	%D	AMC II
BNB-01	0.89	0%	3%	1%	96%	79.4
DB-01	0.34	0%	15%	21%	64%	75.9
FB-01	0.26	0%	32%	0%	68%	73.9
FC-01	0.15	0%	3%	17%	80%	78.4
FC-02	0.13	0%	36%	7%	56%	72.7
FC-03	0.23	0%	77%	0%	23%	65.3
FC-04	0.12	0%	55%	0%	45%	69.6
FC-05	0.08	0%	50%	26%	24%	69.0
FC-06	0.06	0%	38%	40%	22%	70.4
FC-07	0.21	0%	10%	26%	64%	76.6
FC-08	0.14	0%	55%	16%	29%	68.6
FC-08A	0.07	0%	51%	0%	49%	70.4
FC-09	0.30	0%	28%	23%	50%	73.4
FC-10	0.35	0%	47%	15%	38%	70.2
FC-11	0.53	0%	29%	11%	61%	73.9
FC-12	0.19	0%	11%	1%	88%	77.9
FC-13	0.13	0%	28%	26%	46%	73.1
FC-14	0.13	0%	25%	16%	58%	74.2
FC-14A	0.27	0%	5%	9%	86%	78.5
FC-15	0.04	0%	0%	38%	62%	77.7
FC-16	0.32	0%	0%	5%	95%	79.7
FC-17	0.21	0%	0%	0%	100%	80.0
FC-18	0.58	0%	0%	0%	100%	80.0
FC-18A	0.13	0%	0%	0%	100%	80.0
FC-19	0.45	0%	0%	0%	100%	80.0
FC-20	0.73	0%	0%	0%	100%	80.0
FC-21	0.74	0%	0%	0%	100%	80.0

Sub-basin	Total Area (sq. mi.)	Percent of Soil Type				Weighted Curve Number
		%A	%B	%C	%D	AMC II
FC-22	0.82	0%	0%	4%	96%	79.7
FC-23	0.49	0%	0%	0%	100%	80.0
FC-24	0.81	0%	0%	4%	96%	79.8
KB-01	0.27	0%	0%	4%	96%	79.8
KB-02	0.54	0%	0%	8%	92%	79.5
KB-03	0.05	0%	0%	0%	100%	80.0
KB-04	0.37	0%	0%	5%	95%	79.7
KC-01	3.40	0%	10%	0%	90%	78.0
LB-01	0.41	0%	34%	0%	66%	73.5
MB-01	0.23	0%	0%	5%	95%	79.7
NF-01	0.27	0%	18%	13%	69%	75.8
NF-02	0.19	0%	15%	22%	63%	75.8
NF-03	0.35	0%	6%	13%	81%	78.0
NF-04	0.34	0%	0%	1%	99%	79.9
NF-05	0.29	0%	14%	30%	56%	75.5
NF-06	0.35	0%	8%	0%	92%	78.4
NF-07	0.38	0%	2%	2%	95%	79.4
NF-08	0.40	0%	0%	3%	97%	79.8
NF-08A	0.55	0%	0%	4%	96%	79.8
NF-09	0.59	0%	0%	17%	83%	79.0
NF-09A	0.29	0%	0%	8%	92%	79.5
NF-10	0.18	0%	0%	26%	74%	78.5
NF-11	0.70	0%	0%	26%	74%	78.5
NF-12	0.49	0%	0%	15%	85%	79.1
NF-13	0.26	0%	0%	18%	82%	78.9
NF-14	0.54	0%	0%	33%	67%	78.0
OB-01	0.06	0%	43%	35%	22%	69.7
RB-01	0.41	0%	6%	1%	92%	78.7
UNB-01	0.14	0%	0%	4%	96%	79.7
UNB-02	0.66	0%	0%	2%	98%	79.9
UNB-03	0.58	0%	0%	0%	100%	80.0
UNC-01	0.50	0%	0%	0%	100%	80.0
UNC-02	1.26	0%	0%	6%	94%	79.6
UND-01	0.14	0%	48%	0%	52%	70.9

Lag times were calculated using the procedures described in NRCS Technical Release 55 (TR-55). Existing land use data was imported into the ArcGIS map and the area of land use type in each sub-basin was measured. Each land use was assigned a percent impervious cover, and a composite percent impervious cover was generated for each sub-basin using the weighted average method. Two sets of impervious cover data were generated for each sub-basin, one set based on existing conditions and the second set based on future land use projections provided by the City. The area, lag time, curve number and impervious cover for each sub basin are shown in **Table IV-2**.

Table IV-2: Summary of Hydrologic Parameters

Sub-basin Name	Drainage Area (sq. mi.)	Lag Time (minutes)	AMC II CN	Existing Impervious Cover	Future Impervious Cover
BNB-01	0.89	37.0	79.4	32.1%	51.6%
DB-01	0.34	26.0	75.9	39.2%	39.2%
FB-01	0.26	19.0	73.9	40.9%	40.9%
FC-01	0.15	52.0	78.4	25.3%	25.3%
FC-02	0.13	11.0	72.7	27.2%	27.2%
FC-03	0.23	33.0	65.3	16.8%	16.8%
FC-04	0.12	8.0	69.6	21.2%	43.4%
FC-05	0.08	7.0	69.0	13.2%	45.5%
FC-06	0.06	15.0	70.4	38.4%	41.1%
FC-07	0.21	13.0	76.6	53.7%	71.4%
FC-08	0.14	12.0	68.6	58.7%	58.7%
FC-08A	0.07	17.0	70.4	38.1%	47.7%
FC-09	0.30	21.0	73.4	34.1%	54.9%
FC-10	0.35	20.0	70.2	24.6%	37.9%
FC-11	0.53	30.0	73.9	21.5%	25.0%
FC-12	0.19	16.0	77.9	32.0%	36.0%
FC-13	0.13	22.0	73.1	22.2%	28.2%
FC-14	0.13	16.0	74.2	31.1%	31.1%
FC-14A	0.27	14.0	78.5	37.2%	37.2%
FC-15	0.04	15.0	77.7	28.1%	56.4%
FC-16	0.32	29.0	79.7	43.3%	43.3%
FC-17	0.21	28.0	80.0	25.4%	39.5%
FC-18	0.58	21.0	80.0	27.3%	39.0%
FC-18A	0.13	14.0	80.0	17.8%	28.2%
FC-19	0.45	30.0	80.0	28.4%	41.3%
FC-20	0.73	35.0	80.0	31.5%	37.3%
FC-21	0.74	24.0	80.0	30.9%	42.1%
FC-22	0.82	18.0	79.7	37.1%	47.5%
FC-23	0.49	22.0	80.0	26.9%	48.7%
FC-24	0.81	12.0	79.8	41.2%	52.8%
KB-01	0.27	23.0	79.8	26.6%	74.6%
KB-02	0.54	24.0	79.5	32.9%	44.7%
KB-03	0.05	9.0	80.0	35.0%	35.0%
KB-04	0.37	18.0	79.7	50.3%	58.7%
LB-01	0.41	20.0	73.5	29.2%	46.1%
MB-01	0.23	21.0	79.7	28.9%	53.3%
NF-01	0.27	19.0	75.8	36.3%	40.5%
NF-02	0.19	21.0	75.8	3.7%	80.9%
NF-03	0.35	33.0	78.0	8.1%	84.4%

Sub-basin Name	Drainage Area (sq. mi.)	Lag Time (minutes)	AMC II CN	Existing Impervious Cover	Future Impervious Cover
NF-04	0.34	19.0	79.9	32.8%	47.7%
NF-05	0.29	18.0	75.5	10.4%	51.0%
NF-06	0.35	21.0	78.4	29.7%	47.0%
NF-07	0.38	20.0	79.4	26.5%	59.3%
NF-08	0.40	20.0	79.8	32.1%	60.4%
NF-08A	0.55	26.0	79.8	43.9%	66.9%
NF-09	0.59	16.0	79.0	43.4%	54.5%
NF-09A	0.29	17.0	79.5	35.3%	45.4%
NF-10	0.18	15.0	78.5	33.8%	51.0%
NF-11	0.70	24.0	78.5	35.5%	50.6%
NF-12	0.49	14.0	79.1	38.7%	52.1%
NF-13	0.26	15.0	78.9	33.7%	48.0%
NF-14	0.54	17.0	78.0	37.0%	48.5%
OB-01	0.06	12.0	69.7	35.9%	36.3%
RB-01	0.41	27.0	78.7	38.0%	39.7%
UNB-01	0.14	15.0	79.7	33.0%	33.1%
UNB-02	0.66	33.0	79.9	34.3%	34.3%
UNB-03	0.58	19.0	80.0	33.0%	33.1%
UNC-01	0.50	32.0	80.0	34.7%	34.7%
UNC-02	1.26	36.0	79.6	29.3%	29.3%
UND-01	0.14	16.0	70.9	36.3%	36.3%

2. **Computed Discharges**
The hydrologic analysis was completed using methods prescribed by the FEMA Guidelines and Specifications for Flood Mapping Partners. The design storm distribution used was the nested and balanced distribution, with rainfall depths derived from the *City of Grand Prairie Drainage Design Manual* (December 2010). A 24-hour storm duration was assumed for all the watersheds. HEC-HMS version 3.5 was used to compute the peak discharges. **Table IV-3** lists the computed peak flow rates.

Table IV-3: Summary of Discharges from this Study

Flooding Source and Location	XS ID	Peak Discharges (cfs)			
		10% Flood	2% Flood	1% Flood	0.20% Flood
Fish Creek					
At upstream limit of study	43,484	8,213	11,720	13,417	17,994
Matthew Road	25,980	11,542	17,467	20,017	26,630
Robinson Road	17,750	11,377	17,656	20,019	26,768
North Fork of Fish Creek	16,845	17,030	26,455	30,127	38,382
Carrier Parkway	14,575	17,125	26,902	30,076	38,956
D/S of Kirby Creek	4,4725	18,462	28,005	31,837	40,779

Flooding Source and Location	XS ID	Peak Discharges (cfs)			
		10% Flood	2% Flood	1% Flood	0.20% Flood
Fish Creek					
Beltline Road	3,288	18,287	27,375	31,315	40,160
At downstream limit of study	1,848	18,337	27,451	31,398	40,274
North Fork of Fish Creek (Prairie Creek)					
S.H.360	25,164	5,820	7,993	8,950	11,223
Great Southwest Pkwy	1,2994	6,199	8,680	10,129	13,667
S.H.161	4,317	6,518	9,279	10,886	15,123
Robinson Road	2,210	6,522	9,301	10,869	14,917
At downstream end of study	971	6,576	9,412	10,960	15,053

3. **Effective Discharges**
The current effective discharges were obtained from a print-out of the HEC-2 model dated February 1996. These records were provided by the City of Grand Prairie and are shown on **Table IV-4**.

Table IV-4: FEMA Effective Discharges (June 1994)

Flooding Source and Location	XS ID	Peak Discharges (cfs)			
		10% Flood	2% Flood	1% Flood	0.20% Flood
Fish Creek					
At upstream limit of study	45,070	8,300	11,900	13,600	17,300
Matthew Road	27,125	10,700	15,550	17,800	23,100
Robinson Road	19,120	10,300	14,900	17,100	22,400
North Fork of Fish Creek	17,985	14,700	21,000	24,000	30,900
Carrier Parkway	15,875	14,700	21,000	24,000	30,900
D/S of Kirby Creek	5,300	14,800	22,100	25,600	33,600
Beltline Road	3,100	14,800	23,000	25,800	33,700
At downstream limit of study	1,848	14,800	23,000	25,800	33,700
North Fork of Fish Creek (Prairie Creek)					
S.H.360	23,890	5,900	8,000	9000	11,300
Great Southwest Pkwy	12,893	4,900	6,800	7,600	9,700
S.H.161	4,317	4,900	6,800	7,600	9,700
Robinson Road	2,210	4,900	6,800	7,600	9,700
At downstream end of study	971	4,900	6,800	7,600	9,700

4. Comparison with Revised Discharges

The results of this model were compared to the effective model dated June, 1994. The peak flows in the upper reaches of the drainage basins tended to be slightly less than previous studies with the lower reaches having significantly higher peak flows. These higher peaks are to be expected as urbanization has increased the impervious cover in the drainage basins. The restudy peak discharges are show on **Table IV-3,** and the comparison between the current effective flows and the restudy are shown on **Table IV-5**.

Table IV-5: Comparison of Restudy Discharges and Effective Discharges (cfs)

Discharge Location	Restudy Drainage Area (mi^2)	Restudy 1% Flood Discharge	Effective FIS 1% Flood Discharge	Percent Change
Cottonwood Creek				
At upstream limit of study	7.3	13,417	13,600	-1.3%
Matthew Road	13.6	20,017	17,800	12.5%
Robinson Road	14.7	20,019	17,100	17.1%
North Fork of Fish Creek	20.9	30,127	24,000	25.5%
Carrier Parkway	21.5	30,076	24,000	25.3%
D/S of Kirby Creek	25.9	31,837	25,600	24.4%
Beltline Road	26.5	31,315	25,800	21.4%
At downstream limit of study	26.6	31,398	25,800	21.7%
North Fork of Fish Creek (Prairie Creek)				
S. H. 360	3.1	8,950	9,000	-0.6%
Great Southwest Pkwy	4.4	10,129	7,600	33.3%
S. H. 161	5.7	10,886	7,600	43.2%
Robinson Road	5.9	10,869	7,600	43.0%
At Downstream end of study	6.2	10,960	7,600	44.2%

5. Summary of Final Discharge Values

The peak discharge flow rates calculated with the HEC-HMS model are listed in **Table IV-6**.

Table IV-6: Fish Creek Basin Peak Run-Off

HEC-RAS Location			Peak Flows				
River	Reach	RS	Existing 10 yr	Existing 50 yr	Existing 100 yr	Existing 500 yr	Ultimate 100 yr
FISH CREEK	US	43,484	8,213	11,720	13,417	17,994	13,842
FISH CREEK	US	42,574	8,274	11,848	13,497	18,142	13,873
FISH CREEK	US	41,093	8,661	12,439	14,124	19,047	14,611
FISH CREEK	US	40,008	9,202	13,280	15,149	20,329	15,487
FISH CREEK	US	36,983	9,307	13,581	15,642	20,971	15,802
FISH CREEK	US	34,603	10,235	15,376	17,632	23,600	17,715
FISH CREEK	US	31,772	10,743	16,132	18,414	24,600	18,507
FISH CREEK	US	31,603	10,817	16,237	18,539	24,726	18,625
FISH CREEK	US	26,695	10,930	16,516	18,964	25,308	19,055
FISH CREEK	US	25,980	11,542	17,467	20,017	26,630	20,153
FISH CREEK	US	21,523	11,556	17,734	20,137	26,935	20,295
FISH CREEK	US	17,750	11,377	17,656	20,019	26,768	20,187
FISH CREEK	DS	17,314	17,030	26,455	30,127	38,382	29,903
FISH CREEK	DS	16,845	17,030	26,455	30,127	38,382	29,903
FISH CREEK	DS	16,060	17,048	26,558	30,115	38,493	29,909
FISH CREEK	DS	15,727	17,053	26,639	30,123	38,518	29,887
FISH CREEK	DS	14,725	17,069	26,710	30,263	38,542	30,043
FISH CREEK	DS	12,580	17,052	26,637	30,166	38,573	30,037
FISH CREEK	DS	12,085	17,129	26,759	30,338	38,749	30,217
FISH CREEK	DS	10,541	17,136	26,753	30,333	38,735	30,229
FISH CREEK	DS	9,945	17,171	26,775	30,278	38,837	30,178
FISH CREEK	DS	7,473	17,163	26,453	29,978	38,466	29,903
FISH CREEK	DS	5,968	18,429	27,947	31,943	40,736	31,939
FISH CREEK	DS	4,059	18,346	27,583	31,535	40,384	31,560
FISH CREEK	DS	3,288	18,287	27,375	31,315	40,160	31,354
FISH CREEK	DS	2,802	18,337	27,451	31,398	40,274	31,450
NORTH FISH	MAINSTEM	26,747	4,801	6,682	7,533	9,597	7,527
NORTH FISH	MAINSTEM	25,164	5,820	7,993	8,950	11,223	8,082
NORTH FISH	MAINSTEM	24,089	6,637	8,854	10,331	13,156	9,199
NORTH FISH	MAINSTEM	17,616	6,544	8,980	10,321	13,422	9,748
NORTH FISH	MAINSTEM	13,805	6,199	8,680	10,129	13,667	9,680
NORTH FISH	MAINSTEM	10,240	6,162	8,726	10,214	13,960	9,825
NORTH FISH	MAINSTEM	6,270	6,318	8,968	10,498	14,482	10,172
NORTH FISH	MAINSTEM	5,252	6,518	9,279	10,886	15,123	10,627
NORTH FISH	MAINSTEM	4,462	6,518	9,272	10,883	15,083	10,620
NORTH FISH	MAINSTEM	2,210	6,522	9,301	10,869	14,917	10,793
NORTH FISH	MAINSTEM	1,270	6,576	9,412	10,960	15,053	10,865

B. Hydraulic Study Results

The hydraulic model for the Fish Creek Basin is divided into two river segments, Fish Creek with two reaches upstream and downstream, and North Fish Creek (Prairie Creek) with Main Stem.

The ultimate conditions steady-state calculated water surface elevations are very similar to existing conditions. The flow rates for the ultimate conditions 1% event are an average of 1% greater than existing, but this does not translate to a significant increase in depth. The calculated water surface elevations are an average of 0.12 ft higher in the ultimate conditions, with the largest increase being 1.14 ft. The existing conditions floodplains are shown on the Floodplain Work Maps. The areal extent of the ultimate floodplain is very similar to the existing floodplain. **Table IV-7** shows the water surface elevations for the various events at selected locations.

Table IV-7: Water Surface Elevations

FISH CREEK									
Location	XS River Sta.	2-YR (ft)	5-YR (ft)	10-YR (ft)	25-YR (ft)	50-YR (ft)	100-YR (ft)	500-YR (ft)	Ultimate 100-YR
Matthew Road	25,980	496.55	499.08	499.95	500.93	501.68	502.35	503.9	502.46
Bardin Road	21,523	489.22	491.62	492.98	494.33	495.33	496.08	498.19	496.21
Robinson Road	17,750	483.23	485.92	487.85	489.68	491.1	491.9	494.06	492.08
Prairie Creek	16,845	481.86	484.21	485.56	486.95	488.07	488.97	490.99	489.24
Carrier Parkway	14,725	479.52	481.1	482.11	483.46	484.4	485.19	486.63	485.33
D/S of Kirby Creek	4,059	464.54	466.47	467.66	468.51	469.59	470.67	473.12	470.89

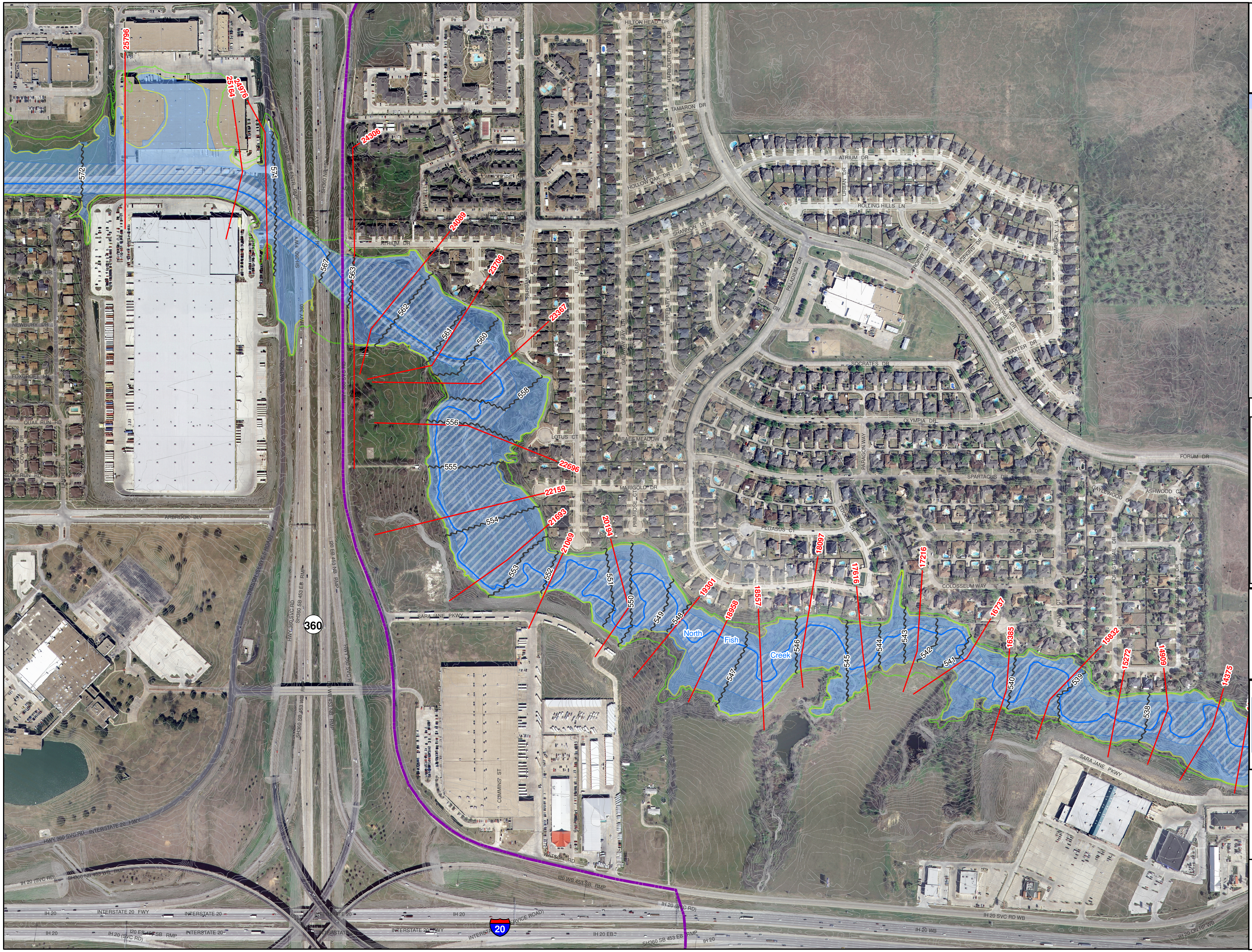
NORTH FORK FISH CREEK (PRAIRIE CREEK)									
Location	XS River Sta.	2-YR (ft)	5-YR (ft)	10-YR (ft)	25-YR (ft)	50-YR (ft)	100-YR (ft)	500-YR (ft)	Ultimate 100-YR
S.H.360	25,164	562.75	565.75	569.31	572.02	572.92	573.42	574.16	573.49
Great Southwest Pkwy	13,805	522.23	528.31	532.5	535.35	536.61	537.6	539.31	537.81
S.H.161	5,252	497.15	499.2	500.07	500.85	501.51	502.21	503.59	502.39
Robinson Road	2,210	482.66	484.74	486.32	487.7	489.05	491.74	493.63	491.82
Upstream of Fish Creek	1,270	482.68	484.67	486.26	487.94	489.17	490.02	492.07	490.2

V. FLOODPLAIN MAPPING

RPS Espey re-mapped Fish Creek and North Fork Fish Creek (Prairie Creek). Mapping included delineations for the existing 100-year, existing 500-year, and ultimate 100-year floodplains. Existing conditions Base Flood Elevations (BFEs), Floodways and Depth Grids were also delineated for these streams. The BFEs, Floodways, existing 100-year, existing 500-year, and ultimate 100-year floodplains are shown on the Floodplain Work Maps and shapefiles are included on CD-ROM in **Appendix G**.

A. FEMA Map Revisions

The City of Grand Prairie has submitted the results of the Risk MAP Project to FEMA. This project will culminate with the production of revised effective hydrologic and hydraulic modeling, floodplain mapping and Digital Flood Insurance Rate Maps (DFIRMs).



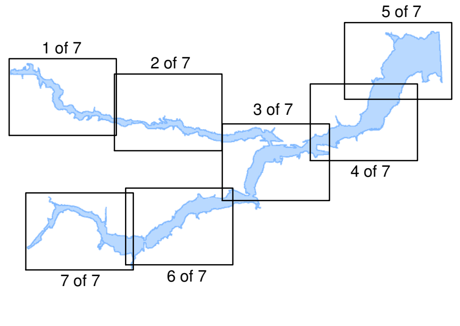
FLOODPLAIN WORK MAPS
FISH - 1 OF 7

KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

N
W E
S

MAP INDEX



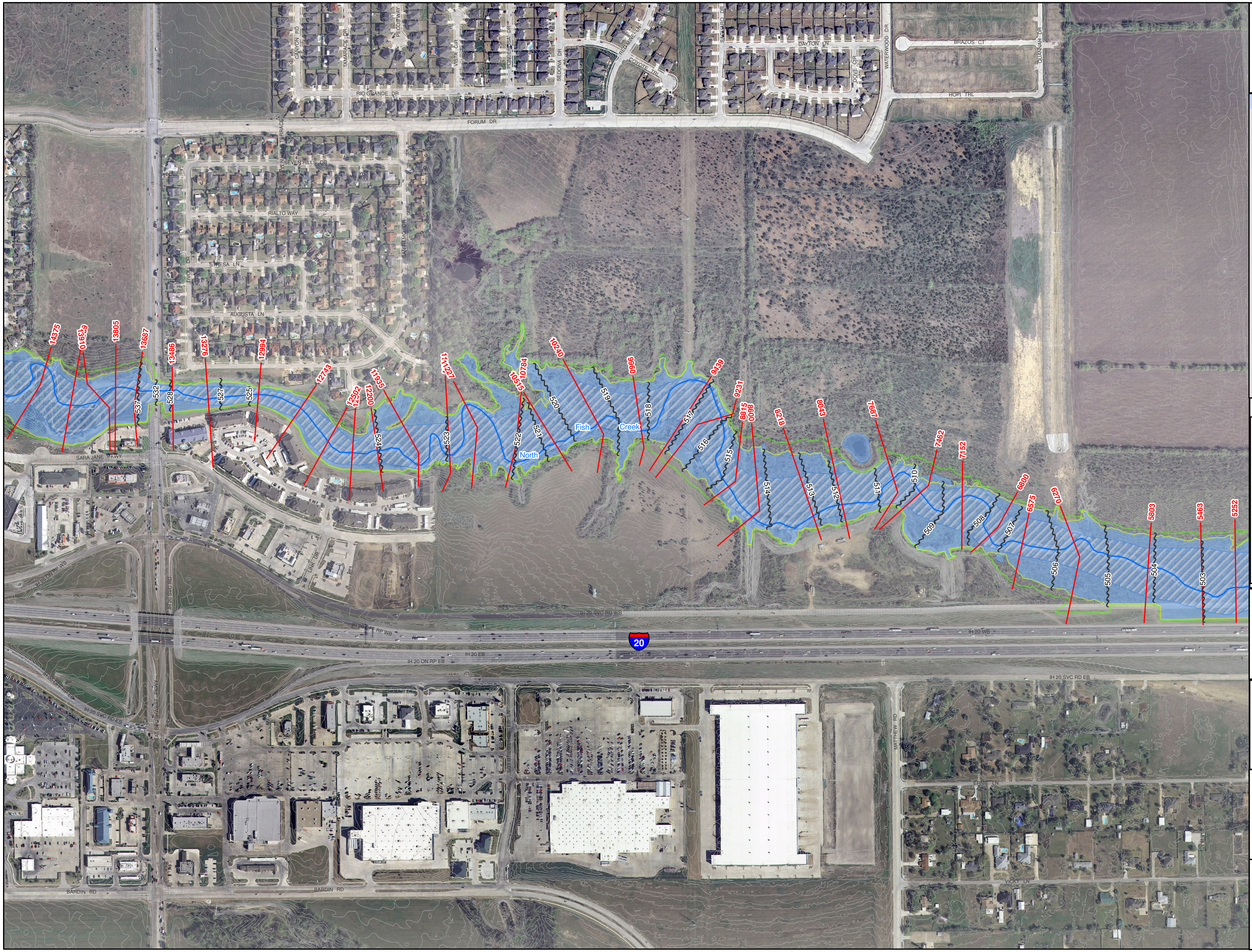
0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

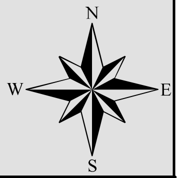
Grand Prairie
TEXAS



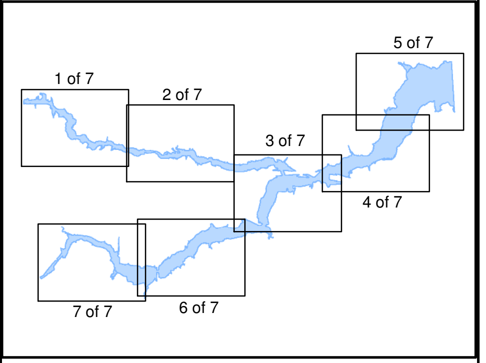
FLOODPLAIN WORK MAPS
FISH - 2 OF 7

KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain



MAP INDEX



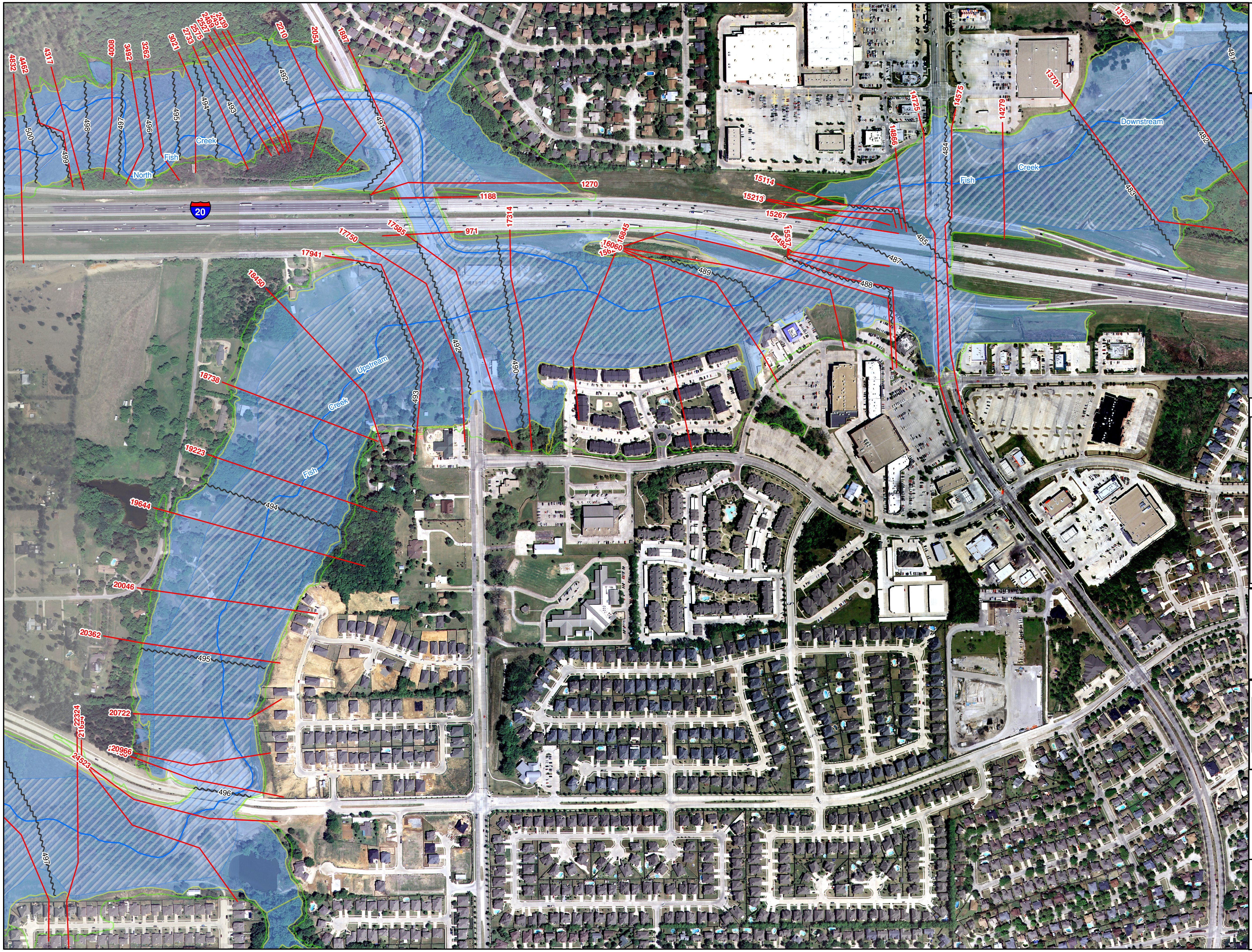
0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

Grand Prairie
TEXAS



FLOODPLAIN WORK MAPS

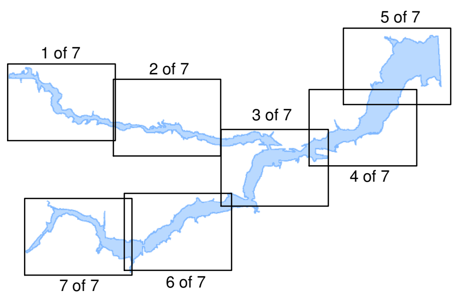
FISH - 3 OF 7

KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

N
W E
S

MAP INDEX



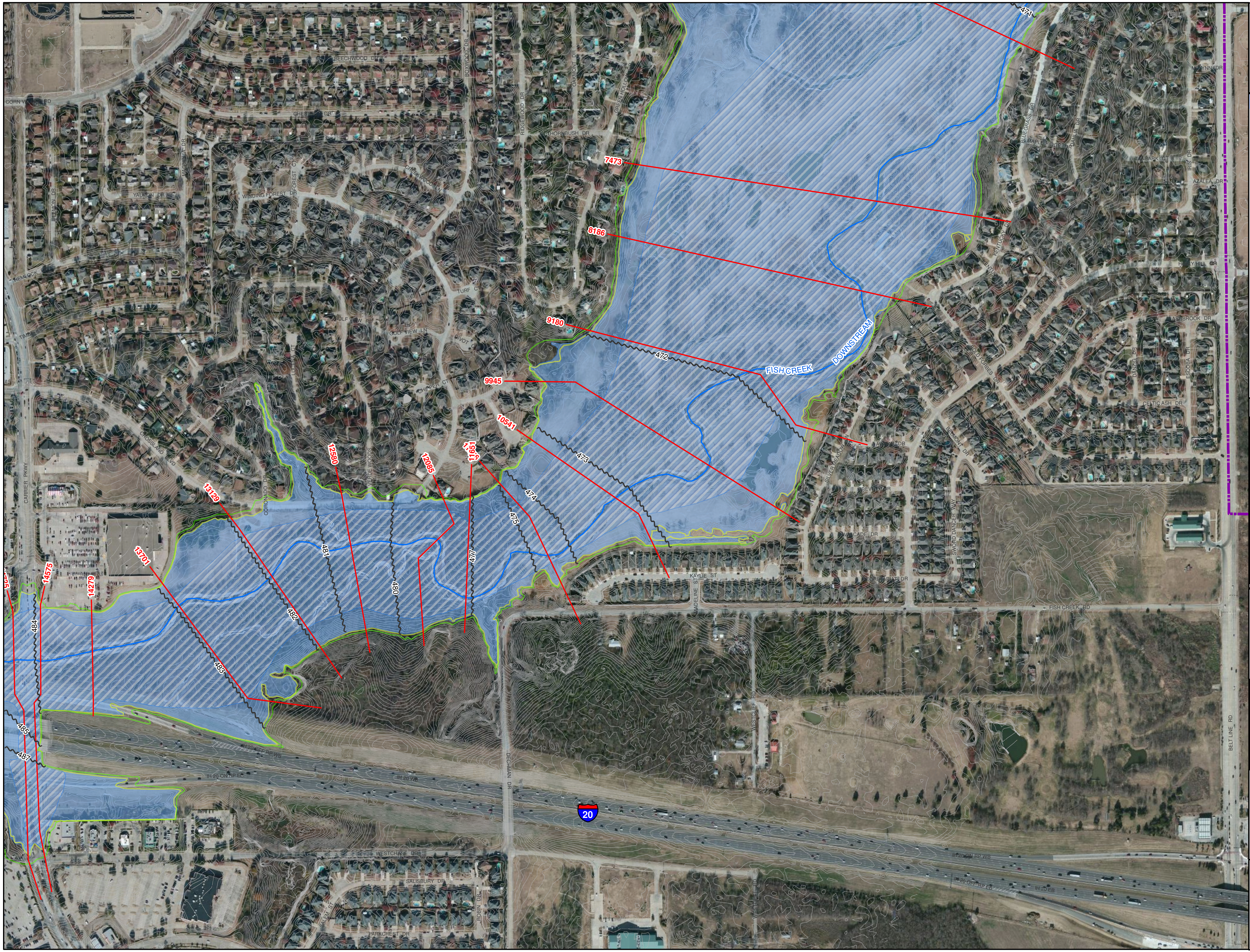
0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

Grand Prairie
TEXAS



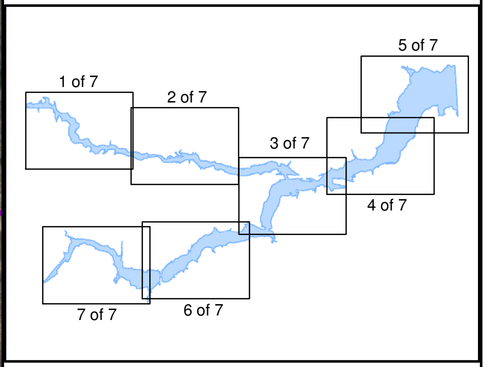
FLOODPLAIN WORK MAPS
FISH - 4 OF 7

KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

N
W E
S

MAP INDEX



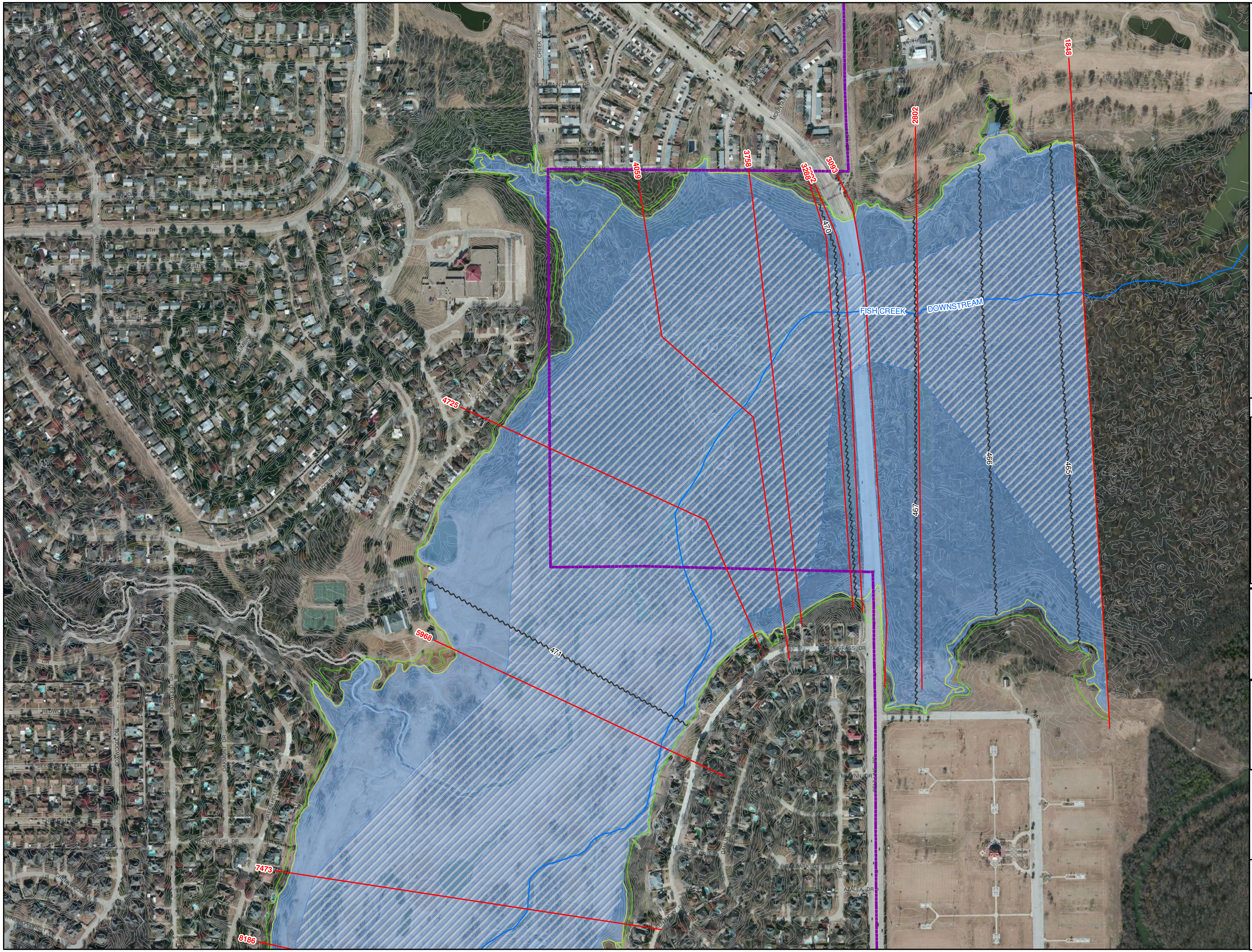
0 250 500 1,000
Scale in Feet

RPS Espey

FEMA

Grand Prairie
TEXAS

FLOODPLAIN WORK MAPS
FISH - 5 OF 7



KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

N
W E
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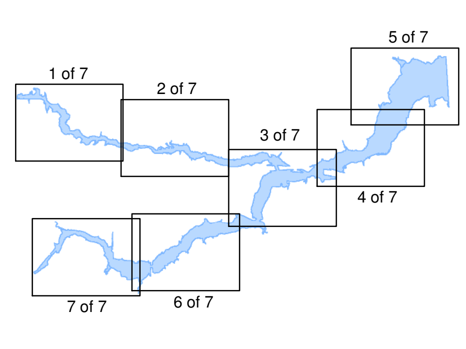
MAP INDEX



0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

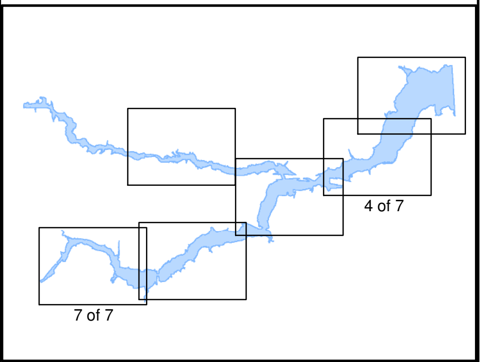
Grand Prairie TEXAS

FLOODPLAIN WORK MAPS
FISH - 6 OF 7

KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

MAP INDEX



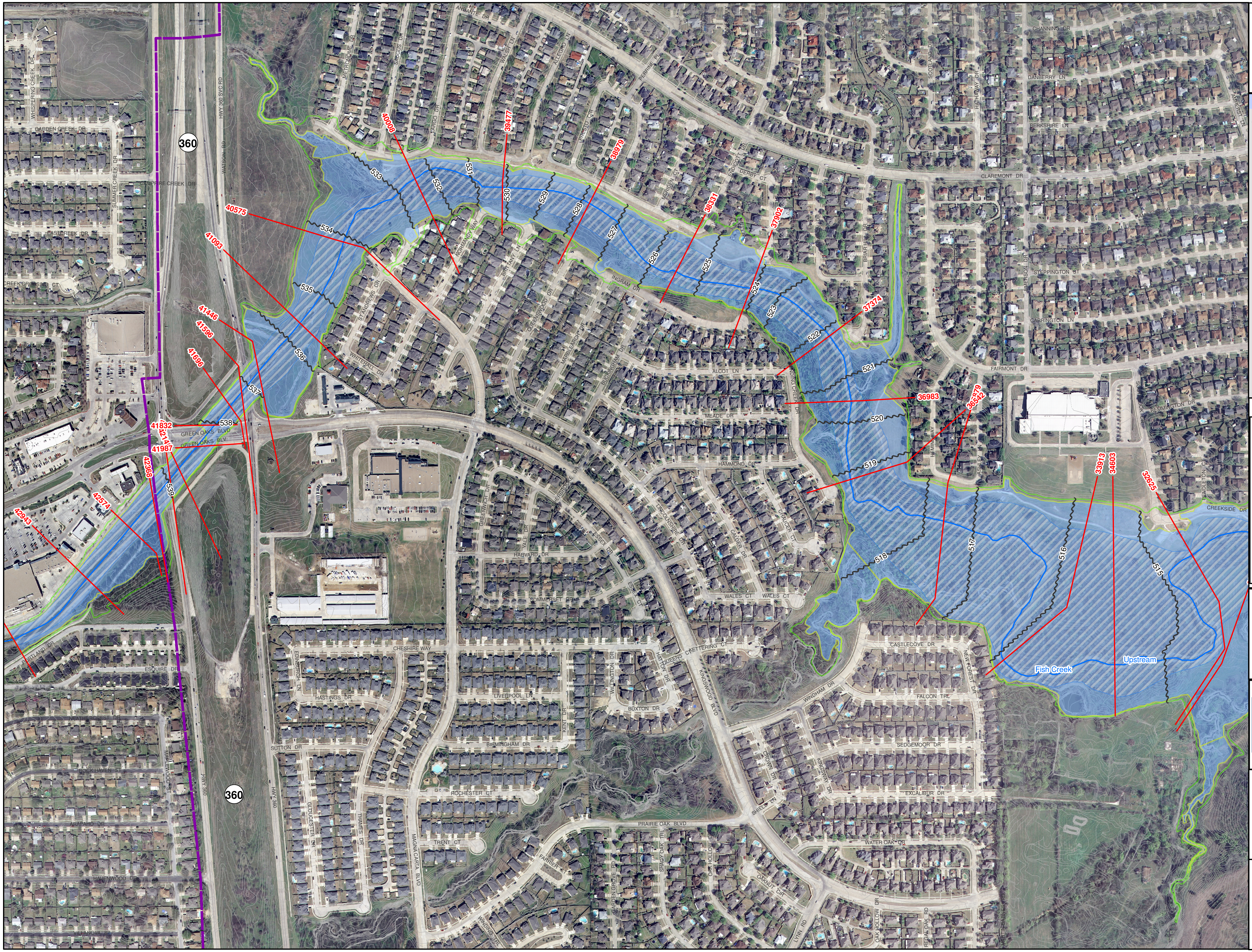
0 250 500 1,000
Scale in Feet

RPS Espey

FEMA

Grand Prairie TEXAS

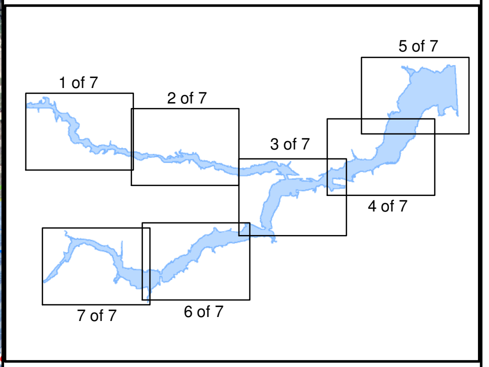
FLOODPLAIN WORK MAPS
FISH - 7 OF 7



KEY TO FEATURES

- BFE
- Mapping XS
- Grand Prairie City Limit
- Stream CL
- Floodway
- Existing 100 Yr Floodplain
- Existing 500 Yr Floodplain
- Ultimate 100 Yr Floodplain

MAP INDEX



0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

Grand Prairie TEXAS

VI. ROADWAY CROSSINGS

A. Evaluation of Existing Roadway Crossings

The 31 existing roadway crossings within the Fish Creek Basin were evaluated on their level of protection against the existing 50%, 20%, 10%, 4%, 2%, and 1% (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year) chance flood events. The following tables include the river station and description of the roadway crossing, and if the roadway crossing is overtopped by the existing 50%, 20%, 10%, 4%, 2%, or 1% chance flood event.

Table VI-1: Existing Bridge Crossings

Stream: Fish Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
1	3202	Beltline Road *525' Bridge*	473.00	No WSEL = 464.16	No WSEL = 465.93	No WSEL = 467.02	No WSEL = 467.69	No WSEL = 468.75	No WSEL = 469.82
2	4860	Ridgewood Drive *80' Bridge*	481.49	No WSEL = 474.24	No WSEL = 476.38	No WSEL = 477.24	No WSEL = 477.99	No WSEL = 478.59	No WSEL = 480.65
11	14725	Carrier Parkway *120' Bridge*	481.00	No WSEL = 479.52	Yes WSEL = 481.10	Yes WSEL = 482.11	Yes WSEL = 483.46	Yes WSEL = 484.40	Yes WSEL = 485.19
12	15169	I-20 WB On-Ramp *228' Bridge*	485.35	No WSEL = 479.72	No WSEL = 481.41	No WSEL = 482.41	No WSEL = 483.70	No WSEL = 484.71	Yes WSEL = 485.66
Note: Roadway to the west of crossing at Carrier Parkway intersection has an elevation of 484.73 and overtops during a 50-yr flood event.									
13	15498	I-20 Main Lanes *245' Bridge*	494.00	No WSEL = 479.74	No WSEL = 481.45	No WSEL = 482.47	No WSEL = 483.77	No WSEL = 484.79	No WSEL = 485.75
14	15620	I-20 EB Off-Ramp *177' Bridge*	489.00	No WSEL = 479.76	No WSEL = 481.48	No WSEL = 482.51	No WSEL = 483.82	No WSEL = 484.85	No WSEL = 485.56
Note: Roadway to the west of crossing at Carrier Parkway intersection has an elevation of 484.36 and overtops during a 50-yr flood event.									
19	17750	Robinson Road *180' Bridge*	495.00	No WSEL = 483.92	No WSEL = 486.50	No WSEL = 488.26	No WSEL = 490.00	No WSEL = 491.26	No WSEL = 491.90
Note: Roadway to the north of bridge has an elevation of 487.42 and overtops during a 10-yr flood event.									
20	21523	Bardin Road *300' Bridge*	500.79	No WSEL = 489.24	No WSEL = 491.65	No WSEL = 493.02	No WSEL = 494.39	No WSEL = 495.36	No WSEL = 496.08
21	25980	Matthew Road *120' Bridge*	497.61	No WSEL = 496.55	Yes WSEL = 499.08	Yes WSEL = 499.96	Yes WSEL = 500.93	Yes WSEL = 501.68	Yes WSEL = 502.35
22	31772	Great Southwest Parkway *210' Bridge*	517.20	No WSEL = 505.62	No WSEL = 508.37	No WSEL = 509.68	No WSEL = 510.94	No WSEL = 511.90	No WSEL = 513.54

Stream: Fish Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
23	41596	SH 360 NB Frontage *233' Bridge*	546.00	No WSEL = 532.21	No WSEL = 534.20	No WSEL = 535.17	No WSEL = 535.95	No WSEL = 536.55	No WSEL = 537.14
24	41987	SH 360 *277' Bridge*	548.00	No WSEL = 532.56	No WSEL = 534.81	No WSEL = 535.95	No WSEL = 536.92	No WSEL = 537.65	No WSEL = 538.36
25	42368	SH 360 SB Frontage *225' Bridge*	546.50	No WSEL = 532.69	No WSEL = 535.32	No WSEL = 536.64	No WSEL = 537.81	No WSEL = 538.68	No WSEL = 539.55

Stream: Prairie Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
15	1188	I-20 Main Lanes *280' Bridge*	499.97	No WSEL = 482.75	No WSEL = 484.55	No WSEL = 485.79	No WSEL = 487.09	No WSEL = 488.14	No WSEL = 489.56
16	2054	Robinson Road *106' Bridge*	494.50	No WSEL = 483.19	No WSEL = 485.45	No WSEL = 486.81	No WSEL = 488.10	No WSEL = 489.24	No WSEL = 491.94
Note: Roadway to the south of crossing has an elevation of 489.72 and overtops during a 50-yr flood event.									
17	161	SH 161 *1160' Bridge*	525.40	No WSEL = 496.76	No WSEL = 498.76	No WSEL = 499.66	No WSEL = 500.47	No WSEL = 501.14	No WSEL = 501.86
18	13687	Great Southwest Parkway *4-10'x9' MBC*	533.53	No WSEL = 522.24	No WSEL = 528.28	No WSEL = 532.45	Yes WSEL = 535.32	Yes WSEL = 536.58	Yes WSEL = 537.56

Figure VI-1: Existing Roadway Crossings

Two types of mitigation were evaluated for the roadways overtopped by the 1% (100-yr storm) flood chance event: storage and structural modifications. A summary of the recommended improvements is included in **Table VI-2**. Refer to **Section VII** for detailed descriptions of proposed conceptual existing roadway crossing improvements.

Table VI-2: Existing Roadway Proposed Alternatives

Stream Name	Roadway	100-Year Ultimate Discharge (cfs)	Existing Crossing (ft)	Minimum Top of Road Elevation		Proposed Improvement	100-Year Ultimate WSEL (ft)	Change in WSEL (ft)
				Existing	Proposed			
Fish	Carrier Parkway	30,940	120’ Bridge	481.00	481.00	Widen Fish Creek channel downstream of Carrier Parkway; widen bridge at Carrier; replace existing channel at Carrier and IH-20 with trapezoidal concrete channel and section under IH-20 with rectangular channel		
Fish	I-20 WB On-Ramp	30,756	228’ Bridge	485.35	485.35			
Fish	I-20 EB Off-ramp	30,756	177’ Bridge	489.00	489.00			
Fish	Robinson Road	9,150	180’ Bridge	487.40	487.40			
Prairie	Robinson Road	11,379	106’ Bridge	489.72	489.72			
Fish	Matthew Road	20,273	120’ Bridge	497.61	-	No proposed improvement		
Prairie	Great Southwest Parkway	10,589	4-10’x9’ MBC	533.53	533.53	Add 4-10’x10’ MBC		

B. Evaluation of Proposed and Future Roadway Crossings

According to the 2010 City of Grand Prairie’s Master Thoroughfare Plan, there are only four planned thoroughfare crossings within the Fish Creek Basin, including: Highway 161; the extension of Fish Creek Drive to Crossland Boulevard, a undivided four lane arterial; the extension of Lake Ridge Parkway to I-20, a divided six lane arterial; and the extension of Magna Carta Boulevard to Claremont Drive, an undivided four lane arterial. Refer to **Appendix F** of this report for a map of the current Master Thoroughfare Plan. **Table VI-3** is a list of the studied tributaries that would have a future crossing (or crossings) under the current thoroughfare plan.

Table VI-3: Fish Creek Basin Studied Tributaries with Future Thoroughfare Crossings

Tributary Name	Master Thoroughfare Crossing
Prairie Creek	Highway 161[1]
Fish Creek	Fish Creek Road
Fish Creek	Lake Ridge Parkway
Fish Creek	Magna Carta Boulevard

[1] Currently under construction.

Design of Future Thoroughfare Crossings

Future thoroughfare crossings within the Fish Creek Basin shall be designed to pass the ultimate 100-year flood frequency event and to not create adverse impacts to upstream or downstream structures and adjacent property owners (caused by increases in 100-year computed water surface elevations). It would be desirable for roadway crossings to span the entire 100-year future floodplain; however, if this cannot be achieved, it would be desirable for the future crossing to minimize encroachment, thus minimizing impacts to upstream reaches. Highway 161, which crosses both Kirby Creek and Prairie Creek, is currently under construction. It is anticipated that the bridge design of the crossings is sufficient to pass the 100-year ultimate flow without overtopping the roadway.

VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS

Three types of mitigation were evaluated for the areas within the Fish Creek Basin subjected to flooding damage: buy-outs, storage, and structural modifications. RPS Espey (EC) determined and evaluated proposed alternatives for structures inundated by the ultimate 100-yr flood event and existing roadway crossings overtopped by the existing 100-yr flood event within Fish Creek Basin. In addition to the residential buildings discussed below, there are seven road crossings which are overtopped by a 100-yr storm.

Proposed bridge alternatives were considered for all existing roadway crossings modeled within the Fish Creek Basin that were overtopped by the existing 100-year flood event. Each proposed crossing alternative was designed to pass the 100-year ultimate discharge so that the roadway was not overtopped. Detailed cost estimates for each flood control alternative can be found in **Section XII** of this report.

All property owners within the United States and its territories must adhere to the provisions of the Clean Water Act. If any contemplated activity might impact waters of the United States, including adjacent or isolated wetlands, a permit application must be made. If jurisdictional waters and/or wetlands are found to exist, then any activity which would involve filling, excavating, or dredging these wetlands would require the issuance of a permit. The final authority to determine whether or not jurisdictional waters exist lies with U.S. Army Corp of Engineers (USACE). There is a strong likelihood that waters of the U.S. jurisdictional areas exist along the main stem and secondary channels of Fish and Prairie Creeks. A wetland investigation and determination should be performed prior to construction of any proposed improvements within the channel. Minor improvements to jurisdictional waters may fall into a Nationwide Permit category, where more extensive modifications of jurisdictional waters would require an extensive Individual Permit process. Improvements to roadway crossings which would require construction within the waters of the United States may be able to be permitted under Nationwide Permit 14 (NWP 14) for Linear Transportation Crossings to satisfy the USACE requirements from Section 404 of the Clean Water Act. It is recommended that the City engage the USACE early in its design process for any structural improvements on channels. Refer to **Appendix F** for more information regarding Section 404 Permits.

The following is a brief description of the proposed conceptual improvements within the Fish Creek Basin. Refer to **Table VI-2** for a summary of proposed conceptual existing bridge crossing improvements.

A. Carrier Parkway at Fish Creek (Stream Station 147+25)
I-20 West-Bound On-Ramp at Fish Creek (Stream Station 151+69)
I-20 East-Bound Off-Ramp at Fish Creek (Stream Station 151+69)
Robinson Road at Fish Creek (Stream Station 177+50)
Robinson Road at Prairie Creek (Stream Station 50+54)

There are eight residences located in the 100-yr floodplain along the section of Fish Creek between Bardin Road and Robinson Road. All of these residences are on large lots which back up to the creek. Two of these homes are located on Our Lane, five are located on Vineyard Road, and one is adjacent to Interstate-20. The home at 802 Our Lane is a repetitive loss structure. In addition to the residential structures, there are two commercial buildings on Robinson Road which are in the floodplain.

Robinson Road crosses Fish Creek with a 106’ five-span bridge approximately seven hundred fifty feet upstream of the confluence with Prairie Creek. Proceeding upstream from its confluence with Fish Creek, Prairie Creek runs parallel with IH-20 for a short distance and then turns north, crossing under IH-20, running adjacent to Robinson Road. Prairie Creek then makes a sharp turn west and crosses under Robinson Road a short distance north of IH-20. The IH-20 Bridge which crosses over both Prairie Creek and Robinson Road is a 280' four-span structure. The Robinson Road Bridge is only 700' north of IH-20; it is a 106' long three-span structure.

These bridges are being discussed as a group because the short distances between structures and the common roadway connections result in flooding at one bridge impacting adjacent roads and backwater from each bridge affecting the next bridge upstream. The Carrier Parkway Bridge will pass a 2-yr storm. Flooding, from a 5-yr and greater storm events, closes Carrier Parkway at the bridge, under the IH-20 overpass, as well as the IH-20 ramps on both the north and south sides of IH-20. The backwater from Carrier negatively affects the hydraulic capacity of the upstream bridges. Both of the IH-20 ramp bridges will pass a 50-yr storm; however, flooding at Carrier effectively closes these roads. The bridge at Robinson Road and Fish Creek will pass a 10-yr storm. The bridge itself is not overtopped; however, the roadway north of the bridge is flooded along with the ramp on the south side of IH-20. The IH-20 main lane bridge crosses over both Robinson Road and Prairie Creek. This bridge will pass a 500-yr storm; however, a 10-yr storm will flood Robinson Road and both intersecting ramps at this location. The bridge at Robinson Road and Prairie Creek will pass a 25-yr storm. Again, the bridge is not overtopped, but the roadway to the south of the bridge floods during a 25-yr storm.

Table VII-1: Existing Bridge Crossings

Stream: Fish Creek

River Station	Roadway	Existing Roadway Elevation	% Chance Flood Event Overtops Road					
			50%	20%	10%	4%	2%	1%
14725	Carrier Parkway	481.00	No WSEL = 479.52	Yes WSEL = 481.10	Yes WSEL = 482.11	Yes WSEL = 483.46	Yes WSEL = 484.40	Yes WSEL = 485.19
15169	I-20 WB On-Ramp	485.35	No WSEL = 479.72	No WSEL = 481.41	No WSEL = 482.41	No WSEL = 483.70	No WSEL = 484.71	Yes WSEL = 485.66
15620	I-20 EB Off-Ramp	484.36	No WSEL = 479.76	No WSEL = 481.48	No WSEL = 482.51	No WSEL = 483.82	Yes WSEL = 484.85	Yes WSEL = 485.56
17750	Robinson Road	495.00	No WSEL = 483.92	No WSEL = 486.50	No WSEL = 488.26	No WSEL = 490.00	No WSEL = 491.26	No WSEL = 491.90

Stream: Prairie Creek

River Station	Roadway	Existing Roadway Elevation	% Chance Flood Event Overtops Road					
			50%	20%	10%	4%	2%	1%
2054	Robinson Road	494.50	No WSEL = 483.19	No WSEL = 485.45	No WSEL = 486.81	No WSEL = 488.10	No WSEL = 489.24	No WSEL = 491.94

Proposed Improvements

- Widen the Fish Creek Channel downstream of Carrier Parkway 190' to 450' bottom width approximately 3,000 feet to the future Crossland Boulevard.
- Widen bridge at Carrier Parkway to 170'

- Replace existing channel between Carrier Parkway and IH-20 with a 160'-190' trapezoidal concrete channel
- Improve east bank of Fish Creek upstream of IH-20 to eliminate the existing overflow on the south side of the interstate.

Statement of Probable Cost – 2012	
Construction Cost	$ 22,559,000
Land & Mitigation Cost	$ 1,320,000
Engineering, Survey, Geotech (22%)	$ 4,963,000
Total Project	**$ 28,842,000**

Refer to **Section XII** of this report for a detailed breakdown of the preliminary cost estimate. This is a variation of a concept proposed by Halff Associates in a report titled, "Capital Improvements Study along Kirby, Prairie & Fish Creek Drainage Basins," dated April 2006. The original concept proposed benching Fish Creek from Robinson Road upstream to Great Southwest Parkway a distance of approximately 10,000 feet. EC's variation would be to reduce the benching along Fish Creek by benching a portion of Prairie Creek. A key component in this proposed project is the widening of the Fish Creek channel downstream of Carrier Parkway. This section of Fish Creek traverses an urban forest preserve which presents a significant challenge to obtaining permission for this type of construction. Typically mitigation for construction through this type of environment requires setting aside a mitigation area on a three to one basis. That is, the City of Grand Prairie would have to set aside three acres of land as mitigation for every acre of disturbed area. The urban forest mitigation will need to be confirmed with Dallas County if this option is pursued.

B. Matthew Road at Fish Creek (Stream Station 259+80)

The existing bridge at Matthew Road is approximately 120' long and is overtopped by a 5-year storm event with the ultimate 100-year storm event overtopping the roadway by over five feet.

Stream: Fish Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
25980	Matthew Road *120' Bridge*	497.61	No WSEL = 496.55	Yes WSEL = 499.08	Yes WSEL = 499.96	Yes WSEL = 500.93	Yes WSEL = 501.68	Yes WSEL = 502.35

No improvements were proposed to Matthew Road, as the City of Grand Prairie's Thoroughfare Master Plan shows that Matthew Road is to be re-routed and widened in the future.

C. Great Southwest Parkway at Prairie Creek (Stream Station 136+87)

The existing crossing at Great Southwest Parkway consists of a four barrel 10’ x 9’ box culvert and is overtopped by the 25-year storm event with the ultimate 100-year storm event overtopping the roadway by more than four feet.

Stream: Prairie Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
13687	Great Southwest Parkway	533.53	No WSEL = 522.24	No WSEL = 528.28	No WSEL = 532.45	Yes WSEL = 535.32	Yes WSEL = 536.58	Yes WSEL = 537.56

Proposed Improvements

- Add an additional four barrel 10’ x 10’ multiple box culvert to the existing crossing

Statement of Probable Cost - 2012	
Construction Cost	$467,000
Non-Construction Cost (22%)	$103,000
TOTAL	**$570,000**

Refer to **Section XII** of this report for a detailed breakdown of the preliminary cost estimate. If the proposed improvements at Great Southwest Parkway were implemented, the roadway would not be overtopped by the ultimate 100-year storm event.

VIII. STORMWATER INFRASTRUCTURE ANALYSIS

A. Overview

No stormwater infrastructure analysis was performed as a part of the FEMA CTP and Road Map Drainage Master Plan Study (Y#0881) contract. Analyses will be added to the Drainage Master Plan as they are completed.

IX. CHANNEL STABILITY ASSESSMENT AND EROSION HAZARD ANALYSIS

A. Introduction

As part of the *FEMA CTP and Road Map City-Wide Drainage Master Plan*, RPS Espey has been tasked to prepare an analysis of stream bank restoration improvement alternatives along with preliminary quantities/estimates of probable cost. The critical data utilized for this analysis comes from the *Fish Creek Geomorphic Stream Assessment* that was prepared by Freese and Nichols, Inc. (FNI) included in **Appendix E**. The report investigated each waterway with field observations. FNI reviewed the channel geometry, planform stability of the natural channel, and the various reasons for erosion of channel banks and flowlines. The FNI reports note that the watershed is almost "built out." They also note that within each analyzed watershed there are areas where the channel has been previously altered for protection and/or stabilization purposes.

The FNI report notes a number of factors impacting the stability and erosion hazard potential of the waterways. The build-out of the watersheds has resulted in an increase in flow in the 1-year storm event which has been called the "channel forming" flow and is thus the flow regime studied in the FNI report. The introduction of channelized sections, particularly those with concrete riprap are typically straightened and steepened as compared to the natural meandering creek. The resulting increase in flow and velocity has resulted in downcutting of the channel bottom and erosion of the streambanks downstream of these "improvements." This, in turn, results in slope failures and tree falls in the natural segments of the streambed that then can cause log jams and streambed widening. These are natural processes that can be expected to occur in dynamically changing streams. However, they are accelerated when urbanization occurs. The downcutting of the streambed has exposed several other problems. There are now numerous pipeline crossings that, though they are concrete encased, are now partially or wholly exposed to flow. Protection of these pipeline crossings is necessary to avoid sanitary spills if the pipelines are damaged by flooding. The other problem found is the exposure of the Eagle Ford shale formation in various channel bottom or sideslopes. Slaking of the exposed shale is noted by FNI as a particular concern.

Finally, the FNI reports cite the numerous aerial crossings of both TRA and Grand Prairie wastewater pipelines as recipients and causes of erosion hazards. A number of the Grand Prairie lines are elevated ten or more feet above the streambed. These do not, for the most part, cause problems with the geomorphic flow regime. However, several crossing locations were noted as suffering scouring around the support piers. Of more particular concern are those pipeline aerial crossings that are within two to five feet of the streambed. Many, if not all, of these are TRA pipelines and they were noted to be clogged with log jams resulting in drops forming over the pipes and erosion downstream. It is our understanding that a number of the TRA pipeline aerial crossings in Fish Creek will be replaced and removed with new underground pipes in the near future by TRA.

From a geomorphic standpoint, the key element to stabilizing the Fish Creek stream network is the equilibrium slope of the streambed. In most reaches, FNI recommends the placement of permanent drop structures for grade control. They recommend a series of small, with approximately 3 feet of vertical drop, drop structures. This resulting equilibrium slope will provide the best environment for maintaining the natural channel planform. The proposed drop locations can also be adjusted to protect exposed pipelines that will not be removed by other projects.

The following sections present findings of stream assessment (identified issues such as utility crossings, bank instability, scour, and sedimentation), current channel slope, preferred equilibrium slope, and alternatives (non-structural and structural measures).

B. Standard Erosion Prevention Measures

1. Non-Structural Measures

As defined by the City of Grand Prairie Drainage Design Manual (DDM), an **erosion hazard setback** (EHS) is defined as the minimum horizontal distance from the toe of the slope of the bank of a watercourse that a structure must be constructed or placed to be outside the erosion hazard area. **Figure IX-1** below represents a generic schematic of the erosion hazard setback based on the City's DDM.

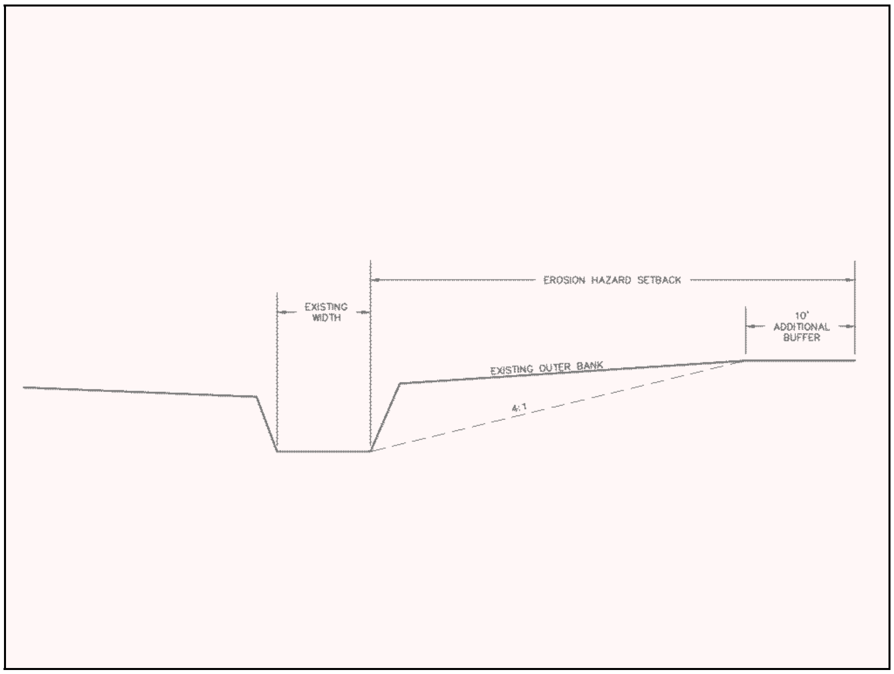


Figure IX-1: Erosion Hazard Setback Schematic

Steps used to determine the erosion control setback is outlined in the City's DDM. The DDM's steps are as follows;

a. Locate the toe of the natural stream bank
b. From this toe, construct a line sloping 4:1 towards the bank until it intersects natural ground.
c. From this intersection, add 10 feet in the direction away from the stream to locate the outer edge of the erosion hazard setback.

The erosion control setback measure will be recommended to the City for problem areas that the City does not deem as a critical project area or for areas where no structures or infrastructure exist.

2. Structural Measures

This section will provide the City with typical structural measures that will assist in erosion prevention.

a. Channel bank improvement recommendations will incorporate natural vegetation on the upper slopes while armoring the critical portion of the channel toe. Surface roughening of slopes, including stair-step grading with small benches or terraces (where right-of-way is available), will facilitate the establishment of vegetative cover, improve water infiltration, enhance seed germination, and decrease runoff velocity. Toe protection will be provided by interconnected **stacked gabion baskets** (SGB). **Figure IX-2** below is an example of the type of gabion basket bank design that would be recommended in areas with severe channel bank erosion.

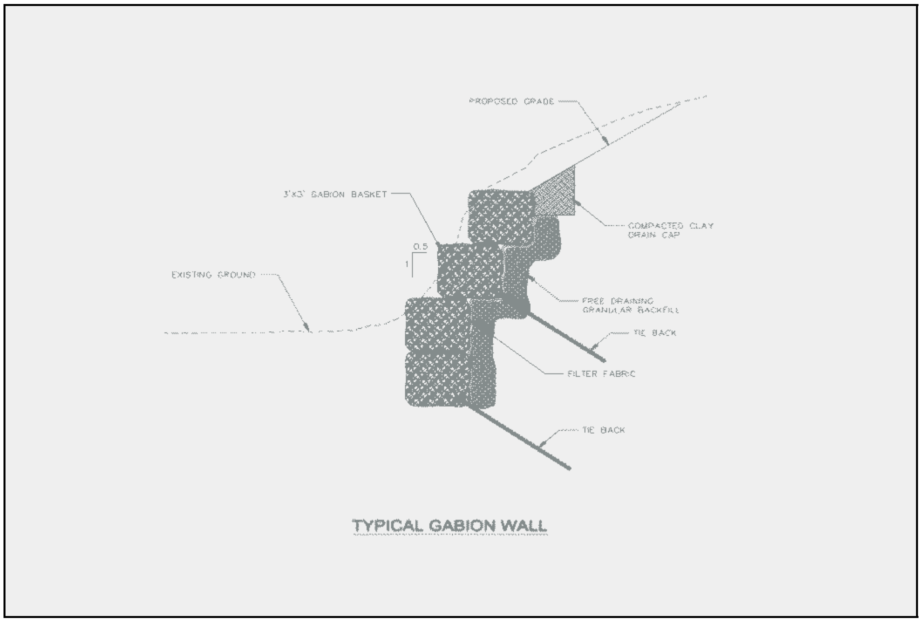


Figure IX-2: Typical Stacked Gabion Basket

b. **Drop structures** (DS) will be utilized at locations along the channel reach were steep slopes have created a flow regime that is conducive to high levels of channel erosion and downcutting. Drop structures placed at specific locations along the channel reach are designed to dissipate energy and velocity. **Figures IX-3** and **IX-4** are a recommended drop structure design that can be applied to locations with or without a utility crossing.

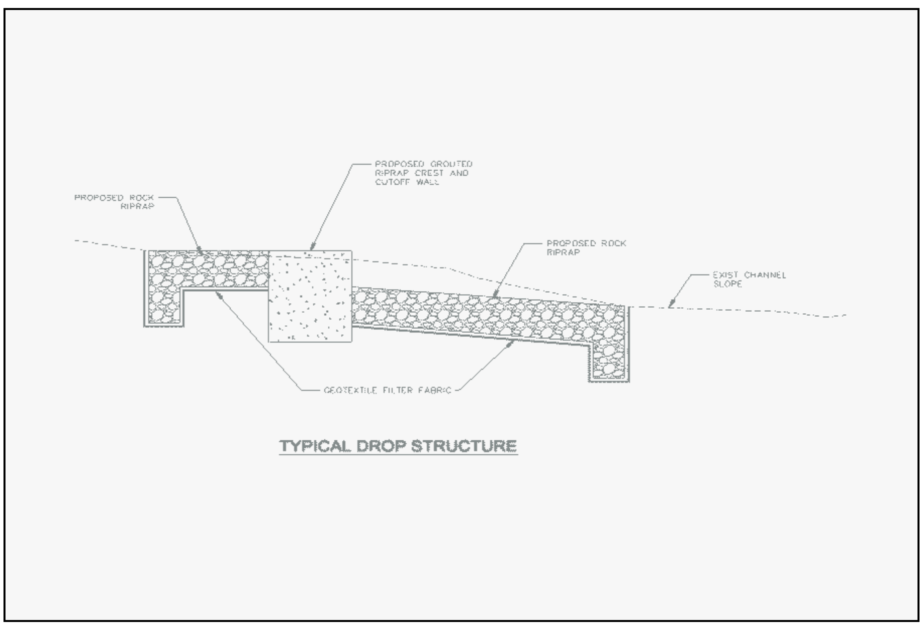


Figure IX-3: Typical Drop Structure

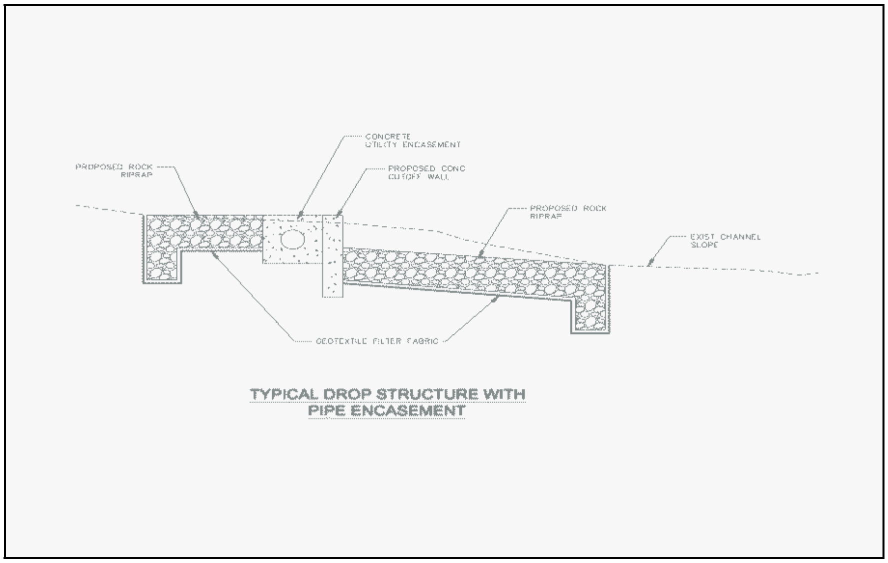


Figure IX-4: Typical Drop Structure with Pipe Encasement

c. The FNI report identifies were the 3-foot vertical drop structures are to be placed. These areas typically suffer from high levels of channel erosion and downcutting. **Dry rock riprap** (DRR) will be recommended for areas currently experiencing downstream, scour, and channel erosion downstream of existing culverts and drop structures.

For the purposes of this report the proposed structures will focus on drop structures with and without pipe encasements as a method of erosion/grade control for each creek section. Stacked gabion baskets are considered specific control solutions for specific problem areas and as such will not be included in proposed overall project recommendations and cost estimates.

C. Fish Creek Main Stem

For this analysis, the Fish Creek Main Stem (FISH) project area extends from Grand Oaks Country Club to just downstream of SH-130. The existing slope for FISH is 0.0018 (ft/ft). The FNI recommended stable slope is 0.001. The FNI report segments FISH by hydraulic model cross section. For this analysis, EC has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure IX-5** shows the general locations of the stream segments discussed below while **Exhibit 1**, within **Appendix A,** shows the extents of the FISH project area in greater detail.

Table IX-1: Fish Creek Main Stem Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
FISH-1	40575-38979	10.4	3 - 3.5 ft	DS, EHS
FISH-2	38979-32167	6.5	2 - 3.5 ft	DS, EHS
FISH-3	32167-31603	0	0	STABLE
FISH-4	31603-27236	0	0	EHS
FISH-5	27236-26695	0	0	EHS
FISH-6	26695-25904	4	2 - 2 ft	DS
FISH-7	25904-20362	0	0	EHS
FISH-8	20362-19644	5.3	2 - 2.5 ft	DS, EHS
FISH-9	19644-17941	0.3	0	EHS
FISH-10	17941-15727	1.1	1 - 1 ft	DS
FISH-11	15727-14575	1.5	2 - 1 ft	DS
FISH-12	14575-5968	0	0	EHS

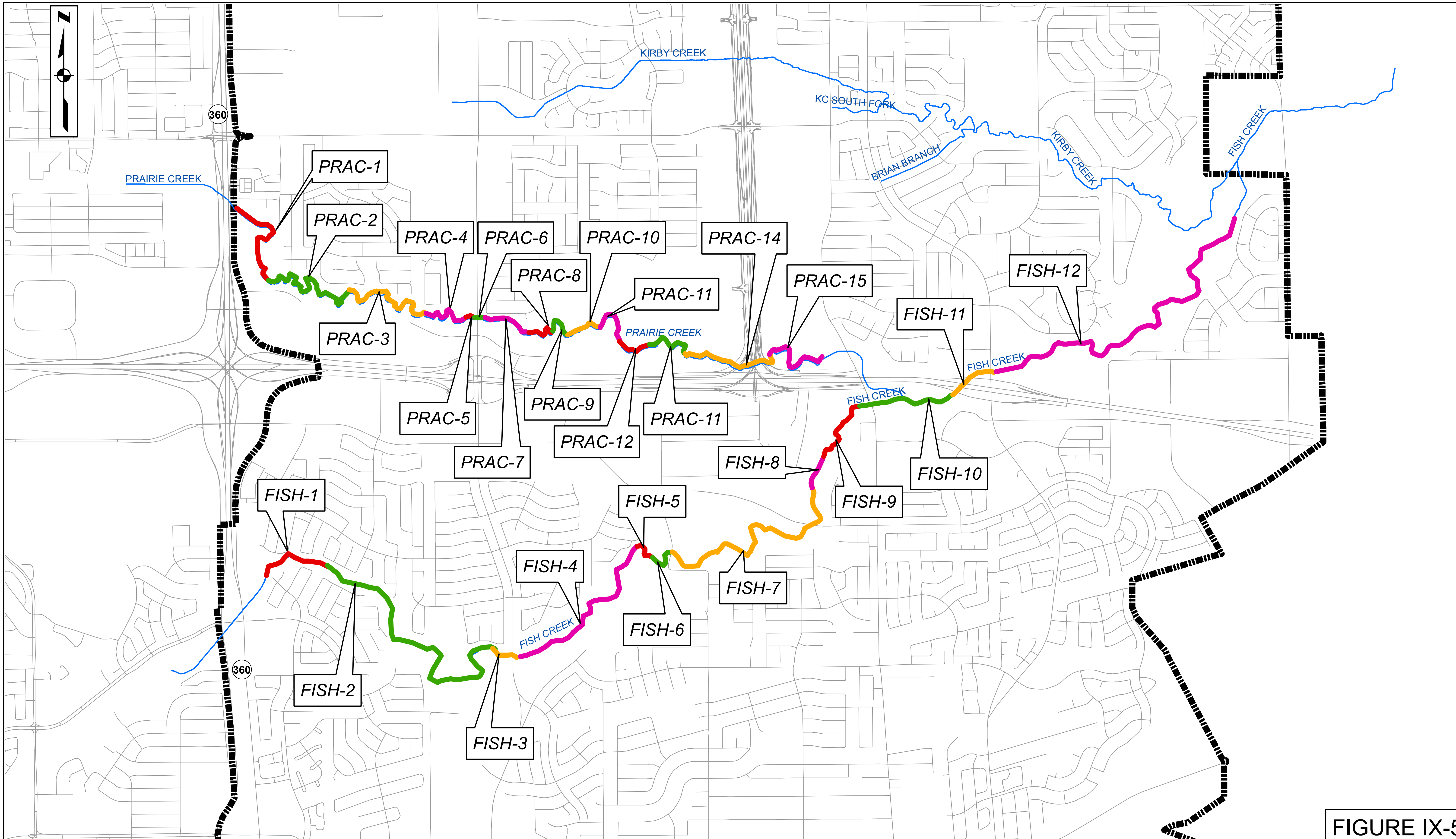


FIGURE IX-5

Grand Prairie TEXAS

RPS Espey

CAPITAL IMPROVEMENT PROJECTS
FISH CREEK

City Wide Drainage Master Plan

July 2012 **GRAND PRAIRIE, TEXAS** PROJECT # 11006

1. **FISH-1**
   It is recommended that a series of three drop structures each 3.5 feet in height be placed starting just downstream of cross section 405+75, along with the establishment of an erosion hazard setback along the left bank.

2. **FISH-2**
   Figure IX-6 shows significant bank erosion near cross section 321+67. An erosion hazard setback should be established in areas that are currently undeveloped. It is also recommended that two 3.5-foot drop structures be placed at cross section 389+79 and 32+167.

Figure IX-6: Bank Erosion at Cross Section 321+67

3. **FISH-4 & 5**
   For areas where no development or City infrastructure exists, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

4. **FISH-6**
   It is recommended that two 2-foot drop structures be placed in series just downstream of cross section 266+95.

5. **FISH-7**
   Figure IX-7 is taken at cross section 252+91 near Matthew Road. Severe bank erosion is within close proximity to transportation infrastructure. Besides the above mentioned area, most of FISH-7 is not directly surrounded by development, so it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

Figure IX-7: Bank Erosion at Cross Section 252+91

6. **FISH-8**

   Figure IX-8 shows significant bank erosion near cross section 200+46.

Figure IX-8: Bank Erosion at Cross Section 200+46

For areas where no development or City infrastructure exists, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place. Two 2-foot drop structures in series should be placed at cross section 203+62.

7. **FISH-9**

   For areas where no development or City infrastructure exists, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

8. **FISH-10**

   It is recommended that a 1-foot drop structure be placed at cross section 179+41.

9. FISH-11

It is recommended that a 2-foot drop structure be placed at cross section 147+25.

10. FISH-12

For areas where no development or City infrastructure exists, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place. **Table IX-2** is an estimated cost summary for the recommended structural measures within NFCC. A more detailed cost estimate is included in **Section XII** of this report.

Table IX-2: FISH Structural Measures Cost Summary

Construction Subtotal	$ 247,950
Approximate Contigency (25%)	$ 61,990
Construction Total	$ 309,940
Approximate Engineering and Survey (15%)	$ 46,490
Total	$ 356,430

D. Prairie Creek Main Stem

For this analysis, the Prairie Creek (PRAC) project area extends from just upstream of S. Robinson Road up to SH-360. The existing slope for PRAC is 0.0037 (ft/ft). The FNI recommended stable slope is 0.0011. The FNI report segments PRAC by hydraulic model cross section. For this analysis, EC has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Exhibit 2** within **Appendix A** shows the extents of the PRAC project area.

Table IX-3: Prairie Creek Main Stem Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
PRAC-1	24306-21693	2.7	1 -3 ft	DS, DRR, EHS
PRAC-2	21693-18097	8.4	4 - 2 ft	DS, EHS
PRAC-3	18097-15272	8.2	4 - 2 ft	DS, EHS
PRAC-4	15272-13910	3.6	1 - 4 ft	DS, EHS
PRAC-5	13910-13687	2.8	1 - 3 ft	DS, EHS
PRAC-6	13687-13486	0	0	none
PRAC-7	13486-12343	1.2	1 - 1 ft	DS
PRAC-8	12343-11554	2.2	1 - 2.5 ft	DS, EHS
PRAC-9	11554-10784	2.2	1 - 2.5 ft	DS, EHS
PRAC-10	10784-9960	0	0	EHS
PRAC-11	9960-8815	5.4	2 - 2.5 ft	DS, EHS
PRAC-12	8815-8043	1	1 - 1 ft	DS, EHS
PRAC-13	8043-6800	3.8	2 - 2 ft	DS, EHS
PRAC-14	6800-4462	4.7	2 - 2.5 ft	DS, EHS
PRAC-15	4462-2757	2.4	1 - 2 ft	DS, EHS

1. **PRAC-1**
   Figure IX-9 shows significant damage to the downstream side of the SH-360 culvert. It is recommended that this damaged area be filled with a combination of grouted riprap and dry rock riprap to a level that matches the downstream flow line of the culvert.

Figure IX-9: Downstream Culvert Damage at SH-360

   It is also recommended that a 3-foot drop structure be placed at cross section 226+96 along with the establishment of an erosion hazard setback.

2. **PRAC-2**
   Figure IX-10 shows significant bank erosion near cross section 210+69, which is in close proximity to residential development. An erosion hazard setback should be established in areas that are currently undeveloped, specifically the right bank of PRAC-2.

Figure IX-10: Bank Erosion at Cross Section 210+69

   It is also recommended that four 2-foot drop structures be placed at various locations near cross sections 216+93 and 201+94.

3. PRAC-3

Similar to PRAC-2, **Figure IX-11** shows significant bank erosion near cross section 180+97, which is in close proximity to residential development. An erosion hazard setback should be established in areas that are currently undeveloped, specifically the right bank. It is also recommended that four 2-foot drop structures be placed at various locations near cross sections 180+97 and 158+32.

Figure IX-11: Bank Erosion at Cross Section 180+97

4. PRAC-4

Figure IX-12 shows significant bank erosion near cross section 149+09, which is in close proximity to residential development. An erosion hazard setback should be established in areas that are currently undeveloped, specifically the right bank of PRAC-4. It is also recommended that a 4-foot drop structure be placed at cross section 104+89.

Figure IX-12: Bank Erosion at Cross Section 9-4

5. PRAC-5

It is recommended that a 1-foot drop structure be placed at cross section 138+05.

6. **PRAC-6**
There are no recommendations outside of stacked gabion baskets to be placed along the left bank just downstream of Great Southwest Parkway.

7. **PRAC-7**
Similar to PRAC-2, **Figure IX-13** shows significant bank erosion near cross section 132+76, which is in close proximity to residential development. It is recommended that a 1-foot drop structure be placed at cross section 123+43.

Figure IX-13: Bank Erosion at Cross Section 132+76

8. **PRAC-8**
Figure IX-14 shows significant bank erosion near cross section 115+54, which is in close proximity to residential development. It is recommended that an erosion hazard setback should be established in areas that are currently undeveloped.

Figure IX-14: Bank Erosion at Cross Section 115+54

It is also recommended that a 2.5-foot drop structure be placed at cross section 119+35.

9. **PRAC-9**
It is recommended that a 2.5-foot drop structure be placed at cross section 115+54.

10. PRAC-10

For areas where no development or City infrastructure exists, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

11. PRAC-11

It is recommended that two 2.5-foot drop structures be placed at cross sections 99+60 and 92+31.

12. PRAC-12

It is recommended that a 1-foot drop structure be placed at cross section 80+43.

13. PRAC-13

It is recommended that two 2-foot drop structures be placed at cross sections 74+62 and 71+52.

14. PRAC-14

Figure IX-15 shows bank erosion at the right bank of cross section 24+63, near the elevated portions of the IH-20 access road. It is recommended two 2.5-foot drop structures be placed at cross sections 52+52 and 48+32. An erosion hazard setback should be established for the entire portion of PRAC-14 that is currently undeveloped.

Figure IX-15: Bank Erosion at Cross Section 24+63

The following table is an estimated cost summary for the recommended structural measures within PRAC. A more detailed cost estimate is included in **Section XII** of this report.

Table IX-4: SFCC Structural Measures Cost Summary

Construction Subtotal	$ 506,370
Approximate Contigency (25%)	$ 126,595
Construction Total	$ 632,965
Approximate Engineering and Survey (15%)	$ 94,945
Total	$ 727,910

X. DAMS / LEVEES / DETENTION / DRAINAGE REVIEWS

A. Dams / Levees

There are fourteen small lakes in the Fish Creek watershed, all of which were rated as in Good Condition

B. Detention Ponds

The City of Grand Prairie's GIS database indicated forty-six (46) possible detention ponds within the Fish Creek Basin. All of these locations were visited to verify the existence and condition of the ponds. There are twenty-seven (27) ponds designed to provide detention for fourteen (14) small lakes. The locations of these ponds are shown on **Figure X-1.**

C. Detention Pond Maintenance

A visual inspection of all the ponds was conducted and condition was ranked according to the following:

1. **Good –** Requires no corrective maintenance, continued normal inspections.
2. **Fair –** Requires some corrective maintenance, not immediate.
3. **Poor –** Requires immediate corrective maintenance.
4. **Failure –**Requires immediate assistance beyond corrective maintenance.

The majority of the ponds are in good condition. Nine (9) of the twenty-seven (27) detention ponds were rated as fair. Most of the ponds rated fair were given this rating due to their need of mowing, particularly around the headwalls. One of these ponds was rated fair due to a minor amount of erosion on the south bank near two headwalls. This erosion could progressively become more significant if maintenance is not conducted. **Table X-1** describes the condition assigned to each detention pond. Each entries pond number correlates with **Figure X-1.**

Table X-1: Fish Creek Detention Pond Maintenance Condition

Pond No.	City Plan ID	Type	Condition
1	53	Detention	Good
2	154	Detention	Good
3	153	Detention	Fair – Erosion on South Bank
4	332	Detention	Good
5	54	Detention	Good
6	52	Detention	Good
7	51	Detention	Good
8	341	Detention	Good
9	168	Detention	Fair – Needs Mowing
10	185	Detention	Good
11	319	Detention	Fair – Bar Screen needs to be Fastened
12	318	Detention	Fair – Needs Mowing
13	179	Detention	Fair – Needs Mowing
14	323	Detention	Fair – Needs Mowing
15	161	Detention	Good
16	160	Detention	Fair – Needs Mowing
17	322	Detention	Good
18	321	Detention	Good

Pond No.	City Plan ID	Type	Condition
19	209	Off Channel Pond	Low Point Pond not used for Detention
20	46	Natural	Good
21	163	Detention	Good
22	162	Natural	Good
23	344	Detention	Fair – Needs Mowing
24	165	Retention	Good
25	50	Off Channel Pond	Good
26	307	Off Channel Pond	Good
27	308	Off Channel Pond	Good
28	311	Off Channel Pond	Good
29	309/310	Off Channel Pond	Good
30	201	Off Channel Pond	Good
31	312	Off Channel Pond	Good
32	169	On Channel Pond	Good
33	166	Natural	Good
34	167/172	Natural	Good
35	47	Retention	Good
36	207	Wetland	Area is a Wetland
37	205	Wetland	Area is a Wetland
38	178	Does not Exist	Detention Pond Does Not Exist
39	206	Off Channel Pond	Private Off Channel Pond
40	314	Wetland	Area is a Wetland
41	208	Off Channel Pond	Private Stock Tank
42	238	Detention	Fair – Needs Mowing
43	45	On Channel Pond	Good
44	143	On Channel Pond	Good
45	83	On Channel Pond	Good
46	210	Off Channel Pond	Good

Photos were taken in June 2011 as part of the individual verification of each pond and to document condition and any maintenance issues noted during the visual inspection.

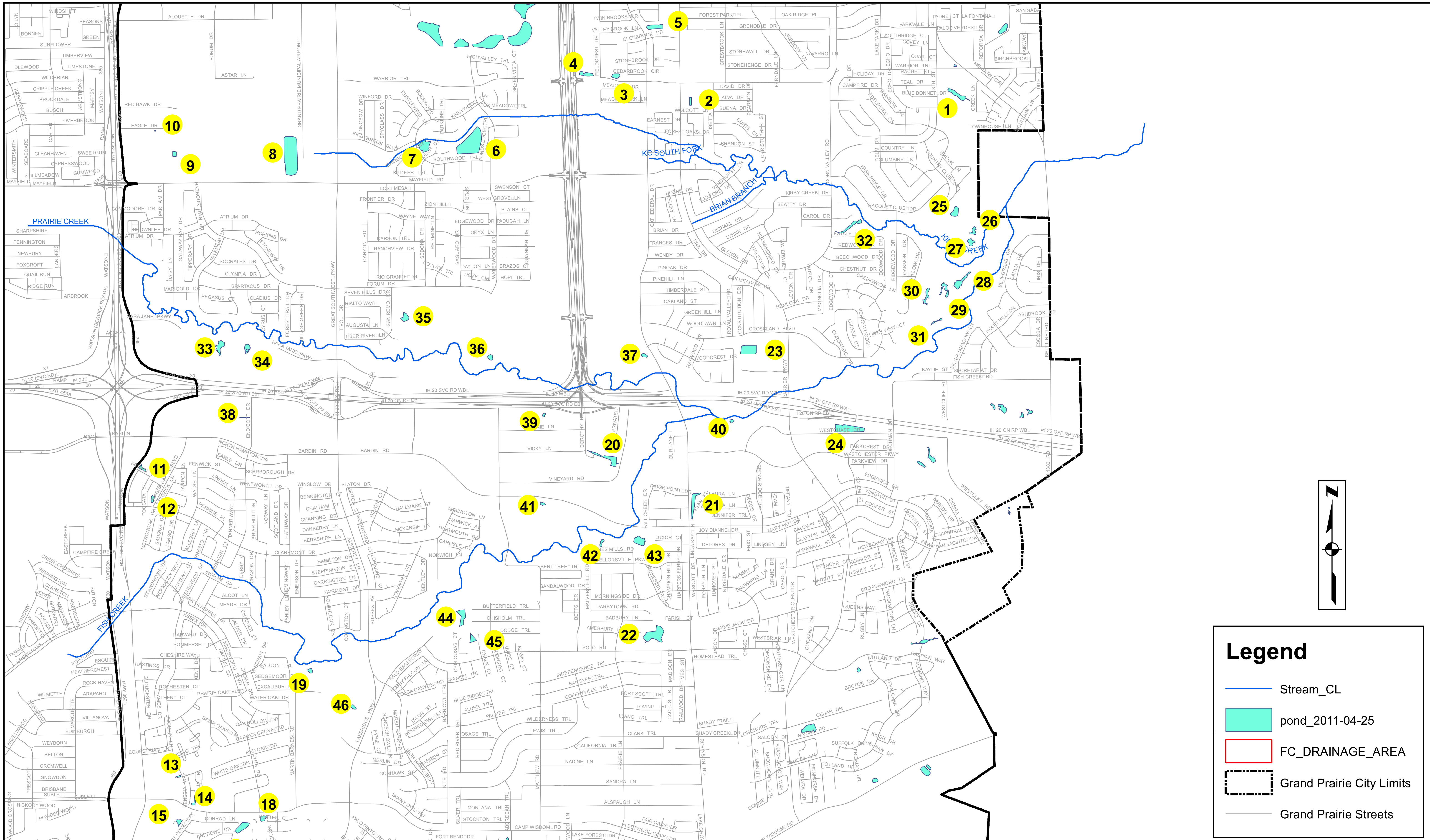


FIGURE X-1
DETENTION PONDS
FISH CREEK
City Wide Drainage Master Plan
GRAND PRAIRIE, TEXAS

March 2012

PROJECT # 11006

Figure X-2: FC Detention Pond No. 1: Homestead Cemetery

Figure X-3: FC Detention Pond No. 2: Behind Crossroads Natural Health

Figure X-4: FC Detention Pond No. 3: Thurgood Marshall Elementary School

Figure X-5: FC Detention Pond No. 4: Dubiski Career High School

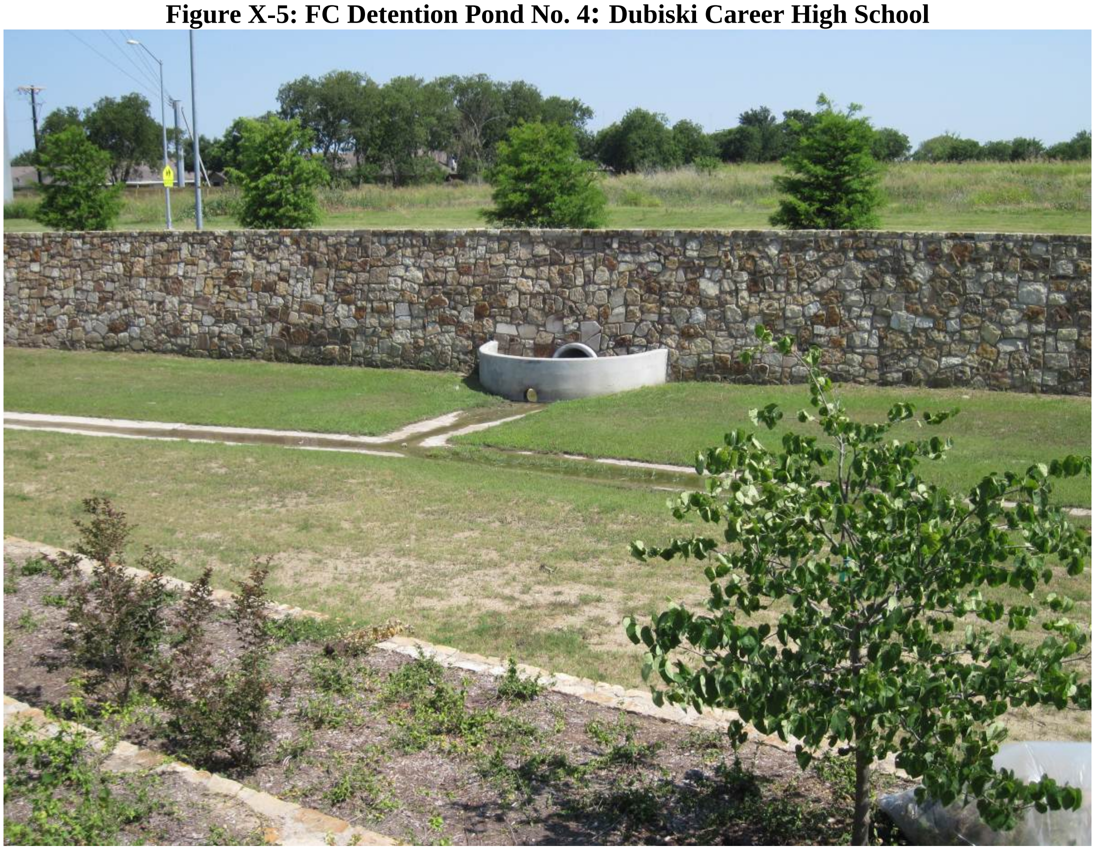


Figure X-6: FC Detention Pond No. 5: Residential Pond off Robinson Road

Figure X-7: FC Detention Pond No. 6: Large Pond Behind Southwood Trail

Figure X-8: FC Detention Pond No. 7: Small Pond Behind Southwood Trail

Figure X-9: FC Detention Pond No. 7: Small Pond Behind Southwood Trail

Figure X-10: FC Detention Pond No. 8: Near Grand Prairie Airport

Figure X-11: FC Detention Pond No. 9: Behind Furniture Market off Mayfield Road

Figure X-12: FC Detention Pond No. 10: Off Eagle Drive

Figure X-13: FC Detention Pond No. 11: Apartments off I-20 Frontage

Figure X-14: FC Detention Pond No. 12: Apartments off Magna Carta Boulevard

Figure X-15: FC Detention Pond No. 13: Westside of Magna Carta just North of Camp Wisdom

Figure X-16: FC Detention Pond No. 14: Eastside of Magna Carta just north of W Camp Wisdom

Figure X-17: FC Detention Pond No. 15: Commercial Development South of W Camp Wisdom

Figure X-18: FC Detention Pond No. 16: Large Commercial Development Behind Home Depot

Figure X-19: FC Detention Pond Outfall No. 16: Large Commercial Development Behind Home Depot

Figure X-20: FC Detention Pond No. 17: Between Conrad Lane & Brewster Court

Figure X-21: FC Detention Pond No. 18: Off Potter Court

Figure X-22: FC Off-Channel Pond No. 19: North of Excalibur Drive

Figure X-23: FC Natural Pond No. 20: Between Dorothy & Vineyard Road

Figure X-24: FC Detention Pond No. 21: NE Corner of Robinson and Bardin Roads

Figure X-25: FC Natural Pond No. 22: North of W Polo Road, East of Boscombe Court

Figure X-26: FC Natural Pond No. 23: Behind Target West of S. Carrier Parkway

Figure X-27: FC Retention Pond No. 24: Next to Chilis off I-20

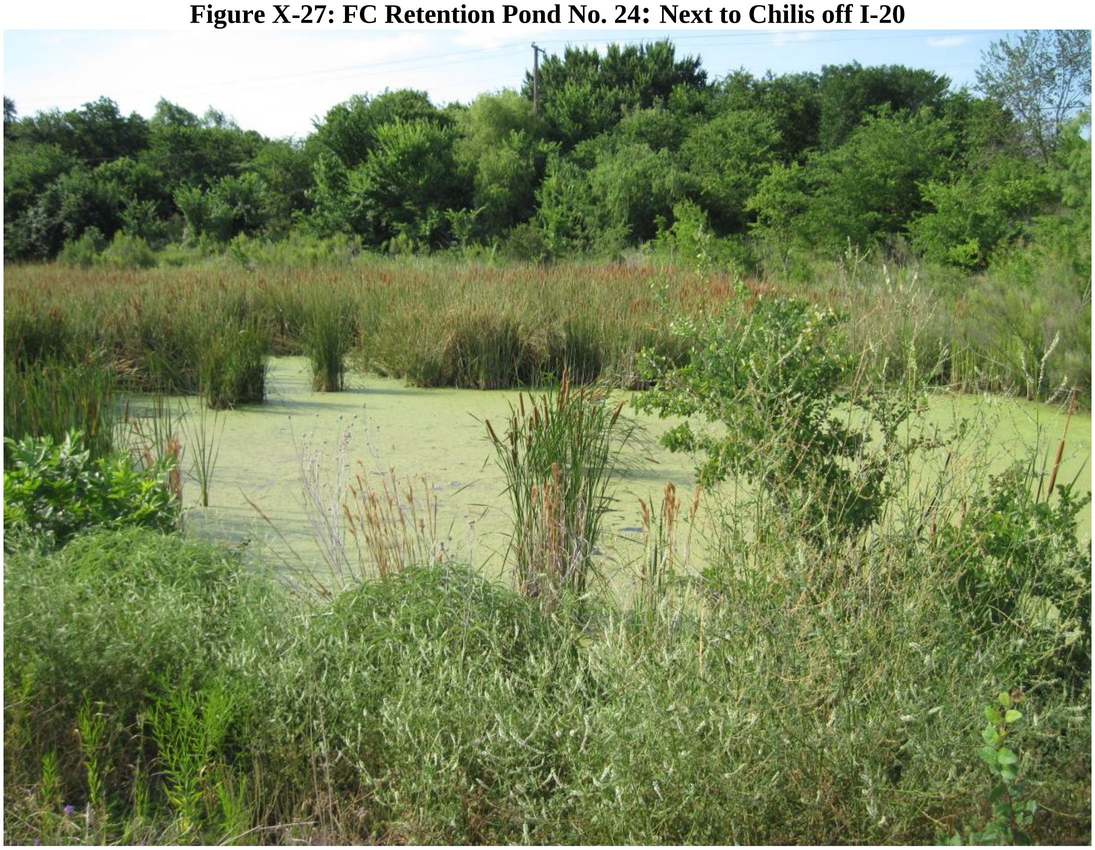


Figure X-28: FC On-Channel Pond No. 32: Behind Estate Drive off Corn Valley Road

Figure X-29: FC Detention Pond No. 42: Behind Gaines Mills Road

Figure X-30: FC On-Channel Pond No. 43: South of Bardin, Behind Luxor Court

Figure X-31: FC On-Channel Pond No. 44: Behind Chisholm Trail

Figure X-32: FC On-Channel Pond No. 45: Off Chalk Court

XI. STORM DRAIN OUTFALL ASSESSMENT

The City of Grand Prairie provided photographs of each storm drain outfall as well as a GIS shapefile showing their locations and conditions at the time the photographs were taken. RPS Espey examined this information and compiled the following condition assessment. Outfalls recommended as high priority were field verified.

A. Condition and Criteria

The City of Grand Prairie's database of storm drain outfalls, inlets, channels, culverts and bridges was utilized for this study. These structures were ranked in terms of needing maintenance and repair. For the Fish Creek watershed, there were 357 structures in the City of Grand Prairie's database.

The structures were assigned one of the four following conditions:

1. **Good –** Requires no corrective maintenance, continued normal inspections.
2. **Fair –** Requires some corrective maintenance, not immediate.
3. **Poor –** Requires immediate corrective maintenance.
4. **Failure –** Requires immediate assistance beyond corrective maintenance.

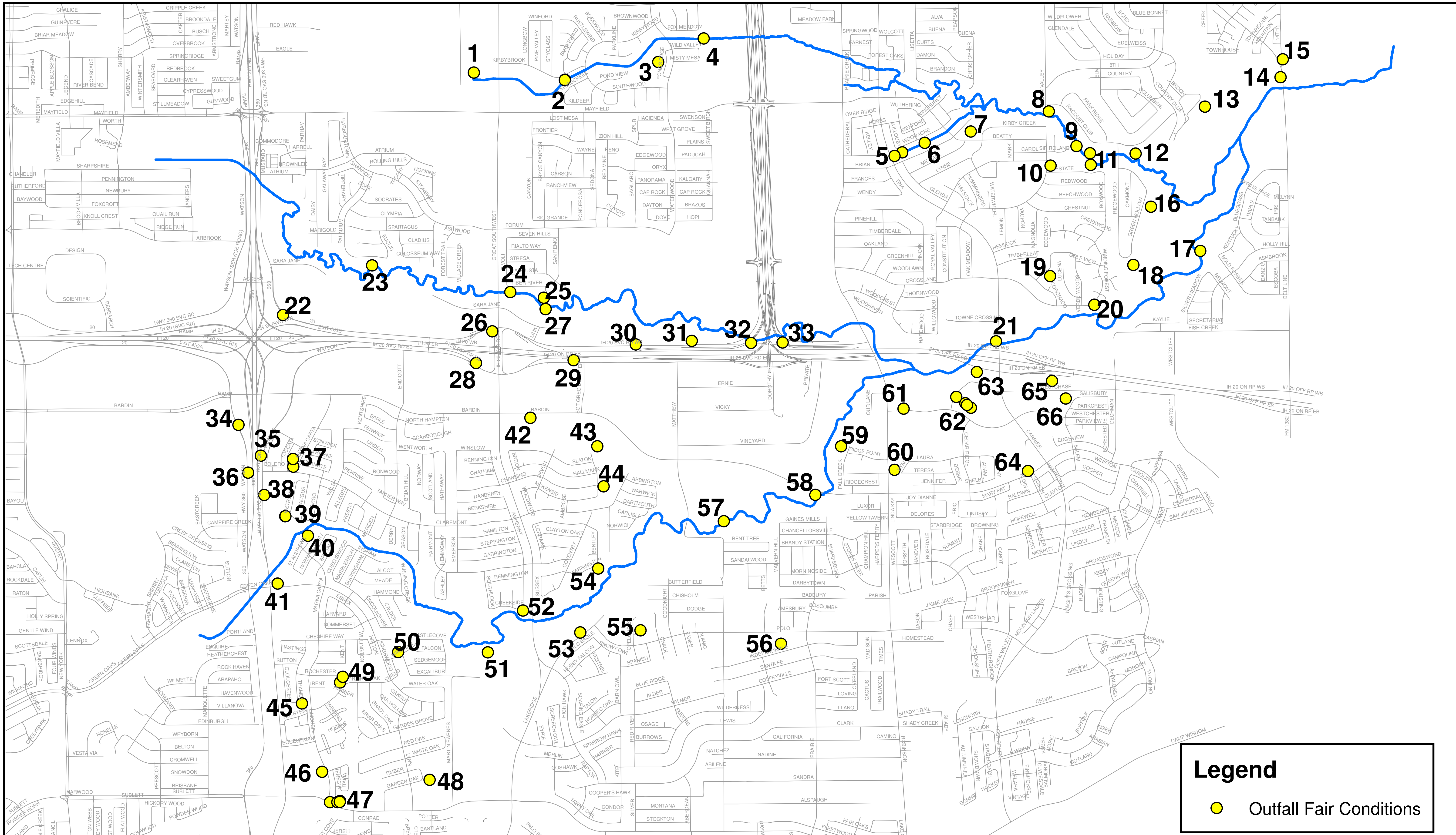
The majority of the structures are in good condition – 239 of 357 rated Good (67%). Seventy-eight (78) structures were rated as fair (22%), mostly due to the need for erosion control and siltation/vegetation clearing. The following **Table XI-1** lists the structures assigned as having a fair condition. Each entries map number correlates with the Fish Creek Structure Locations – Fair Conditions Map, **Figure XI-1**.

Table XI-1: Fish Creek Structures – Fair Conditions

Map No.	SDD_ID_N	TYPE	COMMENTS
1	259	OUTFALL	Fair – End of Rip Rap Needs to be Repaired
2	684	OUTFALL	Fair – Vegetation at Outflow Needs Clearing
2	685	OUTFALL	Fair – Vegetation at Outflow Needs Clearing
3	854	OUTFALL	Fair – Cracked Headwall
4	686	OUTFALL	Fair – Vegetation Needs Clearing
5	823	OUTFALL	Fair – Serious Crack near Headwall Needs to be Repaired
5	713	OUTFALL	Fair – Slight Cracking on Rip Rap at Top of Pipe
6	712	OUTFALL	Fair – Slight Cracking on Rip Rap at Top of Pipe
7	524	OUTFALL	Fair – Eroding Beneath Apron Erosion Control Bedding Needed
8	273	OUTFALL	Fair – Erosion Around Pipe. Needs Rip Rap
9	825	OUTFALL	Fair – Large Gravel Rip Rap Needed on Both Sides of Channel
10	437	OUTFALL	Fair – Bank on Private Property Eroding Badly
11	495	OUTFALL	Fair – Erosion Under Apron and Wingwalls
11	431	OUTFALL	Fair – Erosion Protection Needed on Outlines of the Apron
12	496	OUTFALL	Fair – Structure Could Use Rip/Rap. Slight Erosion
13	439	OUTFALL	Fair – Apron Needs Erosion Protection Reinforcements
14	1054	OUTFALL	Fair – Needs Graded Rip Rap Channel to Prevent Erosion Near/Under Bridge Ramp
15	992	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared. Tree Removal
16	486	OUTFALL	Fair – Moderate Failing in Rip Rap Needs Repair. Also Cracking in Flowline of Flume

Map No.	SDD_ID_N	TYPE	COMMENTS
17	700	OUTFALL	Fair – Structure needs Rip/Rap. Erosion Under Apron
18	485	OUTFALL	Fair – Outfall Structure Needs Backfall Protection
19	474	OUTFALL	Fair – Outfall Needs Clearing. Erosion Protection Needed at Outfall
20	677	OUTFALL	Fair – Channel Needs to be Graded. Standing Water in Flowline
21	680	OUTFALL	Fair – Cracking in Rip Rap to be Monitored
22	1218	OUTFALL	Fair – Flow Line Needs to be Graded. Siltation Needs to be Cleared
23	830	OUTFALL	Fair – Slight Erosion Beneath Headwall Needs to be Re-Grouted
24	481	OUTFALL	Fair – Channel Needs Dredging. Pipe Half Full of Siltation
25	1139	OUTFALL	Fair – Heavy Siltation and Debris Needs Clearing
26	982	OUTFALL	Fair – Flow Line Needs to be Graded. Siltation Needs to be Cleared
27	104	OUTFALL	Fair – Rip Rap Needed
28	979	OUTFALL	Fair – Erosion Control Bedding Needed. Siltation Needs to be Cleared
29	985	OUTFALL	Fair – Pipe is Full of Siltation. Needs to be Cleared
30	986	OUTFALL	Fair – Needs Protective Toe Wall. Erosion Will Undercut Structure Quickly
31	987	OUTFALL	Fair – Needs Rip Rap Between Apron and Channel. Cracking Under Apron
32	988	OUTFALL	Fair – Flow Line Needs to be Graded. Siltation Needs to be Cleared
33	990	OUTFALL	Fair – Eroding Beneath Apron. Channel Needs Rip Rap
34	1220	OUTFALL	Fair – Pipe is Full of Siltation. Needs to be Cleared
35	1185	OUTFALL	Fair – Structure is Cracking. Will Eventually Need Attention
36	1222	OUTFALL	Fair – Needs Erosion Control Bedding
37	1579	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared
37	1363	OUTFALL	Fair – Needs Toe Wall and Rip/Rap Around Wingwalls. Erosion Accruing
38	1184	OUTFALL	Fair – Heavy Vegetation in 2 Boxes Needs to be Removed
39	1365	OUTFALL	Fair – Siltation Needs to be Cleared
39	1366	OUTFALL	Fair – Siltation Needs to be Cleared
40	119	OUTFALL	Fair – Vegetation Needs to be Cleared. Tree Removal
41	602	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared.
42	587	OUTFALL	Fair – Vegetation Needs to be Cleared
43	201	OUTFALL	Fair – Siltation Needs to be Cleared
44	202	OUTFALL	Fair – Erosion Under Apron. Vegetation Needs to be Cleared
45	156	OUTFALL	Fair – Vegetation Needs to be Cleared
46	1775	OUTFALL	Fair – Trash and Debris Needs to be Removed from Pipe
47	160	OUTFALL	Fair – Siltation Needs to be Cleared
47	1676	OUTFALL	Fair – Flow Line Needs to be Graded. Siltation Needs to be Cleared
47	1678	OUTFALL	Fair – Heavy Siltation Needs to be Removed. Rip Rap Bedding Needs to be Installed
47	1679	OUTFALL	Fair – Heavy Siltation Needs to be Removed. Rip Rap Bedding Needs to be Installed
48	162	OUTFALL	Fair – Siltation Needs to be Cleared
49	159	OUTFALL	Fair – Vegetation Needs to be Cleared
49	164	OUTFALL	Fair – Siltation Needs to be Cleared
50	166	OUTFALL	Fair – Siltation Needs to be Cleared
51	1509	OUTFALL	Fair – Rip Rap Needed at Flow Line of Channel to Prevent Undercutting
52	206	OUTFALL	Fair – Debris Needs to be Cleared
53	175	OUTFALL	Fair – Vegetation Needs to be Cleared
54	205	OUTFALL	Fair – Slight Erosion Beneath Wingwall
55	881	OUTFALL	Fair – Erosion Control Bedding Needed
56	885	OUTFALL	Fair – Pipe Exposed Needs Backfill

Map No.	SDD_ID_N	TYPE	COMMENTS
57	212	OUTFALL	Fair – Toe Wall Needed to Prevent Further Erosion
58	1498	OUTFALL	Fair – Erosion Control Rip Rap is Needed
59	102	OUTFALL	Fair – Starting to Erode Around Headwall. Channel Needs to be Cleared
60	1230	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared
61	419	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared. Tree Removal.
62	889	OUTFALL	Fair – Signs of Erosion Along Top of Headwall. Siltation Clearing Needed. Reestablish Rip Rap
62	890	OUTFALL	Fair – Re-grading and Rip Rap Needed Along Channel
62	1585	OUTFALL	Fair – Siltation Needs to be Cleared. Tree Removal
62	1586	OUTFALL	Fair – Re-grading and Rip Rap Needed Along Channel
63	1473	OUTFALL	Fair – Flow Line Needs to be Graded to Prevent Holding Water
64	113	OUTFALL	Fair – Vegetation Needs to be Cleared
65	1767	OUTFALL	Fair – Debris Needs to be Cleared
66	590	OUTFALL	Fair – Channel Needs to be Graded. Standing Water in Flowline



Grand Prairie TEXAS

RPS Espey

MARCH 2012

FIGURE XI-1
FISH CREEK OUTFALL LOCATIONS
FAIR CONDITIONS
FEMA CTP MAPPING
GRAND PRAIRIE, TEXAS

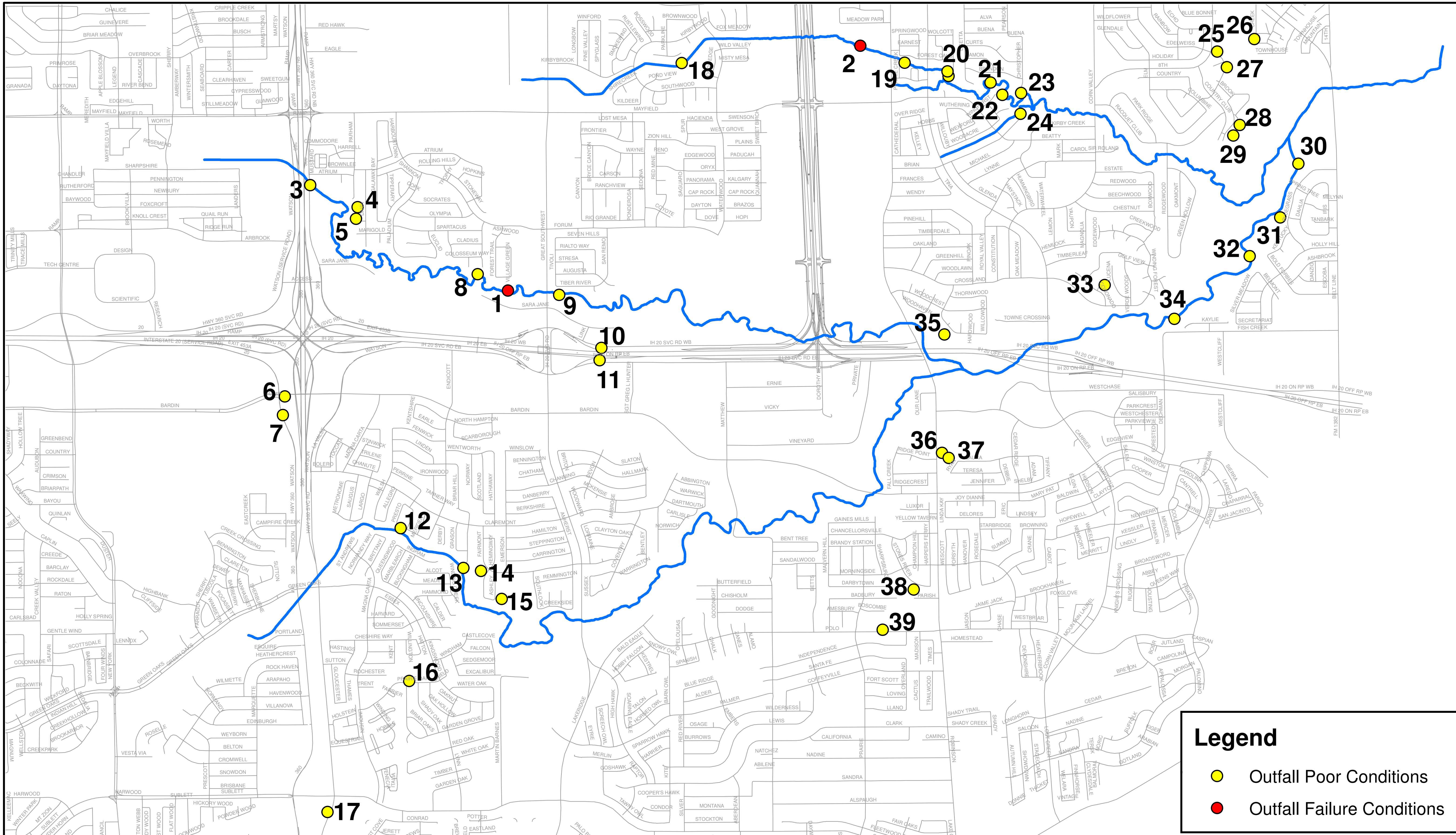
PROJECT # 10060

There were thirty-eight (38) structures rated as being poor, which requires immediate corrective maintenance. This rating was given mostly when erosion has begun to significantly undercut or erode behind the structure and/or when the structure was completely covered with siltation/vegetation. Without corrective repair, erosion will continue to cause the structures to ultimately fail. **Table XI-2** lists the structures assigned as having a poor/failure condition. Each entries map number correlates with the Fish Creek Structure Locations – Poor/Failure Conditions Map, **Figure XI-2**.

Table XI-2: Fish Creek Structures – Poor Conditions

Map No.	SDD_ID_N	TYPE	COMMENTS
1	429	OUTFALL	**Failure** – Pipe Joint Failure. Structure has Washed Downstream. Belongs on Opposite Side of Creek
2	432	OUTFALL	**Failure** – Structure Completely Washed Away and Separated
3	828	OUTFALL	**Poor** – Apron Washed Out/Failed. Large Main Box Structure is Sound but Undercutting will Occur. TXDOT Issue
4	572	OUTFALL	**Poor** – Outfall Completely Blocked. Needs to be Cleared
5	573	OUTFALL	**Poor** – Outfall Completely Blocked. Needs to be Cleared
6	1224	OUTFALL	**Poor** – Wingwall Separated from Rip-Rap. Cracked Wingwall. Erosion Beneath Apron
7	1219	OUTFALL	**Poor** – Pipe is Completely Covered with Siltation. Needs to be Cleared
8	504	OUTFALL	**Poor** – Apron/Wingwall Completely Eroded. Sandbags Placed under Wingwalls to Temporarily Prevent Failure.
9	599	OUTFALL	**Poor** – Structure Washed Out Beneath Apron. Toewall Required
10	547	OUTFALL	**Poor** – Outfall Completely Full of Siltation/Vegetation. Needs to be Cleared
11	984	OUTFALL	**Poor** – Heavy Vegetation Needs to be Cleared. Possible Tree Removal
12	191	OUTFALL	**Poor** – Fully Eroded Beneath Apron
13	194	OUTFALL	**Poor** – Fully Eroded Beneath Apron. Cracking already Occurring
14	1233	OUTFALL	**Poor** – Channel Needs to be Cleared. Full of Debris
15	611	OUTFALL	**Poor** – Heavy Vegetation Needs to be Cleared. Check for Structure Failures
16	170	OUTFALL	**Poor** – Heavy Erosion Undercutting Apron.
17	1187	OUTFALL	**Poor** – Pipe Completely Full of Siltation Needs Clearing. Rip Rap Needed
18	852	OUTFALL	**Poor** – Completely Eroded Down to the Pipe Behind Outfall Structure
19	1465	OUTFALL	**Poor** – Pipe Completely Covered with Rip/Rap and Vegetation
20	400	OUTFALL	**Poor** – Erosion had Undercut Apron. Will Eventually Undercut Outfall
20	401	OUTFALL	**Poor** – Outfall 90% Full of Siltation. Needs to be Cleared.
21	489	OUTFALL	**Poor** – Completely Eroded Beneath Wingwalls. Cracked Pipe Separated at Joint
22	425	OUTFALL	**Poor** – Major Erosion and Siltation needs Clearing
23	488	OUTFALL	**Poor** – Apron Eroded. Heavy Vegetation Needs Clearing.
24	1136	OUTFALL	**Poor** – Completely Eroded Around Structure
25	1217	OUTFALL	**Poor** – Heavy Debris Needs Clearing. Possible Wingwall Failure
26	913	OUTFALL	**Poor** – Pipe Completely Full of Siltation. Needs Rip Rap Bedding. Flow Line Needs to be Graded.
27	521	OUTFALL	**Poor** – Erosion has Fully Undercut Apron which is Monolithically part of Structure
28	438	OUTFALL	**Poor** – Erosion Undercutting Apron. Heavy Vegetation Needs Clearing
29	436	OUTFALL	**Poor** – Erosion Severely Undercutting Flume
30	428	OUTFALL	**Poor** – Ditch Needs Re-Grading. Pipe Full of Siltation. Structure Needs Erosion Control Bedding.
31	435	OUTFALL	**Poor** – Toewall Installation Needed. Erosion will Undercut Structure Very Soon
32	701	OUTFALL	**Poor** – Possible Pipe Flowline Failure. Needs Rip Rap and Erosion Control

Map No.	SDD_ID_N	TYPE	COMMENTS
33	475	OUTFALL	**Poor** – Outfall Completely Full of Silt. Needs Clearing
34	544	OUTFALL	**Poor** – Outfall Completely Blocked. Needs to be Cleared
35	483	OUTFALL	**Poor** – Completely Eroded Underneath Apron. Apron Part of Outfall Structure.
36	195	OUTFALL	**Poor** – Erosion Undercutting West Side of Flume
37	1229	OUTFALL	**Poor** – Heavy Debris Needs Clearing
38	1492	OUTFALL	**Poor** – Brush and Debris Completely Blocking Outflow
39	886	OUTFALL	**Poor** – Apron Severely Undercut. Could Lead to Erosion Under Bridge



Grand Prairie TEXAS

RPS Espey

MARCH 2012

FIGURE XI-2
FISH CREEK OUTFALL LOCATIONS
POOR/FAILURE CONDITIONS
FEMA CTP MAPPING
GRAND PRAIRIE, TEXAS

PROJECT # 10060

XII. PRELIMINARY QUANTITIES / ESTIMATES OF PROBABLE COST

A. Stream and Open Channel Improvements

Table XII-1: Summary of Stream and Open Channel Improvements

Location	Proposed Project	Probable Cost
Carrier Pkwy, IH-20, & Robinson Road at Fish & Prairie Creeks	Widen the Bridge at Carrier, widen the downstream channel, replace the concrete channel under IH-20, improve the upstream channel.	$ 28,842,000
Great Southwest Parkway at Prairie Creek	Add an additional four barrel 10' x 10' multiple box culvert to the existing crossing	$570,000

Carrier Parkway, IH-20, & Robinson Road at Fish & Prairie Creeks				
Description	Quantity	Units	Unit Price	Cost
Site/ROW Preparation	1	L.S.	$ 500,000	$ 500,000
Channel Excavation	723,000	C.Y.	$ 9.60	$ 6,941,000
Embankment (Density Control)	16,000	C.Y.	$ 12.00	$ 192,000
Demolition (Existing Conc. Liner)	29,500	S.Y.	$ 12.00	$ 354,000
Bridge Deck	24,000	S.F.	$ 65.00	$ 1,560,000
Concrete Channel Lining (unformed)	371,000	S.F.	$ 24.00	$ 8,904,000
Concrete Retaining Wall	39,400	S.F.	$ 60.00	$ 2,364,000
Topsoil	35,000	S.Y.	$ 2.40	$ 84,000
Seed & Fertilize	35,000	S.Y.	$ 2.40	$ 84,000
Soil Retention Blanket	35,000	S.Y.	$ 2.40	$ 84,000
24" Rock Riprap	2,000	C.Y.	$ 120.00	$ 240,000
Filter Fabric	6,600	S.Y.	$ 2.40	$ 16,000
Relocate 30" Waterline	300	L.F.	$ 360.00	$ 108,000
Relocate 60" TRA Sanitary Sewer	1,460	L.F.	$ 600.00	$ 876,000
Misc. Utility Adjustments	1	L.S.	$ 252,000	$ 252,000
		Construction Cost		$ 22,559,000
Land Acquisition	32	ac.	$ 10,000	$ 320,000
Forest Preserve Mitigation	75	ac.	$ 10,000	$ 750,000
Stream Mitigation	5	ac.	$ 50,000	$ 250,000
		Land & Mitigation Cost		$ 1,320,000
	Construction Cost			$ 22,559,000
	Engineering, Survey, Geotech (22%)			$4,963,000
	Land & Mitigation Cost			$ 1,320,000
	Total Project			**$ 28,842,000**

Great Southwest at Prairie				
Add an additional four barrel 10' x 10' multiple box culvert to the existing crossing				
Description	Quantity	Units	Unit Price	Cost
Pavement	400	lf	$114.00	$45,600.00
Road Demolition	1,000	sy	$6.40	$6,400.00
Headwall Demolition	1	ls	$6,000.00	$6,000.00
10x10 Box Culvert	552	lf	$650.00	$358,800.00
Headwall	2	ea	$12,000.00	$24,000.00
Riprap	180	cy	$120.00	$21,600.00
Channel Excavation	350	cy	$10.00	$3,500.00
Hauling	350	cy	$3.00	$1,050.00
			Construction Cost	$466,950.00
			Construction Cost	$467,000.00
			Non-Construction Cost (Engineering, Survey, Geotech – 22%)	$103,000.00
			Total Project	**$570,000.00**

B. Stream Bank Stability

Table XII-2: Summary of Stream Stability Improvements

Location	Probable Cost
Fish Creek	$356,430
North Fork Fish (Prairie) Creek	$727,910

FISH CREEK PROBABLE COST					
Item Description	**Qty**	**Unit**	**Unit Cost**		**Amount**
Site Preparation	400	STA	$50.00	$	20,000
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$	5,000
Construction Entrance	7	EA	$5,000.00	$	35,000
Unclassified Channel Excavation	1,748	CY	$10.40	$	18,180
Grouted Riprap (24" thick)	219	CY	$150.00	$	32,850
Loose Riprap (D50 = 12", 24" thick)	1,141	CY	$120.00	$	136,920
Approximate 25% Contingency					$ 61,990
			SUBTOTAL		**$ 309,940**
Engineering and Surveying (15%)					$ 46,490
			TOTAL ESTIMATED COST		**$ 356,430**

Construction Subtotal	$ 247,950
Approximate Contingency (25%)	$ 61,990
Construction Total	$ 309,940
Approximate Engineering and Survey (15%)	$ 46,490
Total	**$ 356,430**

PRAIRIE CREEK PROBABLE COST				
Item Description	**Qty**	**Unit**	**Unit Cost**	**Amount**
Site Preparation	1,460	STA	$50.00	$ 73,000
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	14	EA	$5,000.00	$ 70,000
Unclassified Channel Excavation	2,904	CY	$10.40	$ 30,200
Grouted Riprap (24" thick)	363	CY	$150.00	$ 54,450
Loose Riprap (D50 = 12", 24" thick)	2,281	CY	$120.00	$ 273,720
Approximate 25% Contingency				$ 126,595
				$ 632,965
Engineering and Surveying (15%)				$ 94,945
			TOTAL ESTIMATED COST	**$ 727,910**

Construction Subtotal	$ 506,370
Approximate Contingency (25%)	$ 126,595
Construction Total	$ 632,965
Approximate Engineering and Survey (15%)	$ 94,945
Total	**$ 727,910**

XIII. EVALUATION AND PRIORITIZATION / PHASING AND IMPLEMENTATION

A. Evaluation and Prioritization

The City of Grand Prairie's *City-Wide Drainage Master Plan Road Map* has a procedure for ranking and prioritizing drainage improvement projects. The ranking matrix is shown in **Table XIII-1**.

- **Step 1** of the Prioritization Plan would develop the Initial Ranking Factor based on the estimate of probable cost versus the number of properties/structures benefitted:

Table XIII-1: Ranking Matrix

Ranking Matrix				
		Number of Properties Benefitted		
		High > 10	**Medium 5 to 10**	**Small < 5**
Estimate of Probable Cost ($)	**Small < $500k**	1	2	3
	Medium $500 k to $1.5 mil	2	3	4
	Large > $1.5 mil	3	4	5
	X-Large (>$5M)	6	7	8
	Super-Size (>$10M)	9	10	11

- **Step 2** of the Prioritization Plan would be to develop a second factor for ranking based on the number of citizens impacted, by potential for roadway shutdowns if no improvements were made on existing roadways, and by a cost to benefit ratio of proposed improvements per roadway citizens impacted.

<u>Sub-Step 1 – Determine Existing Roadway Type</u>

Table XIII-2: Roadway Classifications

Roadway Classification
HWY
P7U
P6D
P4D
P3U
M5U
M4U
M3U
C2U

Sub-Step 2 – Determine Existing Conditions Roadway Flood Event Protection and Percentage of Roadway Citizens Protected

Table XIII-3: Citizens Protected

Roadway Flood Event Protection	Percentage of Citizens Protected[1]
1-Year	0%
2-Year	15%
5-Year	35%
10-Year	50%
25-Year	70%
50-Year	85%
100-Year	100%

[1]Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% and with 100-Year Event protecting 100%

Sub-Step 3 – Determine Percentage of Roadway Citizens Impacted

100% minus percentage of citizens protected in Sub-Step 2

Sub-Step 4 – Determine Number of Roadway Citizens Impacted

Table XIII-4: Citizens Impacted

Roadway Type Benefitted	Percentage of Citizens Protected[1]
HWY	20800
P7U	12740
P6D	11700
P4D	7800
P3U	5460
M5U	8450
M4U	6760
M3U	5070
C2U	2730

[1] Based on percentage of citizens impacted multiplied by [No. Lanes * 4 hours impacted * hourly volume per lane * Level of Service C Traffic Volume (see following Table)]

Table XIII-5: Roadway Benefit

Grand Prairie Classification	NCTCOG Classification	Lanes	Hourly Service Vol./lane	NCTCOG LOS*			Current UDC "LOS C" Traffic Volume
				Roadway Capacity LOS E	LOS D	LOS C	
P7U	Principal Arterial-Undiv.	7	700	49,000	39,200	31,850	42,000
P6D	Principal Arterial-Divided	6	750	45,000	36,000	29,250	42,000
P4D	Principal Arterial-Divided	4	750	30,000	24,000	19,500	28,000
P3U	Principal Arterial-Undiv.	3	700	21,000	16,800	13,650	18,000
M5U	Minor Arterial	5	650	32,500	26,000	21,125	28,000
M4U	Minor Arterial	4	650	26,000	20,800	16,900	22,000
M3U	Minor Arterial	3	650	19,500	15,600	12,675	18,000
C2U	Collector	2	525	10,500	8,400	6,825	10,000
L2U	Local Street	2	525	10,500	8,400	6,825	8,000
LU	Local Street	1	525	5,250	4,200	3,413	8,000
R2U	Rural Street	2	525	10,500	8,400	6,825	8,000

* = from the Dallas-Fort Worth Regional Travel Model Manual, Exhibits 23 and 24
NCTCOG capacity: LOS E = (# lanes) * 10 * (NCTCOG Hourly Service Volume per Lane)
NCTCOG capacity: LOS D = (LOS E) * .8
NCTCOG capacity: LOS C = (LOS E) * .65

<u>Sub-Step 5 – Determine Cost to Benefit of Roadway Number of Citizens Impacted</u>

Divide the estimate of probable cost by the results from Sub-Step 4 to determine the cost to benefit ratio (in dollars).

<u>Sub-Step 6</u> – Develop Second Ranking Factor with highest rank being the lowest cost to benefit ratio.

- <u>Step 3</u> of the Prioritization Plan would be to determine the total tax value of all the properties with structures that are benefitted by the project from Step 1. Develop Third Ranking Factor based on the table below.

Table XIII-6: Value of Benefitted Structures

Total Tax Value of Properties with Structures Benefitted	Third Ranking Factor
$2,000,000+	1
≥ $1,900,000	2
≥ $1,800,000	3
≥ $1,700,000	4
≥ $1,600,000	5
≥ $1,500,000	6
≥ $1,400,000	7
≥ $1,300,000	8
≥ $1,200,000	9
≥ $1,100,000	10
≥ $1,000,000	11
≥ $ 900,000	12
≥ $ 800,000	13
≥ $ 700,000	14

Total Tax Value of Properties with Structures Benefitted	Third Ranking Factor
≥ $ 600,000	15
≥ $ 500,000	16
≥ $ 400,000	17
≥ $ 300,000	18
≥ $ 200,000	19
$0 to $ 199,000	20

- **<u>Step 4</u>** – Provide sum of first, second, and third ranking factors. Next, provide the initial ranking, with the top-ranked (#1) project having the lowest total ranking factor. Continue this method until all projects are ranked.

- **<u>Step 5</u>** – If two or more projects are ranked the same in Step 4, then these projects need to be sorted further. The higher ranked of these projects would be the one that has the <u>greatest ultimate 100-year discharge at the project location</u>.

- **<u>Step 6</u>** – Provide the Final Ranking, with the top-ranked (#1) project having the lowest total ranking factor and include the sorted project rankings from Step 5.

- **Additional Notes on Ranking**

  - Phased projects shall be ranked in order of phasing. *For example, Phase1 of a project shall be ranked higher than Phase 2 of a project.* Note: that if this occurs, the Phased projects can only move down in the overall rankings, not up.
  - Also, if a project is dependent on another downstream project, then the consultant shall take this into account and consider this as phasing of an overall project.
  - If two projects in different watersheds have the same rank in Step 4 and need to be sorted in Step 5, but have similar ultimate 100-year discharges (within 500 cfs), then the projects should be ranked in order of the <u>lowest estimate of probable cost.</u>
  - Rankings will be adjusted as each individual watershed master plan is completed. Each project will be ranked as follows:
    - Ranked among other projects in same watershed
    - Ranked among other projects in City of Grand Prairie
    - Ranked among various size projects in City of Grand Prairie (Small, Medium, Large, and Extra Large/Super Size)

Table XIII-7: Roadway Level of Service Classifications

Level of Service Classifications and Capacities		
Classification	**Lanes**	**Max. Daily Traffic Volume (vehicles per day)**
HWY-Highway	-	-
P7U-Major Principal Arterial	7 undivided	33,000
P6D-Major Principal Arterial	6 undivided	35,500
P4D-MinorPrincipal Arterial	4 undivided	24,000
M5U-Minor Arterial	5 undivided	21,000
M4U-Major Collector	4 undivided	17,000
C2U-Collector	2 undivided	8,500
*note: 5U and 7U roadways contain center turn lanes		

The project priorities are shown in **Table XIII-8**. Project receiving a ranking of 3 or less in Step 1 of the ranking process are considered short term priorities, while projects receiving ranking of 4 or higher are considered long term priorities. There are four projects with a ranking of 2, making them short term priority, and seven long term priority projects.

Table XIII-8 : Project Priorities

City Wide Drainage Master Plan

Fish Creek

	Capital Improvement Project Alternative	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property Structures [7]		Sum of 1st, 2nd, and 3rd Factors - Step 4	Initial Rank - Step 4	100-Year Ultimate Discharge at CIP Location - Step 5		Final Rank - Step 6
			# Structures	Cost	1st Factor [1]	Type	Roadway Flood Event Protection	Roadway % Citizens Protected [3]	Roadway % Citizens Impacted [4]	Roadway # Citizens Impacted [5]	Cost to Benefit Roadway # Citizens Impacted [6]	2nd Factor	Tax Value of Property Structures Benefited	3rd Factor	Total	Rank [8]	Ultimate Q_{100}	Sorting [9]	Rank [10]
1	IH-20/Carrier at Fish Creek	Super-Size/Long-Term	10	$28,842,000	10	HWY	2	15%	85%	66200	$435.68	2	$2,000,000	1	13	1	26,347		1
2	GSW Pkwy at Prairie Creek	Medium/Long-Term	0	$570,000	4	P4D	10	50%	50%	3900	$146.15	1	$0	20	25	2	10,589		2
3	Fish Creek Stream Stability Projects	Small/Short-Term	0	$356,430	3	N/A	N/A	N/A	N/A	N/A	N/A	3	$0	20	26	3			3
4	North Fish (Prairie) Creek Stream Stability Projects	Medium/Long-Term	0	$727,910	4	N/A	N/A	N/A	N/A	N/A	N/A	3	$0	20	27	4			4

1 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 1
2 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 2
3 Based on approximation, using logarithmic chart, with 1-Year Event coverage protecting 0% of traffic volume and 100-Year Event coverage protecting 100% of traffic volume
4 Percent Impacted = 100% minus % of Roadway Citizens Protected (approximate)
5 Number Impacted = % Impacted multiplied by [No. Lanes * 4 Hours Impacted * Hourly Volume Per Lane * Level of Service "C" Traffic Volume]
6 Cost of CIP divided by Roadway # Citizens Impacted
7 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 3
8 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 4
9 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 5
10 Refer to City-Wide Drainage Master Plan Road Map, Section II.G - Implementation Plan - Step 6
Additional Notes:
a. Phased projects shall be ranked in order of Phasing (i.e. Phase 1 shall be ranked higher than Phase 2, etc.)
b. In Step 5, when comparing projects between two different watersheds: If two projects have same rank in Step 4 and need to be sorted, but have similar 100-Year Ultimate Discharges, then projects should be ranked in order of lowest cost estimate

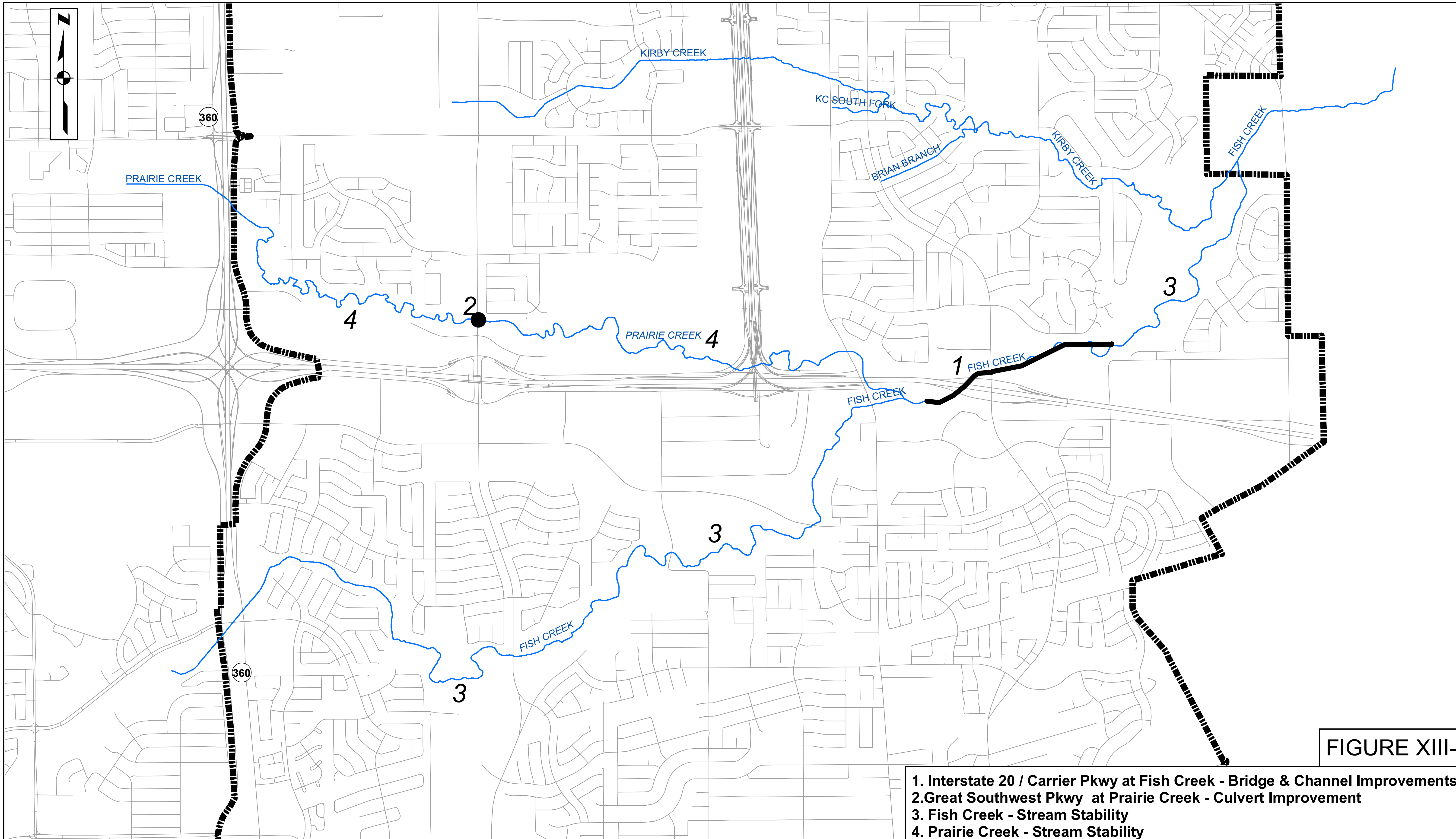


FIGURE XIII-I

1. Interstate 20 / Carrier Pkwy at Fish Creek - Bridge & Channel Improvements
2.Great Southwest Pkwy at Prairie Creek - Culvert Improvement
3. Fish Creek - Stream Stability
4. Prairie Creek - Stream Stability

Grand Prairie TEXAS

RPS Espey

CAPITAL IMPROVEMENT PROJECTS
FISH CREEK

City Wide Drainage Master Plan

March 2012

GRAND PRAIRIE, TEXAS

PROJECT # 11006

B. Implementation

A number of factors must be taken into consideration in the implementation of any specific project. These include:

- Coordination of projects within a watershed
- Availability of funding
- City-wide prioritization

1. **Coordination of Projects Within a Watershed.** A flood mitigation project can affect peak flows and flood levels both upstream and downstream of the project. The magnitude of these effects can vary considerably and are very project specific. The details of a specific project and its relationship with other projects within a watershed should be carefully considered. Construction of multiple projects or phasing of a large project should be planned so as to minimize these effects. In general, projects which improve the conveyance or capacity of a stream, such as a channel improvement or enlarging a culvert, tend to reduce flood level along the project as well as upstream of the project while tending to increase peak flow rates downstream of the project; therefore, the normal practice for these types of projects is to begin downstream and work upstream. Detention or storage projects tend to reduce peak flows downstream and should be constructed before any channel improvements which may be located downstream of the storage project.

2. **Availability of Funding.** The availability of funding will also be an important factor in the determination of which projects are constructed and the timing of the construction. Projects which will benefit other governmental entities as well as the City of Grand Prairie may qualify for joint funding; an obvious example would be an improvement to a roadway owned and operated by the Texas Department of Transportation could possibly be funded in part by TxDOT. The City may also be eligible for funds from FEMA's Flood Mitigation Assistance Program.

3. **City-Wide Prioritization.** The methodologies for project rankings and priorities, discussed in **Section XIII-A,** have been applied to the projects within the Fish watershed. The City of Grand Prairie has developed a *City-Wide Drainage Master Plan Road Map* which provides a strategy for implementing drainage projects across the entire City. The projects in the watersheds will be included in this Master Plan. All of the projects from the various watersheds will be ranked using the same criteria and a City-wide priority list will be created. In this City-wide approach, the projects which provide the most benefits for the least cost will tend to be highest on the priority list. Final implementation will be based on these priorities.

XIV. SHORT TERM PRIORITIES AND LONG TERM PLAN

A. Short-Term Priorities Implementation

There is one short-term project in the Fish Creek Basin. The Fish Creek stream stabilization project. Construction access will have a significant bearing on this project, and permanent easements will be required at all locations were the City does not have drainage easements or property ownership. This project would most likely qualify for nationwide permits under CWA Section 404, which would require a wetlands delineation and pre-construction notification of the United States Army Corps of Engineers (Corps) at a minimum.

B. Long-Term Plan Implementation

Great Southwest at Prairie Creek is a culvert modification project; therefore, the majority of the construction should occur within existing street Right-of-Way minimizing the requirements for obtaining easements. This project would most likely qualify for nationwide permits under CWA Section 404, which would require a wetlands delineation and pre-construction notification of the Corps at a minimum.

A key component of the proposed project for IH-20 and Fish Creek is the widening of the Fish Creek channel downstream of Carrier Parkway. This section of Fish Creek traverses an urban forest preserve which presents a significant challenge to obtaining permission for this type of construction. Typically, mitigation for construction through this type of environment requires setting aside a mitigation area on a three-to-one basis. That is the City of Grand Prairie would have to set aside three acres of land as mitigation for every acre of disturbed area.

XV. MASTER PLAN STUDY WRAP-UP AND RECOMMENDATIONS

The fundamental objective of this Fish Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed for the Fish Creek watershed as well as to address existing flooding, erosion, and sedimentation within the basin. Future watershed conditions are also projected, particularly the fully developed watershed conditions and planned transportation improvements now being implemented. The information presented in this report will provide the City of Grand Prairie with the necessary updated drainage information to coordinate future development according to the City's drainage requirements and help minimize existing and potential flood damages within the Fish Creek watershed.

A. Streams and Open Channels

There is one stream improvement project, IH-20/Carrier Parkway at Fish Creek, which serves to mitigate flooding of businesses as well as roadways. The remaining project is designed to mitigate roadway flooding at the Great Southwest Parkway culvert. These projects should be included in the evaluation future Capital Improvement Projects for the City.

B. Stream Bank Stability

Fish Creek varied from severely to moderately unstable and twelve project areas have been identified along this Creek. North Fork of Fish (Prairie) Creek also varied from severely to moderately unstable; fourteen project areas have been identified along this Prairie Creek. The projects in the severely unstable reaches of the creeks should be given higher priorities as the stream will continue to degrade until they have been stabilized.

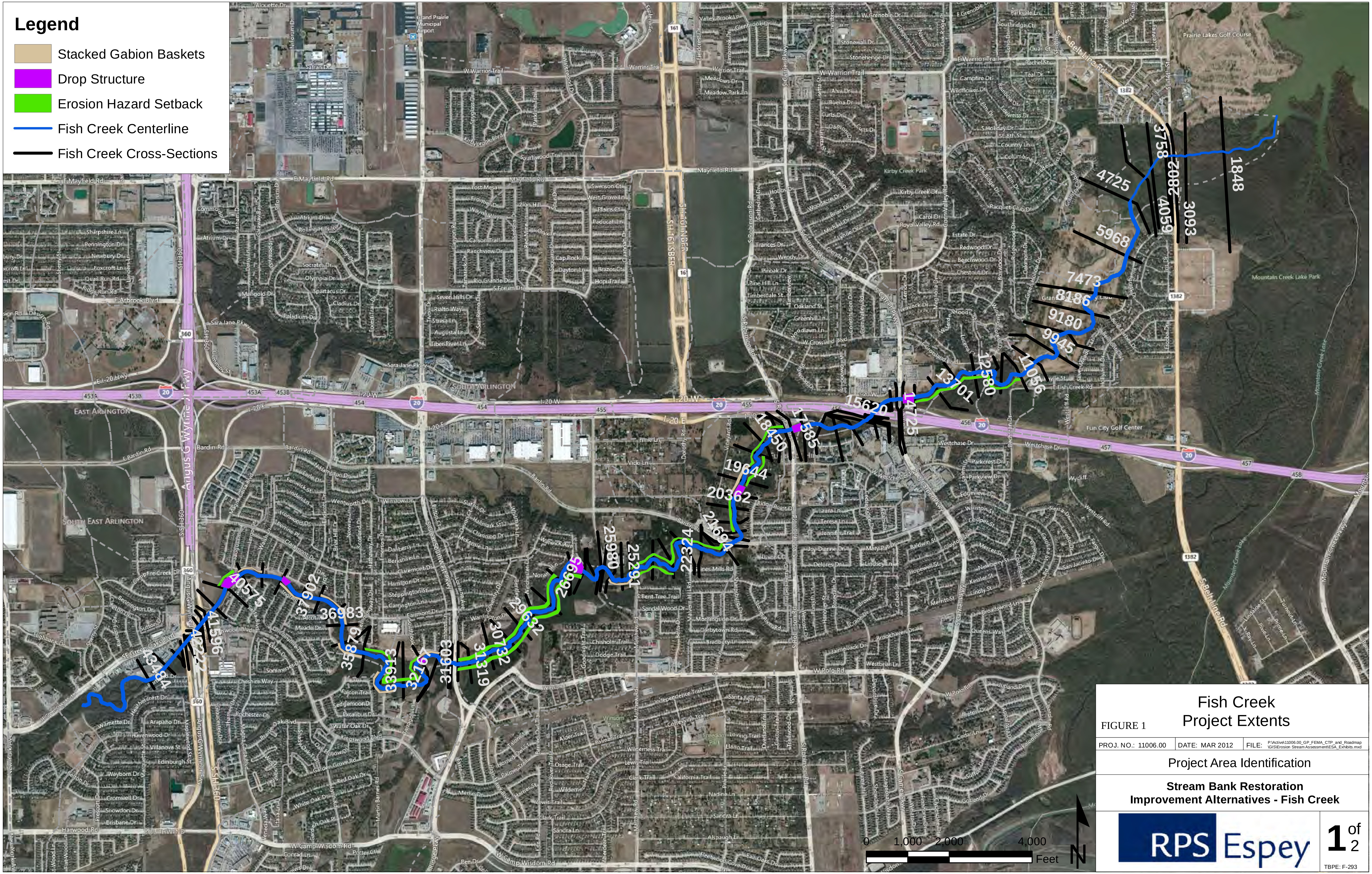
C. Maintenance

The storm drain outfalls and detention ponds rated as poor or worse should be scheduled for maintenance as soon as budget allows. Maintenance is an ongoing task, and it is recommended that the City establish a program of regular inspection of storm drain outlets, bridge abutment and piers, culverts, detention ponds and dams. These inspections would then be used to establish the budget for the next maintenance cycle.

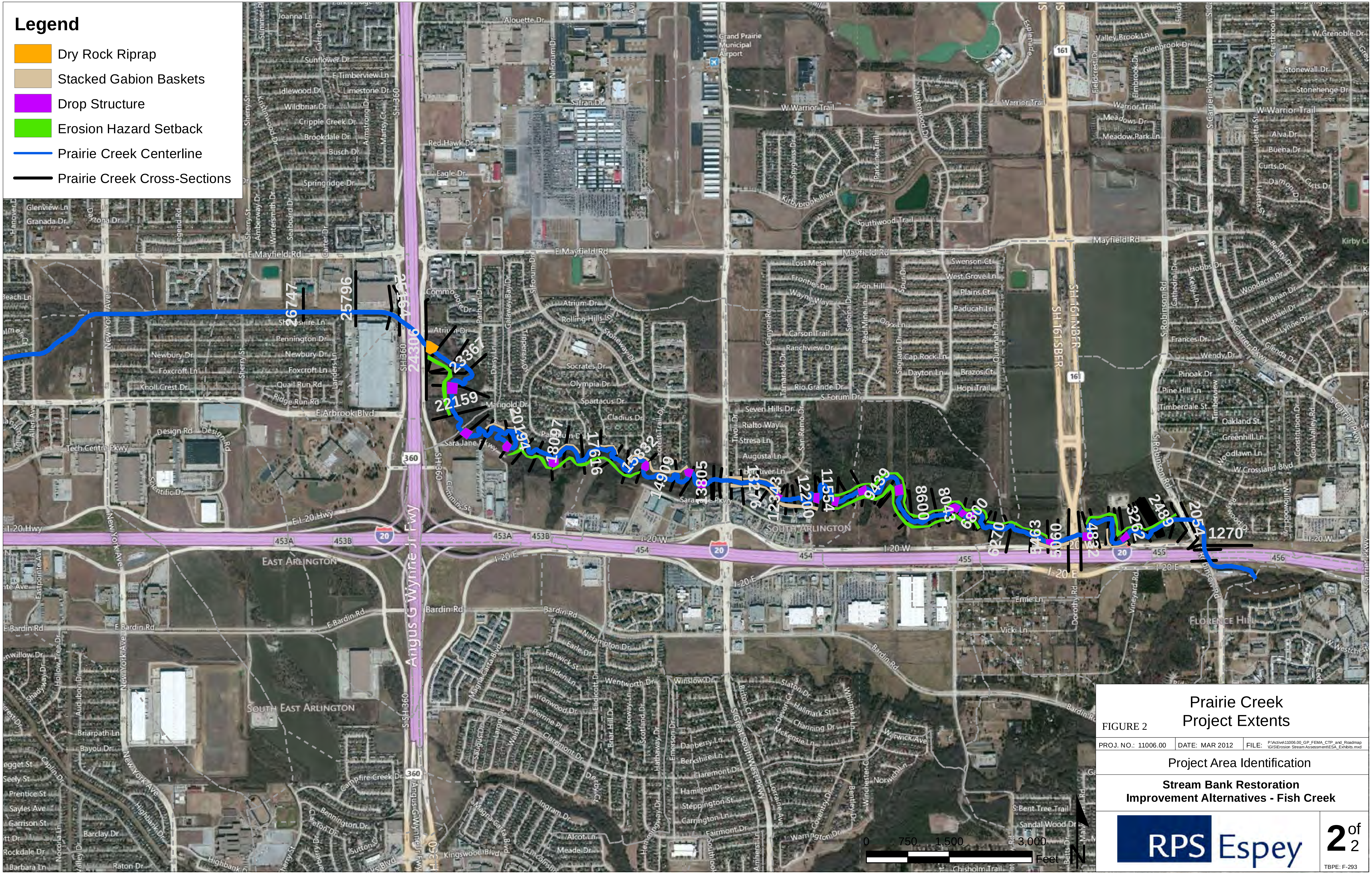
D. Future Studies and Report Updates

This Master Plan has been envisioned as a living document; as projects are completed and new studies done, the appropriate sections of this report should be updated to reflect the latest information and conditions. As was discussed in **Section VIII,** there are several stormwater infrastructure modeling projects scheduled for FY2013 in this basin. The results of these analyses should be included in this report as they become available.

Appendix A
Figures



Legend
Stacked Gabion Baskets
Drop Structure
Erosion Hazard Setback
Fish Creek Centerline
Fish Creek Cross-Sections
1848
2082
3093
3758
4059
4725
5968
7473
8186
9180
9945
11056
12580
13701
14725
15620
17585
18450
19644
20362
21694
22324
25291
25980
26695
29632
30732
31319
31603
32176
33013
35873
36983
37902
40575
41596
43184
Fish Creek
Project Extents
FIGURE 1
PROJ. NO.: 11006.00
DATE: MAR 2012
Project Area Identification
Stream Bank Restoration
Improvement Alternatives - Fish Creek
RPS Espey
1 of 2
TBPE: F-293
0 1,000 2,000 4,000
Feet
N


Legend
Dry Rock Riprap
Stacked Gabion Baskets
Drop Structure
Erosion Hazard Setback
Prairie Creek Centerline
Prairie Creek Cross-Sections
0 750 1,500 3,000
Feet
N
FIGURE 2
Prairie Creek
Project Extents
PROJ. NO.: 11006.00
DATE: MAR 2012
FILE:
Project Area Identification
Stream Bank Restoration
Improvement Alternatives - Fish Creek
RPS Espey
2 of 2
TBPE: F-293

Appendix B
Tables

	A	B	C	D	E	F	G	H	I	J	K
1	**EXISTING CONDITIONS**										
2	**TR-55 Method of Computing the Time of Concentration**										
3					FC_01	FC_02	FC_03	FC_04	FC_05	FC_06	FC_07
4	**Sheet Flow**		variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.011	0.240	0.013	0.013	0.240	0.240
6		Flow Length	L	feet	60.00	20.00	50.00	20.00	20.00	50.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.023	0.018	0.005	0.005	0.010	0.010
9		Travel time	Tt	hours	0.202	0.005	0.139	0.011	0.011	0.175	0.175
10	**Shallow Concentrated Flow**			min.	12.1	0.3	8.4	0.6	0.6	10.5	10.5
11		Flow Length	L	feet	300.00	100.00	810.00	260.00	250.00	455.00	140.00
12		Slope	s	ft/ft	0.003	0.021	0.024	0.001	0.003	0.019	0.004
13		Surface (1=paved or 2=unpaved)		n/a	2.000	1.000	1.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	0.887	3.010	3.198	0.651	1.128	2.840	1.303
15		Travel time	Tt	hours	0.094	0.009	0.070	0.111	0.062	0.045	0.030
16	**Manning's Equation**			min.	5.6	0.6	4.2	6.7	3.7	2.7	1.8
17	##	Flow Length	L	feet	4333.00	1705.00	400.00	1050.00	950.00	890.00	1400.00
18		Slope	S	ft/ft	0.001	0.011	0.028	0.025	0.025	0.023	0.004
19		roughness	n	n/a	0.060	0.013	0.013	0.013	0.040	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	50	0	0	0	45	0	0
22		Side Slopes (H:1)	H	feet	20	0	0	0	10	0	0
23		Depth	d	feet	2.50	0.00	0.00	0.00	1.25	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	0.00	2.00	1.50	2.13	0.00	3.00	3.00
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	250.00	3.14	1.77	3.55	71.88	7.07	7.07
28		Flow Rate	Q	cfs	265.04	23.82	17.54	41.98	432.01	101.42	39.97
29		Velocity	V	ft/sec	1.1	7.6	9.9	11.8	6.0	14.3	5.7
30		Travel time	Tt	hours	1.135	0.062	0.011	0.025	0.044	0.017	0.069
31	2	Flow Length	L	feet	0.00	1400.00	4890.00	850.00	897.69	1625.00	600.00
32		Slope	S	ft/ft	0.000	0.008	0.003	0.027	0.006	0.007	0.003
33		roughness	n	n/a	0.000	0.050	0.060	0.013	0.050	0.050	0.013
34		Open Channel									
35		Bottom Width	BW	feet	0	20	50	0	50	70	0
36		Side Slopes (H:1)	H	feet	0	10	20	0	20	30	0
37		Depth	d	feet	0.00	2.00	2.50	0.00	2.00	1.25	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	5.00	0.00	0.00	3.50
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	0.00	80.00	250.00	19.63	180.00	134.38	9.62
42		Flow Rate	Q	cfs	0.00	263.43	486.41	294.52	508.70	318.40	51.11
43		Velocity	V	ft/sec	0.0	3.3	1.9	15.0	2.8	2.4	5.3
44		Travel time	Tt	hours	0.000	0.118	0.698	0.016	0.088	0.191	0.031
45	3	Flow Length	L	feet	0.00	796.69	0.00	519.52	0.00	0.00	2604.40
46		Slope	S	ft/ft	0.000	0.003	0.000	0.004	0.000	0.000	0.019
47		roughness	n	n/a	0.000	0.060	0.000	0.050	0.000	0.000	0.013
48		Open Channel									
49		Bottom Width	BW	feet	0	50	0	50	0	0	0
50		Side Slopes (H:1)	H	feet	0	20	0	20	0	0	0
51		Depth	d	feet	0.00	2.75	0.00	2.00	0.00	0.00	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	4.50
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	0.00	288.75	0.00	180.00	0.00	0.00	15.90
56		Flow Rate	Q	cfs	0.00	558.10	0.00	431.22	0.00	0.00	238.56
57		Velocity	V	ft/sec	0.0	1.9	0.0	2.4	0.0	0.0	15.0
58		Travel time	Tt	hours	0.000	0.114	0.000	0.060	0.000	0.000	0.048
59	**Total Travel Time**		TC	hours	1.43	0.31	0.92	0.22	0.20	0.43	0.35
60			TC	min.	85.89	18.57	55.14	13.33	12.27	25.63	21.19
61	**Lag Time**		TL	hours	0.9	0.2	0.6	0.1	0.1	0.3	0.2
62			TL	min.	51.5	11.1	33.1	8.0	7.4	15.4	12.7

	A	B	C	D	L	M	N	O	P	Q	R
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					FC_08	FC_08A	FC_09	FC_10	FC_11	FC_12	FC_13
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	50.00	50.00	50.00	20.00	50.00	50.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.175	0.175	0.175	0.083	0.175	0.175	0.175
10		**Shallow Concentrated Flow**		min.	10.5	10.5	10.5	5.0	10.5	10.5	10.5
11		Flow Length	L	feet	310.00	350.00	350.00	850.00	420.00	1150.00	630.00
12		Slope	s	ft/ft	0.008	0.008	0.011	0.060	0.016	0.009	0.010
13		Surface (1=paved or 2=unpaved)		n/a	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	1.843	1.843	2.157	5.060	2.631	2.005	2.009
15		Travel time	Tt	hours	0.047	0.053	0.045	0.047	0.044	0.159	0.087
16		**Manning's Equation**		min.	2.8	3.2	2.7	2.8	2.7	9.6	5.2
17	##	Flow Length	L	feet	1539.00	2820.00	2450.00	2100.00	650.00	730.00	950.00
18		Slope	S	ft/ft	0.020	0.007	0.011	0.003	0.051	0.005	0.043
19		roughness	n	n/a	0.013	0.013	0.040	0.050	0.013	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	3	35	0	0	0
22		Side Slopes (H:1)	H	feet	0	0	5	7	0	0	0
23		Depth	d	feet	0.00	0.00	3.00	3.00	0.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	3.00	3.00	0.00	0.00	2.75	2.00	2.75
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	7.07	7.07	54.00	168.00	5.94	3.14	5.94
28		Flow Rate	Q	cfs	94.52	55.03	294.00	427.10	119.38	16.16	89.09
29		Velocity	V	ft/sec	13.4	7.8	5.4	2.5	20.1	5.1	15.0
30		Travel time	Tt	hours	0.032	0.101	0.125	0.229	0.009	0.039	0.018
31	2	Flow Length	L	feet	1007.00	1930.00	1500.00	1843.00	600.00	1950.00	2578.00
32		Slope	S	ft/ft	0.027	0.022	0.025	0.002	0.044	0.007	0.003
33		roughness	n	n/a	0.013	0.013	0.040	0.060	0.040	0.013	0.050
34		Open Channel									
35		Bottom Width	BW	feet	0	0	110	35	15	0	30
36		Side Slopes (H:1)	H	feet	0	0	15	7	12	0	20
37		Depth	d	feet	0.00	0.00	1.50	5.00	2.00	0.00	2.50
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	6.00	5.50	0.00	0.00	0.00	4.50	0.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	28.27	23.76	198.75	350.00	78.00	15.90	200.00
42		Flow Rate	Q	cfs	424.12	356.37	1393.22	915.00	701.73	159.86	427.69
43		Velocity	V	ft/sec	15.0	15.0	7.0	2.6	9.0	10.1	2.1
44		Travel time	Tt	hours	0.019	0.036	0.059	0.196	0.019	0.054	0.335
45	3	Flow Length	L	feet	714.91	750.00	1704.23	0.00	4628.54	1238.45	0.00
46		Slope	S	ft/ft	0.006	0.002	0.002	0.000	0.001	0.031	0.000
47		roughness	n	n/a	0.050	0.050	0.050	0.000	0.060	0.013	0.000
48		Open Channel									
49		Bottom Width	BW	feet	20	20	30	0	40	0	0
50		Side Slopes (H:1)	H	feet	8	8	5	0	10	0	0
51		Depth	d	feet	3.00	3.00	5.25	0.00	5.75	0.00	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	6.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	132.00	132.00	295.31	0.00	560.63	28.27	0.00
56		Flow Rate	Q	cfs	485.75	258.31	815.18	0.00	1224.96	424.12	0.00
57		Velocity	V	ft/sec	3.7	2.0	2.8	0.0	2.2	15.0	0.0
58		Travel time	Tt	hours	0.054	0.106	0.171	0.000	0.588	0.023	0.000
59		**Total Travel Time**	TC	hours	0.33	0.47	0.58	0.55	0.84	0.45	0.61
60			TC	min.	19.57	28.23	34.55	33.28	50.11	27.03	36.87
61		**Lag Time**	TL	hours	0.2	0.3	0.3	0.3	0.5	0.3	0.4
62			TL	min.	11.7	16.9	20.7	20.0	30.1	16.2	22.1

	A	B	C	D	S	T	U	V	W	X	Y
1	**EXISTING CONDITIONS**										
2	**TR-55 Method of Computing the Time of Concentrati**										
3					FC_14	FC_14A	FC_15	FC_16	FC_17	FC_18	FC_18A
4	**Sheet Flow**		variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	50.00	50.00	20.00	60.00	50.00	50.00	60.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.011	0.028	0.031	0.010	0.012	0.010
9		Travel time	Tt	hours	0.175	0.168	0.056	0.129	0.175	0.163	0.202
10	**Shallow Concentrated Flow**			min.	10.5	10.1	3.3	7.7	10.5	9.8	12.1
11		Flow Length	L	feet	1166.00	630.00	1400.00	760.00	510.00	375.00	421.00
12		Slope	s	ft/ft	0.012	0.017	0.027	0.018	0.005	0.021	0.005
13		Surface (1=paved or 2=unpaved)		n/a	1.000	1.000	1.000	2.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	2.289	2.655	2.000	2.158	1.435	2.952	1.400
15		Travel time	Tt	hours	0.141	0.066	0.194	0.098	0.099	0.035	0.084
16	**Manning's Equation**			min.	8.5	4.0	11.7	5.9	5.9	2.1	5.0
17	##	Flow Length	L	feet	2305.00	1185.00	823.00	2300.00	890.00	2500.00	1006.00
18		Slope	S	ft/ft	0.011	0.025	0.001	0.010	0.021	0.010	0.020
19		roughness	n	n/a	0.013	0.013	0.050	0.013	0.013	0.013	0.040
20		Open Channel									
21		Bottom Width	BW	feet	0	0	30	0	0	0	2
22		Side Slopes (H:1)	H	feet	0	0	10	0	0	0	3
23		Depth	d	feet	0.00	0.00	2.25	0.00	0.00	0.00	1.50
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	3.00	2.50	0.00	3.00	3.50	4.00	4.00
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	7.07	4.91	118.13	7.07	9.62	12.57	9.75
28		Flow Rate	Q	cfs	71.33	65.49	164.16	67.38	144.32	142.41	46.16
29		Velocity	V	ft/sec	10.1	13.3	1.4	9.5	15.0	11.3	4.7
30		Travel time	Tt	hours	0.063	0.025	0.165	0.067	0.016	0.061	0.059
31	2	Flow Length	L	feet	303.00	2329.00	0.00	1970.00	1470.00	3420.00	2055.25
32		Slope	S	ft/ft	0.042	0.007	0.000	0.005	0.020	0.006	0.013
33		roughness	n	n/a	0.050	0.050	0.000	0.050	0.050	0.060	0.013
34		Open Channel									
35		Bottom Width	BW	feet	15	35	0	40	55	110	0
36		Side Slopes (H:1)	H	feet	20	10	0	15	10	30	0
37		Depth	d	feet	2.00	4.00	0.00	3.00	2.00	3.00	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	5.50
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	110.00	300.00	0.00	255.00	150.00	600.00	23.76
42		Flow Rate	Q	cfs	744.22	1382.65	0.00	812.20	855.16	1838.87	356.37
43		Velocity	V	ft/sec	6.8	4.6	0.0	3.2	5.7	3.1	15.0
44		Travel time	Tt	hours	0.012	0.140	0.000	0.172	0.072	0.310	0.038
45	3	Flow Length	L	feet	632.17	0.00	0.00	2403.96	2471.60	0.00	0.00
46		Slope	S	ft/ft	0.004	0.000	0.000	0.001	0.003	0.000	0.000
47		roughness	n	n/a	0.050	0.000	0.000	0.050	0.060	0.000	0.000
48		Open Channel									
49		Bottom Width	BW	feet	35	0	0	50	110	0	0
50		Side Slopes (H:1)	H	feet	10	0	0	10	25	0	0
51		Depth	d	feet	2.50	0.00	0.00	4.00	2.00	0.00	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	150.00	0.00	0.00	360.00	320.00	0.00	0.00
56		Flow Rate	Q	cfs	422.39	0.00	0.00	728.79	537.04	0.00	0.00
57		Velocity	V	ft/sec	2.8	0.0	0.0	2.0	1.7	0.0	0.0
58		Travel time	Tt	hours	0.062	0.000	0.000	0.330	0.409	0.000	0.000
59	**Total Travel Time**		TC	hours	0.45	0.40	0.41	0.80	0.77	0.57	0.38
60			TC	min.	27.28	23.96	24.88	47.71	46.25	34.20	22.98
61	**Lag Time**		TL	hours	0.3	0.2	0.2	0.5	0.5	0.3	0.2
62			TL	min.	16.4	14.4	14.9	28.6	27.7	20.5	13.8

	A	B	C	D	Z	AA	AB	AC	AD	AE	AF
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					FC_19	FC_20	FC_21	FC_22	FC_23	FC_24	BB_01
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	60.00	60.00	50.00	50.00	50.00	20.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.202	0.202	0.175	0.175	0.175	0.084	0.175
10		**Shallow Concentrated Flow**		min.	12.1	12.1	10.5	10.5	10.5	5.0	10.5
11		Flow Length	L	feet	1110.00	1775.00	1290.00	935.00	1339.00	540.00	1140.00
12		Slope	s	ft/ft	0.012	0.009	0.010	0.010	0.015	0.020	0.005
13		Surface (1=paved or 2=unpaved)		n/a	1.000	2.000	2.000	1.000	2.000	2.000	1.000
14		Velocity	V	ft/sec	2.257	1.537	1.620	2.060	1.984	2.291	1.445
15		Travel time	Tt	hours	0.137	0.321	0.221	0.126	0.187	0.065	0.219
16		**Manning's Equation**		min.	8.2	19.2	13.3	7.6	11.2	3.9	13.1
17	##	Flow Length	L	feet	1482.00	6462.00	1865.00	2400.00	2100.00	1958.00	1091.00
18		Slope	S	ft/ft	0.008	0.008	0.008	0.011	0.014	0.006	0.001
19		roughness	n	n/a	0.040	0.060	0.013	0.013	0.013	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	3	100	0	0	0	0	0
22		Side Slopes (H:1)	H	feet	3	10	0	0	0	0	0
23		Depth	d	feet	1.50	3.00	0.00	0.00	0.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	0.00	0.00	3.50	5.00	5.00	4.00	3.50
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	11.25	390.00	9.62	19.63	19.63	12.57	9.62
28		Flow Rate	Q	cfs	34.18	1541.12	90.23	271.81	294.52	112.76	28.64
29		Velocity	V	ft/sec	3.0	4.0	9.4	13.8	15.0	9.0	3.0
30		Travel time	Tt	hours	0.136	0.454	0.055	0.048	0.039	0.061	0.102
31	2	Flow Length	L	feet	4279.00	0.00	1172.00	5460.00	3275.00	4900.00	1809.00
32		Slope	S	ft/ft	0.007	0.000	0.007	0.008	0.006	0.011	0.013
33		roughness	n	n/a	0.060	0.000	0.013	0.013	0.050	0.013	0.013
34		Open Channel									
35		Bottom Width	BW	feet	35	0	0	10	10	10	10
36		Side Slopes (H:1)	H	feet	15	0	0	5	7	5	5
37		Depth	d	feet	3.50	0.00	0.00	4.00	5.00	6.00	2.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	5.00	0.00	0.00	0.00	0.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	306.25	0.00	19.63	120.00	225.00	240.00	40.00
42		Flow Rate	Q	cfs	1035.57	0.00	218.49	1200.00	1028.78	2880.00	600.00
43		Velocity	V	ft/sec	3.4	0.0	11.1	10.0	4.6	12.0	15.0
44		Travel time	Tt	hours	0.352	0.000	0.029	0.152	0.199	0.113	0.034
45	3	Flow Length	L	feet	0.00	0.00	3705.00	0.00	0.00	0.00	727.94
46		Slope	S	ft/ft	0.000	0.000	0.007	0.000	0.000	0.000	0.020
47		roughness	n	n/a	0.000	0.000	0.050	0.000	0.000	0.000	0.060
48		Open Channel									
49		Bottom Width	BW	feet	0	0	10	0	0	0	25
50		Side Slopes (H:1)	H	feet	0	0	7	0	0	0	4
51		Depth	d	feet	0.00	0.00	6.25	0.00	0.00	0.00	2.50
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	0.00	0.00	335.94	0.00	0.00	0.00	87.50
56		Flow Rate	Q	cfs	0.00	0.00	1830.17	0.00	0.00	0.00	474.58
57		Velocity	V	ft/sec	0.0	0.0	5.4	0.0	0.0	0.0	5.4
58		Travel time	Tt	hours	0.000	0.000	0.189	0.000	0.000	0.000	0.037
59		**Total Travel Time**	TC	hours	0.83	0.98	0.67	0.50	0.60	0.32	0.57
60			TC	min.	49.56	58.64	40.17	30.05	36.01	19.41	33.99
61		**Lag Time**	TL	hours	0.5	0.6	0.4	0.3	0.4	0.2	0.3
62			TL	min.	29.7	35.2	24.1	18.0	21.6	11.6	20.4

	A	B	C	D	AG	AH	AI	AJ	AK	AL	AM
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					BNB_01	DB_01	FB_01	GB_01	KB_01	KB_02	KB_03
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.011	0.240	0.240	0.240
6		Flow Length	L	feet	50.00	50.00	50.00	20.00	60.00	20.00	20.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.005	0.010	0.013	0.010
9		Travel time	Tt	hours	0.175	0.175	0.175	0.009	0.202	0.077	0.084
10		**Shallow Concentrated Flow**		min.	10.5	10.5	10.5	0.6	12.1	4.6	5.0
11		Flow Length	L	feet	1610.00	860.00	340.00	160.00	560.00	1230.00	60.00
12		Slope	s	ft/ft	0.005	0.005	0.006	0.005	0.008	0.017	0.149
13		Surface (1=paved or 2=unpaved)		n/a	1.000	1.000	1.000	1.000	2.000	2.000	2.000
14		Velocity	V	ft/sec	1.506	1.500	1.596	1.440	1.481	2.113	2.000
15		Travel time	Tt	hours	0.297	0.159	0.059	0.031	0.105	0.162	0.008
16		**Manning's Equation**		min.	17.8	9.6	3.6	1.9	6.3	9.7	0.5
17	##	Flow Length	L	feet	1580.00	1965.00	2500.00	2064.00	4100.00	1000.00	930.00
18		Slope	S	ft/ft	0.007	0.004	0.005	0.003	0.009	0.008	0.008
19		roughness	n	n/a	0.013	0.013	0.013	0.013	0.040	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	0	0	20	3	0
22		Side Slopes (H:1)	H	feet	0	0	0	0	15	5	0
23		Depth	d	feet	0.00	0.00	0.00	0.00	2.50	2.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	4.50	4.25	4.50	3.50	0.00	0.00	2.50
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	15.90	14.19	15.90	9.62	143.75	26.00	4.91
28		Flow Rate	Q	cfs	169.58	102.67	136.63	53.21	684.95	291.71	36.95
29		Velocity	V	ft/sec	10.7	7.2	8.6	5.5	4.8	11.2	7.5
30		Travel time	Tt	hours	0.041	0.075	0.081	0.104	0.239	0.025	0.034
31	2	Flow Length	L	feet	2500.00	1500.00	800.00	1950.00	1416.00	6200.00	4450.00
32		Slope	S	ft/ft	0.010	0.008	0.016	0.006	0.012	0.008	0.005
33		roughness	n	n/a	0.040	0.013	0.013	0.013	0.050	0.050	0.013
34		Open Channel									
35		Bottom Width	BW	feet	25	0	10	0	30	25	0
36		Side Slopes (H:1)	H	feet	20	0	3	0	15	12	0
37		Depth	d	feet	3.00	0.00	2.00	0.00	2.25	4.00	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	10.00	0.00	6.00	0.00	0.00	5.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	4.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	255.00	78.54	32.00	24.00	143.44	292.00	19.63
42		Flow Rate	Q	cfs	1358.34	1178.10	480.00	249.64	610.69	1361.40	188.31
43		Velocity	V	ft/sec	5.3	15.0	15.0	10.4	4.3	4.7	9.6
44		Travel time	Tt	hours	0.130	0.028	0.015	0.052	0.092	0.369	0.129
45	3	Flow Length	L	feet	6558.37	3859.10	3020.87	7152.53	0.00	1747.87	0.00
46		Slope	S	ft/ft	0.007	0.011	0.011	0.007	0.000	0.005	0.000
47		roughness	n	n/a	0.050	0.050	0.050	0.050	0.000	0.013	0.000
48		Open Channel									
49		Bottom Width	BW	feet	45	65	50	55	0	10	0
50		Side Slopes (H:1)	H	feet	10	20	15	10	0	10	0
51		Depth	d	feet	4.00	2.00	2.50	4.50	0.00	3.00	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	340.00	210.00	218.75	450.00	0.00	120.00	0.00
56		Flow Rate	Q	cfs	1609.88	823.77	982.12	2434.93	0.00	1421.30	0.00
57		Velocity	V	ft/sec	4.7	3.9	4.5	5.4	0.0	11.8	0.0
58		Travel time	Tt	hours	0.385	0.273	0.187	0.367	0.000	0.041	0.000
59		**Total Travel Time**	TC	hours	1.03	0.71	0.52	0.56	0.64	0.67	0.26
60			TC	min.	61.69	42.63	31.00	33.80	38.32	40.41	15.33
61		**Lag Time**	TL	hours	0.6	0.4	0.3	0.3	0.4	0.4	0.2
62			TL	min.	37.0	25.6	18.6	20.3	23.0	24.2	9.2

	A	B	C	D	AN	AO	AP	AQ	AR	AS	AT
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					KB_04	KC_01	KC_01A	KC_02	KC_03	KC_04	KC_05
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	20.00	50.00	20.00	50.00	50.00	50.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.020	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.084	0.175	0.063	0.175	0.175	0.175	0.175
10		**Shallow Concentrated Flow**		min.	5.0	10.5	3.8	10.5	10.5	10.5	10.5
11		Flow Length	L	feet	660.00	1577.00	435.00	650.00	1920.00	1650.00	350.00
12		Slope	s	ft/ft	0.011	0.012	0.082	0.002	0.004	0.002	0.003
13		Surface (1=paved or 2=unpaved)		n/a	1.000	1.000	1.000	1.000	2.000	1.000	1.000
14		Velocity	V	ft/sec	2.166	2.247	2.000	1.003	1.025	0.988	1.124
15		Travel time	Tt	hours	0.085	0.195	0.060	0.180	0.521	0.464	0.087
16		**Manning's Equation**		min.	5.1	11.7	3.6	10.8	31.2	27.8	5.2
17	##	Flow Length	L	feet	900.00	315.00	1429.80	1950.00	1400.00	675.00	660.00
18		Slope	S	ft/ft	0.013	0.082	0.001	0.001	0.002	0.014	0.012
19		roughness	n	n/a	0.013	0.013	0.050	0.013	0.013	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	35	0	0	0	0
22		Side Slopes (H:1)	H	feet	0	0	10	0	0	0	0
23		Depth	d	feet	0.00	0.00	1.50	0.00	0.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	3.00	1.50	0.00	3.00	3.00	2.70	2.25
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	7.07	1.77	75.00	7.07	7.07	5.73	3.98
28		Flow Rate	Q	cfs	77.25	26.51	90.35	15.61	29.91	58.94	34.63
29		Velocity	V	ft/sec	10.9	15.0	1.2	2.2	4.2	10.3	8.7
30		Travel time	Tt	hours	0.023	0.006	0.330	0.245	0.092	0.018	0.021
31	2	Flow Length	L	feet	2088.00	1870.00	0.00	3729.00	1300.00	576.00	2749.00
32		Slope	S	ft/ft	0.013	0.004	0.000	0.004	0.022	0.048	0.008
33		roughness	n	n/a	0.040	0.050	0.000	0.013	0.013	0.040	0.050
34		Open Channel									
35		Bottom Width	BW	feet	100	60	0	0	0	30	30
36		Side Slopes (H:1)	H	feet	40	10	0	0	0	5	10
37		Depth	d	feet	2.00	2.50	0.00	0.00	0.00	1.00	2.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	5.00	8.00	0.00	0.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	360.00	212.50	0.00	19.63	50.27	35.00	100.00
42		Flow Rate	Q	cfs	1892.57	619.68	0.00	169.38	753.98	261.48	330.77
43		Velocity	V	ft/sec	5.3	2.9	0.0	8.6	15.0	7.5	3.3
44		Travel time	Tt	hours	0.110	0.178	0.000	0.120	0.024	0.021	0.231
45	3	Flow Length	L	feet	4324.07	2781.87	0.00	0.00	2800.00	0.00	0.00
46		Slope	S	ft/ft	0.008	0.002	0.000	0.000	0.006	0.000	0.000
47		roughness	n	n/a	0.040	0.050	0.000	0.000	0.050	0.000	0.000
48		Open Channel									
49		Bottom Width	BW	feet	30	80	0	0	35	0	0
50		Side Slopes (H:1)	H	feet	5	20	0	0	10	0	0
51		Depth	d	feet	3.75	2.50	0.00	0.00	2.25	0.00	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	182.81	325.00	0.00	0.00	129.38	0.00	0.00
56		Flow Rate	Q	cfs	1139.21	573.01	0.00	0.00	410.69	0.00	0.00
57		Velocity	V	ft/sec	6.2	1.8	0.0	0.0	3.2	0.0	0.0
58		Travel time	Tt	hours	0.193	0.438	0.000	0.000	0.245	0.000	0.000
59		**Total Travel Time**	TC	hours	0.49	0.99	0.45	0.72	1.06	0.68	0.51
60			TC	min.	29.68	59.52	27.21	43.22	63.38	40.71	30.80
61		**Lag Time**	TL	hours	0.3	0.6	0.3	0.4	0.6	0.4	0.3
62			TL	min.	17.8	35.7	16.3	25.9	38.0	24.4	18.5

	A	B	C	D	AU	AV	AW	AX	AY	AZ	BA
1	**EXISTING CONDITIONS**										
2	**TR-55 Method of Computing the Time of Concentrati**										
3					KC_06	KC_07	KC_08	KC_09	KC_10	KC_11	KC_12
4	**Sheet Flow**		variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.011	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	50.00	20.00	50.00	50.00	20.00	20.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.005	0.016	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.175	0.009	0.145	0.175	0.084	0.084	0.175
10	**Shallow Concentrated Flow**			min.	10.5	0.6	8.7	10.5	5.0	5.0	10.5
11		Flow Length	L	feet	440.00	419.00	750.00	641.00	1200.00	1950.00	1200.00
12		Slope	s	ft/ft	0.011	0.005	0.009	0.007	0.009	0.011	0.011
13		Surface (1=paved or 2=unpaved)		n/a	1.000	2.000	1.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	2.203	1.146	1.949	1.679	1.907	2.131	2.111
15		Travel time	Tt	hours	0.055	0.102	0.107	0.106	0.175	0.254	0.158
16	**Manning's Equation**			min.	3.3	6.1	6.4	6.4	10.5	15.3	9.5
17	##	Flow Length	L	feet	960.00	1395.00	1155.00	950.00	550.00	1500.00	1020.00
18		Slope	S	ft/ft	0.001	0.008	0.003	0.015	0.008	0.009	0.008
19		roughness	n	n/a	0.013	0.013	0.013	0.013	0.013	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	0	0	0	0	0
22		Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0
23		Depth	d	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	3.00	3.00	2.00	2.00	2.00	6.00	3.00
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	4.000	0.000
27		Cross-Sectional Area	X-A	feet^2	7.07	7.07	3.14	3.14	3.14	24.00	7.07
28		Flow Rate	Q	cfs	16.16	61.02	11.78	27.89	20.65	298.39	59.41
29		Velocity	V	ft/sec	2.3	8.6	3.7	8.9	6.6	12.4	8.4
30		Travel time	Tt	hours	0.117	0.045	0.086	0.030	0.023	0.034	0.034
31	2	Flow Length	L	feet	2070.00	575.00	360.00	860.00	2100.00	840.00	2400.00
32		Slope	S	ft/ft	0.008	0.002	0.017	0.009	0.008	0.008	0.003
33		roughness	n	n/a	0.013	0.013	0.013	0.013	0.013	0.040	0.013
34		Open Channel									
35		Bottom Width	BW	feet	0	0	5	0	0	5	0
36		Side Slopes (H:1)	H	feet	0	0	8	0	0	8	0
37		Depth	d	feet	0.00	0.00	2.00	0.00	0.00	3.00	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	6.00	6.00	0.00	3.50	4.00	0.00	5.50
40		Span (0 if circular)	S	feet	0.000	4.000	0.000	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	28.27	24.00	42.00	9.62	12.57	87.00	23.76
42		Flow Rate	Q	cfs	385.24	146.76	420.00	95.90	132.50	394.64	183.93
43		Velocity	V	ft/sec	13.6	6.1	10.0	10.0	10.5	4.5	7.7
44		Travel time	Tt	hours	0.042	0.026	0.010	0.024	0.055	0.051	0.086
45	3	Flow Length	L	feet	581.73	2686.49	1495.12	612.72	823.77	646.79	1435.18
46		Slope	S	ft/ft	0.006	0.004	0.005	0.008	0.005	0.011	0.003
47		roughness	n	n/a	0.040	0.013	0.040	0.013	0.013	0.050	0.013
48		Open Channel									
49		Bottom Width	BW	feet	30	0	10	5	5	30	0
50		Side Slopes (H:1)	H	feet	10	0	10	8	8	8	0
51		Depth	d	feet	2.25	0.00	4.00	2.25	3.00	4.25	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	8.00	0.00	0.00	0.00	0.00	8.00
54		Span (0 if circular)	S	feet	0.000	6.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	118.13	48.00	200.00	51.75	87.00	272.00	50.27
56		Flow Rate	Q	cfs	459.00	518.86	849.58	628.60	1010.69	1665.81	500.92
57		Velocity	V	ft/sec	3.9	10.8	4.2	12.1	11.6	6.1	10.0
58		Travel time	Tt	hours	0.042	0.069	0.098	0.014	0.020	0.029	0.040
59	**Total Travel Time**		TC	hours	0.43	0.25	0.44	0.35	0.36	0.45	0.49
60			TC	min.	25.85	15.07	26.69	20.92	21.43	27.15	29.55
61	**Lag Time**		TL	hours	0.3	0.2	0.3	0.2	0.2	0.3	0.3
62			TL	min.	15.5	9.0	16.0	12.5	12.9	16.3	17.7

	A	B	C	D	BB	BC	BD	BE	BF	BG	BH
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					LB_01	MB_01	OB_01	PC_01	PC_02	PC_03	PC_04
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	40.00	20.00	50.00	50.00	20.00	60.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.146	0.084	0.175	0.175	0.084	0.202	0.175
10		**Shallow Concentrated Flow**		min.	8.8	5.0	10.5	10.5	5.0	12.1	10.5
11		Flow Length	L	feet	620.00	1925.00	1100.00	1150.00	1500.00	600.00	715.00
12		Slope	s	ft/ft	0.004	0.008	0.024	0.004	0.002	0.003	0.006
13		Surface (1=paved or 2=unpaved)		n/a	1.000	2.000	1.000	1.000	1.000	2.000	1.000
14		Velocity	V	ft/sec	1.269	1.452	3.219	1.352	1.015	0.852	1.641
15		Travel time	Tt	hours	0.136	0.368	0.095	0.236	0.411	0.196	0.121
16		**Manning's Equation**		min.	8.1	22.1	5.7	14.2	24.6	11.7	7.3
17	##	Flow Length	L	feet	1100.00	900.00	1242.00	2315.00	800.00	740.00	2800.00
18		Slope	S	ft/ft	0.001	0.008	0.016	0.007	0.002	0.002	0.010
19		roughness	n	n/a	0.013	0.013	0.050	0.013	0.013	0.060	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	30	0	0	6	0
22		Side Slopes (H:1)	H	feet	0	0	10	0	0	5	0
23		Depth	d	feet	0.00	0.00	2.00	0.00	0.00	3.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	3.50	5.00	0.00	5.00	4.00	0.00	4.00
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	9.62	19.63	100.00	19.63	12.57	63.00	12.57
28		Flow Rate	Q	cfs	36.64	230.25	476.90	225.35	64.41	106.30	145.41
29		Velocity	V	ft/sec	3.8	11.7	4.8	11.5	5.1	1.7	11.6
30		Travel time	Tt	hours	0.080	0.021	0.072	0.056	0.043	0.122	0.067
31	2	Flow Length	L	feet	2950.00	3000.00	0.00	2261.00	2313.00	2051.00	1990.00
32		Slope	S	ft/ft	0.010	0.012	0.000	0.016	0.022	0.001	0.003
33		roughness	n	n/a	0.013	0.013	0.060	0.013	0.013	0.060	0.013
34		Open Channel									
35		Bottom Width	BW	feet	0	0	0	10	0	6	0
36		Side Slopes (H:1)	H	feet	0	0	0	5	0	5	0
37		Depth	d	feet	0.00	0.00	0.00	2.00	0.00	4.00	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	4.50	7.00	0.00	0.00	5.00	0.00	9.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	5.000
41		Cross-Sectional Area	X-A	feet^2	15.90	38.48	0.00	40.00	19.63	104.00	45.00
42		Flow Rate	Q	cfs	194.98	577.27	0.00	400.00	294.52	161.12	363.20
43		Velocity	V	ft/sec	12.3	15.0	0.0	10.0	15.0	1.5	8.1
44		Travel time	Tt	hours	0.067	0.056	0.000	0.063	0.043	0.368	0.068
45	3	Flow Length	L	feet	2305.95	1113.09	0.00	0.00	0.00	1181.86	2444.59
46		Slope	S	ft/ft	0.010	0.015	0.000	0.000	0.000	0.040	0.019
47		roughness	n	n/a	0.050	0.050	0.060	0.000	0.000	0.060	0.040
48		Open Channel									
49		Bottom Width	BW	feet	75	15	0	0	0	6	10
50		Side Slopes (H:1)	H	feet	15	5	0	0	0	6	10
51		Depth	d	feet	2.50	3.50	0.00	0.00	0.00	4.00	3.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	281.25	113.75	0.00	0.00	0.00	120.00	120.00
56		Flow Rate	Q	cfs	1293.39	715.88	0.00	0.00	0.00	1002.29	884.81
57		Velocity	V	ft/sec	4.6	6.3	0.0	0.0	0.0	8.4	7.4
58		Travel time	Tt	hours	0.139	0.049	0.000	0.000	0.000	0.039	0.092
59		**Total Travel Time**	TC	hours	0.57	0.58	0.34	0.53	0.58	0.93	0.52
60			TC	min.	34.10	34.70	20.53	31.80	34.85	55.61	31.42
61		**Lag Time**	TL	hours	0.3	0.3	0.2	0.3	0.3	0.6	0.3
62			TL	min.	20.5	20.8	12.3	19.1	20.9	33.4	18.9

	A	B	C	D	BI	BJ	BK	BL	BM	BN	BO
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					PC_05	PC_06	PC_07	PC_08	PC_08A	PC_09	PC_09A
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	20.00	20.00	50.00	50.00	50.00	50.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.013	0.010	0.010	0.012	0.010	0.011
9		Travel time	Tt	hours	0.084	0.076	0.175	0.175	0.162	0.175	0.166
10		**Shallow Concentrated Flow**		min.	5.0	4.5	10.5	10.5	9.7	10.5	10.0
11		Flow Length	L	feet	1240.00	2080.00	1100.00	1066.00	1577.00	574.00	1665.00
12		Slope	s	ft/ft	0.017	0.009	0.009	0.017	0.010	0.021	0.012
13		Surface (1=paved or 2=unpaved)		n/a	1.000	2.000	1.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	2.650	1.551	1.960	2.671	2.073	2.987	2.298
15		Travel time	Tt	hours	0.130	0.373	0.156	0.111	0.211	0.053	0.201
16		**Manning's Equation**		min.	7.8	22.4	9.4	6.7	12.7	3.2	12.1
17	##	Flow Length	L	feet	626.00	2379.00	2575.00	1529.00	3075.00	4113.00	3500.00
18		Slope	S	ft/ft	0.064	0.013	0.017	0.008	0.009	0.010	0.012
19		roughness	n	n/a	0.050	0.013	0.013	0.013	0.040	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	10	0	0	0	15	0	0
22		Side Slopes (H:1)	H	feet	5	0	0	0	7	0	0
23		Depth	d	feet	1.50	0.00	0.00	0.00	3.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	0.00	4.50	3.50	3.50	0.00	3.50	4.33
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	26.25	15.90	9.62	9.62	108.00	9.62	14.75
28		Flow Rate	Q	cfs	202.71	224.27	131.06	92.84	589.49	103.12	192.30
29		Velocity	V	ft/sec	7.7	14.1	13.6	9.6	5.5	10.7	13.0
30		Travel time	Tt	hours	0.023	0.047	0.053	0.044	0.156	0.107	0.075
31	2	Flow Length	L	feet	2947.00	1914.00	2364.00	998.00	2030.00	985.00	985.00
32		Slope	S	ft/ft	0.003	0.009	0.007	0.028	0.011	0.012	0.007
33		roughness	n	n/a	0.050	0.050	0.050	0.013	0.013	0.050	0.013
34		Open Channel									
35		Bottom Width	BW	feet	25	30	20	0	0	20	5
36		Side Slopes (H:1)	H	feet	7	5	20	0	0	15	5
37		Depth	d	feet	4.25	3.75	3.50	0.00	0.00	3.00	3.25
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	6.00	10.00	0.00	0.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	6.000	6.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	232.69	182.81	315.00	36.00	60.00	195.00	69.06
42		Flow Rate	Q	cfs	693.86	1005.11	1231.87	540.00	900.00	932.15	690.63
43		Velocity	V	ft/sec	3.0	5.5	3.9	15.0	15.0	4.8	10.0
44		Travel time	Tt	hours	0.275	0.097	0.168	0.018	0.038	0.057	0.027
45	3	Flow Length	L	feet	0.00	0.00	0.00	1939.07	2337.57	2231.35	0.00
46		Slope	S	ft/ft	0.000	0.000	0.000	0.003	0.006	0.005	0.160
47		roughness	n	n/a	0.000	0.000	0.000	0.060	0.060	0.013	0.000
48		Open Channel									
49		Bottom Width	BW	feet	0	0	0	35	35	10	0
50		Side Slopes (H:1)	H	feet	0	0	0	10	10	5	0
51		Depth	d	feet	0.00	0.00	0.00	5.00	4.50	4.25	0.00
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	425.00	360.00	132.81	0.00
56		Flow Rate	Q	cfs	0.00	0.00	0.00	1161.23	1398.54	1328.13	0.00
57		Velocity	V	ft/sec	0.0	0.0	0.0	2.7	3.9	10.0	0.0
58		Travel time	Tt	hours	0.000	0.000	0.000	0.197	0.167	0.062	0.000
59		**Total Travel Time**	TC	hours	0.51	0.59	0.55	0.55	0.73	0.45	
60			TC	min.	30.66	35.51	33.07	32.72	44.06	27.24	
61		**Lag Time**	TL	hours	0.3	0.4	0.3	0.3	0.4	0.3	
62			TL	min.	18.4	21.3	19.8	19.6	26.4	16.3	

	A	B	C	D	BP	BQ	BR	BS	BT	BU	BV
1	**EXISTING CONDITIONS**										
2	**TR-55 Method of Computing the Time of Concentrati**										
3					PC_10	PC_11	PC_12	PC_13	PC_14	RB_01	SFKC_01
4	**Sheet Flow**		variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	60.00	50.00	20.00	50.00	20.00	50.00	20.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.012	0.010	0.010	0.010
9		Travel time	Tt	hours	0.200	0.175	0.084	0.164	0.084	0.175	0.084
10	**Shallow Concentrated Flow**			min.	12.0	10.5	5.0	9.8	5.0	10.5	5.0
11		Flow Length	L	feet	1190.00	2130.00	740.00	580.00	656.00	2000.00	1523.00
12		Slope	s	ft/ft	0.013	0.010	0.012	0.016	0.013	0.010	0.003
13		Surface (1=paved or 2=unpaved)		n/a	2.000	1.000	1.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	1.849	2.020	2.257	2.638	2.349	2.073	1.068
15		Travel time	Tt	hours	0.179	0.293	0.091	0.061	0.078	0.268	0.396
16	**Manning's Equation**			min.	10.7	17.6	5.5	3.7	4.7	16.1	23.8
17	##	Flow Length	L	feet	2185.00	1932.00	3630.00	1995.00	2500.00	4355.00	1211.00
18		Slope	S	ft/ft	0.008	0.011	0.008	0.012	0.014	0.003	0.001
19		roughness	n	n/a	0.013	0.013	0.013	0.013	0.013	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	5	0	0	0	0	0	0
22		Side Slopes (H:1)	H	feet	5	0	0	0	0	0	0
23		Depth	d	feet	2.50	0.00	0.00	0.00	0.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	0.00	4.00	5.00	3.00	4.33	7.00	4.50
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	4.000	0.000
27		Cross-Sectional Area	X-A	feet^2	43.75	12.57	19.63	7.07	14.75	28.00	15.90
28		Flow Rate	Q	cfs	570.22	150.36	237.41	73.38	210.97	210.20	68.45
29		Velocity	V	ft/sec	13.0	12.0	12.1	10.4	14.3	7.5	4.3
30		Travel time	Tt	hours	0.047	0.045	0.083	0.053	0.049	0.161	0.078
31	2	Flow Length	L	feet	0.00	3058.00	4480.00	3000.00	3800.00	3505.00	1100.00
32		Slope	S	ft/ft	0.000	0.007	0.007	0.009	0.005	0.013	0.001
33		roughness	n	n/a	0.000	0.013	0.013	0.013	0.050	0.050	0.013
34		Open Channel									
35		Bottom Width	BW	feet	0	5	10	5	20	35	0
36		Side Slopes (H:1)	H	feet	0	5	5	5	15	5	0
37		Depth	d	feet	0.00	3.00	5.00	2.75	4.75	3.25	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	10.00
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	8.000
41		Cross-Sectional Area	X-A	feet^2	0.00	60.00	175.00	51.56	433.44	166.56	80.00
42		Flow Rate	Q	cfs	0.00	819.18	1750.00	515.63	1799.97	1021.13	492.51
43		Velocity	V	ft/sec	0.0	13.7	10.0	10.0	4.2	6.1	6.2
44		Travel time	Tt	hours	0.000	0.062	0.124	0.083	0.254	0.159	0.050
45	3	Flow Length	L	feet	0.00	1822.89	0.00	784.06	0.00	0.00	1319.99
46		Slope	S	ft/ft	0.000	0.007	0.000	0.006	0.000	0.000	0.013
47		roughness	n	n/a	0.000	0.040	0.000	0.050	0.000	0.000	0.050
48		Open Channel									
49		Bottom Width	BW	feet	0	10	0	20	0	0	25
50		Side Slopes (H:1)	H	feet	0	10	0	15	0	0	5
51		Depth	d	feet	0.00	4.75	0.00	3.50	0.00	0.00	2.50
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	0.00	273.13	0.00	253.75	0.00	0.00	93.75
56		Flow Rate	Q	cfs	0.00	1652.42	0.00	902.25	0.00	0.00	487.18
57		Velocity	V	ft/sec	0.0	6.1	0.0	3.6	0.0	0.0	5.2
58		Travel time	Tt	hours	0.000	0.084	0.000	0.061	0.000	0.000	0.071
59	**Total Travel Time**		TC	hours	0.43	0.66	0.38	0.42	0.46	0.76	0.68
60			TC	min.	25.50	39.51	22.98	25.37	27.86	45.77	40.71
61	**Lag Time**		TL	hours	0.3	0.4	0.2	0.3	0.3	0.5	0.4
62			TL	min.	15.3	23.7	13.8	15.2	16.7	27.5	24.4

	A	B	C	D	BW	BX	BY	BZ	CA	CB	CC
1		**EXISTING CONDITIONS**									
2		**TR-55 Method of Computing the Time of Concentrati**									
3					UKN_B	UKN_BA	UKN_C	UKN_D	UKN_E	UKN_F	VB_01
4		**Sheet Flow**	variable	units							
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	60.00	20.00	20.00	20.00	20.00	50.00	50.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.011	0.010	0.010	0.028	0.010	0.013	0.010
9		Travel time	Tt	hours	0.193	0.084	0.084	0.056	0.084	0.158	0.175
10		**Shallow Concentrated Flow**		min.	11.6	5.0	5.0	3.3	5.0	9.5	10.5
11		Flow Length	L	feet	160.00	650.00	1980.00	1100.00	2500.00	1150.00	1150.00
12		Slope	s	ft/ft	0.045	0.013	0.023	0.006	0.010	0.004	0.002
13		Surface (1=paved or 2=unpaved)		n/a	2.000	1.000	2.000	1.000	1.000	1.000	1.000
14		Velocity	V	ft/sec	3.437	2.361	2.479	1.590	2.060	1.339	0.977
15		Travel time	Tt	hours	0.013	0.076	0.222	0.192	0.337	0.239	0.327
16		**Manning's Equation**		min.	0.8	4.6	13.3	11.5	20.2	14.3	19.6
17	##	Flow Length	L	feet	1029.00	1011.00	5273.98	1065.00	7900.00	1250.00	1050.00
18		Slope	S	ft/ft	0.025	0.012	0.005	0.010	0.015	0.018	0.004
19		roughness	n	n/a	0.013	0.013	0.035	0.013	0.040	0.013	0.013
20		Open Channel									
21		Bottom Width	BW	feet	0	0	10	0	2	0	0
22		Side Slopes (H:1)	H	feet	0	0	5	0	3	0	0
23		Depth	d	feet	0.00	0.00	6.00	0.00	2.00	0.00	0.00
24		...or Closed Conduit									
25		Rise / Diameter	R / D	feet	2.25	3.00	0.00	2.00	0.00	3.50	3.00
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	3.98	7.07	240.00	3.14	16.00	9.62	7.07
28		Flow Rate	Q	cfs	48.78	72.50	1688.66	22.47	77.42	133.68	41.94
29		Velocity	V	ft/sec	12.3	10.3	7.0	7.2	4.8	13.9	5.9
30		Travel time	Tt	hours	0.023	0.027	0.208	0.041	0.454	0.025	0.049
31	2	Flow Length	L	feet	2742.00	4519.00	0.00	5960.00	1825.00	1824.00	1300.00
32		Slope	S	ft/ft	0.008	0.005	0.000	0.006	0.014	0.011	0.017
33		roughness	n	n/a	0.050	0.040	0.000	0.050	0.013	0.013	0.013
34		Open Channel									
35		Bottom Width	BW	feet	15	10	0	20	10	0	0
36		Side Slopes (H:1)	H	feet	6	15	0	5	5	0	0
37		Depth	d	feet	3.25	3.00	0.00	4.00	6.00	0.00	0.00
38		...or Closed Conduit									
39		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	7.00	3.75
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	4.000	0.000
41		Cross-Sectional Area	X-A	feet^2	112.13	165.00	0.00	160.00	240.00	28.00	11.04
42		Flow Rate	Q	cfs	486.13	631.27	0.00	704.06	2400.00	402.25	156.63
43		Velocity	V	ft/sec	4.3	3.8	0.0	4.4	10.0	14.4	14.2
44		Travel time	Tt	hours	0.176	0.328	0.000	0.376	0.051	0.035	0.025
45	3	Flow Length	L	feet	0.00	3986.29	0.00	2800.00	0.00	0.00	802.08
46		Slope	S	ft/ft	0.000	0.007	0.000	0.004	0.000	0.000	0.014
47		roughness	n	n/a	0.000	0.050	0.000	0.050	0.000	0.000	0.040
48		Open Channel									
49		Bottom Width	BW	feet	0	30	0	30	0	0	40
50		Side Slopes (H:1)	H	feet	0	15	0	10	0	0	10
51		Depth	d	feet	0.00	3.75	0.00	4.25	0.00	0.00	1.50
52		...or Closed Conduit									
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	0.00	323.44	0.00	308.13	0.00	0.00	82.50
56		Flow Rate	Q	cfs	0.00	1385.65	0.00	1117.57	0.00	0.00	401.80
57		Velocity	V	ft/sec	0.0	4.3	0.0	3.6	0.0	0.0	4.9
58		Travel time	Tt	hours	0.000	0.258	0.000	0.214	0.000	0.000	0.046
59		**Total Travel Time**	TC	hours	0.40	0.77	0.51	0.88	0.93	0.46	0.62
60			TC	min.	24.30	46.47	30.84	52.79	55.52	27.42	37.34
61		**Lag Time**	TL	hours	0.2	0.5	0.3	0.5	0.6	0.3	0.4
62			TL	min.	14.6	27.9	18.5	31.7	33.3	16.5	22.4

	A	B	C	D	CD	CE	CF	CG
1	**EXISTING CONDITIONS**							
2	**TR-55 Method of Computing the Time of Concentrati**							
3					WB_01	WB_02	WB_03	WB_04
4	**Sheet Flow**		variable	units				
5		Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240
6		Flow Length	L	feet	20.00	50.00	60.00	60.00
7		2-year, 24-hour rainfall	P2	inches	3.400	3.400	3.400	3.400
8		Slope	s	ft/ft	0.010	0.010	0.010	0.010
9		Travel time	Tt	hours	0.084	0.175	0.202	0.202
10	**Shallow Concentrated Flow**			min.	5.0	10.5	12.1	12.1
11		Flow Length	L	feet	70.00	1809.00	1560.00	1790.00
12		Slope	s	ft/ft	0.006	0.006	0.006	0.005
13		Surface (1=paved or 2=unpaved)		n/a	1.000	1.000	1.000	2.000
14		Velocity	V	ft/sec	1.596	1.549	1.549	1.150
15		Travel time	Tt	hours	0.012	0.324	0.280	0.432
16	**Manning's Equation**			min.	0.7	19.5	16.8	25.9
17	##	Flow Length	L	feet	1130.00	200.00	2500.00	1730.00
18		Slope	S	ft/ft	0.009	0.006	0.007	0.009
19		roughness	n	n/a	0.013	0.013	0.013	0.013
20		Open Channel						
21		Bottom Width	BW	feet	0	0	0	0
22		Side Slopes (H:1)	H	feet	0	0	0	0
23		Depth	d	feet	0.00	0.00	0.00	0.00
24		...or Closed Conduit						
25		Rise / Diameter	R / D	feet	2.00	3.00	3.50	4.50
26		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000
27		Cross-Sectional Area	X-A	feet^2	3.14	7.07	9.62	15.90
28		Flow Rate	Q	cfs	21.01	51.80	86.99	182.82
29		Velocity	V	ft/sec	6.7	7.3	9.0	11.5
30		Travel time	Tt	hours	0.047	0.008	0.077	0.042
31	2	Flow Length	L	feet	950.00	467.00	3282.00	1647.00
32		Slope	S	ft/ft	0.030	0.044	0.008	0.011
33		roughness	n	n/a	0.013	0.050	0.050	0.013
34		Open Channel						
35		Bottom Width	BW	feet	0	10	30	0
36		Side Slopes (H:1)	H	feet	0	5	15	0
37		Depth	d	feet	0.00	2.00	2.50	0.00
38		...or Closed Conduit						
39		Rise / Diameter	R / D	feet	3.50	0.00	0.00	5.50
40		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000
41		Cross-Sectional Area	X-A	feet^2	9.62	40.00	168.75	23.76
42		Flow Rate	Q	cfs	144.32	299.35	612.25	345.26
43		Velocity	V	ft/sec	15.0	7.5	3.6	14.5
44		Travel time	Tt	hours	0.018	0.017	0.251	0.031
45	3	Flow Length	L	feet	2331.26	0.00	0.00	0.00
46		Slope	S	ft/ft	0.010	0.000	0.000	0.000
47		roughness	n	n/a	0.050	0.000	0.000	0.000
48		Open Channel						
49		Bottom Width	BW	feet	30	0	0	0
50		Side Slopes (H:1)	H	feet	6	0	0	0
51		Depth	d	feet	3.00	0.00	0.00	0.00
52		...or Closed Conduit						
53		Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00
54		Span (0 if circular)	S	feet	0.000	0.000	0.000	0.000
55		Cross-Sectional Area	X-A	feet^2	144.00	0.00	0.00	0.00
56		Flow Rate	Q	cfs	728.52	0.00	0.00	0.00
57		Velocity	V	ft/sec	5.1	0.0	0.0	0.0
58		Travel time	Tt	hours	0.128	0.000	0.000	0.000
59	**Total Travel Time**		TC	hours	0.29	0.52	0.81	0.71
60			TC	min.	17.32	31.45	48.61	42.47
61	**Lag Time**		TL	hours	0.2	0.3	0.5	0.4
62			TL	min.	10.4	18.9	29.2	25.5

Appendix C
Hydrologic & Hydraulic Model Output

Project: Fish_Creek_Jul_2011 Simulation Run: Existing 10% - 10 yr

Start of Run:	31Aug2009, 00:00	Basin Model:	Fish - 10 yr
End of Run:	02Sep2009, 00:00	Meteorologic Model:	24hr_10% 1
Compute Time:	03Apr2012, 15:00:54	Control Specifications:	Control Spe

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	1324.6	31Aug2009, 12:42	4.76
DB-01	0.3400	594.8	31Aug2009, 12:30	4.71
FB-01	0.2600	514.4	31Aug2009, 12:21	4.63
FC-01	0.1500	175.1	31Aug2009, 12:57	4.53
FC-02	0.1300	289.6	31Aug2009, 12:12	4.15
FC-03	0.2300	248.1	31Aug2009, 12:39	3.25
FC-04	0.1200	267.6	31Aug2009, 12:09	3.73
FC-05	0.0800	174.4	31Aug2009, 12:09	3.42
FC-06	0.0600	122.8	31Aug2009, 12:18	4.35
FC-07	0.2100	527.3	31Aug2009, 12:15	5.13
FC-08	0.1400	340.9	31Aug2009, 12:15	4.93
FC-08A	0.0700	135.5	31Aug2009, 12:21	4.34
FC-09	0.3000	546.4	31Aug2009, 12:24	4.41
FC-10	0.3500	581.1	31Aug2009, 12:24	3.89
FC-11	0.5300	766.5	31Aug2009, 12:33	4.08
FC-12	0.1900	414.3	31Aug2009, 12:18	4.66
FC-13	0.1300	216.1	31Aug2009, 12:27	4.03
FC-14	0.1300	265.5	31Aug2009, 12:18	4.37
FC-14A	0.2700	634.0	31Aug2009, 12:15	4.82
FC-15	0.0400	88.1	31Aug2009, 12:18	4.54
FC-16	0.3200	565.4	31Aug2009, 12:33	5.04
FC-17	0.2100	358.7	31Aug2009, 12:30	4.66
FC-18	0.5800	1147.5	31Aug2009, 12:24	4.70
FC-18A	0.1300	294.0	31Aug2009, 12:18	4.49
FC-19	0.4500	749.8	31Aug2009, 12:33	4.72
FC-20	0.7300	1129.9	31Aug2009, 12:39	4.79

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	1389.5	31Aug2009, 12:27	4.78
FC-22	0.8200	1779.6	31Aug2009, 12:21	4.90
FC-23	0.4900	945.8	31Aug2009, 12:24	4.69
FC-24	0.8100	2081.2	31Aug2009, 12:15	5.00
FC-J0	26.4633	18361.0	31Aug2009, 14:15	4.76
FC-J01	26.3333	18415.6	31Aug2009, 14:09	4.76
FC-J02	25.9233	18498.7	31Aug2009, 14:03	4.77
FC-J02A	22.5233	17239.8	31Aug2009, 14:00	4.73
FC-J03	22.2933	17256.1	31Aug2009, 13:54	4.74
FC-J04	22.0333	17222.9	31Aug2009, 13:54	4.75
FC-J05	21.9533	17208.4	31Aug2009, 13:54	4.76
FC-J06	21.6133	17147.4	31Aug2009, 13:51	4.76
FC-J07	21.4933	17161.0	31Aug2009, 13:48	4.76
FC-J08	21.2833	17129.2	31Aug2009, 13:48	4.76
FC-J09	21.1433	17126.6	31Aug2009, 13:45	4.75
FC-J10	20.8833	17098.2	31Aug2009, 13:42	4.76
FC-J11	14.7133	11714.0	31Aug2009, 13:57	4.78
FC-J12	14.3433	11942.2	31Aug2009, 13:33	4.79
FC-J13	13.5833	11923.1	31Aug2009, 13:18	4.81
FC-J13A	12.8600	11372.2	31Aug2009, 13:18	4.78
FC-J14	12.3300	11268.6	31Aug2009, 13:03	4.82
FC-J15	12.1400	11198.1	31Aug2009, 13:00	4.82
FC-J16	11.2100	10290.8	31Aug2009, 12:51	4.81
FC-J17	10.1900	9313.6	31Aug2009, 13:24	4.81
FC-J18	9.6900	9209.1	31Aug2009, 13:21	4.82
FC-J19	8.4200	8662.8	31Aug2009, 13:21	4.81
FC-J20	7.6200	8274.9	31Aug2009, 13:21	4.80
FC-J21	7.3000	8213.6	31Aug2009, 13:15	4.79
FC-J21A	4.9600	6337.9	31Aug2009, 13:18	4.80
FC-J22	4.7500	6342.7	31Aug2009, 13:09	4.81
FC-J22A	4.1700	6372.0	31Aug2009, 12:54	4.82

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	6359.0	31Aug2009, 12:51	4.83
FC-J23A	2.4900	3876.9	31Aug2009, 12:51	4.82
FC-J24	2.0400	3521.3	31Aug2009, 12:42	4.85
FC-J25	1.3000	2800.6	31Aug2009, 12:24	4.88
FC-J26	0.8100	2081.2	31Aug2009, 12:15	5.00
FC-J27	1.5500	2751.1	31Aug2009, 12:33	4.85
FC-J27A	0.8200	1779.6	31Aug2009, 12:21	4.90
FC-R00	26.4633	18351.5	31Aug2009, 14:18	4.76
FC-R01	26.3333	18341.0	31Aug2009, 14:15	4.76
FC-R02	25.9233	18345.5	31Aug2009, 14:09	4.77
FC-R02A	22.5233	17184.2	31Aug2009, 14:06	4.73
FC-R03	22.2933	17193.3	31Aug2009, 14:00	4.74
FC-R04	22.0333	17212.6	31Aug2009, 13:54	4.75
FC-R05	21.9533	17210.5	31Aug2009, 13:54	4.76
FC-R06	21.6133	17133.8	31Aug2009, 13:54	4.76
FC-R07	21.4933	17126.8	31Aug2009, 13:51	4.76
FC-R08	21.2833	17121.6	31Aug2009, 13:48	4.76
FC-R09	21.1433	17103.9	31Aug2009, 13:48	4.75
FC-R10	20.8833	17077.3	31Aug2009, 13:45	4.76
FC-R11	14.7133	11712.2	31Aug2009, 13:57	4.78
FC-R12	14.3433	11647.0	31Aug2009, 13:57	4.79
FC-R13	13.5833	11719.3	31Aug2009, 13:33	4.81
FC-R13A	12.8600	11370.0	31Aug2009, 13:18	4.78
FC-R14	12.3300	11076.9	31Aug2009, 13:18	4.82
FC-R15	12.1400	11175.2	31Aug2009, 13:03	4.82
FC-R16	11.2100	10195.2	31Aug2009, 13:03	4.81
FC-R17	10.1900	9301.7	31Aug2009, 13:27	4.81
FC-R18	9.6900	9173.4	31Aug2009, 13:24	4.82
FC-R19	8.4200	8657.2	31Aug2009, 13:24	4.81
FC-R20	7.6200	8265.2	31Aug2009, 13:24	4.80
FC-R21	7.3000	8095.9	31Aug2009, 13:24	4.79

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	6319.5	31Aug2009, 13:21	4.80
FC-R22	4.7500	6218.9	31Aug2009, 13:18	4.81
FC-R23	4.1700	6042.9	31Aug2009, 13:12	4.82
FC-R23A	4.0400	6297.1	31Aug2009, 12:54	4.83
FC-R23B	2.4900	3844.8	31Aug2009, 12:54	4.82
FC-R24	2.0400	3306.7	31Aug2009, 12:54	4.85
FC-R25	1.3000	2461.2	31Aug2009, 12:45	4.88
FC-R26	0.8100	1854.8	31Aug2009, 12:24	5.00
FC-R27	1.5500	2573.5	31Aug2009, 12:48	4.85
FC-R27A	0.8200	1673.0	31Aug2009, 12:30	4.90
Garden Branch	0.8000	1137.2	31Aug2009, 12:39	5.13
KB-01	0.2700	508.8	31Aug2009, 12:27	4.67
KB-02	0.5400	1012.5	31Aug2009, 12:27	4.79
KB-03	0.0500	138.6	31Aug2009, 12:12	4.87
KB-04	0.3700	834.6	31Aug2009, 12:21	5.20
KB-J01	0.9600	1892.7	31Aug2009, 12:24	4.95
KB-J02	0.9100	1812.4	31Aug2009, 12:24	4.96
KB-R01	0.9600	1884.1	31Aug2009, 12:27	4.95
KB-R02	0.9100	1810.1	31Aug2009, 12:24	4.96
Kirby Creek	3.4000	3923.6	31Aug2009, 12:30	5.03
LB-01	0.4100	745.4	31Aug2009, 12:24	4.27
MB-01	0.2300	455.1	31Aug2009, 12:24	4.71
Mountain Creek Lake	26.6133	18402.6	31Aug2009, 14:18	4.75
NF-01	0.2700	538.1	31Aug2009, 12:21	4.62
NF-02	0.1900	314.2	31Aug2009, 12:24	3.75
NF-03	0.3500	495.2	31Aug2009, 12:36	4.07
NF-04	0.3400	712.2	31Aug2009, 12:21	4.81
NF-05	0.2900	526.3	31Aug2009, 12:21	3.90
NF-06	0.3500	679.4	31Aug2009, 12:24	4.63
NF-07	0.3800	756.7	31Aug2009, 12:24	4.63
NF-08	0.4000	815.3	31Aug2009, 12:24	4.79

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	1028.6	31Aug2009, 12:30	5.06
NF-09	0.5900	1356.3	31Aug2009, 12:18	5.00
NF-09A	0.2900	636.0	31Aug2009, 12:21	4.84
NF-10	0.1800	409.0	31Aug2009, 12:18	4.74
NF-11	0.7000	1303.1	31Aug2009, 12:27	4.78
NF-12	0.4900	1164.9	31Aug2009, 12:15	4.90
NF-13	0.2600	594.2	31Aug2009, 12:18	4.77
NF-14	0.5400	1165.9	31Aug2009, 12:21	4.78
NF-J01	6.1700	6568.6	31Aug2009, 13:27	4.70
NF-J02	5.9000	6513.6	31Aug2009, 13:24	4.71
NF-J03	5.7100	6515.8	31Aug2009, 13:21	4.74
NF-J04	5.7100	6516.3	31Aug2009, 13:18	4.74
NF-J05	5.3600	6316.6	31Aug2009, 13:18	4.78
NF-J06	4.7300	6160.6	31Aug2009, 13:09	4.83
NF-J07	4.3800	6198.7	31Aug2009, 13:00	4.85
NF-J08	4.0000	6543.5	31Aug2009, 12:45	4.87
NF-J09	3.6000	6637.4	31Aug2009, 12:30	4.88
NF-J10	3.0500	5820.3	31Aug2009, 12:24	4.85
NF-J11	2.4600	4801.1	31Aug2009, 12:24	4.81
NF-J12	1.9900	3838.9	31Aug2009, 12:24	4.81
NF-J13	1.2900	2578.3	31Aug2009, 12:21	4.82
NF-J14	0.5400	1165.9	31Aug2009, 12:21	4.78
NF-R01	6.1700	6558.7	31Aug2009, 13:30	4.70
NF-R02	5.9000	6495.5	31Aug2009, 13:27	4.71
NF-R03	5.7100	6455.6	31Aug2009, 13:24	4.74
NF-R04	5.7100	6515.8	31Aug2009, 13:21	4.74
NF-R05	5.3600	6309.7	31Aug2009, 13:21	4.78
NF-R06	4.7300	6097.9	31Aug2009, 13:18	4.83
NF-R07	4.3800	5974.7	31Aug2009, 13:09	4.85
NF-R08	4.0000	5944.5	31Aug2009, 13:00	4.87
NF-R09	3.6000	6079.7	31Aug2009, 12:45	4.88

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	5608.8	31Aug2009, 12:30	4.85
NF-R11	2.4600	4637.0	31Aug2009, 12:27	4.81
NF-R12	1.9900	3819.6	31Aug2009, 12:24	4.81
NF-R13	1.2900	2554.3	31Aug2009, 12:24	4.82
NF-R14	0.5400	1057.1	31Aug2009, 12:30	4.78
OB-01	0.0600	129.9	31Aug2009, 12:15	4.23
RB-01	0.4100	729.4	31Aug2009, 12:30	4.86
UNB-01	0.1400	323.3	31Aug2009, 12:18	4.81
UNB-02	0.6600	1157.3	31Aug2009, 12:30	4.85
UNB-03	0.5800	1218.6	31Aug2009, 12:21	4.83
UNB-J01A	1.8400	2651.2	31Aug2009, 12:39	4.75
UNB-J1	0.8000	1375.8	31Aug2009, 12:30	4.84
UNB-J2	0.6600	1157.3	31Aug2009, 12:30	4.85
UNB-R01A	1.8400	2651.3	31Aug2009, 12:39	4.75
UNB-R1	0.8000	1374.3	31Aug2009, 12:30	4.84
UNB-R2	0.6600	1156.7	31Aug2009, 12:33	4.85
UNC-01	0.5000	820.8	31Aug2009, 12:36	4.87
UNC-02	1.2600	1987.1	31Aug2009, 12:36	4.71
UNC-J01	2.3400	3462.9	31Aug2009, 12:39	4.77
UNC-J02	1.2600	1987.1	31Aug2009, 12:36	4.71
UNC-R01	2.3400	3422.0	31Aug2009, 12:42	4.77
UNC-R02	1.2600	1922.3	31Aug2009, 12:45	4.71
UND-01	0.1400	277.6	31Aug2009, 12:18	4.31
Willis Branch	0.7233	1262.9	31Aug2009, 12:36	5.25

Project: Fish_Creek_Jul_2011 Simulation Run: Existing 04% - 25yr

Start of Run: 31Aug2009, 00:00 Basin Model: Fish - 25 yr
End of Run: 02Sep2009, 00:00 Meteorologic Model: 24hr_04% 2
Compute Time: 17Oct2011, 05:17:34 Control Specifications: Control Spec

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	1623.5	31Aug2009, 12:42	5.86
DB-01	0.3400	728.7	31Aug2009, 12:30	5.79
FB-01	0.2600	630.0	31Aug2009, 12:21	5.71
FC-01	0.1500	216.8	31Aug2009, 12:57	5.61
FC-02	0.1300	359.3	31Aug2009, 12:12	5.20
FC-03	0.2300	322.9	31Aug2009, 12:39	4.19
FC-04	0.1200	337.4	31Aug2009, 12:09	4.74
FC-05	0.0800	222.4	31Aug2009, 12:09	4.40
FC-06	0.0600	151.4	31Aug2009, 12:18	5.39
FC-07	0.2100	633.7	31Aug2009, 12:15	6.24
FC-08	0.1400	411.5	31Aug2009, 12:15	6.01
FC-08A	0.0700	167.3	31Aug2009, 12:21	5.38
FC-09	0.3000	674.8	31Aug2009, 12:24	5.47
FC-10	0.3500	731.0	31Aug2009, 12:24	4.90
FC-11	0.5300	961.7	31Aug2009, 12:33	5.12
FC-12	0.1900	505.7	31Aug2009, 12:18	5.74
FC-13	0.1300	270.6	31Aug2009, 12:24	5.07
FC-14	0.1300	327.4	31Aug2009, 12:18	5.43
FC-14A	0.2700	769.5	31Aug2009, 12:15	5.92
FC-15	0.0400	107.8	31Aug2009, 12:18	5.63
FC-16	0.3200	686.2	31Aug2009, 12:33	6.15
FC-17	0.2100	440.1	31Aug2009, 12:30	5.75
FC-18	0.5800	1401.4	31Aug2009, 12:24	5.80
FC-18A	0.1300	360.0	31Aug2009, 12:15	5.57
FC-19	0.4500	918.6	31Aug2009, 12:33	5.82
FC-20	0.7300	1383.1	31Aug2009, 12:39	5.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	1695.5	31Aug2009, 12:27	5.88
FC-22	0.8200	2157.4	31Aug2009, 12:21	6.00
FC-23	0.4900	1156.4	31Aug2009, 12:24	5.79
FC-24	0.8100	2505.1	31Aug2009, 12:15	6.11
FC-J0	26.4633	23345.4	31Aug2009, 14:18	5.85
FC-J01	26.3333	23510.1	31Aug2009, 14:12	5.85
FC-J02	25.9233	23810.1	31Aug2009, 14:06	5.86
FC-J02A	22.5233	22369.7	31Aug2009, 14:00	5.82
FC-J03	22.2933	22586.0	31Aug2009, 13:54	5.84
FC-J04	22.0333	22570.0	31Aug2009, 13:51	5.84
FC-J05	21.9533	22561.9	31Aug2009, 13:51	5.85
FC-J06	21.6133	22465.0	31Aug2009, 13:48	5.85
FC-J07	21.4933	22532.9	31Aug2009, 13:45	5.85
FC-J08	21.2833	22499.2	31Aug2009, 13:48	5.85
FC-J09	21.1433	22470.0	31Aug2009, 13:45	5.85
FC-J10	20.8833	22416.1	31Aug2009, 13:45	5.85
FC-J11	14.7133	15086.8	31Aug2009, 13:48	5.87
FC-J12	14.3433	15305.1	31Aug2009, 13:27	5.89
FC-J13	13.5833	15136.3	31Aug2009, 13:15	5.91
FC-J13A	12.8600	14482.3	31Aug2009, 13:15	5.88
FC-J14	12.3300	14281.7	31Aug2009, 13:00	5.92
FC-J15	12.1400	14191.6	31Aug2009, 13:00	5.92
FC-J16	11.2100	13095.7	31Aug2009, 12:51	5.91
FC-J17	10.1900	11675.5	31Aug2009, 13:18	5.92
FC-J18	9.6900	11499.5	31Aug2009, 13:15	5.92
FC-J19	8.4200	10766.2	31Aug2009, 13:21	5.91
FC-J20	7.6200	10270.8	31Aug2009, 13:21	5.90
FC-J21	7.3000	10151.6	31Aug2009, 13:15	5.89
FC-J21A	4.9600	7878.4	31Aug2009, 13:18	5.90
FC-J22	4.7500	7881.3	31Aug2009, 13:09	5.91
FC-J22A	4.1700	7940.9	31Aug2009, 12:54	5.92

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	7951.1	31Aug2009, 12:51	5.94
FC-J23A	2.4900	4893.5	31Aug2009, 12:48	5.93
FC-J24	2.0400	4366.9	31Aug2009, 12:39	5.95
FC-J25	1.3000	3400.9	31Aug2009, 12:24	5.99
FC-J26	0.8100	2505.1	31Aug2009, 12:15	6.11
FC-J27	1.5500	3354.3	31Aug2009, 12:33	5.95
FC-J27A	0.8200	2157.4	31Aug2009, 12:21	6.00
FC-R00	26.4633	23346.0	31Aug2009, 14:21	5.85
FC-R01	26.3333	23322.2	31Aug2009, 14:18	5.85
FC-R02	25.9233	23427.3	31Aug2009, 14:12	5.86
FC-R02A	22.5233	22233.5	31Aug2009, 14:06	5.82
FC-R03	22.2933	22308.6	31Aug2009, 14:00	5.84
FC-R04	22.0333	22532.8	31Aug2009, 13:54	5.84
FC-R05	21.9533	22554.8	31Aug2009, 13:51	5.85
FC-R06	21.6133	22463.0	31Aug2009, 13:51	5.85
FC-R07	21.4933	22439.3	31Aug2009, 13:48	5.85
FC-R08	21.2833	22484.0	31Aug2009, 13:45	5.85
FC-R09	21.1433	22468.2	31Aug2009, 13:48	5.85
FC-R10	20.8833	22405.6	31Aug2009, 13:45	5.85
FC-R11	14.7133	15079.9	31Aug2009, 13:48	5.87
FC-R12	14.3433	14996.3	31Aug2009, 13:48	5.89
FC-R13	13.5833	14982.3	31Aug2009, 13:30	5.91
FC-R13A	12.8600	14477.9	31Aug2009, 13:15	5.88
FC-R14	12.3300	14084.2	31Aug2009, 13:15	5.92
FC-R15	12.1400	14160.4	31Aug2009, 13:03	5.92
FC-R16	11.2100	12964.0	31Aug2009, 13:03	5.91
FC-R17	10.1900	11668.7	31Aug2009, 13:21	5.92
FC-R18	9.6900	11476.3	31Aug2009, 13:21	5.92
FC-R19	8.4200	10767.1	31Aug2009, 13:21	5.91
FC-R20	7.6200	10255.3	31Aug2009, 13:21	5.90
FC-R21	7.3000	10052.6	31Aug2009, 13:21	5.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	7849.2	31Aug2009, 13:21	5.90
FC-R22	4.7500	7732.9	31Aug2009, 13:18	5.91
FC-R23	4.1700	7502.1	31Aug2009, 13:09	5.92
FC-R23A	4.0400	7849.7	31Aug2009, 12:54	5.94
FC-R23B	2.4900	4843.7	31Aug2009, 12:51	5.93
FC-R24	2.0400	4167.5	31Aug2009, 12:51	5.95
FC-R25	1.3000	3025.9	31Aug2009, 12:42	5.99
FC-R26	0.8100	2244.5	31Aug2009, 12:24	6.11
FC-R27	1.5500	3152.4	31Aug2009, 12:48	5.95
FC-R27A	0.8200	2047.4	31Aug2009, 12:30	6.00
Garden Branch	0.8000	1407.0	31Aug2009, 12:39	6.24
KB-01	0.2700	622.5	31Aug2009, 12:27	5.76
KB-02	0.5400	1235.4	31Aug2009, 12:27	5.89
KB-03	0.0500	166.9	31Aug2009, 12:12	5.98
KB-04	0.3700	1003.6	31Aug2009, 12:21	6.32
KB-J01	0.9600	2296.7	31Aug2009, 12:24	6.06
KB-J02	0.9100	2198.6	31Aug2009, 12:24	6.06
KB-R01	0.9600	2285.0	31Aug2009, 12:27	6.06
KB-R02	0.9100	2195.9	31Aug2009, 12:24	6.06
Kirby Creek	3.4000	4865.1	31Aug2009, 12:27	6.12
LB-01	0.4100	924.1	31Aug2009, 12:24	5.32
MB-01	0.2300	555.6	31Aug2009, 12:24	5.81
Mountain Creek Lake	26.6133	23406.7	31Aug2009, 14:21	5.85
NF-01	0.2700	659.1	31Aug2009, 12:21	5.70
NF-02	0.1900	397.4	31Aug2009, 12:24	4.78
NF-03	0.3500	621.0	31Aug2009, 12:36	5.14
NF-04	0.3400	866.3	31Aug2009, 12:21	5.92
NF-05	0.2900	660.5	31Aug2009, 12:21	4.94
NF-06	0.3500	831.8	31Aug2009, 12:24	5.72
NF-07	0.3800	925.3	31Aug2009, 12:24	5.73
NF-08	0.4000	992.3	31Aug2009, 12:24	5.89

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	1246.2	31Aug2009, 12:30	6.17
NF-09	0.5900	1638.4	31Aug2009, 12:18	6.11
NF-09A	0.2900	771.6	31Aug2009, 12:21	5.95
NF-10	0.1800	497.3	31Aug2009, 12:18	5.83
NF-11	0.7000	1590.9	31Aug2009, 12:27	5.88
NF-12	0.4900	1410.6	31Aug2009, 12:15	6.00
NF-13	0.2600	721.7	31Aug2009, 12:18	5.86
NF-14	0.5400	1417.5	31Aug2009, 12:21	5.88
NF-J01	6.1700	7985.1	31Aug2009, 13:27	5.79
NF-J02	5.9000	7915.8	31Aug2009, 13:24	5.80
NF-J03	5.7100	7917.0	31Aug2009, 13:21	5.83
NF-J04	5.7100	7921.1	31Aug2009, 13:21	5.83
NF-J05	5.3600	7672.1	31Aug2009, 13:18	5.88
NF-J06	4.7300	7462.6	31Aug2009, 13:09	5.93
NF-J07	4.3800	7421.3	31Aug2009, 13:03	5.95
NF-J08	4.0000	7801.9	31Aug2009, 12:48	5.97
NF-J09	3.6000	7706.9	31Aug2009, 12:33	5.98
NF-J10	3.0500	6978.5	31Aug2009, 12:27	5.94
NF-J11	2.4600	5859.6	31Aug2009, 12:24	5.90
NF-J12	1.9900	4693.6	31Aug2009, 12:24	5.91
NF-J13	1.2900	3155.4	31Aug2009, 12:21	5.92
NF-J14	0.5400	1417.5	31Aug2009, 12:21	5.88
NF-R01	6.1700	7983.5	31Aug2009, 13:27	5.79
NF-R02	5.9000	7891.2	31Aug2009, 13:27	5.80
NF-R03	5.7100	7844.8	31Aug2009, 13:27	5.83
NF-R04	5.7100	7917.0	31Aug2009, 13:21	5.83
NF-R05	5.3600	7665.1	31Aug2009, 13:21	5.88
NF-R06	4.7300	7399.6	31Aug2009, 13:18	5.93
NF-R07	4.3800	7248.8	31Aug2009, 13:12	5.95
NF-R08	4.0000	7140.3	31Aug2009, 13:03	5.97
NF-R09	3.6000	7294.3	31Aug2009, 12:48	5.98

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	6483.3	31Aug2009, 12:33	5.94
NF-R11	2.4600	5602.6	31Aug2009, 12:30	5.90
NF-R12	1.9900	4667.4	31Aug2009, 12:24	5.91
NF-R13	1.2900	3127.7	31Aug2009, 12:21	5.92
NF-R14	0.5400	1291.8	31Aug2009, 12:30	5.88
OB-01	0.0600	160.5	31Aug2009, 12:15	5.26
RB-01	0.4100	889.6	31Aug2009, 12:30	5.95
UNB-01	0.1400	392.2	31Aug2009, 12:18	5.91
UNB-02	0.6600	1412.0	31Aug2009, 12:30	5.95
UNB-03	0.5800	1481.7	31Aug2009, 12:21	5.93
UNB-J01A	1.8400	3275.8	31Aug2009, 12:36	5.85
UNB-J1	0.8000	1681.7	31Aug2009, 12:30	5.94
UNB-J2	0.6600	1412.0	31Aug2009, 12:30	5.95
UNB-R01A	1.8400	3272.1	31Aug2009, 12:39	5.85
UNB-R1	0.8000	1680.1	31Aug2009, 12:30	5.94
UNB-R2	0.6600	1410.8	31Aug2009, 12:33	5.95
UNC-01	0.5000	1001.8	31Aug2009, 12:36	5.97
UNC-02	1.2600	2437.8	31Aug2009, 12:36	5.81
UNC-J01	2.3400	4269.6	31Aug2009, 12:36	5.87
UNC-J02	1.2600	2437.8	31Aug2009, 12:36	5.81
UNC-R01	2.3400	4230.6	31Aug2009, 12:42	5.87
UNC-R02	1.2600	2363.4	31Aug2009, 12:45	5.81
UND-01	0.1400	343.1	31Aug2009, 12:18	5.36
Willis Branch	0.7233	1538.0	31Aug2009, 12:36	6.36

Project: Fish_Creek_Jul_2011 Simulation Run: Existing 02% - 50yr

Start of Run: 31Aug2009, 00:00 Basin Model: Fish - 50 yr
End of Run: 02Sep2009, 00:00 Meteorologic Model: 24hr_02%5(
Compute Time: 03Apr2012, 15:14:42 Control Specifications: Control Spe(

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	1881.5	31Aug2009, 12:42	6.84
DB-01	0.3400	842.7	31Aug2009, 12:30	6.76
FB-01	0.2600	725.9	31Aug2009, 12:21	6.66
FC-01	0.1500	252.8	31Aug2009, 12:57	6.58
FC-02	0.1300	414.6	31Aug2009, 12:12	6.13
FC-03	0.2300	389.8	31Aug2009, 12:39	5.05
FC-04	0.1200	392.3	31Aug2009, 12:09	5.64
FC-05	0.0800	260.1	31Aug2009, 12:09	5.29
FC-06	0.0600	174.8	31Aug2009, 12:18	6.33
FC-07	0.2100	717.7	31Aug2009, 12:15	7.22
FC-08	0.1400	467.4	31Aug2009, 12:15	6.96
FC-08A	0.0700	193.7	31Aug2009, 12:21	6.32
FC-09	0.3000	782.8	31Aug2009, 12:24	6.41
FC-10	0.3500	858.4	31Aug2009, 12:24	5.82
FC-11	0.5300	1130.6	31Aug2009, 12:33	6.05
FC-12	0.1900	579.9	31Aug2009, 12:18	6.71
FC-13	0.1300	316.9	31Aug2009, 12:24	6.00
FC-14	0.1300	378.0	31Aug2009, 12:18	6.38
FC-14A	0.2700	877.5	31Aug2009, 12:15	6.89
FC-15	0.0400	123.7	31Aug2009, 12:18	6.59
FC-16	0.3200	789.2	31Aug2009, 12:33	7.13
FC-17	0.2100	509.4	31Aug2009, 12:30	6.72
FC-18	0.5800	1612.5	31Aug2009, 12:24	6.77
FC-18A	0.1300	412.9	31Aug2009, 12:15	6.54
FC-19	0.4500	1062.8	31Aug2009, 12:33	6.80
FC-20	0.7300	1600.9	31Aug2009, 12:39	6.87

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	1952.9	31Aug2009, 12:27	6.86
FC-22	0.8200	2466.7	31Aug2009, 12:21	6.98
FC-23	0.4900	1332.1	31Aug2009, 12:24	6.76
FC-24	0.8100	2836.6	31Aug2009, 12:15	7.09
FC-J0	26.4633	27466.8	31Aug2009, 14:18	6.82
FC-J01	26.3333	27670.3	31Aug2009, 14:12	6.82
FC-J02	25.9233	28045.3	31Aug2009, 14:03	6.83
FC-J02A	22.5233	26587.4	31Aug2009, 13:51	6.79
FC-J03	22.2933	26897.0	31Aug2009, 13:45	6.81
FC-J04	22.0333	26897.8	31Aug2009, 13:42	6.81
FC-J05	21.9533	26876.6	31Aug2009, 13:42	6.82
FC-J06	21.6133	26776.3	31Aug2009, 13:39	6.82
FC-J07	21.4933	26943.1	31Aug2009, 13:39	6.82
FC-J08	21.2833	26771.2	31Aug2009, 13:36	6.82
FC-J09	21.1433	26852.8	31Aug2009, 13:36	6.82
FC-J10	20.8833	26574.7	31Aug2009, 13:36	6.82
FC-J11	14.7133	17931.3	31Aug2009, 13:42	6.85
FC-J12	14.3433	18002.7	31Aug2009, 13:27	6.86
FC-J13	13.5833	17771.2	31Aug2009, 13:12	6.88
FC-J13A	12.8600	17032.6	31Aug2009, 13:15	6.86
FC-J14	12.3300	16807.2	31Aug2009, 13:00	6.89
FC-J15	12.1400	16704.8	31Aug2009, 12:57	6.89
FC-J16	11.2100	15447.0	31Aug2009, 12:51	6.88
FC-J17	10.1900	13606.3	31Aug2009, 12:51	6.89
FC-J18	9.6900	13290.5	31Aug2009, 13:12	6.89
FC-J19	8.4200	12440.9	31Aug2009, 13:18	6.88
FC-J20	7.6200	11849.3	31Aug2009, 13:18	6.88
FC-J21	7.3000	11720.6	31Aug2009, 13:09	6.87
FC-J21A	4.9600	9063.0	31Aug2009, 13:21	6.88
FC-J22	4.7500	9061.2	31Aug2009, 13:09	6.88
FC-J22A	4.1700	9174.8	31Aug2009, 12:54	6.90

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	9197.9	31Aug2009, 12:51	6.91
FC-J23A	2.4900	5674.1	31Aug2009, 12:48	6.90
FC-J24	2.0400	5049.3	31Aug2009, 12:39	6.93
FC-J25	1.3000	3893.3	31Aug2009, 12:24	6.97
FC-J26	0.8100	2836.6	31Aug2009, 12:15	7.09
FC-J27	1.5500	3863.4	31Aug2009, 12:33	6.93
FC-J27A	0.8200	2466.7	31Aug2009, 12:21	6.98
FC-R00	26.4633	27454.0	31Aug2009, 14:18	6.82
FC-R01	26.3333	27439.1	31Aug2009, 14:18	6.82
FC-R02	25.9233	27571.2	31Aug2009, 14:12	6.83
FC-R02A	22.5233	26187.8	31Aug2009, 14:03	6.79
FC-R03	22.2933	26501.4	31Aug2009, 13:51	6.81
FC-R04	22.0333	26828.8	31Aug2009, 13:45	6.81
FC-R05	21.9533	26878.4	31Aug2009, 13:42	6.82
FC-R06	21.6133	26739.7	31Aug2009, 13:42	6.82
FC-R07	21.4933	26742.9	31Aug2009, 13:39	6.82
FC-R08	21.2833	26881.3	31Aug2009, 13:39	6.82
FC-R09	21.1433	26730.9	31Aug2009, 13:36	6.82
FC-R10	20.8833	26764.0	31Aug2009, 13:36	6.82
FC-R11	14.7133	17918.3	31Aug2009, 13:42	6.85
FC-R12	14.3433	17812.3	31Aug2009, 13:42	6.86
FC-R13	13.5833	17621.5	31Aug2009, 13:27	6.88
FC-R13A	12.8600	17034.2	31Aug2009, 13:15	6.86
FC-R14	12.3300	16577.3	31Aug2009, 13:15	6.89
FC-R15	12.1400	16670.6	31Aug2009, 13:00	6.89
FC-R16	11.2100	15297.0	31Aug2009, 13:00	6.88
FC-R17	10.1900	13591.9	31Aug2009, 12:54	6.89
FC-R18	9.6900	13278.9	31Aug2009, 13:18	6.89
FC-R19	8.4200	12436.0	31Aug2009, 13:18	6.88
FC-R20	7.6200	11841.3	31Aug2009, 13:21	6.88
FC-R21	7.3000	11594.5	31Aug2009, 13:21	6.87

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	9048.7	31Aug2009, 13:21	6.88
FC-R22	4.7500	8912.1	31Aug2009, 13:21	6.88
FC-R23	4.1700	8674.8	31Aug2009, 13:12	6.90
FC-R23A	4.0400	9073.1	31Aug2009, 12:54	6.91
FC-R23B	2.4900	5613.2	31Aug2009, 12:51	6.90
FC-R24	2.0400	4824.1	31Aug2009, 12:51	6.93
FC-R25	1.3000	3488.4	31Aug2009, 12:45	6.97
FC-R26	0.8100	2566.7	31Aug2009, 12:21	7.09
FC-R27	1.5500	3641.8	31Aug2009, 12:48	6.93
FC-R27A	0.8200	2355.9	31Aug2009, 12:30	6.98
Garden Branch	0.8000	1654.6	31Aug2009, 12:39	7.22
KB-01	0.2700	718.0	31Aug2009, 12:27	6.73
KB-02	0.5400	1423.0	31Aug2009, 12:27	6.86
KB-03	0.0500	188.5	31Aug2009, 12:12	6.95
KB-04	0.3700	1141.6	31Aug2009, 12:21	7.30
KB-J01	0.9600	2635.4	31Aug2009, 12:24	7.04
KB-J02	0.9100	2520.8	31Aug2009, 12:24	7.04
KB-R01	0.9600	2621.5	31Aug2009, 12:27	7.04
KB-R02	0.9100	2517.8	31Aug2009, 12:24	7.04
Kirby Creek	3.4000	5654.6	31Aug2009, 12:27	7.10
LB-01	0.4100	1074.4	31Aug2009, 12:24	6.26
MB-01	0.2300	639.2	31Aug2009, 12:24	6.78
Mountain Creek Lake	26.6133	27528.5	31Aug2009, 14:18	6.81
NF-01	0.2700	759.2	31Aug2009, 12:21	6.66
NF-02	0.1900	467.6	31Aug2009, 12:24	5.71
NF-03	0.3500	729.7	31Aug2009, 12:36	6.09
NF-04	0.3400	992.9	31Aug2009, 12:21	6.89
NF-05	0.2900	772.0	31Aug2009, 12:21	5.88
NF-06	0.3500	958.9	31Aug2009, 12:24	6.69
NF-07	0.3800	1065.6	31Aug2009, 12:24	6.70
NF-08	0.4000	1139.3	31Aug2009, 12:24	6.87

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	1430.5	31Aug2009, 12:30	7.15
NF-09	0.5900	1866.0	31Aug2009, 12:18	7.09
NF-09A	0.2900	882.4	31Aug2009, 12:21	6.92
NF-10	0.1800	568.4	31Aug2009, 12:18	6.80
NF-11	0.7000	1833.4	31Aug2009, 12:27	6.85
NF-12	0.4900	1606.1	31Aug2009, 12:15	6.98
NF-13	0.2600	824.4	31Aug2009, 12:18	6.83
NF-14	0.5400	1623.7	31Aug2009, 12:21	6.85
NF-J01	6.1700	9400.3	31Aug2009, 13:24	6.76
NF-J02	5.9000	9289.2	31Aug2009, 13:21	6.77
NF-J03	5.7100	9269.8	31Aug2009, 13:18	6.80
NF-J04	5.7100	9277.6	31Aug2009, 13:18	6.80
NF-J05	5.3600	8966.0	31Aug2009, 13:15	6.85
NF-J06	4.7300	8724.8	31Aug2009, 13:06	6.91
NF-J07	4.3800	8679.9	31Aug2009, 13:00	6.92
NF-J08	4.0000	8979.6	31Aug2009, 12:45	6.95
NF-J09	3.6000	8853.7	31Aug2009, 12:33	6.95
NF-J10	3.0500	7993.0	31Aug2009, 12:27	6.92
NF-J11	2.4600	6681.8	31Aug2009, 12:24	6.88
NF-J12	1.9900	5414.6	31Aug2009, 12:24	6.88
NF-J13	1.2900	3636.0	31Aug2009, 12:21	6.89
NF-J14	0.5400	1623.7	31Aug2009, 12:21	6.85
NF-R01	6.1700	9413.4	31Aug2009, 13:24	6.76
NF-R02	5.9000	9283.3	31Aug2009, 13:24	6.77
NF-R03	5.7100	9197.1	31Aug2009, 13:21	6.80
NF-R04	5.7100	9269.8	31Aug2009, 13:18	6.80
NF-R05	5.3600	8960.8	31Aug2009, 13:18	6.85
NF-R06	4.7300	8636.0	31Aug2009, 13:18	6.91
NF-R07	4.3800	8469.6	31Aug2009, 13:09	6.92
NF-R08	4.0000	8331.1	31Aug2009, 13:00	6.95
NF-R09	3.6000	8377.1	31Aug2009, 12:48	6.95

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	7474.1	31Aug2009, 12:36	6.92
NF-R11	2.4600	6445.4	31Aug2009, 12:30	6.88
NF-R12	1.9900	5364.5	31Aug2009, 12:27	6.88
NF-R13	1.2900	3604.7	31Aug2009, 12:24	6.89
NF-R14	0.5400	1500.9	31Aug2009, 12:30	6.85
OB-01	0.0600	185.0	31Aug2009, 12:15	6.18
RB-01	0.4100	1025.7	31Aug2009, 12:30	6.93
UNB-01	0.1400	447.5	31Aug2009, 12:18	6.88
UNB-02	0.6600	1628.3	31Aug2009, 12:30	6.93
UNB-03	0.5800	1697.8	31Aug2009, 12:21	6.91
UNB-J01A	1.8400	3815.9	31Aug2009, 12:36	6.82
UNB-J1	0.8000	1943.0	31Aug2009, 12:30	6.92
UNB-J2	0.6600	1628.3	31Aug2009, 12:30	6.93
UNB-R01A	1.8400	3809.7	31Aug2009, 12:39	6.82
UNB-R1	0.8000	1941.2	31Aug2009, 12:30	6.92
UNB-R2	0.6600	1626.9	31Aug2009, 12:33	6.93
UNC-01	0.5000	1157.0	31Aug2009, 12:36	6.95
UNC-02	1.2600	2824.8	31Aug2009, 12:36	6.78
UNC-J01	2.3400	4965.1	31Aug2009, 12:36	6.85
UNC-J02	1.2600	2824.8	31Aug2009, 12:36	6.78
UNC-R01	2.3400	4937.5	31Aug2009, 12:39	6.85
UNC-R02	1.2600	2742.8	31Aug2009, 12:45	6.78
UND-01	0.1400	396.9	31Aug2009, 12:18	6.29
Willis Branch	0.7233	1755.6	31Aug2009, 12:36	7.35

Project: Fish_Creek_Jul_2011 Simulation Run: Existing 01% - 100yr

Start of Run:	31Aug2009, 00:00	Basin Model:	Fish - 100 yr
End of Run:	02Sep2009, 00:00	Meteorologic Model:	24hr_01% 1
Compute Time:	12Oct2011, 08:34:01	Control Specifications:	Control Spec

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	2130.1	31Aug2009, 12:42	7.83
DB-01	0.3400	953.3	31Aug2009, 12:30	7.74
FB-01	0.2600	820.3	31Aug2009, 12:21	7.64
FC-01	0.1500	288.0	31Aug2009, 12:57	7.56
FC-02	0.1300	470.2	31Aug2009, 12:12	7.09
FC-03	0.2300	455.8	31Aug2009, 12:39	5.95
FC-04	0.1200	447.8	31Aug2009, 12:09	6.57
FC-05	0.0800	298.4	31Aug2009, 12:09	6.20
FC-06	0.0600	198.1	31Aug2009, 12:18	7.28
FC-07	0.2100	801.5	31Aug2009, 12:15	8.21
FC-08	0.1400	523.7	31Aug2009, 12:15	7.93
FC-08A	0.0700	219.9	31Aug2009, 12:21	7.27
FC-09	0.3000	888.7	31Aug2009, 12:24	7.38
FC-10	0.3500	984.0	31Aug2009, 12:24	6.76
FC-11	0.5300	1295.1	31Aug2009, 12:33	7.01
FC-12	0.1900	653.1	31Aug2009, 12:18	7.70
FC-13	0.1300	362.4	31Aug2009, 12:24	6.96
FC-14	0.1300	428.2	31Aug2009, 12:18	7.35
FC-14A	0.2700	984.7	31Aug2009, 12:15	7.89
FC-15	0.0400	139.4	31Aug2009, 12:18	7.57
FC-16	0.3200	888.3	31Aug2009, 12:33	8.13
FC-17	0.2100	576.3	31Aug2009, 12:30	7.71
FC-18	0.5800	1818.2	31Aug2009, 12:24	7.76
FC-18A	0.1300	465.3	31Aug2009, 12:15	7.53
FC-19	0.4500	1201.9	31Aug2009, 12:33	7.79
FC-20	0.7300	1810.7	31Aug2009, 12:39	7.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	2202.5	31Aug2009, 12:27	7.85
FC-22	0.8200	2769.8	31Aug2009, 12:21	7.98
FC-23	0.4900	1503.1	31Aug2009, 12:24	7.75
FC-24	0.8100	3167.7	31Aug2009, 12:15	8.09
FC-J0	26.4633	31260.2	31Aug2009, 14:15	7.80
FC-J01	26.3333	31458.0	31Aug2009, 14:06	7.81
FC-J02	25.9233	31860.7	31Aug2009, 13:57	7.82
FC-J02A	22.5233	29897.8	31Aug2009, 13:48	7.77
FC-J03	22.2933	30166.5	31Aug2009, 13:39	7.79
FC-J04	22.0333	30234.3	31Aug2009, 13:36	7.80
FC-J05	21.9533	30217.8	31Aug2009, 13:33	7.81
FC-J06	21.6133	30065.0	31Aug2009, 13:33	7.81
FC-J07	21.4933	30102.1	31Aug2009, 13:33	7.81
FC-J08	21.2833	29986.1	31Aug2009, 13:33	7.81
FC-J09	21.1433	30020.7	31Aug2009, 13:30	7.81
FC-J10	20.8833	30008.6	31Aug2009, 13:27	7.81
FC-J11	14.7133	20262.7	31Aug2009, 13:54	7.84
FC-J12	14.3433	20428.7	31Aug2009, 13:30	7.85
FC-J13	13.5833	20365.0	31Aug2009, 13:12	7.87
FC-J13A	12.8600	19533.8	31Aug2009, 13:12	7.85
FC-J14	12.3300	19148.0	31Aug2009, 13:00	7.88
FC-J15	12.1400	19032.7	31Aug2009, 13:00	7.89
FC-J16	11.2100	17710.2	31Aug2009, 12:51	7.87
FC-J17	10.1900	15666.0	31Aug2009, 12:54	7.89
FC-J18	9.6900	15171.2	31Aug2009, 12:54	7.89
FC-J19	8.4200	14125.9	31Aug2009, 13:21	7.88
FC-J20	7.6200	13498.6	31Aug2009, 13:21	7.87
FC-J21	7.3000	13417.5	31Aug2009, 13:15	7.86
FC-J21A	4.9600	10372.6	31Aug2009, 13:18	7.87
FC-J22	4.7500	10350.8	31Aug2009, 13:09	7.88
FC-J22A	4.1700	10391.8	31Aug2009, 12:54	7.90

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	10477.4	31Aug2009, 12:48	7.91
FC-J23A	2.4900	6518.7	31Aug2009, 12:48	7.90
FC-J24	2.0400	5698.0	31Aug2009, 12:39	7.92
FC-J25	1.3000	4388.0	31Aug2009, 12:24	7.96
FC-J26	0.8100	3167.7	31Aug2009, 12:15	8.09
FC-J27	1.5500	4362.9	31Aug2009, 12:30	7.92
FC-J27A	0.8200	2769.8	31Aug2009, 12:21	7.98
FC-R00	26.4633	31251.8	31Aug2009, 14:15	7.80
FC-R01	26.3333	31227.0	31Aug2009, 14:15	7.81
FC-R02	25.9233	31339.5	31Aug2009, 14:06	7.82
FC-R02A	22.5233	29701.9	31Aug2009, 14:00	7.77
FC-R03	22.2933	29796.2	31Aug2009, 13:48	7.79
FC-R04	22.0333	30090.4	31Aug2009, 13:39	7.80
FC-R05	21.9533	30213.1	31Aug2009, 13:36	7.81
FC-R06	21.6133	30041.2	31Aug2009, 13:36	7.81
FC-R07	21.4933	30028.1	31Aug2009, 13:33	7.81
FC-R08	21.2833	30034.9	31Aug2009, 13:33	7.81
FC-R09	21.1433	29943.5	31Aug2009, 13:33	7.81
FC-R10	20.8833	29914.8	31Aug2009, 13:30	7.81
FC-R11	14.7133	20263.5	31Aug2009, 13:54	7.84
FC-R12	14.3433	20148.2	31Aug2009, 13:54	7.85
FC-R13	13.5833	20046.7	31Aug2009, 13:33	7.87
FC-R13A	12.8600	19528.6	31Aug2009, 13:15	7.85
FC-R14	12.3300	18995.8	31Aug2009, 13:15	7.88
FC-R15	12.1400	18999.2	31Aug2009, 13:03	7.89
FC-R16	11.2100	17525.1	31Aug2009, 13:03	7.87
FC-R17	10.1900	15653.3	31Aug2009, 12:57	7.89
FC-R18	9.6900	15159.3	31Aug2009, 13:00	7.89
FC-R19	8.4200	14126.5	31Aug2009, 13:21	7.88
FC-R20	7.6200	13478.2	31Aug2009, 13:21	7.87
FC-R21	7.3000	13221.8	31Aug2009, 13:21	7.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	10320.6	31Aug2009, 13:18	7.87
FC-R22	4.7500	10186.5	31Aug2009, 13:18	7.88
FC-R23	4.1700	9869.9	31Aug2009, 13:09	7.90
FC-R23A	4.0400	10274.9	31Aug2009, 12:54	7.91
FC-R23B	2.4900	6431.8	31Aug2009, 12:51	7.90
FC-R24	2.0400	5514.4	31Aug2009, 12:48	7.92
FC-R25	1.3000	3926.6	31Aug2009, 12:45	7.96
FC-R26	0.8100	2903.6	31Aug2009, 12:21	8.09
FC-R27	1.5500	4104.3	31Aug2009, 12:45	7.92
FC-R27A	0.8200	2667.5	31Aug2009, 12:27	7.98
Garden Branch	0.8000	1891.5	31Aug2009, 12:39	8.22
KB-01	0.2700	810.6	31Aug2009, 12:27	7.72
KB-02	0.5400	1604.9	31Aug2009, 12:27	7.86
KB-03	0.0500	210.3	31Aug2009, 12:12	7.95
KB-04	0.3700	1276.8	31Aug2009, 12:21	8.31
KB-J01	0.9600	2963.8	31Aug2009, 12:24	8.04
KB-J02	0.9100	2834.2	31Aug2009, 12:24	8.04
KB-R01	0.9600	2949.1	31Aug2009, 12:27	8.04
KB-R02	0.9100	2830.9	31Aug2009, 12:24	8.04
Kirby Creek	3.4000	6496.4	31Aug2009, 12:27	8.09
LB-01	0.4100	1221.9	31Aug2009, 12:24	7.23
MB-01	0.2300	720.7	31Aug2009, 12:24	7.77
Mountain Creek Lake	26.6133	31339.1	31Aug2009, 14:15	7.80
NF-01	0.2700	857.7	31Aug2009, 12:21	7.64
NF-02	0.1900	536.4	31Aug2009, 12:24	6.67
NF-03	0.3500	835.0	31Aug2009, 12:36	7.06
NF-04	0.3400	1116.9	31Aug2009, 12:21	7.89
NF-05	0.2900	882.0	31Aug2009, 12:21	6.83
NF-06	0.3500	1082.9	31Aug2009, 12:24	7.68
NF-07	0.3800	1202.2	31Aug2009, 12:24	7.68
NF-08	0.4000	1282.4	31Aug2009, 12:24	7.86

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	1608.3	31Aug2009, 12:30	8.15
NF-09	0.5900	2090.6	31Aug2009, 12:18	8.08
NF-09A	0.2900	991.2	31Aug2009, 12:18	7.92
NF-10	0.1800	638.7	31Aug2009, 12:18	7.79
NF-11	0.7000	2068.7	31Aug2009, 12:27	7.84
NF-12	0.4900	1800.0	31Aug2009, 12:15	7.97
NF-13	0.2600	925.9	31Aug2009, 12:18	7.82
NF-14	0.5400	1826.1	31Aug2009, 12:21	7.84
NF-J01	6.1700	10946.3	31Aug2009, 13:21	7.75
NF-J02	5.9000	10855.1	31Aug2009, 13:18	7.76
NF-J03	5.7100	10881.6	31Aug2009, 13:15	7.79
NF-J04	5.7100	10883.9	31Aug2009, 13:12	7.79
NF-J05	5.3600	10496.3	31Aug2009, 13:12	7.84
NF-J06	4.7300	10212.2	31Aug2009, 13:03	7.90
NF-J07	4.3800	10128.7	31Aug2009, 12:57	7.92
NF-J08	4.0000	10320.6	31Aug2009, 12:45	7.94
NF-J09	3.6000	10331.0	31Aug2009, 12:30	7.95
NF-J10	3.0500	8950.4	31Aug2009, 12:27	7.91
NF-J11	2.4600	7533.0	31Aug2009, 12:24	7.87
NF-J12	1.9900	6136.2	31Aug2009, 12:24	7.87
NF-J13	1.2900	4128.7	31Aug2009, 12:21	7.89
NF-J14	0.5400	1826.1	31Aug2009, 12:21	7.84
NF-R01	6.1700	10938.8	31Aug2009, 13:21	7.75
NF-R02	5.9000	10807.0	31Aug2009, 13:21	7.76
NF-R03	5.7100	10741.8	31Aug2009, 13:18	7.79
NF-R04	5.7100	10881.6	31Aug2009, 13:15	7.79
NF-R05	5.3600	10471.1	31Aug2009, 13:15	7.84
NF-R06	4.7300	10085.8	31Aug2009, 13:12	7.90
NF-R07	4.3800	9863.4	31Aug2009, 13:03	7.92
NF-R08	4.0000	9682.9	31Aug2009, 12:57	7.94
NF-R09	3.6000	9572.6	31Aug2009, 12:45	7.95

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	8750.0	31Aug2009, 12:33	7.91
NF-R11	2.4600	7227.5	31Aug2009, 12:30	7.87
NF-R12	1.9900	6052.6	31Aug2009, 12:27	7.87
NF-R13	1.2900	4097.6	31Aug2009, 12:21	7.89
NF-R14	0.5400	1697.8	31Aug2009, 12:30	7.84
OB-01	0.0600	209.7	31Aug2009, 12:15	7.13
RB-01	0.4100	1157.3	31Aug2009, 12:30	7.92
UNB-01	0.1400	502.2	31Aug2009, 12:18	7.88
UNB-02	0.6600	1837.4	31Aug2009, 12:30	7.92
UNB-03	0.5800	1909.4	31Aug2009, 12:21	7.90
UNB-J01A	1.8400	4333.4	31Aug2009, 12:36	7.81
UNB-J1	0.8000	2193.9	31Aug2009, 12:30	7.92
UNB-J2	0.6600	1837.4	31Aug2009, 12:30	7.92
UNB-R01A	1.8400	4328.9	31Aug2009, 12:36	7.81
UNB-R1	0.8000	2192.1	31Aug2009, 12:30	7.92
UNB-R2	0.6600	1835.4	31Aug2009, 12:33	7.92
UNC-01	0.5000	1306.4	31Aug2009, 12:36	7.94
UNC-02	1.2600	3197.9	31Aug2009, 12:36	7.77
UNC-J01	2.3400	5635.3	31Aug2009, 12:36	7.84
UNC-J02	1.2600	3197.9	31Aug2009, 12:36	7.77
UNC-R01	2.3400	5606.2	31Aug2009, 12:39	7.84
UNC-R02	1.2600	3106.0	31Aug2009, 12:45	7.77
UND-01	0.1400	450.5	31Aug2009, 12:18	7.25
Willis Branch	0.7233	1966.8	31Aug2009, 12:36	8.35

Project: Fish_Creek_Jul_2011 Simulation Run: Existing 0.2% - 500 yr

Start of Run: 31Aug2009, 00:00 Basin Model: Fish - 500 yr
End of Run: 02Sep2009, 00:00 Meteorologic Model: 24hr_0.2% 5
Compute Time: 03Apr2012, 15:24:28 Control Specifications: Control Spec

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	2762.1	31Aug2009, 12:42	10.21
DB-01	0.3400	1227.8	31Aug2009, 12:30	10.10
FB-01	0.2600	1046.7	31Aug2009, 12:21	9.99
FC-01	0.1500	378.4	31Aug2009, 12:57	9.93
FC-02	0.1300	595.3	31Aug2009, 12:12	9.40
FC-03	0.2300	624.0	31Aug2009, 12:39	8.14
FC-04	0.1200	569.9	31Aug2009, 12:09	8.84
FC-05	0.0800	381.6	31Aug2009, 12:09	8.44
FC-06	0.0600	252.8	31Aug2009, 12:18	9.60
FC-07	0.2100	993.1	31Aug2009, 12:15	10.60
FC-08	0.1400	652.4	31Aug2009, 12:15	10.28
FC-08A	0.0700	282.4	31Aug2009, 12:21	9.59
FC-09	0.3000	1146.0	31Aug2009, 12:24	9.71
FC-10	0.3500	1289.2	31Aug2009, 12:24	9.04
FC-11	0.5300	1706.6	31Aug2009, 12:33	9.33
FC-12	0.1900	824.5	31Aug2009, 12:18	10.07
FC-13	0.1300	473.3	31Aug2009, 12:24	9.27
FC-14	0.1300	546.0	31Aug2009, 12:18	9.69
FC-14A	0.2700	1231.4	31Aug2009, 12:15	10.27
FC-15	0.0400	176.0	31Aug2009, 12:18	9.94
FC-16	0.3200	1136.8	31Aug2009, 12:33	10.53
FC-17	0.2100	742.5	31Aug2009, 12:30	10.09
FC-18	0.5800	2315.5	31Aug2009, 12:24	10.14
FC-18A	0.1300	585.6	31Aug2009, 12:15	9.90
FC-19	0.4500	1549.7	31Aug2009, 12:33	10.17
FC-20	0.7300	2341.8	31Aug2009, 12:39	10.25

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	2814.7	31Aug2009, 12:27	10.23
FC-22	0.8200	3491.3	31Aug2009, 12:21	10.37
FC-23	0.4900	1917.9	31Aug2009, 12:24	10.13
FC-24	0.8100	3917.3	31Aug2009, 12:15	10.48
FC-J0	26.4633	40200.6	31Aug2009, 14:21	10.17
FC-J01	26.3333	40425.3	31Aug2009, 14:15	10.18
FC-J02	25.9233	40841.0	31Aug2009, 14:06	10.19
FC-J02A	22.5233	38802.1	31Aug2009, 13:54	10.15
FC-J03	22.2933	39179.8	31Aug2009, 13:48	10.17
FC-J04	22.0333	39156.3	31Aug2009, 13:48	10.18
FC-J05	21.9533	39117.4	31Aug2009, 13:48	10.19
FC-J06	21.6133	38988.1	31Aug2009, 13:45	10.19
FC-J07	21.4933	39030.1	31Aug2009, 13:45	10.19
FC-J08	21.2833	38972.8	31Aug2009, 13:42	10.19
FC-J09	21.1433	39007.1	31Aug2009, 13:42	10.19
FC-J10	20.8833	38917.2	31Aug2009, 13:42	10.19
FC-J11	14.7133	27228.2	31Aug2009, 13:42	10.21
FC-J12	14.3433	27358.8	31Aug2009, 13:27	10.23
FC-J13	13.5833	27086.1	31Aug2009, 13:12	10.26
FC-J13A	12.8600	26038.4	31Aug2009, 13:12	10.23
FC-J14	12.3300	25520.9	31Aug2009, 13:03	10.27
FC-J15	12.1400	25416.2	31Aug2009, 13:00	10.27
FC-J16	11.2100	23695.9	31Aug2009, 12:51	10.26
FC-J17	10.1900	21001.0	31Aug2009, 12:51	10.27
FC-J18	9.6900	20343.8	31Aug2009, 13:12	10.27
FC-J19	8.4200	19048.3	31Aug2009, 13:18	10.26
FC-J20	7.6200	18143.2	31Aug2009, 13:18	10.26
FC-J21	7.3000	17993.8	31Aug2009, 13:09	10.25
FC-J21A	4.9600	13738.6	31Aug2009, 13:15	10.26
FC-J22	4.7500	13622.1	31Aug2009, 13:06	10.26
FC-J22A	4.1700	13690.3	31Aug2009, 12:51	10.28

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	13782.7	31Aug2009, 12:48	10.29
FC-J23A	2.4900	8729.4	31Aug2009, 12:45	10.28
FC-J24	2.0400	7385.0	31Aug2009, 12:39	10.31
FC-J25	1.3000	5535.8	31Aug2009, 12:24	10.35
FC-J26	0.8100	3917.3	31Aug2009, 12:15	10.48
FC-J27	1.5500	5583.8	31Aug2009, 12:30	10.31
FC-J27A	0.8200	3491.3	31Aug2009, 12:21	10.37
FC-R00	26.4633	40185.1	31Aug2009, 14:21	10.17
FC-R01	26.3333	40162.6	31Aug2009, 14:21	10.18
FC-R02	25.9233	40286.8	31Aug2009, 14:15	10.19
FC-R02A	22.5233	38097.7	31Aug2009, 14:06	10.15
FC-R03	22.2933	38667.9	31Aug2009, 13:54	10.17
FC-R04	22.0333	39078.8	31Aug2009, 13:48	10.18
FC-R05	21.9533	39128.9	31Aug2009, 13:48	10.19
FC-R06	21.6133	38923.6	31Aug2009, 13:48	10.19
FC-R07	21.4933	38938.2	31Aug2009, 13:45	10.19
FC-R08	21.2833	38940.2	31Aug2009, 13:45	10.19
FC-R09	21.1433	38912.6	31Aug2009, 13:42	10.19
FC-R10	20.8833	38876.9	31Aug2009, 13:42	10.19
FC-R11	14.7133	27309.6	31Aug2009, 13:42	10.21
FC-R12	14.3433	27037.1	31Aug2009, 13:42	10.23
FC-R13	13.5833	26766.6	31Aug2009, 13:27	10.26
FC-R13A	12.8600	26021.7	31Aug2009, 13:15	10.23
FC-R14	12.3300	25303.3	31Aug2009, 13:15	10.27
FC-R15	12.1400	25334.2	31Aug2009, 13:03	10.27
FC-R16	11.2100	23414.8	31Aug2009, 13:03	10.26
FC-R17	10.1900	20965.7	31Aug2009, 12:54	10.27
FC-R18	9.6900	20320.7	31Aug2009, 13:18	10.27
FC-R19	8.4200	19052.0	31Aug2009, 13:18	10.26
FC-R20	7.6200	18121.1	31Aug2009, 13:18	10.26
FC-R21	7.3000	17747.6	31Aug2009, 13:18	10.25

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	13688.7	31Aug2009, 13:18	10.26
FC-R22	4.7500	13471.5	31Aug2009, 13:15	10.26
FC-R23	4.1700	12965.5	31Aug2009, 13:09	10.28
FC-R23A	4.0400	13515.5	31Aug2009, 12:51	10.29
FC-R23B	2.4900	8527.8	31Aug2009, 12:48	10.28
FC-R24	2.0400	7340.2	31Aug2009, 12:45	10.31
FC-R25	1.3000	5051.5	31Aug2009, 12:42	10.35
FC-R26	0.8100	3629.1	31Aug2009, 12:21	10.48
FC-R27	1.5500	5301.4	31Aug2009, 12:45	10.31
FC-R27A	0.8200	3407.7	31Aug2009, 12:27	10.37
Garden Branch	0.8000	2568.9	31Aug2009, 12:36	10.61
KB-01	0.2700	1037.3	31Aug2009, 12:27	10.10
KB-02	0.5400	2051.4	31Aug2009, 12:27	10.24
KB-03	0.0500	258.2	31Aug2009, 12:09	10.34
KB-04	0.3700	1599.5	31Aug2009, 12:21	10.71
KB-J01	0.9600	3768.4	31Aug2009, 12:24	10.43
KB-J02	0.9100	3597.7	31Aug2009, 12:24	10.43
KB-R01	0.9600	3748.6	31Aug2009, 12:27	10.42
KB-R02	0.9100	3593.9	31Aug2009, 12:24	10.43
Kirby Creek	3.4000	8550.5	31Aug2009, 12:30	10.46
LB-01	0.4100	1579.0	31Aug2009, 12:24	9.55
MB-01	0.2300	917.8	31Aug2009, 12:24	10.15
Mountain Creek Lake	26.6133	40292.9	31Aug2009, 14:21	10.17
NF-01	0.2700	1093.3	31Aug2009, 12:21	10.00
NF-02	0.1900	702.6	31Aug2009, 12:24	8.98
NF-03	0.3500	1098.9	31Aug2009, 12:36	9.40
NF-04	0.3400	1413.0	31Aug2009, 12:21	10.27
NF-05	0.2900	1143.5	31Aug2009, 12:21	9.15
NF-06	0.3500	1383.0	31Aug2009, 12:24	10.05
NF-07	0.3800	1532.0	31Aug2009, 12:24	10.06
NF-08	0.4000	1628.1	31Aug2009, 12:24	10.24

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	2049.8	31Aug2009, 12:30	10.55
NF-09	0.5900	2616.8	31Aug2009, 12:18	10.47
NF-09A	0.2900	1249.1	31Aug2009, 12:21	10.30
NF-10	0.1800	802.4	31Aug2009, 12:18	10.17
NF-11	0.7000	2646.8	31Aug2009, 12:27	10.22
NF-12	0.4900	2246.4	31Aug2009, 12:15	10.36
NF-13	0.2600	1162.2	31Aug2009, 12:18	10.20
NF-14	0.5400	2307.1	31Aug2009, 12:21	10.21
NF-J01	6.1700	15025.3	31Aug2009, 13:15	10.13
NF-J02	5.9000	14894.4	31Aug2009, 13:12	10.13
NF-J03	5.7100	15081.1	31Aug2009, 13:09	10.17
NF-J04	5.7100	15120.6	31Aug2009, 13:06	10.17
NF-J05	5.3600	14479.8	31Aug2009, 13:06	10.22
NF-J06	4.7300	13957.9	31Aug2009, 12:57	10.28
NF-J07	4.3800	13666.2	31Aug2009, 12:51	10.30
NF-J08	4.0000	13421.6	31Aug2009, 12:45	10.32
NF-J09	3.6000	13156.2	31Aug2009, 12:30	10.33
NF-J10	3.0500	11222.6	31Aug2009, 12:27	10.29
NF-J11	2.4600	9597.2	31Aug2009, 12:24	10.25
NF-J12	1.9900	7786.7	31Aug2009, 12:24	10.25
NF-J13	1.2900	5226.1	31Aug2009, 12:21	10.27
NF-J14	0.5400	2307.1	31Aug2009, 12:21	10.21
NF-R01	6.1700	15021.8	31Aug2009, 13:18	10.13
NF-R02	5.9000	14802.7	31Aug2009, 13:15	10.13
NF-R03	5.7100	14713.2	31Aug2009, 13:12	10.17
NF-R04	5.7100	15081.1	31Aug2009, 13:09	10.17
NF-R05	5.3600	14456.4	31Aug2009, 13:06	10.22
NF-R06	4.7300	13832.9	31Aug2009, 13:06	10.28
NF-R07	4.3800	13404.8	31Aug2009, 13:00	10.30
NF-R08	4.0000	12963.4	31Aug2009, 12:54	10.32
NF-R09	3.6000	12435.9	31Aug2009, 12:45	10.33

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	11108.1	31Aug2009, 12:33	10.29
NF-R11	2.4600	9085.2	31Aug2009, 12:30	10.25
NF-R12	1.9900	7728.5	31Aug2009, 12:27	10.25
NF-R13	1.2900	5171.6	31Aug2009, 12:24	10.27
NF-R14	0.5400	2138.8	31Aug2009, 12:30	10.21
OB-01	0.0600	266.2	31Aug2009, 12:15	9.44
RB-01	0.4100	1484.2	31Aug2009, 12:30	10.30
UNB-01	0.1400	629.3	31Aug2009, 12:18	10.26
UNB-02	0.6600	2357.1	31Aug2009, 12:30	10.31
UNB-03	0.5800	2414.7	31Aug2009, 12:21	10.29
UNB-J01A	1.8400	5623.3	31Aug2009, 12:36	10.20
UNB-J1	0.8000	2823.2	31Aug2009, 12:30	10.30
UNB-J2	0.6600	2357.1	31Aug2009, 12:30	10.31
UNB-R01A	1.8400	5619.4	31Aug2009, 12:36	10.20
UNB-R1	0.8000	2821.1	31Aug2009, 12:30	10.30
UNB-R2	0.6600	2355.4	31Aug2009, 12:33	10.31
UNC-01	0.5000	1682.8	31Aug2009, 12:36	10.33
UNC-02	1.2600	4137.6	31Aug2009, 12:36	10.15
UNC-J01	2.3400	7302.1	31Aug2009, 12:36	10.22
UNC-J02	1.2600	4137.6	31Aug2009, 12:36	10.15
UNC-R01	2.3400	7273.1	31Aug2009, 12:39	10.22
UNC-R02	1.2600	4005.7	31Aug2009, 12:45	10.15
UND-01	0.1400	576.8	31Aug2009, 12:18	9.56
Willis Branch	0.7233	2543.0	31Aug2009, 12:36	10.74

Project: Fish_Creek_Jul_2011 Simulation Run: Ultimate 01% - 100 yr

Start of Run:	31Aug2009, 00:00	Basin Model:	Fish - Ultima
End of Run:	02Sep2009, 00:00	Meteorologic Model:	24hr_01% 1
Compute Time:	03Apr2012, 15:30:22	Control Specifications:	Control Spec

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
BNB-01	0.8900	2204.8	31Aug2009, 12:39	8.32
DB-01	0.3400	953.3	31Aug2009, 12:30	7.74
FB-01	0.2600	820.4	31Aug2009, 12:21	7.64
FC-01	0.1500	288.0	31Aug2009, 12:57	7.56
FC-02	0.1300	470.3	31Aug2009, 12:12	7.09
FC-03	0.2300	455.8	31Aug2009, 12:39	5.95
FC-04	0.1200	485.5	31Aug2009, 12:09	7.41
FC-05	0.0800	336.3	31Aug2009, 12:09	7.45
FC-06	0.0600	199.8	31Aug2009, 12:18	7.38
FC-07	0.2100	830.9	31Aug2009, 12:15	8.72
FC-08	0.1400	523.8	31Aug2009, 12:15	7.94
FC-08A	0.0700	226.8	31Aug2009, 12:21	7.62
FC-09	0.3000	940.5	31Aug2009, 12:24	8.06
FC-10	0.3500	1030.2	31Aug2009, 12:24	7.25
FC-11	0.5300	1308.0	31Aug2009, 12:33	7.12
FC-12	0.1900	658.3	31Aug2009, 12:18	7.81
FC-13	0.1300	369.0	31Aug2009, 12:24	7.16
FC-14	0.1300	428.2	31Aug2009, 12:18	7.35
FC-14A	0.2700	984.7	31Aug2009, 12:15	7.89
FC-15	0.0400	147.1	31Aug2009, 12:18	8.35
FC-16	0.3200	888.4	31Aug2009, 12:33	8.13
FC-17	0.2100	590.3	31Aug2009, 12:30	8.06
FC-18	0.5800	1853.1	31Aug2009, 12:24	8.05
FC-18A	0.1300	473.4	31Aug2009, 12:15	7.78
FC-19	0.4500	1228.1	31Aug2009, 12:33	8.10
FC-20	0.7300	1828.3	31Aug2009, 12:39	8.01

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-21	0.7400	2243.3	31Aug2009, 12:27	8.13
FC-22	0.8200	2817.0	31Aug2009, 12:21	8.24
FC-23	0.4900	1558.1	31Aug2009, 12:24	8.29
FC-24	0.8100	3225.4	31Aug2009, 12:15	8.38
FC-J0	26.4633	31623.7	31Aug2009, 14:15	8.08
FC-J01	26.3333	31825.8	31Aug2009, 14:06	8.09
FC-J02	25.9233	32213.3	31Aug2009, 13:57	8.09
FC-J02A	22.5233	30253.8	31Aug2009, 13:48	8.10
FC-J03	22.2933	30576.0	31Aug2009, 13:39	8.12
FC-J04	22.0333	30678.7	31Aug2009, 13:36	8.13
FC-J05	21.9533	30676.4	31Aug2009, 13:36	8.13
FC-J06	21.6133	30524.4	31Aug2009, 13:33	8.14
FC-J07	21.4933	30549.2	31Aug2009, 13:33	8.14
FC-J08	21.2833	30476.9	31Aug2009, 13:33	8.14
FC-J09	21.1433	30501.9	31Aug2009, 13:30	8.14
FC-J10	20.8833	30459.4	31Aug2009, 13:27	8.14
FC-J11	14.7133	20350.1	31Aug2009, 13:54	8.05
FC-J12	14.3433	20487.8	31Aug2009, 13:33	8.05
FC-J13	13.5833	20401.1	31Aug2009, 13:12	8.07
FC-J13A	12.8600	19592.4	31Aug2009, 13:15	8.06
FC-J14	12.3300	19201.6	31Aug2009, 13:03	8.10
FC-J15	12.1400	19088.4	31Aug2009, 13:00	8.10
FC-J16	11.2100	17786.9	31Aug2009, 12:54	8.11
FC-J17	10.1900	15819.4	31Aug2009, 13:00	8.10
FC-J18	9.6900	15496.9	31Aug2009, 13:18	8.10
FC-J19	8.4200	14612.7	31Aug2009, 13:21	8.05
FC-J20	7.6200	13874.4	31Aug2009, 13:21	8.06
FC-J21	7.3000	13841.7	31Aug2009, 13:15	8.06
FC-J21A	4.9600	10625.1	31Aug2009, 13:15	8.16
FC-J22	4.7500	10598.3	31Aug2009, 13:09	8.16
FC-J22A	4.1700	10606.0	31Aug2009, 12:54	8.18

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-J23	4.0400	10707.8	31Aug2009, 12:48	8.19
FC-J23A	2.4900	6680.2	31Aug2009, 12:48	8.23
FC-J24	2.0400	5832.2	31Aug2009, 12:39	8.26
FC-J25	1.3000	4495.1	31Aug2009, 12:24	8.34
FC-J26	0.8100	3225.4	31Aug2009, 12:15	8.38
FC-J27	1.5500	4427.0	31Aug2009, 12:30	8.13
FC-J27A	0.8200	2817.0	31Aug2009, 12:21	8.24
FC-R00	26.4633	31620.5	31Aug2009, 14:15	8.08
FC-R01	26.3333	31590.4	31Aug2009, 14:15	8.09
FC-R02	25.9233	31704.9	31Aug2009, 14:06	8.09
FC-R02A	22.5233	30048.1	31Aug2009, 13:57	8.10
FC-R03	22.2933	30152.2	31Aug2009, 13:48	8.12
FC-R04	22.0333	30498.6	31Aug2009, 13:39	8.13
FC-R05	21.9533	30656.2	31Aug2009, 13:36	8.13
FC-R06	21.6133	30508.2	31Aug2009, 13:36	8.14
FC-R07	21.4933	30487.5	31Aug2009, 13:33	8.14
FC-R08	21.2833	30480.9	31Aug2009, 13:33	8.14
FC-R09	21.1433	30434.3	31Aug2009, 13:33	8.14
FC-R10	20.8833	30396.0	31Aug2009, 13:30	8.14
FC-R11	14.7133	20345.9	31Aug2009, 13:54	8.05
FC-R12	14.3433	20232.7	31Aug2009, 13:54	8.05
FC-R13	13.5833	20119.6	31Aug2009, 13:33	8.07
FC-R13A	12.8600	19590.9	31Aug2009, 13:15	8.06
FC-R14	12.3300	19065.2	31Aug2009, 13:15	8.10
FC-R15	12.1400	19058.2	31Aug2009, 13:03	8.10
FC-R16	11.2100	17639.2	31Aug2009, 13:06	8.11
FC-R17	10.1900	15812.5	31Aug2009, 13:03	8.10
FC-R18	9.6900	15481.6	31Aug2009, 13:21	8.10
FC-R19	8.4200	14606.9	31Aug2009, 13:21	8.05
FC-R20	7.6200	13844.8	31Aug2009, 13:24	8.06
FC-R21	7.3000	13597.6	31Aug2009, 13:21	8.06

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
FC-R21A	4.9600	10579.9	31Aug2009, 13:18	8.16
FC-R22	4.7500	10419.0	31Aug2009, 13:15	8.16
FC-R23	4.1700	10112.0	31Aug2009, 13:09	8.18
FC-R23A	4.0400	10488.1	31Aug2009, 12:54	8.19
FC-R23B	2.4900	6594.3	31Aug2009, 12:51	8.23
FC-R24	2.0400	5657.8	31Aug2009, 12:48	8.26
FC-R25	1.3000	4025.5	31Aug2009, 12:42	8.34
FC-R26	0.8100	2958.2	31Aug2009, 12:21	8.38
FC-R27	1.5500	4163.3	31Aug2009, 12:45	8.13
FC-R27A	0.8200	2718.6	31Aug2009, 12:27	8.24
Garden Branch	0.8000	1891.5	31Aug2009, 12:39	8.22
KB-01	0.2700	875.3	31Aug2009, 12:27	8.92
KB-02	0.5400	1637.5	31Aug2009, 12:27	8.15
KB-03	0.0500	210.3	31Aug2009, 12:12	7.95
KB-04	0.3700	1294.2	31Aug2009, 12:21	8.52
KB-J01	0.9600	3013.8	31Aug2009, 12:24	8.28
KB-J02	0.9100	2884.2	31Aug2009, 12:24	8.30
KB-R01	0.9600	2996.8	31Aug2009, 12:27	8.29
KB-R02	0.9100	2880.9	31Aug2009, 12:24	8.30
Kirby Creek	3.4000	6496.4	31Aug2009, 12:27	8.09
LB-01	0.4100	1278.9	31Aug2009, 12:24	7.78
MB-01	0.2300	750.4	31Aug2009, 12:24	8.38
Mountain Creek Lake	26.6133	31707.8	31Aug2009, 14:15	8.08
NF-01	0.2700	866.1	31Aug2009, 12:21	7.77
NF-02	0.1900	640.5	31Aug2009, 12:24	8.98
NF-03	0.3500	970.8	31Aug2009, 12:36	9.12
NF-04	0.3400	1144.4	31Aug2009, 12:21	8.25
NF-05	0.2900	971.6	31Aug2009, 12:21	8.06
NF-06	0.3500	1118.5	31Aug2009, 12:24	8.14
NF-07	0.3800	1269.4	31Aug2009, 12:24	8.52
NF-08	0.4000	1341.4	31Aug2009, 12:21	8.56

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-08A	0.5500	1668.6	31Aug2009, 12:30	8.72
NF-09	0.5900	2131.1	31Aug2009, 12:18	8.37
NF-09A	0.2900	1008.7	31Aug2009, 12:18	8.17
NF-10	0.1800	658.6	31Aug2009, 12:18	8.25
NF-11	0.7000	2127.5	31Aug2009, 12:27	8.24
NF-12	0.4900	1842.9	31Aug2009, 12:15	8.32
NF-13	0.2600	949.1	31Aug2009, 12:18	8.20
NF-14	0.5400	1867.1	31Aug2009, 12:18	8.15
NF-J01	6.1700	11353.3	31Aug2009, 13:21	8.37
NF-J02	5.9000	11279.3	31Aug2009, 13:18	8.39
NF-J03	5.7100	11363.8	31Aug2009, 13:12	8.37
NF-J04	5.7100	11376.8	31Aug2009, 13:12	8.37
NF-J05	5.3600	10902.5	31Aug2009, 13:09	8.32
NF-J06	4.7300	10597.8	31Aug2009, 13:03	8.35
NF-J07	4.3800	10495.9	31Aug2009, 12:54	8.36
NF-J08	4.0000	10629.3	31Aug2009, 12:45	8.35
NF-J09	3.6000	10585.4	31Aug2009, 12:30	8.32
NF-J10	3.0500	9138.1	31Aug2009, 12:27	8.25
NF-J11	2.4600	7721.4	31Aug2009, 12:24	8.22
NF-J12	1.9900	6293.7	31Aug2009, 12:24	8.23
NF-J13	1.2900	4234.3	31Aug2009, 12:21	8.22
NF-J14	0.5400	1867.1	31Aug2009, 12:18	8.15
NF-R01	6.1700	11349.8	31Aug2009, 13:21	8.37
NF-R02	5.9000	11213.3	31Aug2009, 13:21	8.39
NF-R03	5.7100	11154.0	31Aug2009, 13:18	8.37
NF-R04	5.7100	11363.8	31Aug2009, 13:12	8.37
NF-R05	5.3600	10901.9	31Aug2009, 13:12	8.32
NF-R06	4.7300	10456.9	31Aug2009, 13:12	8.35
NF-R07	4.3800	10241.9	31Aug2009, 13:03	8.36
NF-R08	4.0000	9995.1	31Aug2009, 12:57	8.35
NF-R09	3.6000	9855.9	31Aug2009, 12:45	8.32

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
NF-R10	3.0500	8935.4	31Aug2009, 12:33	8.25
NF-R11	2.4600	7383.2	31Aug2009, 12:30	8.22
NF-R12	1.9900	6203.6	31Aug2009, 12:27	8.23
NF-R13	1.2900	4208.3	31Aug2009, 12:21	8.22
NF-R14	0.5400	1734.5	31Aug2009, 12:30	8.15
OB-01	0.0600	210.0	31Aug2009, 12:15	7.15
RB-01	0.4100	1161.0	31Aug2009, 12:30	7.97
UNB-01	0.1400	502.2	31Aug2009, 12:18	7.88
UNB-02	0.6600	1694.6	31Aug2009, 12:36	7.92
UNB-03	0.5800	1909.5	31Aug2009, 12:21	7.90
UNB-J1	0.8000	1988.6	31Aug2009, 12:33	7.92
UNB-J2	0.6600	1694.6	31Aug2009, 12:36	7.92
UNB-R1	0.8000	1985.4	31Aug2009, 12:33	7.92
UNB-R2	0.6600	1690.1	31Aug2009, 12:39	7.92
UNC-01	0.5000	1306.4	31Aug2009, 12:36	7.94
UNC-02	1.2600	3055.2	31Aug2009, 12:39	7.78
UNC-J01	2.3400	5384.7	31Aug2009, 12:39	7.84
UNC-J01A	1.8400	4094.0	31Aug2009, 12:39	7.82
UNC-J02	1.2600	3055.2	31Aug2009, 12:39	7.78
UNC-R01	2.3400	5358.8	31Aug2009, 12:42	7.84
UNC-R01A	1.8400	4093.3	31Aug2009, 12:39	7.82
UNC-R02	1.2600	2979.3	31Aug2009, 12:48	7.78
UND-01	0.1400	450.5	31Aug2009, 12:18	7.25
Willis Branch	0.7233	1966.8	31Aug2009, 12:36	8.35

HEC-RAS Plan: P1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	26747	10 yr	4801.00	564.00	571.26	571.26	573.49	0.002083	12.00	400.20	91.14	1.01
NORTH FISH	MAIN STEM	26747	50 yr	6682.00	564.00	572.59	572.59	575.05	0.001832	12.58	544.03	164.28	0.97
NORTH FISH	MAIN STEM	26747	100 yr	7533.00	564.00	573.23	573.23	575.63	0.001553	12.51	673.86	244.97	0.91
NORTH FISH	MAIN STEM	26747	500 yr	9597.00	564.00	574.53	574.53	576.73	0.001150	12.32	1093.91	381.02	0.81
NORTH FISH	MAIN STEM	26747	U_100 yr	7590.00	564.00	573.27	573.27	575.67	0.001539	12.51	683.40	249.87	0.91
NORTH FISH	MAIN STEM	25796	10 yr	4801.00	559.00	569.37	565.46	570.08	0.000334	6.78	708.18	93.33	0.43
NORTH FISH	MAIN STEM	25796	50 yr	6682.00	559.00	570.97	566.81	571.87	0.000352	7.67	954.90	194.00	0.46
NORTH FISH	MAIN STEM	25796	100 yr	7533.00	559.00	571.57	567.36	572.55	0.000352	8.00	1073.14	196.12	0.46
NORTH FISH	MAIN STEM	25796	500 yr	9597.00	559.00	572.49	568.57	573.73	0.000404	9.12	1254.92	199.78	0.50
NORTH FISH	MAIN STEM	25796	U_100 yr	7590.00	559.00	571.64	567.38	572.61	0.000348	8.00	1086.22	196.39	0.46
NORTH FISH	MAIN STEM	25164	10 yr	5820.00	557.00	569.08	565.05	569.86	0.000341	7.10	819.64	103.37	0.44
NORTH FISH	MAIN STEM	25164	50 yr	7993.00	557.00	570.60	566.41	571.62	0.000390	8.13	983.28	112.76	0.48
NORTH FISH	MAIN STEM	25164	100 yr	8950.00	557.00	571.16	566.95	572.29	0.000401	8.55	1063.69	186.86	0.49
NORTH FISH	MAIN STEM	25164	500 yr	11223.00	557.00	571.94	568.16	573.43	0.000476	9.83	1221.82	218.21	0.55
NORTH FISH	MAIN STEM	25164	U_100 yr	9045.00	557.00	571.21	567.00	572.36	0.000401	8.59	1073.80	189.17	0.49
NORTH FISH	MAIN STEM	24976	10 yr	5820.00	553.90	569.49	559.00	569.64	0.000034	3.12	1867.60	318.06	0.15
NORTH FISH	MAIN STEM	24976	50 yr	7993.00	553.90	571.14	560.12	571.33	0.000042	3.53	2875.25	617.99	0.17
NORTH FISH	MAIN STEM	24976	100 yr	8950.00	553.90	571.77	560.58	571.97	0.000043	3.71	3267.36	638.41	0.17
NORTH FISH	MAIN STEM	24976	500 yr	11223.00	553.90	572.75	561.56	573.01	0.000051	4.21	3919.68	679.88	0.19
NORTH FISH	MAIN STEM	24976	U_100 yr	9045.00	553.90	571.83	560.63	572.03	0.000043	3.72	3305.48	640.25	0.18
NORTH FISH	MAIN STEM	24725		Culvert									
NORTH FISH	MAIN STEM	24306	10 yr	5820.00	548.64	560.95	556.72	561.81	0.003190	7.43	782.96	362.32	0.42
NORTH FISH	MAIN STEM	24306	50 yr	7993.00	548.64	561.87	557.99	563.22	0.004446	9.32	857.35	379.03	0.50
NORTH FISH	MAIN STEM	24306	100 yr	8950.00	548.64	562.64	558.50	563.11	0.002229	6.29	2127.03	387.63	0.35
NORTH FISH	MAIN STEM	24306	500 yr	11223.00	548.64	563.63	559.70	564.16	0.002274	6.77	2520.83	409.38	0.36
NORTH FISH	MAIN STEM	24306	U_100 yr	9045.00	548.64	562.70	558.58	563.17	0.002216	6.29	2149.50	388.24	0.35
NORTH FISH	MAIN STEM	24089	10 yr	6637.00	549.00	560.70	559.00	560.91	0.001801	5.15	2445.50	525.79	0.31
NORTH FISH	MAIN STEM	24089	50 yr	8854.00	549.00	561.70	559.01	561.94	0.001840	5.60	2983.02	549.68	0.32
NORTH FISH	MAIN STEM	24089	100 yr	10331.00	549.00	562.29	559.09	562.55	0.001885	5.90	3311.84	558.60	0.32
NORTH FISH	MAIN STEM	24089	500 yr	13156.00	549.00	563.29	559.60	563.58	0.001908	6.31	3872.11	562.57	0.33
NORTH FISH	MAIN STEM	24089	U_100 yr	10485.00	549.00	562.35	559.13	562.61	0.001886	5.92	3344.48	558.82	0.32
NORTH FISH	MAIN STEM	23706	10 yr	6637.00	549.00	559.48		559.96	0.003878	7.54	1623.63	350.86	0.44
NORTH FISH	MAIN STEM	23706	50 yr	8854.00	549.00	560.40		560.95	0.004116	8.28	1955.99	380.14	0.46
NORTH FISH	MAIN STEM	23706	100 yr	10331.00	549.00	560.94		561.54	0.004246	8.71	2168.14	397.22	0.47
NORTH FISH	MAIN STEM	23706	500 yr	13156.00	549.00	561.86		562.54	0.004454	9.43	2539.21	408.87	0.49
NORTH FISH	MAIN STEM	23706	U_100 yr	10485.00	549.00	560.99		561.59	0.004257	8.75	2189.78	397.65	0.47
NORTH FISH	MAIN STEM	23367	10 yr	6637.00	547.00	557.86		558.45	0.005314	8.09	1515.22	393.39	0.52
NORTH FISH	MAIN STEM	23367	50 yr	8854.00	547.00	558.61		559.31	0.005940	9.10	1818.44	420.48	0.55
NORTH FISH	MAIN STEM	23367	100 yr	10331.00	547.00	559.05		559.83	0.006285	9.69	2007.47	437.52	0.58
NORTH FISH	MAIN STEM	23367	500 yr	13156.00	547.00	559.87		560.75	0.006605	10.54	2378.82	469.62	0.60
NORTH FISH	MAIN STEM	23367	U_100 yr	10485.00	547.00	559.10		559.88	0.006316	9.75	2027.39	439.62	0.58
NORTH FISH	MAIN STEM	22696	10 yr	6637.00	546.00	554.32		554.82	0.007633	8.25	1561.40	482.86	0.60
NORTH FISH	MAIN STEM	22696	50 yr	8854.00	546.00	555.21		555.70	0.006566	8.41	1995.42	493.40	0.57
NORTH FISH	MAIN STEM	22696	100 yr	10331.00	546.00	555.79		556.28	0.005954	8.46	2284.60	500.29	0.55
NORTH FISH	MAIN STEM	22696	500 yr	13156.00	546.00	556.92		557.40	0.004915	8.47	2857.85	515.03	0.51
NORTH FISH	MAIN STEM	22696	U_100 yr	10485.00	546.00	555.85		556.34	0.005893	8.47	2314.97	501.01	0.55
NORTH FISH	MAIN STEM	22159	10 yr	6637.00	544.00	552.17		552.30	0.002281	4.86	2433.90	486.16	0.33
NORTH FISH	MAIN STEM	22159	50 yr	8854.00	544.00	553.38		553.53	0.002023	5.10	3025.75	493.51	0.32
NORTH FISH	MAIN STEM	22159	100 yr	10331.00	544.00	554.13		554.29	0.001899	5.24	3399.73	498.21	0.31
NORTH FISH	MAIN STEM	22159	500 yr	13156.00	544.00	555.54		555.72	0.001684	5.45	4109.33	507.13	0.30
NORTH FISH	MAIN STEM	22159	U_100 yr	10485.00	544.00	554.21		554.37	0.001887	5.25	3438.28	498.68	0.31
NORTH FISH	MAIN STEM	21693	10 yr	6637.00	542.00	551.45		551.57	0.001769	4.54	2595.42	470.51	0.29
NORTH FISH	MAIN STEM	21693	50 yr	8854.00	542.00	552.73		552.87	0.001609	4.79	3206.17	479.65	0.28
NORTH FISH	MAIN STEM	21693	100 yr	10331.00	542.00	553.53		553.67	0.001534	4.95	3587.61	485.28	0.28
NORTH FISH	MAIN STEM	21693	500 yr	13156.00	542.00	555.00		555.16	0.001393	5.18	4312.88	498.32	0.27
NORTH FISH	MAIN STEM	21693	U_100 yr	10485.00	542.00	553.61		553.75	0.001526	4.97	3626.87	485.86	0.28
NORTH FISH	MAIN STEM	21069	10 yr	6637.00	537.48	549.71		550.52	0.006699	10.66	1182.15	210.50	0.58
NORTH FISH	MAIN STEM	21069	50 yr	8854.00	537.48	551.03		551.91	0.006506	11.36	1467.75	222.61	0.58
NORTH FISH	MAIN STEM	21069	100 yr	10331.00	537.48	551.82		552.75	0.006401	11.77	1647.23	229.63	0.58
NORTH FISH	MAIN STEM	21069	500 yr	13156.00	537.48	553.34		554.33	0.005983	12.27	2007.20	244.91	0.57
NORTH FISH	MAIN STEM	21069	U_100 yr	10485.00	537.48	551.90		552.84	0.006386	11.80	1666.03	230.36	0.58
NORTH FISH	MAIN STEM	20194	10 yr	6637.00	539.00	548.51		548.59	0.001037	3.68	3137.14	503.73	0.23
NORTH FISH	MAIN STEM	20194	50 yr	8854.00	539.00	549.97		550.06	0.000938	3.91	3884.06	516.31	0.22
NORTH FISH	MAIN STEM	20194	100 yr	10331.00	539.00	550.84		550.94	0.000905	4.07	4335.85	524.48	0.22
NORTH FISH	MAIN STEM	20194	500 yr	13156.00	539.00	552.52		552.63	0.000818	4.28	5230.10	540.23	0.22
NORTH FISH	MAIN STEM	20194	U_100 yr	10485.00	539.00	550.93		551.03	0.000901	4.09	4383.01	525.32	0.22

HEC-RAS Plan: P1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	19301	10 yr	6637.00	533.00	545.74		547.23	0.007333	11.49	912.60	167.94	0.64
NORTH FISH	MAIN STEM	19301	50 yr	8854.00	533.00	547.08		548.80	0.007568	12.68	1151.93	191.69	0.66
NORTH FISH	MAIN STEM	19301	100 yr	10331.00	533.00	547.83		549.71	0.007767	13.40	1302.25	207.02	0.68
NORTH FISH	MAIN STEM	19301	500 yr	13156.00	533.00	549.23		551.45	0.008259	14.85	1620.73	279.24	0.71
NORTH FISH	MAIN STEM	19301	U_100 yr	10485.00	533.00	547.92		549.80	0.007748	13.45	1320.55	208.87	0.68
NORTH FISH	MAIN STEM	18958	10 yr	6637.00	532.00	544.73	543.08	545.29	0.003288	7.74	1641.85	363.43	0.43
NORTH FISH	MAIN STEM	18958	50 yr	8854.00	532.00	546.41	543.81	546.88	0.002525	7.50	2269.05	386.41	0.38
NORTH FISH	MAIN STEM	18958	100 yr	10331.00	532.00	547.26	544.21	547.74	0.002393	7.65	2608.51	403.95	0.38
NORTH FISH	MAIN STEM	18958	500 yr	13156.00	532.00	548.91	544.90	549.36	0.002078	7.72	3301.19	436.80	0.36
NORTH FISH	MAIN STEM	18958	U_100 yr	10485.00	532.00	547.37	544.25	547.84	0.002368	7.65	2649.95	406.57	0.38
NORTH FISH	MAIN STEM	18557	10 yr	6637.00	530.59	544.20	539.51	544.38	0.001310	5.09	2283.62	307.23	0.27
NORTH FISH	MAIN STEM	18557	50 yr	8854.00	530.59	545.92	540.16	546.13	0.001340	5.66	2853.95	345.80	0.27
NORTH FISH	MAIN STEM	18557	100 yr	10331.00	530.59	546.75	540.54	547.00	0.001468	6.17	3157.45	384.12	0.29
NORTH FISH	MAIN STEM	18557	500 yr	13156.00	530.59	548.41	541.22	548.69	0.001495	6.71	3877.03	462.94	0.30
NORTH FISH	MAIN STEM	18557	U_100 yr	10485.00	530.59	546.85	540.58	547.11	0.001472	6.21	3197.26	389.21	0.29
NORTH FISH	MAIN STEM	18097	10 yr	6637.00	530.00	543.27		543.71	0.002298	6.72	1672.23	277.07	0.37
NORTH FISH	MAIN STEM	18097	50 yr	8854.00	530.00	545.05		545.50	0.001986	6.94	2184.97	295.52	0.35
NORTH FISH	MAIN STEM	18097	100 yr	10331.00	530.00	545.84		546.33	0.002032	7.31	2421.59	302.02	0.36
NORTH FISH	MAIN STEM	18097	500 yr	13156.00	530.00	547.51		548.03	0.001923	7.71	2938.04	317.54	0.35
NORTH FISH	MAIN STEM	18097	U_100 yr	10485.00	530.00	545.95		546.44	0.002017	7.33	2453.73	302.92	0.36
NORTH FISH	MAIN STEM	17616	10 yr	6544.00	528.52	542.15	538.56	542.65	0.002597	7.83	1552.10	230.30	0.39
NORTH FISH	MAIN STEM	17616	50 yr	8980.00	528.52	543.91	539.55	544.50	0.002730	8.75	1998.32	302.13	0.40
NORTH FISH	MAIN STEM	17616	100 yr	10321.00	528.52	544.70	540.05	545.33	0.002732	9.07	2222.69	327.23	0.41
NORTH FISH	MAIN STEM	17616	500 yr	13422.00	528.52	546.49	541.00	547.11	0.002502	9.34	2896.20	362.21	0.40
NORTH FISH	MAIN STEM	17616	U_100 yr	10509.00	528.52	544.81	540.09	545.44	0.002730	9.11	2253.88	333.61	0.41
NORTH FISH	MAIN STEM	17216	10 yr	6544.00	525.61	539.84		541.19	0.006174	11.06	995.31	192.54	0.57
NORTH FISH	MAIN STEM	17216	50 yr	8980.00	525.61	541.59		543.01	0.005924	11.90	1384.83	246.78	0.57
NORTH FISH	MAIN STEM	17216	100 yr	10321.00	525.61	542.46		543.87	0.005649	12.12	1608.75	269.96	0.57
NORTH FISH	MAIN STEM	17216	500 yr	13422.00	525.61	544.39		545.78	0.005130	12.58	2219.58	367.71	0.55
NORTH FISH	MAIN STEM	17216	U_100 yr	10509.00	525.61	542.58		543.98	0.005602	12.14	1641.90	273.35	0.57
NORTH FISH	MAIN STEM	16737	10 yr	6544.00	525.00	537.80		538.80	0.004853	9.93	1080.06	172.34	0.53
NORTH FISH	MAIN STEM	16737	50 yr	8980.00	525.00	539.81		540.84	0.004302	10.45	1436.16	184.04	0.51
NORTH FISH	MAIN STEM	16737	100 yr	10321.00	525.00	540.67		541.79	0.004353	10.97	1599.98	197.91	0.52
NORTH FISH	MAIN STEM	16737	500 yr	13422.00	525.00	542.37		543.80	0.004909	12.58	2016.44	303.92	0.56
NORTH FISH	MAIN STEM	16737	U_100 yr	10509.00	525.00	540.79		541.92	0.004370	11.05	1623.32	201.20	0.52
NORTH FISH	MAIN STEM	16385	10 yr	6544.00	523.00	536.78		537.32	0.003846	8.41	1468.47	256.78	0.43
NORTH FISH	MAIN STEM	16385	50 yr	8980.00	523.00	539.18		539.61	0.002572	7.78	2105.18	273.34	0.36
NORTH FISH	MAIN STEM	16385	100 yr	10321.00	523.00	540.12		540.56	0.002419	7.87	2365.46	279.71	0.36
NORTH FISH	MAIN STEM	16385	500 yr	13422.00	523.00	541.95		542.43	0.002309	8.30	2889.42	295.09	0.35
NORTH FISH	MAIN STEM	16385	U_100 yr	10509.00	523.00	540.25		540.69	0.002400	7.89	2401.16	280.53	0.36
NORTH FISH	MAIN STEM	15832	10 yr	6544.00	521.00	535.49		535.94	0.001638	6.41	1667.35	245.14	0.31
NORTH FISH	MAIN STEM	15832	50 yr	8980.00	521.00	538.27		538.68	0.001269	6.40	2402.78	298.33	0.28
NORTH FISH	MAIN STEM	15832	100 yr	10321.00	521.00	539.23		539.67	0.001284	6.69	2712.81	342.24	0.28
NORTH FISH	MAIN STEM	15832	500 yr	13422.00	521.00	541.03		541.54	0.001397	7.46	3396.17	425.91	0.30
NORTH FISH	MAIN STEM	15832	U_100 yr	10509.00	521.00	539.36		539.80	0.001284	6.72	2758.09	346.57	0.28
NORTH FISH	MAIN STEM	15272	10 yr	6544.00	519.00	533.65		534.68	0.003799	9.10	1008.06	183.32	0.46
NORTH FISH	MAIN STEM	15272	50 yr	8980.00	519.00	537.22		537.87	0.001966	7.76	1759.54	237.64	0.34
NORTH FISH	MAIN STEM	15272	100 yr	10321.00	519.00	538.21		538.87	0.001901	7.94	2002.08	251.97	0.34
NORTH FISH	MAIN STEM	15272	500 yr	13422.00	519.00	539.98		540.71	0.001931	8.56	2471.51	279.37	0.35
NORTH FISH	MAIN STEM	15272	U_100 yr	10509.00	519.00	538.35		539.01	0.001891	7.97	2036.45	253.93	0.34
NORTH FISH	MAIN STEM	14909	10 yr	6544.00	517.00	532.93		533.55	0.002091	7.25	1418.70	218.78	0.34
NORTH FISH	MAIN STEM	14909	50 yr	8980.00	517.00	536.87		537.28	0.001174	6.41	2450.22	296.03	0.27
NORTH FISH	MAIN STEM	14909	100 yr	10321.00	517.00	537.86		538.30	0.001189	6.68	2754.84	316.62	0.27
NORTH FISH	MAIN STEM	14909	500 yr	13422.00	517.00	539.62		540.12	0.001281	7.36	3340.73	348.05	0.28
NORTH FISH	MAIN STEM	14909	U_100 yr	10509.00	517.00	538.00		538.44	0.001190	6.72	2798.36	319.45	0.27
NORTH FISH	MAIN STEM	14375	10 yr	6544.00	515.28	532.54		532.82	0.000527	4.91	2347.59	320.33	0.21
NORTH FISH	MAIN STEM	14375	50 yr	8980.00	515.28	536.67		536.88	0.000329	4.51	3784.46	374.57	0.18
NORTH FISH	MAIN STEM	14375	100 yr	10321.00	515.28	537.67		537.89	0.000345	4.77	4163.17	387.96	0.18
NORTH FISH	MAIN STEM	14375	500 yr	13422.00	515.28	539.40		539.68	0.000403	5.43	4862.57	419.39	0.20
NORTH FISH	MAIN STEM	14375	U_100 yr	10509.00	515.28	537.80		538.03	0.000347	4.80	4216.40	390.04	0.18
NORTH FISH	MAIN STEM	14089	10 yr	6544.00	515.00	532.43		532.67	0.000534	5.03	2392.08	293.75	0.22
NORTH FISH	MAIN STEM	14089	50 yr	8980.00	515.00	536.62		536.78	0.000304	4.43	3737.05	351.27	0.17
NORTH FISH	MAIN STEM	14089	100 yr	10321.00	515.00	537.61		537.79	0.000317	4.67	4096.34	374.86	0.18
NORTH FISH	MAIN STEM	14089	500 yr	13422.00	515.00	539.35		539.57	0.000359	5.23	4788.98	420.64	0.19
NORTH FISH	MAIN STEM	14089	U_100 yr	10509.00	515.00	537.75		537.93	0.000318	4.70	4147.90	378.65	0.18

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	13910	10 yr	6544.00	514.00	532.42		532.57	0.000231	3.41	2284.15	243.18	0.15
NORTH FISH	MAIN STEM	13910	50 yr	8980.00	514.00	536.60		536.73	0.000148	3.21	3366.73	283.99	0.13
NORTH FISH	MAIN STEM	13910	100 yr	10321.00	514.00	537.59		537.74	0.000158	3.42	3661.52	309.63	0.13
NORTH FISH	MAIN STEM	13910	500 yr	13422.00	514.00	539.32		539.51	0.000186	3.92	4245.72	361.32	0.15
NORTH FISH	MAIN STEM	13910	U_100 yr	10509.00	514.00	537.73		537.88	0.000159	3.45	3703.91	312.44	0.13
NORTH FISH	MAIN STEM	13805	10 yr	6199.00	513.00	532.36		532.54	0.000298	3.79	1963.37	228.00	0.17
NORTH FISH	MAIN STEM	13805	50 yr	8680.00	513.00	536.56		536.71	0.000185	3.49	2990.06	270.46	0.14
NORTH FISH	MAIN STEM	13805	100 yr	10129.00	513.00	537.55		537.72	0.000200	3.75	3266.74	293.03	0.14
NORTH FISH	MAIN STEM	13805	500 yr	13667.00	513.00	539.25		539.49	0.000249	4.41	3793.98	325.12	0.16
NORTH FISH	MAIN STEM	13805	U_100 yr	10366.00	513.00	537.68		537.86	0.000203	3.79	3306.20	296.05	0.14
NORTH FISH	MAIN STEM	13687	10 yr	6199.00	510.97	532.32	519.15	532.51	0.000222	4.01	2058.60	221.41	0.16
NORTH FISH	MAIN STEM	13687	50 yr	8680.00	510.97	536.53	520.97	536.69	0.000157	3.82	3127.04	297.82	0.13
NORTH FISH	MAIN STEM	13687	100 yr	10129.00	510.97	537.51	522.04	537.70	0.000172	4.10	3431.92	323.36	0.14
NORTH FISH	MAIN STEM	13687	500 yr	13667.00	510.97	539.21	524.13	539.46	0.000218	4.81	4019.12	364.04	0.16
NORTH FISH	MAIN STEM	13687	U_100 yr	10366.00	510.97	537.64	522.17	537.83	0.000175	4.15	3475.33	327.78	0.14
NORTH FISH	MAIN STEM	13587		Culvert									
NORTH FISH	MAIN STEM	13486	10 yr	6199.00	510.35	524.65	518.54	525.47	0.001469	7.48	891.91	133.83	0.36
NORTH FISH	MAIN STEM	13486	50 yr	8680.00	510.35	526.76	520.25	527.90	0.001706	8.87	1056.16	144.79	0.39
NORTH FISH	MAIN STEM	13486	100 yr	10129.00	510.35	527.84	521.17	529.16	0.001825	9.59	1140.13	157.55	0.41
NORTH FISH	MAIN STEM	13486	500 yr	13667.00	510.35	530.39	523.14	532.12	0.001988	11.00	1339.39	177.10	0.44
NORTH FISH	MAIN STEM	13486	U_100 yr	10366.00	510.35	528.01	521.32	529.36	0.001841	9.70	1153.74	159.24	0.41
NORTH FISH	MAIN STEM	13276	10 yr	6199.00	511.00	524.45		525.07	0.001448	7.43	1052.74	124.84	0.37
NORTH FISH	MAIN STEM	13276	50 yr	8680.00	511.00	526.63		527.38	0.001445	8.26	1336.21	135.51	0.38
NORTH FISH	MAIN STEM	13276	100 yr	10129.00	511.00	527.75		528.58	0.001453	8.69	1491.33	141.60	0.38
NORTH FISH	MAIN STEM	13276	500 yr	13667.00	511.00	530.43		531.38	0.001423	9.55	1897.20	161.54	0.39
NORTH FISH	MAIN STEM	13276	U_100 yr	10366.00	511.00	527.93		528.77	0.001451	8.75	1517.28	142.56	0.38
NORTH FISH	MAIN STEM	12994	10 yr	6199.00	509.51	522.47		524.34	0.004170	11.76	628.84	78.42	0.61
NORTH FISH	MAIN STEM	12994	50 yr	8680.00	509.51	523.93		526.56	0.005133	14.13	747.07	84.36	0.70
NORTH FISH	MAIN STEM	12994	100 yr	10129.00	509.51	524.48		527.68	0.005942	15.64	794.68	87.33	0.75
NORTH FISH	MAIN STEM	12994	500 yr	13667.00	509.51	525.52	524.86	530.31	0.008170	19.28	889.88	96.15	0.89
NORTH FISH	MAIN STEM	12994	U_100 yr	10366.00	509.51	524.58		527.86	0.006051	15.86	803.29	87.88	0.76
NORTH FISH	MAIN STEM	12743	10 yr	6199.00	509.55	522.28		523.25	0.002591	9.44	915.86	126.14	0.49
NORTH FISH	MAIN STEM	12743	50 yr	8680.00	509.55	523.89		525.17	0.002982	11.04	1135.14	149.22	0.54
NORTH FISH	MAIN STEM	12743	100 yr	10129.00	509.55	524.57		526.05	0.003278	11.97	1239.54	159.35	0.57
NORTH FISH	MAIN STEM	12743	500 yr	13667.00	509.55	526.15		528.00	0.003685	13.63	1508.17	179.48	0.61
NORTH FISH	MAIN STEM	12743	U_100 yr	10366.00	509.55	524.70		526.20	0.003300	12.08	1259.78	161.17	0.57
NORTH FISH	MAIN STEM	12502	10 yr	6199.00	508.00	522.26		522.65	0.000892	6.20	1451.92	177.61	0.30
NORTH FISH	MAIN STEM	12502	50 yr	8680.00	508.00	523.93		524.45	0.001060	7.30	1758.03	190.48	0.33
NORTH FISH	MAIN STEM	12502	100 yr	10129.00	508.00	524.63		525.24	0.001192	7.98	1893.68	197.70	0.35
NORTH FISH	MAIN STEM	12502	500 yr	13667.00	508.00	526.25		527.06	0.001451	9.38	2233.35	222.11	0.39
NORTH FISH	MAIN STEM	12502	U_100 yr	10366.00	508.00	524.76		525.38	0.001207	8.07	1919.61	199.43	0.35
NORTH FISH	MAIN STEM	12343	10 yr	6199.00	508.00	521.91		522.47	0.001092	6.56	1213.72	164.90	0.32
NORTH FISH	MAIN STEM	12343	50 yr	8680.00	508.00	523.47		524.23	0.001317	7.79	1488.04	186.76	0.36
NORTH FISH	MAIN STEM	12343	100 yr	10129.00	508.00	524.09		525.00	0.001497	8.54	1606.70	196.16	0.39
NORTH FISH	MAIN STEM	12343	500 yr	13667.00	508.00	525.55		526.76	0.001831	10.05	1912.88	224.02	0.44
NORTH FISH	MAIN STEM	12343	U_100 yr	10366.00	508.00	524.21		525.14	0.001516	8.64	1630.66	198.39	0.39
NORTH FISH	MAIN STEM	12200	10 yr	6199.00	506.45	521.45	518.75	522.20	0.004483	7.93	1152.37	258.68	0.40
NORTH FISH	MAIN STEM	12200	50 yr	8680.00	506.45	523.12	520.34	523.94	0.004447	8.62	1516.90	311.69	0.41
NORTH FISH	MAIN STEM	12200	100 yr	10129.00	506.45	524.02	520.94	524.61	0.003387	7.85	2167.68	331.24	0.36
NORTH FISH	MAIN STEM	12200	500 yr	13667.00	506.45	525.62	522.16	526.25	0.003369	8.39	2705.23	339.15	0.37
NORTH FISH	MAIN STEM	12200	U_100 yr	10366.00	506.45	524.15	521.00	524.74	0.003361	7.87	2211.94	331.91	0.36
NORTH FISH	MAIN STEM	11935	10 yr	6199.00	506.00	521.02	517.42	521.30	0.001838	5.33	1821.65	384.33	0.27
NORTH FISH	MAIN STEM	11935	50 yr	8680.00	506.00	522.72	518.36	523.04	0.001870	5.86	2310.25	407.95	0.28
NORTH FISH	MAIN STEM	11935	100 yr	10129.00	506.00	523.56	518.80	523.92	0.001921	6.17	2564.30	423.30	0.28
NORTH FISH	MAIN STEM	11935	500 yr	13667.00	506.00	525.35	519.73	525.60	0.001380	5.64	4104.78	463.16	0.24
NORTH FISH	MAIN STEM	11935	U_100 yr	10366.00	506.00	523.70	518.87	524.05	0.001928	6.22	2604.84	425.75	0.28
NORTH FISH	MAIN STEM	11554	10 yr	6199.00	505.00	520.43		520.72	0.001975	5.55	1726.12	251.98	0.27
NORTH FISH	MAIN STEM	11554	50 yr	8680.00	505.00	522.11		522.46	0.002071	6.17	2158.68	261.72	0.29
NORTH FISH	MAIN STEM	11554	100 yr	10129.00	505.00	522.94		523.33	0.002144	6.52	2377.75	267.69	0.29
NORTH FISH	MAIN STEM	11554	500 yr	13667.00	505.00	524.61		525.09	0.002379	7.36	2833.50	278.91	0.31
NORTH FISH	MAIN STEM	11554	U_100 yr	10366.00	505.00	523.07		523.46	0.002160	6.58	2412.18	268.47	0.29
NORTH FISH	MAIN STEM	11227	10 yr	6199.00	503.50	520.01		520.27	0.001316	5.16	2162.63	384.90	0.24
NORTH FISH	MAIN STEM	11227	50 yr	8680.00	503.50	521.73		522.00	0.001296	5.51	2839.54	404.47	0.24
NORTH FISH	MAIN STEM	11227	100 yr	10129.00	503.50	522.56		522.84	0.001324	5.75	3182.38	420.34	0.24
NORTH FISH	MAIN STEM	11227	500 yr	13667.00	503.50	524.24		524.56	0.001392	6.27	3910.52	440.89	0.25
NORTH FISH	MAIN STEM	11227	U_100 yr	10366.00	503.50	522.69		522.98	0.001331	5.79	3236.67	423.62	0.24

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	10784	10 yr	6199.00	502.00	519.50		519.74	0.001335	5.12	2250.01	409.35	0.23
NORTH FISH	MAIN STEM	10784	50 yr	8680.00	502.00	521.26		521.49	0.001267	5.37	2988.36	432.84	0.23
NORTH FISH	MAIN STEM	10784	100 yr	10129.00	502.00	522.08		522.33	0.001320	5.66	3356.54	464.87	0.24
NORTH FISH	MAIN STEM	10784	500 yr	13667.00	502.00	523.73		524.02	0.001438	6.27	4164.53	524.39	0.25
NORTH FISH	MAIN STEM	10784	U_100 yr	10366.00	502.00	522.21		522.46	0.001323	5.69	3416.40	467.96	0.24
NORTH FISH	MAIN STEM	10515	10 yr	6199.00	501.00	518.14		519.14	0.004373	8.93	1038.52	189.79	0.41
NORTH FISH	MAIN STEM	10515	50 yr	8680.00	501.00	519.58		520.87	0.005359	10.52	1363.33	259.59	0.46
NORTH FISH	MAIN STEM	10515	100 yr	10129.00	501.00	520.27		521.68	0.005765	11.21	1552.88	291.38	0.48
NORTH FISH	MAIN STEM	10515	500 yr	13667.00	501.00	521.74		523.31	0.006340	12.43	2034.62	362.38	0.51
NORTH FISH	MAIN STEM	10515	U_100 yr	10366.00	501.00	520.38		521.81	0.005819	11.31	1585.52	297.41	0.48
NORTH FISH	MAIN STEM	10240	10 yr	6162.00	501.00	517.32	512.99	517.99	0.003368	7.67	1244.48	320.41	0.37
NORTH FISH	MAIN STEM	10240	50 yr	8726.00	501.00	518.81	514.79	519.49	0.003468	8.35	2004.99	430.87	0.38
NORTH FISH	MAIN STEM	10240	100 yr	10214.00	501.00	519.55	515.45	520.22	0.003362	8.50	2333.51	446.90	0.38
NORTH FISH	MAIN STEM	10240	500 yr	13960.00	501.00	521.06	516.53	521.73	0.003366	9.04	3032.15	485.19	0.38
NORTH FISH	MAIN STEM	10240	U_100 yr	10476.00	501.00	519.67	515.56	520.33	0.003357	8.53	2385.70	449.31	0.38
NORTH FISH	MAIN STEM	9960	10 yr	6162.00	502.35	516.11		516.91	0.004688	8.36	1216.79	281.33	0.43
NORTH FISH	MAIN STEM	9960	50 yr	8726.00	502.35	517.53		518.39	0.004816	9.15	1633.51	309.81	0.45
NORTH FISH	MAIN STEM	9960	100 yr	10214.00	502.35	518.26		519.13	0.004776	9.45	1865.42	321.34	0.45
NORTH FISH	MAIN STEM	9960	500 yr	13960.00	502.35	519.60		520.60	0.005198	10.48	2309.36	347.64	0.47
NORTH FISH	MAIN STEM	9960	U_100 yr	10476.00	502.35	518.37		519.25	0.004798	9.52	1899.75	322.68	0.45
NORTH FISH	MAIN STEM	9439	10 yr	6162.00	498.26	514.72		515.20	0.002307	6.22	1252.77	277.91	0.30
NORTH FISH	MAIN STEM	9439	50 yr	8726.00	498.26	516.28		516.74	0.002168	6.48	1826.99	407.36	0.29
NORTH FISH	MAIN STEM	9439	100 yr	10214.00	498.26	517.13		517.57	0.001987	6.44	2182.91	464.91	0.28
NORTH FISH	MAIN STEM	9439	500 yr	13960.00	498.26	518.61		519.03	0.001745	6.40	2895.65	506.11	0.27
NORTH FISH	MAIN STEM	9439	U_100 yr	10476.00	498.26	517.26		517.69	0.001948	6.41	2242.11	467.94	0.28
NORTH FISH	MAIN STEM	9231	10 yr	6162.00	499.00	514.09		514.72	0.003353	7.28	1087.42	242.53	0.36
NORTH FISH	MAIN STEM	9231	50 yr	8726.00	499.00	515.78		516.35	0.002818	7.25	1590.26	319.57	0.34
NORTH FISH	MAIN STEM	9231	100 yr	10214.00	499.00	516.61		517.20	0.002844	7.56	1892.17	410.52	0.34
NORTH FISH	MAIN STEM	9231	500 yr	13960.00	499.00	518.20		518.74	0.002364	7.36	2607.59	478.77	0.32
NORTH FISH	MAIN STEM	9231	U_100 yr	10476.00	499.00	516.75		517.33	0.002819	7.57	1947.15	422.63	0.34
NORTH FISH	MAIN STEM	8815	10 yr	6162.00	495.79	512.38		513.24	0.003895	8.02	1098.18	246.34	0.39
NORTH FISH	MAIN STEM	8815	50 yr	8726.00	495.79	513.98		514.97	0.004248	9.03	1543.54	308.24	0.41
NORTH FISH	MAIN STEM	8815	100 yr	10214.00	495.79	514.72		515.78	0.004492	9.59	1785.68	350.47	0.43
NORTH FISH	MAIN STEM	8815	500 yr	13960.00	495.79	516.31		517.45	0.004713	10.47	2400.23	425.08	0.44
NORTH FISH	MAIN STEM	8815	U_100 yr	10476.00	495.79	514.83		515.91	0.004538	9.68	1827.27	358.13	0.43
NORTH FISH	MAIN STEM	8600	10 yr	6162.00	495.00	511.84		512.43	0.002955	7.05	1435.57	344.51	0.33
NORTH FISH	MAIN STEM	8600	50 yr	8726.00	495.00	513.52		514.10	0.002859	7.49	2087.76	433.27	0.34
NORTH FISH	MAIN STEM	8600	100 yr	10214.00	495.00	514.29		514.86	0.002845	7.72	2437.96	477.31	0.34
NORTH FISH	MAIN STEM	8600	500 yr	13960.00	495.00	515.95		516.50	0.002687	8.00	3299.98	552.09	0.33
NORTH FISH	MAIN STEM	8600	U_100 yr	10476.00	495.00	514.41		514.99	0.002829	7.73	2498.74	481.10	0.34
NORTH FISH	MAIN STEM	8218	10 yr	6162.00	494.00	510.76		511.39	0.002786	7.03	1377.28	326.40	0.33
NORTH FISH	MAIN STEM	8218	50 yr	8726.00	494.00	512.45		513.09	0.002799	7.60	2014.22	412.19	0.34
NORTH FISH	MAIN STEM	8218	100 yr	10214.00	494.00	513.22		513.87	0.002805	7.86	2345.29	440.13	0.34
NORTH FISH	MAIN STEM	8218	500 yr	13960.00	494.00	514.86		515.54	0.002873	8.48	3135.55	523.07	0.35
NORTH FISH	MAIN STEM	8218	U_100 yr	10476.00	494.00	513.35		514.00	0.002800	7.90	2402.57	443.47	0.34
NORTH FISH	MAIN STEM	8043	10 yr	6162.00	494.00	509.22		510.60	0.007693	10.49	893.65	226.16	0.52
NORTH FISH	MAIN STEM	8043	50 yr	8726.00	494.00	510.97		512.31	0.007256	11.10	1347.77	301.62	0.51
NORTH FISH	MAIN STEM	8043	100 yr	10214.00	494.00	511.85		513.11	0.006761	11.14	1626.95	329.11	0.50
NORTH FISH	MAIN STEM	8043	500 yr	13960.00	494.00	513.61		514.79	0.006244	11.51	2292.25	415.34	0.49
NORTH FISH	MAIN STEM	8043	U_100 yr	10476.00	494.00	511.99		513.24	0.006715	11.17	1672.66	334.31	0.50
NORTH FISH	MAIN STEM	7687	10 yr	6162.00	492.00	508.01		508.56	0.002809	6.77	1322.57	213.82	0.33
NORTH FISH	MAIN STEM	7687	50 yr	8726.00	492.00	509.72		510.37	0.003067	7.68	1722.14	254.12	0.35
NORTH FISH	MAIN STEM	7687	100 yr	10214.00	492.00	510.59		511.30	0.003145	8.09	1955.60	279.65	0.36
NORTH FISH	MAIN STEM	7687	500 yr	13960.00	492.00	512.22		513.09	0.003556	9.19	2454.05	344.06	0.39
NORTH FISH	MAIN STEM	7687	U_100 yr	10476.00	492.00	510.72		511.44	0.003169	8.16	1992.63	283.41	0.36
NORTH FISH	MAIN STEM	7462	10 yr	6162.00	492.06	506.84		507.79	0.006033	9.20	1007.16	181.82	0.47
NORTH FISH	MAIN STEM	7462	50 yr	8726.00	492.06	508.52		509.59	0.006095	10.11	1332.45	205.55	0.48
NORTH FISH	MAIN STEM	7462	100 yr	10214.00	492.06	509.33		510.50	0.006328	10.70	1517.08	263.02	0.50
NORTH FISH	MAIN STEM	7462	500 yr	13960.00	492.06	510.95		512.24	0.006488	11.64	2000.84	327.78	0.51
NORTH FISH	MAIN STEM	7462	U_100 yr	10476.00	492.06	509.46		510.64	0.006345	10.78	1551.20	269.93	0.50
NORTH FISH	MAIN STEM	7152	10 yr	6162.00	491.00	506.06		506.34	0.001893	5.39	1882.74	328.81	0.27
NORTH FISH	MAIN STEM	7152	50 yr	8726.00	491.00	507.81		508.11	0.001829	5.80	2480.45	351.93	0.27
NORTH FISH	MAIN STEM	7152	100 yr	10214.00	491.00	508.64		508.96	0.001842	6.05	2774.50	361.90	0.28
NORTH FISH	MAIN STEM	7152	500 yr	13960.00	491.00	510.25		510.64	0.002009	6.77	3388.14	401.23	0.30
NORTH FISH	MAIN STEM	7152	U_100 yr	10476.00	491.00	508.77		509.09	0.001851	6.10	2821.15	363.93	0.28

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	6800	10 yr	6162.00	489.00	505.17		505.70	0.002532	7.01	1458.87	251.89	0.33
NORTH FISH	MAIN STEM	6800	50 yr	8726.00	489.00	506.79		507.45	0.002953	8.14	1900.42	311.73	0.36
NORTH FISH	MAIN STEM	6800	100 yr	10214.00	489.00	507.58		508.28	0.003090	8.60	2162.89	345.95	0.37
NORTH FISH	MAIN STEM	6800	500 yr	13960.00	489.00	509.16		509.93	0.003268	9.40	2730.10	369.20	0.39
NORTH FISH	MAIN STEM	6800	U_100 yr	10476.00	489.00	507.70		508.41	0.003102	8.66	2206.86	349.23	0.37
NORTH FISH	MAIN STEM	6575	10 yr	6162.00	488.48	504.31		505.05	0.004045	7.96	1188.59	217.95	0.38
NORTH FISH	MAIN STEM	6575	50 yr	8726.00	488.48	505.81		506.71	0.004657	9.16	1552.99	280.27	0.42
NORTH FISH	MAIN STEM	6575	100 yr	10214.00	488.48	506.53		507.52	0.004947	9.74	1781.87	359.96	0.43
NORTH FISH	MAIN STEM	6575	500 yr	13960.00	488.48	508.17		509.17	0.004876	10.33	2452.12	439.86	0.44
NORTH FISH	MAIN STEM	6575	U_100 yr	10476.00	488.48	506.65		507.65	0.004967	9.81	1826.80	370.40	0.43
NORTH FISH	MAIN STEM	6270	10 yr	6318.00	488.00	503.59		504.04	0.002167	5.91	1533.18	317.95	0.30
NORTH FISH	MAIN STEM	6270	50 yr	8968.00	488.00	505.00		505.55	0.002512	6.83	2035.42	395.27	0.32
NORTH FISH	MAIN STEM	6270	100 yr	10498.00	488.00	505.69		506.28	0.002626	7.22	2320.58	425.90	0.33
NORTH FISH	MAIN STEM	6270	500 yr	14482.00	488.00	507.23		507.93	0.002942	8.17	3061.13	551.51	0.36
NORTH FISH	MAIN STEM	6270	U_100 yr	10767.00	488.00	505.81		506.41	0.002639	7.28	2371.77	431.34	0.34
NORTH FISH	MAIN STEM	5803	10 yr	6318.00	487.00	502.07		502.74	0.003914	7.87	1420.23	342.75	0.39
NORTH FISH	MAIN STEM	5803	50 yr	8968.00	487.00	503.43		504.14	0.004065	8.58	1902.89	369.50	0.40
NORTH FISH	MAIN STEM	5803	100 yr	10498.00	487.00	504.11		504.83	0.004105	8.90	2159.19	382.52	0.41
NORTH FISH	MAIN STEM	5803	500 yr	14482.00	487.00	505.61		506.38	0.004186	9.59	2749.48	401.33	0.42
NORTH FISH	MAIN STEM	5803	U_100 yr	10767.00	487.00	504.24		504.96	0.004085	8.93	2207.48	384.40	0.41
NORTH FISH	MAIN STEM	5463	10 yr	6318.00	486.00	500.97		501.48	0.003445	7.16	1621.34	394.41	0.36
NORTH FISH	MAIN STEM	5463	50 yr	8968.00	486.00	502.33		502.85	0.003461	7.70	2179.36	429.43	0.37
NORTH FISH	MAIN STEM	5463	100 yr	10498.00	486.00	503.02		503.55	0.003413	7.90	2483.54	443.43	0.37
NORTH FISH	MAIN STEM	5463	500 yr	14482.00	486.00	504.51		505.07	0.003506	8.56	3167.73	481.14	0.38
NORTH FISH	MAIN STEM	5463	U_100 yr	10767.00	486.00	503.16		503.68	0.003362	7.90	2546.24	445.24	0.37
NORTH FISH	MAIN STEM	5252	10 yr	6518.00	487.00	500.05		500.66	0.004753	7.98	1485.56	368.90	0.42
NORTH FISH	MAIN STEM	5252	50 yr	9279.00	487.00	501.48		502.06	0.004373	8.29	2023.17	384.03	0.41
NORTH FISH	MAIN STEM	5252	100 yr	10886.00	487.00	502.17		502.77	0.004320	8.54	2294.43	393.96	0.41
NORTH FISH	MAIN STEM	5252	500 yr	15123.00	487.00	503.57		504.26	0.004670	9.48	2866.54	436.98	0.43
NORTH FISH	MAIN STEM	5252	U_100 yr	11248.00	487.00	502.31		502.91	0.004349	8.62	2346.15	396.08	0.41
NORTH FISH	MAIN STEM	5060	10 yr	6518.00	485.00	499.64	495.42	500.06	0.000850	6.06	1622.91	417.28	0.32
NORTH FISH	MAIN STEM	5060	50 yr	9279.00	485.00	501.11	497.95	501.51	0.000777	6.29	2261.37	454.61	0.31
NORTH FISH	MAIN STEM	5060	100 yr	10886.00	485.00	501.82	499.03	502.23	0.000753	6.42	2591.51	469.51	0.31
NORTH FISH	MAIN STEM	5060	500 yr	15123.00	485.00	503.20	499.96	503.66	0.000791	7.03	3261.27	498.97	0.32
NORTH FISH	MAIN STEM	5060	U_100 yr	11248.00	485.00	501.95	499.08	502.36	0.000756	6.48	2652.88	472.04	0.31
NORTH FISH	MAIN STEM	4985		Bridge									
NORTH FISH	MAIN STEM	4832	10 yr	6518.00	484.59	498.60		499.44	0.004826	8.40	1264.27	316.65	0.44
NORTH FISH	MAIN STEM	4832	50 yr	9279.00	484.59	499.85		500.83	0.005403	9.52	1698.37	376.59	0.47
NORTH FISH	MAIN STEM	4832	100 yr	10886.00	484.59	500.45		501.51	0.005742	10.12	1940.47	428.21	0.49
NORTH FISH	MAIN STEM	4832	500 yr	15123.00	484.59	501.76		502.90	0.006025	11.04	2525.24	459.62	0.51
NORTH FISH	MAIN STEM	4832	U_100 yr	11248.00	484.59	500.57		501.64	0.005802	10.23	1989.64	432.15	0.49
NORTH FISH	MAIN STEM	4462	10 yr	6518.00	482.00	497.20	494.00	497.90	0.004226	8.05	1488.82	408.93	0.40
NORTH FISH	MAIN STEM	4462	50 yr	9272.00	482.00	498.39	496.82	499.17	0.004732	9.05	2012.25	494.14	0.43
NORTH FISH	MAIN STEM	4462	100 yr	10883.00	482.00	498.93	497.40	499.78	0.005082	9.62	2296.57	547.74	0.45
NORTH FISH	MAIN STEM	4462	500 yr	15083.00	482.00	500.42	497.82	501.18	0.004660	9.85	3155.08	608.51	0.44
NORTH FISH	MAIN STEM	4462	U_100 yr	11228.00	482.00	499.06	497.49	499.90	0.005062	9.66	2365.30	552.87	0.45
NORTH FISH	MAIN STEM	4317	10 yr	6518.00	482.00	496.76	493.60	497.42	0.003788	7.64	1420.21	372.53	0.39
NORTH FISH	MAIN STEM	4317	50 yr	9272.00	482.00	497.82	495.13	498.64	0.004649	8.96	1890.38	435.77	0.44
NORTH FISH	MAIN STEM	4317	100 yr	10883.00	482.00	498.36	495.13	499.23	0.004893	9.44	2130.75	455.50	0.45
NORTH FISH	MAIN STEM	4317	500 yr	15083.00	482.00	499.78	497.98	500.68	0.004902	10.11	2838.73	527.38	0.46
NORTH FISH	MAIN STEM	4317	U_100 yr	11228.00	482.00	498.47	495.13	499.35	0.004930	9.53	2182.53	459.55	0.45
NORTH FISH	MAIN STEM	4008	10 yr	6518.00	483.00	496.11	493.85	496.43	0.002915	6.03	1933.24	438.97	0.33
NORTH FISH	MAIN STEM	4008	50 yr	9272.00	483.00	497.09	494.70	497.48	0.003398	6.92	2364.73	477.91	0.36
NORTH FISH	MAIN STEM	4008	100 yr	10883.00	483.00	497.58	495.02	498.02	0.003654	7.38	2586.96	501.49	0.38
NORTH FISH	MAIN STEM	4008	500 yr	15083.00	483.00	499.01	495.95	499.51	0.003663	7.98	3255.78	544.60	0.39
NORTH FISH	MAIN STEM	4008	U_100 yr	11228.00	483.00	497.68	495.10	498.13	0.003695	7.47	2635.27	506.97	0.38
NORTH FISH	MAIN STEM	3492	10 yr	6518.00	481.98	494.90		495.34	0.003810	7.21	1898.97	554.22	0.38
NORTH FISH	MAIN STEM	3492	50 yr	9272.00	481.98	495.97		496.40	0.003781	7.62	2502.68	572.23	0.38
NORTH FISH	MAIN STEM	3492	100 yr	10883.00	481.98	496.49		496.93	0.003823	7.88	2801.32	577.94	0.38
NORTH FISH	MAIN STEM	3492	500 yr	15083.00	481.98	498.16		498.56	0.003205	7.82	3809.93	628.89	0.36
NORTH FISH	MAIN STEM	3492	U_100 yr	11228.00	481.98	496.60		497.04	0.003846	7.94	2863.16	581.97	0.39
NORTH FISH	MAIN STEM	3262	10 yr	6518.00	481.00	494.17		494.66	0.003700	7.50	1801.37	497.46	0.39
NORTH FISH	MAIN STEM	3262	50 yr	9272.00	481.00	495.21		495.74	0.003966	8.22	2332.73	523.05	0.41
NORTH FISH	MAIN STEM	3262	100 yr	10883.00	481.00	495.71		496.27	0.004139	8.62	2595.85	533.09	0.42
NORTH FISH	MAIN STEM	3262	500 yr	15083.00	481.00	497.60		498.06	0.003166	8.24	3631.91	561.36	0.37
NORTH FISH	MAIN STEM	3262	U_100 yr	11228.00	481.00	495.82		496.38	0.004170	8.70	2651.10	535.42	0.42

HEC-RAS Plan: P1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	3021	10 yr	6518.00	479.80	493.02		493.60	0.005565	7.93	1576.19	481.75	0.45
NORTH FISH	MAIN STEM	3021	50 yr	9272.00	479.80	494.00		494.62	0.005759	8.62	2059.63	504.84	0.47
NORTH FISH	MAIN STEM	3021	100 yr	10883.00	479.80	494.42		495.09	0.006116	9.11	2272.07	511.79	0.49
NORTH FISH	MAIN STEM	3021	500 yr	15083.00	479.80	496.85		497.28	0.003358	7.72	3556.74	548.13	0.37
NORTH FISH	MAIN STEM	3021	U_100 yr	11228.00	479.80	494.52		495.19	0.006154	9.19	2319.96	513.28	0.49
NORTH FISH	MAIN STEM	2733	10 yr	6518.00	478.40	492.21	490.77	492.54	0.003110	6.04	2075.23	584.92	0.34
NORTH FISH	MAIN STEM	2733	50 yr	9272.00	478.40	493.23	491.43	493.57	0.003175	6.53	2674.50	593.93	0.35
NORTH FISH	MAIN STEM	2733	100 yr	10883.00	478.40	493.59	491.74	493.98	0.003514	7.02	2890.85	596.66	0.37
NORTH FISH	MAIN STEM	2733	500 yr	15083.00	478.40	496.48	492.44	496.71	0.001748	5.78	4746.25	681.55	0.27
NORTH FISH	MAIN STEM	2733	U_100 yr	11228.00	478.40	493.68	491.80	494.08	0.003549	7.09	2944.54	597.33	0.37
NORTH FISH	MAIN STEM	2575	10 yr	6518.00	477.70	490.88	490.81	491.80	0.012408	10.40	1273.72	490.45	0.64
NORTH FISH	MAIN STEM	2575	50 yr	9272.00	477.70	492.41	491.38	492.97	0.007240	8.90	2086.97	560.05	0.50
NORTH FISH	MAIN STEM	2575	100 yr	10883.00	477.70	492.65	491.67	493.31	0.008383	9.73	2221.75	565.02	0.54
NORTH FISH	MAIN STEM	2575	500 yr	15083.00	477.70	496.21	492.43	496.46	0.002331	6.28	4353.86	639.12	0.30
NORTH FISH	MAIN STEM	2575	U_100 yr	11228.00	477.70	492.74	491.72	493.40	0.008375	9.78	2272.73	566.89	0.54
NORTH FISH	MAIN STEM	2527	10 yr	6518.00	481.80	490.10	490.10	491.16	0.012756	9.59	1148.76	509.67	0.66
NORTH FISH	MAIN STEM	2527	50 yr	9272.00	481.80	492.18	490.73	492.63	0.004842	7.12	2265.69	562.24	0.43
NORTH FISH	MAIN STEM	2527	100 yr	10883.00	481.80	492.35	491.05	492.92	0.005961	8.00	2361.37	565.93	0.48
NORTH FISH	MAIN STEM	2527	500 yr	15083.00	481.80	496.12	491.74	496.35	0.001695	5.42	4660.70	655.81	0.27
NORTH FISH	MAIN STEM	2527	U_100 yr	11228.00	481.80	492.43	491.12	493.01	0.006006	8.09	2409.62	567.94	0.48
NORTH FISH	MAIN STEM	2489	10 yr	6518.00	480.06	489.56	487.83	490.04	0.000587	6.83	2482.74	496.31	0.44
NORTH FISH	MAIN STEM	2489	50 yr	9272.00	480.06	492.09	488.01	492.52	0.000384	6.69	3835.97	566.69	0.37
NORTH FISH	MAIN STEM	2489	100 yr	10883.00	480.06	492.22	488.45	492.78	0.000504	7.73	3906.78	569.43	0.43
NORTH FISH	MAIN STEM	2489	500 yr	15083.00	480.06	495.82	488.08	496.28	0.000299	7.28	6123.84	668.41	0.34
NORTH FISH	MAIN STEM	2489	U_100 yr	11228.00	480.06	492.29	488.54	492.88	0.000523	7.91	3944.59	570.88	0.43
NORTH FISH	MAIN STEM	2457	10 yr	6518.00	479.00	486.85	486.85	489.76	0.003416	13.71	475.42	363.47	1.00
NORTH FISH	MAIN STEM	2457	50 yr	9272.00	479.00	492.11	488.48	492.50	0.000320	6.28	3947.08	566.18	0.34
NORTH FISH	MAIN STEM	2457	100 yr	10883.00	479.00	492.23	489.00	492.76	0.000421	7.25	4020.06	568.66	0.39
NORTH FISH	MAIN STEM	2457	500 yr	15083.00	479.00	495.83	489.18	496.27	0.000259	6.89	6223.07	659.74	0.32
NORTH FISH	MAIN STEM	2457	U_100 yr	11228.00	479.00	492.30	489.01	492.85	0.000437	7.42	4058.18	569.88	0.40
NORTH FISH	MAIN STEM	2439	10 yr	6518.00	477.00	486.21	485.62	488.83	0.001460	12.97	502.54	325.25	0.88
NORTH FISH	MAIN STEM	2439	50 yr	9272.00	477.00	492.20	487.49	492.45	0.000111	5.18	3772.02	558.16	0.27
NORTH FISH	MAIN STEM	2439	100 yr	10883.00	477.00	492.37	488.44	492.69	0.000143	5.94	3863.67	560.27	0.30
NORTH FISH	MAIN STEM	2439	500 yr	15083.00	477.00	495.96	489.06	496.21	0.000085	5.46	6054.01	658.01	0.25
NORTH FISH	MAIN STEM	2439	U_100 yr	11228.00	477.00	492.44	488.64	492.78	0.000148	6.07	3905.19	561.43	0.31
NORTH FISH	MAIN STEM	2210	10 yr	6516.00	475.20	486.34	484.61	488.37	0.001002	11.43	570.07	142.85	0.73
NORTH FISH	MAIN STEM	2210	50 yr	9292.00	475.20	491.75	486.63	492.38	0.000206	7.15	2418.02	496.93	0.36
NORTH FISH	MAIN STEM	2210	100 yr	10857.00	475.20	491.73	487.59	492.59	0.000283	8.39	2406.49	496.08	0.42
NORTH FISH	MAIN STEM	2210	500 yr	14898.00	475.20	495.70	490.23	496.16	0.000129	6.83	4693.21	616.02	0.30
NORTH FISH	MAIN STEM	2210	U_100 yr	11166.00	475.20	491.78	487.78	492.68	0.000294	8.56	2430.83	497.87	0.43
NORTH FISH	MAIN STEM	2054	10 yr	6516.00	474.00	487.21	481.55	487.86	0.000194	6.50	1038.21	194.26	0.35
NORTH FISH	MAIN STEM	2054	50 yr	9292.00	474.00	491.89	483.23	492.29	0.000086	5.50	2833.03	668.30	0.25
NORTH FISH	MAIN STEM	2054	100 yr	10857.00	474.00	491.92	484.02	492.46	0.000116	6.41	2848.06	670.65	0.29
NORTH FISH	MAIN STEM	2054	500 yr	14898.00	474.00	495.78	485.83	496.10	0.000063	5.51	6056.07	772.80	0.22
NORTH FISH	MAIN STEM	2054	U_100 yr	11166.00	474.00	491.98	484.15	492.54	0.000120	6.55	2872.29	674.39	0.29
NORTH FISH	MAIN STEM	1988		Bridge									
NORTH FISH	MAIN STEM	1887	10 yr	6516.00	473.00	486.75	481.60	487.43	0.000232	6.61	997.26	242.62	0.38
NORTH FISH	MAIN STEM	1887	50 yr	9292.00	473.00	489.91	483.28	490.38	0.000131	6.01	2845.54	714.76	0.30
NORTH FISH	MAIN STEM	1887	100 yr	10857.00	473.00	490.88	484.11	491.33	0.000120	6.06	3584.72	781.72	0.29
NORTH FISH	MAIN STEM	1887	500 yr	14898.00	473.00	495.44	485.90	495.64	0.000048	4.64	7395.46	871.26	0.19
NORTH FISH	MAIN STEM	1887	U_100 yr	11166.00	473.00	490.98	484.28	491.44	0.000123	6.14	3662.36	785.24	0.29
NORTH FISH	MAIN STEM	1270	10 yr	6571.00	471.89	486.29	482.05	487.24	0.000384	7.86	993.15	530.86	0.47
NORTH FISH	MAIN STEM	1270	50 yr	9403.00	471.89	489.72	484.07	490.30	0.000178	6.71	3723.24	933.16	0.34
NORTH FISH	MAIN STEM	1270	100 yr	10949.00	471.89	490.67	485.06	491.25	0.000168	6.85	4649.07	978.59	0.34
NORTH FISH	MAIN STEM	1270	500 yr	15030.00	471.89	495.30	488.13	495.60	0.000071	5.47	9523.65	1121.26	0.23
NORTH FISH	MAIN STEM	1270	U_100 yr	11245.00	471.89	490.77	485.22	491.36	0.000171	6.95	4740.25	982.69	0.34
NORTH FISH	MAIN STEM	1188	10 yr	6571.00	471.44	486.39	480.65	487.16	0.000249	7.07	950.06	152.52	0.39
NORTH FISH	MAIN STEM	1188	50 yr	9403.00	471.44	489.41	482.60	490.26	0.000200	7.54	1488.61	190.33	0.36
NORTH FISH	MAIN STEM	1188	100 yr	10949.00	471.44	490.21	483.50	491.20	0.000218	8.17	1642.74	194.89	0.38
NORTH FISH	MAIN STEM	1188	500 yr	15030.00	471.44	494.64	485.61	495.53	0.000145	7.99	2562.07	219.97	0.33
NORTH FISH	MAIN STEM	1188	U_100 yr	11245.00	471.44	490.27	483.67	491.30	0.000226	8.35	1654.16	195.23	0.39
NORTH FISH	MAIN STEM	1081		Bridge									
NORTH FISH	MAIN STEM	971	10 yr	6571.00	471.69	486.22		486.99	0.000264	7.10	971.71	171.82	0.40
NORTH FISH	MAIN STEM	971	50 yr	9403.00	471.69	489.29		490.10	0.000200	7.42	1531.17	192.44	0.36

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
NORTH FISH	MAIN STEM	971	100 yr	10949.00	471.69	490.07		491.02	0.000217	8.04	1685.01	197.68	0.38
NORTH FISH	MAIN STEM	971	500 yr	15030.00	471.69	494.57		495.41	0.000140	7.79	2633.41	223.52	0.32
NORTH FISH	MAIN STEM	971	U_100 yr	11245.00	471.69	490.13		491.12	0.000226	8.22	1695.23	198.01	0.39
FISH CREEK	US	43484	10 yr	8214.00	527.00	537.31	536.18	539.54	0.003008	12.02	712.77	118.99	0.79
FISH CREEK	US	43484	50 yr	11721.00	527.00	539.01	538.05	541.89	0.003178	13.71	930.59	137.79	0.83
FISH CREEK	US	43484	100 yr	13418.00	527.00	539.71	538.87	542.88	0.003254	14.41	1030.17	143.62	0.85
FISH CREEK	US	43484	500 yr	17994.00	527.00	542.51	540.78	545.59	0.002491	14.32	1463.40	166.11	0.76
FISH CREEK	US	43484	U_100 yr	13842.00	527.00	539.87	539.03	543.12	0.003285	14.59	1052.71	144.87	0.85
FISH CREEK	US	42943	10 yr	8214.00	526.00	536.77		538.02	0.001537	8.97	924.68	129.41	0.57
FISH CREEK	US	42943	50 yr	11721.00	526.00	538.58		540.22	0.001621	10.29	1173.82	146.95	0.60
FISH CREEK	US	42943	100 yr	13418.00	526.00	539.31		541.15	0.001679	10.89	1289.35	186.04	0.62
FISH CREEK	US	42943	500 yr	17994.00	526.00	542.47		544.17	0.001217	10.61	2053.12	280.29	0.54
FISH CREEK	US	42943	U_100 yr	13842.00	526.00	539.47		541.36	0.001699	11.05	1320.74	199.79	0.62
FISH CREEK	US	42574	10 yr	8274.00	524.00	536.39		537.43	0.001319	8.21	1039.97	191.37	0.53
FISH CREEK	US	42574	50 yr	11848.00	524.00	538.28		539.57	0.001331	9.19	1487.31	276.34	0.54
FISH CREEK	US	42574	100 yr	13498.00	524.00	539.10		540.45	0.001301	9.47	1726.95	304.66	0.54
FISH CREEK	US	42574	500 yr	18142.00	524.00	542.52		543.62	0.000789	8.74	2995.02	439.16	0.44
FISH CREEK	US	42574	U_100 yr	13873.00	524.00	539.29		540.65	0.001292	9.52	1784.71	311.64	0.54
FISH CREEK	US	42368	10 yr	8274.00	524.00	536.61	531.31	537.07	0.000510	5.59	1702.07	328.35	0.33
FISH CREEK	US	42368	50 yr	11848.00	524.00	538.64	532.93	539.15	0.000481	6.00	2430.42	392.32	0.33
FISH CREEK	US	42368	100 yr	13498.00	524.00	539.51	533.64	540.02	0.000463	6.11	2785.16	429.18	0.33
FISH CREEK	US	42368	500 yr	18142.00	524.00	542.92	535.60	543.30	0.000270	5.50	4518.51	570.91	0.26
FISH CREEK	US	42368	U_100 yr	13873.00	524.00	539.71	533.80	540.22	0.000459	6.14	2870.03	440.73	0.33
FISH CREEK	US	42268		Bridge									
FISH CREEK	US	42222	10 yr	8274.00	524.52	536.32		536.89	0.000708	6.03	1371.74	181.55	0.39
FISH CREEK	US	42222	50 yr	11848.00	524.52	538.17		538.91	0.000743	6.90	1715.91	191.65	0.41
FISH CREEK	US	42222	100 yr	13498.00	524.52	538.95		539.76	0.000749	7.23	1866.93	195.38	0.41
FISH CREEK	US	42222	500 yr	18142.00	524.52	540.94		541.94	0.000759	8.01	2265.75	204.82	0.42
FISH CREEK	US	42222	U_100 yr	13873.00	524.52	539.13		539.95	0.000748	7.30	1901.64	196.19	0.41
FISH CREEK	US	42145	10 yr	8274.00	523.71	535.80		536.71	0.001202	7.69	1076.63	145.74	0.50
FISH CREEK	US	42145	50 yr	11848.00	523.71	537.44		538.69	0.001345	8.95	1324.29	154.94	0.54
FISH CREEK	US	42145	100 yr	13498.00	523.71	538.14		539.52	0.001386	9.41	1433.69	158.73	0.55
FISH CREEK	US	42145	500 yr	18142.00	523.71	539.94		541.65	0.001474	10.49	1729.84	170.42	0.58
FISH CREEK	US	42145	U_100 yr	13873.00	523.71	538.31		539.71	0.001390	9.50	1460.08	159.82	0.55
FISH CREEK	US	41987	10 yr	8274.00	523.69	535.92	530.72	536.47	0.000480	6.14	1501.16	186.56	0.34
FISH CREEK	US	41987	50 yr	11848.00	523.69	537.61	532.27	538.40	0.000569	7.39	1828.21	200.29	0.37
FISH CREEK	US	41987	100 yr	13498.00	523.69	538.32	532.88	539.21	0.000599	7.88	1973.54	205.96	0.39
FISH CREEK	US	41987	500 yr	18142.00	523.69	540.16	534.40	541.31	0.000659	9.04	2365.58	220.53	0.42
FISH CREEK	US	41987	U_100 yr	13873.00	523.69	538.49	533.01	539.40	0.000603	7.98	2008.39	207.30	0.39
FISH CREEK	US	41940		Bridge									
FISH CREEK	US	41832	10 yr	8274.00	523.00	535.80		536.31	0.000443	5.81	1520.92	184.17	0.32
FISH CREEK	US	41832	50 yr	11848.00	523.00	537.48		538.21	0.000530	7.03	1836.44	193.40	0.36
FISH CREEK	US	41832	100 yr	13498.00	523.00	538.19		539.02	0.000559	7.50	1975.51	197.84	0.37
FISH CREEK	US	41832	500 yr	18142.00	523.00	540.03		541.12	0.000617	8.64	2349.84	208.22	0.40
FISH CREEK	US	41832	U_100 yr	13873.00	523.00	538.36		539.21	0.000563	7.59	2008.98	198.98	0.37
FISH CREEK	US	41696	10 yr	8274.00	523.00	534.77		536.00	0.001765	8.91	928.49	135.18	0.60
FISH CREEK	US	41696	50 yr	11848.00	523.00	535.94		537.77	0.002293	10.84	1092.62	144.04	0.69
FISH CREEK	US	41696	100 yr	13498.00	523.00	536.43		538.52	0.002482	11.59	1164.38	147.29	0.73
FISH CREEK	US	41696	500 yr	18142.00	523.00	537.67		540.47	0.002939	13.43	1351.01	155.38	0.80
FISH CREEK	US	41696	U_100 yr	13873.00	523.00	536.57		538.70	0.002493	11.71	1185.12	148.22	0.73
FISH CREEK	US	41596	10 yr	8274.00	523.00	535.13	530.51	535.67	0.000654	5.91	1400.32	180.17	0.37
FISH CREEK	US	41596	50 yr	11848.00	523.00	536.50	531.92	537.30	0.000843	7.15	1657.40	193.70	0.43
FISH CREEK	US	41596	100 yr	13498.00	523.00	537.09	532.52	537.99	0.000905	7.61	1773.46	198.91	0.45
FISH CREEK	US	41596	500 yr	18142.00	523.00	538.60	533.98	539.78	0.001029	8.71	2082.40	210.96	0.49
FISH CREEK	US	41596	U_100 yr	13873.00	523.00	537.25	532.65	538.17	0.000909	7.69	1804.49	200.13	0.45
FISH CREEK	US	41555		Bridge									
FISH CREEK	US	41446	10 yr	8274.00	522.45	534.70	530.74	535.36	0.001892	6.73	1360.01	292.09	0.40
FISH CREEK	US	41446	50 yr	11848.00	522.45	536.12	532.31	536.92	0.001962	7.58	1807.14	429.03	0.42
FISH CREEK	US	41446	100 yr	13498.00	522.45	536.73	532.88	537.56	0.001929	7.82	2013.09	440.49	0.42
FISH CREEK	US	41446	500 yr	18142.00	522.45	538.29	534.06	539.20	0.001818	8.32	2543.59	460.08	0.42
FISH CREEK	US	41446	U_100 yr	13873.00	522.45	536.89	532.94	537.72	0.001893	7.83	2069.50	443.60	0.42
FISH CREEK	US	41093	10 yr	8661.00	522.00	533.82	531.74	534.55	0.002510	7.47	1323.67	241.96	0.46
FISH CREEK	US	41093	50 yr	12440.00	522.00	534.98	532.85	535.99	0.002923	8.80	1612.33	255.51	0.51
FISH CREEK	US	41093	100 yr	14125.00	522.00	535.49	533.28	536.61	0.003006	9.25	1746.15	264.58	0.52

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	US	41093	500 yr	19047.00	522.00	536.80	534.42	538.19	0.003229	10.41	2106.27	287.55	0.55
FISH CREEK	US	41093	U_100 yr	14611.00	522.00	535.61	533.40	536.76	0.003056	9.40	1777.94	266.77	0.52
FISH CREEK	US	40575	10 yr	8661.00	521.00	531.97	531.32	532.89	0.004326	9.06	1230.71	326.09	0.59
FISH CREEK	US	40575	50 yr	12440.00	521.00	533.45	532.12	534.35	0.003342	9.00	1725.87	346.53	0.54
FISH CREEK	US	40575	100 yr	14125.00	521.00	534.12	532.45	535.00	0.002955	8.88	1961.12	355.51	0.51
FISH CREEK	US	40575	500 yr	19047.00	521.00	535.57	533.31	536.54	0.002661	9.28	2495.65	419.61	0.50
FISH CREEK	US	40575	U_100 yr	14611.00	521.00	534.22	532.54	535.13	0.002990	9.00	1998.80	357.04	0.51
FISH CREEK	US	40008	10 yr	9206.00	516.00	529.76	527.61	530.44	0.004193	8.44	1596.00	286.82	0.42
FISH CREEK	US	40008	50 yr	13287.00	516.00	531.67	528.86	532.35	0.003615	8.62	2178.62	324.05	0.40
FISH CREEK	US	40008	100 yr	15164.00	516.00	532.54	529.29	533.21	0.003278	8.53	2469.47	346.36	0.38
FISH CREEK	US	40008	500 yr	20340.00	516.00	534.13	530.37	534.88	0.003180	8.98	3083.89	423.13	0.39
FISH CREEK	US	40008	U_100 yr	15495.00	516.00	532.65	529.37	533.33	0.003279	8.58	2507.34	358.64	0.39
FISH CREEK	US	39477	10 yr	9206.00	514.00	527.51	524.21	528.26	0.004356	8.77	1386.11	186.81	0.43
FISH CREEK	US	39477	50 yr	13287.00	514.00	529.34	525.65	530.30	0.004588	9.85	1753.49	234.16	0.45
FISH CREEK	US	39477	100 yr	15164.00	514.00	530.17	526.20	531.21	0.004923	10.58	1977.24	295.09	0.48
FISH CREEK	US	39477	500 yr	20340.00	514.00	531.85	527.69	532.98	0.004592	10.96	2486.33	358.88	0.47
FISH CREEK	US	39477	U_100 yr	15495.00	514.00	530.29	526.33	531.33	0.004887	10.60	2012.09	297.20	0.47
FISH CREEK	US	38979	10 yr	9206.00	509.00	524.83	522.02	525.77	0.006021	11.18	1609.68	268.50	0.51
FISH CREEK	US	38979	50 yr	13287.00	509.00	526.94	523.68	527.87	0.005426	11.60	2200.87	288.34	0.50
FISH CREEK	US	38979	100 yr	15164.00	509.00	527.74	524.52	528.69	0.005328	11.86	2435.06	297.08	0.50
FISH CREEK	US	38979	500 yr	20340.00	509.00	529.57	526.11	530.59	0.005190	12.49	2998.75	321.98	0.50
FISH CREEK	US	38979	U_100 yr	15495.00	509.00	527.87	524.67	528.82	0.005329	11.91	2473.26	298.71	0.50
FISH CREEK	US	38331	10 yr	9206.00	504.98	522.40		523.02	0.002359	7.54	1877.92	249.92	0.33
FISH CREEK	US	38331	50 yr	13287.00	504.98	524.61		525.32	0.002453	8.38	2501.81	310.16	0.34
FISH CREEK	US	38331	100 yr	15164.00	504.98	525.42		526.16	0.002501	8.70	2760.03	330.05	0.35
FISH CREEK	US	38331	500 yr	20340.00	504.98	527.25		528.08	0.002610	9.45	3403.80	396.88	0.36
FISH CREEK	US	38331	U_100 yr	15495.00	504.98	525.54		526.29	0.002520	8.77	2799.97	333.83	0.35
FISH CREEK	US	37902	10 yr	9206.00	503.00	521.36		521.93	0.002737	7.50	1907.44	234.47	0.34
FISH CREEK	US	37902	50 yr	13287.00	503.00	523.39		524.13	0.003227	8.85	2409.55	268.97	0.37
FISH CREEK	US	37902	100 yr	15164.00	503.00	524.14		524.94	0.003361	9.29	2623.40	300.86	0.38
FISH CREEK	US	37902	500 yr	20340.00	503.00	525.85		526.78	0.003641	10.26	3199.99	372.55	0.41
FISH CREEK	US	37902	U_100 yr	15495.00	503.00	524.24		525.05	0.003402	9.38	2654.76	304.52	0.39
FISH CREEK	US	37374	10 yr	9206.00	501.66	519.56		520.28	0.003773	8.49	1738.28	251.55	0.39
FISH CREEK	US	37374	50 yr	13287.00	501.66	521.18		522.15	0.004688	10.15	2186.39	302.50	0.44
FISH CREEK	US	37374	100 yr	15164.00	501.66	521.82		522.87	0.004925	10.68	2387.73	319.63	0.46
FISH CREEK	US	37374	500 yr	20340.00	501.66	523.26		524.51	0.005534	11.96	2861.53	339.74	0.49
FISH CREEK	US	37374	U_100 yr	15495.00	501.66	521.87		522.95	0.005060	10.85	2402.85	320.59	0.47
FISH CREEK	US	36983	10 yr	9310.00	501.00	518.23	514.91	518.88	0.003789	8.34	1986.23	353.42	0.39
FISH CREEK	US	36983	50 yr	13595.00	501.00	519.73	516.20	520.48	0.004161	9.35	2592.59	450.42	0.42
FISH CREEK	US	36983	100 yr	15656.00	501.00	520.38	516.20	521.14	0.004161	9.61	2894.02	478.34	0.42
FISH CREEK	US	36983	500 yr	20990.00	501.00	521.88	518.97	522.65	0.003988	9.98	3656.06	538.73	0.42
FISH CREEK	US	36983	U_100 yr	15813.00	501.00	520.42	516.20	521.18	0.004170	9.64	2913.85	480.15	0.42
FISH CREEK	US	36542	10 yr	9310.00	500.37	516.72		517.24	0.003702	7.55	1981.78	377.77	0.38
FISH CREEK	US	36542	50 yr	13595.00	500.37	518.11		518.72	0.003910	8.33	2516.31	390.61	0.39
FISH CREEK	US	36542	100 yr	15656.00	500.37	518.77		519.40	0.003848	8.52	2775.57	398.64	0.39
FISH CREEK	US	36542	500 yr	20990.00	500.37	520.31		521.01	0.003675	8.90	3405.23	420.65	0.39
FISH CREEK	US	36542	U_100 yr	15813.00	500.37	518.80		519.44	0.003868	8.55	2788.94	399.12	0.39
FISH CREEK	US	35879	10 yr	9310.00	499.00	515.29	512.41	515.49	0.001732	5.51	3408.11	632.63	0.26
FISH CREEK	US	35879	50 yr	13595.00	499.00	516.62	513.96	516.86	0.001971	6.24	4261.73	655.72	0.28
FISH CREEK	US	35879	100 yr	15656.00	499.00	517.33	513.99	517.58	0.001940	6.38	4733.55	668.93	0.28
FISH CREEK	US	35879	500 yr	20990.00	499.00	519.00	514.22	519.26	0.001885	6.71	5873.54	702.41	0.28
FISH CREEK	US	35879	U_100 yr	15813.00	499.00	517.36	513.99	517.60	0.001960	6.42	4749.39	669.35	0.28
FISH CREEK	US	34603	10 yr	10273.00	496.00	513.20	510.69	513.45	0.002509	6.17	3695.01	1084.28	0.30
FISH CREEK	US	34603	50 yr	15430.00	496.00	514.84	511.30	515.03	0.001785	5.64	5501.44	1121.88	0.26
FISH CREEK	US	34603	100 yr	17693.00	496.00	515.84	511.30	516.00	0.001317	5.06	6632.72	1131.96	0.23
FISH CREEK	US	34603	500 yr	23679.00	496.00	517.75	513.30	517.88	0.000963	4.68	8804.45	1148.67	0.20
FISH CREEK	US	34603	U_100 yr	17775.00	496.00	515.86	511.30	516.01	0.001318	5.07	6650.82	1132.09	0.23
FISH CREEK	US	33913	10 yr	10273.00	495.39	512.57	507.94	512.67	0.000775	3.76	4718.06	1123.44	0.18
FISH CREEK	US	33913	50 yr	15430.00	495.39	514.41	510.31	514.51	0.000604	3.62	6816.90	1149.00	0.16
FISH CREEK	US	33913	100 yr	17693.00	495.39	515.53	510.73	515.62	0.000469	3.34	8114.34	1163.24	0.15
FISH CREEK	US	33913	500 yr	23679.00	495.39	517.53	511.23	517.61	0.000384	3.26	10451.25	1184.90	0.13
FISH CREEK	US	33913	U_100 yr	17775.00	495.39	515.55	510.73	515.64	0.000470	3.35	8132.65	1163.41	0.15
FISH CREEK	US	32625	10 yr	10273.00	496.00	510.87		511.45	0.002528	7.54	2686.62	710.78	0.39
FISH CREEK	US	32625	50 yr	15430.00	496.00	513.18		513.62	0.001870	7.32	4505.52	895.74	0.35
FISH CREEK	US	32625	100 yr	17693.00	496.00	514.64		514.97	0.001327	6.59	5966.12	1082.41	0.30
FISH CREEK	US	32625	500 yr	23679.00	496.00	516.90		517.13	0.000905	5.96	8627.24	1227.96	0.25

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	US	32625	U_100 yr	17775.00	496.00	514.66		514.98	0.001331	6.60	5980.98	1082.92	0.30
FISH CREEK	US	32167	10 yr	10273.00	495.67	510.43	504.36	510.68	0.000874	4.66	3386.76	751.47	0.23
FISH CREEK	US	32167	50 yr	15430.00	495.67	512.80	505.99	513.07	0.000857	5.18	4743.01	960.35	0.24
FISH CREEK	US	32167	100 yr	17693.00	495.67	514.34	507.21	514.58	0.000672	4.90	5674.05	1191.40	0.21
FISH CREEK	US	32167	500 yr	23679.00	495.67	516.60	508.82	516.86	0.000621	5.13	7046.16	1245.48	0.21
FISH CREEK	US	32167	U_100 yr	17775.00	495.67	514.36	507.24	514.60	0.000676	4.92	5681.46	1191.64	0.21
FISH CREEK	US	31824	10 yr	10273.00	488.97	510.24	502.37	510.42	0.000542	3.71	3399.61	680.97	0.18
FISH CREEK	US	31824	50 yr	15430.00	488.97	512.58	504.32	512.82	0.000598	4.36	4465.30	788.25	0.20
FISH CREEK	US	31824	100 yr	17693.00	488.97	514.16	504.95	514.38	0.000488	4.21	5234.69	836.41	0.18
FISH CREEK	US	31824	500 yr	23679.00	488.97	516.42	506.44	516.68	0.000479	4.53	6331.42	891.92	0.18
FISH CREEK	US	31824	U_100 yr	17775.00	488.97	514.18	504.97	514.40	0.000491	4.22	5240.13	836.75	0.18
FISH CREEK	US	31772	10 yr	11175.00	488.74	510.01	501.76	510.34	0.000881	4.81	2540.18	669.98	0.23
FISH CREEK	US	31772	50 yr	16680.00	488.74	512.24	503.77	512.71	0.001019	5.73	3157.41	778.18	0.26
FISH CREEK	US	31772	100 yr	19011.00	488.74	513.81	504.55	514.28	0.000883	5.69	3593.33	825.27	0.24
FISH CREEK	US	31772	500 yr	25393.00	488.74	515.93	506.41	516.54	0.000970	6.45	4180.36	882.22	0.26
FISH CREEK	US	31772	U_100 yr	19070.00	488.74	513.82	504.58	514.29	0.000886	5.70	3596.15	825.60	0.24
FISH CREEK	US	31709		Bridge									
FISH CREEK	US	31603	10 yr	11246.00	488.50	509.62	498.26	509.89	0.000578	4.31	2770.23	458.56	0.19
FISH CREEK	US	31603	50 yr	16783.00	488.50	511.62	500.71	512.04	0.000758	5.35	3293.36	578.42	0.23
FISH CREEK	US	31603	100 yr	19124.00	488.50	512.42	501.62	512.89	0.000811	5.71	3501.15	625.05	0.24
FISH CREEK	US	31603	500 yr	25498.00	488.50	514.04	504.82	514.71	0.001002	6.71	3923.71	722.06	0.27
FISH CREEK	US	31603	U_100 yr	19183.00	488.50	512.43	501.65	512.91	0.000813	5.72	3505.55	626.05	0.24
FISH CREEK	US	31319	10 yr	11246.00	487.97	509.27	505.41	509.61	0.001837	6.54	3315.73	749.59	0.27
FISH CREEK	US	31319	50 yr	16783.00	487.97	511.35	507.00	511.71	0.001828	7.03	4437.01	861.04	0.28
FISH CREEK	US	31319	100 yr	19124.00	487.97	512.16	507.81	512.53	0.001806	7.17	4873.34	872.54	0.28
FISH CREEK	US	31319	500 yr	25498.00	487.97	513.78	508.75	514.22	0.001957	7.85	5750.62	914.92	0.29
FISH CREEK	US	31319	U_100 yr	19183.00	487.97	512.17	507.82	512.54	0.001807	7.18	4882.50	872.78	0.28
FISH CREEK	US	30732	10 yr	11246.00	488.00	508.35		508.66	0.001554	5.92	3657.98	647.39	0.26
FISH CREEK	US	30732	50 yr	16783.00	488.00	510.44		510.76	0.001555	6.43	5098.79	726.30	0.27
FISH CREEK	US	30732	100 yr	19124.00	488.00	511.17		511.55	0.001738	6.98	5668.26	875.82	0.28
FISH CREEK	US	30732	500 yr	25498.00	488.00	512.81		513.19	0.001732	7.36	7161.74	944.57	0.29
FISH CREEK	US	30732	U_100 yr	19183.00	488.00	511.19		511.57	0.001737	6.98	5683.56	876.75	0.28
FISH CREEK	US	30084	10 yr	11246.00	486.00	507.70		507.90	0.000911	4.51	4197.18	793.85	0.20
FISH CREEK	US	30084	50 yr	16783.00	486.00	509.88		510.06	0.000761	4.49	6007.32	862.97	0.18
FISH CREEK	US	30084	100 yr	19124.00	486.00	510.60		510.78	0.000737	4.53	6637.56	878.72	0.18
FISH CREEK	US	30084	500 yr	25498.00	486.00	512.25		512.44	0.000719	4.73	8107.48	910.85	0.18
FISH CREEK	US	30084	U_100 yr	19183.00	486.00	510.62		510.80	0.000737	4.53	6653.22	879.08	0.18
FISH CREEK	US	29632	10 yr	11246.00	485.00	507.10	502.15	507.39	0.001485	5.98	3358.68	487.10	0.25
FISH CREEK	US	29632	50 yr	16783.00	485.00	509.27	503.58	509.59	0.001525	6.54	4512.64	610.07	0.26
FISH CREEK	US	29632	100 yr	19124.00	485.00	510.00	504.05	510.33	0.001524	6.69	4957.88	625.81	0.26
FISH CREEK	US	29632	500 yr	25498.00	485.00	511.62	505.52	511.99	0.001533	7.06	5977.56	664.12	0.26
FISH CREEK	US	29632	U_100 yr	19183.00	485.00	510.01	504.07	510.34	0.001523	6.70	4968.98	626.15	0.26
FISH CREEK	US	29091	10 yr	11246.00	485.00	505.72	500.94	506.33	0.003122	7.77	3036.60	501.36	0.35
FISH CREEK	US	29091	50 yr	16783.00	485.00	507.61	503.45	508.43	0.003910	9.41	4109.67	675.48	0.40
FISH CREEK	US	29091	100 yr	19124.00	485.00	508.29	504.00	509.16	0.004036	9.82	4592.20	720.37	0.41
FISH CREEK	US	29091	500 yr	25498.00	485.00	509.90	505.05	510.81	0.004193	10.61	5785.49	765.27	0.43
FISH CREEK	US	29091	U_100 yr	19183.00	485.00	508.31	504.00	509.17	0.004035	9.83	4605.58	721.22	0.41
FISH CREEK	US	28546	10 yr	11246.00	484.36	504.82		505.09	0.001426	5.75	3850.14	646.53	0.25
FISH CREEK	US	28546	50 yr	16783.00	484.36	506.60		506.92	0.001611	6.54	5061.13	728.15	0.27
FISH CREEK	US	28546	100 yr	19124.00	484.36	507.27		507.60	0.001642	6.77	5558.95	748.69	0.27
FISH CREEK	US	28546	500 yr	25498.00	484.36	508.84		509.21	0.001726	7.31	6770.28	790.76	0.28
FISH CREEK	US	28546	U_100 yr	19183.00	484.36	507.29		507.62	0.001641	6.77	5573.33	749.21	0.27
FISH CREEK	US	27747	10 yr	11246.00	485.00	503.30		503.78	0.002355	7.26	3058.17	583.45	0.32
FISH CREEK	US	27747	50 yr	16783.00	485.00	504.92		505.46	0.002626	8.18	4038.68	624.22	0.34
FISH CREEK	US	27747	100 yr	19124.00	485.00	505.56		506.12	0.002705	8.50	4441.58	652.86	0.35
FISH CREEK	US	27747	500 yr	25498.00	485.00	507.06		507.67	0.002821	9.15	5462.27	696.00	0.36
FISH CREEK	US	27747	U_100 yr	19183.00	485.00	505.58		506.14	0.002709	8.51	4453.28	655.20	0.35
FISH CREEK	US	27236	10 yr	11246.00	483.56	502.41		502.74	0.001974	6.43	3571.73	721.79	0.29
FISH CREEK	US	27236	50 yr	16783.00	483.56	503.98		504.34	0.002119	7.11	4743.08	763.93	0.30
FISH CREEK	US	27236	100 yr	19124.00	483.56	504.60		504.98	0.002135	7.31	5234.60	788.91	0.31
FISH CREEK	US	27236	500 yr	25498.00	483.56	506.12		506.51	0.002116	7.69	6445.40	812.57	0.31
FISH CREEK	US	27236	U_100 yr	19183.00	483.56	504.62		505.00	0.002131	7.31	5249.70	789.19	0.31
FISH CREEK	US	26695	10 yr	11348.00	482.00	501.31		501.72	0.002558	6.56	3341.93	792.53	0.32
FISH CREEK	US	26695	50 yr	17008.00	482.00	502.90		503.32	0.002549	7.08	4658.87	850.26	0.33
FISH CREEK	US	26695	100 yr	19508.00	482.00	503.55		503.97	0.002522	7.24	5218.77	880.13	0.33

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	US	26695	500 yr	26012.00	482.00	505.11		505.54	0.002445	7.61	6650.41	969.15	0.33
FISH CREEK	US	26695	U_100 yr	19573.00	482.00	503.57		503.99	0.002513	7.24	5238.87	880.78	0.33
FISH CREEK	US	26243	10 yr	11348.00	481.00	500.64	497.77	500.79	0.002290	3.51	3985.32	907.26	0.27
FISH CREEK	US	26243	50 yr	17008.00	481.00	502.33	498.45	502.50	0.001917	3.71	5579.97	978.81	0.26
FISH CREEK	US	26243	100 yr	19508.00	481.00	503.01	498.72	503.18	0.001791	3.79	6253.01	1001.44	0.25
FISH CREEK	US	26243	500 yr	26012.00	481.00	504.62	499.29	504.81	0.001614	4.00	7930.21	1084.91	0.25
FISH CREEK	US	26243	U_100 yr	19573.00	481.00	503.04	498.72	503.21	0.001781	3.78	6278.57	1002.39	0.25
FISH CREEK	US	25980	10 yr	11897.00	478.57	500.13	494.26	500.35	0.000846	4.47	4421.63	1005.60	0.19
FISH CREEK	US	25980	50 yr	17743.00	478.57	501.84	495.87	502.10	0.000887	4.86	6267.03	1129.50	0.19
FISH CREEK	US	25980	100 yr	20338.00	478.57	502.52	496.52	502.80	0.000946	5.13	7067.32	1226.64	0.20
FISH CREEK	US	25980	500 yr	27058.00	478.57	504.17	498.16	504.47	0.000852	5.14	9194.06	1355.66	0.19
FISH CREEK	US	25980	U_100 yr	20379.00	478.57	502.55	496.52	502.82	0.000939	5.12	7103.46	1229.31	0.20
FISH CREEK	US	25946		Bridge									
FISH CREEK	US	25904	10 yr	11897.00	477.24	499.84	494.83	500.20	0.001807	6.42	3497.33	805.68	0.27
FISH CREEK	US	25904	50 yr	17743.00	477.24	501.70	498.74	502.02	0.001560	6.37	5078.81	911.34	0.25
FISH CREEK	US	25904	100 yr	20338.00	477.24	502.41	499.00	502.72	0.001475	6.35	5733.94	945.42	0.25
FISH CREEK	US	25904	500 yr	27058.00	477.24	504.09	499.99	504.40	0.001297	6.28	7396.75	1031.48	0.24
FISH CREEK	US	25904	U_100 yr	20379.00	477.24	502.44	499.00	502.75	0.001460	6.32	5763.44	946.67	0.25
FISH CREEK	US	25626	10 yr	11897.00	478.31	499.52	494.89	499.75	0.001247	4.63	3389.54	751.86	0.22
FISH CREEK	US	25626	50 yr	17743.00	478.31	501.43	497.42	501.67	0.001006	4.55	5068.57	905.33	0.21
FISH CREEK	US	25626	100 yr	20338.00	478.31	502.15	497.74	502.39	0.000960	4.58	5731.78	953.00	0.20
FISH CREEK	US	25626	500 yr	27058.00	478.31	503.87	498.45	504.12	0.000811	4.51	7430.68	1020.75	0.19
FISH CREEK	US	25626	U_100 yr	20379.00	478.31	502.19	497.75	502.42	0.000949	4.56	5764.24	954.83	0.20
FISH CREEK	US	25291	10 yr	11897.00	478.00	499.29	496.15	499.47	0.000919	4.46	3821.72	763.88	0.19
FISH CREEK	US	25291	50 yr	17743.00	478.00	501.26	497.08	501.45	0.000737	4.30	5487.21	889.21	0.17
FISH CREEK	US	25291	100 yr	20338.00	478.00	501.99	497.39	502.18	0.000686	4.25	6142.58	903.93	0.17
FISH CREEK	US	25291	500 yr	27058.00	478.00	503.74	498.06	503.94	0.000599	4.21	7759.84	951.51	0.16
FISH CREEK	US	25291	U_100 yr	20379.00	478.00	502.03	497.40	502.22	0.000678	4.23	6175.26	904.92	0.17
FISH CREEK	US	24966	10 yr	11897.00	477.81	498.84	492.45	499.15	0.001429	5.65	3882.74	691.79	0.25
FISH CREEK	US	24966	50 yr	17743.00	477.81	500.83	496.23	501.17	0.001499	6.26	5337.24	764.26	0.26
FISH CREEK	US	24966	100 yr	20338.00	477.81	501.56	496.75	501.92	0.001548	6.53	5907.55	798.61	0.27
FISH CREEK	US	24966	500 yr	27058.00	477.81	503.33	497.69	503.70	0.001550	6.94	7379.97	856.86	0.27
FISH CREEK	US	24966	U_100 yr	20379.00	477.81	501.60	496.77	501.95	0.001534	6.51	5939.89	800.87	0.27
FISH CREEK	US	24313	10 yr	11897.00	477.00	497.16		497.88	0.003247	8.28	2667.99	556.90	0.36
FISH CREEK	US	24313	50 yr	17743.00	477.00	499.22		499.90	0.003113	8.79	3893.71	640.84	0.36
FISH CREEK	US	24313	100 yr	20338.00	477.00	499.93		500.63	0.003134	9.04	4363.32	671.57	0.37
FISH CREEK	US	24313	500 yr	27058.00	477.00	501.81		502.47	0.002866	9.21	5670.45	717.86	0.36
FISH CREEK	US	24313	U_100 yr	20379.00	477.00	500.00		500.68	0.003069	8.97	4409.90	674.54	0.36
FISH CREEK	US	23728	10 yr	11897.00	476.00	495.51		496.23	0.002941	8.64	2584.65	489.40	0.36
FISH CREEK	US	23728	50 yr	17743.00	476.00	497.42		498.23	0.003321	9.83	3723.33	651.17	0.39
FISH CREEK	US	23728	100 yr	20338.00	476.00	498.16		498.97	0.003319	10.08	4223.44	684.87	0.39
FISH CREEK	US	23728	500 yr	27058.00	476.00	500.48		501.12	0.002611	9.61	5844.49	718.76	0.36
FISH CREEK	US	23728	U_100 yr	20379.00	476.00	498.35		499.11	0.003102	9.80	4352.71	687.70	0.38
FISH CREEK	US	22868	10 yr	11897.00	476.00	494.19	489.50	494.49	0.001465	5.05	3081.92	711.19	0.25
FISH CREEK	US	22868	50 yr	17743.00	476.00	496.30	492.00	496.56	0.001017	4.66	4629.36	765.33	0.21
FISH CREEK	US	22868	100 yr	20338.00	476.00	497.09	492.77	497.36	0.000943	4.64	5248.20	833.82	0.21
FISH CREEK	US	22868	500 yr	27058.00	476.00	499.72	493.94	499.95	0.000598	4.10	7644.18	1138.54	0.17
FISH CREEK	US	22868	U_100 yr	20379.00	476.00	497.37	492.78	497.62	0.000844	4.44	5481.72	871.40	0.20
FISH CREEK	US	22324	10 yr	11897.00	475.00	493.73	490.06	493.93	0.000992	3.95	3735.16	686.95	0.20
FISH CREEK	US	22324	50 yr	17743.00	475.00	495.97	490.93	496.19	0.000772	3.91	5306.87	717.23	0.18
FISH CREEK	US	22324	100 yr	20338.00	475.00	496.78	491.33	497.01	0.000743	3.97	5893.24	730.85	0.18
FISH CREEK	US	22324	500 yr	27058.00	475.00	499.48	492.23	499.72	0.000584	3.93	8013.77	1057.88	0.16
FISH CREEK	US	22324	U_100 yr	20379.00	475.00	497.09	491.32	497.31	0.000667	3.82	6122.55	764.93	0.17
FISH CREEK	US	21694	10 yr	11897.00	475.00	493.27		493.46	0.000715	4.87	4417.20	761.43	0.22
FISH CREEK	US	21694	50 yr	17743.00	475.00	495.64		495.80	0.000592	4.87	6516.93	963.07	0.20
FISH CREEK	US	21694	100 yr	20338.00	475.00	496.48		496.64	0.000559	4.87	7345.66	1011.00	0.20
FISH CREEK	US	21694	500 yr	27058.00	475.00	499.28		499.42	0.000415	4.60	10439.23	1260.78	0.17
FISH CREEK	US	21694	U_100 yr	20379.00	475.00	496.83		496.97	0.000490	4.62	7703.80	1025.38	0.19
FISH CREEK	US	21523	10 yr	11914.00	475.00	493.20	484.20	493.34	0.000304	3.33	4161.77	487.70	0.14
FISH CREEK	US	21523	50 yr	17976.00	475.00	495.49	485.41	495.70	0.000369	3.99	5100.69	765.58	0.16
FISH CREEK	US	21523	100 yr	20403.00	475.00	496.30	485.86	496.54	0.000388	4.21	5433.70	798.78	0.17
FISH CREEK	US	21523	500 yr	27329.00	475.00	499.03	487.07	499.33	0.000379	4.53	6560.00	1070.04	0.17
FISH CREEK	US	21523	U_100 yr	20467.00	475.00	496.66	485.87	496.88	0.000358	4.09	5580.14	812.69	0.16
FISH CREEK	US	21367		Bridge									

HEC-RAS Plan: P1 (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	US	21180	10 yr	11914.00	473.98	492.97	482.65	493.12	0.000350	3.75	4037.66	545.34	0.15
FISH CREEK	US	21180	50 yr	17976.00	473.98	495.14	484.08	495.37	0.000462	4.64	4809.39	621.08	0.18
FISH CREEK	US	21180	100 yr	20403.00	473.98	495.90	484.58	496.16	0.000498	4.93	5083.07	639.43	0.19
FISH CREEK	US	21180	500 yr	27329.00	473.98	498.30	485.91	498.64	0.000536	5.49	5949.11	730.80	0.20
FISH CREEK	US	21180	U_100 yr	20467.00	473.98	496.27	484.60	496.53	0.000460	4.79	5219.09	659.44	0.18
FISH CREEK	US	20966	10 yr	11914.00	475.00	492.81	484.76	493.03	0.000716	5.04	3568.58	582.55	0.22
FISH CREEK	US	20966	50 yr	17976.00	475.00	495.05	486.49	495.29	0.000717	5.49	5098.15	617.22	0.22
FISH CREEK	US	20966	100 yr	20403.00	475.00	495.83	487.10	496.08	0.000708	5.60	5581.26	625.25	0.22
FISH CREEK	US	20966	500 yr	27329.00	475.00	498.26	487.58	498.53	0.000658	5.84	7155.35	700.84	0.22
FISH CREEK	US	20966	U_100 yr	20467.00	475.00	496.22	487.11	496.45	0.000627	5.35	5825.83	629.36	0.21
FISH CREEK	US	20722	10 yr	11914.00	474.51	492.41	488.24	492.76	0.001661	5.87	3108.44	533.28	0.27
FISH CREEK	US	20722	50 yr	17976.00	474.51	494.67	490.21	495.02	0.001520	6.18	4352.18	569.84	0.26
FISH CREEK	US	20722	100 yr	20403.00	474.51	495.45	490.67	495.81	0.001479	6.28	4802.14	620.82	0.26
FISH CREEK	US	20722	500 yr	27329.00	474.51	497.94	491.77	498.29	0.001249	6.30	6424.83	659.84	0.25
FISH CREEK	US	20722	U_100 yr	20467.00	474.51	495.89	490.68	496.21	0.001288	5.95	5055.85	631.67	0.25
FISH CREEK	US	20362	10 yr	11914.00	474.00	491.66		492.04	0.002415	6.32	2952.11	617.99	0.32
FISH CREEK	US	20362	50 yr	17976.00	474.00	494.11		494.43	0.001703	5.98	4604.26	704.51	0.27
FISH CREEK	US	20362	100 yr	20403.00	474.00	494.95		495.25	0.001547	5.91	5193.94	715.33	0.26
FISH CREEK	US	20362	500 yr	27329.00	474.00	497.57		497.84	0.001121	5.58	7111.40	762.28	0.23
FISH CREEK	US	20362	U_100 yr	20467.00	474.00	495.47		495.73	0.001265	5.46	5572.08	720.81	0.24
FISH CREEK	US	20046	10 yr	11914.00	467.69	491.11	482.28	491.44	0.001361	5.48	3445.31	691.64	0.24
FISH CREEK	US	20046	50 yr	17976.00	467.69	493.71	485.58	493.99	0.001077	5.39	5325.01	744.21	0.22
FISH CREEK	US	20046	100 yr	20403.00	467.69	494.58	489.04	494.85	0.001017	5.39	5970.54	752.39	0.21
FISH CREEK	US	20046	500 yr	27329.00	467.69	497.30	490.64	497.54	0.000792	5.19	8091.50	803.31	0.19
FISH CREEK	US	20046	U_100 yr	20467.00	467.69	495.17	488.97	495.40	0.000844	5.01	6420.49	766.11	0.20
FISH CREEK	US	19644	10 yr	11914.00	468.00	490.65	487.54	490.90	0.001241	5.76	4018.27	719.48	0.24
FISH CREEK	US	19644	50 yr	17976.00	468.00	493.38	488.73	493.58	0.000888	5.37	6194.27	850.29	0.21
FISH CREEK	US	19644	100 yr	20403.00	468.00	494.27	489.07	494.46	0.000805	5.26	6959.90	867.92	0.20
FISH CREEK	US	19644	500 yr	27329.00	468.00	497.08	489.88	497.25	0.000571	4.82	9508.75	992.78	0.17
FISH CREEK	US	19644	U_100 yr	20467.00	468.00	494.92	489.08	495.08	0.000640	4.79	7534.22	906.31	0.18
FISH CREEK	US	19223	10 yr	11914.00	466.00	489.98		490.36	0.001549	6.26	3634.02	637.54	0.26
FISH CREEK	US	19223	50 yr	17976.00	466.00	492.86		493.17	0.001261	6.22	5601.19	727.90	0.24
FISH CREEK	US	19223	100 yr	20403.00	466.00	493.78		494.08	0.001226	6.31	6283.12	763.35	0.23
FISH CREEK	US	19223	500 yr	27329.00	466.00	496.72		496.97	0.000956	6.05	8648.76	841.04	0.21
FISH CREEK	US	19223	U_100 yr	20467.00	466.00	494.53		494.79	0.000983	5.77	6870.72	786.63	0.21
FISH CREEK	US	18738	10 yr	11914.00	468.00	489.55		489.74	0.000978	4.62	4190.76	684.44	0.20
FISH CREEK	US	18738	50 yr	17976.00	468.00	492.55		492.71	0.000683	4.33	6375.47	771.25	0.17
FISH CREEK	US	18738	100 yr	20403.00	468.00	493.48		493.64	0.000636	4.31	7103.22	787.73	0.17
FISH CREEK	US	18738	500 yr	27329.00	468.00	496.49		496.64	0.000482	4.12	9551.41	864.46	0.15
FISH CREEK	US	18738	U_100 yr	20467.00	468.00	494.30		494.44	0.000488	3.88	7755.13	798.83	0.15
FISH CREEK	US	18450	10 yr	11914.00	466.00	489.22		489.43	0.001083	5.97	4312.12	794.14	0.23
FISH CREEK	US	18450	50 yr	17976.00	466.00	492.36		492.50	0.000650	5.06	6931.71	876.56	0.18
FISH CREEK	US	18450	100 yr	20403.00	466.00	493.31		493.45	0.000601	4.99	7776.78	900.38	0.17
FISH CREEK	US	18450	500 yr	27329.00	466.00	496.36		496.49	0.000440	4.60	10591.52	958.00	0.15
FISH CREEK	US	18450	U_100 yr	20467.00	466.00	494.17		494.29	0.000456	4.44	8561.89	912.27	0.15
FISH CREEK	US	17941	10 yr	11914.00	466.00	488.65	485.66	488.92	0.001084	6.04	3778.86	864.53	0.23
FISH CREEK	US	17941	50 yr	17976.00	466.00	492.02	486.76	492.21	0.000602	4.95	6048.80	1046.90	0.17
FISH CREEK	US	17941	100 yr	20403.00	466.00	492.98	487.10	493.18	0.000561	4.90	6698.80	1075.16	0.17
FISH CREEK	US	17941	500 yr	27329.00	466.00	496.22	487.99	496.32	0.000280	3.74	12187.75	1198.54	0.12
FISH CREEK	US	17941	U_100 yr	20467.00	466.00	493.92	487.11	494.08	0.000422	4.35	7332.49	1100.95	0.15
FISH CREEK	US	17750	10 yr	11689.00	465.89	487.94	481.01	488.61	0.001947	7.78	2438.45	775.69	0.32
FISH CREEK	US	17750	50 yr	17903.00	465.89	491.27	485.79	491.98	0.001890	8.56	4108.97	1203.86	0.32
FISH CREEK	US	17750	100 yr	20240.00	465.89	492.33	486.40	492.97	0.001712	8.41	4799.07	1216.81	0.31
FISH CREEK	US	17750	500 yr	27195.00	465.89	496.14	487.93	496.26	0.000416	4.59	13199.62	1255.42	0.16
FISH CREEK	US	17750	U_100 yr	20331.00	465.89	493.47	486.42	493.93	0.001219	7.33	5551.84	1224.43	0.26
FISH CREEK	US	17674		Bridge									
FISH CREEK	US	17585	10 yr	11689.00	464.00	486.21	478.33	487.14	0.002063	9.01	2024.57	494.50	0.35
FISH CREEK	US	17585	50 yr	17903.00	464.00	489.75	481.59	490.30	0.001281	7.88	3936.24	1164.28	0.28
FISH CREEK	US	17585	100 yr	20240.00	464.00	490.76	482.37	491.25	0.001144	7.65	4473.62	1208.31	0.27
FISH CREEK	US	17585	500 yr	27195.00	464.00	495.24	485.00	495.33	0.000196	3.53	12466.44	1336.99	0.11
FISH CREEK	US	17585	U_100 yr	20331.00	464.00	490.87	482.37	491.35	0.001109	7.56	4536.25	1212.85	0.26
FISH CREEK	DS	17314	10 yr	17061.00	465.00	485.16		486.64	0.000470	3.46	2971.33	619.13	0.15
FISH CREEK	DS	17314	50 yr	26524.00	465.00	488.63		489.86	0.000435	3.76	5557.26	913.14	0.15
FISH CREEK	DS	17314	100 yr	29975.00	465.00	489.82		490.87	0.000404	3.76	6690.37	987.08	0.14
FISH CREEK	DS	17314	500 yr	38851.00	465.00	494.68		495.16	0.000208	3.08	11999.32	1162.28	0.11
FISH CREEK	DS	17314	U_100 yr	30329.00	465.00	489.95		490.98	0.000399	3.75	6816.70	993.18	0.14

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	DS	16845	10 yr	17061.00	463.41	485.51	482.70	486.03	0.002000	7.58	3797.61	622.51	0.31
FISH CREEK	DS	16845	50 yr	26524.00	463.41	488.93	484.36	489.33	0.001338	6.94	5983.40	648.76	0.26
FISH CREEK	DS	16845	100 yr	29975.00	463.41	490.02	484.77	490.41	0.001214	6.83	6694.84	653.47	0.25
FISH CREEK	DS	16845	500 yr	38851.00	463.41	494.69	485.70	494.96	0.000715	5.93	10529.88	1015.80	0.20
FISH CREEK	DS	16845	U_100 yr	30329.00	463.41	490.14	484.81	490.53	0.001200	6.81	6772.36	654.00	0.25
FISH CREEK	DS	16476	10 yr	17061.00	464.00	484.61	480.83	485.03	0.002548	5.37	3496.42	574.05	0.24
FISH CREEK	DS	16476	50 yr	26524.00	464.00	488.37	482.31	488.73	0.001379	4.55	5776.75	636.28	0.18
FISH CREEK	DS	16476	100 yr	29975.00	464.00	489.52	482.76	489.88	0.001203	4.41	6515.74	645.71	0.17
FISH CREEK	DS	16476	500 yr	38851.00	464.00	494.43	483.78	494.63	0.000707	3.89	10976.59	1213.47	0.13
FISH CREEK	DS	16476	U_100 yr	30329.00	464.00	489.65	482.81	490.00	0.001184	4.39	6596.75	646.54	0.17
FISH CREEK	DS	16060	10 yr	17091.00	463.00	483.11	479.64	484.00	0.002277	8.42	2740.13	599.39	0.45
FISH CREEK	DS	16060	50 yr	26776.00	463.00	487.81	482.71	488.27	0.000916	6.77	6016.51	784.44	0.30
FISH CREEK	DS	16060	100 yr	29999.00	463.00	489.06	483.24	489.49	0.000806	6.68	7066.36	886.12	0.29
FISH CREEK	DS	16060	500 yr	38921.00	463.00	494.22	484.43	494.44	0.000323	5.05	12086.41	1119.09	0.19
FISH CREEK	DS	16060	U_100 yr	30382.00	463.00	489.20	483.30	489.62	0.000787	6.64	7189.86	887.94	0.28
FISH CREEK	DS	15727	10 yr	17094.00	462.69	482.91	476.01	483.21	0.001343	4.55	4340.70	567.62	0.25
FISH CREEK	DS	15727	50 yr	26715.00	462.69	487.67	478.62	487.93	0.000769	4.46	7234.08	662.46	0.21
FISH CREEK	DS	15727	100 yr	29969.00	462.69	488.91	479.05	489.19	0.000715	4.54	8091.53	707.73	0.20
FISH CREEK	DS	15727	500 yr	38883.00	462.69	494.08	480.52	494.31	0.000439	4.29	13561.46	1454.54	0.16
FISH CREEK	DS	15727	U_100 yr	30343.00	462.69	489.05	479.05	489.33	0.000711	4.56	8189.41	723.67	0.20
FISH CREEK	DS	15620	10 yr	17094.00	460.94	482.18	472.84	483.07	0.000177	7.55	2264.48	322.13	0.35
FISH CREEK	DS	15620	50 yr	26715.00	460.94	486.96	476.34	487.82	0.000144	7.87	4985.75	951.26	0.33
FISH CREEK	DS	15620	100 yr	29969.00	460.94	488.26	477.32	489.08	0.000133	7.87	5890.20	1272.27	0.32
FISH CREEK	DS	15620	500 yr	38883.00	460.94	493.96	479.76	494.28	0.000049	5.67	15698.84	1774.74	0.20
FISH CREEK	DS	15620	U_100 yr	30343.00	460.94	488.40	477.43	489.22	0.000131	7.87	5991.86	1296.58	0.31
FISH CREEK	DS	15591		Bridge									
FISH CREEK	DS	15578	10 yr	17094.00	460.90	481.94	472.72	482.92	0.000193	7.93	2156.32	402.63	0.36
FISH CREEK	DS	15578	50 yr	26715.00	460.90	486.39	476.23	487.76	0.000217	9.39	2844.95	646.00	0.40
FISH CREEK	DS	15578	100 yr	29969.00	460.90	488.11	477.27	488.92	0.000139	7.90	6035.02	698.22	0.32
FISH CREEK	DS	15578	500 yr	38883.00	460.90	493.54	479.84	494.06	0.000075	6.82	10377.58	928.66	0.25
FISH CREEK	DS	15578	U_100 yr	30343.00	460.90	488.25	477.39	489.06	0.000138	7.90	6134.12	701.38	0.32
FISH CREEK	DS	15537	10 yr	17094.00	460.86	481.95	472.73	482.90	0.000190	7.86	2175.21	148.21	0.36
FISH CREEK	DS	15537	50 yr	26715.00	460.86	486.40	476.21	487.74	0.000203	9.32	2952.93	216.51	0.39
FISH CREEK	DS	15537	100 yr	29969.00	460.86	487.14	477.24	488.69	0.000225	10.02	3116.72	229.31	0.41
FISH CREEK	DS	15537	500 yr	38883.00	460.86	492.42	479.79	493.80	0.000155	9.67	4834.51	363.37	0.35
FISH CREEK	DS	15537	U_100 yr	30343.00	460.86	487.25	477.36	488.82	0.000226	10.08	3142.88	235.48	0.41
FISH CREEK	DS	15498	10 yr	17094.00	460.82	481.95	472.71	482.89	0.000186	7.80	2191.85	148.56	0.36
FISH CREEK	DS	15498	50 yr	26715.00	460.82	486.41	476.16	487.72	0.000216	9.20	2903.69	171.16	0.39
FISH CREEK	DS	15498	100 yr	29969.00	460.82	487.15	477.14	488.67	0.000242	9.88	3032.21	174.66	0.42
FISH CREEK	DS	15498	500 yr	38883.00	460.82	492.31	479.71	493.79	0.000189	9.74	3999.84	202.30	0.38
FISH CREEK	DS	15498	U_100 yr	30343.00	460.82	487.27	477.29	488.80	0.000243	9.94	3052.08	175.19	0.42
FISH CREEK	DS	15371		Bridge									
FISH CREEK	DS	15267	10 yr	17094.00	460.59	481.81	472.46	482.65	0.000167	7.33	2331.16	160.38	0.34
FISH CREEK	DS	15267	50 yr	26715.00	460.59	486.24	475.75	487.41	0.000181	8.66	3088.33	182.06	0.36
FISH CREEK	DS	15267	100 yr	29969.00	460.59	486.96	476.70	488.31	0.000200	9.34	3219.45	186.78	0.38
FISH CREEK	DS	15267	500 yr	38883.00	460.59	489.02	479.10	490.85	0.000235	10.87	3616.59	197.58	0.42
FISH CREEK	DS	15267	U_100 yr	30343.00	460.59	487.07	476.80	488.44	0.000201	9.39	3240.21	187.52	0.39
FISH CREEK	DS	15213	10 yr	17094.00	460.54	481.82	472.51	482.63	0.000165	7.21	2369.44	166.56	0.34
FISH CREEK	DS	15213	50 yr	26715.00	460.54	486.26	475.82	487.37	0.000183	8.47	3155.74	188.05	0.36
FISH CREEK	DS	15213	100 yr	29969.00	460.54	486.98	476.77	488.26	0.000205	9.10	3291.96	191.83	0.39
FISH CREEK	DS	15213	500 yr	38883.00	460.54	489.08	479.11	490.76	0.000282	10.38	3772.60	374.06	0.45
FISH CREEK	DS	15213	U_100 yr	30343.00	460.54	487.09	476.87	488.39	0.000208	9.16	3313.48	193.27	0.39
FISH CREEK	DS	15169	10 yr	17094.00	460.50	481.70	472.34	482.61	0.000174	7.63	2240.08	149.34	0.35
FISH CREEK	DS	15169	50 yr	26715.00	460.50	486.05	475.65	487.35	0.000205	9.14	2922.13	198.03	0.39
FISH CREEK	DS	15169	100 yr	29969.00	460.50	486.72	476.69	488.23	0.000240	9.87	3036.41	222.58	0.42
FISH CREEK	DS	15169	500 yr	38883.00	460.50	488.71	479.18	490.70	0.000292	11.39	3550.49	334.69	0.46
FISH CREEK	DS	15169	U_100 yr	30343.00	460.50	486.83	476.79	488.36	0.000243	9.93	3055.17	226.18	0.42
FISH CREEK	DS	15133		Bridge									
FISH CREEK	DS	15114	10 yr	17094.00	460.44	481.53	472.31	482.48	0.000192	7.82	2184.72	151.10	0.36
FISH CREEK	DS	15114	50 yr	26715.00	460.44	483.37	475.81	485.19	0.000332	10.82	2468.45	157.70	0.48
FISH CREEK	DS	15114	100 yr	29969.00	460.44	483.84	476.85	486.00	0.000385	11.78	2543.25	175.69	0.52
FISH CREEK	DS	15114	500 yr	38883.00	460.44	484.93	479.44	488.11	0.000540	14.29	2720.76	288.11	0.62
FISH CREEK	DS	15114	U_100 yr	30343.00	460.44	483.89	476.95	486.09	0.000391	11.89	2551.65	180.09	0.52

HEC-RAS Plan: P1 (Continued)

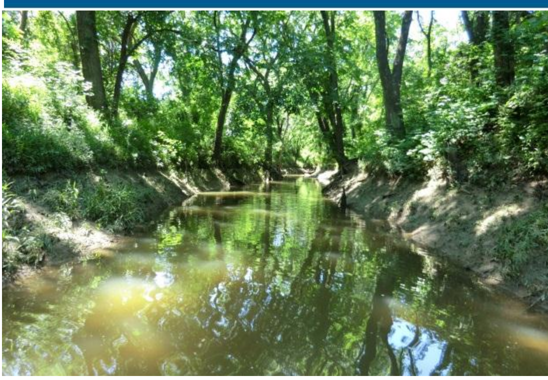
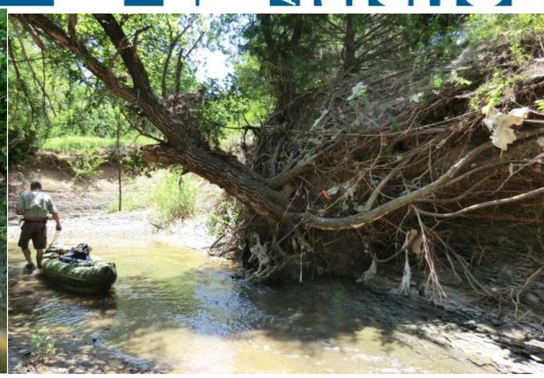
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	DS	14866	10 yr	17094.00	460.29	481.59		482.37	0.000133	7.17	2604.10	213.53	0.31
FISH CREEK	DS	14866	50 yr	26715.00	460.29	483.49		484.98	0.000223	9.96	3061.07	269.77	0.41
FISH CREEK	DS	14866	100 yr	29969.00	460.29	483.99		485.75	0.000255	10.85	3205.44	316.86	0.44
FISH CREEK	DS	14866	500 yr	38883.00	460.29	485.18		487.73	0.000341	13.09	3639.20	385.24	0.52
FISH CREEK	DS	14866	U_100 yr	30343.00	460.29	484.04		485.84	0.000258	10.95	3223.10	325.34	0.44
FISH CREEK	DS	14725	10 yr	17125.00	460.15	481.64	472.24	482.31	0.000148	6.97	3926.88	1115.47	0.32
FISH CREEK	DS	14725	50 yr	26902.00	460.15	483.98	475.81	484.74	0.000156	7.91	6834.75	1299.86	0.34
FISH CREEK	DS	14725	100 yr	30076.00	460.15	484.67	476.85	485.42	0.000155	8.09	7749.38	1348.85	0.34
FISH CREEK	DS	14725	500 yr	38956.00	460.15	486.42	482.30	487.15	0.000149	8.45	10184.03	1452.80	0.34
FISH CREEK	DS	14725	U_100 yr	30454.00	460.15	484.75	476.98	485.50	0.000155	8.11	7854.93	1353.09	0.34
FISH CREEK	DS	14668		Bridge									
FISH CREEK	DS	14575	10 yr	17125.00	460.00	481.26	472.11	482.29	0.000169	8.29	3629.64	1264.01	0.35
FISH CREEK	DS	14575	50 yr	26902.00	460.00	483.31	475.77	484.70	0.000225	10.29	6814.45	1341.82	0.41
FISH CREEK	DS	14575	100 yr	30076.00	460.00	483.86	476.73	485.39	0.000243	10.90	7561.03	1361.99	0.43
FISH CREEK	DS	14575	500 yr	38956.00	460.00	485.26	481.99	487.11	0.000287	12.38	9520.23	1435.23	0.47
FISH CREEK	DS	14575	U_100 yr	30454.00	460.00	483.92	476.83	485.47	0.000245	10.97	7644.04	1364.97	0.43
FISH CREEK	DS	14279	10 yr	17125.00	463.29	481.31	479.04	482.05	0.003150	8.28	2996.87	488.04	0.39
FISH CREEK	DS	14279	50 yr	26902.00	463.29	483.37	480.51	484.39	0.003368	9.37	4113.28	559.38	0.41
FISH CREEK	DS	14279	100 yr	30076.00	463.29	483.95	480.94	485.03	0.003382	9.61	4436.08	564.61	0.41
FISH CREEK	DS	14279	500 yr	38956.00	463.29	485.39	481.91	486.67	0.003444	10.25	5259.90	577.62	0.42
FISH CREEK	DS	14279	U_100 yr	30454.00	463.29	484.01	481.01	485.10	0.003387	9.64	4471.91	565.18	0.41
FISH CREEK	DS	13701	10 yr	17125.00	461.00	480.19	476.97	480.45	0.001744	6.00	5371.07	877.84	0.29
FISH CREEK	DS	13701	50 yr	26902.00	461.00	482.36	478.12	482.67	0.001703	6.55	7312.33	906.18	0.29
FISH CREEK	DS	13701	100 yr	30076.00	461.00	482.97	478.43	483.29	0.001700	6.71	7864.49	911.40	0.29
FISH CREEK	DS	13701	500 yr	38956.00	461.00	484.46	479.19	484.85	0.001782	7.28	9259.75	957.41	0.30
FISH CREEK	DS	13701	U_100 yr	30454.00	461.00	483.04	478.46	483.36	0.001704	6.74	7923.68	912.74	0.29
FISH CREEK	DS	13129	10 yr	17125.00	461.00	479.17	475.48	479.46	0.001924	6.35	4840.65	762.70	0.30
FISH CREEK	DS	13129	50 yr	26902.00	461.00	481.34	476.75	481.69	0.001933	7.01	6583.35	841.91	0.31
FISH CREEK	DS	13129	100 yr	30076.00	461.00	481.95	477.09	482.31	0.001931	7.18	7103.70	865.87	0.31
FISH CREEK	DS	13129	500 yr	38956.00	461.00	483.43	477.94	483.85	0.001933	7.61	8414.66	904.48	0.31
FISH CREEK	DS	13129	U_100 yr	30454.00	461.00	482.01	477.13	482.38	0.001936	7.21	7157.84	868.23	0.31
FISH CREEK	DS	12580	10 yr	17112.00	459.00	478.15	474.65	478.49	0.002065	7.36	4743.09	650.44	0.31
FISH CREEK	DS	12580	50 yr	26729.00	459.00	480.11	475.91	480.60	0.002664	8.99	6114.75	756.60	0.36
FISH CREEK	DS	12580	100 yr	30043.00	459.00	480.69	476.26	481.21	0.002761	9.33	6555.14	764.16	0.37
FISH CREEK	DS	12580	500 yr	38907.00	459.00	482.09	477.17	482.70	0.003045	10.26	7638.13	803.55	0.39
FISH CREEK	DS	12580	U_100 yr	30398.00	459.00	480.75	476.31	481.27	0.002773	9.37	6599.45	764.92	0.37
FISH CREEK	DS	12085	10 yr	17174.00	460.00	477.24	474.10	477.55	0.002233	6.81	4996.03	780.52	0.32
FISH CREEK	DS	12085	50 yr	26838.00	460.00	479.02	475.24	479.43	0.002671	8.05	6413.86	814.37	0.35
FISH CREEK	DS	12085	100 yr	30196.00	460.00	479.55	475.56	479.99	0.002788	8.40	6849.07	822.07	0.36
FISH CREEK	DS	12085	500 yr	39049.00	460.00	480.83	476.35	481.36	0.003068	9.26	7915.05	848.24	0.39
FISH CREEK	DS	12085	U_100 yr	30544.00	460.00	479.60	475.61	480.05	0.002799	8.44	6892.69	822.85	0.36
FISH CREEK	DS	11651	10 yr	17174.00	459.67	475.19	474.63	476.37	0.007877	11.67	2882.38	630.03	0.60
FISH CREEK	DS	11651	50 yr	26838.00	459.67	476.68	475.84	478.10	0.008911	13.44	3838.43	656.08	0.65
FISH CREEK	DS	11651	100 yr	30196.00	459.67	477.13	476.20	478.62	0.009189	13.96	4132.97	663.54	0.67
FISH CREEK	DS	11651	500 yr	39049.00	459.67	478.22	477.11	479.89	0.009657	15.07	4865.69	675.56	0.69
FISH CREEK	DS	11651	U_100 yr	30544.00	459.67	477.17	476.24	478.67	0.009215	14.01	4162.49	664.03	0.67
FISH CREEK	DS	11056	10 yr	17174.00	458.93	472.83	471.66	473.64	0.002351	8.91	2651.67	628.89	0.46
FISH CREEK	DS	11056	50 yr	26838.00	458.93	473.92	472.98	475.06	0.002931	10.57	3342.62	644.02	0.53
FISH CREEK	DS	11056	100 yr	30196.00	458.93	474.26	473.30	475.51	0.003060	11.00	3565.11	647.92	0.54
FISH CREEK	DS	11056	500 yr	39049.00	458.93	475.30	474.04	476.72	0.003012	11.49	4245.58	659.83	0.54
FISH CREEK	DS	11056	U_100 yr	30544.00	458.93	474.30	473.32	475.56	0.003074	11.04	3587.02	648.30	0.54
FISH CREEK	DS	10541	10 yr	17187.00	459.00	471.70	471.05	472.35	0.002944	8.77	2877.61	895.38	0.50
FISH CREEK	DS	10541	50 yr	26858.00	459.00	472.73	471.51	473.56	0.003044	9.53	3807.48	911.06	0.51
FISH CREEK	DS	10541	100 yr	30214.00	459.00	473.14	472.09	474.00	0.002865	9.49	4188.42	918.68	0.50
FISH CREEK	DS	10541	500 yr	39081.00	459.00	474.54	472.66	475.35	0.002057	8.69	5495.54	946.95	0.43
FISH CREEK	DS	10541	U_100 yr	30555.00	459.00	473.18	472.11	474.04	0.002854	9.49	4224.19	919.56	0.50
FISH CREEK	DS	9945	10 yr	17220.00	458.03	470.60	469.77	470.98	0.002071	6.79	3754.09	1382.74	0.41
FISH CREEK	DS	9945	50 yr	26858.00	458.03	471.85	470.42	472.25	0.001607	6.57	5454.41	1473.94	0.37
FISH CREEK	DS	9945	100 yr	30146.00	458.03	472.44	470.60	472.80	0.001309	6.17	6439.36	1525.02	0.34
FISH CREEK	DS	9945	500 yr	39099.00	458.03	474.21	471.04	474.50	0.000718	5.08	9182.46	1564.52	0.26
FISH CREEK	DS	9945	U_100 yr	30461.00	458.03	472.49	470.62	472.85	0.001288	6.14	6516.92	1529.34	0.34
FISH CREEK	DS	9180	10 yr	17220.00	459.06	469.69	468.00	469.95	0.001554	3.74	4277.67	1283.63	0.33
FISH CREEK	DS	9180	50 yr	26858.00	459.06	471.20	468.66	471.48	0.001162	3.98	6355.24	1373.91	0.30
FISH CREEK	DS	9180	100 yr	30146.00	459.06	471.92	468.88	472.18	0.000913	3.83	7350.59	1391.44	0.27
FISH CREEK	DS	9180	500 yr	39099.00	459.06	473.92	469.40	474.15	0.000541	3.54	10199.60	1452.99	0.22
FISH CREEK	DS	9180	U_100 yr	30461.00	459.06	471.98	468.90	472.24	0.000899	3.82	7433.74	1392.82	0.27

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
FISH CREEK	DS	8186	10 yr	17220.00	458.13	468.93	466.57	469.08	0.000620	3.57	5633.91	1410.89	0.22
FISH CREEK	DS	8186	50 yr	26858.00	458.13	470.65	467.26	470.83	0.000465	3.52	8084.17	1467.82	0.20
FISH CREEK	DS	8186	100 yr	30146.00	458.13	471.50	467.42	471.66	0.000370	3.32	9306.87	1501.98	0.18
FISH CREEK	DS	8186	500 yr	39099.00	458.13	473.68	467.88	473.84	0.000238	3.02	12503.59	1581.62	0.15
FISH CREEK	DS	8186	U_100 yr	30461.00	458.13	471.57	467.46	471.73	0.000365	3.31	9403.60	1503.59	0.18
FISH CREEK	DS	7473	10 yr	17205.00	457.38	468.74		468.82	0.000314	2.71	7649.14	1819.04	0.16
FISH CREEK	DS	7473	50 yr	26546.00	457.38	470.53		470.62	0.000235	2.66	10947.19	1861.13	0.15
FISH CREEK	DS	7473	100 yr	29876.00	457.38	471.41		471.50	0.000189	2.52	12596.39	1882.68	0.13
FISH CREEK	DS	7473	500 yr	38709.00	457.38	473.64		473.72	0.000125	2.31	16857.39	1937.59	0.11
FISH CREEK	DS	7473	U_100 yr	30148.00	457.38	471.48		471.57	0.000186	2.51	12726.18	1884.28	0.13
FISH CREEK	DS	5968	10 yr	18462.00	456.00	468.26		468.38	0.000318	3.28	7034.21	1334.48	0.17
FISH CREEK	DS	5968	50 yr	28005.00	456.00	470.13		470.27	0.000275	3.37	9561.98	1369.66	0.16
FISH CREEK	DS	5968	100 yr	31837.00	456.00	471.06		471.20	0.000236	3.27	10848.55	1381.31	0.15
FISH CREEK	DS	5968	500 yr	40779.00	456.00	473.39		473.52	0.000167	3.03	14086.67	1407.37	0.13
FISH CREEK	DS	5968	U_100 yr	32111.00	456.00	471.14		471.28	0.000233	3.26	10949.29	1382.14	0.15
FISH CREEK	DS	4725	10 yr	18462.00	455.00	467.89		467.93	0.000470	2.44	12675.21	1904.29	0.14
FISH CREEK	DS	4725	50 yr	28005.00	455.00	469.80		469.85	0.000474	2.79	16333.33	1924.91	0.15
FISH CREEK	DS	4725	100 yr	31837.00	455.00	470.79		470.84	0.000428	2.81	18231.26	1935.92	0.14
FISH CREEK	DS	4725	500 yr	40779.00	455.00	473.20		473.25	0.000336	2.82	22941.01	1972.58	0.13
FISH CREEK	DS	4725	U_100 yr	32111.00	455.00	470.86		470.91	0.000424	2.81	18379.71	1936.81	0.14
FISH CREEK	DS	4059	10 yr	18381.00	459.00	467.69		467.71	0.000243	1.65	17152.15	2470.08	0.10
FISH CREEK	DS	4059	50 yr	27633.00	459.00	469.60		469.63	0.000250	1.94	21914.31	2511.64	0.11
FISH CREEK	DS	4059	100 yr	31431.00	459.00	470.61		470.63	0.000227	1.97	24446.17	2532.85	0.11
FISH CREEK	DS	4059	500 yr	40377.00	459.00	473.06		473.08	0.000183	2.03	30739.17	2618.75	0.10
FISH CREEK	DS	4059	U_100 yr	31724.00	459.00	470.68		470.71	0.000226	1.97	24644.57	2534.41	0.11
FISH CREEK	DS	3758	10 yr	18381.00	455.00	467.62		467.64	0.000172	1.81	18741.29	2403.57	0.09
FISH CREEK	DS	3758	50 yr	27633.00	455.00	469.52		469.55	0.000192	2.11	23365.74	2449.20	0.10
FISH CREEK	DS	3758	100 yr	31431.00	455.00	470.53		470.56	0.000180	2.14	25848.13	2468.35	0.10
FISH CREEK	DS	3758	500 yr	40377.00	455.00	473.00		473.02	0.000149	2.15	31953.79	2486.46	0.09
FISH CREEK	DS	3758	U_100 yr	31724.00	455.00	470.61		470.64	0.000179	2.14	26042.51	2469.13	0.10
FISH CREEK	DS	3288	10 yr	18328.00	454.70	467.35	461.90	467.50	0.001240	4.73	6403.43	2158.66	0.24
FISH CREEK	DS	3288	50 yr	27429.00	454.70	469.17	462.71	469.39	0.001483	5.69	7746.08	2193.37	0.27
FISH CREEK	DS	3288	100 yr	31232.00	454.70	470.18	463.01	470.40	0.001423	5.85	8485.92	2211.02	0.27
FISH CREEK	DS	3288	500 yr	40155.00	454.70	472.64	463.70	472.89	0.001238	6.05	10302.52	2273.10	0.26
FISH CREEK	DS	3288	U_100 yr	31523.00	454.70	470.25	463.04	470.48	0.001417	5.86	8543.81	2212.47	0.27
FISH CREEK	DS	3202	10 yr	18328.00	453.13	467.05	462.68	467.34	0.002224	6.24	4672.41	2123.31	0.33
FISH CREEK	DS	3202	50 yr	27429.00	453.13	468.76	463.71	469.20	0.002710	7.58	5640.52	2191.92	0.37
FISH CREEK	DS	3202	100 yr	31232.00	453.13	469.76	464.08	470.22	0.002575	7.76	6206.16	2221.57	0.37
FISH CREEK	DS	3202	500 yr	40155.00	453.13	472.23	464.95	472.73	0.002190	7.99	7605.25	2301.95	0.35
FISH CREEK	DS	3202	U_100 yr	31523.00	453.13	469.84	464.13	470.30	0.002562	7.77	6250.59	2223.50	0.37
FISH CREEK	DS	3152		Bridge									
FISH CREEK	DS	3093	10 yr	18328.00	458.42	466.16	463.31	466.66	0.006155	7.86	3407.64	2351.59	0.52
FISH CREEK	DS	3093	50 yr	27429.00	458.42	467.71	464.35	468.43	0.006739	9.37	4230.20	2469.09	0.56
FISH CREEK	DS	3093	100 yr	31232.00	458.42	468.29	464.75	469.10	0.006917	9.91	4539.13	2535.21	0.57
FISH CREEK	DS	3093	500 yr	40155.00	458.42	469.54	465.63	470.55	0.007286	11.06	5199.73	2629.46	0.60
FISH CREEK	DS	3093	U_100 yr	31523.00	458.42	468.34	464.78	469.15	0.006928	9.95	4562.40	2536.86	0.57
FISH CREEK	DS	2802	10 yr	18370.00	453.00	464.80	461.78	465.05	0.004645	5.60	4583.71	2526.16	0.34
FISH CREEK	DS	2802	50 yr	27488.00	453.00	466.33	462.54	466.68	0.004657	6.28	5836.75	2565.87	0.35
FISH CREEK	DS	2802	100 yr	31311.00	453.00	466.92	462.82	467.30	0.004654	6.52	6313.01	2579.94	0.36
FISH CREEK	DS	2802	500 yr	40245.00	453.00	468.17	463.46	468.64	0.004664	7.04	7336.19	2610.20	0.36
FISH CREEK	DS	2802	U_100 yr	31607.00	453.00	466.96	462.84	467.35	0.004653	6.54	6349.21	2581.01	0.36
FISH CREEK	DS	1848	10 yr	18370.00	452.00	462.45	458.18	462.47	0.000400	2.13	15425.61	2760.00	0.13
FISH CREEK	DS	1848	50 yr	27488.00	452.00	464.04	458.53	464.08	0.000400	2.41	19870.56	2829.64	0.14
FISH CREEK	DS	1848	100 yr	31311.00	452.00	464.65	458.65	464.69	0.000400	2.51	21598.61	2865.26	0.14
FISH CREEK	DS	1848	500 yr	40245.00	452.00	465.96	458.96	466.00	0.000400	2.72	25385.94	2942.39	0.14
FISH CREEK	DS	1848	U_100 yr	31607.00	452.00	464.70	458.66	464.73	0.000400	2.51	21729.92	2867.95	0.14

Appendix D
Storm Drain Model Output

Appendix E
Geomorphic Stream Assessment

Innovative approaches
Practical results
Outstanding service


Fish Creek

Geomorphic Stream Assessment

Prepared for:

City of Grand Prairie

June21, 2012

Prepared by:

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ESP11227

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EXECUTIVE SUMMARY

Bed	The bed material was highly variable consisting of clay alluvium, weathered limestone, sandstone, shale, sand and gravels. In Fish Creek the D_{50} varied from 9 mm to 28 mm and the D_{90} from 32 mm to 80 mm. Prairie Creek had a D50 that varied from 7 mm to 15 mm and a D90 from 22 mm to 40 mm. Gravel-sized shale particles present in bed material deposits were included in the incipient motion analysis. Field observation suggests that there is a continuous source of shale in locations where the creeks have cut down to shale. It is expected that shale particles will continue to be eroded from the exposed bedrock to replace existing shale particles as they undergo slaking and are eroded.
Bed Stability	For Fish Creek and Prairie Creek, the modeled 1-year peak discharges are capable of mobilizing particle sizes larger than the D_{90} (potential armoring grain size) in the majority of both study reaches. It can be expected that the banks of Fish Creek and Prairie Creek will experience approximately 2 inches of bank loss due to slaking (more loss if there are more wetting and drying cycles).
Banks	The alluvial soils that form the channel banks consist of silty clay, clay, and clay loam soils mapped as the Altoga, Ferris, Frio, Lewisville, Navo and the Wilson.
Bank Stability	Slumps and rotational failures were common in the study area along segments where flood flows became ponded from LWD jams, debris jams, aerial pipelines, etc. and were typically seen on bank slopes less than sixty degrees. Undercut banks, creep, wedge and slab failures, and failure of non-cohesive bank material were common. Generally, bank failures along Fish Creek and Prairie Creek are related to the depth of the bank material in relation to the top of the shale, weathering of the shale, and the height of the shale in the bank. The higher the shale is exposed within the channel bank the more the channel tends to fail by wedge failure, slab failure, and erosive scour. In general, severe erosion was noted on the outside of meanders and where the channel banks were composed of shale and/or over steepened.
Potential Widening	Referring to the incipient motion analysis, the bed material of both creeks is generally mobile, and the channels are actively in a state of downcutting (width/depth ratio greater than 1) and widening.
Potential Degradation	Downcutting was evident in areas where the sediment has been removed (no depositional features, i.e., bars) exposing the shale bedrock. Field observation noted that sediment deposition did not occur in these areas, because channel dimensions are not yet in balance with the available sediment supply and flow regime. The average equilibrium slope for Fish Creek is 0.0010 ft/ft and for Prairie Creek is 0.0011 ft/ft.

EXECUTIVE SUMMARY

Meander Migration	Historical aerial photographs and evidence from the field assessment show that the channels of both creeks have migrated actively over the existing floodplain. Cutoff meanders, some recent, are evidence of past and current channel adjustment and migration. Based on the time series photographs, it was estimated that Fish Creek has meander migration rates between 0.25 and 1.0 feet per year, and Prairie Creek has a meander migration rates between 0.34 and 1.4 feet per year. There are areas along the creeks that contain construction projects (primarily roadway projects) that are at risk and have a potential to be threatened by the widening outer bend of the meanders.
Bank Protection	Bank protection should be considered in areas where the stream assessment has documented severe erosion and threats to infrastructure (Appendix B and D). The design engineer should consider the combined effects of degradation and local scour for foundations of bank protection.

1.0 INTRODUCTION

Fluvial Geomorphology is the study of river related landforms. It investigates how the complex behaviors of streams respond to land use change in a watershed. This dynamic relationship determines the shape of a stream channel. Fluvial Geomorphologists are trained to identify how a stream channel will adjust its physical characteristics in response to land use changes; and consequently, how these adjustments will affect the physical stream system, habitat availability/function, and infrastructure.

On May 24 through June 2, 2011, FNI Hydrologists/Fluvial Geomorphologists performed a geomorphic stream assessment was performed on the channels of Fish Creek and Prairie Creek within the city limits of the City of Grand Prairie. The City of Grand Prairie selected this assessment study area to evaluate and document the location of erosive conditions, channel instability issues, and potential erosion threats to private property and infrastructure adjacent to the creek channel channels. Existing conditions of the creeks were observed and recorded. This report documents the data collected during the field visit, projection of potential future channel changes, and considerations for future channel protection, stabilization, and improvement projects.

1.1 Field Assessment Methodology

The stream assessment entailed a walking/floating survey of the study reaches of Fish Creek and Prairie Creek, making detailed field notes that included a visual summary of channel conditions by reach, and identification of definitive characteristics of channel erosion. For convenience in referencing locations, the reach was divided into segments and numbered the same as the cross sections in the hydrologic and hydraulic model of Fish Creek and Prairie Creek (Espey Consultants, Inc., 2010). Channel geometry was measured with a survey rod and digital range finder at each cross section. All locations were photographed with a GPS-enabled digital camera. Copies of the photos are provided in Attachment 1 of this report. The entire reach was sketched to capture the channel morphology (Appendix A). The bed material was sampled in the field and a Particle-Size Analysis (ASTM D-422) was conducted to quantify the distribution of sediment particle sizes in the streambed material. A Wolman's pebble count was used in the field to quantify the distribution of sediment on bars composed of primarily large gravel and cobble size material (Wolman, 1954). The geology of the reach was noted considering rock type, degree of weathering, and thickness of alluvial soils. Bank stability and degree of erosion were recorded, as were areas where the channel was aggrading from gravel deposition. Bed and bank geomorphic processes were noted using the methodologies developed by Thorne, 1998; Montgomery and Buffington, 1998; Henshaw and Booth, 2000; Rosgen and Silvey, 1995; and Johnson et al., 1999. Stream bank stability and bank erosion characteristics used in this evaluation are shown in Table 1.1. This fluvial geomorphologic study also included a review of the Incised Channel Evolution Model (ICEM) (Schumm, 1977) and the potential for change over time.

Table 1.1 Factors affecting stream bank stability

VARIABLES
- Top width, bottom width, active channel depth and width
- Bed material, bedload size, and depositional features
- Knickpoints and log jams (drops in elevation)
- Gullies and tributaries
- Pools, runs, riffles, and glides
- Channel type (alluvium or rock) and height of soil or rock

STABLE
- Perennial vegetation to waterline
- No raw or undercut banks (some erosion on outside of meander bends OK)
- No recently exposed roots
- No recent tree falls

SLIGHTLY UNSTABLE
- Perennial vegetation to waterline in most places
- Some scalloping of banks
- Minor erosion and/or bank undercutting
- Recently exposed tree roots rare but present
- Minimal scour less than 50 percent of the bank

MODERATELY UNSTABLE
- Perennial vegetation to waterline sparse (mainly scoured or stripped by lateral erosion)
- Bank held by hard points (trees, boulders) and eroded back elsewhere
- Extensive erosion and bank undercutting
- Recently exposed tree roots and fine root hairs common
- Moderate erosion scour from 50 to 75 percent of the bank

SEVERELY UNSTABLE
- No perennial vegetation at waterline
- Banks held by hard points
- Banks are near vertical
- Recently exposed tree roots common
- Tree falls and/or severely undercut banks common
- High erosion greater than 75 percent of the active channel is scoured

(Galli, 1996; modified by Henshaw and Booth, 2000)

2.0 WATERSHED CHARACTERISTICS

The following sections describe the existing conditions of the study area including the climate, topography, soils and geology, and geomorphology. The information was developed from a desktop analysis of available data including topographic maps, aerial photographs, soil survey reports, and geologic maps and reports. Additional information was obtained from the field investigation, when visual observations, photographs and field measurements were collected. Appendix B shows areas of interest along the channels of Fish Creek and Prairie Creek on a 2010 aerial photograph and includes photographs taken during the field investigation.

2.1 Geographic Setting

The geomorphic stream assessment was conducted on the channels of Fish Creek and Prairie Creek within the city limits of the City of Grand Prairie in eastern Tarrant and western Dallas Counties, Texas (Figure 2.1 and Table 2.1).

The watersheds of Fish Creek and Prairie Creek are developed and landuse types include urban, single family residential, and industrial (accounts for approximately 80 percent). Water from Fish Creek and Prairie Creek flows into Mountain Creek Lake which discharges to the West Fork Trinity River. Historically, the watersheds were agricultural from 1890's to 1970's. Residential development began in the 1970's and has continued until present (Figures 2.2 and 2.3). In addition, Segments of each stream flow through riparian corridors and park settings (Appendix A).

2.2 Climate

The study reaches of Fish Creek and Prairie Creek occupy the extreme northern part of the humid subtropical belt which extends inland from the Gulf of Mexico. Average annual temperatures range from 42°F to 84°F. Annual precipitation averages 38 inches. Rainfall in October to March is triggered by southward moving continental polar fronts, which produce low intensity, long duration storms. The most common storms in April to September are thunderstorms which are responsible for most of the serious flooding (100- year peak flows) in small watersheds (1-10 square miles).

2.3 Topography

Elevations in the study area ranged from 610 ft msl to 456 ft msl (Figure 2.4). The average slope of the entire channel of Fish Creek was 0.0027 ft/ft from its headwaters to the confluence with Mountain Creek Lake. The average slope of the Fish Creek study reach was 0.0012 ft/ft. The average slope of the entire channel of Prairie Creek was 0.0046 ft/ft from its headwaters to the confluence with Fish Creek. The average slope of the Prairie Creek study reach was 0.0034 ft/ft.

2.4 Geology and Soils

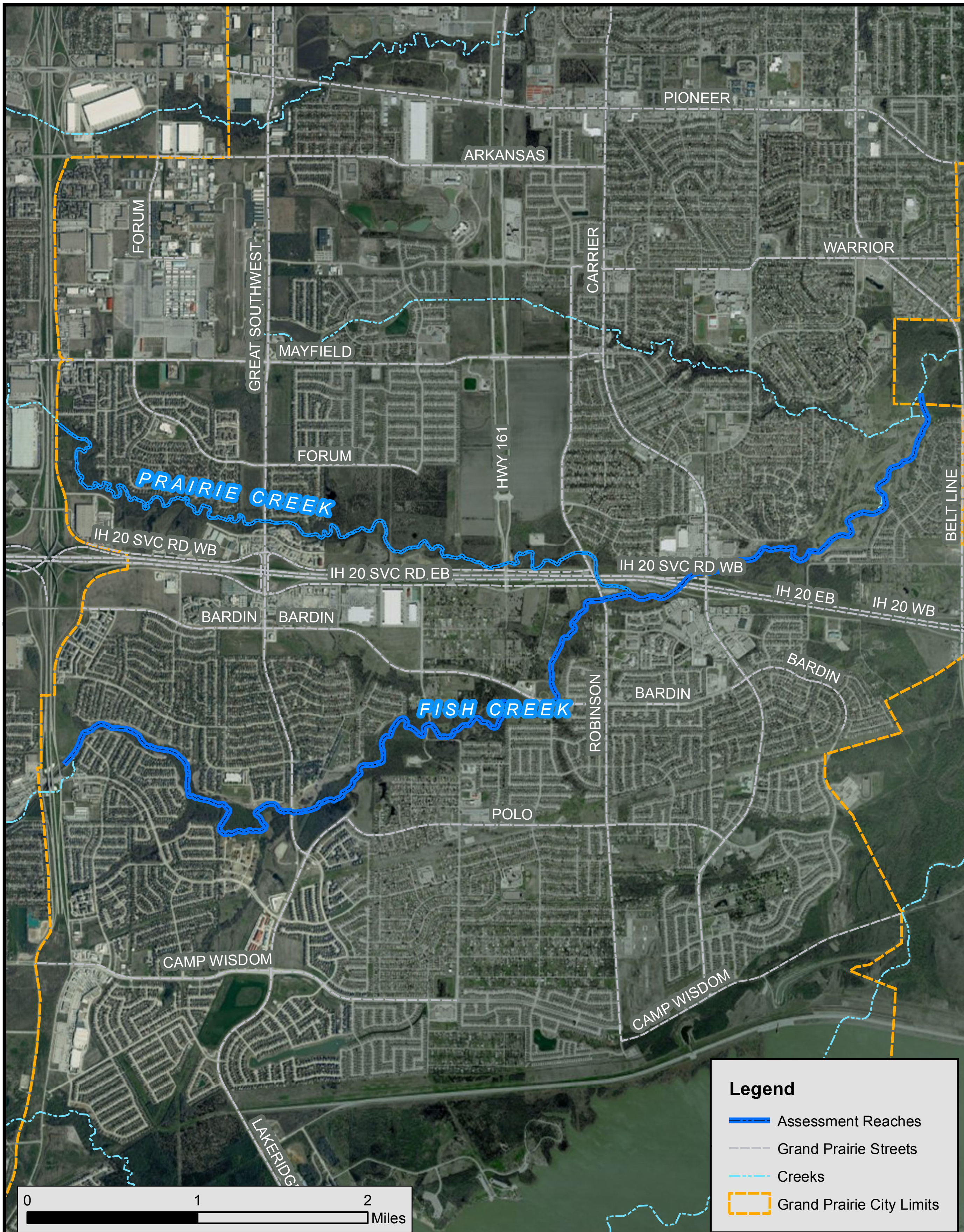
The study area is located in the Blackland Prairie physiographic subprovince of the Gulf Coastal Plain. The Blackland Prairie is underlain by Cretaceous age sandstones (Woodbine Formation), limestones (Austin Chalk Formation) and shales (Eagle Ford Formation), which dip gently to the southeast at 0.54 degrees (Allen and Flannigan, 1985). The Woodbine Formation consists of interbedded sandstone and clay. The sandstone is fine grained, very thinly bedded to massive, with some beds of ironstone (Bureau of Economic Geology, 1988). Massive sandstone boulders originating from the Woodbine Formation have formed small rapids and hardpoints in the upstream portion of the study reach. The majority of both study reaches were underlain by the Eagle Ford Formation (Figure 2.5). The Eagle Ford is a shale formation that consists largely of fissile, dark gray calcareous to noncalcareous clay with thin limestone beds and ashy bentonite seams in the lower unit (Bureau of Economic Geology, 1988). The Quaternary

Alluvium in the study area is composed of undivided floodplain deposits including indistinct low terrace deposits, gravel, sand, silt, silty clay, clay and organic matter (Bureau of Economic Geology, 1988).

The alluvial soils that form the channel banks consist of silty clay, clay, and clay loam soils mapped as the Altoga, Ferris, Frio, Lewisville, Navo and the Wilson by the Natural Resources Conservation Service (NRCS) (Figure 2.6). The Altoga, Navo and Wilson soils are classified as clay (CL) soils with low plasticity (liquid limit less than 50 percent). The Ferris soils are classified as fat clay (CH) soils with high plasticity (liquid limit greater than 50). The Frio and Lewisville soils are classified as CL to CH soils with low to high plasticity. The plasticity index is defined as the range of water content where the soil is plastic. A soil with a low plasticity index means that it goes from a brittle solid to a plastic solid and then to a viscous liquid rather quickly. When the CL soils become saturated, the ability of the soil to remain cohesive or to resist shear forces resulting from surface runoff becomes very low. The study area is, therefore, more susceptible to erosion where the Altoga, Navo, and Wilson soils are located.

2.5 Stream Morphology

The study reaches of Fish Creek and Prairie Creek are part of a dynamic fluvial system. Historical aerial photographs and evidence from the field assessment show that the channels of both creeks have migrated actively over the existing floodplain. Cutoff meanders, some recent (Appendix C, Figure 2.2 and 2.3), are evidence of past and current channel adjustment and migration. Both creeks contain multiple geomorphic units including scour pools, pools, runs, riffles, bars, undercut banks, knickpoints, neck cutoffs, benches (formed of slumped material), ledges, large woody debris (LWD), log jams, and bedrock rapids (Figure 2.7). It was observed in the field that the majority of both channels experience floodplain connectivity during the 2-year peak discharge, or greater, which allows flows to spread out and dissipate during flood events. However, there are segments of both creeks that are entrenched and only connected to the floodplain during flows greater than the 2-year peak discharge. Cutoff meanders are activated during high flows and transport water and sediment downstream. Both Fish Creek and Prairie Creek are characterized as meandering creeks, with channel sinuosity ratios (ratio of stream length to valley length) of 1.47 and 1.28, respectively. There are areas along both Fish Creek and Prairie Creek that have been altered for protection/stabilization purposes (Appendix B).



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Fish Creek Geomorphic Stream Assessment

Location Map

FN JOB NO	ESP11227
FILE	2.1_location.mxd
DATE	March 13 2012
SCALE	1:50,000
DESIGNED	SVC
DRAFTED	SVC

FIGURE 2.1

Table 2.1. Study reach characteristics

Creek	Drainage area (sq.mi.)	Reach length (mi.)	Upstream end of reach	Downstream end of reach	Comment
Fish Creek	23.6 (16 above Fish Creek and Prairie Creek Confluence)	6.7	Began at the State Highway 360 bridge crossing	Confluence of Fish Creek and Kirby Creek	Channel stability was not assessed between cross-sections 32167 - 31603 and 37236 - 26695 because the channel was hard armored and cross sections 14575 - 5968 were affected by backwater
Prairie Creek	6.3	4.6	Began at State Highway 360 bridge crossing	Confluence with Fish Creek and Prairie Creek	Channel was not assessed between cross-sections 13687 - 13486 because the channel flowed through a box culvert

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Figure 2.2 Historical aerial photographs of a segment of Fish Creek

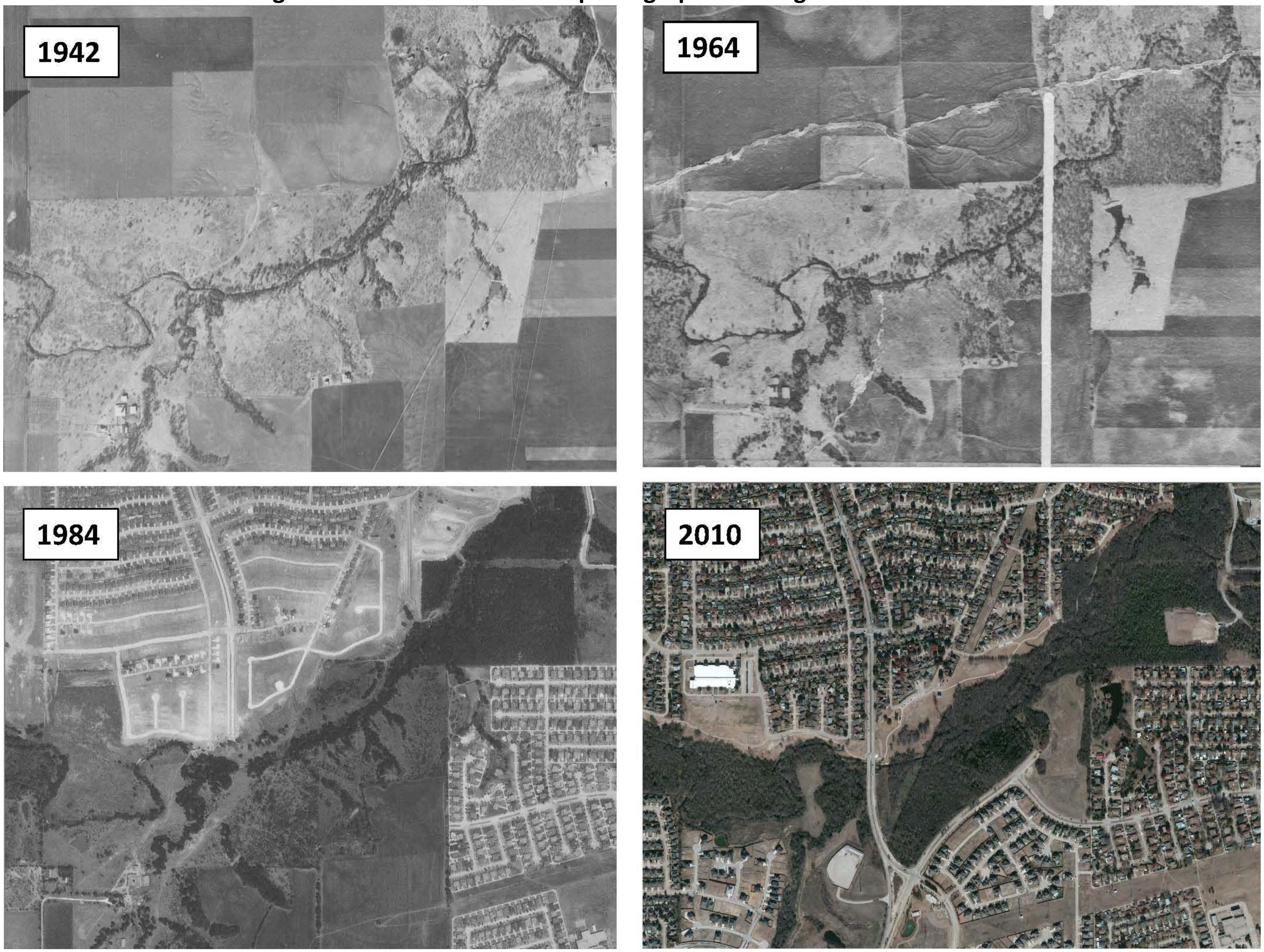
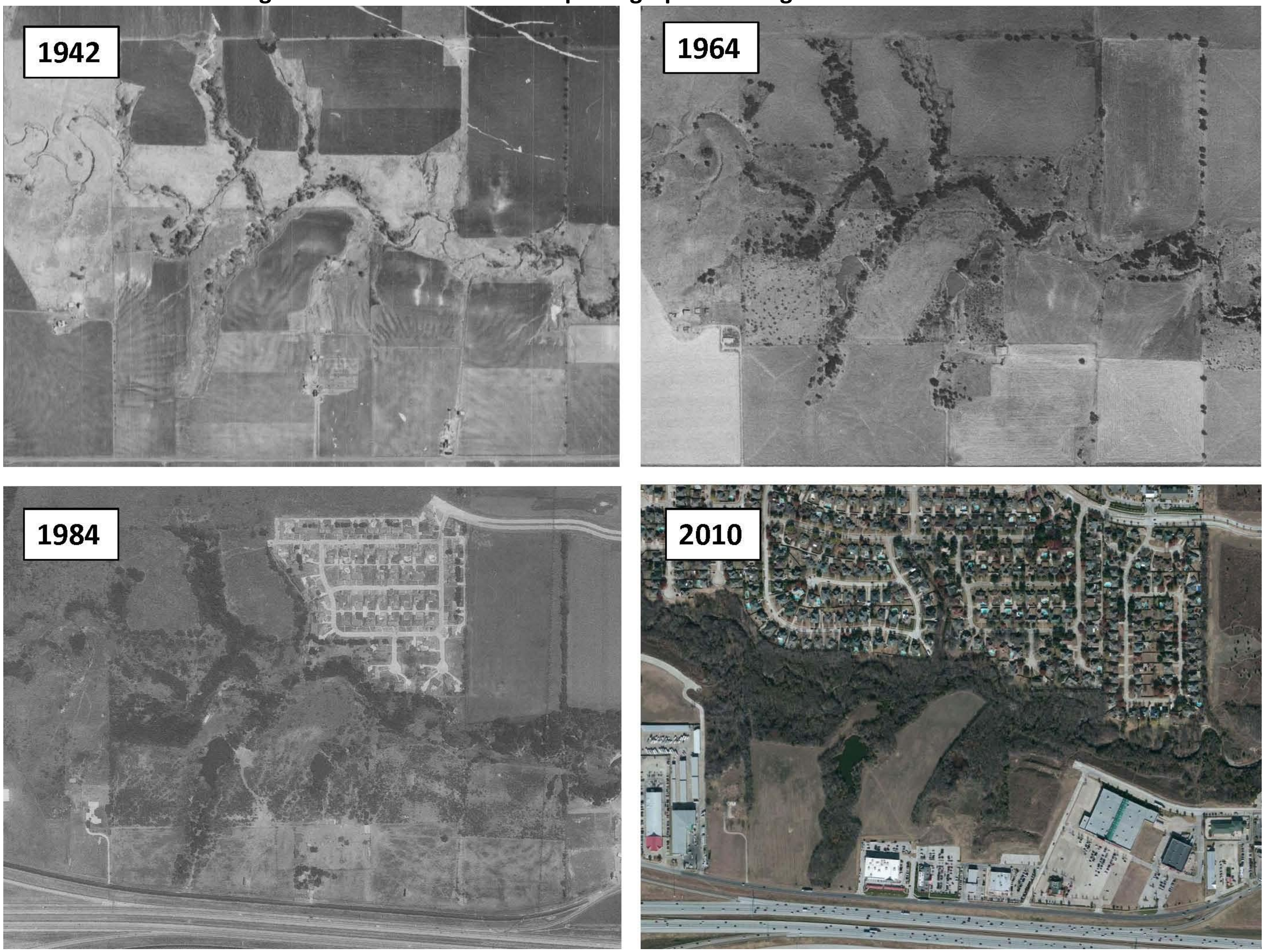
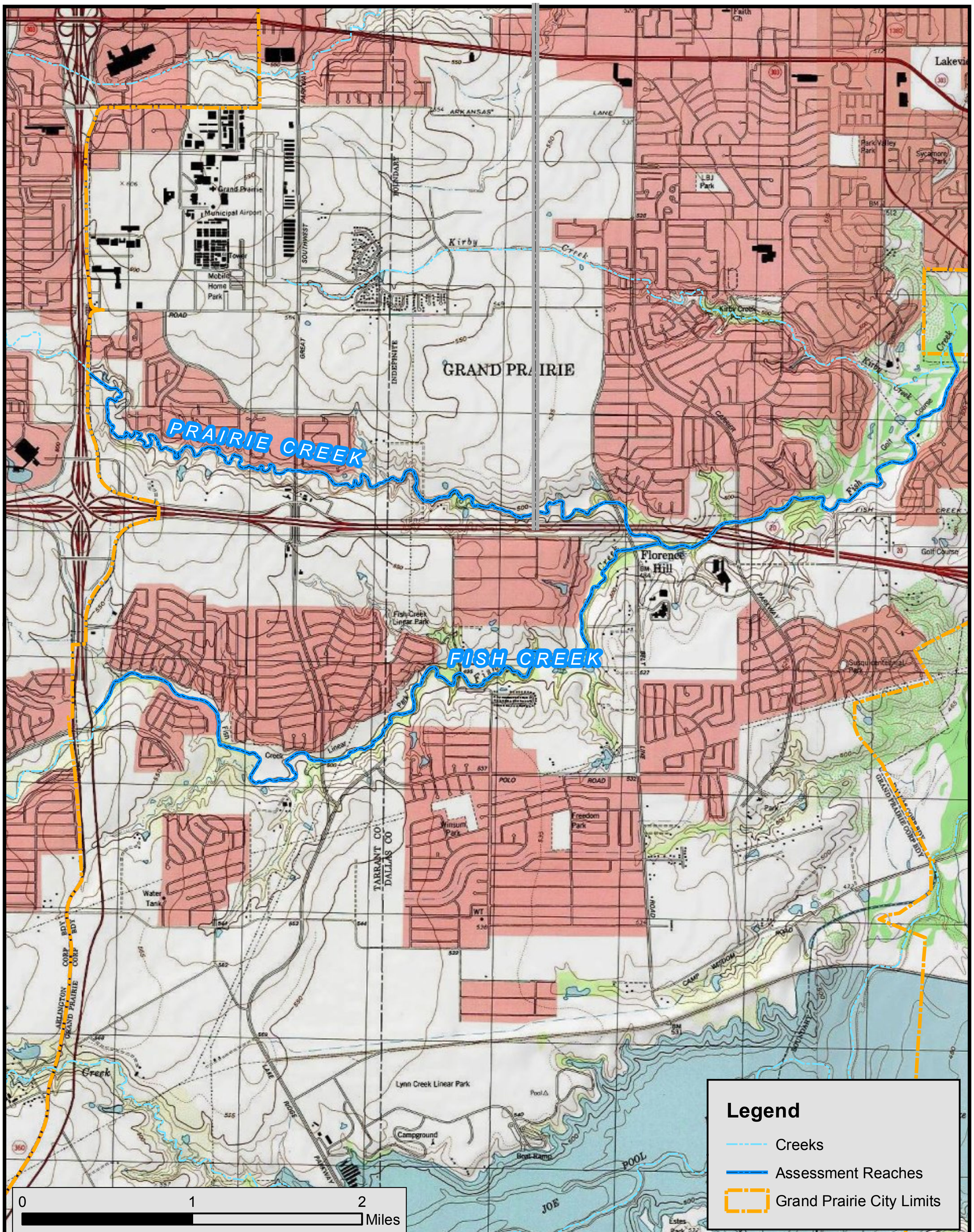


Figure 2.3 Historical aerial photographs of a segment of Prairie Creek





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Fish Creek
Geomorphic Stream Assessment

Topography

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2.4
FIGURE

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Fish Creek
Geomorphic Stream Assessment

Geology

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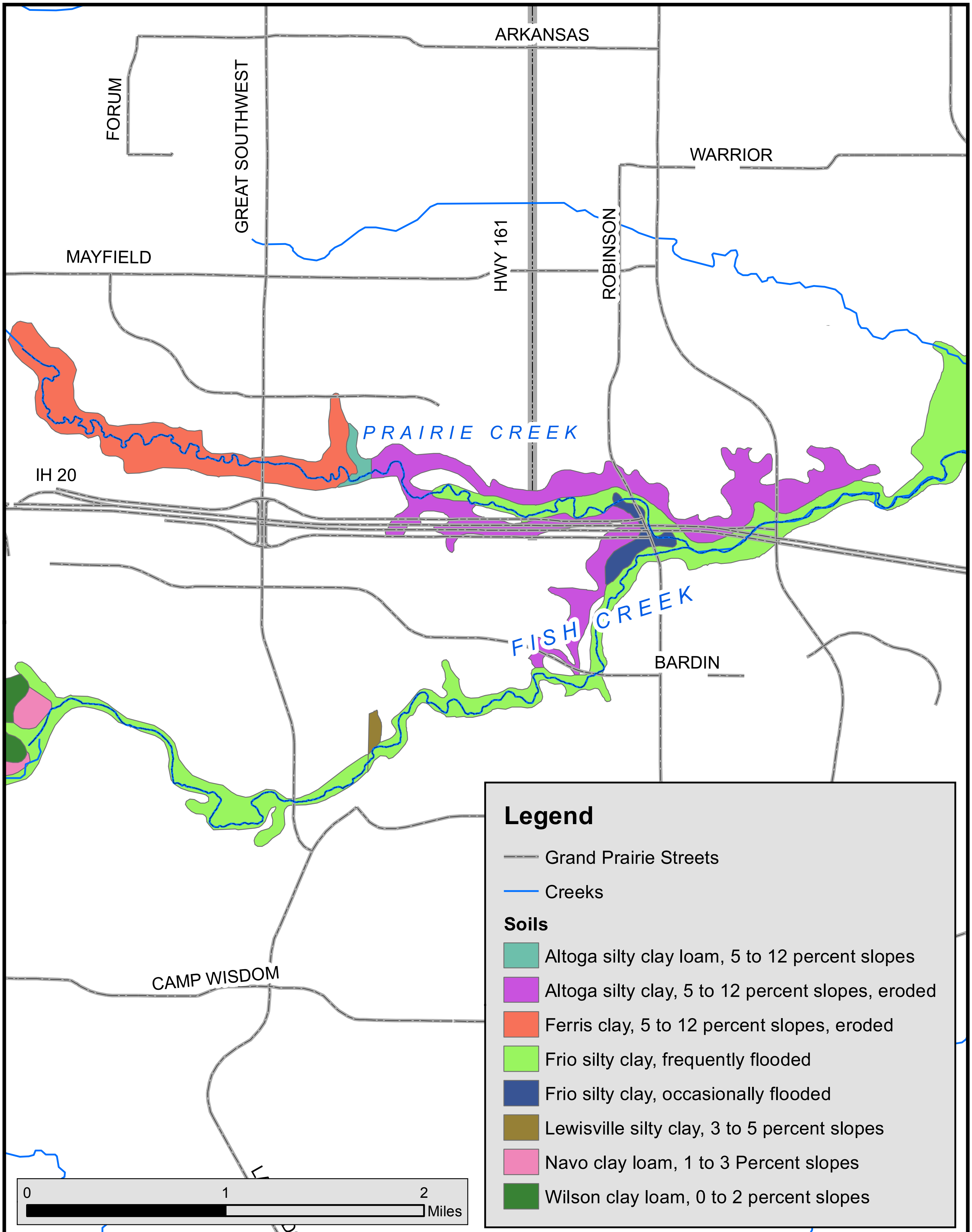
FIGURE



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Fish Creek
Geomorphic Stream Assessment

Soils

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2.6
FIGURE

Figure 2.7 Channel geomorphic examples in Fish Creek and Prairie Creek

Bedrock boulders

Riffles formed by riprap

Undercut banks

Large woody debris

LWD jam

Undercut bank with tree fall

3.0 RESULTS

3.1 Channel Forming Discharge

Research has shown that in many streams and rivers a single discharge can be used to estimate stable channel geometry (Copeland et al, 2000). This single representative discharge is known as the channel forming or effective discharge. The channel forming discharge has been defined as the flow that (1) determines particular channel parameters, such as cross-sectional capacity (Wolman and Leopold, 1957) and (2) performs most of the work, where work is defined in terms of sediment transport (Wolman and Miller, 1960). Theoretically, it is the discharge that if maintained indefinitely would produce the same channel geometry as the natural long-term hydrograph in an undisturbed watershed. The channel-forming discharge is a function of both the magnitude of the event and its frequency of occurrence (Wolman and Miller, 1960). Leopold and Wolman (1957) suggest that the channel forming discharge has an approximate return period between one and two years. In stable perennial alluvial channels, the channel-forming discharge typically reflects the 2-year frequency peak discharge (Thomas et al., 1996; NRCS, 2007). Allen et al. (2002) suggest that the channel forming discharge in urbanized watersheds of the Dallas-Fort Worth area corresponds to a recurrence interval less than the 1.25-year frequency flow.

The active channel discharges for Fish Creek and Prairie Creek were estimated based on field measurements of the active channel dimensions and the use of Manning's Equation. The active channel is commonly described as the channel dimensions that contain the 0.5-year to 2-year frequency discharge.

In summary (by creek):

Fish Creek

- Active channel discharge is approximately 250 cfs (upstream) to 750 cfs (downstream)
- Modeled existing 1-year peak discharge from 2,518 cfs (upstream) to 6,146 cfs (downstream)

Prairie Creek

- Active channel discharge is approximately 200 cfs (upstream) to 600 cfs (downstream)
- Modeled existing 1-year peak discharge from 2,099 cfs (upstream) to 2,441 cfs (downstream)

The watersheds of Fish Creek and Prairie Creek are near full build-out. The hydrologic and hydraulic model (Espey Consultants, Inc., 2010) results produced future 100-year discharges under full build-out conditions that are approximately 1.7 to 2.3 percent higher in Fish Creek and approximately 2.1 to 4.5 percent higher in Prairie Creek than existing modeled 100-year flood conditions. Future flow increases may cause channel instabilities and should be considered during any channel improvement projects.

The modeled 1-year flood discharge and associated hydrologic and hydraulic characteristics for Fish Creek and Prairie Creek (Espey Consultants, Inc., 2010) were used in this assessment to evaluate sediment transport, equilibrium slope, and channel erosion potential. A more detailed hydrologic and hydraulic analysis should be considered as a part of any future channel stabilization, restoration, or protection project.

3.2 Bed and Bank Material Erosion and Armoring Potential

3.2.1 Bed Material Evaluation and Movement Analysis

The distribution of sediment particle grain sizes of the streambed material of Fish Creek and Prairie Creek was quantified by conducting particle size analyses (ASTM D-422) and a Wolman's Pebble Count (Wolman, 1954). Samples were collected in locations where changes in bed material composition were observed. Table 3.1 contains the results of the bed material analyses. Grain size distribution curves are shown in Appendix C.

Table 3.1 Results of bed material grain size analysis for Fish Creek and Prairie Creek

	Station	D_{50} (mm)	D_{90} (mm)
Fish Creek	40008	28	80
Fish Creek	37902	12	36
Fish Creek	28546	9	32
Prairie Creek	21069	15	40
Prairie Creek	8218	7	22

An incipient motion analysis was performed to evaluate the probability of bed material movement and potential for natural bed material armoring. This type of analysis utilizes bed material transport equations with the variables of grain size (D_{50} and D_{90}), depth, channel slope, flow velocity, and discharge. The depth and velocity variables were obtained from the modeled 1-year and ultimate (future conditions) 100-year peak discharges (Espey Consultants, Inc., 2010). The remaining variable, channel slope, was obtained from hydrologic and hydraulic model cross sections (Espey Consultants, Inc., 2010). Four equations (Meyer-Peter Muller, Competent Bottom Velocity, Shields and Yang's Incipient Motion) were used to assess bed material movement as recommended by Pemberton and Lara (1984). The results from the equations were averaged to produce the incipient motion of the bed material for each assessment site. The equations used are for sand and gravel bed streams. Gravel-sized shale particles present in bed material deposits were included in the incipient motion analysis. Field observation suggests that there is a continuous source of shale in locations where the creeks have cut down to shale. It is expected that shale particles will continue to be eroded from the exposed bedrock to replace existing shale particles as they undergo slaking and are eroded.

The results of the incipient motion analysis for Fish Creek show that both the modeled 1-year and the future 100-year peak discharges are capable of mobilizing particle sizes larger than the D_{90} in the majority of the study reach (Figure 3.1). The D_{90} is typically assumed to be the potential non-mobile grain size in alluvial channels. If enough grains of this size are allowed to build up over time, they will armor smaller underlying particle on the stream bed from future erosion. Sites that plot above the red line in Figure 3.1 have no potential for natural armoring under the modeled future 100-year and 1-year flow events. The narrow channel and steep slope at station 11,651 generates higher flow velocities that are capable of transporting larger grain sizes than at any other location in the creek. A grain size of approximately 311 mm (~12 inches) would be necessary to armor the creek bed at this location during the 1-year peak discharge.

The incipient motion analysis for Prairie Creek produced similar results in that both the 1-year and the future 100-year flows are capable of mobilizing particle sizes larger than the D_{90} (Figure 3.2).

Figure 3.1 Incipient motion analysis results for Fish Creek study reach

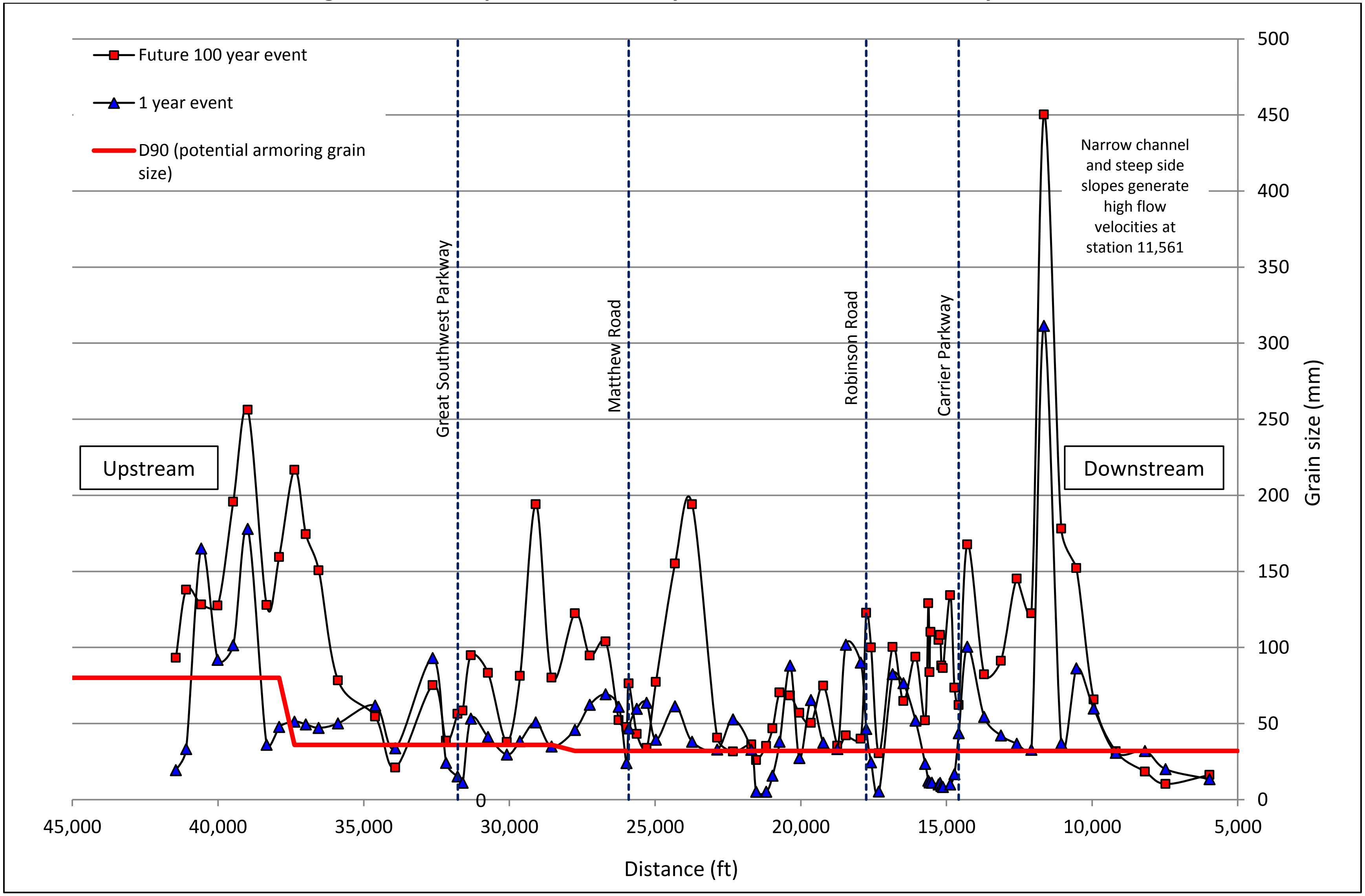
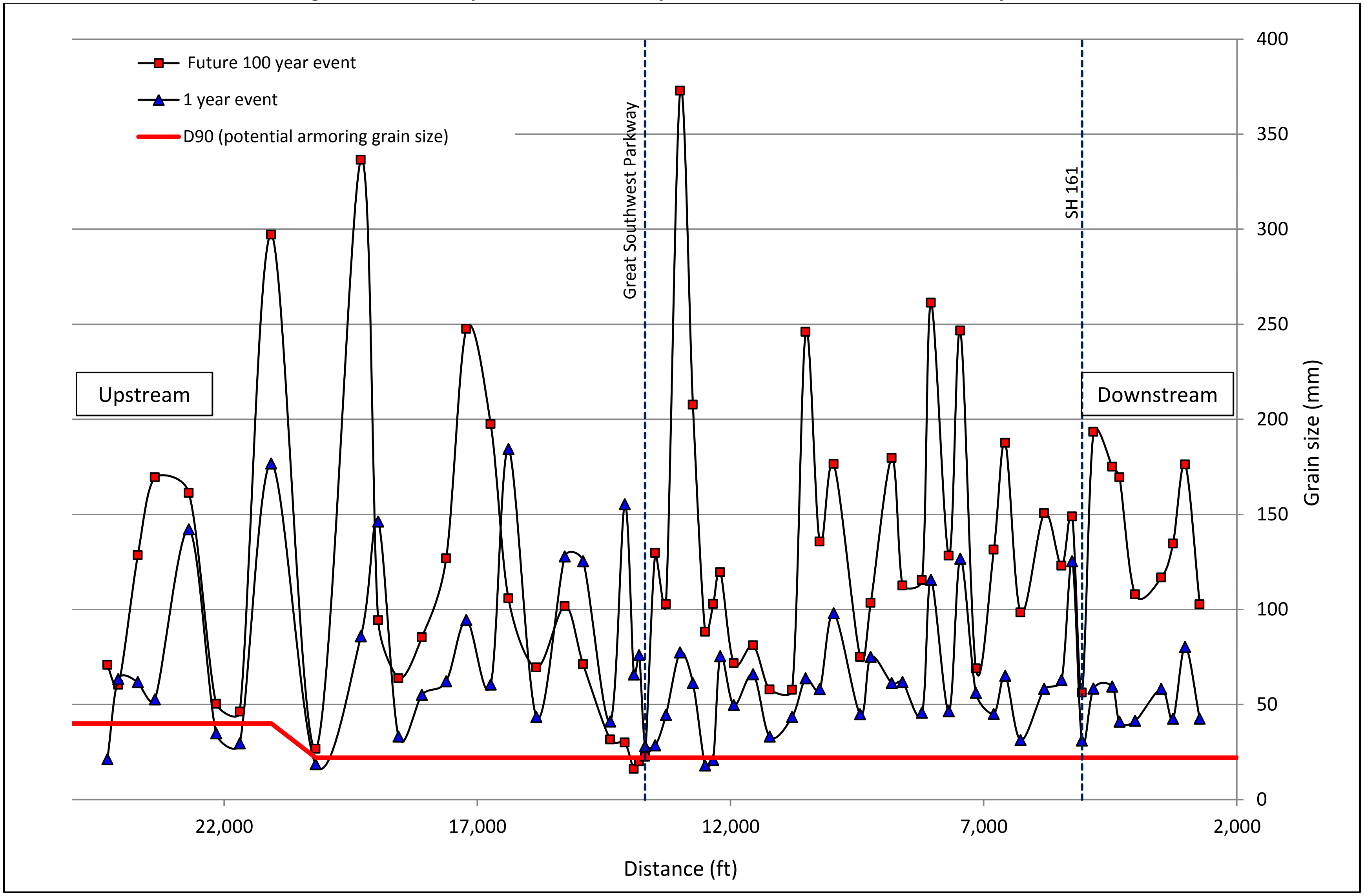


Figure 3.2 Incipient motion analysis results for Prairie Creek study reach



3.2.2 Critical Shear Stress of Channel Bed and Bank Material

Channel stability in the study reach was evaluated by investigating the shear stresses of stream flow in the channel and the critical shear stress of the channel boundary material. Erosion of stream channel bed and bank material occurs when the hydraulic forces exerted by the water flowing in the channel exceed the resisting forces of the materials. The hydraulic force of the water is called the applied shear stress. In other words, it is the force applied to the channel bed and banks. The resisting force of the channel boundary material is called the critical shear stress. The critical shear stress is the maximum shear stress that the channel bed or bank material can resist before it starts to erode. The critical shear stress is a property of the channel bed or bank material and is influenced by a number of factors including cohesion (the bonds between individual particles) and vegetative cover. The critical shear stress of a material generally increases with increasing cohesion and vegetation cover (Fischenich, 2011). Erosion will occur along a channel bed or bank when the applied shear stress is greater than the critical shear stress.

Another procedure to determine erosion potential uses critical velocities. Similar to shear stresses, when the critical velocity of a channel bed or bank material is exceeded by the velocity of the flowing water, the material will erode. The critical velocity procedure is somewhat simplified when compared to the critical shear stress method. At the same mean flow velocity, channels of different shapes and depths have different forces acting on the bed and banks. Fischenich (2001) suggests that a correction factor for depth be applied when using the critical velocity method, and states that this method is most frequently used as a cursory analysis when screening stream protection alternatives.

The USACE (Fischenich, 2001) provides permissible shear stress and permissible velocity values for different types of channel bed and bank materials. The banks of Cottonwood Branch in the study area alternate between clay and shale, and the bed is typically comprised of shale with alluvial deposits present in some areas.

The USACE (Fischenich, 2001) provides permissible (critical) shear stress and permissible velocity values for different types of channel bed and bank materials. The banks of Fish Creek and Prairie Creek in the study area alternate between clay and shale. The bed material is primarily gravel in Fish Creek and primarily shale in Prairie Creek with sand and gravel deposits present in some areas.

The permissible shear stress and permissible velocity values of the bed and bank materials in the study reaches of Fish Creek and Prairie Creeks are (Fischenich, 2001):

- Clay shear stress – 0.26 pounds per square foot
- Shale shear stress– 0.67 pounds per square foot
- Gravel shear stress – 0.03 to 0.54 pounds per square foot (depending on size)

- Clay velocity – 3.0 to 4.5 feet per second
- Shale velocity – 6.0 feet per second
- Gravel velocity – 0.12 to 0.52 feet per second (depending on size)

These representative values mentioned above were determined using flume experiments under controlled flow conditions (Fischenich, 2001) on materials that had not been weakened by weathering processes such as slaking. Shear stress thresholds for weathered channel bed and banks materials should be expected to be lower than those of un-weathered material, meaning the weathered materials will erode more easily than the un-weathered materials.

The shear stress plots in Figures 3.3 and 3.4 show the hydraulic shear stresses in the channels of Fish Creek and Prairie Creek in relation to the critical shear stresses of the channel bed and bank material. The critical shear stress of the most prevalent D_{90} (potential armoring grain size) in each channel was plotted to illustrate the potential for natural armoring of the stream bed by existing gravels. Erosion and scour of bed and bank material can be expected at locations where the points lie above the critical shear stress lines shown on the plots. Both plots show that the shear stresses exerted by the flowing water in the creek channels are generally higher than the critical shear stresses of the bed and bank materials.

Nearly all of the modeled applied shear stresses exceed the critical shear stress value for clay, suggesting that the channel banks comprised of clay will be susceptible to erosion at all flows greater than the modeled 1-year peak discharge. The critical shear stress of the un-weathered shale channel material is also exceeded at some of the study sites for both the modeled 1-year peak discharge and the modeled future 100-year peak discharge, suggesting that erosion can be expected to continue at those sites under the future flow regime.

The hydrologic and hydraulic mode for the study reaches produced the following mean flow velocities for the 1-year peak discharge and the modeled future 100-year peak discharge for Fish Creek and Prairie Creek:

- Fish Creek
  - Mean velocities from 1.67 to 11.98 feet per second (1-year peak discharge)
  - Mean velocities from 2.65 to 15.72 feet per second (future 100-year peak discharge)

- Prairie Creek
  - Mean velocities from 3.06 to 10.35 feet per second (1-year peak discharge)
  - Mean velocities from 3.47 to 16.43 feet per second (future 100-year peak discharge)

The results of the critical velocity analysis show that flow velocities of the modeled 1-year peak discharge and the future 100-year peak discharge exceed the threshold velocity values of the channel boundary material in Fish Creek and Prairie Creek. All of the modeled flow velocities exceed the critical velocity values for clay and gravel, suggesting that the sections of the creeks that contain these materials are susceptible to erosion under the current flow regime. The results suggest that the sections of creek channel composed of shale are susceptible to erosion in some locations.

This discussion of applied and critical shear stresses and critical velocities applies only to bed and bank material removed by flowing water erosion and does not consider material loss due to slaking (which weakens the shale and makes it more susceptible to erosion) or bank failures. These results and the implications mentioned above should be considered when designing any erosion control and/or stream protection structures.

Figure 3.3 Fish Creek hydraulic shear stress and critical shear stress of bed and bank material

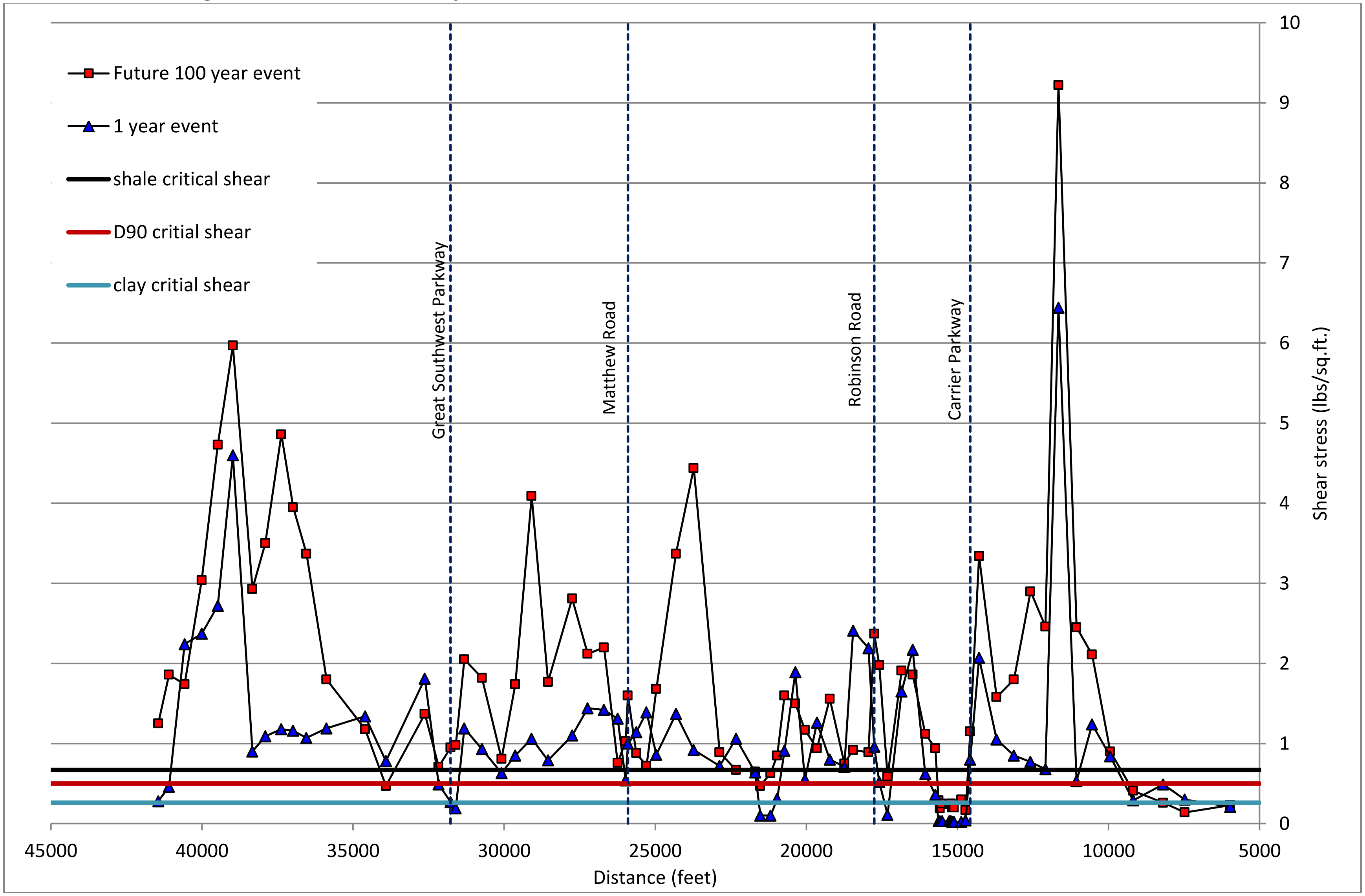
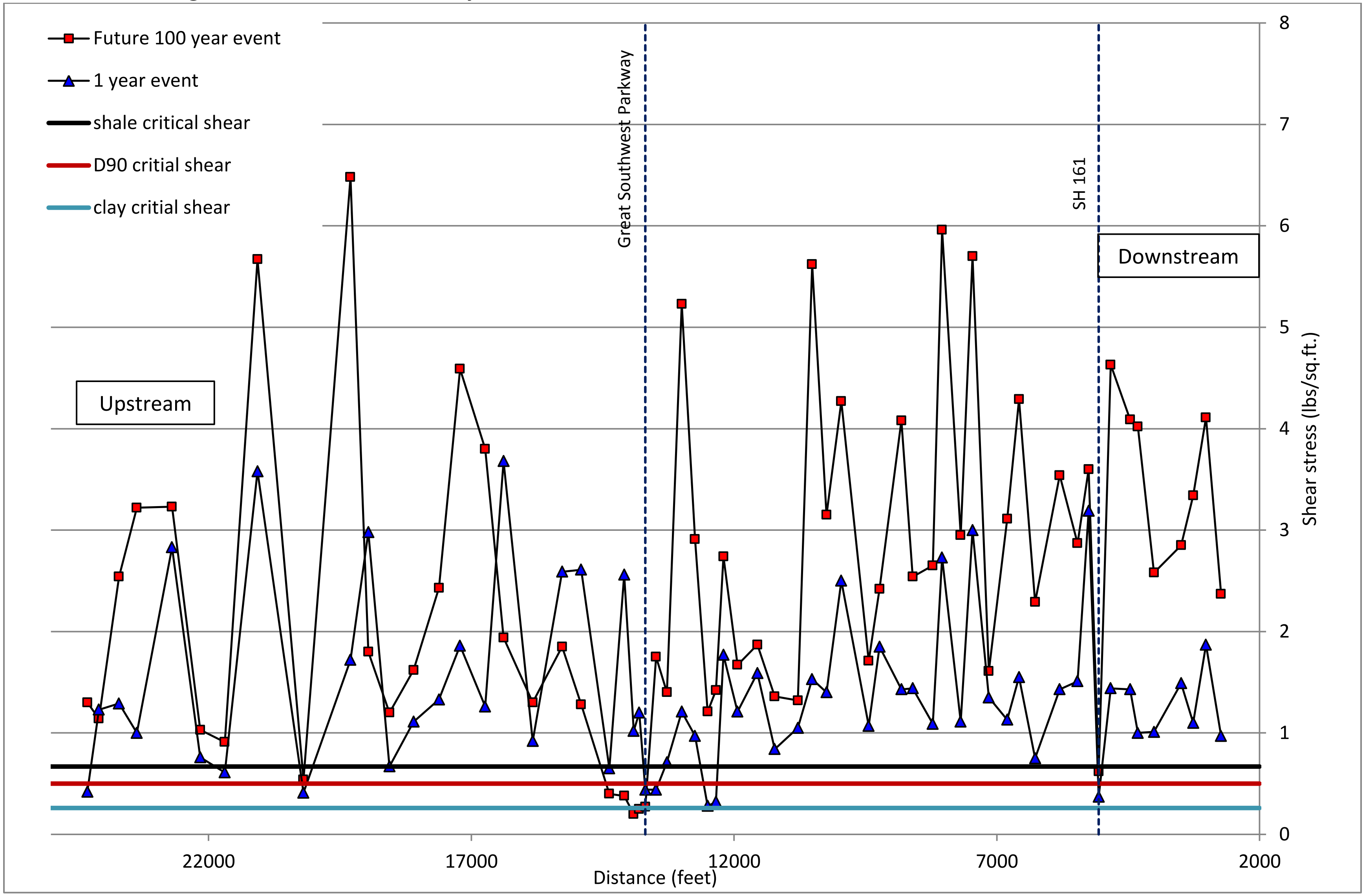


Figure 3.4 Prairie Creek hydraulic shear stress and critical shear stress of bed and bank material



3.2.3 Shale Erosion by Slaking

In areas where Fish Creek and Prairie Creek have downcut into the underlying Eagle Ford Shale, widening of the channel is accomplished through scour of the alluvial material and weathering (slaking) and removal of the exposed shale material. The slake zone is the area of exposed rock that extends from the base flow water surface elevation to the soil/shale interface. Field observations during this assessment noted that the slake zone extended up to approximately 10 feet on the cutbanks of some meanders in Fish Creek and Prairie Creek.

Lower portions of the bank are subject to higher shear stress and numerous wet/dry cycles (Lawler, 1992; Thorne, 1982; Throne, 1998; Allen et al, 2002), therefore the shale in this zone is subject to repeated cycles of slaking and subsequent removal by flooding (Allen et al, 2002). The geotechnical properties of the Eagle Ford Shale are measured at 350 psi (unconfined compressive strength), 117 pcf (unit dry weight), and laboratory slake second-cycle (represents percent of loss from second wet and dry cycle) of 21 (Allen et al, 2002).

Methods described in Allen et al. (2002) were used to estimate the annual slake loss on creek beds and banks composed of Eagle Ford Shale based on the geotechnical properties of the Eagle Ford Shale (listed above) and drainage area. The results of the analysis are presented in Table 3.2.

Table 3.2 Results of shale slaking analysis

Reach	Drainage area (sq. mi.)	Number of Floods above 150 cfs	Annual slake loss (inches)
Fish Ck. above Prairie Ck. confluence	16	6	2.16
Fish Creek	24	9	2.24
Prairie Creek	6	2	1.80

These estimated annual losses should be considered when designing any erosion control and/or stream bank protection structures. It can be expected that Fish Creek and Prairie Creek will experience approximately 2 inches of loss due to slaking the number of listed in Table 3.2 occurred during that year (more loss if there are more wetting and drying cycles).

3.3 Vertical Stability

3.3.1 Equilibrium Slope

Channel equilibrium (stable slope) occurs when sediment discharge, sediment particle size, stream flow, and stream slope, are in balance (Lane, 1955). A regional regression equation for streams in the Blackland Prairie of North Central Texas was produced by FNI using channel slopes and USGS stream gage data. The regional regression equation and three equilibrium slope equations, Meyer-Peter-Mueller, Lane's, and Schoklitsch (Pemberton and Lara, 1984) were used to estimate stable channel slopes for the study reaches of Fish Creek and Prairie Creek.

The equilibrium or design slope, derived from the slope equations, will typically by lower than the existing channel slope because channels in urban areas are still in a mode of adjusting the slope as a result of increased flow. Also because of the confined nature of many urban streams (transportation crossings, houses, commercial structures, alleys), there is typically little room to decrease the channel slope by increasing channel length through meander enlargement. Therefore, many urban channels may require the addition of drop structures in order achieve equilibrium channel slopes. Placement of the structures depends on the amount of predicted degradation, the expected time rate of degradation, channel sinuosity, and local structural constraints such as utility crossings, storm sewers, and bridge and culvert locations and configurations. If spaced close enough and if protected from local scour and undercutting, drop structures can halt headward migrating knickpoints.

Tables 3.3 and 3.4 contain the results of the equilibrium slope analysis of Fish Creek and Prairie Creek. The equilibrium slopes were calculated using the modeled 1-year discharge and minimum channel elevations (Espey Consultants, Inc., 2010). Each study reach was divided into segments between hard points that are expected to halt the headward migration of knickpoints. The hard points were observed in the field and their locations are noted in Appendix B. The amount of downcutting expected between the hard points was calculated by comparing the existing slope with the calculated equilibrium slope over the segment length. The number of three-foot drops (maximum allowable drop height) required to stabilize the existing slope of the channel are presented in Table 3.3 and 3.4. The number of three-foot drops was provided as an example. The actual height of the drop should be selected by the design engineer, as appropriate.

Table 3.3 Results of Fish Creek equilibrium slope analysis

Segment (cross section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
40575 – 38979	0.0010	0.0075	10.4	3.5
38979 – 32167	0.0010	0.0020	6.5	2.2
32167 – 31603*	0.0010	0.0146	armored	0
31603 – 27236	0.0010	0.0009	stable	0
27236 – 26695**	0.0010	0.0029	armored	0
26695 – 25904	0.0010	0.0060	4.0	1.3
25904 – 20362***	0.0010	0.0006	LWD jam	0
20362 – 19644	0.0010	0.0084	5.3	1.8
19644 – 17941	0.0010	0.0012	0.3	0.1
17941 – 15727	0.0010	0.0015	1.1	0.4
15727 – 14575	0.0010	0.0023	1.5	0.5
14575 - 5968	0.0010	0.0005	backwater	0

*Engineered concrete channel at Great Southwest Parkway is not expected to downcut.
**Existing concrete and riprap grade control, hard armored and not expected to downcut.
***There were log jams in this reach that were acting as temporary, natural grade control. Results show the potential amount of downcutting if the log jams were to become dislodged.

Table 3.4 Results of Prairie Creek equilibrium slope analysis

Segment (cross section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
24306 – 21693	0.0011	0.0025	2.7	0.9
21693 – 18097	0.0011	0.0033	8.4	2.8
18097 – 15272	0.0011	0.0039	8.2	2.7
15272 – 13910	0.0011	0.0037	3.6	1.2
13910 – 13687	0.0011	0.0136	2.8	0.9
13687 – 13486*	0.0011	0.0031	armored	0
13486 – 12343	0.0011	0.0021	1.2	0.4
12343 – 11554	0.0011	0.0038	2.2	0.7
11554 – 10784	0.0011	0.0039	2.2	0.7
10784 – 9960	0.0011	-0.0004	deposition	0
9960 – 8815	0.0011	0.0057	5.4	1.8
8815 – 8043	0.0011	0.0023	1.0	0.3
8043 – 6800	0.0011	0.0040	3.8	1.3
6800 – 4462	0.0011	0.0030	4.7	1.6
4462 - 2757	0.0011	0.0023	2.4	0.8

*Box culvert under Great Southwest Parkway

There were a number of LWD jams and aerial pipeline crossings present in both Fish Creek and Prairie Creek that were affecting the channel slopes (Figure 3.5; Appendix B). LWD jams occurred when channel widening caused tree falls, and the trees became lodged in and across the channel. LWD jams and aerial pipelines typically caused local scour to the stream bed and banks downstream and backwater (ponding). More debris and sediment had been trapped at some locations creating either a dam that raised the water surface elevations upstream and/or formed a significant drop (scour hole) in channel bed and water surface elevation. Results show the potential amount of downcutting if the LWD jams were to become dislodged.

Figure 3.5 Photos of LWD jam and an aerial pipeline crossing

There were segments in both creeks that contained LWD jams that were acting as natural drop structures at the time of the field investigations (Appendix B). The natural LWD jams have begun to stabilize the channels upstream by lowering the channel slope. It should be noted that these natural LWD jams are not permanent geomorphic features. If they are removed during a flood event or by human activity, it is likely that the channel will experience a period of severe instability upstream of the removed jam. Placing a hard point upstream of the existing LWD jams may protect the channel and infrastructure upstream of the hard point in the event that the natural grade control is removed.

3.3.2 Channel Evolution

There is an important balance between the supply of bedload at the upstream end of a channel reach and the stream power available to transport it. This is known as the Lane's Balance. Based on extensive field observations, E.W. Lane formulated a qualitative expression for stream equilibrium (Lane, 1955):

$$Q_w S \propto Q_s D_{50}$$

where Q_w is the water discharge (ft^3/s), S is the channel slope (ft/ft), Q_s is the bed material discharge (tons/day), and D_{50} is the average particle size (50 percent) of the bed material (inches).

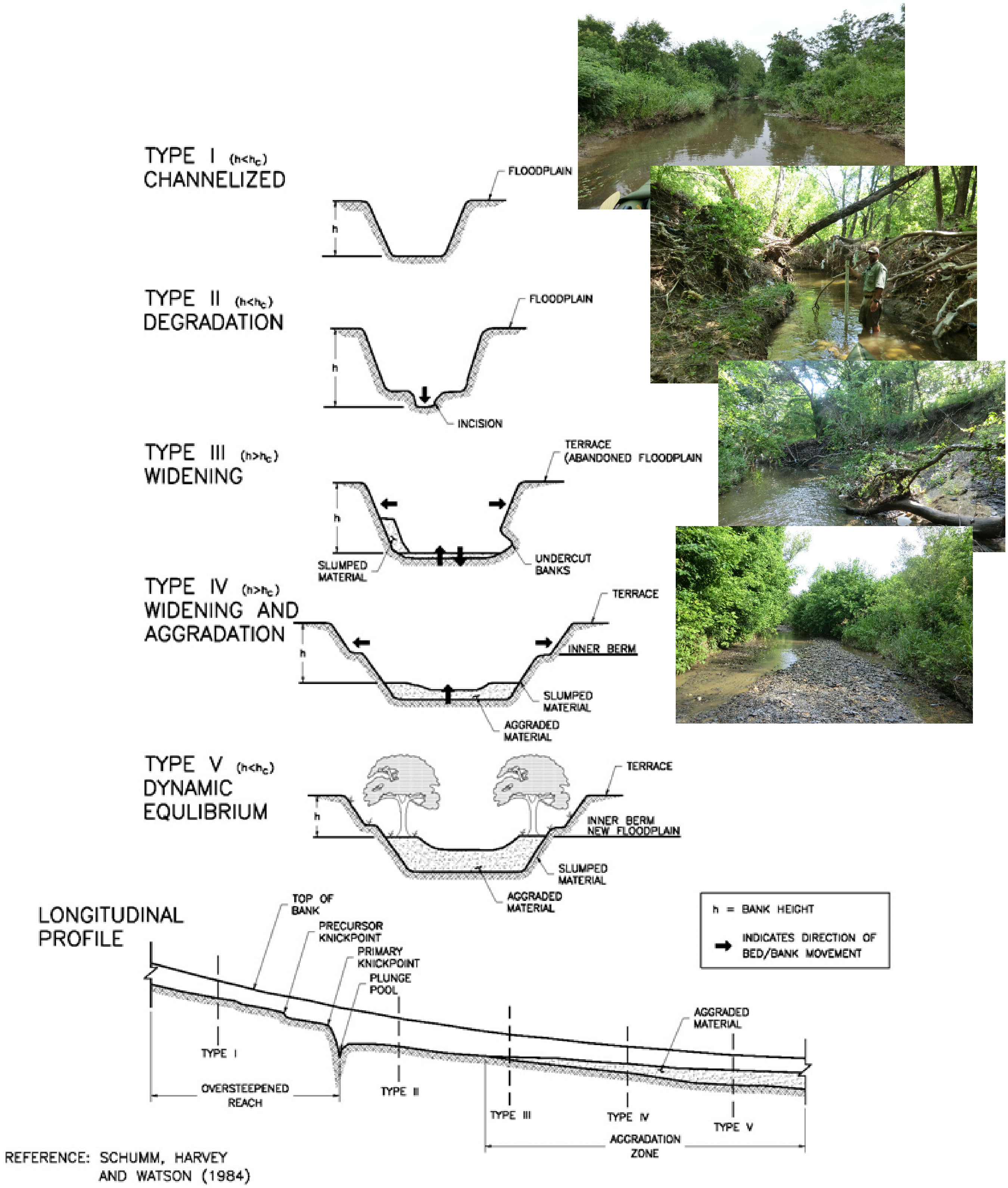
An imbalance will occur if there is an increase in the volume of sediment load in relation to the available stream power. If the stream power is insufficient to transport all of the sediment in the reach, then the balance tips towards aggradation, with net deposition occurring along the reach. Aggradation occurs when sediment supply is increased by upstream channel erosion, mass movement, or human activities. Deposition in the channel may lead to the channel bed becoming elevated above the floodplain surface, and reduced channel capacity due to deposition increases flooding and promotes channel migration (Charlton, 2008).

If the water discharge is increased, over time the channel slope would increase by degrading. Harvey and Watson (1986) have shown that channel evolution occurs as a result of increased discharge and can be assessed in terms of the Incised Channel Evolution Model (ICEM) (Schumm, 1977, Figure 3.6). An assessment of channel evolution using this method allows proper prescription of channel protection measures. Drop structures and grade control are more effective at stabilizing channels if installed while streams are in Stage II (downcutting).

Referring to the incipient motion analysis, the bed material of both creeks is generally mobile, and the channels are actively in a state of downcutting (width/depth ratio greater than 1) and widening. Downcutting was evident in areas where the sediment has been removed (no depositional features, i.e., bars) exposing the shale bedrock. Field observation noted that sediment deposition did not occur in these areas, because channel dimensions are not yet in balance with the available sediment supply and flow regime resulting from watershed urbanization. Exposed shale is prone to slaking, and slaking of the shale on the channel beds will be the primary cause of downcutting in these areas. The slaking process may be slowed if proper grade control and/or drop structures are placed in the channel to promote pools that will keep the shale wet. Even with channel downcutting controlled, widening will occur as a natural progression of channel evolution.

Channel banks that were composed of shale were widening by removal of weathered (slaked) material by sheet flow or flood flows. Channel banks composed of shale will continue to slake and erode indefinitely. Channel widening has caused trees falls and mass wasting that formed LWD jams and caused local sedimentation, respectively. Stabilizing and protecting the shale banks could reduce contact with flowing water and may decrease erosion. Channel widening was also occurring on banks where shale formed the toe of the bank and was overlain by soil. The shale bank toe was being removed by slaking and erosion, causing the banks to become unstable and fail by slumping. This process may be slowed if proper bank protection and structures are placed in the channel to promote channel stability.

Stages I-IV of the ICEM were observed in Fish Creek and Prairie Creek (Figure 3.7). Field observations suggested that in some locations, Fish Creek has moved from Stage II into Stage III as the channel dimensions are adjusting to the flow regime. One segment of Prairie Creek, downstream of Great Southwest Parkway, has moved into Stage IV suggesting increased channel stability with the current flow regime. The length of this segment is approximately 1,700 feet.



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Fish Creek
Geomorphic Stream Assessment

Incised Channel Evolution Model

FN JOB NO	ESP11227
FILE	3.6_ICEM_draw.mxd
DATE	March 14 2012
SCALE	1:0
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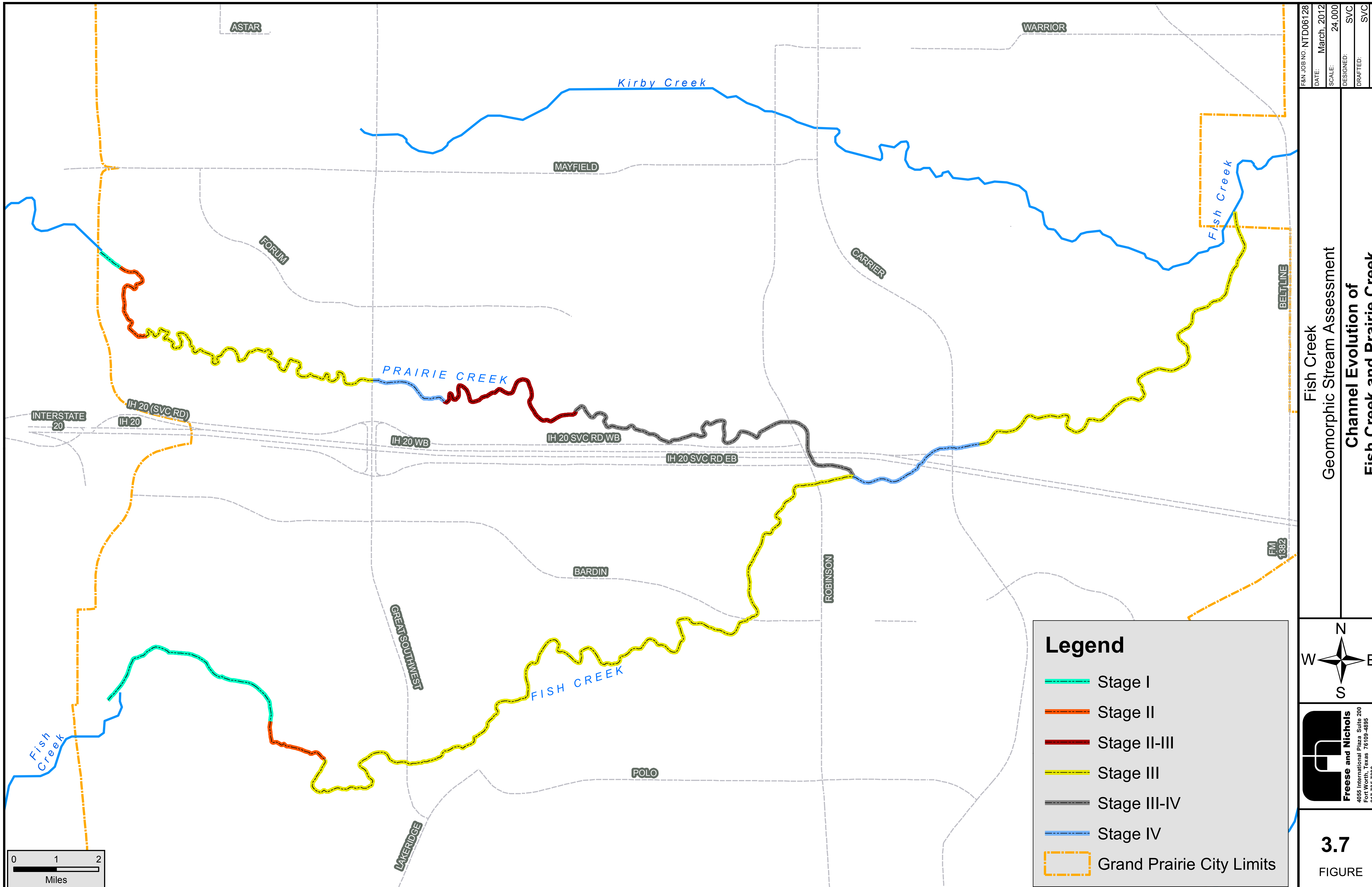
3.6

FIGURE



ASTAR
WARRIOR
Kirby Creek
MAYFIELD
FORUM
CARRIER
BELTLINE
Fish Creek
PRAIRIE CREEK
INTERSTATE 20
IH 20
IH 20 (SVC RD)
IH 20 WB
IH 20 SVC RD WB
IH 20 SVC RD EB
FM 1382
ROBINSON
BARDIN
GREAT SOUTHWEST
FISH CREEK
Fish Creek
POLO
LAKERIDGE
0 1 2
Miles
Legend
Stage I
Stage II
Stage II-III
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DESIGNED: SVC
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Fish Creek
Geomorphic Stream Assessment
Channel Evolution of
Fish Creek and Prairie Creek
Freese and Nichols
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Fort Worth, Texas 76109-4895
817-735-7300
3.7
FIGURE

3.3.3 Existing Condition Channel Geometry

The existing condition geometry assessment included measurement and evaluation of the channel morphology of Fish Creek and Prairie Creek at each cross-section location. The bottom width, active channel depth, active channel width, left bank height and right bank heights were analyzed based on field measurements to identify where possible changes were occurring in the channel (Figures 3.8-3.11). The active channel contains the flow that is responsible for forming the channels of Fish and Prairie Creeks. The active channel is defined as the portion of the channel in which flows occur frequently enough to keep vegetation from becoming established (Wood-Smith and Buffington 1996). Another active channel indicator was the top of depositional bars, which is indicative of the bankfull elevation in incised channels (Simon and Castro, 2003).

Channel dimensions varied throughout the study reaches of both creeks, but in general, channel dimensions increased in the downstream direction. Steep bank side slopes produces similar channel bottom widths and active channel widths throughout the majority of both creeks. Active channel depth typically increased and decreased with bank height. Results of measurements taken in the study area are summarized by creek:

Fish Creek

- Active channel depth ranged from 1 to 8 feet
- Left bank heights ranged from 4 to 18 feet
- Right bank heights ranged from 4 to 20 feet
- Bottom width of the channel ranged from 12 to 44 feet
- Active channel width ranged from 13 to 45 feet

Prairie Creek

- Active channel depth ranged from 2 to 6 feet
- Left bank heights ranged from 4 to 30 feet
- Right bank heights ranged from 6 to 30 feet
- Bottom width of the channel ranged from 7 to 50 feet
- Active channel width ranged from 9 to 60 feet

Figure 3.8 Graph of Fish Creek bank height and active channel depth

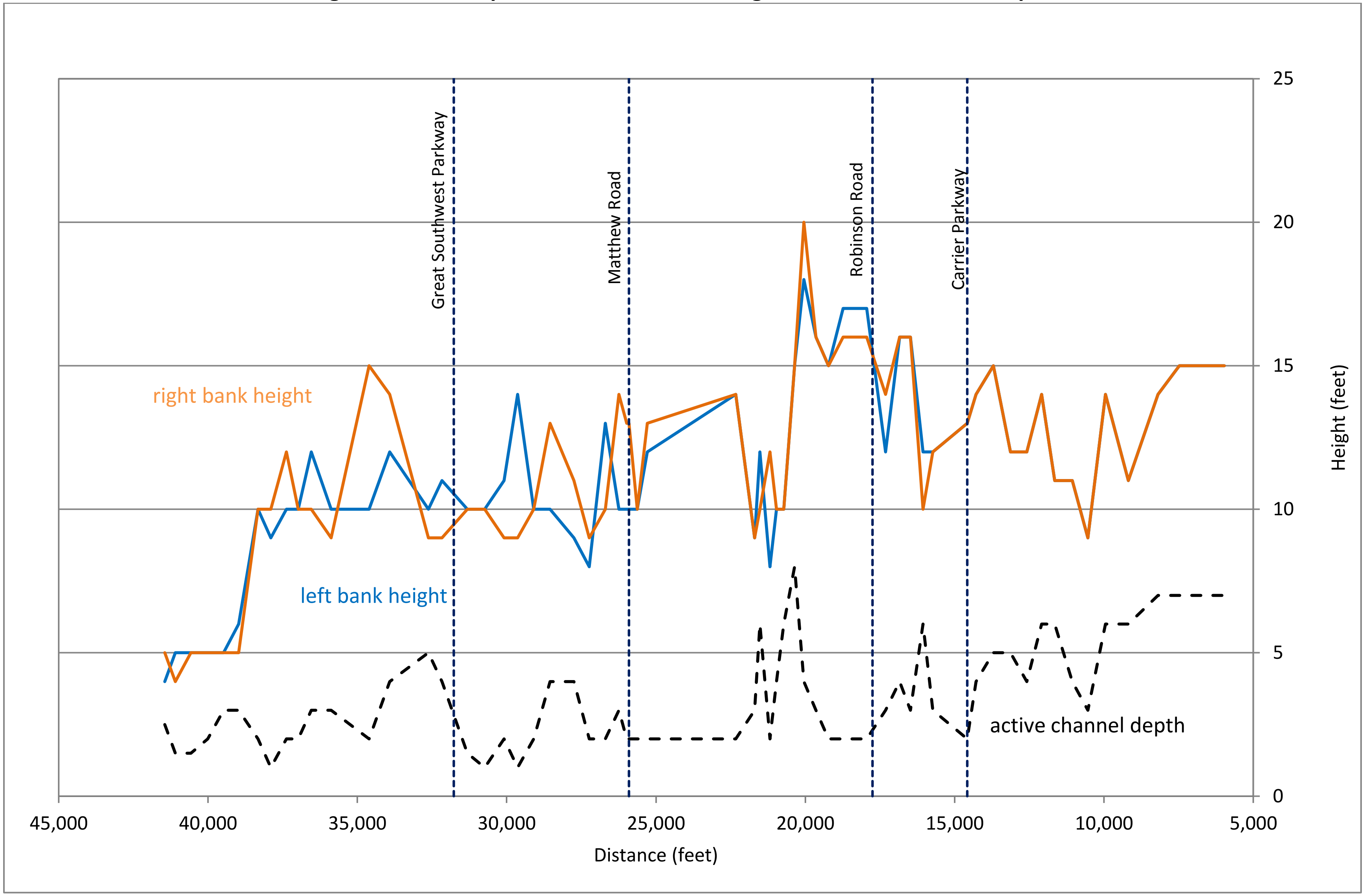


Figure 3.9 Graph of Fish Creek bottom width and active channel width

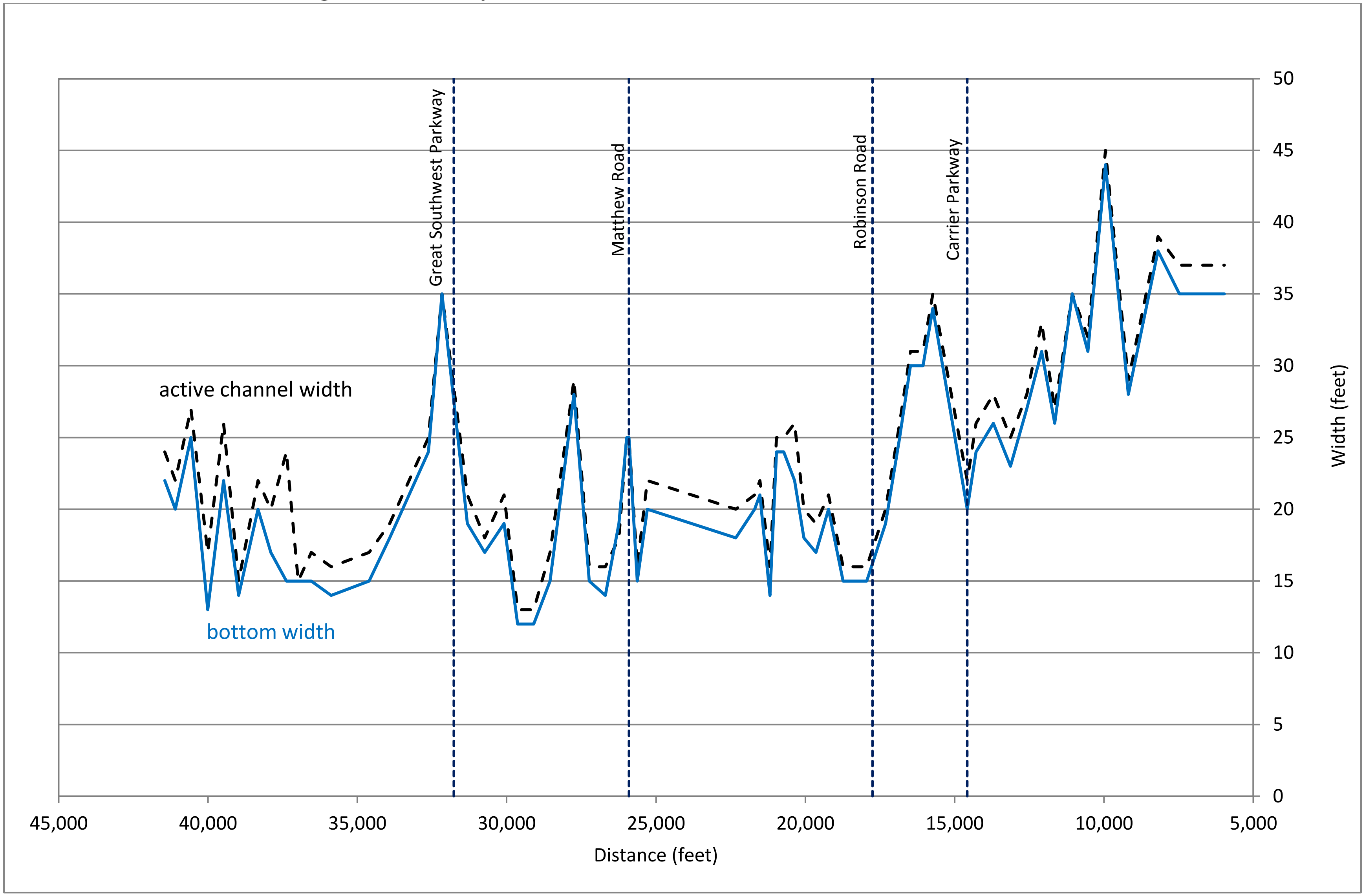


Figure 3.10 Graph of Prairie Creek bank height and active channel depth

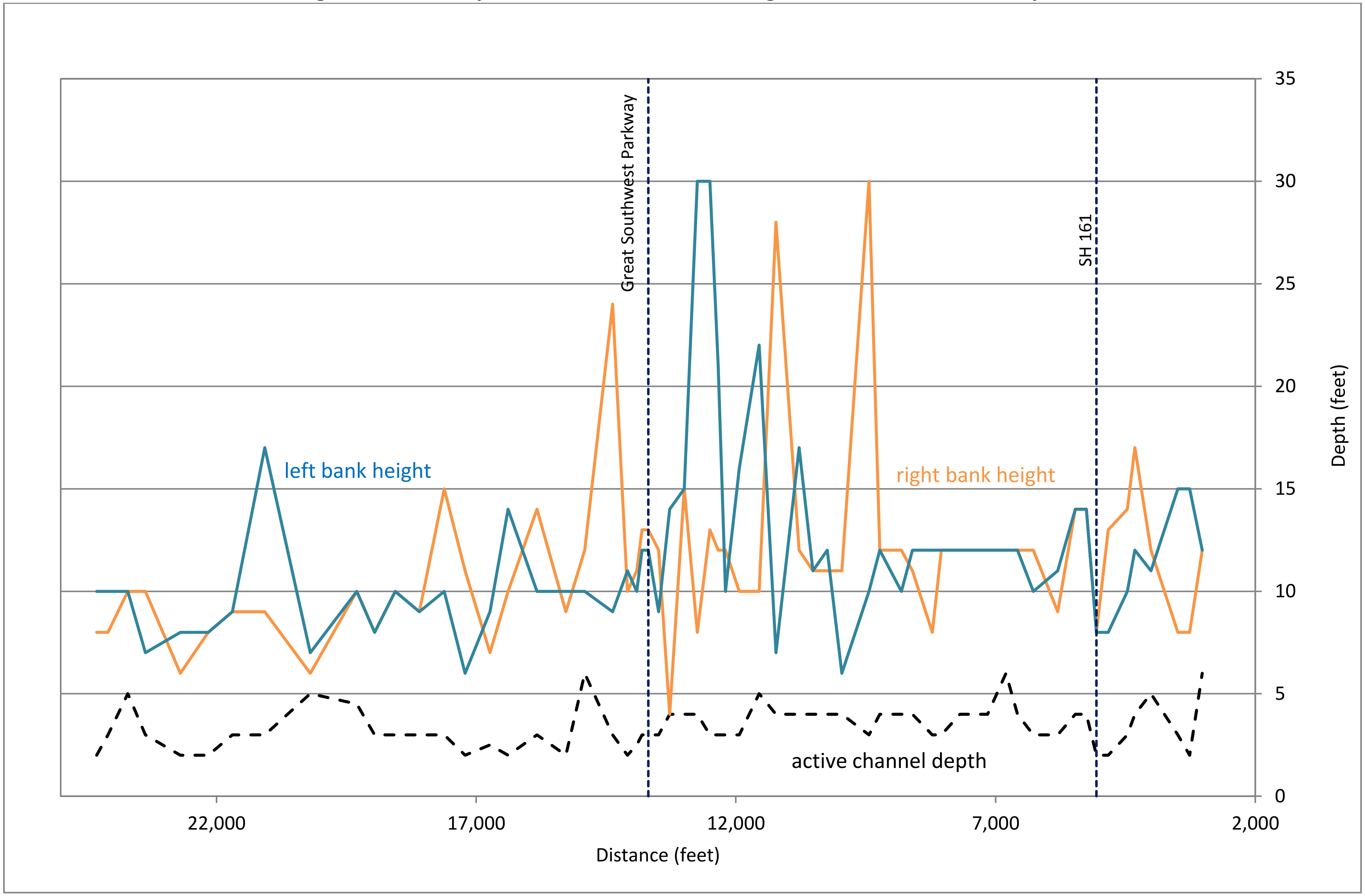
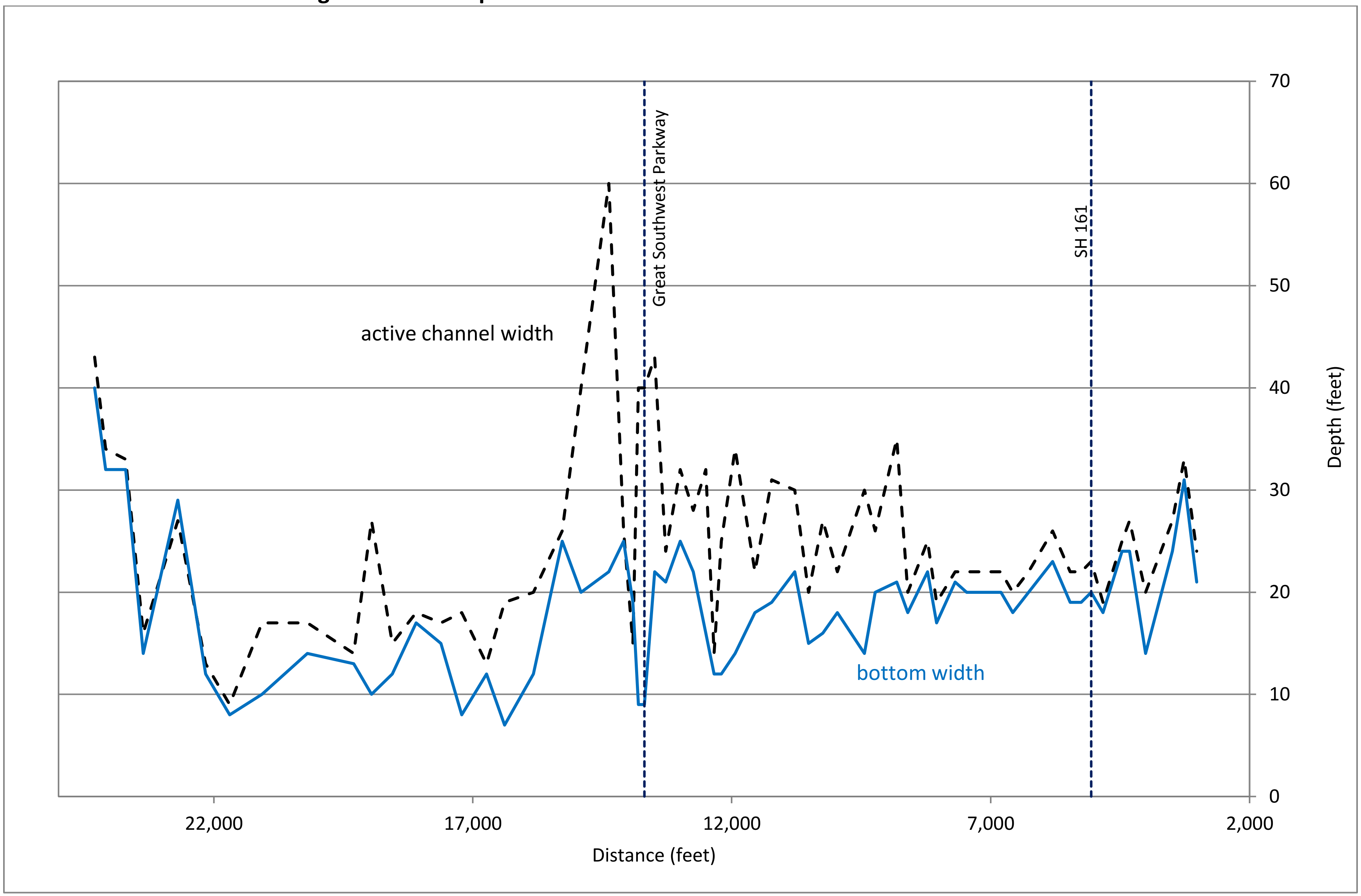


Figure 3.11 Graph of Fish Creek bottom width and active channel width



3.3.4 Existing Condition Channel Erosion and Instability

The existing condition stability assessment documented the channel processes of bank erosion and channel instability. Channel segments were rated (stable, slightly unstable, moderately unstable, or severely unstable) using the criteria in Table 2.1. In addition, the following channel processes were observed and recorded:

- bank undercutting by flowing water
- ratio of bankfull height to bank height (incised channel and steep bank angles)
- rooting depth
- channel scour and collapsed banks (failures)
- bank material (clay, shale, etc.)
- newly-fallen large woody debris
- human-induced alteration (retaining walls and culverts)

Examples of stable, slightly unstable, moderately unstable, and severely unstable channels are shown in Figure 3.12. The existing condition channel stability of Fish Creek and Prairie Creek within the study area indicated active channel downcutting and widening as a result of urbanization and development in the watershed. Urbanization increases impervious surface area which reduces infiltration, increases the drainage density of channels, intercepts subsurface water, and decreases the time necessary for overland runoff to reach the stream channel. Though an urban watershed receives the same amount of precipitation as a rural watershed, it is transported through the urban system much faster, thus resulting in higher peak discharges and increased stream power. This increased stream power can more effectively erode the stream bed and banks. Increased rates and frequency of flood events due to watershed urbanization can result in bank failures, exposed utility crossings in the reach, and threats to adjoining building, streets and retaining walls. Urbanization also decreases base flows because impervious surfaces and rapid runoff reduce the amount of total water that can infiltrate and be stored in the soil.

The channel instability along the study reaches are shown in Appendix D on a 2010 aerial photograph of the study area. In general, the upstream end of the Fish Creek study reach (stations 41446 to 36542) was stable to slightly unstable. The channel bed was lined with concrete from the start of the study reach to station 40575. Downstream of station 40575 the station was underlain by the Woodbine Formation and was generally stable. At station 36542, the underlying geology transitioned from the Woodbine Formation to the Eagle Ford Formation. Downstream of station 36542, the channel stability of Fish Creek varied between slightly unstable, moderately unstable, and severely unstable. Severe erosion was noted primarily on the outside of meanders and where the channel banks were composed of shale and/or over steepened.

The stability of Prairie Creek was more variable, transitioning from slightly unstable to moderately unstable and severely unstable along the entire study reach. The majority of severe erosion was noted on the outside of meanders, incised channels, and where the channel bed and banks were composed of shale and/or the banks were over steepened. Descriptions of specific areas of interest and severe instability are shown in Tables 3.5 and 3.6.

Figure 3.12 Examples of bank stability

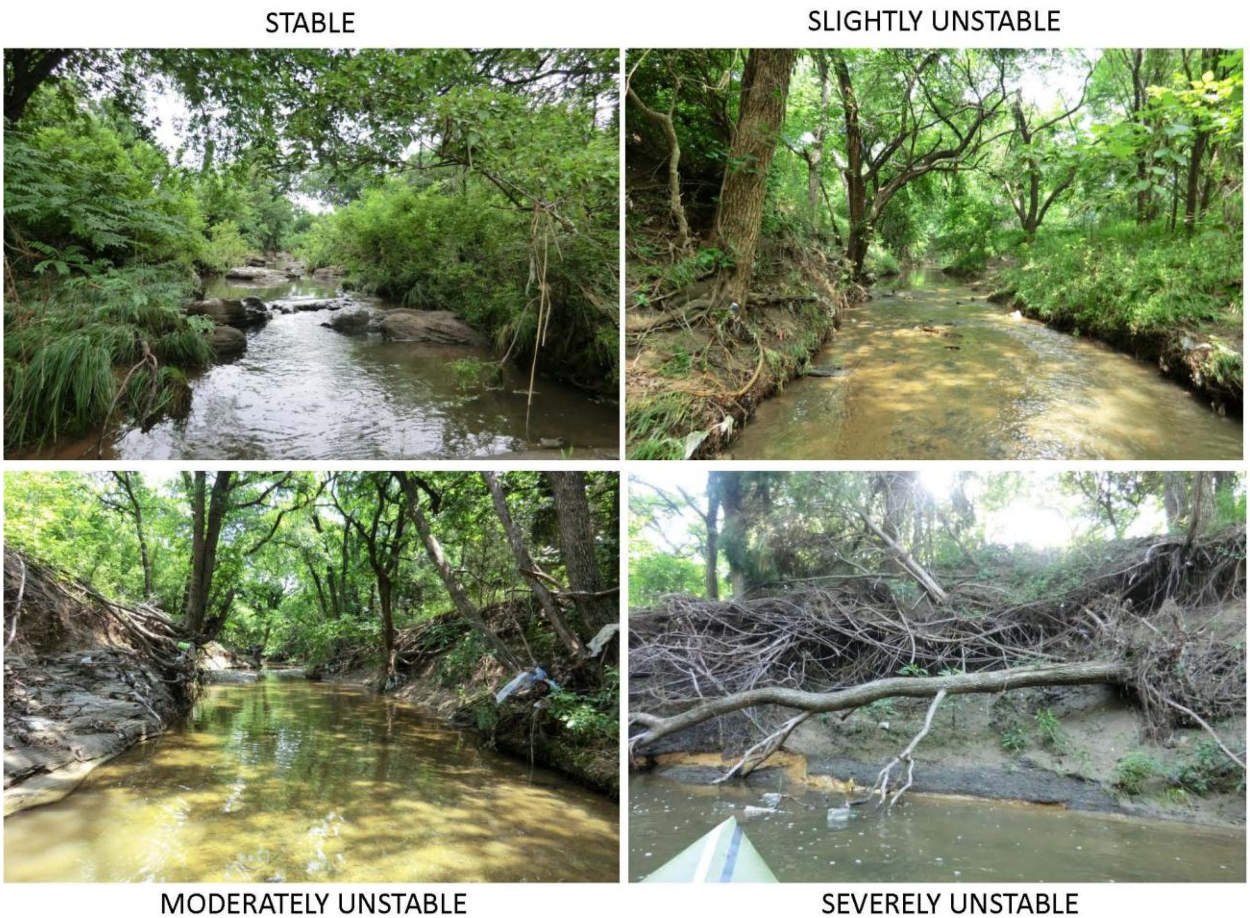


Table 3.5 Descriptions of specific areas of interest and severe instability along Fish Creek

Nearest Cross Section	Description
Fish Creek	
41093	Concrete tributary on left bank with 2-foot drop to main channel of Fish Creek
39477	Articulated block protecting the stream bed under walking bridge, shifted out of place
36542	Aerial pipeline crossing with debris jam, scour downstream and under piers
35879	LWD jam with 3-foot drop
35879	Aerial pipeline with scoured banks and ineffective riprap
34603	Severe erosion and bank loss on outside of meander, threatens homes and stormwater outfall
32625	Undercut and cracked concrete apron at aerial pipeline, strong sewage smell; erosion behind gabions; erosion behind concrete apron
27747	Aerial pipeline crossing with LWD jam creating ponded water upstream of 3-foot drop
27236	Existing grade control – stabilizing channel
26234	Aerial pipelines with local scour and bank failure
25904	Concrete cap protecting water line is broken and undermined, acting as drop; construction site cleared of vegetation is sediment source
25626	Severe bank erosion migrating towards Matthew Rd., large bank failure on eroding bank; sediment source at construction site
22868-21694	Channel drops approximately 11 feet through this section. Large LWD jams collect sediment, back up water and create natural drops. Consider replacing natural drops with engineered drops
20046	Pipeline crossing with LWD jam ponding water upstream and acting as drop
20046-19644	Channel drops approximately 7 feet through this section. House on top of left bank protected with concrete debris and car parts
19223	LWD jam with 3-foot drop in bed elevation,
15727	Aerial pipeline crossing with LWD jam and sediment deposition upstream creating 3.5-foot drop.
14866	Left bank of concrete channel is cracked and undercut 2 feet
14725	Bridge piers at Carrier Parkway scoured 1 to 4 feet
12085	Water line clean-out exposed on severely eroding meander
11056	Erosion and scour at golf cart bridge
9945	Severe erosion at golf cart path
8186	Severe bank erosion, 15 feet from fence on top of bank, threatens houses

Table 3.6 Descriptions of specific areas of interest and severe instability along Prairie Creek

Nearest Cross Section	Description
Prairie Creek	
24306	Erosion and drop downstream of culvert, concrete pipeline protection broken and undermined across channel
23367	2-foot knickpoint migrating towards sewer line
21069	Stormwater outfall severely undercut
19301	Stormwater outfall severely undercut
18557	Road on construction site on outside of meander
18097	Shale banks with houses on top, protected by riprap but erosion has removed most of riprap
17616	Severely eroding banks with houses visible from channel
16737	House is 55 feet from severely eroding shale bank
16385	Severe erosion at stormwater outfall
15832	Severe erosion at stormwater outfall
14909	House about 100 feet from severely eroding shale meander bank; severe erosion and diversion channel acting as meander cutoff for high flows
12994	Steep eroding bank with gullies forming toward apartments
12343	Severe erosion adjacent to stormwater outfall
12220	Severely eroding tributary with 4-foot knickpoint migrating upstream toward houses
11554	Fence across channel could cause debris jam
11227	Concrete encased pipeline with 2-foot drop
10784	Buried concrete pipeline slightly exposed acting as hard point
9960	Concrete encased pipeline with 1-foot drop
8815	Concrete encased pipeline with 2.5-foot drop
8600	Fence across channel causing debris jam and gravel deposition downstream
7687	Concrete encased pipeline with 1.5-foot drop
6800	Concrete encased pipeline with 3-foot drop
6270	Large box culvert on left bank causing severe bank scour behind bank protection and downstream of confluence. Channel bed scour has undermined and collapsed concrete downstream of culvert.
5463	Roadway pier in close proximity to eroding bank on meander
5252	Undercut banks, slumping near guard rails; outfall scour to channel and removal of riprap
4832	Concrete encased pipeline with 1.5-foot drop
4462	Severe bank erosion and gullying to base of highway piers on both sides of channel
3492	Severely unstable bank, eroding shale, undermining gabions, gullying and migrating toward highway pier

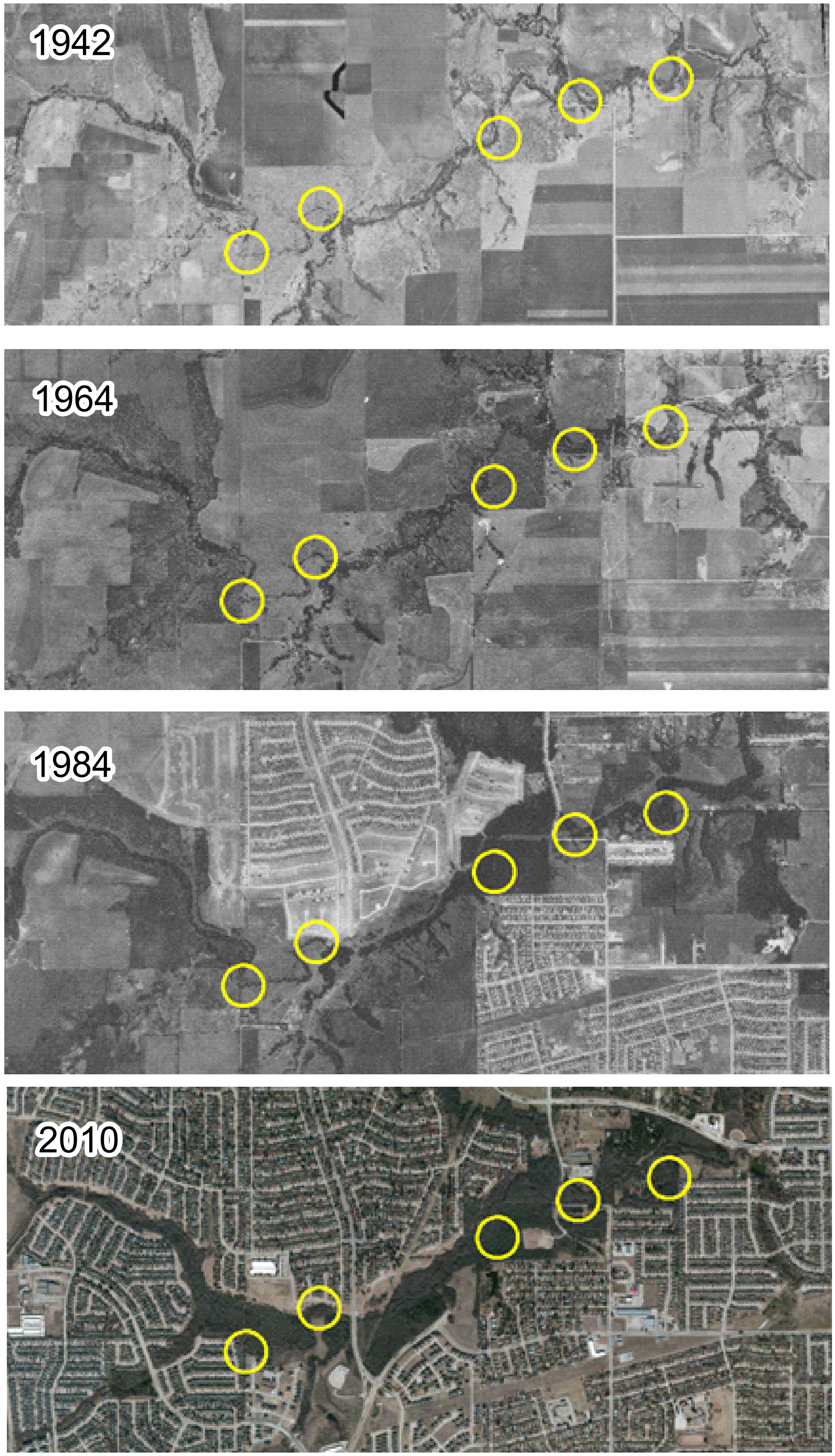
3.4 Planform Stability

3.4.1 Meander

Four aerial photographs (1942, 1964, 1984 and 2010) of Fish Creek and Prairie Creek were analyzed to infer historical meander migration rates. The meanders analyzed are indicated in Figures 3.13 and 3.14. In general, historical aerial photographs are the best way, aside from actual field data collection, to measure lateral channel movement. Based on the series of photographs, meander migration rates were estimated for Fish Creek and Prairie Creek:

- Fish Creek was between 0.25 and 1.0 feet per year
- Prairie Creek was between 0.34 and 1.4 feet per year

These estimates indicate that some form of bank protection will be needed to arrest lateral channel migration along the study reaches of Fish Creek and Prairie Creek where infrastructure is located (i.e. roadways, houses, etc.). There are areas along the creeks that contain construction projects (primarily roadway projects) that are at risk and have a potential to be threatened by the widening outer bend of the meanders. It should be noted that prediction of meander migration is difficult and depends on many factors that cause rates to vary from year to year and over a longer period. Areas of concern are indicated in Appendix B.



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N
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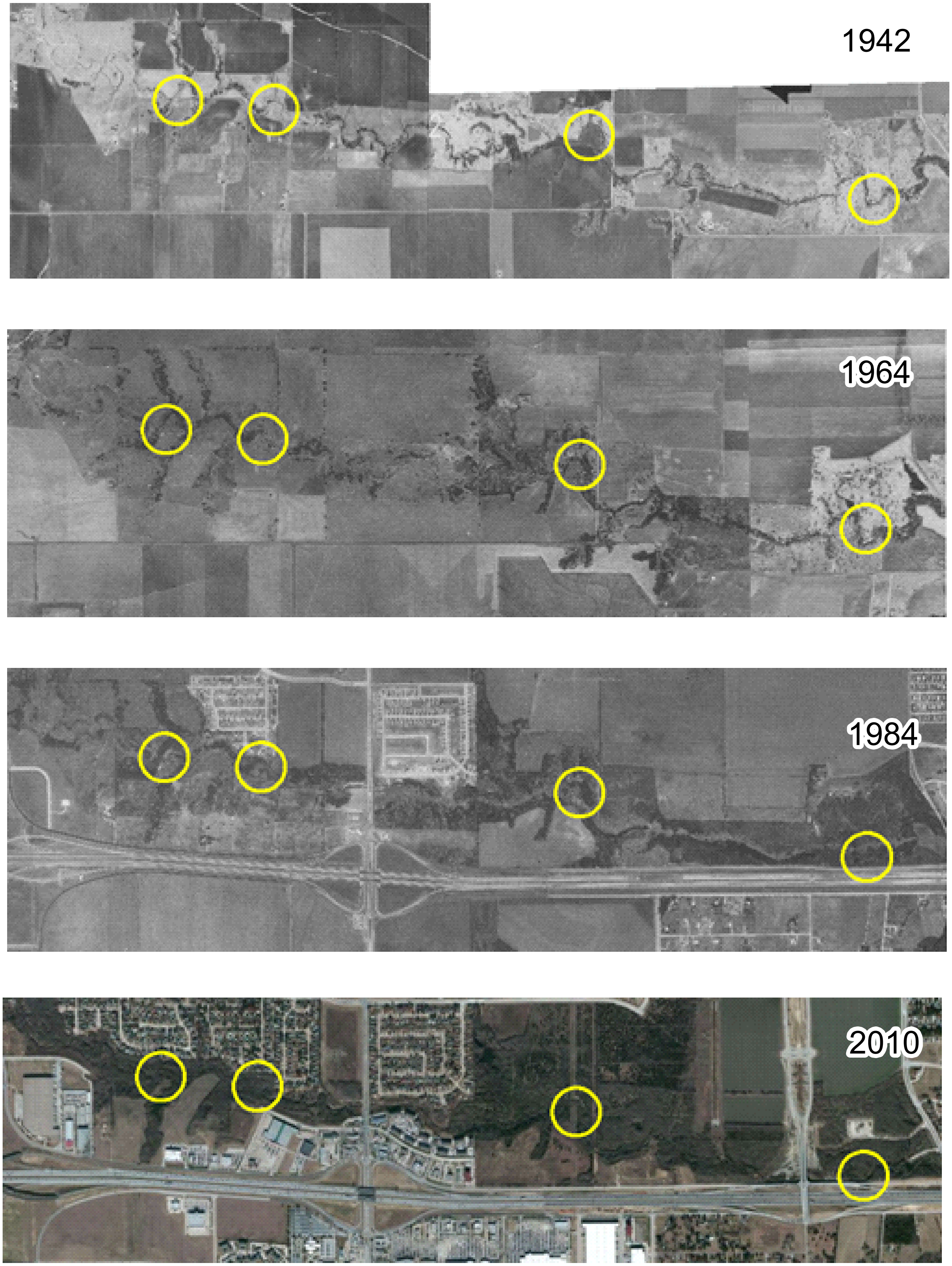
Fish Creek
Geomorphic Stream Assessment

Fish Creek Planform

FN JOB NO	ESP11227
FILE	3.15_fish-planform.mxd
DATE	March 14 2012
SCALE	1:0
DESIGNED	SVC
DRAFTED	SVC

3.13

FIGURE



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Fish Creek
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Prairie Creek Planform

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FILE	3.14_prairie-planform.mxd
DATE	March 14 2012
SCALE	1:0
DESIGNED	SVC
DRAFTED	SVC

3.14

FIGURE

3.4.2 Bank Stability

Processes of bank erosion and stability are important in the development and evolution of channel forms, while the migration of a channel across floodplains involves a combination of bank erosion and deposition. Bank erosion can also create management problems when bridges, buildings and roads are undermined or destroyed.

Bank failure occurs when bank materials becomes unstable and falls or slides to the base of the bank. Different types of bank failures observed in Fish Creek and Prairie Creek are shown in Figure 3.15. There are several types of failures and different failure mechanisms are observed for cohesive and non-cohesive bank materials. In addition, bank height, bank angle, moisture content, groundwater, vegetation, climatic cycles, and duration of stream flow effects bank stability.

Slumps and rotational failures were common in the study area along segments where flood flows became ponded from LWD jams, debris jams, aerial pipelines, etc. and were typically seen on bank slopes less than sixty degrees. In Fish Creek and Prairie Creek slumps occurred in the soil material on the upper banks of the channel. Where the soils material extended the entire bank height and shale was on the channel bed, scouring of the base of the slope (channel toe) resulted in rotational failures and slumps. These types of failures are a result of high pore pressures and are related to floods and intense rain storms which can fill soil cracks and result in bank failure (Kuhn and Zornberg, 2006).

Undercut banks, creep, wedge and slab failures, and failure of non-cohesive bank material were common. Generally, bank failures along Fish Creek and Prairie Creek are related to the depth of the bank material in relation to the top of the shale, weathering of the shale, and the height of the shale in the bank. The higher the shale is positioned (exposed) within the channel bank the more the channel tends to fail by wedge failure, slab failure, and erosive scour. The wedge and slab failures in the shale bed rock occur along fractures, tension cracks, and fault planes. In addition, the shale is weathered by the process of slaking. This occurs when the banks experience repeated wetting and drying. This process causes the shale to dislodge (Throne and Osman, 1988). This occurrence is responsible for undercut banks, scour to the base of bank slopes, and bank retreat (meander migration).

Please note that bank stability is complicated and for design purposes, geotechnical engineers should be consulted and a more detailed geotechnical analysis should be conducted.

Figure 3.15 Photographs of bank failures

4.0 DESIGN AND ENGINEERING CONSIDERATIONS

4.1 Channel Erosion and Instability

Stream bank protection and grade control should be considered at all locations categorized as severely unstable. Priority should be given to the areas in closest proximity to homes and infrastructure. Additionally, there were existing features (natural and man-made) that were effectively stabilizing portions of Fish and Prairie Creeks. These features should be replaced with permanent engineered structures, and will be discussed in detail in the Equilibrium Slope section. Appendix B and Tables 3.5 and 3.6 contain descriptions of specific areas of interest and severe instability along the study reaches of Fish Creek and Prairie Creek.

4.2 Critical Shear Stress of Channel Bed and Bank Material

For design of protection measures and other channel modifications, it is important to remember that even when the critical shear stress is not exceeded by the applied shear stress, some localized erosion may still occur. The USACE suggests using the following equation after Chang (1988) to compute the maximum applied shear stress on a bank in a straight channel:

$$\tau_{max} = 1.5\tau$$

where τ_{max} is the maximum shear stress in pounds per square foot, τ is the calculated or modeled applied shear stress in pounds per square foot. Fischenich (2001) warns that temporal shear stress maximums in turbulent flow can be 10 to 20 percent higher than maximum shear stress calculated with the equation above and that an adjustment of 1.15 should be applied to account for these instantaneous maximums.

4.3 Shale Erosion by Slaking

Slaking is a weather related phenomenon that will continue to take place as the channel is subjected to repeated wet and dry cycles. A way to decrease the slaking process is to keep the exposed shale on the bed under water and protect the exposed shale on the channel banks. When immersed in water, shale does not experience wet/dry cycles, and properly armored shale banks are protected from erosion by sheet flow and flood flows. These slake loss rates only consider slaking and not bank loss due to bank failure. Observations suggest that as shale on the lower banks undergoes slaking and is removed, the upper banks become over-steepened, loose support, and collapse.

4.4 Equilibrium Slope

Drop structures stabilize channels by artificially decreasing the channel slope. A decrease in channel slope will decrease stream power and the erosive power of the flowing water. Drop structures also create wet conditions which slows slaking of the shale by reducing wet/dry cycles. A drop structure height of 3 feet was used to determine the amount of drop structures necessary to protect the creeks from experiencing additional degradation. Drop structures are typically limited to a maximum height of 3 feet to avoid generating dangerous hydraulic rollers during flood conditions.

4.5 Channel Evolution

The channels of Fish Creek and Prairie Creek have evolved as a result of development in the Fish Creek watershed and have begun to temporarily stabilize under the current flow regime as development has slowed. It can be expected that channels will continue to adjust in response to increased watershed development, just as they have done in the past. Two large construction projects were underway immediately adjacent to the creek channels at the time of the field investigation (SH-161 and Sara Jane Extension). Both projects will likely result in increased impervious cover, which will increase stormwater runoff volumes to the creek channels. As stated previously, the creek channels will enlarge in response to increased flows by increasing channel dimensions, decreasing slopes, or both. Future increases in local runoff should be considered before undertaking any channel improvement projects.

4.6 Planform Stability

The shear stress exerted on the outside bank of a meander is greater than the stress on a bank in a straight reach because flow velocities are generally greater along the outsides of meanders. Therefore, during the design phase there is a need to adjust the shear stress produced by the hydrologic and hydraulic model. The United States Army Corps of Engineers (USACE) suggests using the following equation after Chang (1988) to compute the maximum shear stress exerted on a bank on the outside of a meander:

$$\tau_{max} = 2.65\tau \left(\frac{R_c}{W}\right)^{-0.5}$$

where τ_{max} is the maximum shear stress in pounds per square foot, τ is the calculated shear stress in pounds per square foot, R_C is the radius of curvature in feet, and W is the top width of the channel. Fischenich (2001) warns that temporal shear stress maximums in turbulent flow can be 10 to 20 percent higher than maximum shear stress calculated with the equation above and that an adjustment of 1.15 should be applied to account for these instantaneous maximums.

Please note that bank stability is complicated and for design purposes, geotechnical engineers should be consulted and a more detailed geotechnical analysis should be conducted.

5.0 REFERENCES

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Appendix A

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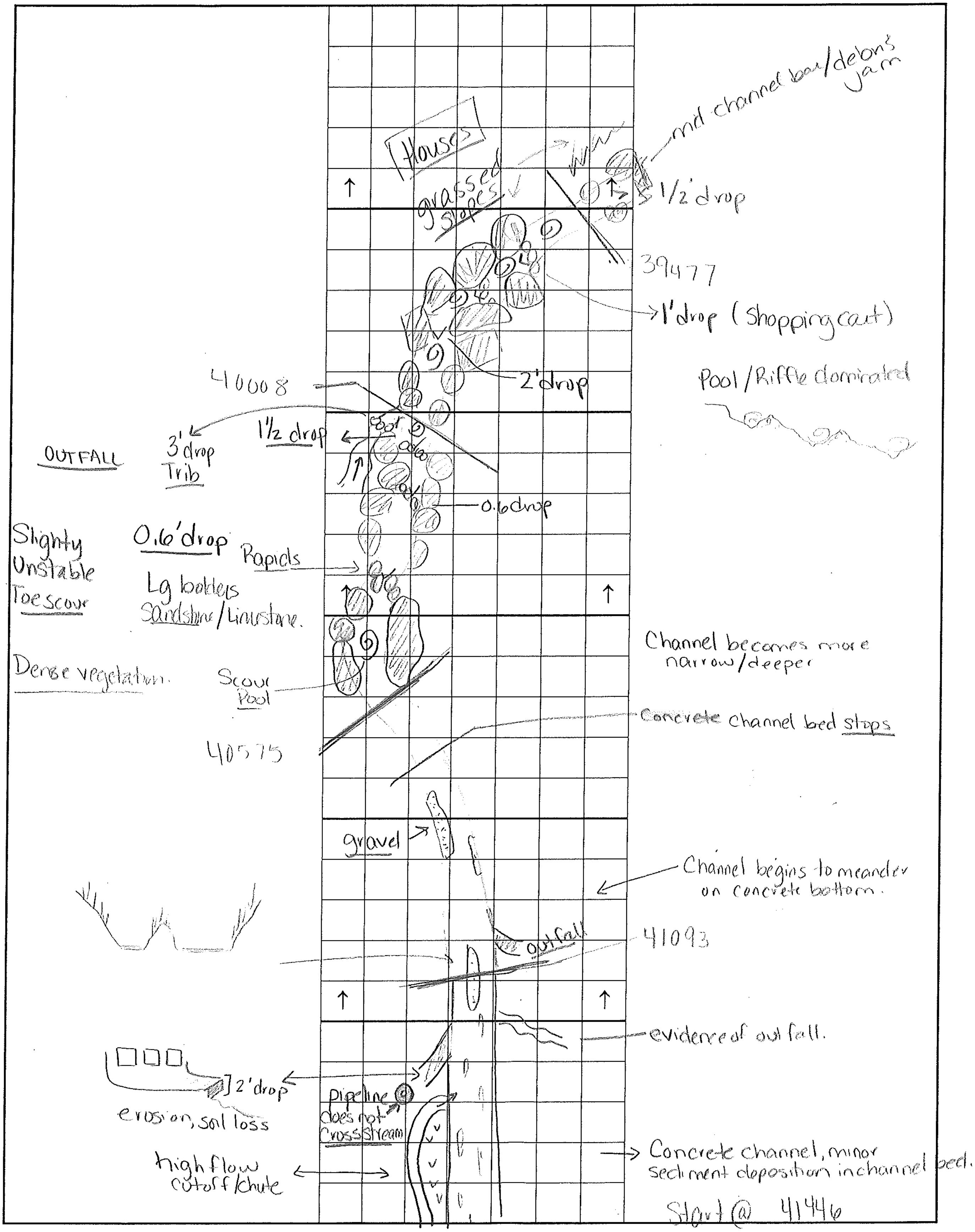

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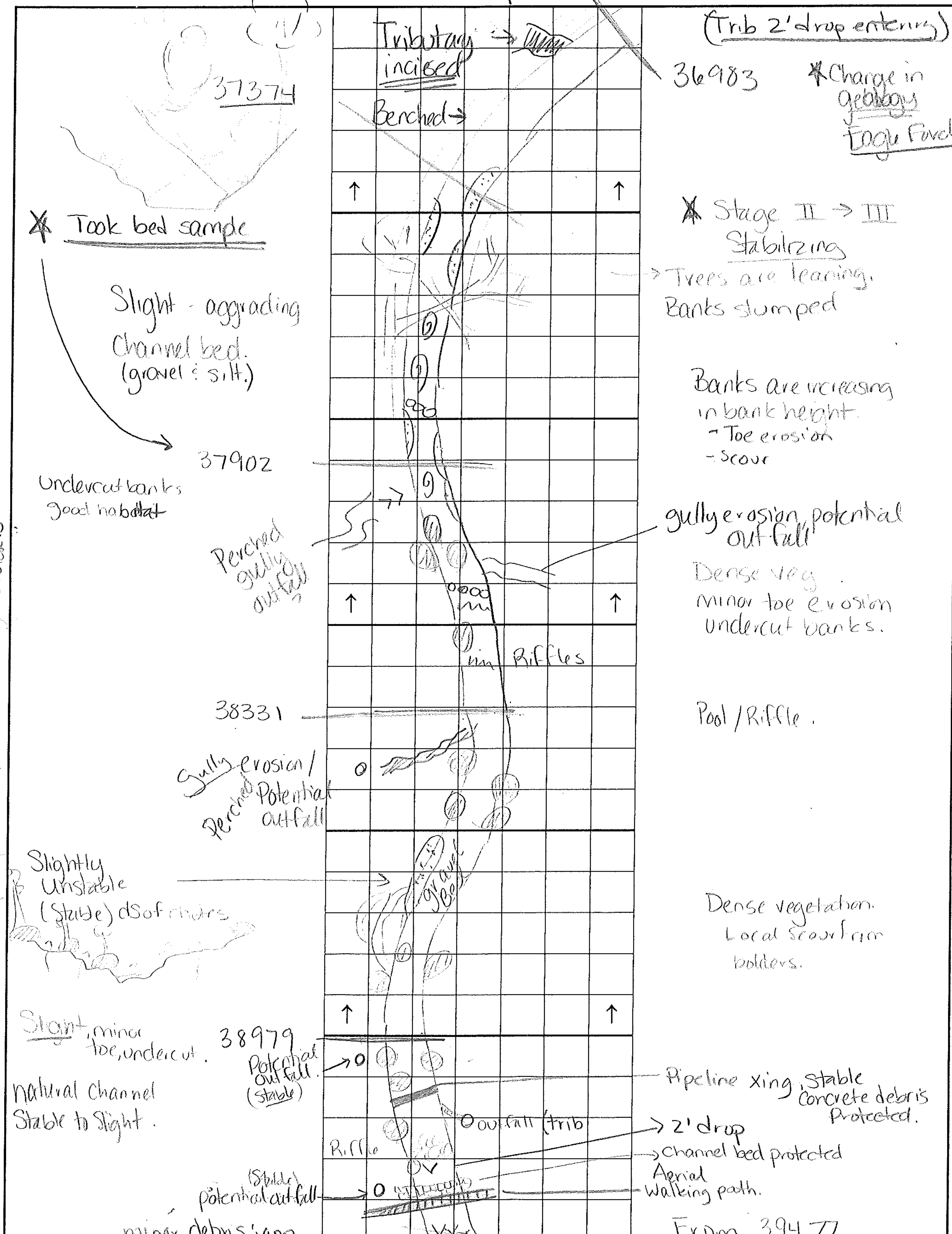

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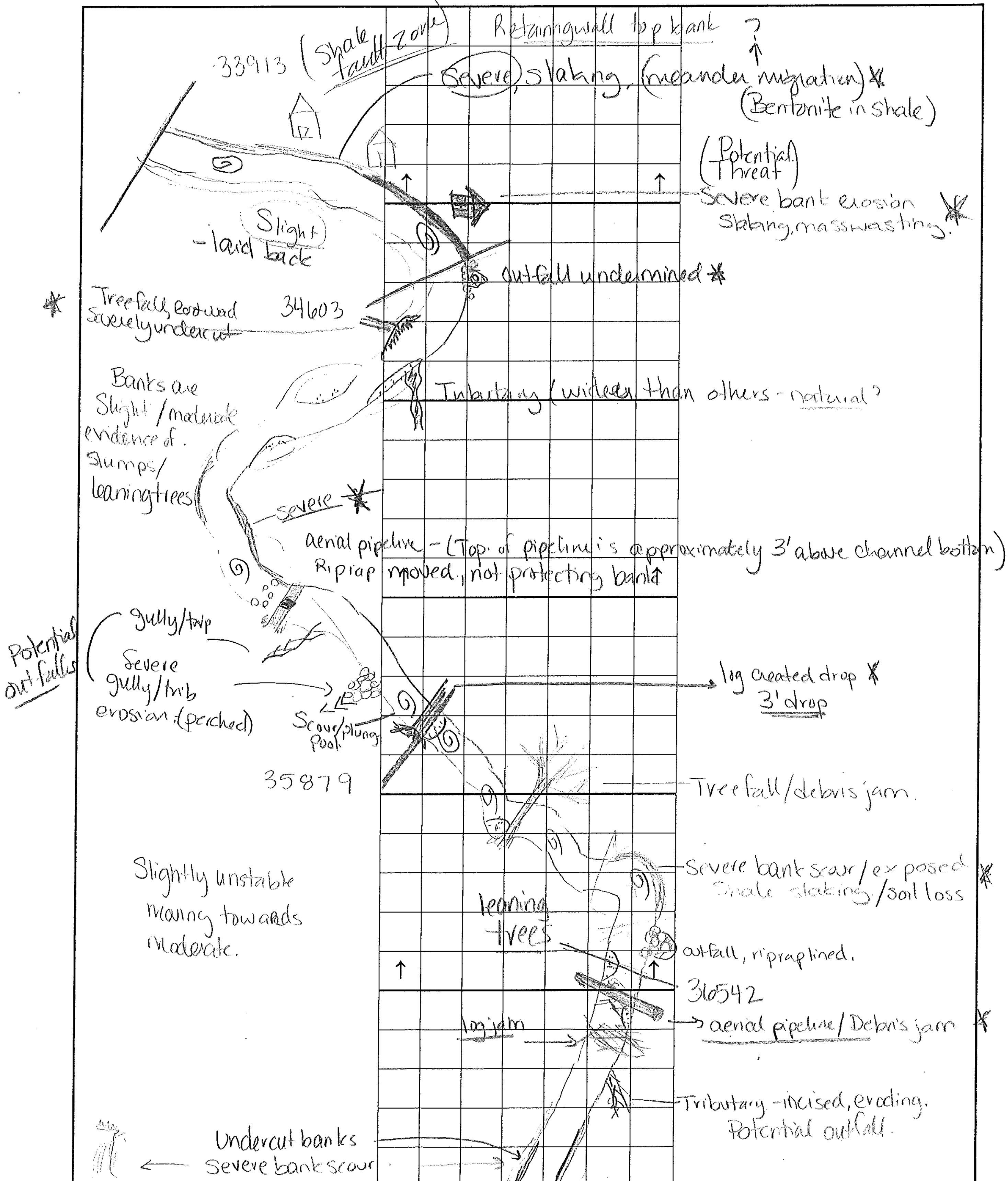

* Eagle Ford Shale plucked from the channel bed near 36983

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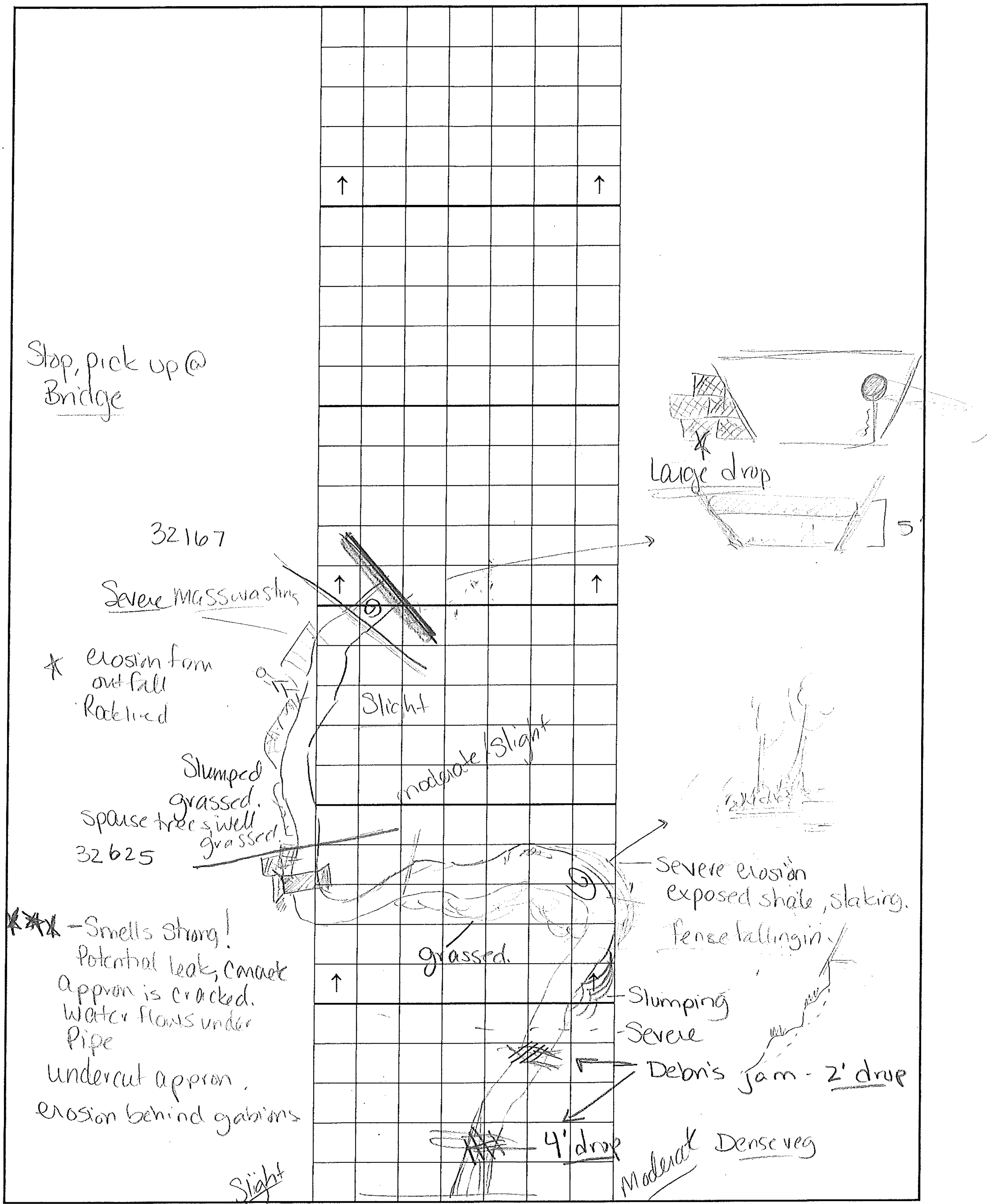

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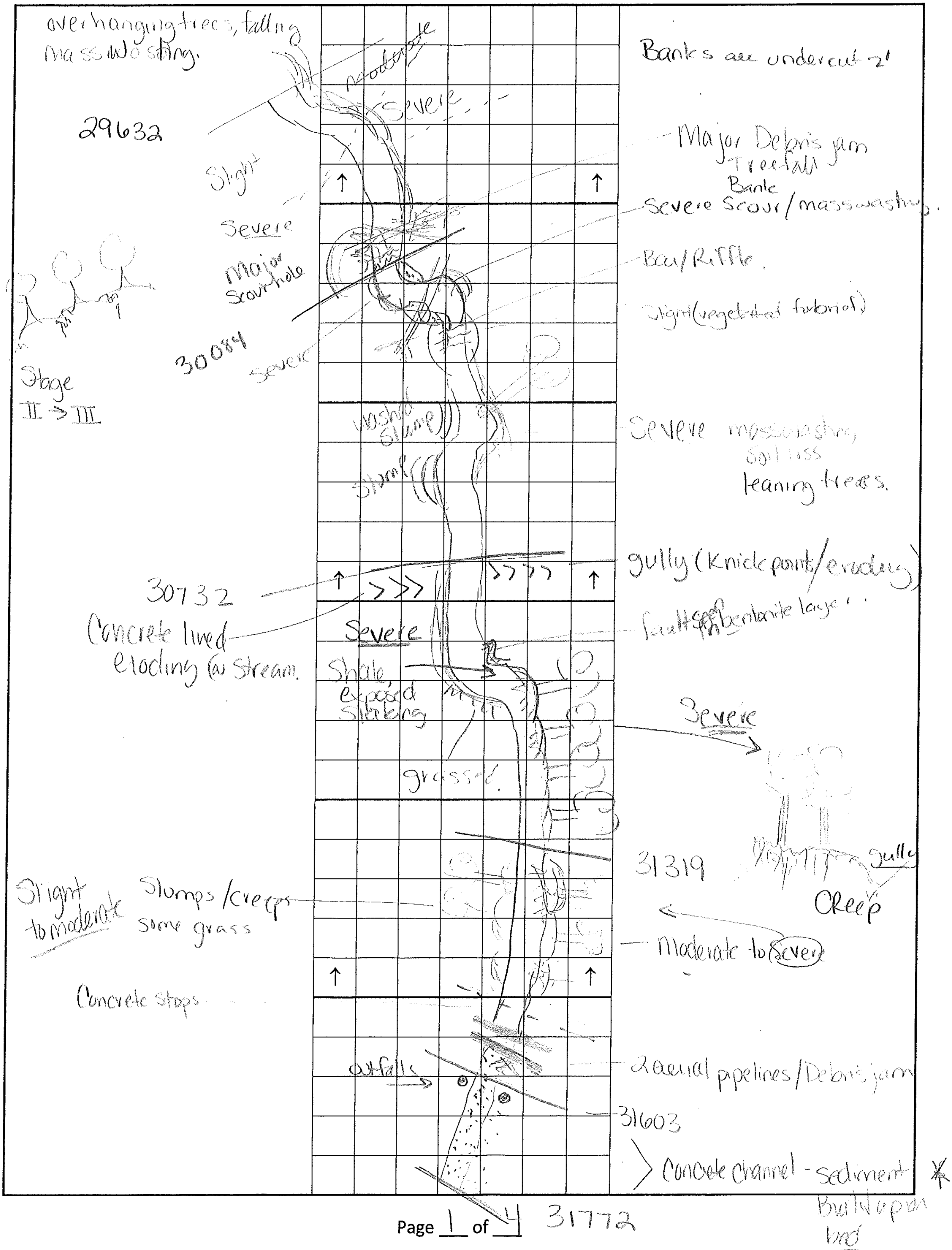

Start 5/25/11 @ Great Southwest

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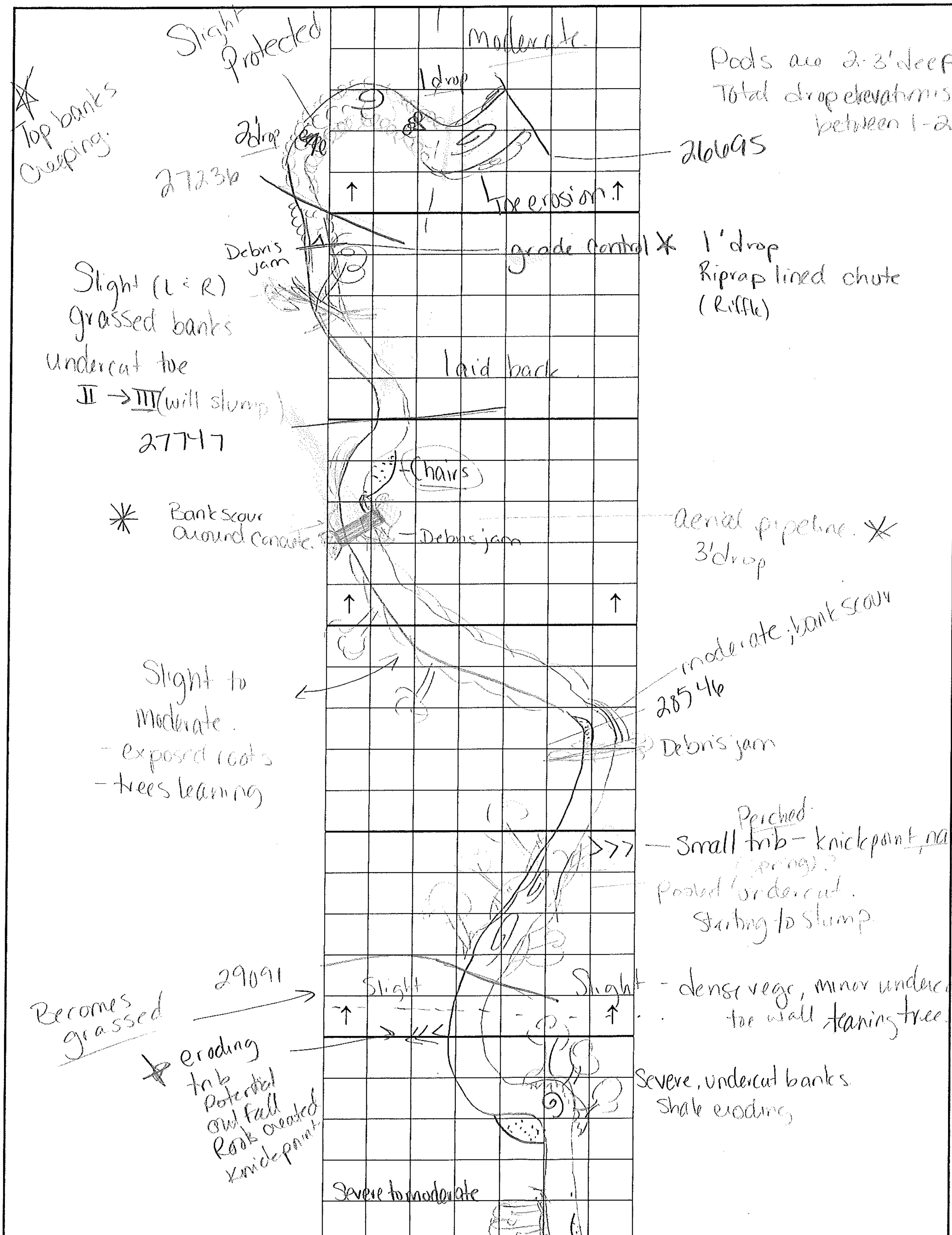

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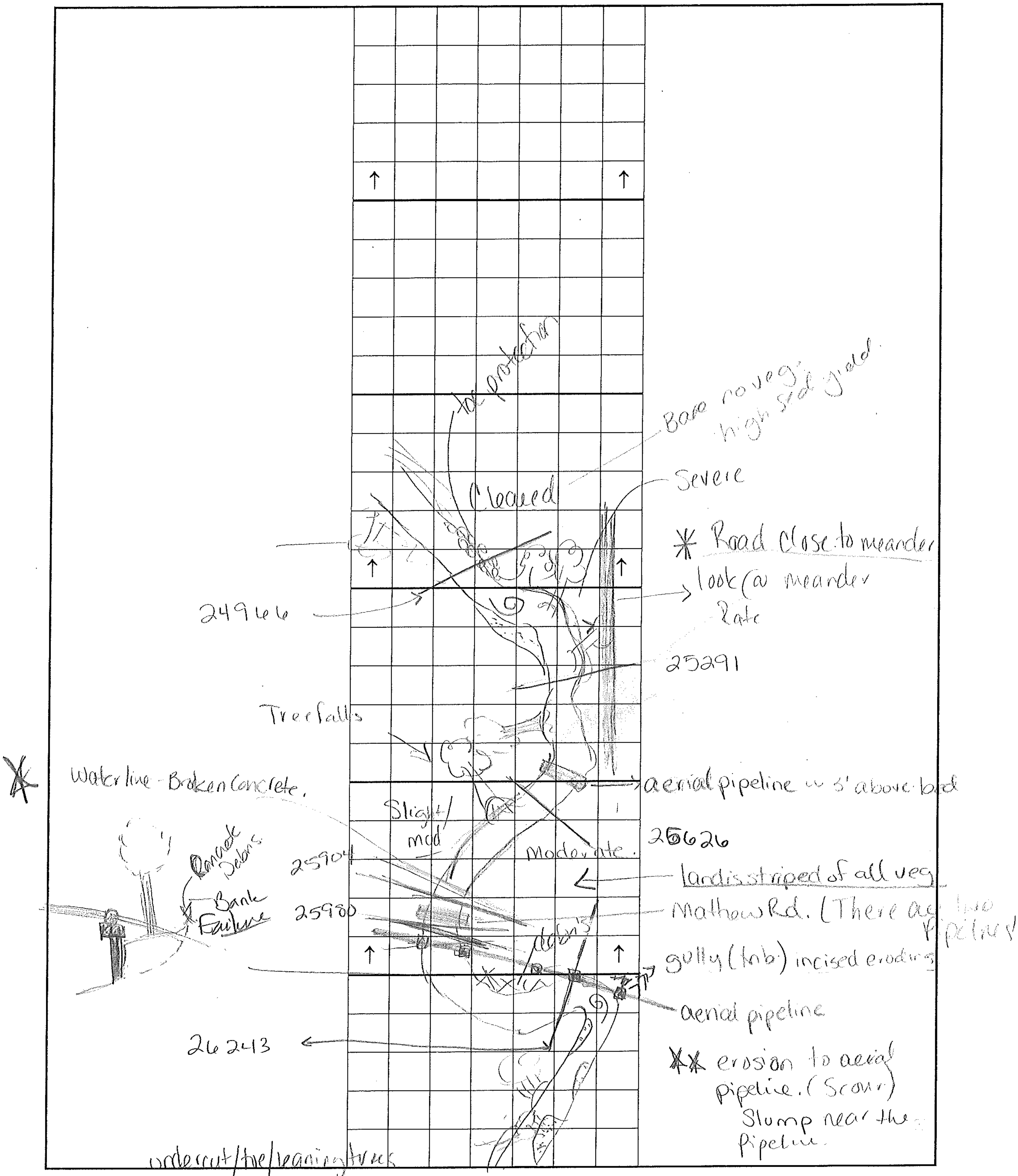

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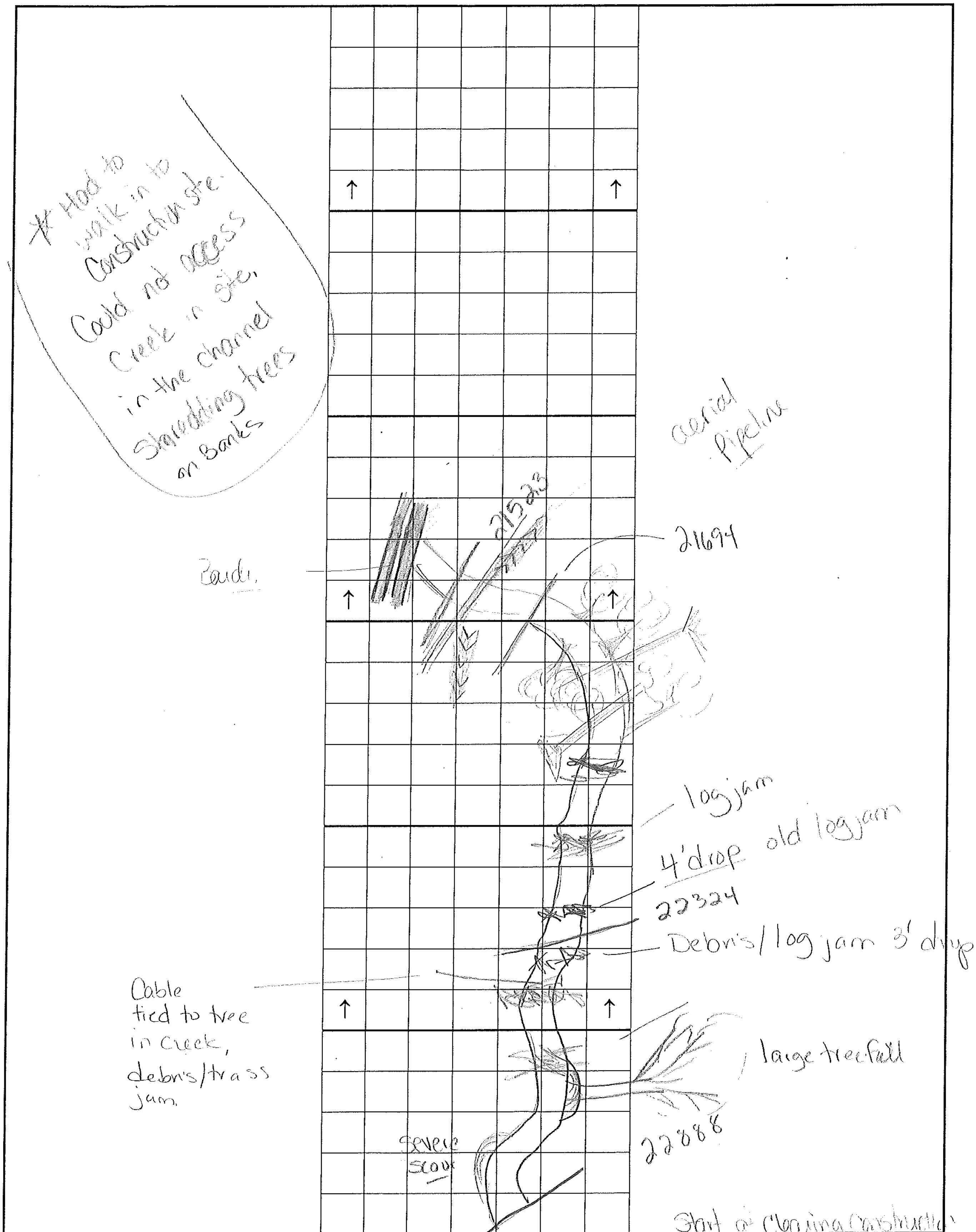

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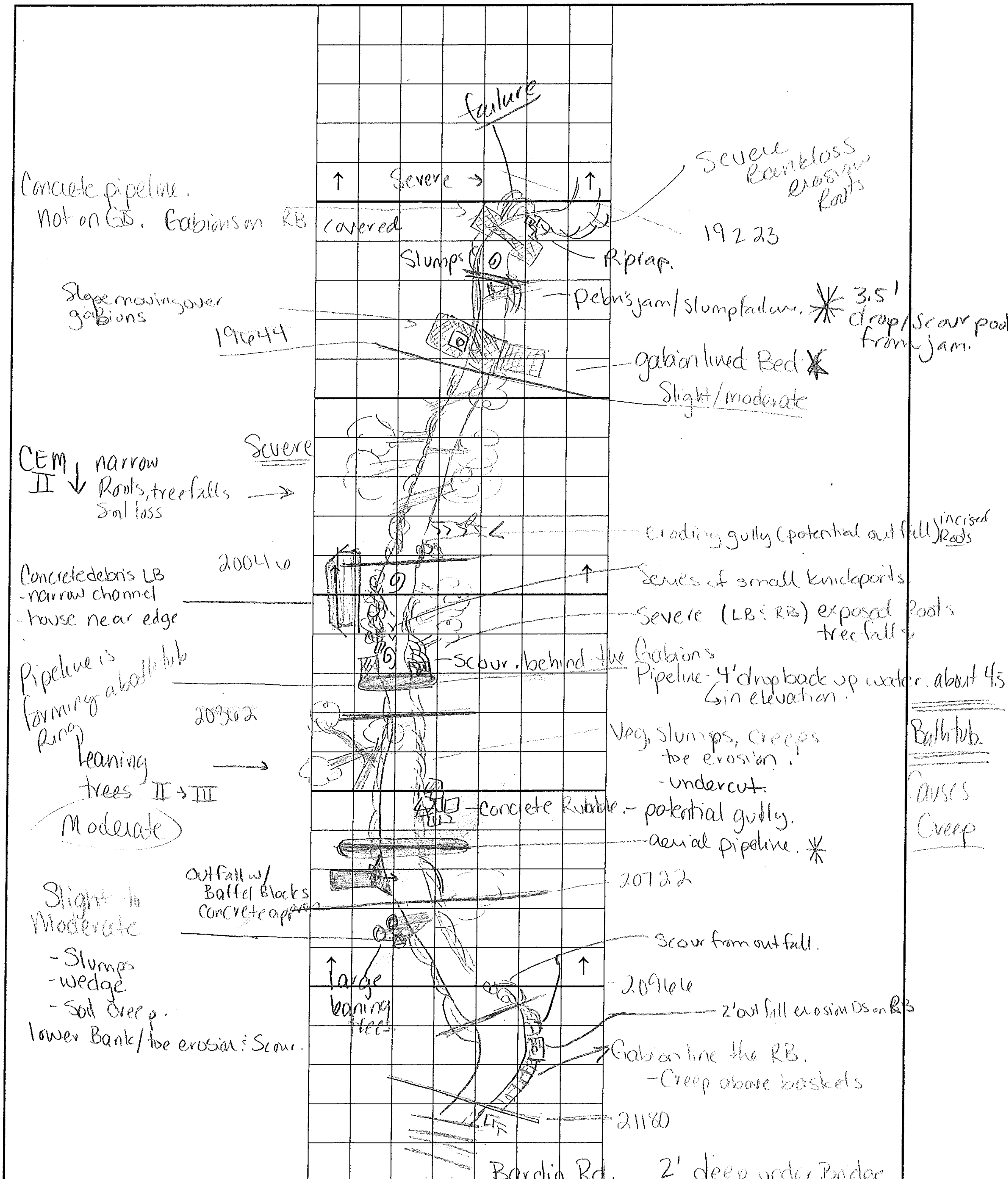

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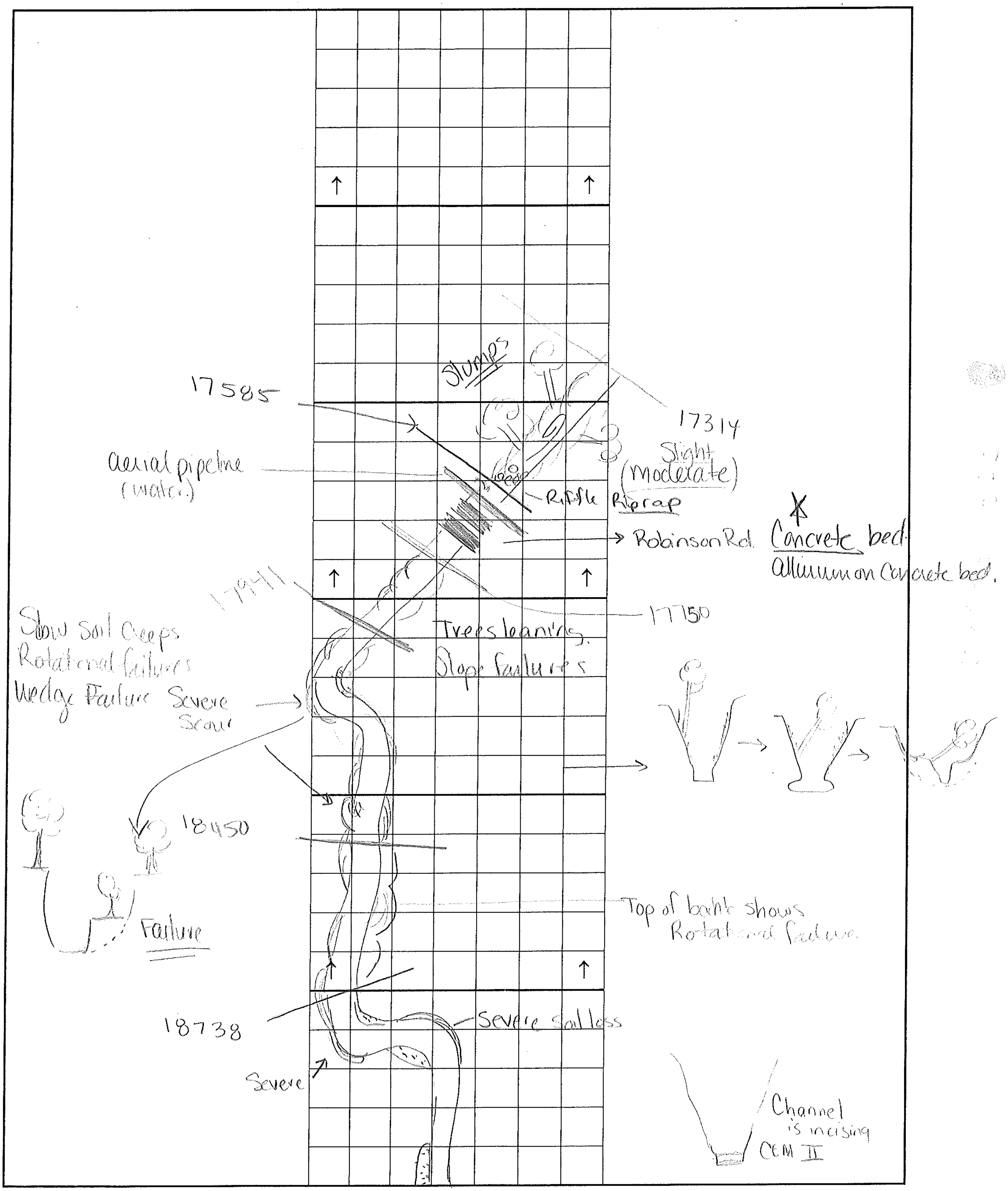

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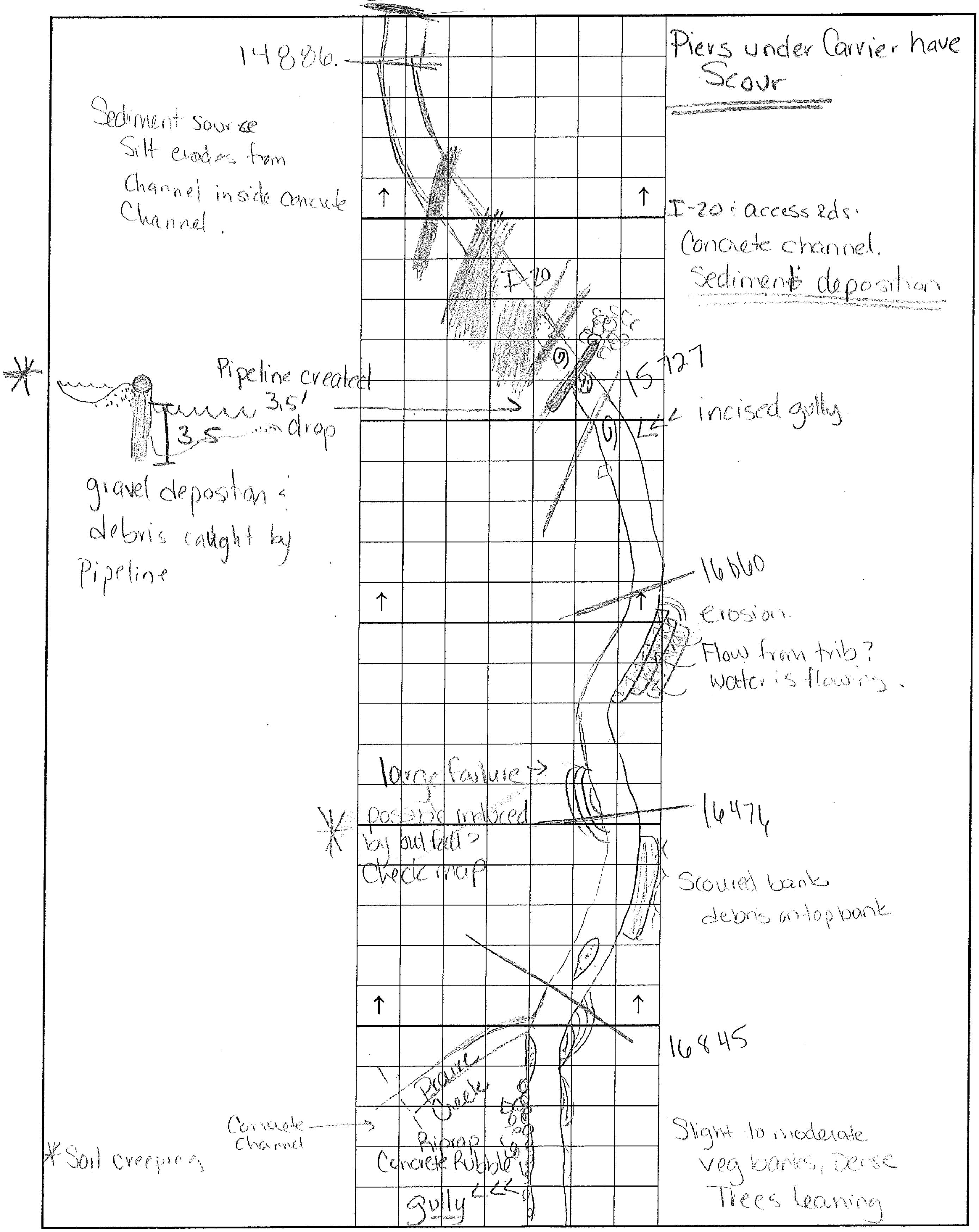

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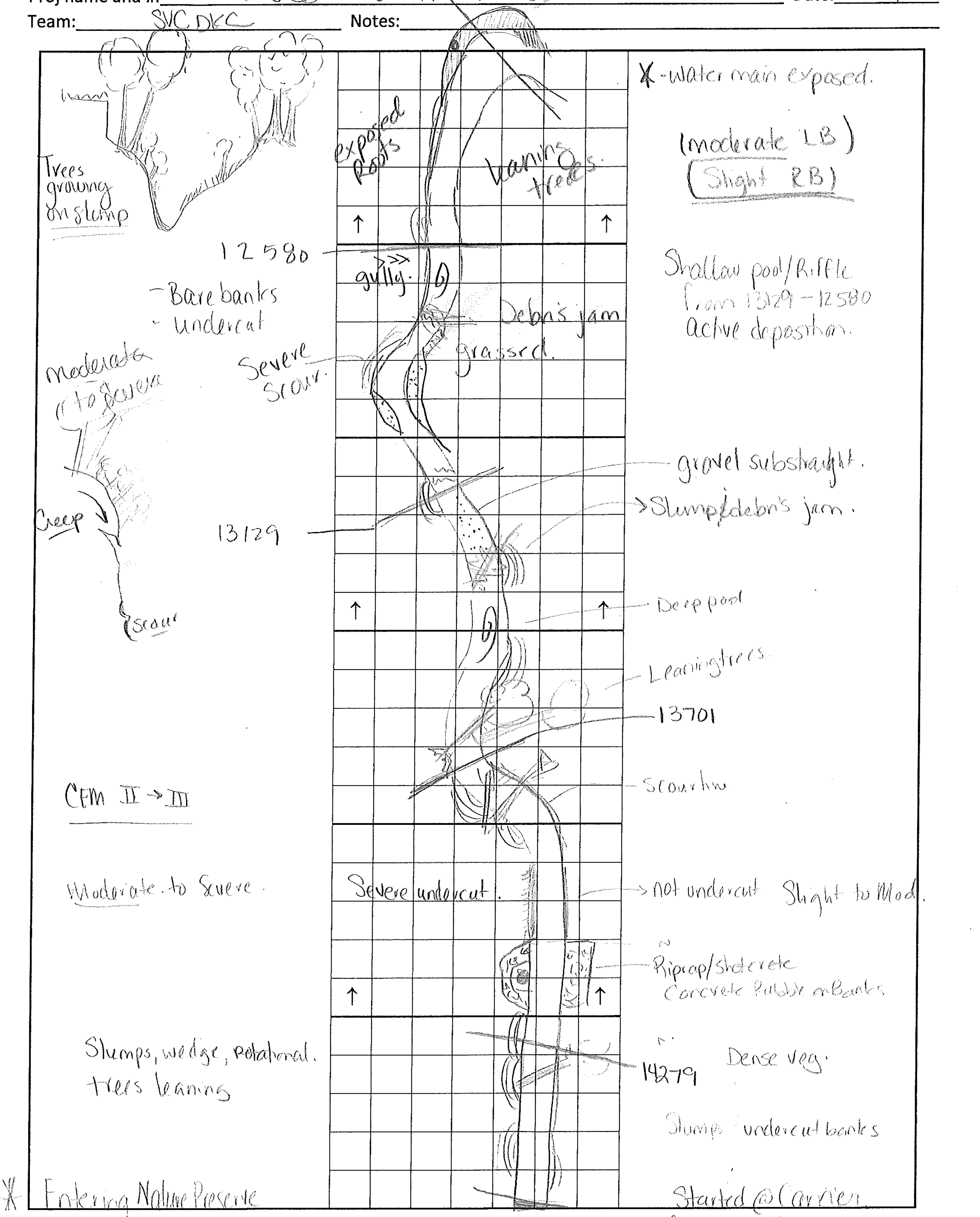

Concrete but scour to piers

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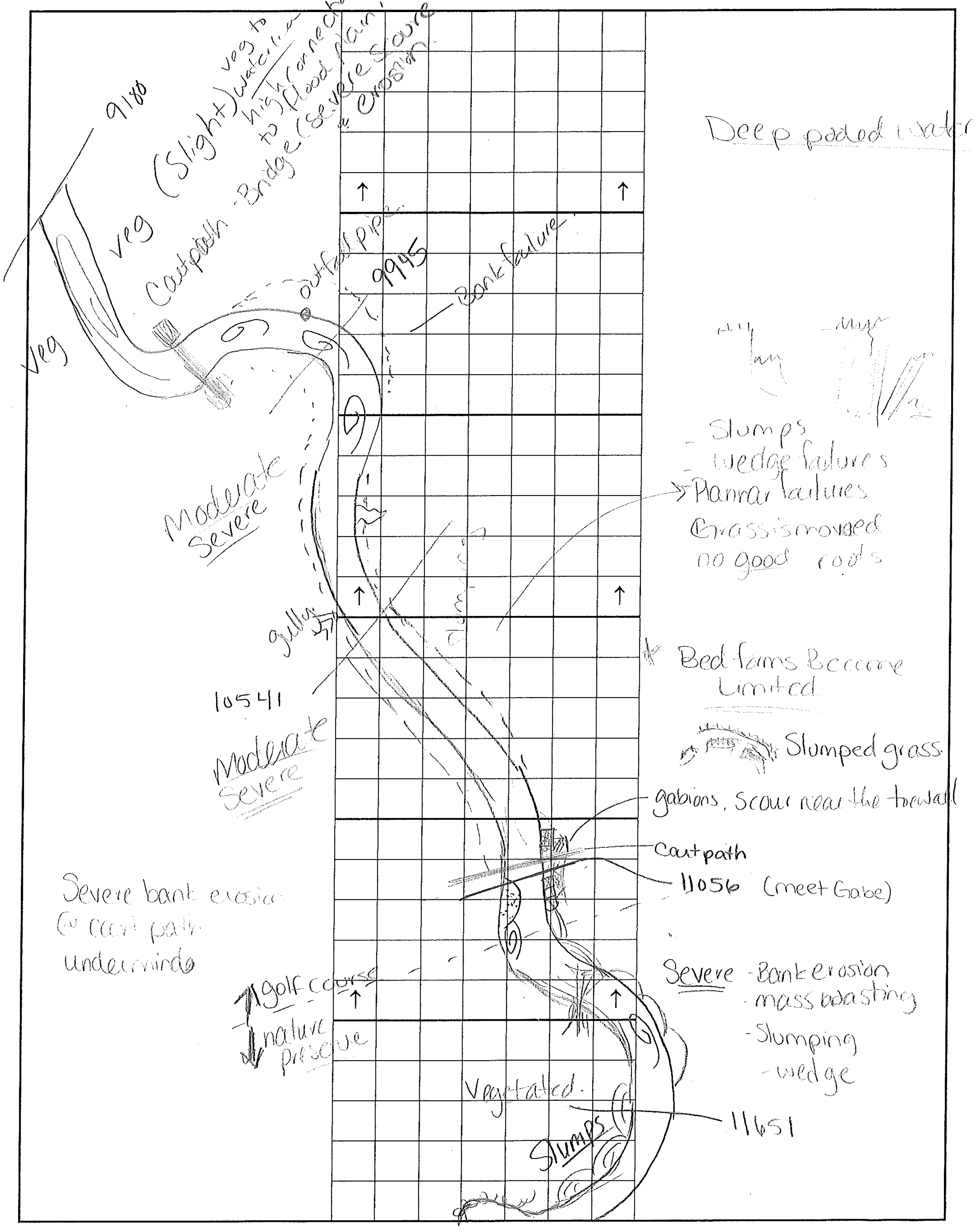

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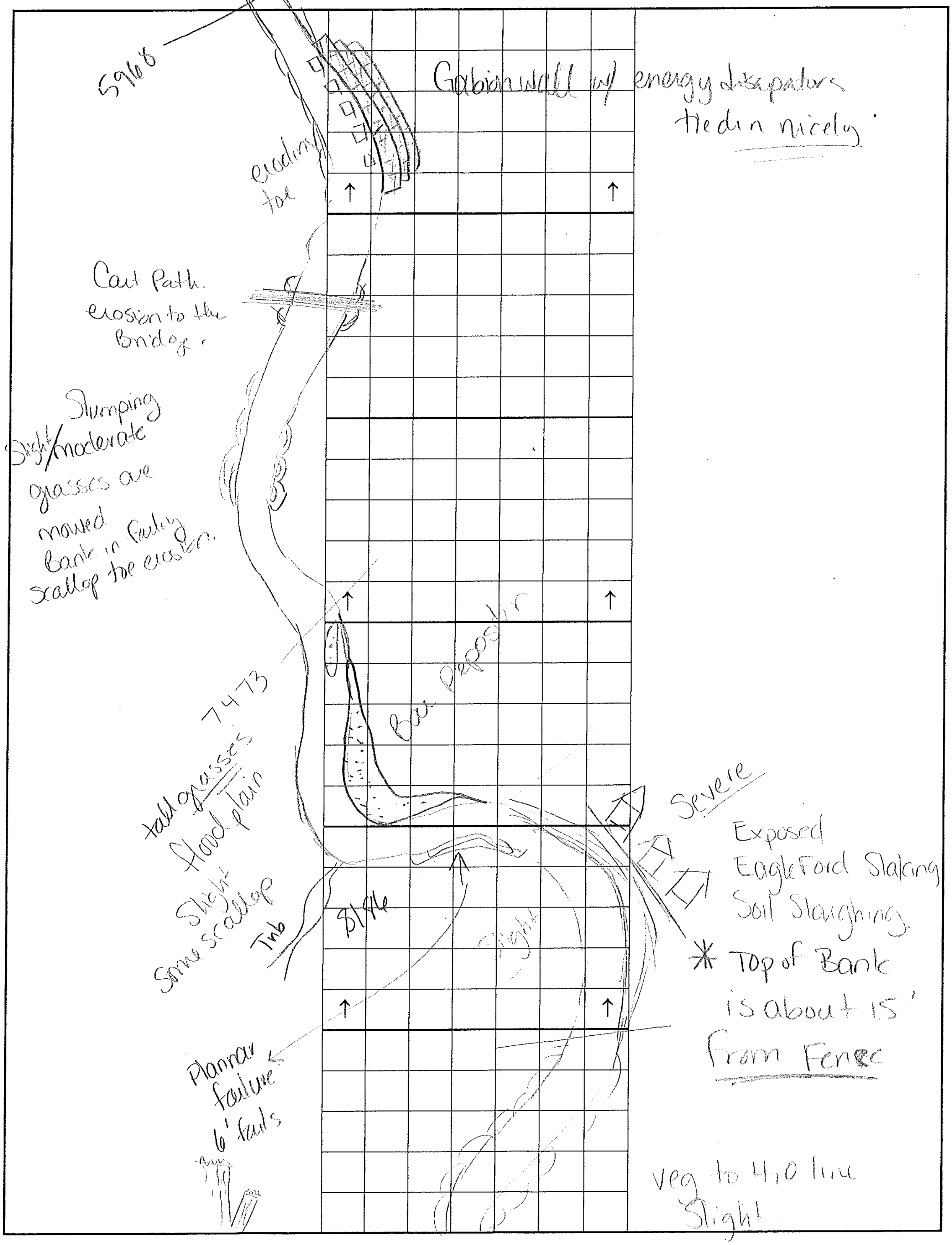

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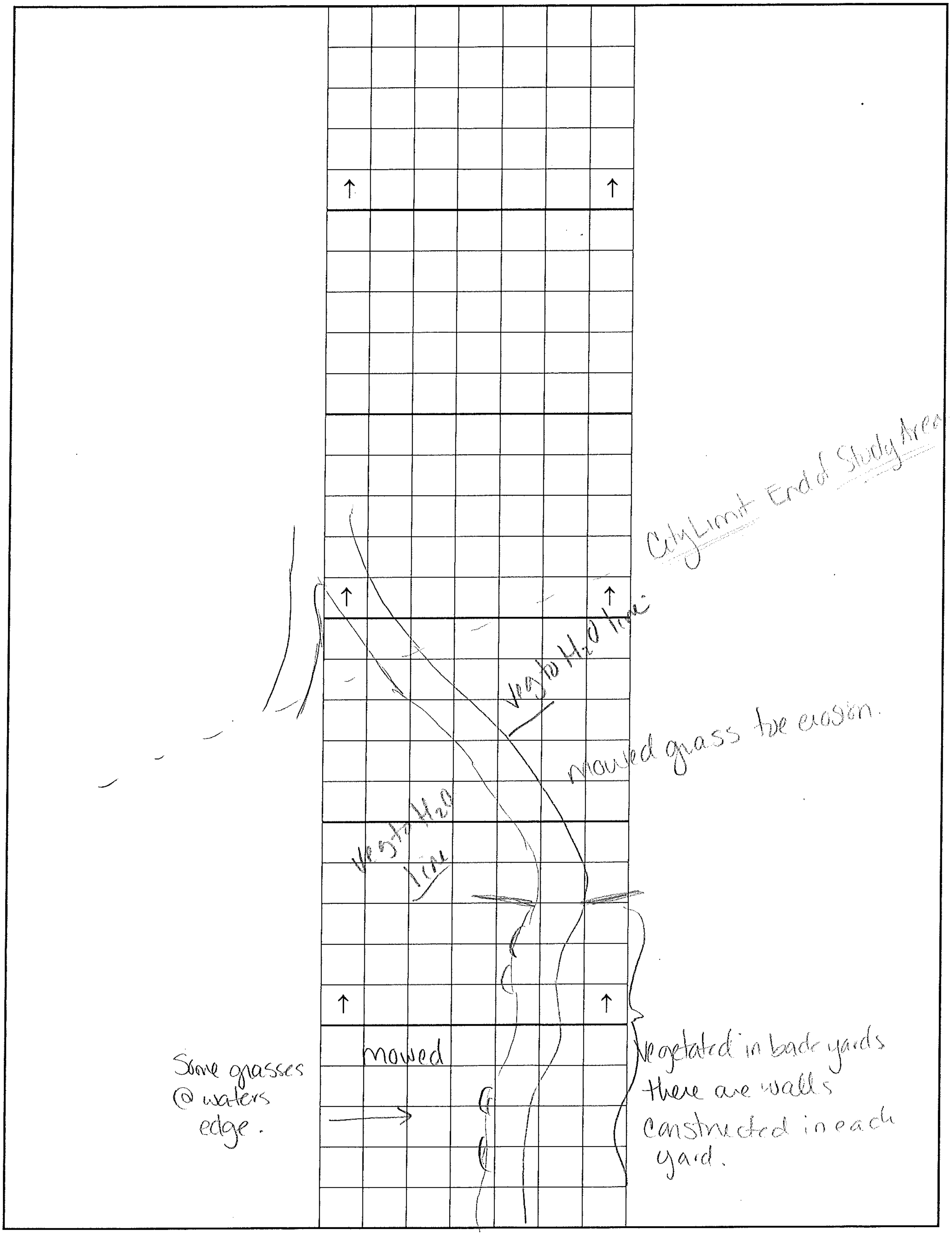

Proj name and #: Fish Creek ESP11227 Praire Creek Date:

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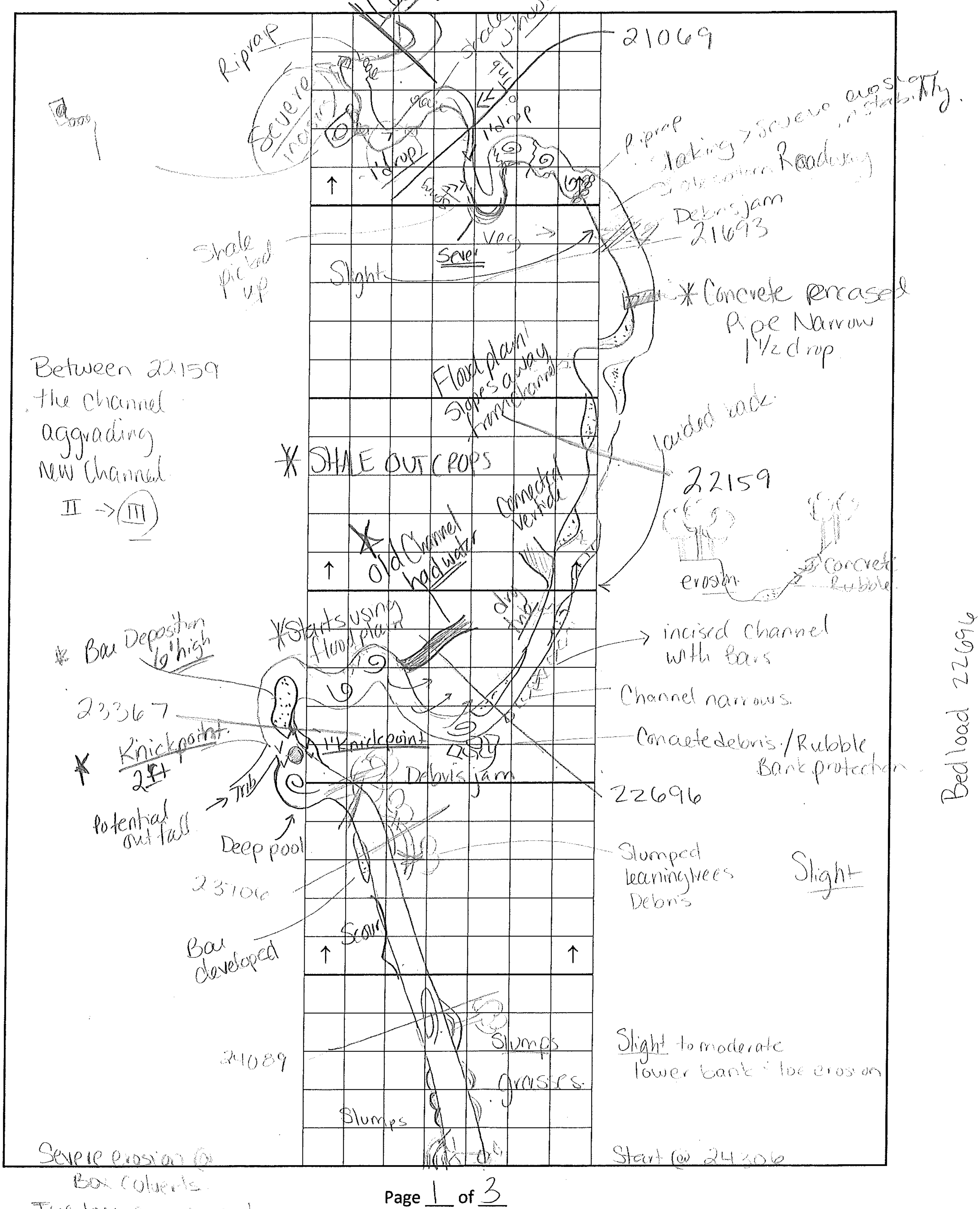

Tree loss, erosion, pipeline exposed, concrete is broken.

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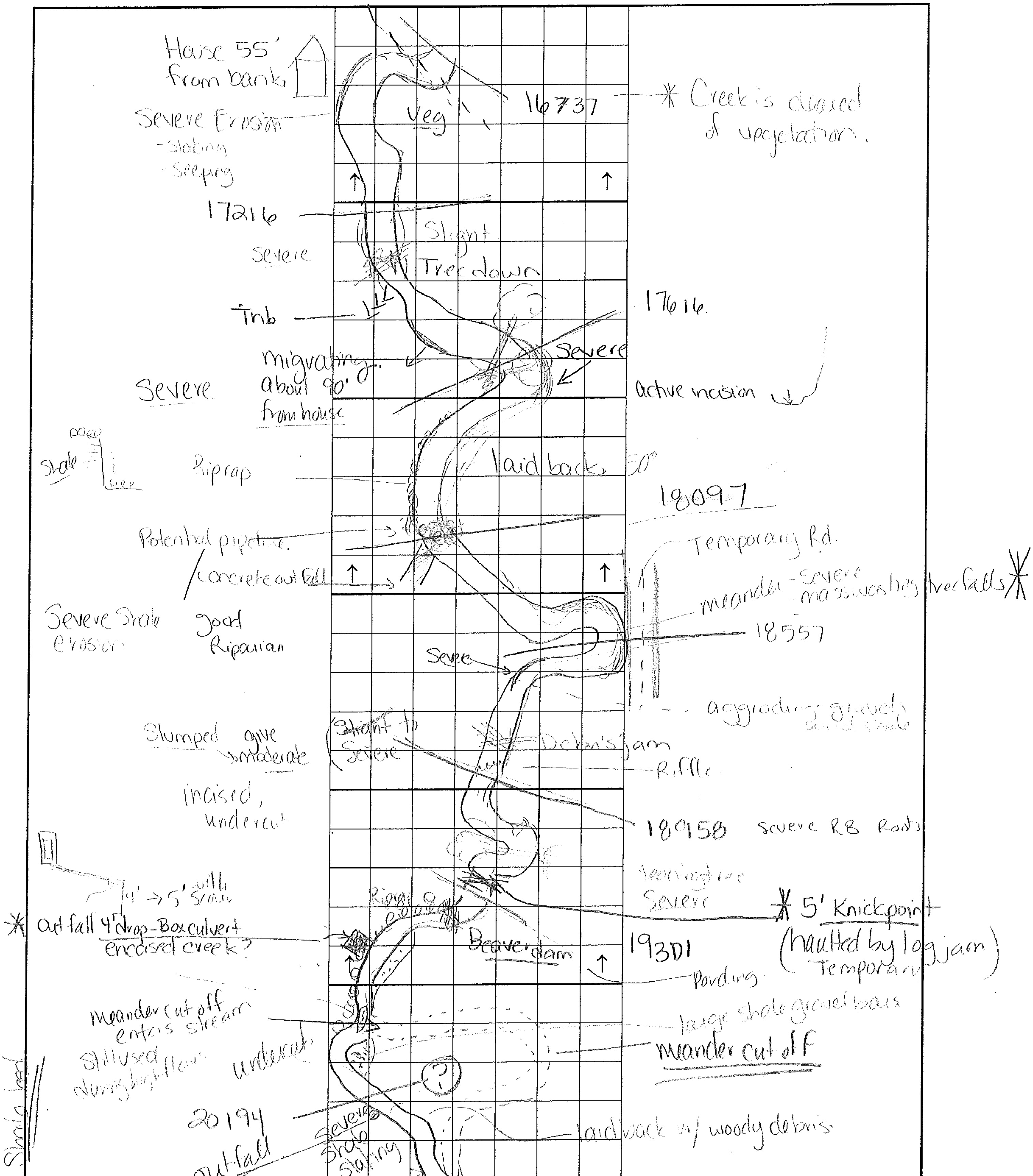

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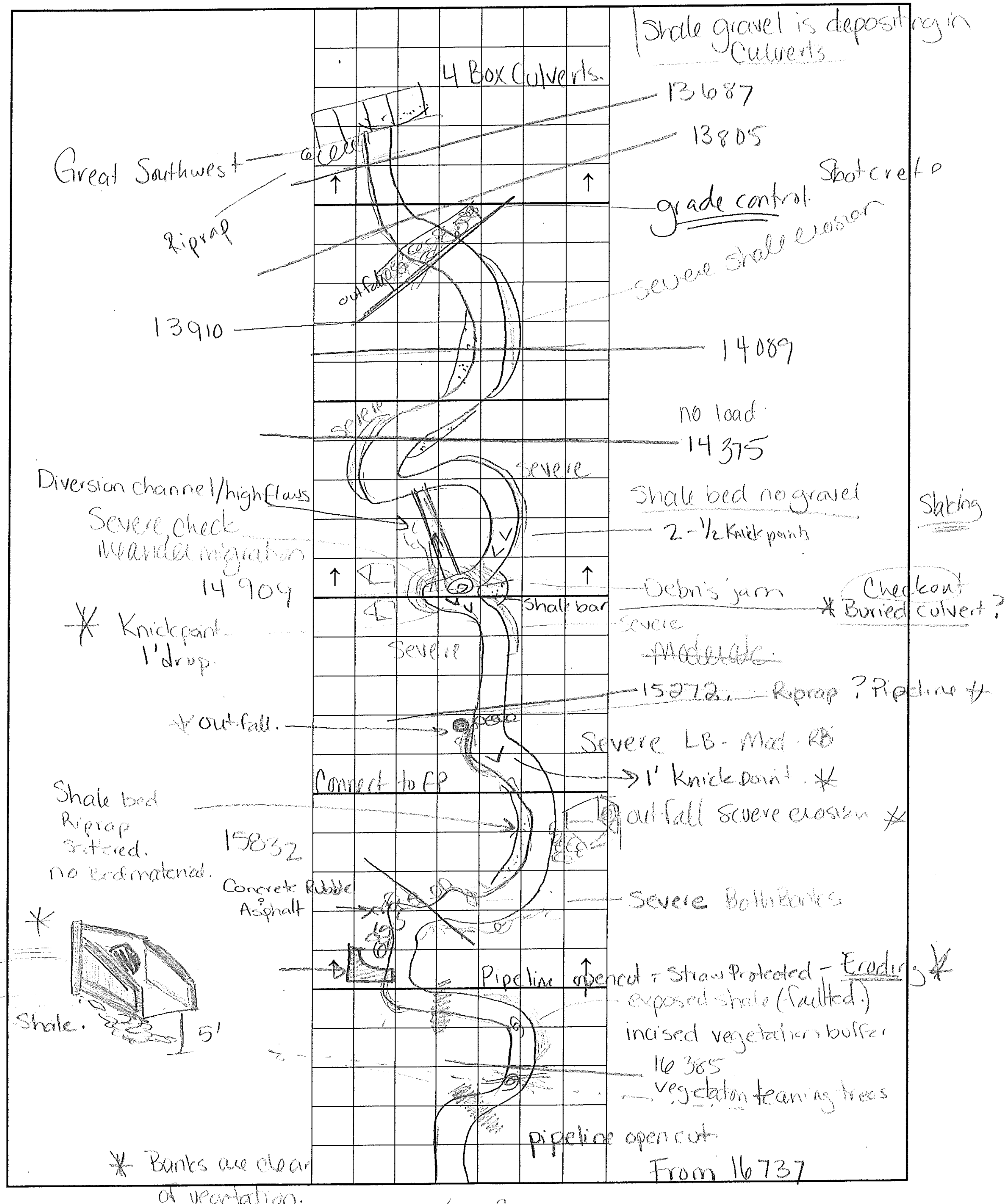

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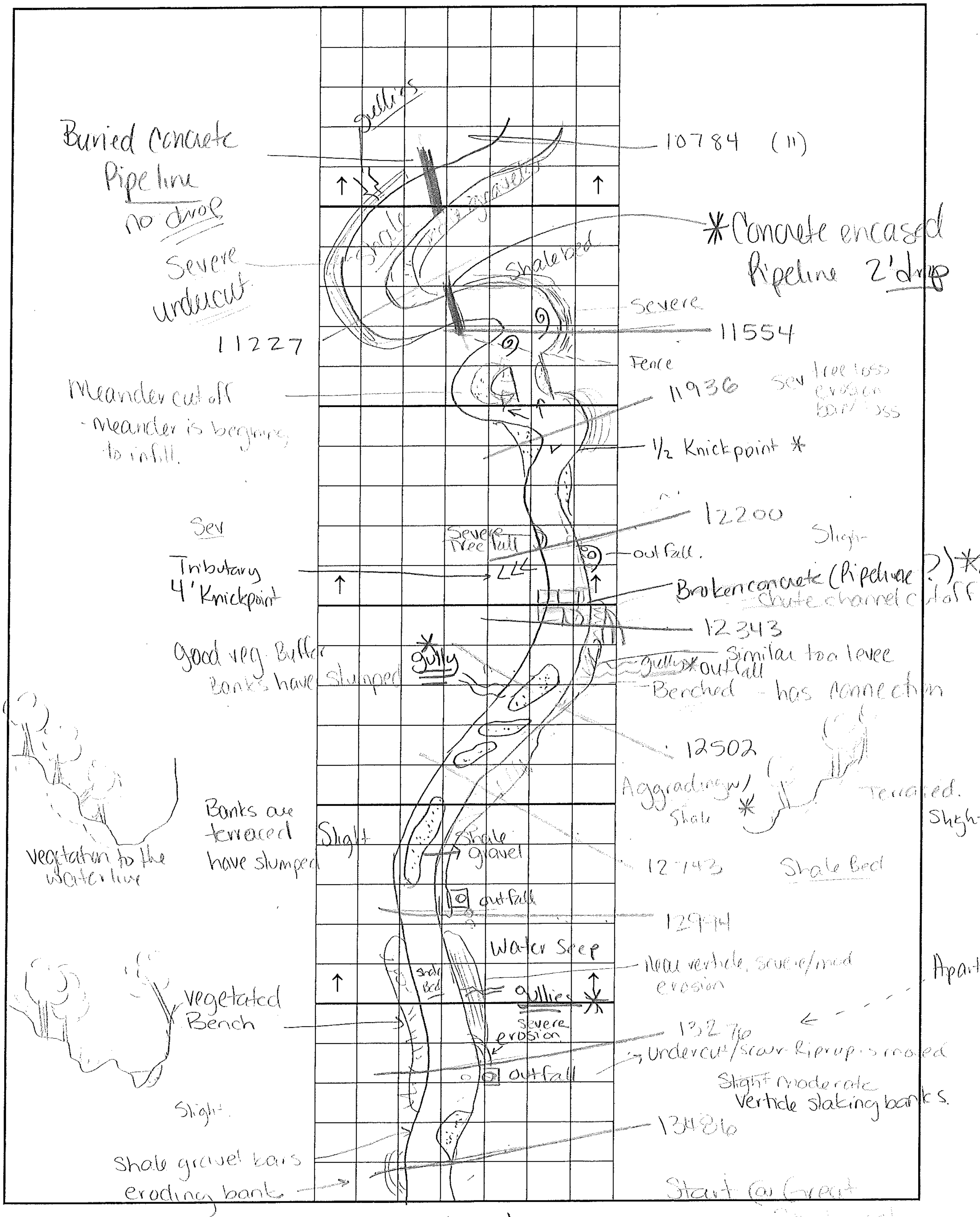
Team: SVC DKC Notes: Prairie Creek



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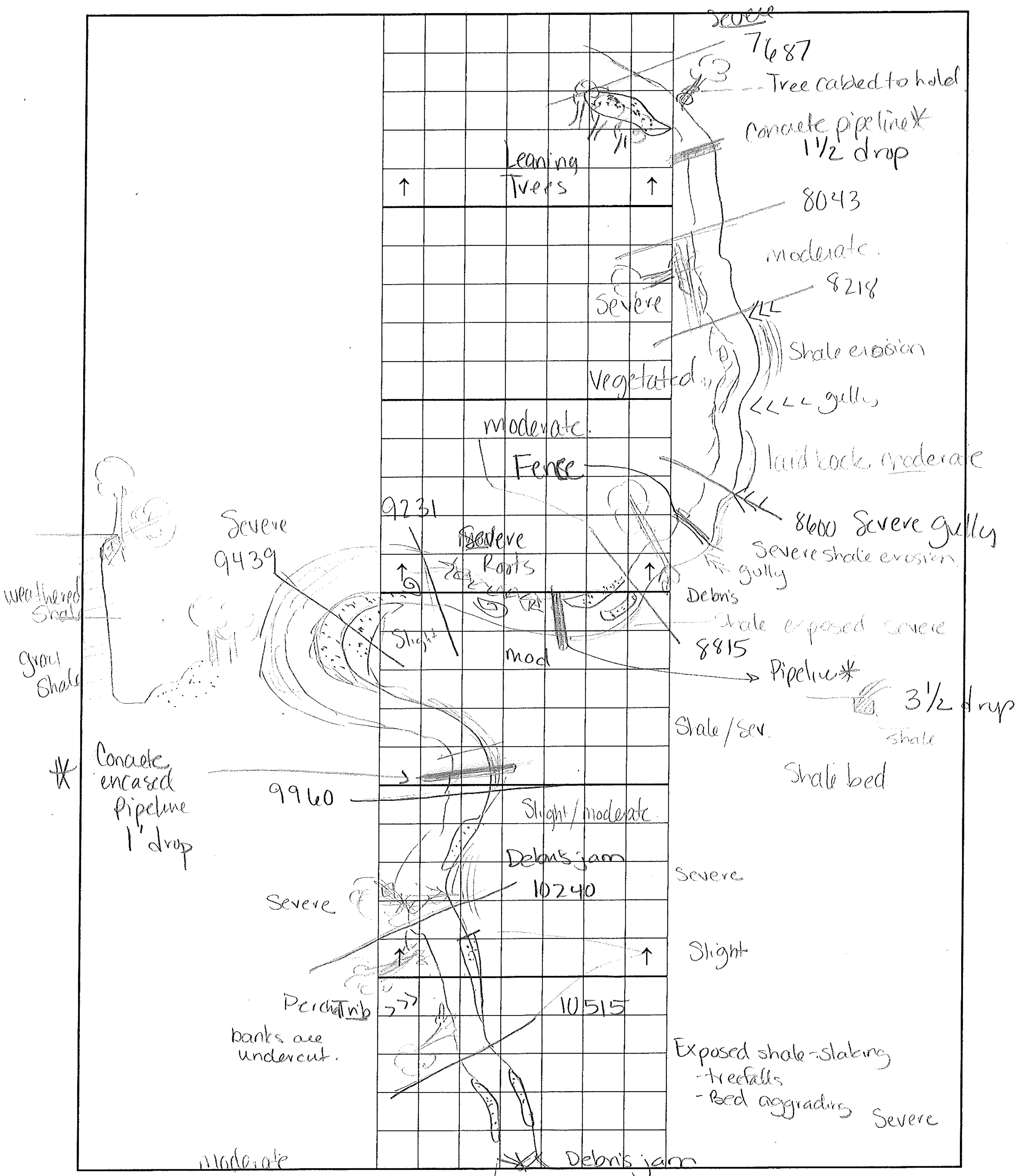

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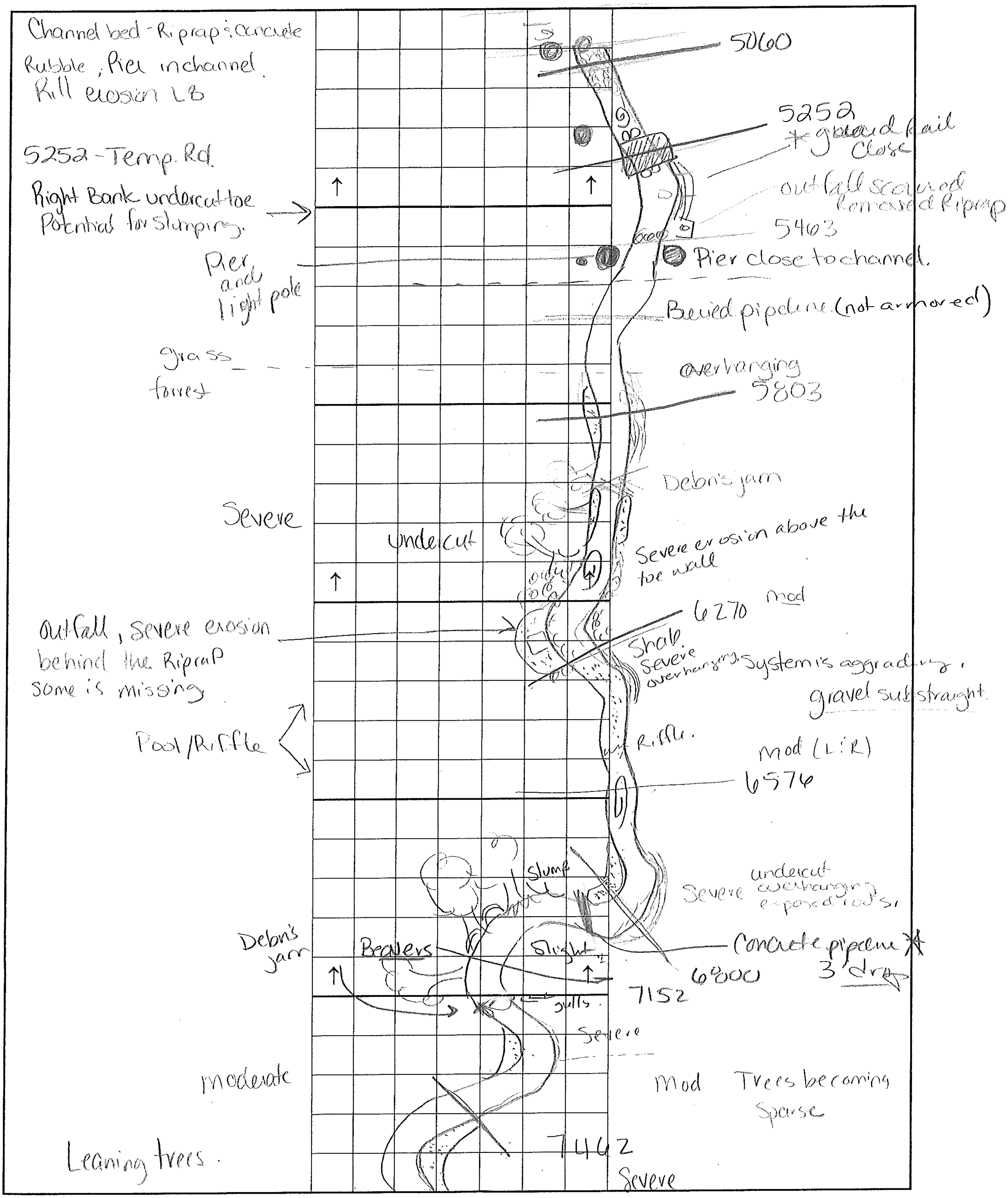

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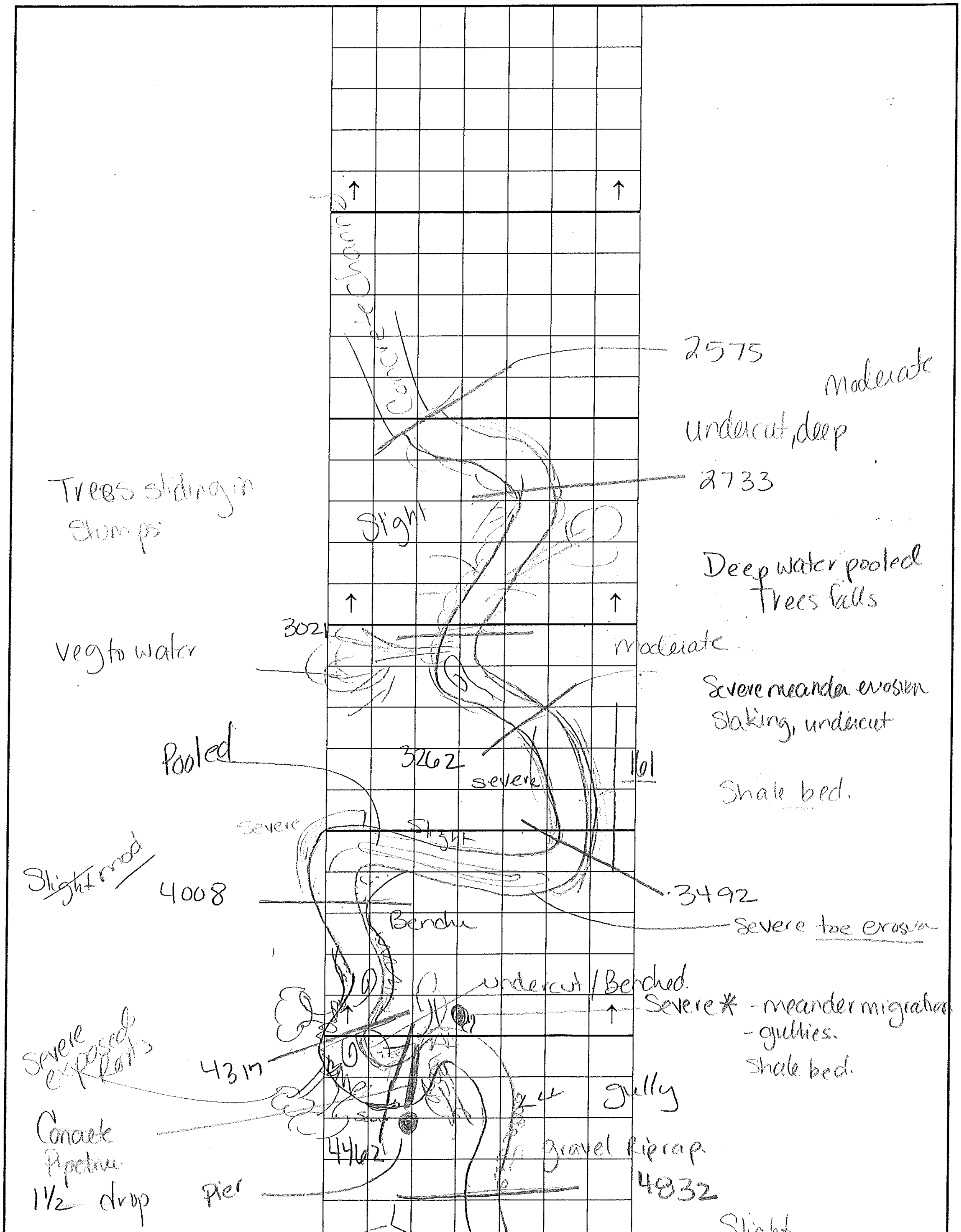
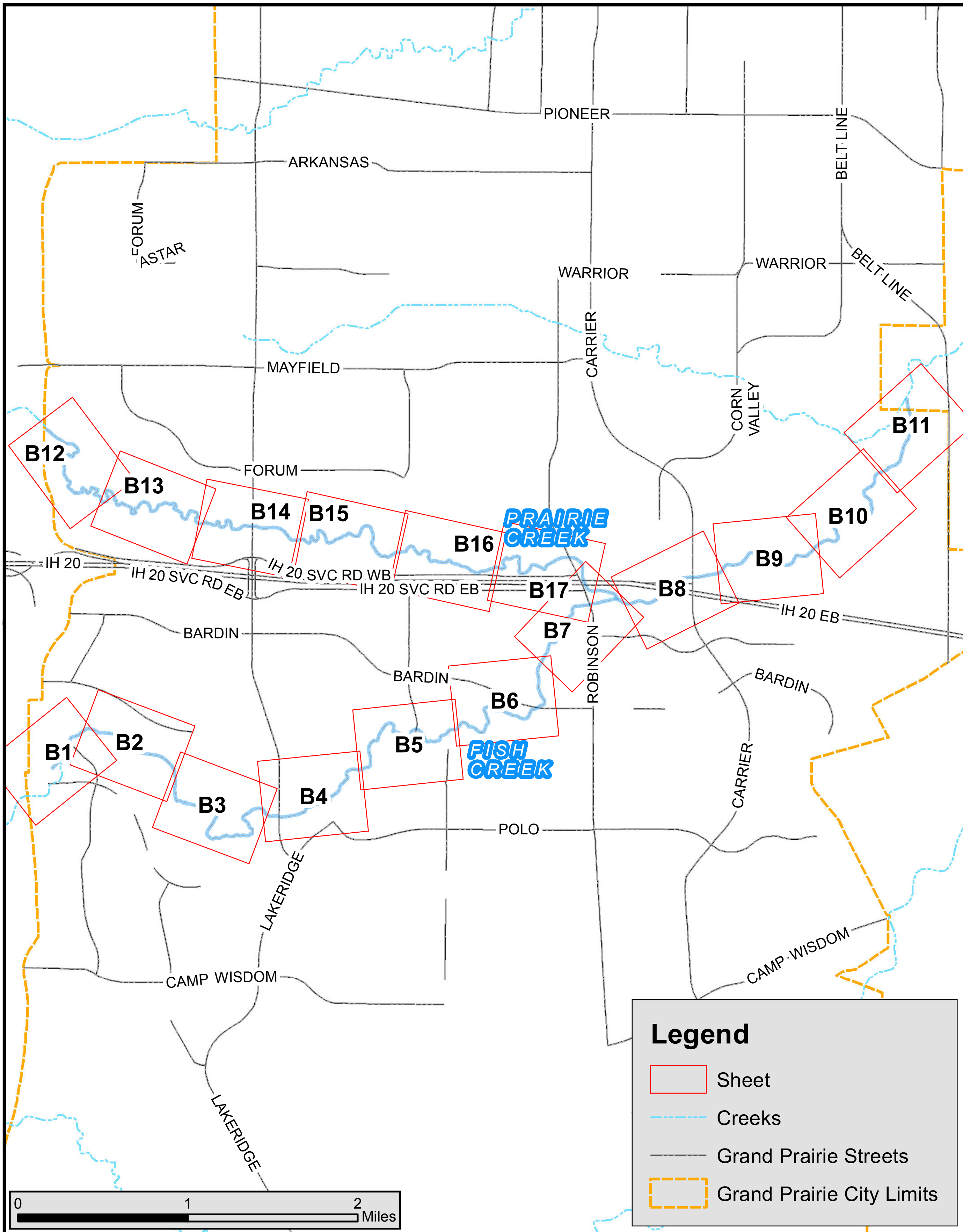


Slight.

exposed alluvium bare, sparse to no veg.

Appendix B



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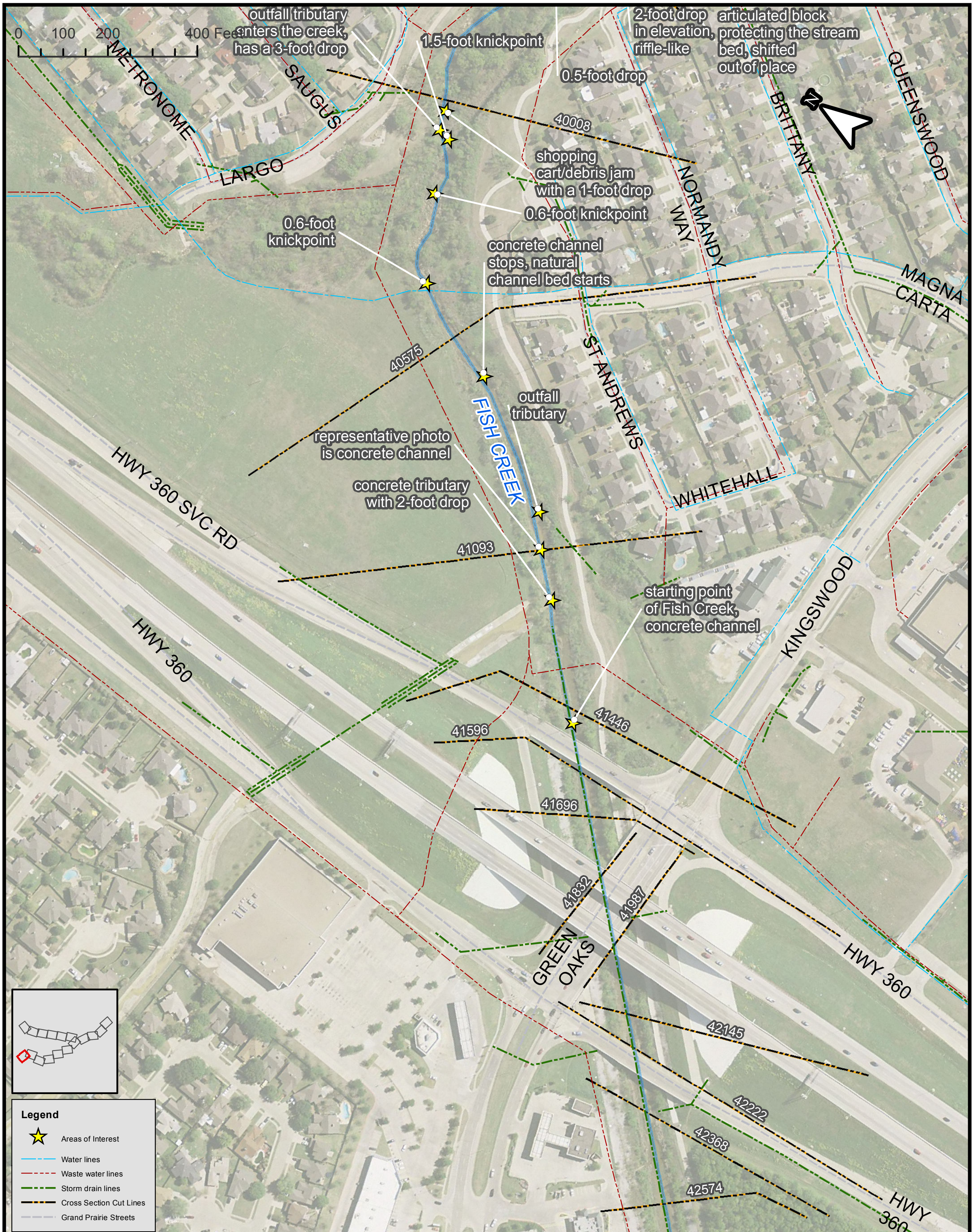
B

FIGURE



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B1
FIGURE

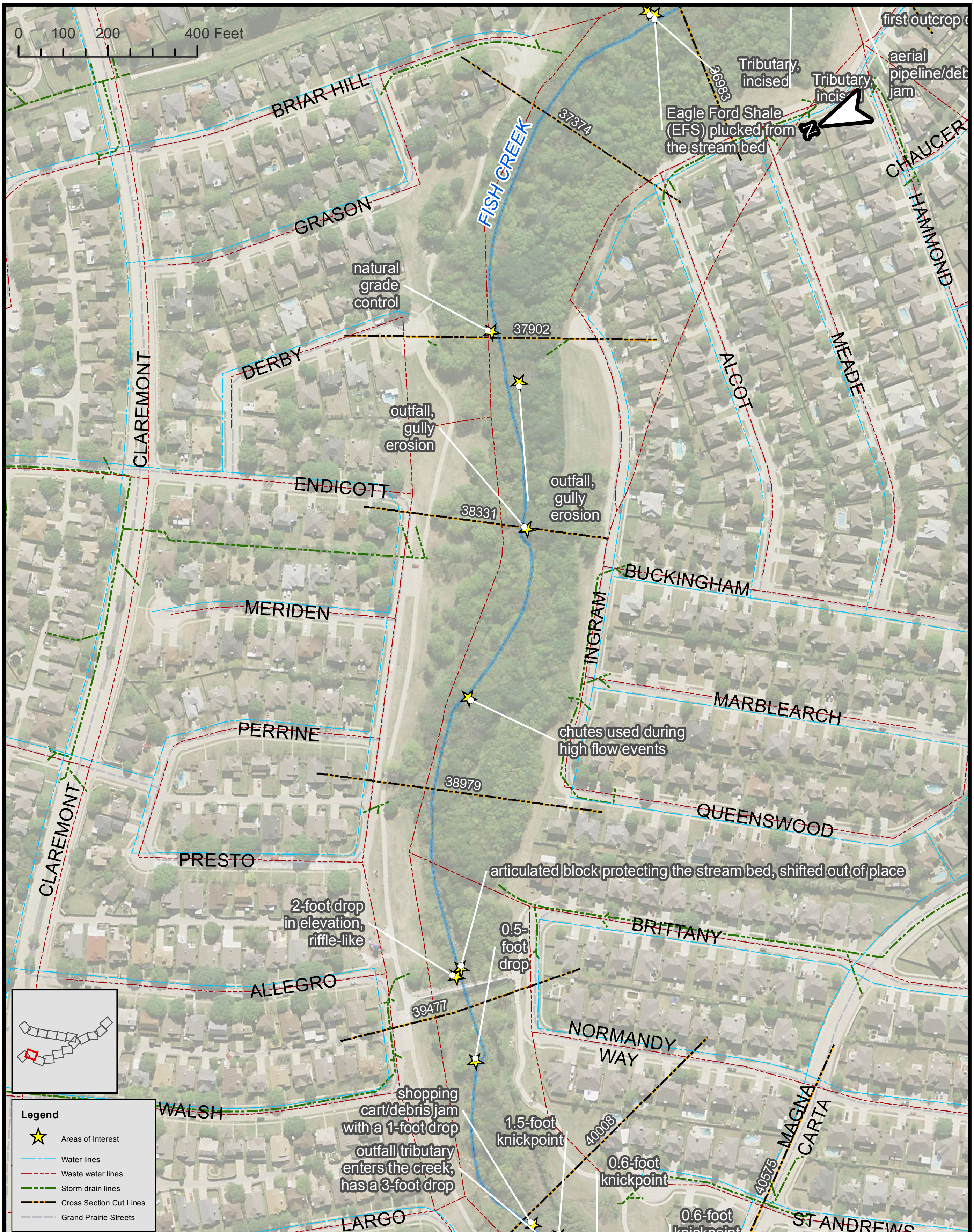

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FIGURE

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FIGURE

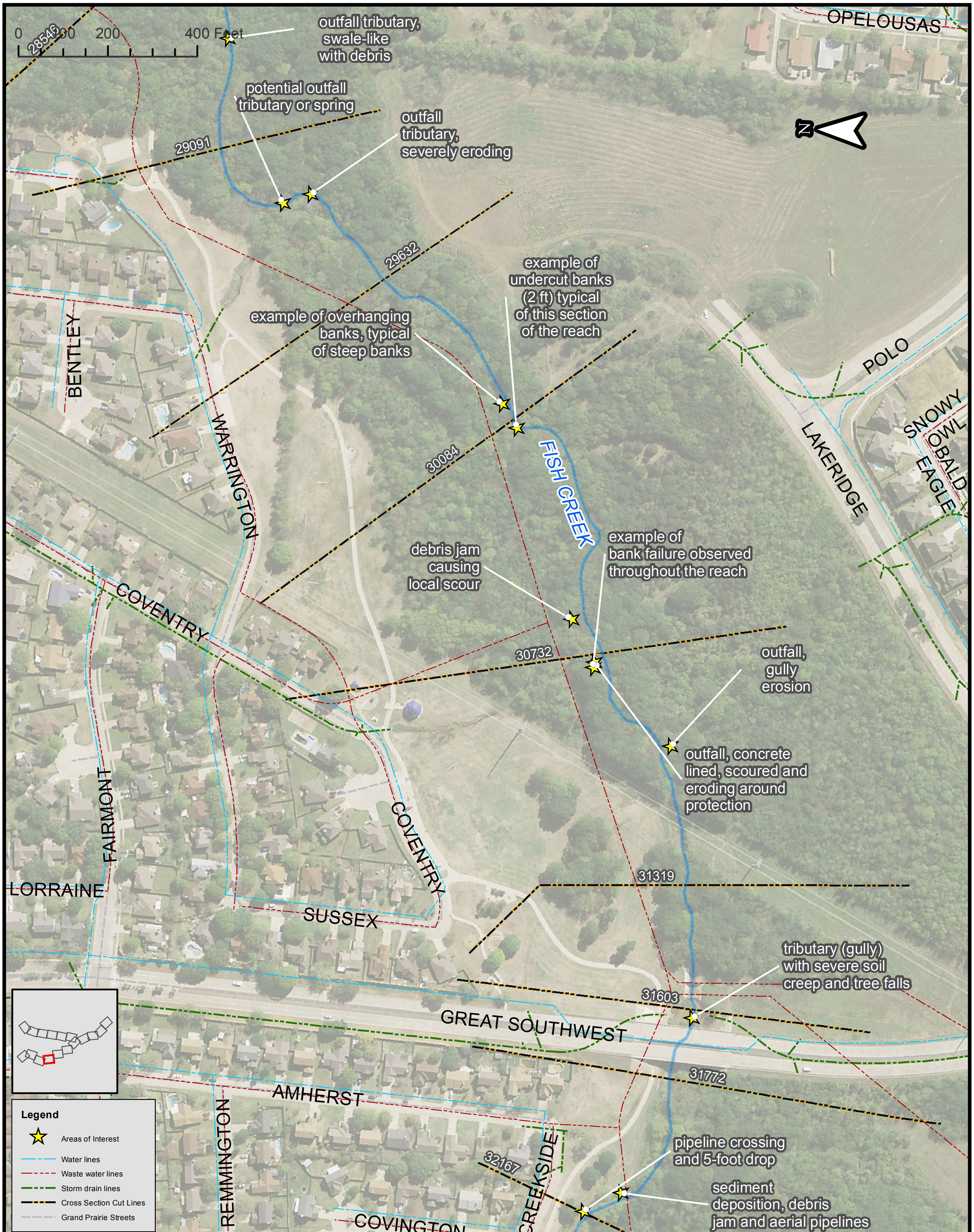

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FIGURE B4

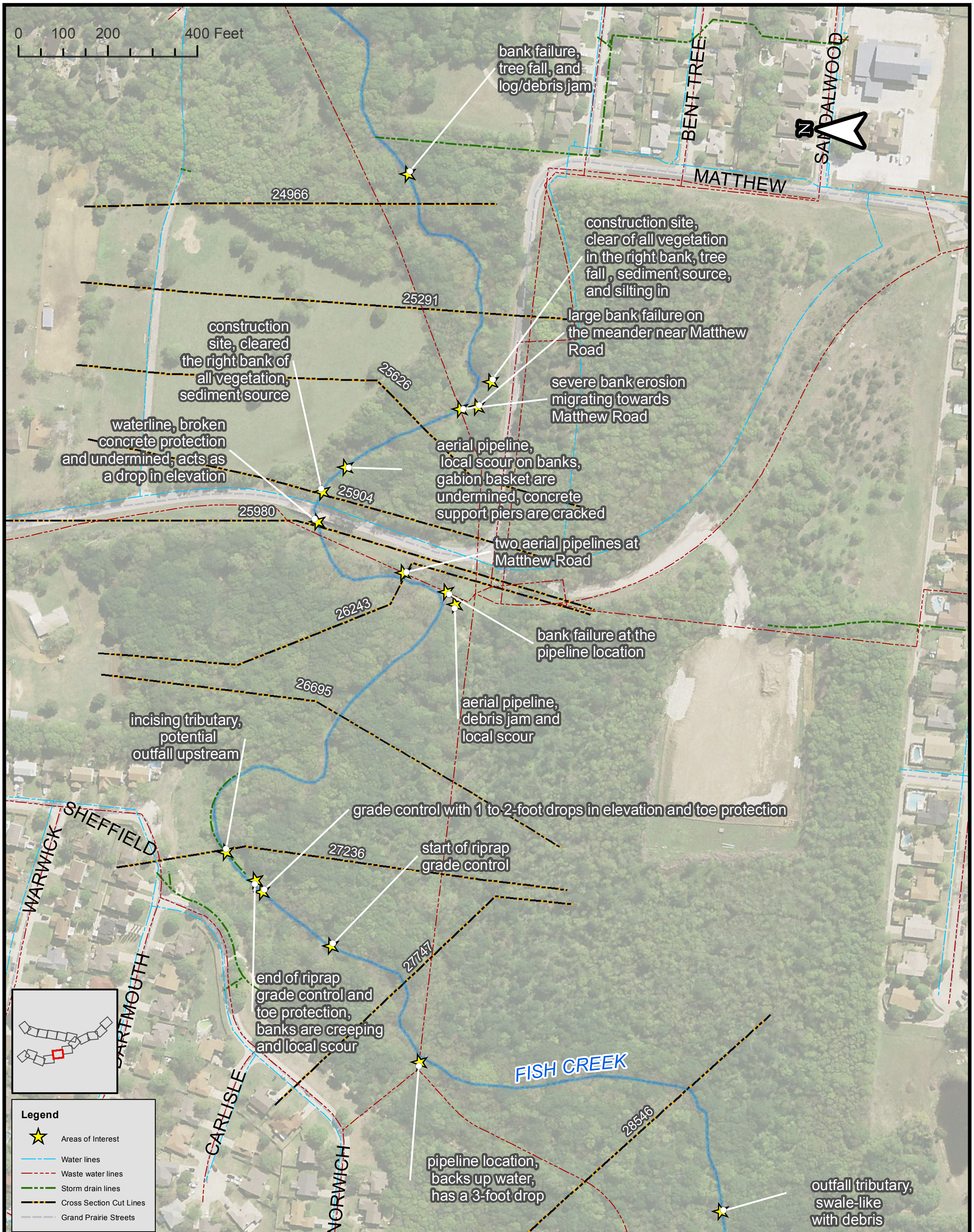

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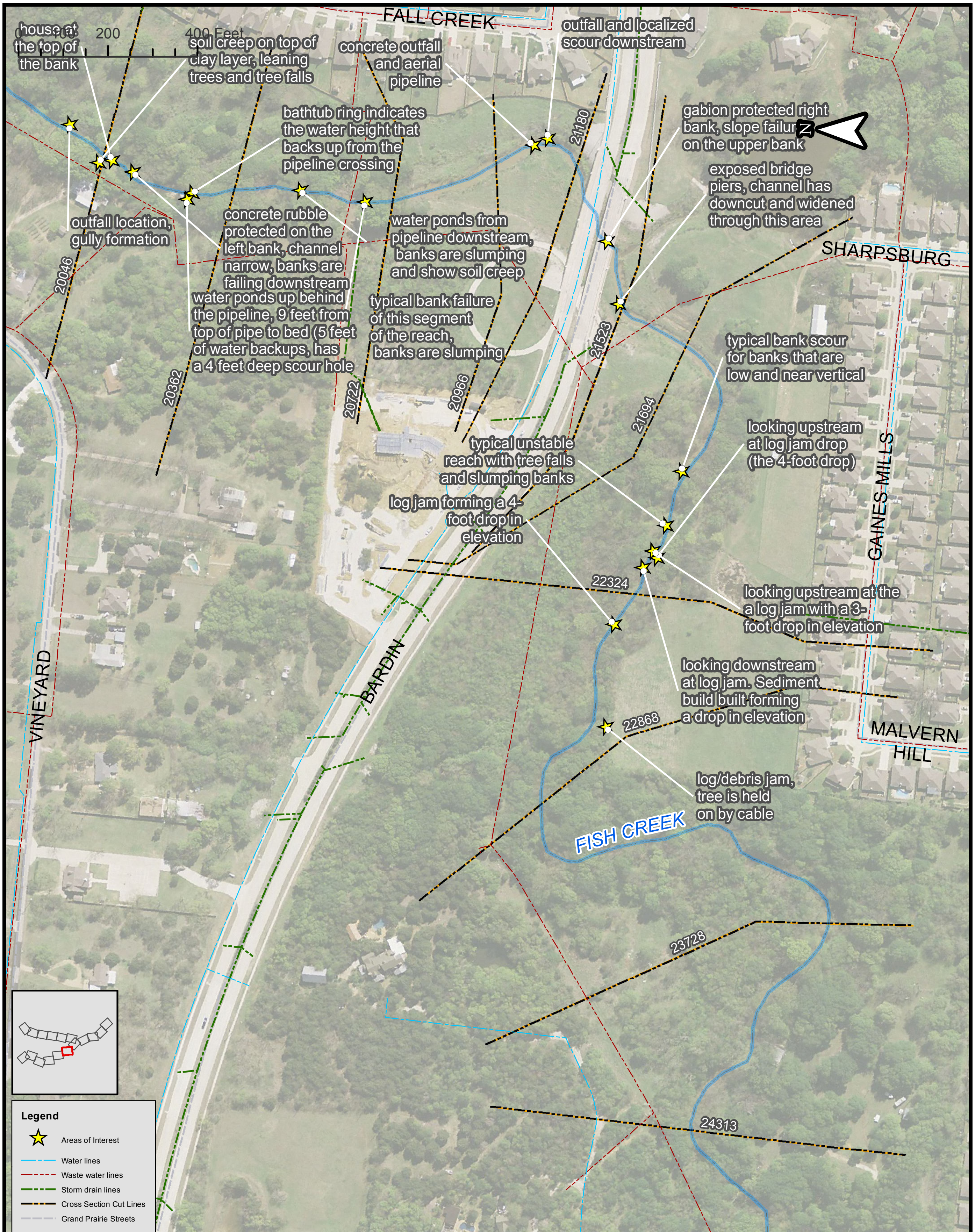
FIGURE



Freese and Nichols 4055 International Plaza, Suite 200 Fort Worth, TX 76109 - 4895 Phone - (817) 735 - 7300	**Fish Creek Geomorphic Stream Assessment** **Areas of Interest**	FN JOB NO ESP11227 FILE APP_B_AOI.mxd DATE June 21 2012 SCALE 1:3,600 DESIGNED SVC DRAFTED DKC	**B6** **FIGURE**

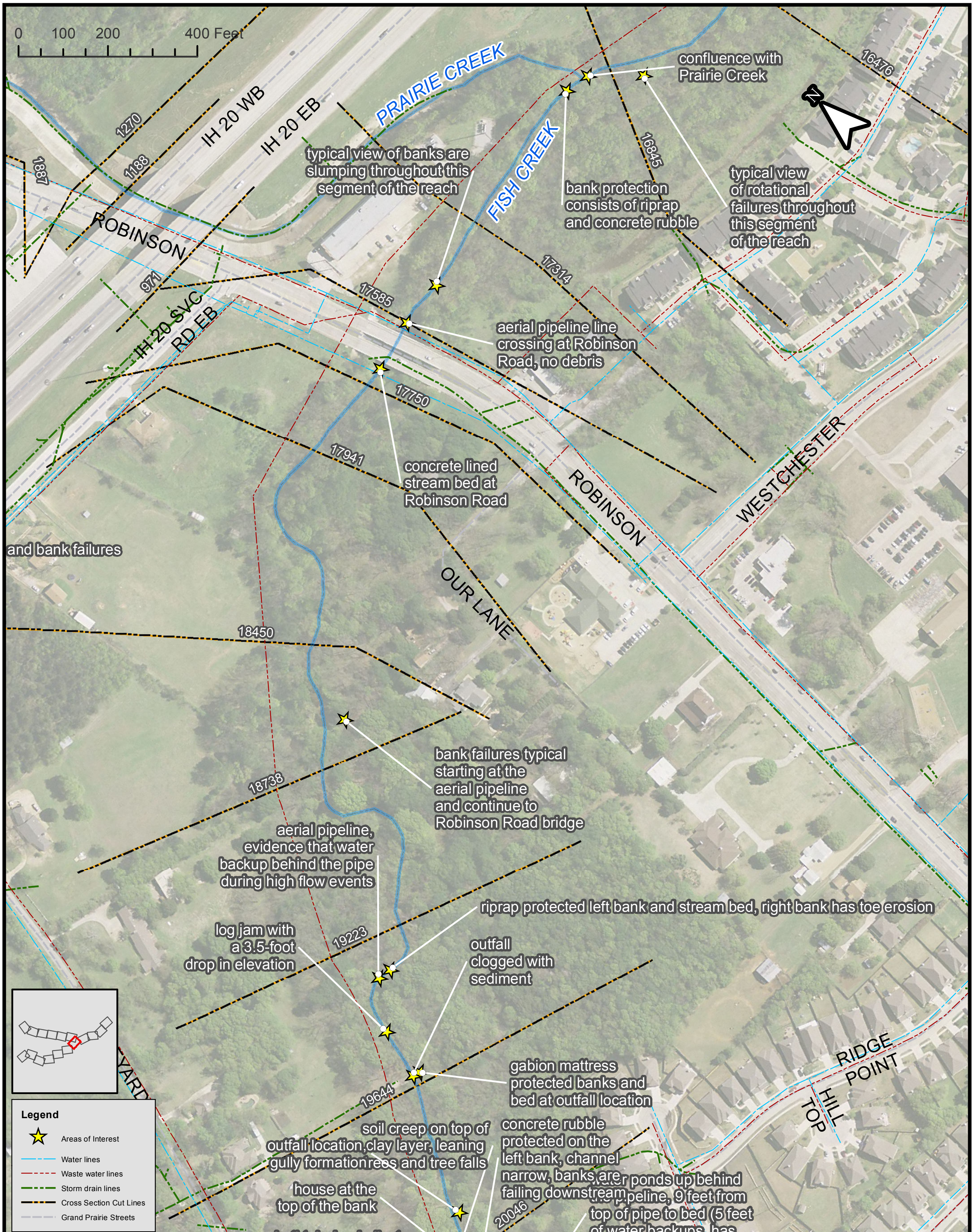


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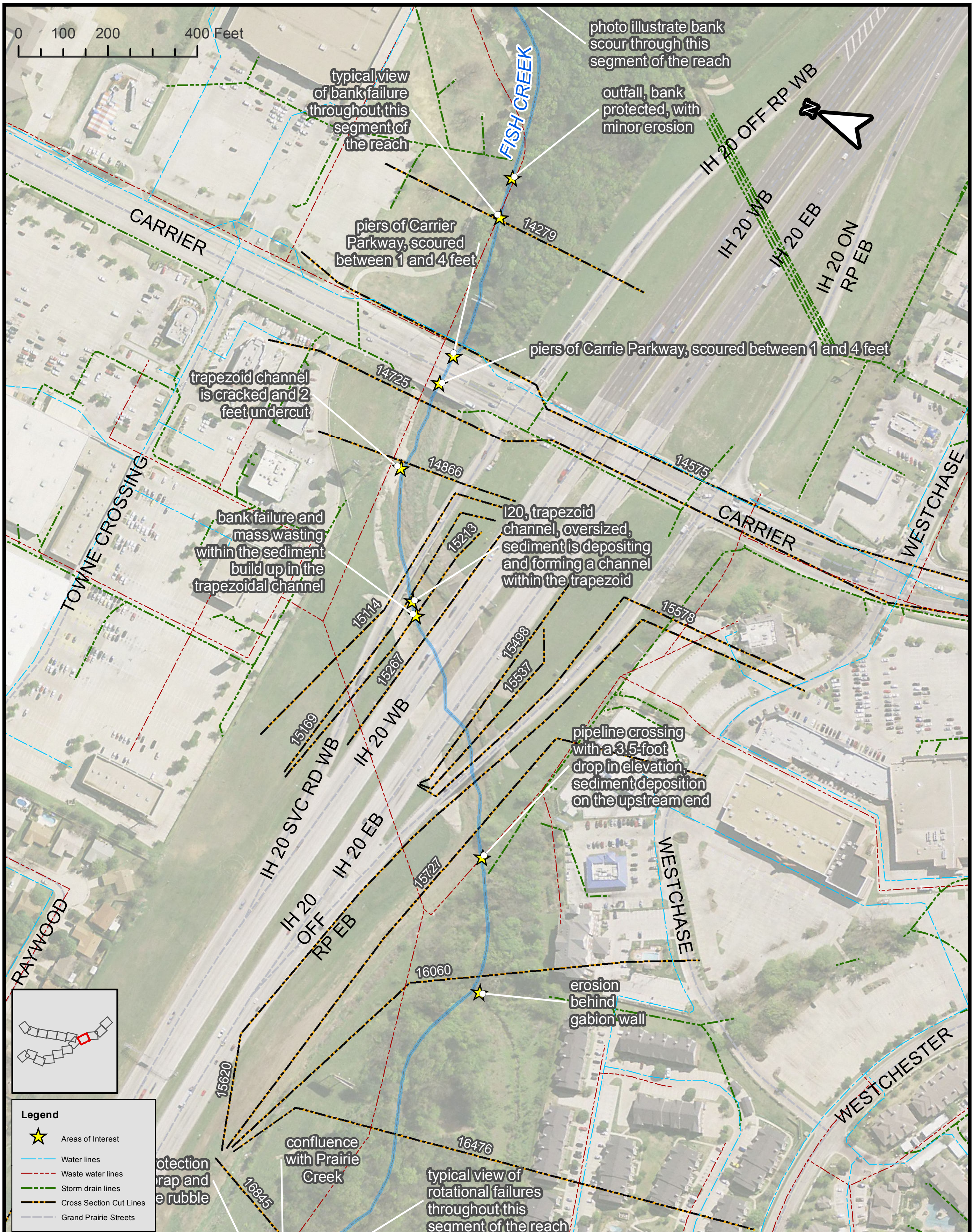
FIGURE



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	Areas of Interest	SCALE: 1:3,600 DESIGNED: SVC DRAFTED: DKC	**FIGURE**

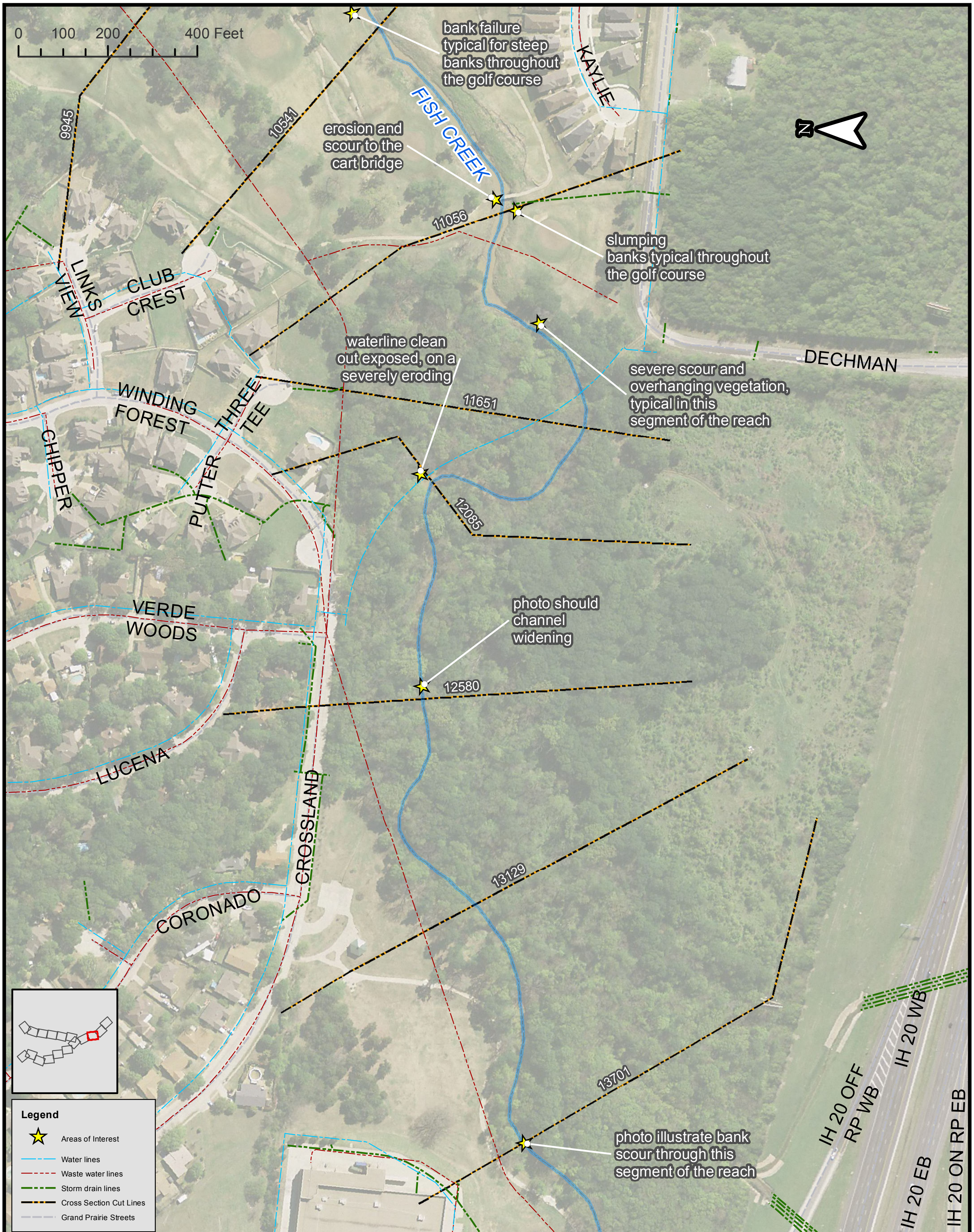

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FIGURE

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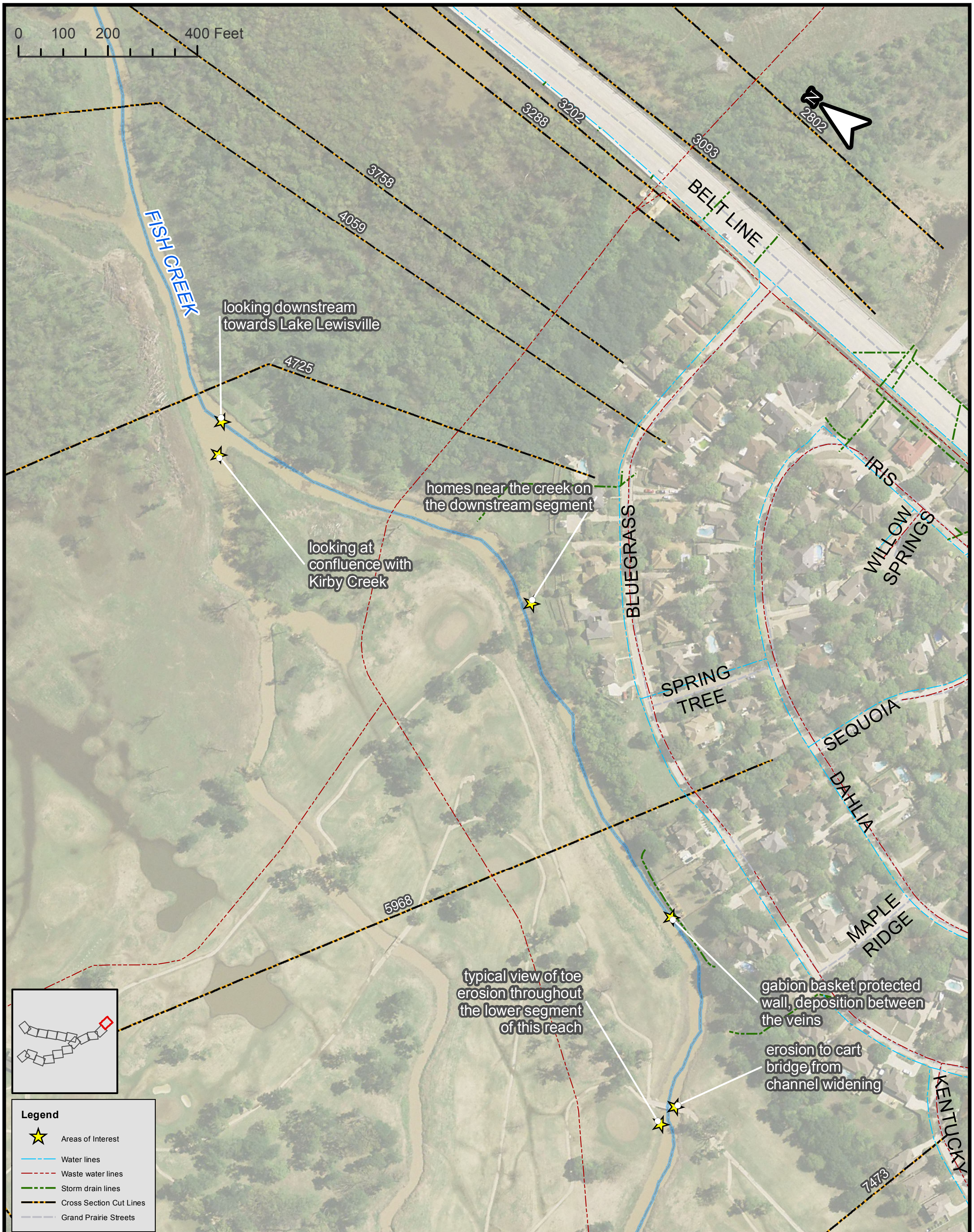

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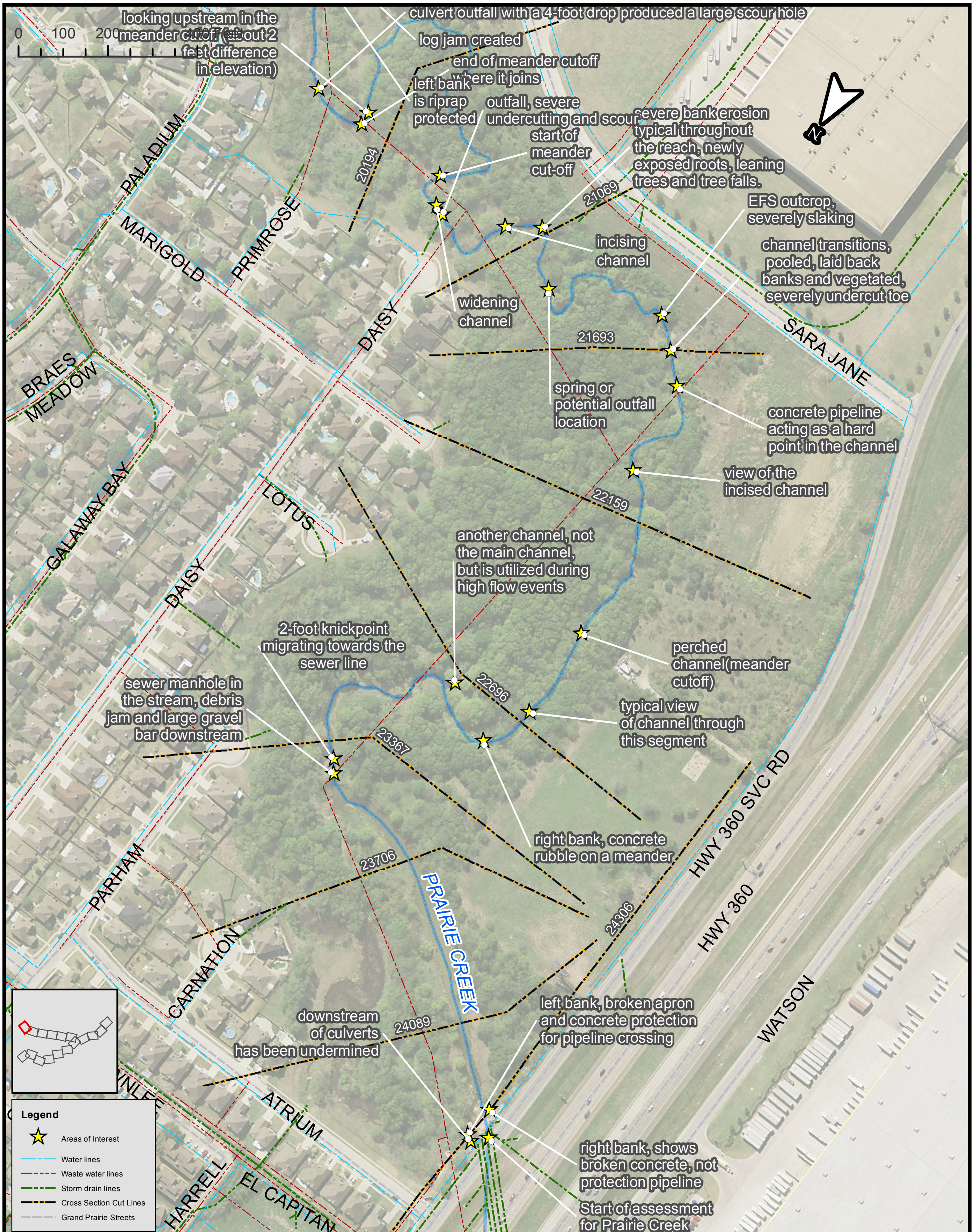

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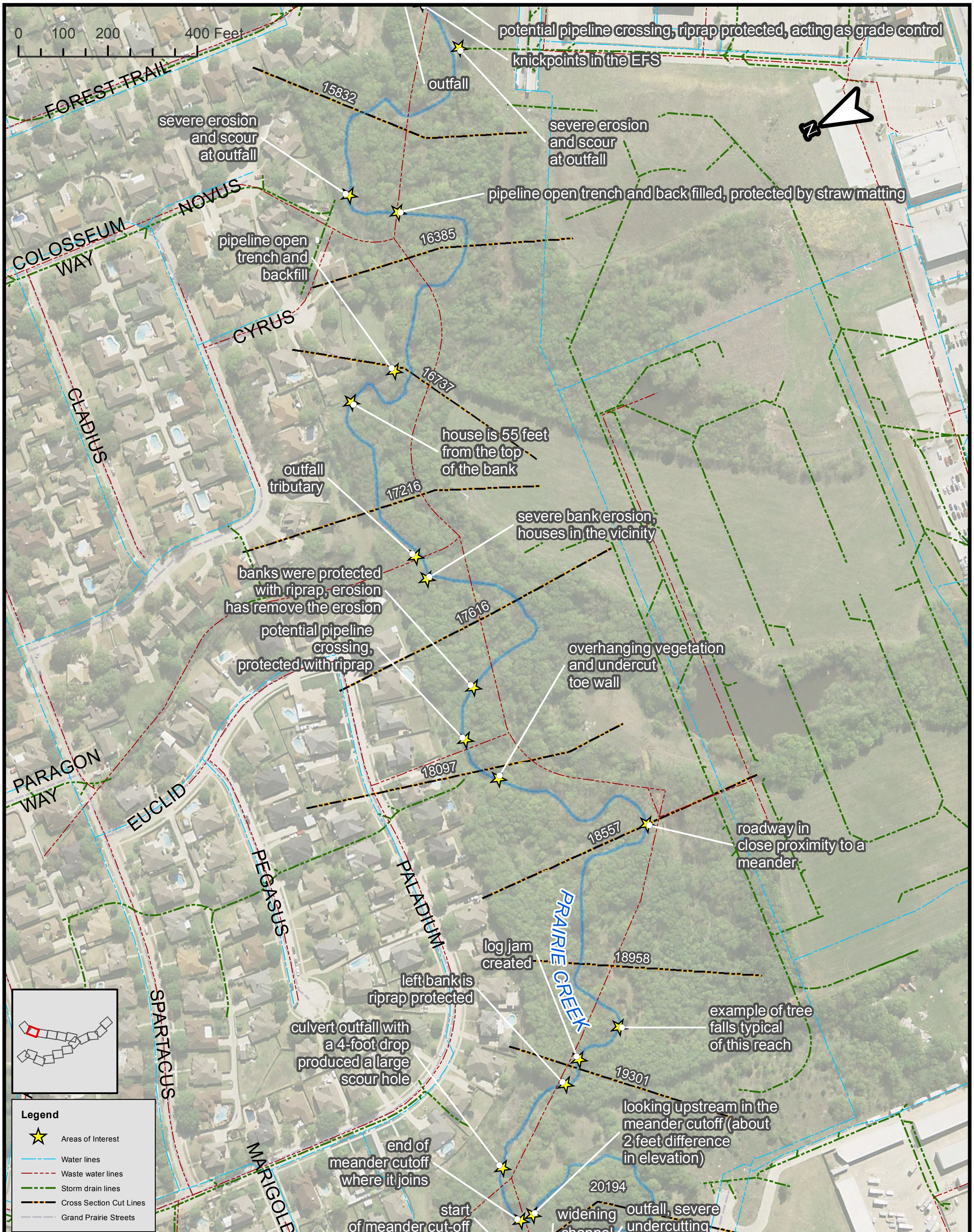

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FIGURE

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FIGURE

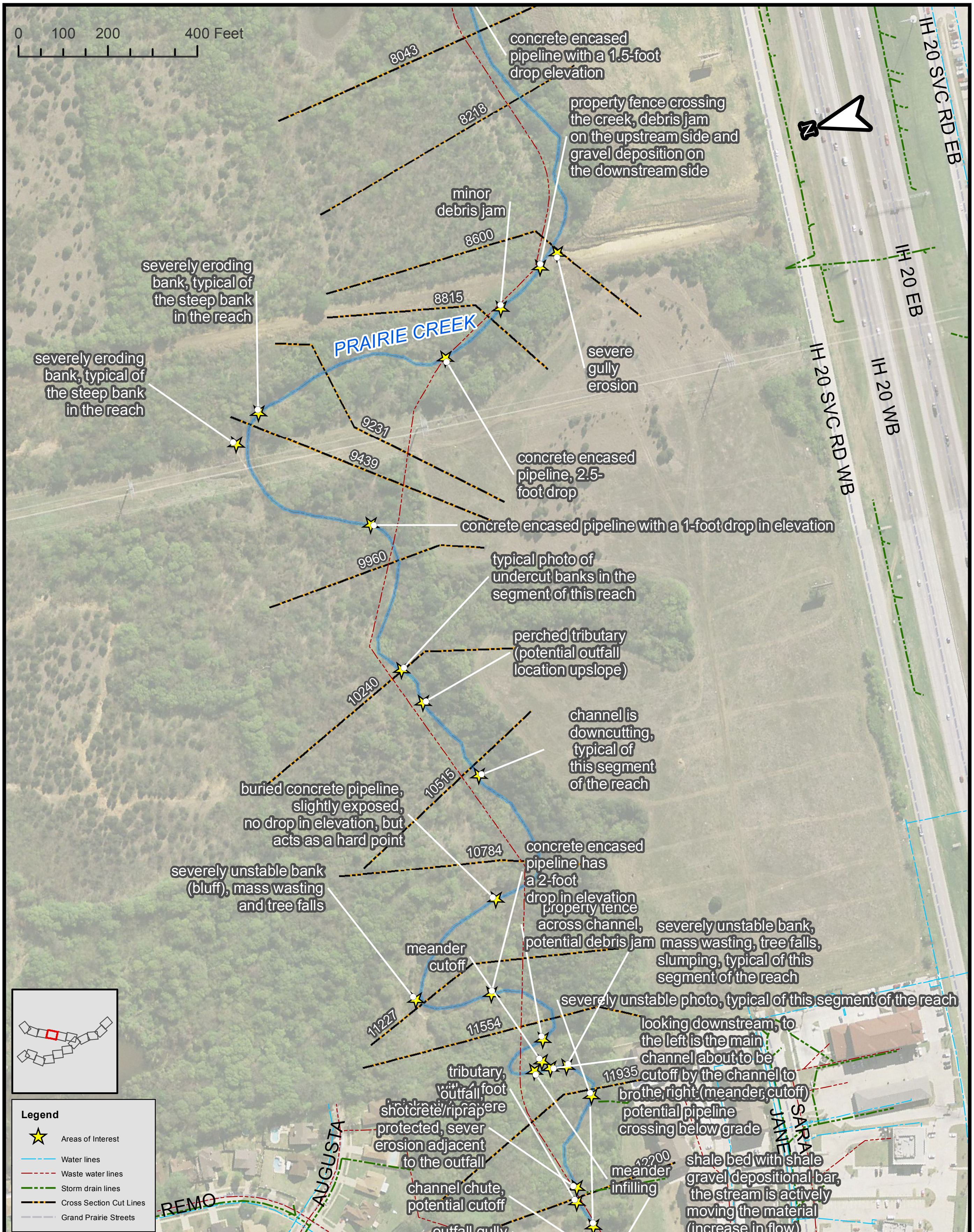

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FIGURE

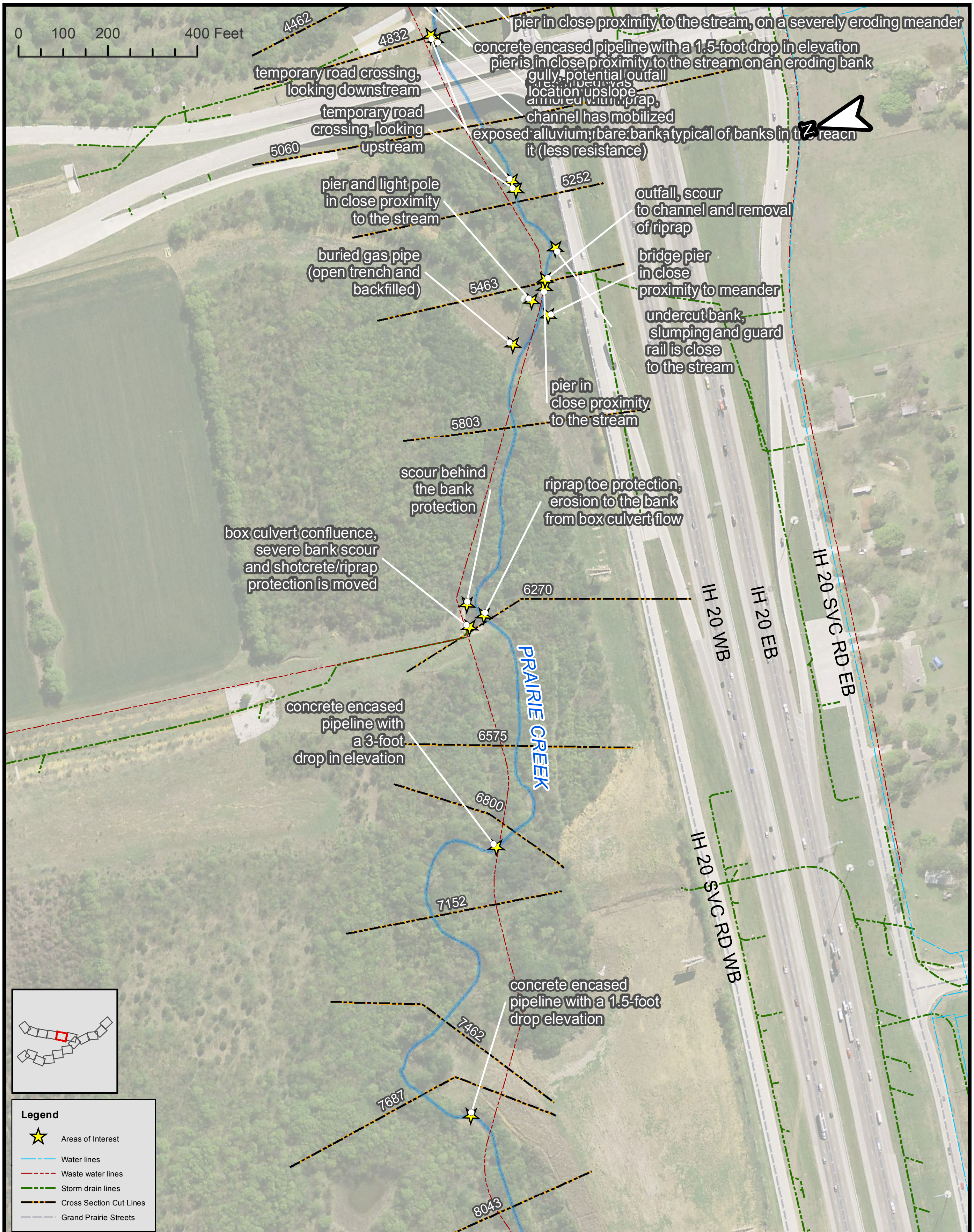

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FIGURE

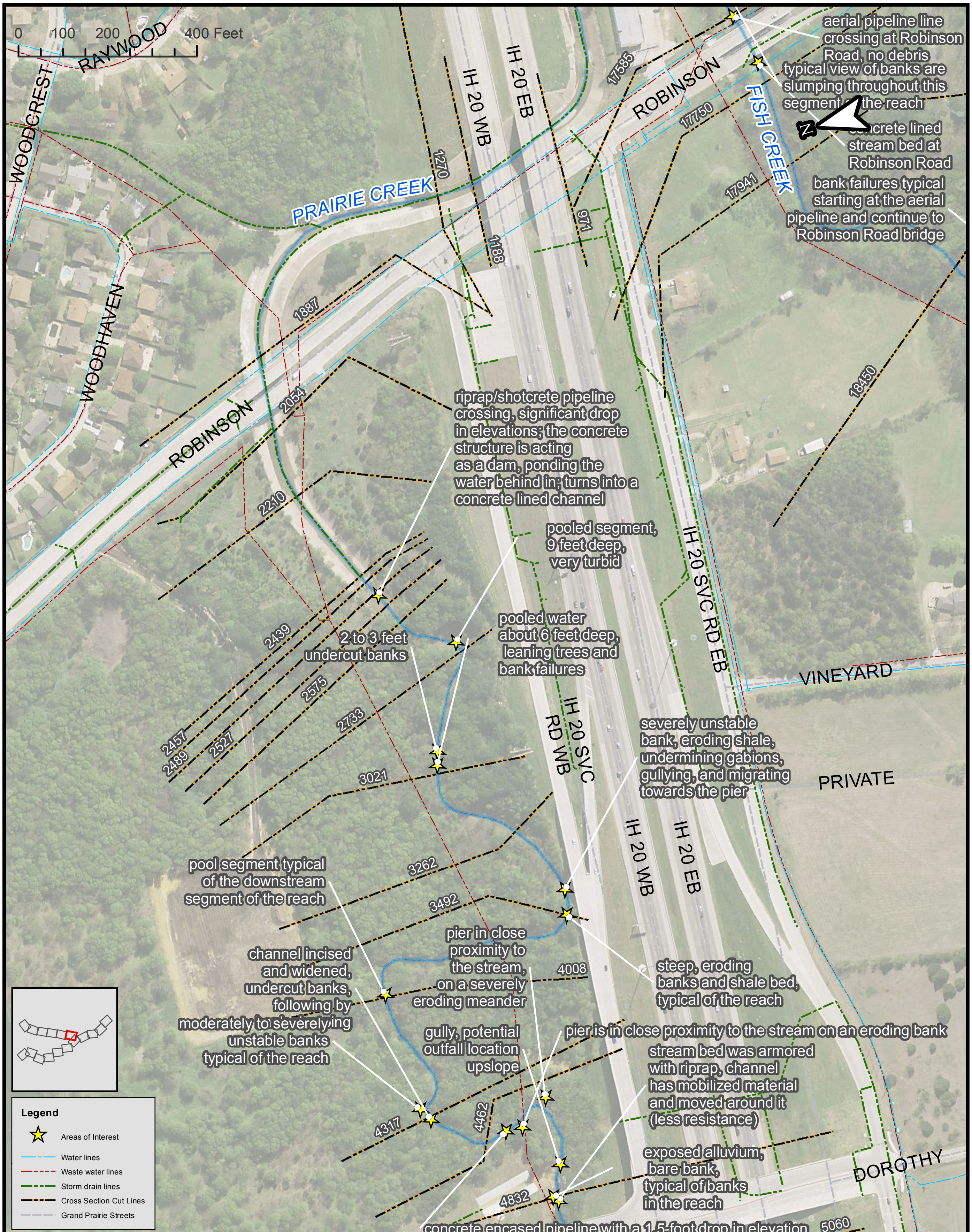

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FIGURE

	
At 41446 starting point of Fish Creek, concrete channel	Upstream of 41093 concrete tributary with 2-foot drop
	
At 41093 representative photo is concrete channel	At 41093 outfall tributary
	
At 40575 concrete channel stops, natural channel bed starts	Downstream of 40575 0.6-foot knickpoint

Fish Creek (41446-40575) downstream of Hwy 360

	
Downstream of 40575 0.6-foot knickpoint	Downstream of 40575 1.5-foot knickpoint
	
Upstream of 40008 outfall tributary enters the creek, has a 3-foot drop	At 40008 shopping cart/debris jab with a 1-foot drop
	
Downstream 40008 of 0.5-foot drop	Downstream of 39477 articulated block protecting the stream bed, shifted out of place

Fish Creek (40575-39477) downstream of Hwy 360

	
Downstream of 39477 2-foot drop in elevation, riffle-like	Downstream of 38979 chutes used during high flow events
	
At 38331 outfall, gully erosion	Upstream of 37902 outfall, gully erosion
	
Upstream of 37902 natural grade control	Downstream of 37374 tributary, incised

Fish Creek (39477-37374) downstream of Hwy 360

	
Downstream of 37374 Eagle Ford Shale (EFS) plucked from the stream bed	Upstream of 36542 tributary, incised
	
Upstream of 36542 aerial pipeline/debris jam	Downstream of 36542 first outcrop of EFS
	
Downstream 35879 log jam with 3-foot drop	Downstream of 35879 outfall, severe gully erosion

Fish Creek (37374-35879) downstream of Hwy 360

	
Downstream of 35879 aerial pipeline, 2 feet above stream bed, riprap not protecting the banks	At 34603 outfall, eroding underneath the shotcrete/riprap, consider inspecting
	
At 34603 severe bank erosion and loss, potential threat to structure	At 34603 severe erosion and bank failure
	
Upstream of 32625 undercut and cracked concrete apron, strong sewage smell	Upstream of 32625 cracked/hole in apron

Fish Creek (35879-32625) upstream of Great Southwest Hwy


Upstream of 32625 erosion behind gabions


Upstream of 32625 erosion behind the apron


Upstream of 32625 mass wasting


At 32167 pipeline crossing and 5-foot drop


Downstream of 32167 sediment deposition, debris jam and aerial pipelines


At 31603 tributary (gully) with severe soil creep and tree falls

Fish Creek (32625-31603) upstream of Great Southwest Hwy

	
Upstream of 30732 outfall, gully erosion	At 30732 outfall, concrete lined, scoured and eroding around protection
	
At 30732example of bank failure observed throughout the reach	Downstream of 30732 debris jam causing local scour
	
Downstream of 30084 example of undercut banks (2 ft) typical of this section of the reach	At 30084 example of overhanging banks, typical of steep banks

Fish Creek (30732-30084) downstream of Great Southwest Hwy

	
Downstream of 29632 outfall tributary, severely eroding	Downstream of 39632 potential outfall tributary or spring
	
Downstream of 29091 pipeline location, backs up water, has a 3-foot drop	Upstream of 27747 outfall tributary, swale-like with debris
	
Downstream 27747 start of riprap grade control	Upstream of 27736 grade control with 1 to 2-foot drops in elevation and toe protection

Fish Creek (29632-27736) downstream of Great Southwest Hwy

	
At 27236 end of riprap grade control and toe protection, banks are creeping and local scour	At 27236 incising tributary, potential outfall upstream
	
Upstream of 26243 aerial pipeline, debris jam and local scour	Upstream of 26243 bank failure at the pipeline location
	
At 26243 two aerial pipelines at Matthew Road	At 25980 waterline, broken concrete protection and undermined, acts as a drop in elevation

Fish Creek (27236-25980) downstream of Great Southwest Hwy and upstream of Matthew Rd

	
At 25904 construction site, cleared the right bank of all vegetation, sediment source	Downstream of 25904 aerial pipeline, local scour on banks, gabion basket are undermined, concrete support piers are cracked
	
Downstream 25626 severe bank erosion migrating towards Matthew Road	Downstream of 25626 large bank failure on the meander near Matthew Road
	
Downstream of 25626 construction site, clear of all vegetation in the right bank, tree fall, sediment source, and silting in	Downstream of 24966 bank failure, tree fall, and log/debris jam

Fish Creek (25904-24969) downstream of Matthew Rd

	
Downstream of 22868 log/debris jam, tree is held on by cable	Upstream of 22324 log jam forming a 4-foot drop in elevation
	
Downstream of 22324 looking downstream at log jam. Sediment build built forming a drop in elevation	Downstream of 22324 looking upstream at log jam drop (the 4-foot drop)
	
Downstream of 22324 looking upstream at the a log jam with a 3-foot drop in elevation	Downstream of 22324 typical unstable reach with tree falls and slumping banks

Fish Creek (22868-22324) downstream of Matthew Rd

	
Upstream of 21694 typical bank scour for banks that are low and near vertical	At 24523 exposed bridge piers, channel has downcut and widened through this area
	
2Downstream of 21523 gabion protected right bank, slope failure on the upper bank	Downstream of 21180 outfall and localized scour downstream
	
Downstream of 21180 concrete outfall and aerial pipeline	Downstream of 20722 typical bank failure of this segment of the reach, banks are slumping

Fish Creek (21694-20722) upstream and downstream of Bardin Rd

	
Downstream of 20722 water ponds from pipeline downstream, banks are slumping and show soil creep	Downstream of 20362 bathtub ring indicates the water height that backs up from the pipeline crossing
	
Downstream of 20362 water ponds up behind the pipeline, 9 feet from top of pipe to bed (5 feet of water backups, has a 4 feet deep scour hole	Upstream of 20046 concrete rubble protected on the left bank, channel narrow, banks are failing downstream
	
At 20046 house at the top of the bank	At 20046 soil creep on top of clay layer, leaning trees and tree falls

Fish Creek (20722-20046) downstream of Bardin Rd

	
Downstream of 20046 outfall location, gully formation	At 19644 gabion mattress protected banks and bed at outfall location
	
At 19644 outfall clogged with sediment	Downstream of 19644 log jam with a 3.5-foot drop in elevation
	
Downstream 19644 aerial pipeline, evidence that water backup behind the pipe during high flow events	Upstream of 19223 riprap protected left bank and stream bed, right bank has toe erosion

Fish Creek (20046-19223) downstream of Bardin Rd

Left and right bank views assume downstream direction

	
Downstream of 18738 bank failures typical starting at the aerial pipeline and continue to Robinson Road bridge	Downstream of 17750 concrete lined stream bed at Robinson Road
	
At 17585 aerial pipeline line crossing at Robinson Road, no debris	Downstream of 16845 typical view of banks are slumping throughout this segment of the reach
	
Upstream of 16845 bank protection consists of riprap and concrete rubble	Upstream of 16845 confluence with Prairie Creek

Fish Creek (18738-16845) downstream of Bardin Rd and upstream of Robinson Rd

Downstream of 16845 typical view of rotational failures throughout this segment of the reach

Upstream of 16060 erosion behind gabion wall

Upstream of 15727pipeline crossing with a 3.5-foot drop in elevation, sediment deposition on the upstream end

2At 15213 I20, trapezoid channel, oversized, sediment is depositing and forming a channel within the trapezoid

At 15213 bank failure and mass wasting within the sediment build up in the trapezoidal channel

At 14866 trapezoid channel is cracked and 2 feet undercut

Fish Creek (16845-14866) downstream of Robinson Rd and upstream of I-20

	
Downstream of 14725 piers of Carrie Parkway, scoured between 1 and 4 feet	Downstream of 14725 piers of Carrier Parkway, scoured between 1 and 4 feet
	
Downstream of 14279 outfall, bank protected, with minor erosion	At 14279 typical view of bank failure throughout this segment of the reach
	
At 13701 photo illustrate bank scour through this segment of the reach	At 12580 photo should channel widening

Fish Creek (14725-12580) downstream of I-20

Left and right bank views assume downstream direction

	
At 12085 waterline clean out exposed, on a severely eroding	Downstream of 11651 severe scour and overhanging vegetation, typical in this segment of the reach
	
At 11056 erosion and scour to the cart bridge	At 11056 slumping banks typical throughout the golf course
	
Downstream of 10541 bank failure typical for steep banks throughout the golf course	Upstream of 9945 steep, severely eroding meander

Fish Creek (12085-9945) downstream of I-20

	
Downstream of 9945 severe erosion to the cart path	Upstream of 8186 severely eroding bank about 15 feet from fence
	
Downstream of 7473 erosion to cart bridge from channel widening	Downstream of 7473 typical view of toe erosion throughout the lower segment of this reach
	
Upstream of 5968 gabion basket protected wall, deposition between the veins	Downstream of 5968 homes near the creek on the downstream segment

Fish Creek (9945-5968) downstream of I-20 and upstream of the confluence with Kirby Creek

	
Upstream of 4725 looking at confluence with Kirby Creek	Upstream of 4725 looking downstream towards Lake Lewisville

Fish Creek (4725) downstream of I-20 and upstream of the confluence with Kirby Creek

	
At 24306 start of assessment for Prairie Creek	At 24306 downstream of culverts has been undermined
	
At 24306 left bank, broken apron and concrete protection for pipeline crossing	At 24306 right bank, shows broken concrete, not protection pipeline

Prairie Creek (24306) downstream of Hwy 360


Upstream of 23367 sewer manhole in the stream, debris jam and large gravel bar downstream


Upstream of 23367 2-foot knickpoint migrating towards the sewer line


Upstream of 22696 right bank, concrete rubble on a meander


Upstream of 22696 another channel, not the main channel, but is utilized during high flow events


Downstream of 22696 typical view of channel through this segment


Downstream of 22696 perched channel(meander cutoff)

Prairie Creek (23367-22696) downstream of Hwy 360

	
Downstream of 22159 view of the incised channel	Upstream of 21693 concrete pipeline acting as a hard point in the channel
	
At 21693 channel transitions, pooled, laid back banks and vegetated, severely undercut toe	Downstream of 21693 EFS outcrop, severely slaking
	
Downstream of 21693 spring or potential outfall location	At 21069 severe bank erosion typical throughout the reach, newly exposed roots, leaning trees and tree falls.

Prairie Creek (22159-21069) downstream of Hwy 360

	
Downstream of 21069 incising channel	Downstream of 21069 widening channel
	
Downstream of 21069 outfall, severe undercutting and scour	Downstream of 21069 start of meander cut-off
	
Downstream of 21069 end of meander cutoff where it joins	Downstream of 20194 looking upstream in the meander cutoff (about 2 feet difference in elevation)

Prairie Creek (21069-20194) downstream of Hwy 360

	
Downstream of 20194 culvert outfall with a 4-foot drop produced a large scour hole	Upstream of 19301left bank is riprap protected
	
At 19301 log jam created	Downstream of 19301 example of tree falls typical of this reach
	
At 18557 roadway in close proximity to a meander	Upstream of 18097 overhanging vegetation and undercut toe wall

Prairie Creek (20194-18097) downstream of Hwy 360

	
Downstream of 18097 potential pipeline crossing, protected with riprap	Downstream of 17616 banks were protected with riprap, erosion has remove the erosion
	
Upstream of 17216 severe bank erosion, houses in the vicinity	Upstream of 17216 outfall tributary
	
Upstream of 16737 house is 55 feet from the top of the bank	Downstream of 16385 pipeline open trench and backfill

Prairie Creek (18097-16385) downstream of Hwy 360

	
At 16737 pipeline open trench and back filled, protected by straw matting	Downstream of 16385 severe erosion and scour at outfall
	
Downstream of 16385 severe erosion and scour at outfall	Downstream of 15832 knickpoints in the EFS
	
Upstream of 15272 outfall	At 15272 potential pipeline crossing, riprap protected, acting as grade control

Prairie Creek (16373-15272) downstream of Hwy 360

	
Upstream of 14909 knickpoint in EPS	At 14909 house about 100 feet from severely eroding meander
	
Downstream of 14909 severe bank erosion and a diversion channel for high flows	Downstream of 14909 buried culvert, potentially not in use
	
Upstream of 14375 steep, severely eroding	Downstream of 14089 typical photo of shale slaking, repeated wet/dry cycle causes high erosion

Prairie Creek (14909-14089) downstream of Hwy 360 and upstream of Great Southwest

	
Downstream of 14089 riprap/shotcrete lined creek bed and banks, acting as a hard point	Downstream of 13910 riprap lined outfall tributary
	
Downstream of 13805 mass wasting, exposed roots, overhanging vegetation, typical of steep banks in this reach	Downstream 13687 4 Box culvert, infilling for shale gravel
	
Upstream of 13486 looking upstream at box culverts, infilling with shale gravels	At 13276 outfall, riprap is missing and toe is eroding

Prairie Creek (14909-14089) upstream and downstream of Great Southwest

	
At 13276 EFS stream bed with a series of knickpoints	Downstream of 13276 steep, eroding bank with gullies forming towards the building
	
At 12994 lower bank is terraced and vegetated	At 12994 outfall, minor erosion
	
Upstream of 12743 slightly unstable photo, typical of this segment of the reach	Downstream of 12502 outfall gully

Prairie Creek (13276-12502) downstream of Great Southwest

	
Downstream of 12502 shale bed with shale gravel depositional bar, the stream is actively moving the material (increase in flow)	At 12343 channel chute, potential cutoff
	
Downstream of 12343 broken concrete slabs, potential pipeline crossing below grade	12200 tributary, with 4-foot knickpoint, severe
	
At 12200 outfall, shotcrete/riprap protected, sever erosion adjacent to the outfall	At 11935 severely unstable photo, typical of this segment of the reach

Prairie Creek (12502-11935) downstream of Great Southwest

	
Downstream of 11935 severely unstable bank, mass wasting, tree falls, slumping, typical of this segment of the reach	Downstream of 11935 looking downstream, to the left is the main channel about to be cutoff by the channel to the right (meander cutoff)
	
Downstream of 11935 meander infilling	Downstream of 11935 meander cutoff
	
Downstream of 11935 property fence across channel, potential debris jam	Upstream of 11227 concrete encased pipeline has a 2-foot drop in elevation

Prairie Creek (11935-11227) downstream of Great Southwest

	
At 11227 severely unstable bank (bluff), mass wasting and tree falls	Upstream of 10784 buried concrete pipeline, slightly exposed, no drop in elevation, but acts as a hard point
	
At 10515 channel is downcutting, typical of this segment of the reach	Upstream of 10240 perched tributary (potential outfall location upslope)
	
At 10240 typical photo of undercut banks in the segment of this reach	Downstream of 9960 concrete encased pipeline with a 1-foot drop in elevation

Prairie Creek (11227-9960) downstream of Great Southwest

	
Upstream of 9439 severely eroding bank, typical of the steep bank in the reach	Upstream of 9439 severely eroding bank, typical of the steep bank in the reach
	
Upstream of 8815 concrete encased pipeline, 2.5-foot drop	Downstream of 8815 minor debris jam
	
Upstream of 8600 property fence crossing the creek, debris jam on the upstream side and gravel deposition on the downstream side	At 8600 severe gully erosion

Prairie Creek (9439-8600) downstream of Great Southwest

	
Upstream of 7687 concrete encased pipeline with a 1.5-foot drop elevation	Upstream of 6800 concrete encased pipeline with a 3-foot drop in elevation
	
At 6270 box culvert confluence, severe bank scour and shotcrete/riprap protection is moved	At 6270 riprap toe protection, erosion to the bank from box culvert flow
	
Downstream of 6270 scour behind the bank protection	Downstream 5803 buried gas pipe (open trench and backfilled)

Prairie Creek (7687-5803) downstream of Great Southwest

	
At 5463 bridge pier in close proximity to meander	Upstream of 5463 pier and light pole in close proximity to the stream
	
Upstream of 5463 pier in close proximity to the stream	At 5463 outfall, scour to channel and removal of riprap
	
Downstream of 5463 undercut bank, slumping and guard rail is close to the stream	Downstream of 5252 temporary road crossing, looking upstream

Prairie Creek (5463-5252) downstream of Great Southwest

	
Downstream of 5252 temporary road crossing, looking downstream	At 4832 stream bed was armored with riprap, channel has mobilized material and moved around it (less resistance)
	
At 4832 exposed alluvium, bare bank, typical of banks in the reach	Downstream of 4832 gully, potential outfall location upslope
	
Downstream of 4832 pier in close proximity to the stream, on a severely eroding meander	Upstream of 4462 pier is in close proximity to the stream on an eroding bank

Prairie Creek (5252-4462) downstream of Great Southwest

	
Upstream of 4462 concrete encased pipeline with a 1.5-foot drop in elevation	At 4317 channel incised and widened, undercut banks, following by bank slumping
	
At 4317 moderately to severely unstable banks typical of the reach	At 4008 pool segment typical of the downstream segment of the reach
	
At 3492 steep, eroding banks and shale bed, typical of the reach	Downstream of 3492 severely unstable bank, eroding shale, undermining gabions, gullying, and migrating towards the pier

Prairie Creek (4462-3492) downstream of Great Southwest

	
At 3021 pooled water about 6 feet deep, leaning trees and bank failures	Downstream of 3021 2 to 3 feet undercut banks
	
At 2733 pooled segment, 9 feet deep, very turbid	At 2489 riprap/shotcrete pipeline crossing, significant drop in elevations; the concrete structure is acting as a dam, ponding the water behind in; turns into a concrete lined channel

Prairie Creek (4462-3492) downstream of Great Southwest

Appendix C

Results of bed material grain size analysis for Fish Creek and Prairie Creek

	Station	D_{50} (mm)	D_{90} (mm)
Fish Creek	40008	28	80
Fish Creek	37902	12	36
Fish Creek	28546	9	32
Prairie Creek	21069	15	40
Prairie Creek	8218	7	22

Figure C1 Bed material gradation from sieve analysis – Fish Creek Station 37902

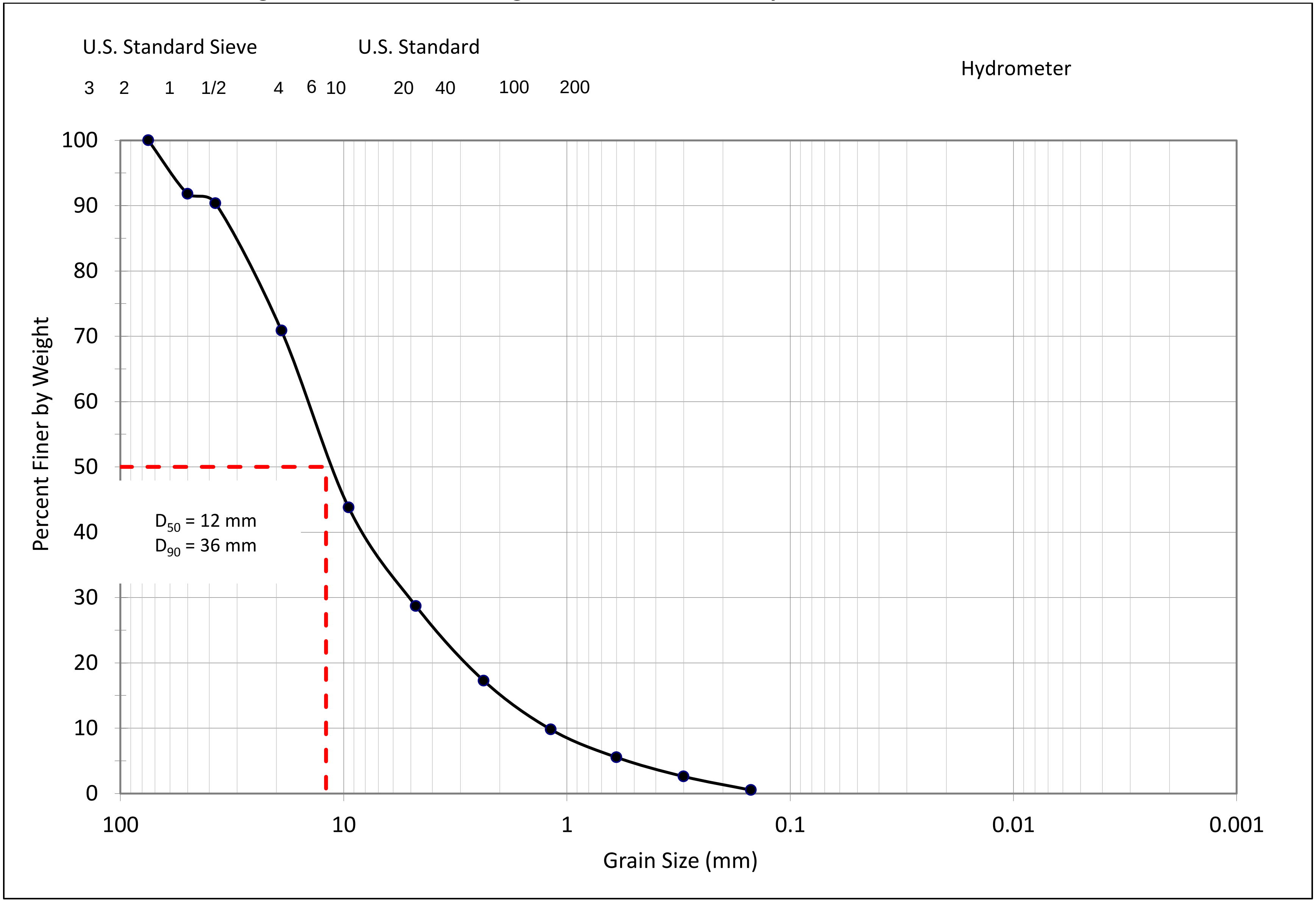


Figure C2 Bed material gradation from sieve analysis – Fish Creek Station 28546

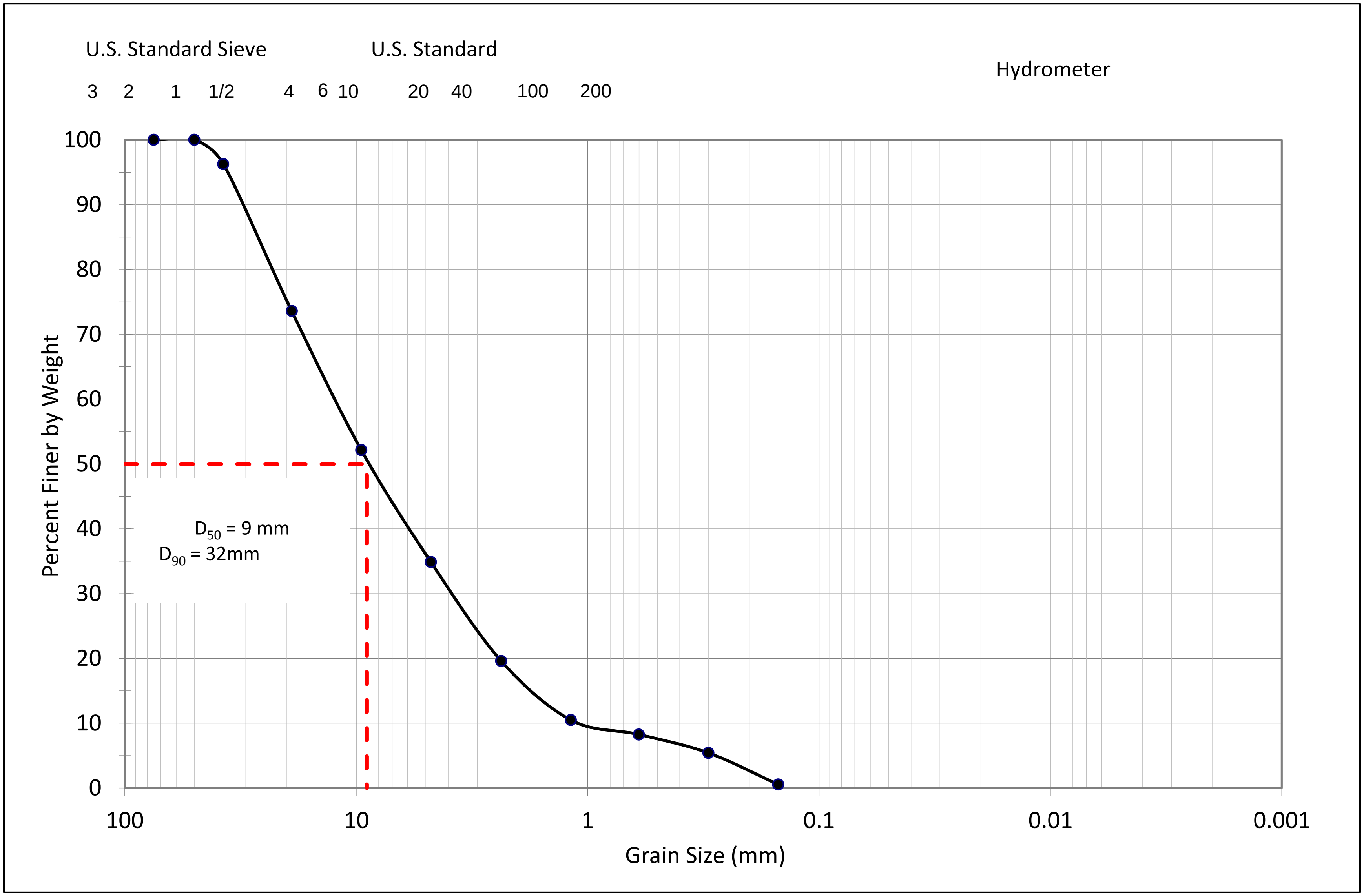


Figure C3 Bed material gradation from pebble count – Fish Creek Station 40008

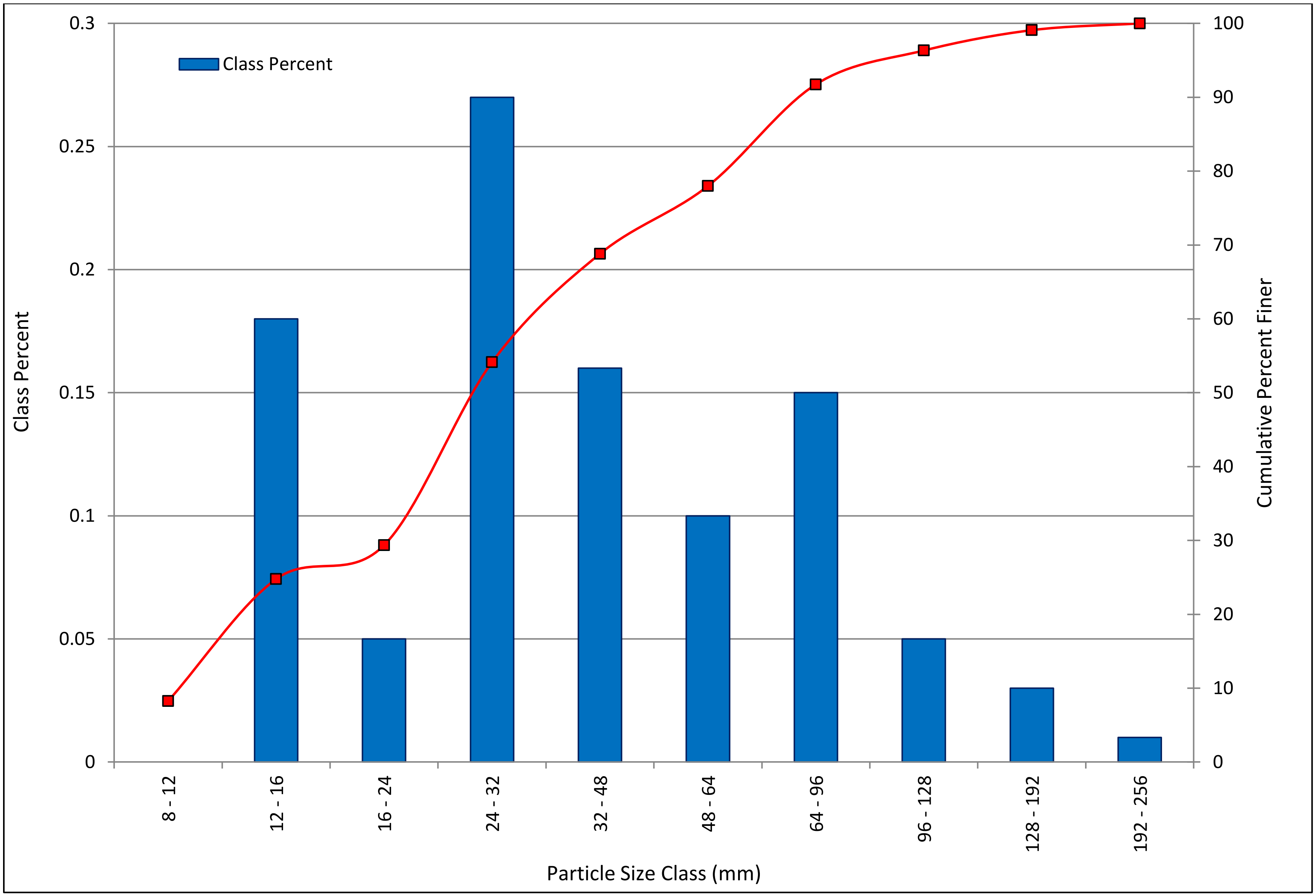


Figure C4 Bed material gradation from sieve analysis – Prairie Creek Station 8218

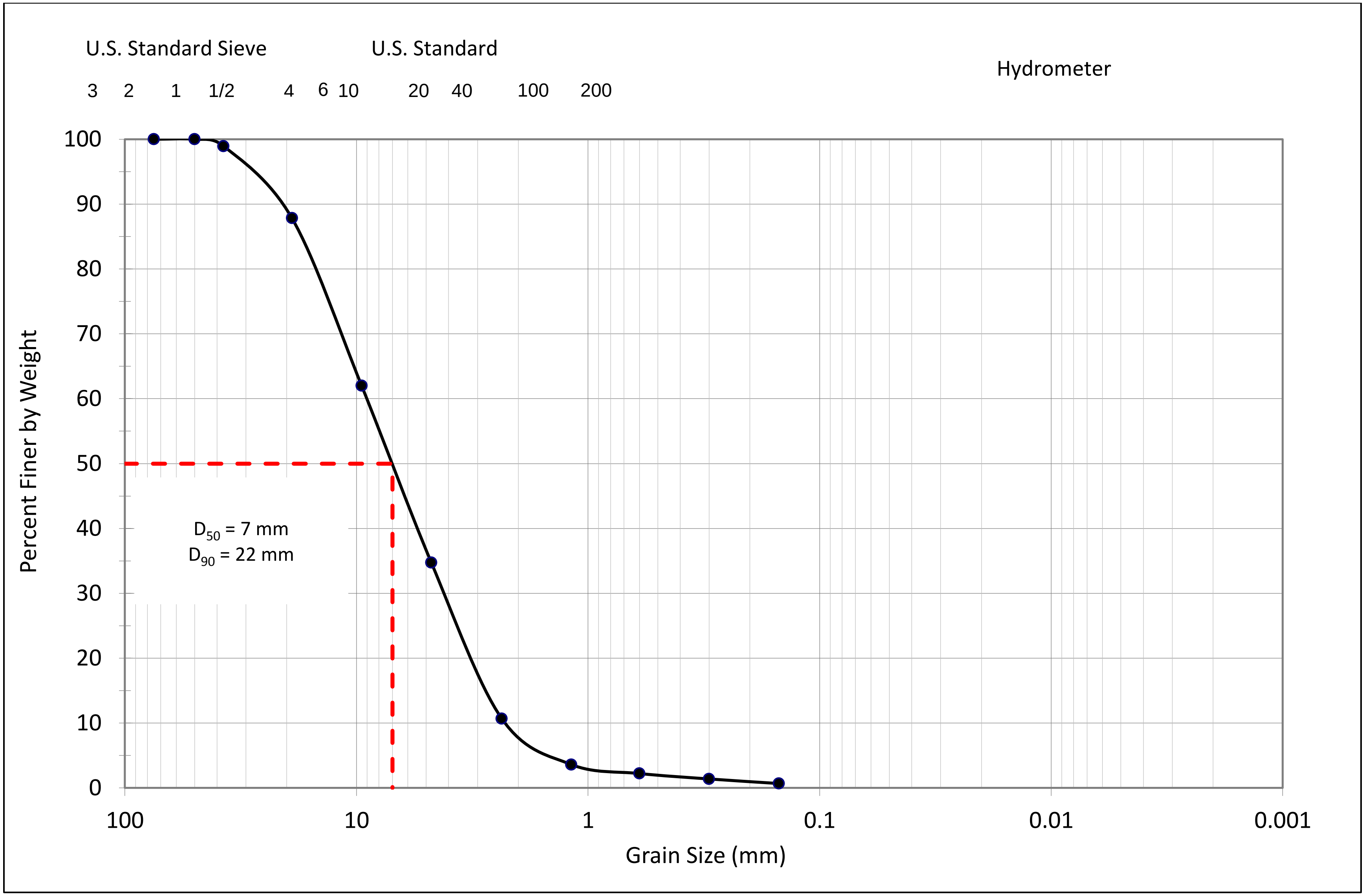
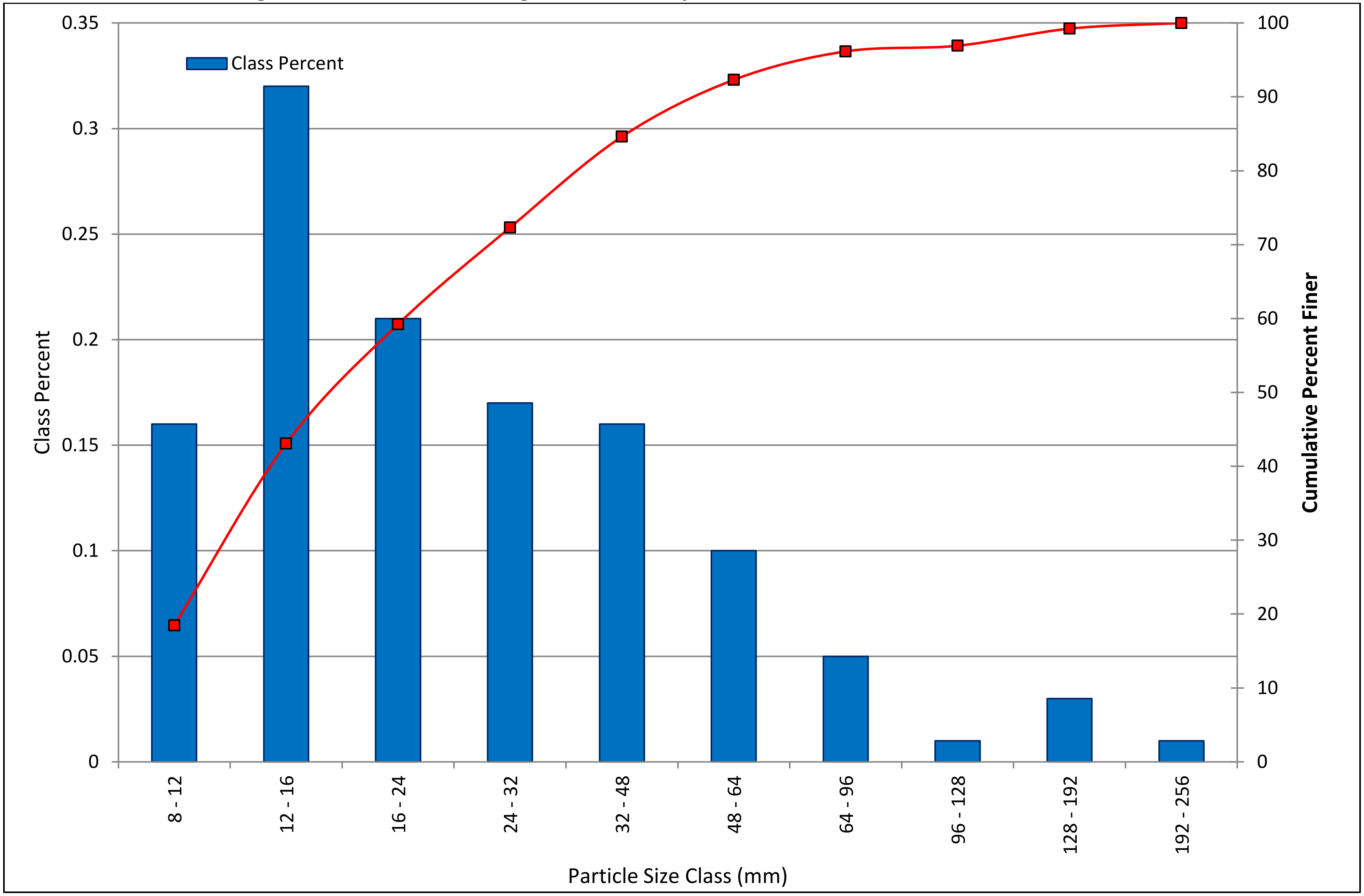


Figure C5 Bed material gradation from pebble count – Prairie Creek Station 21069



Appendix D

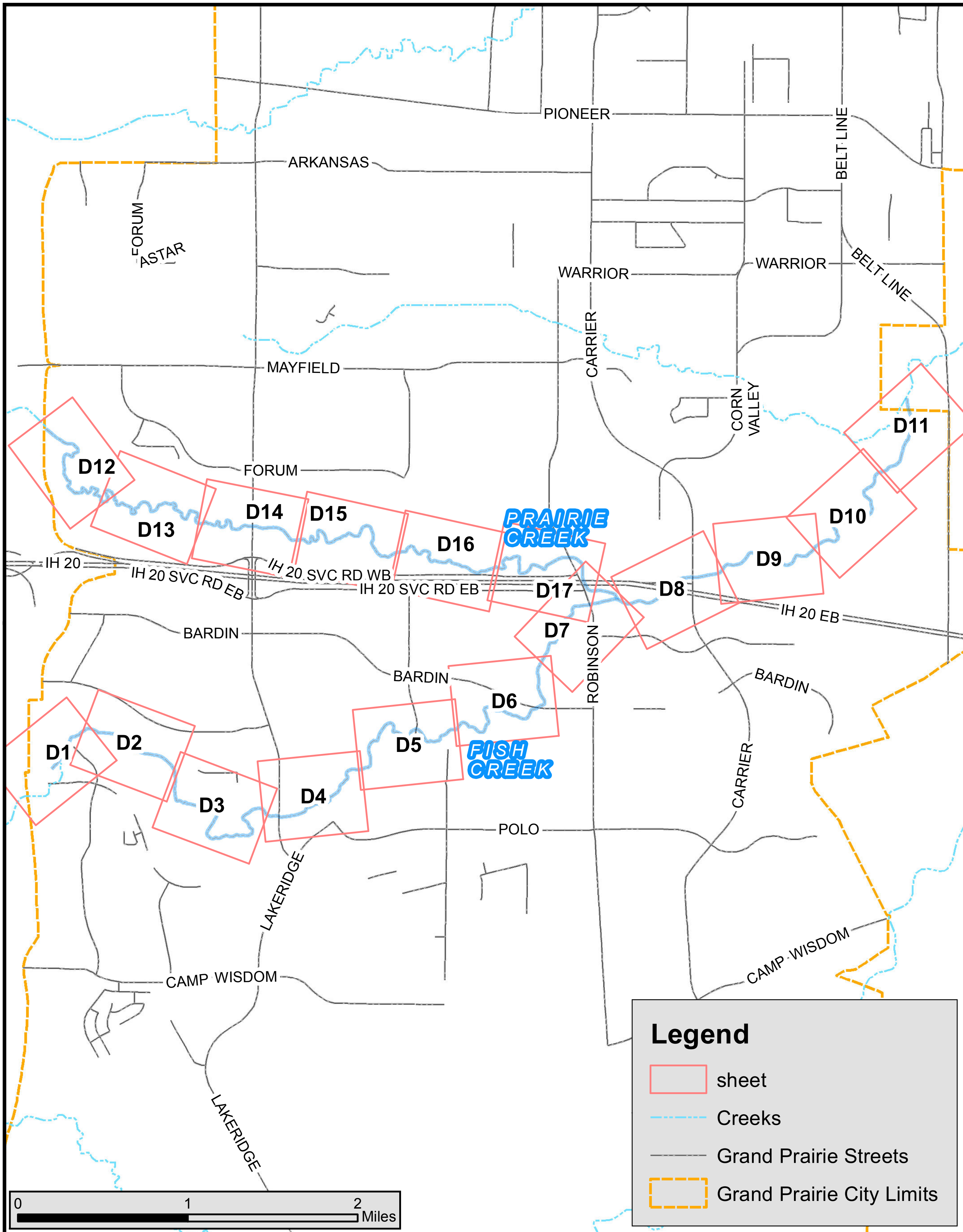


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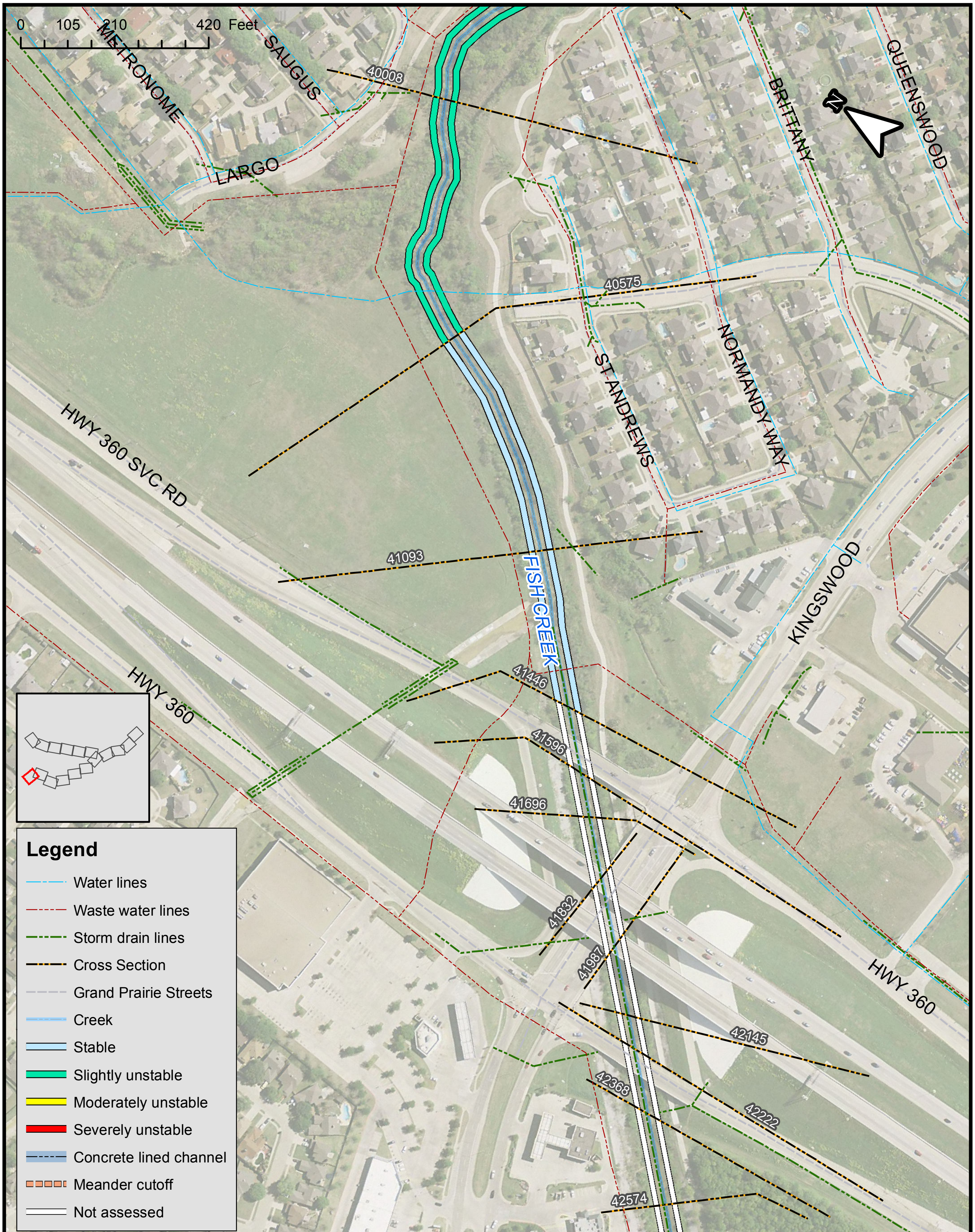
FIGURE



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Channel Erosion and Instability

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FIGURE

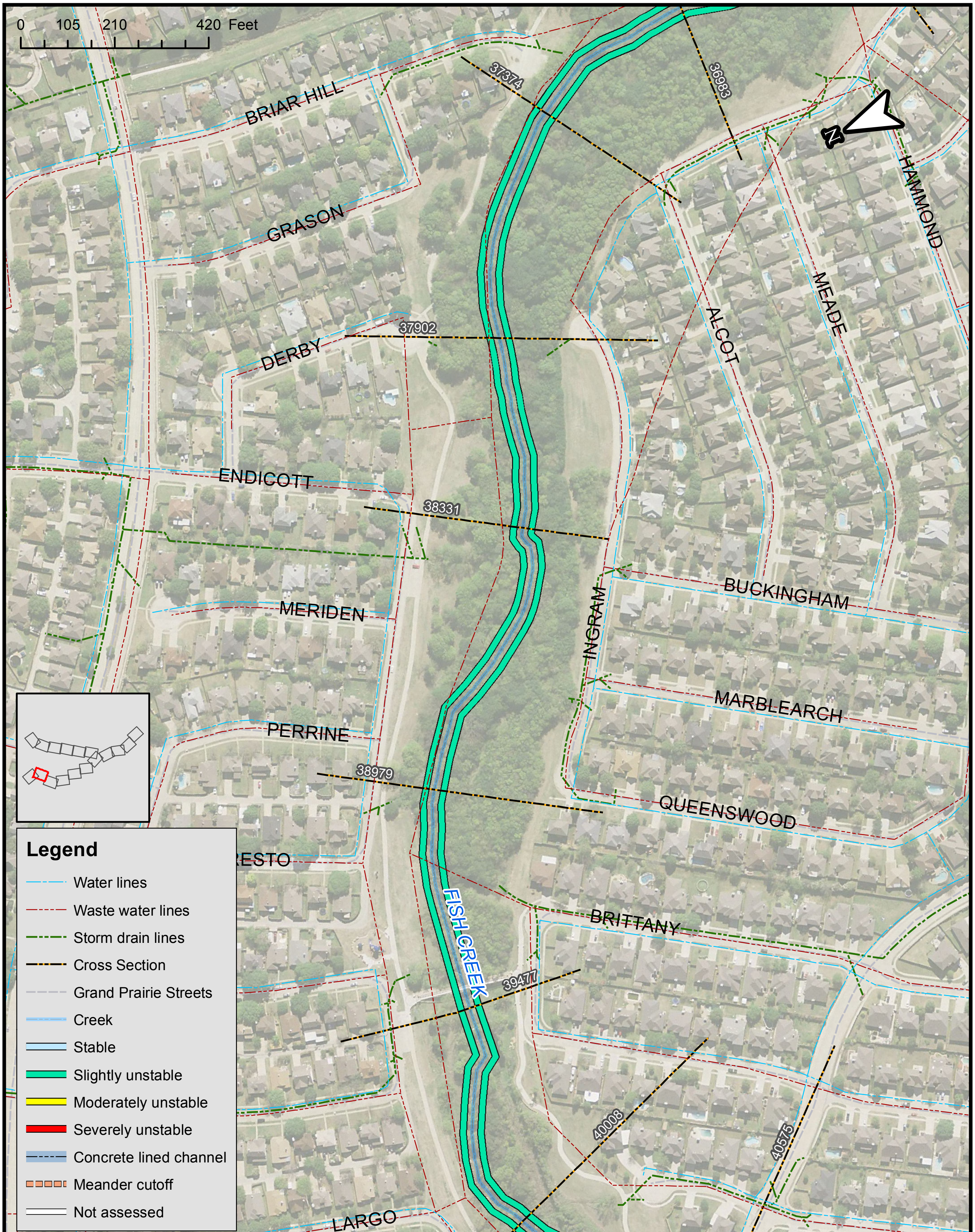

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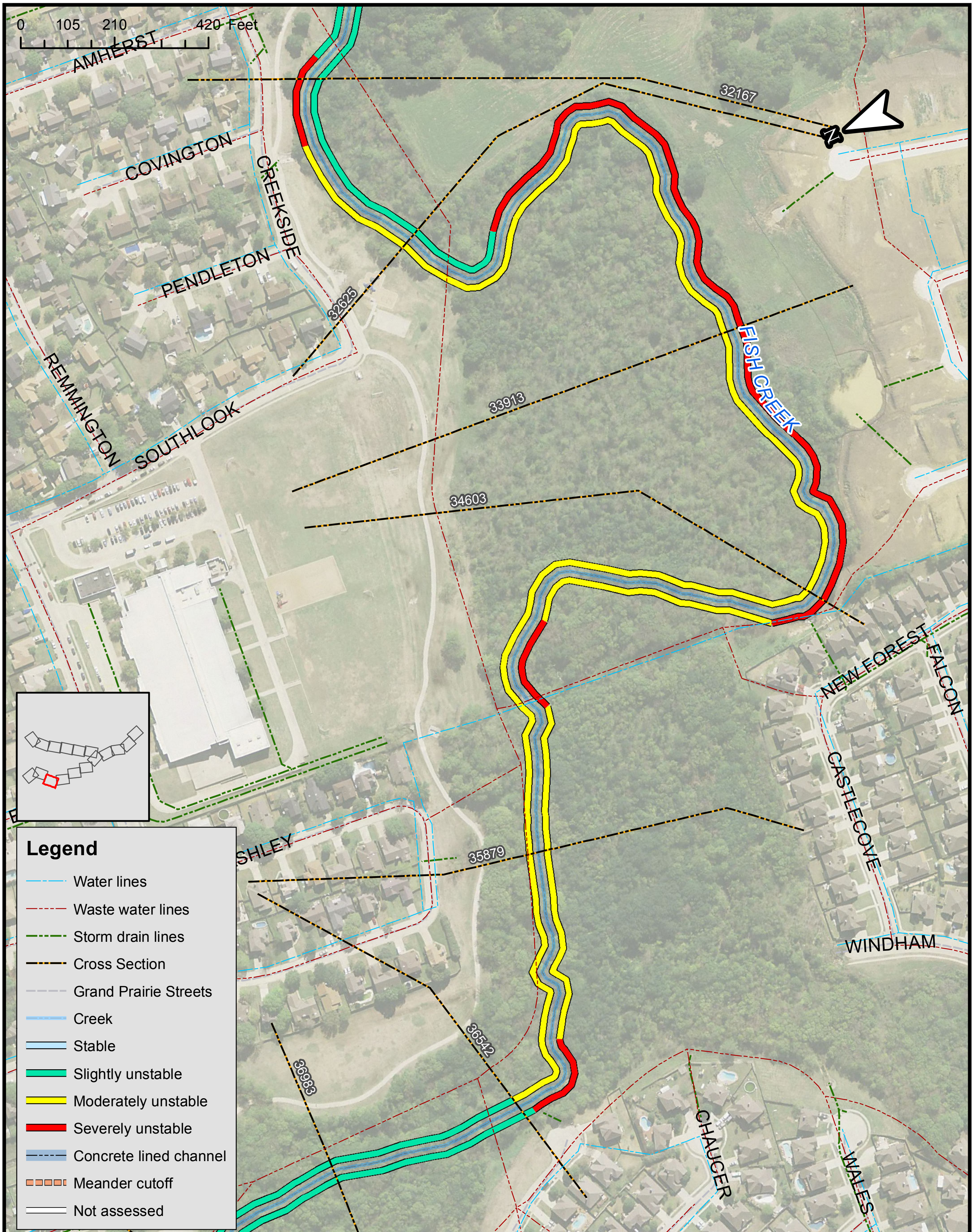
FIGURE



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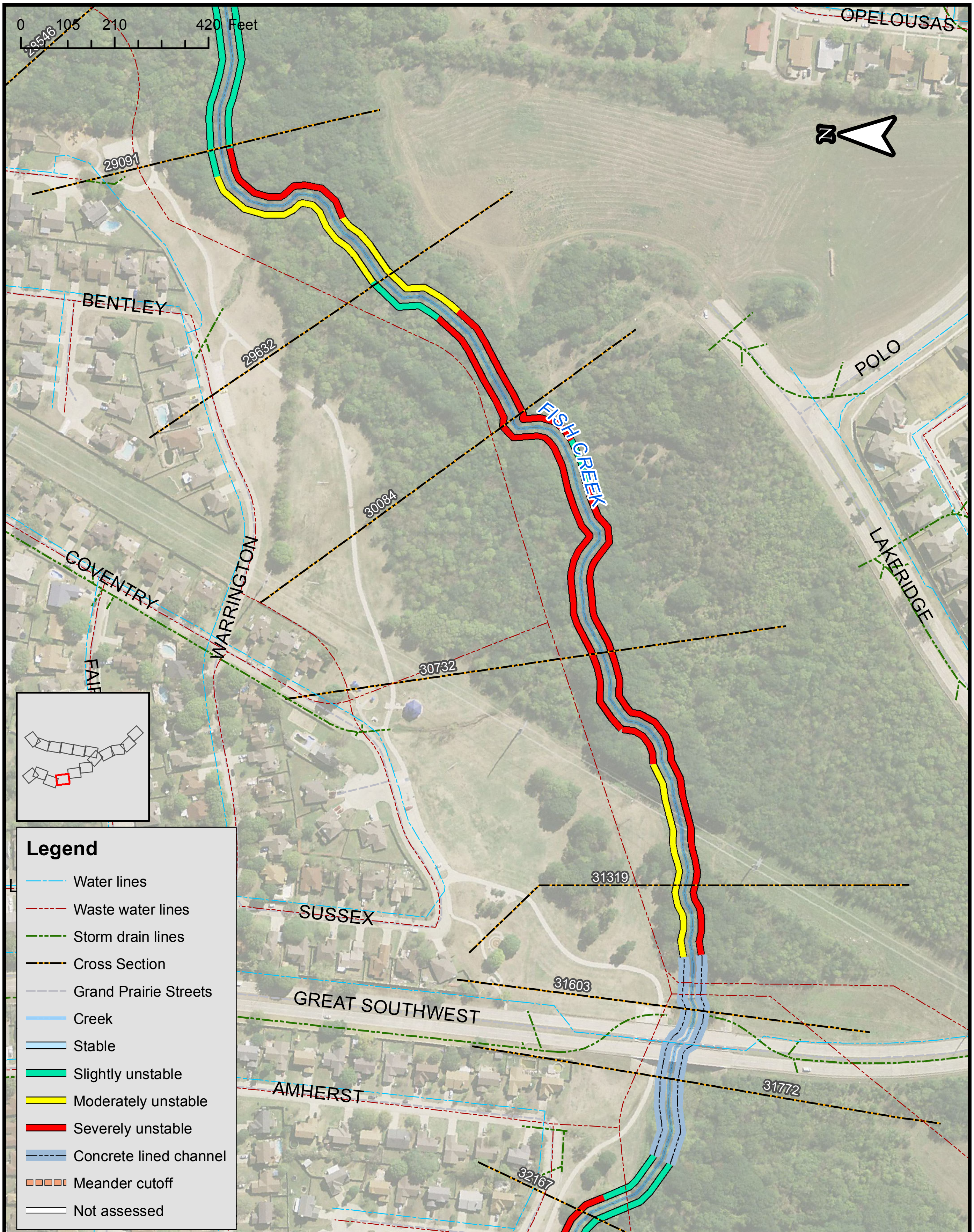
D3
FIGURE



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Fish Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

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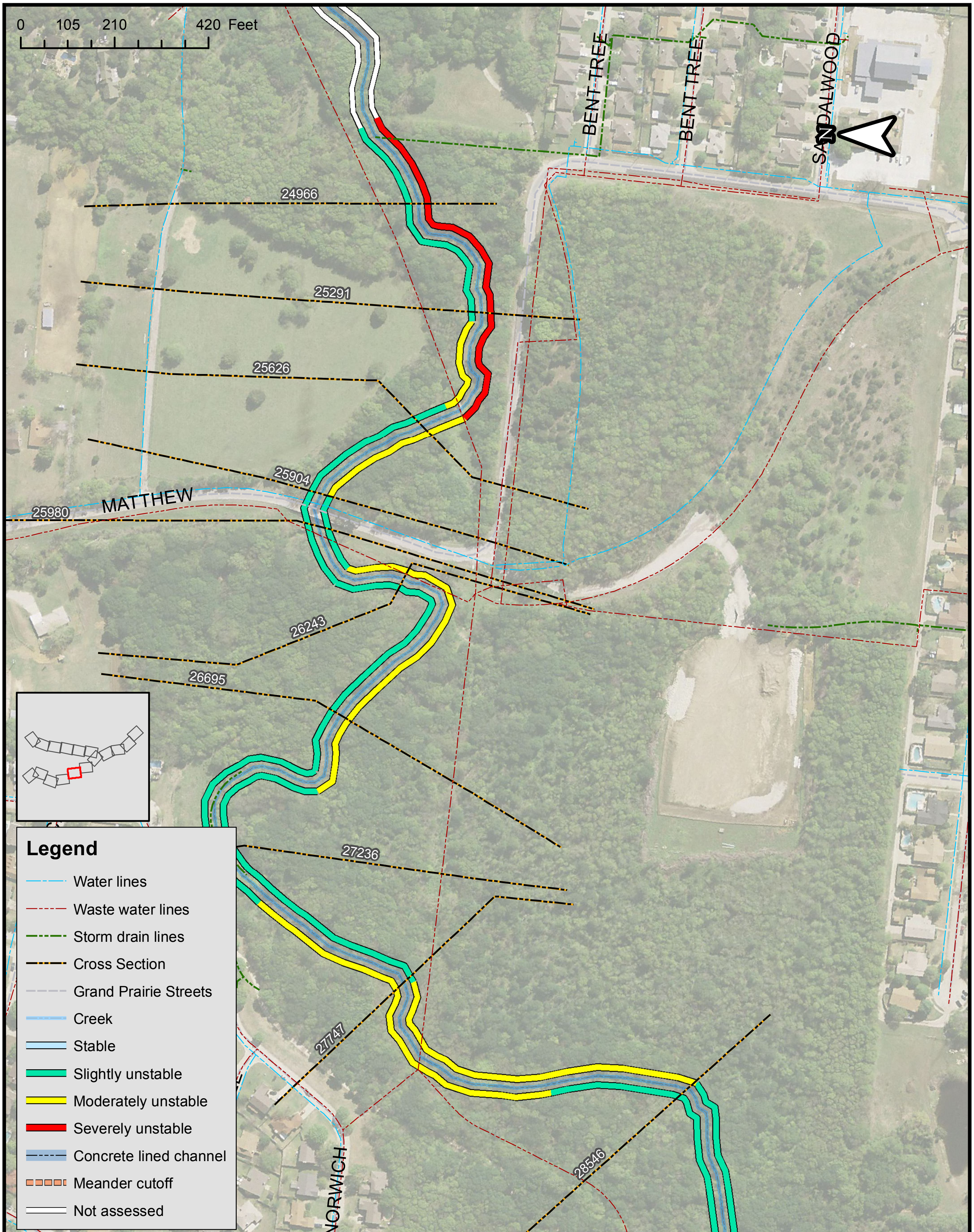

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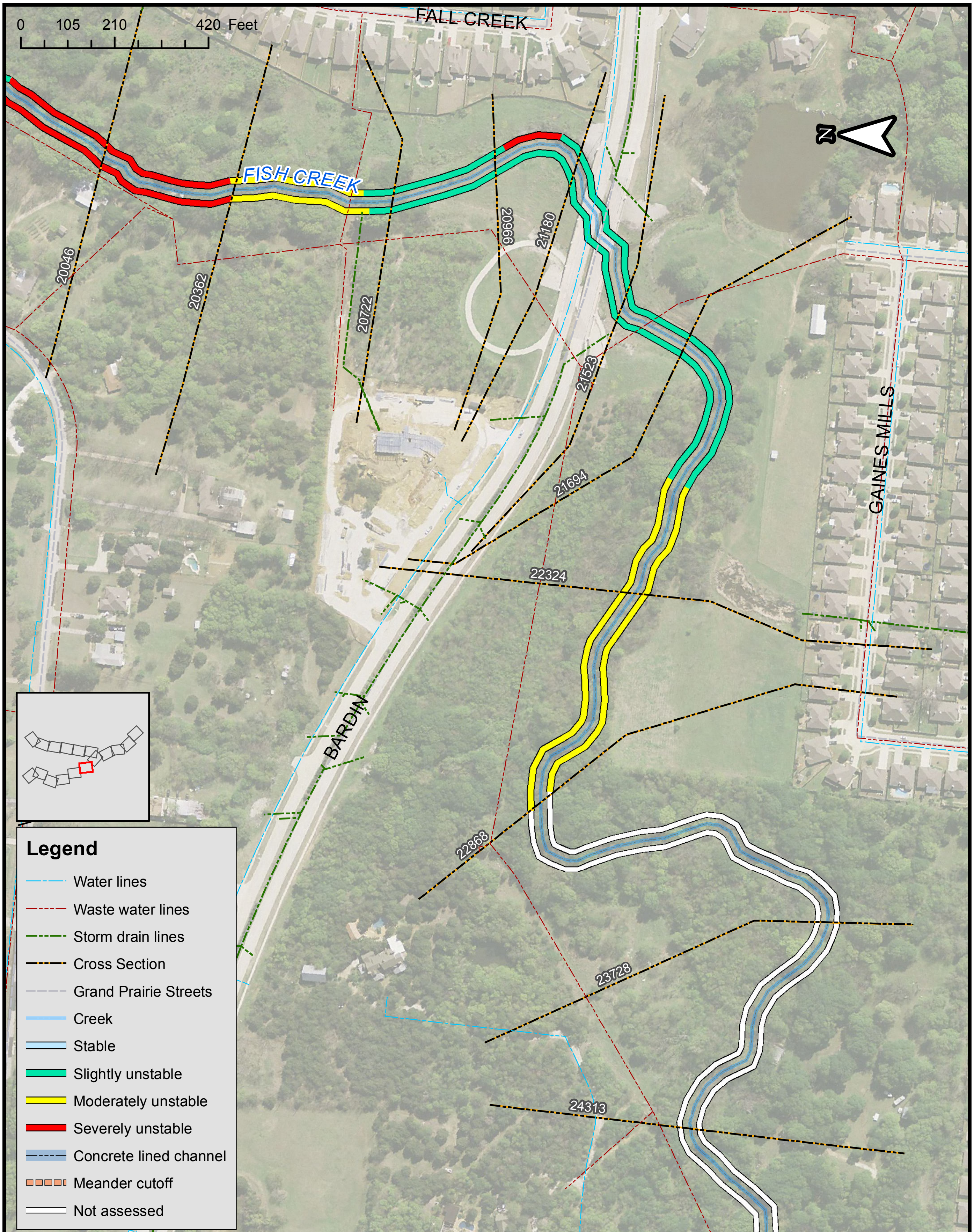

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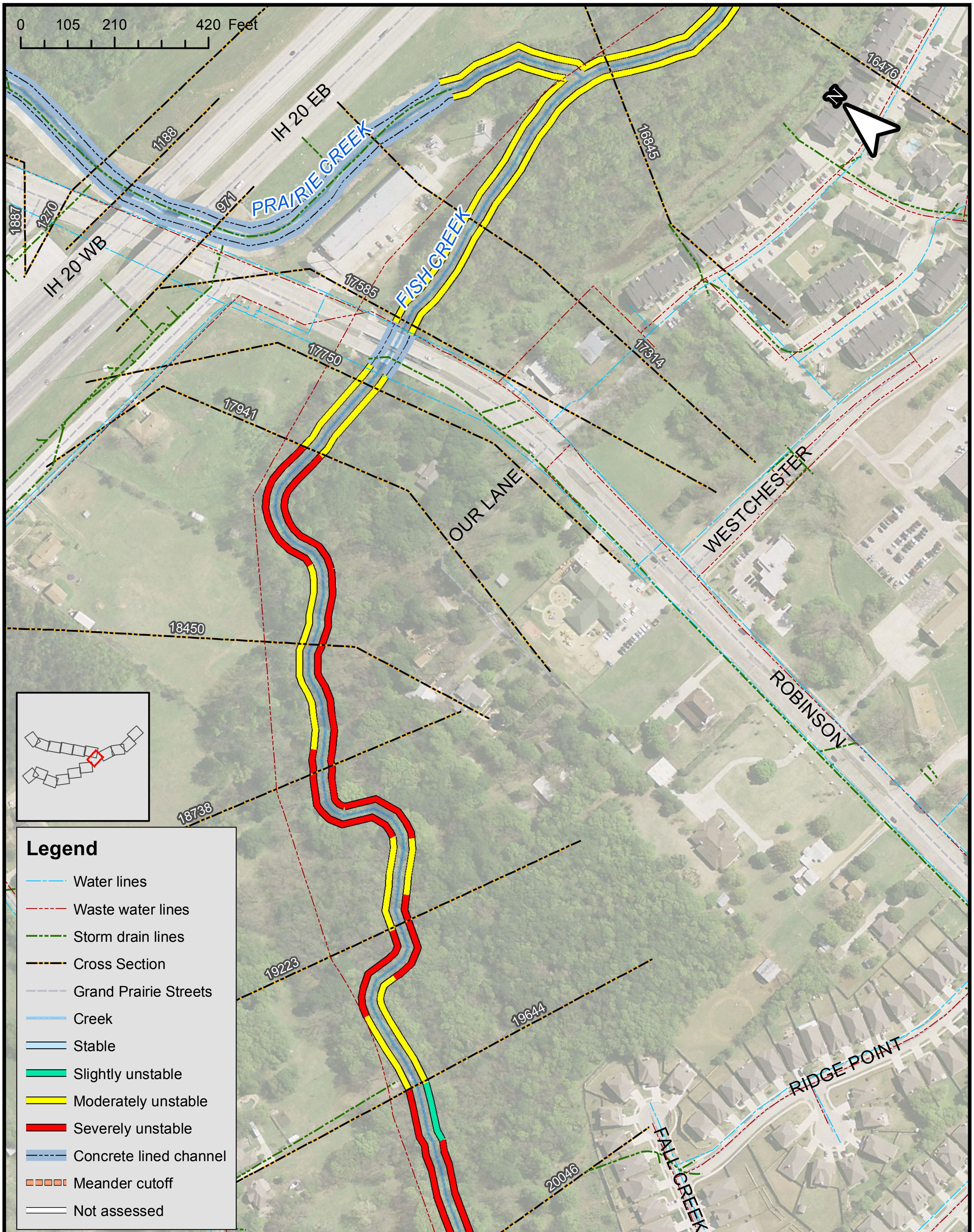

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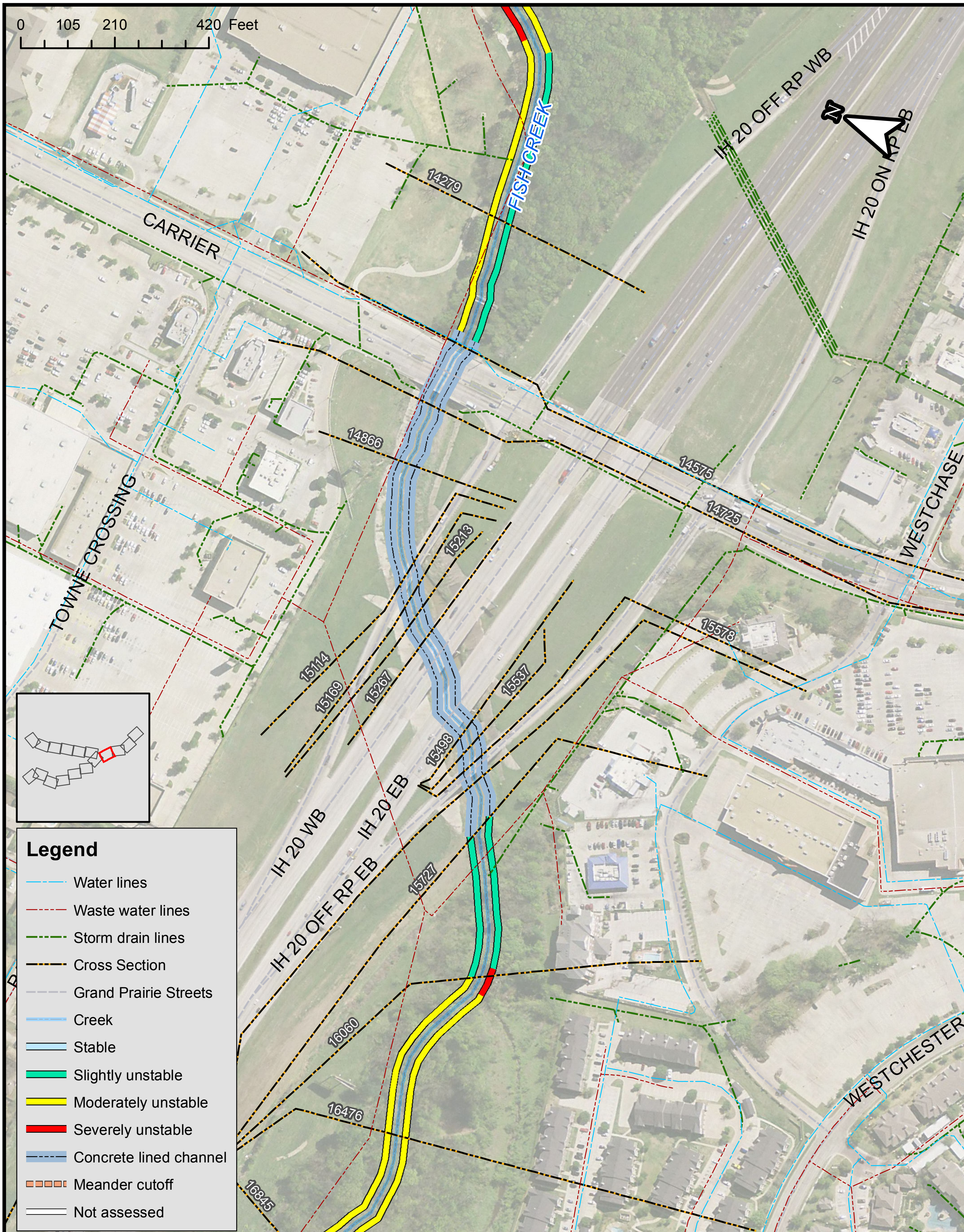

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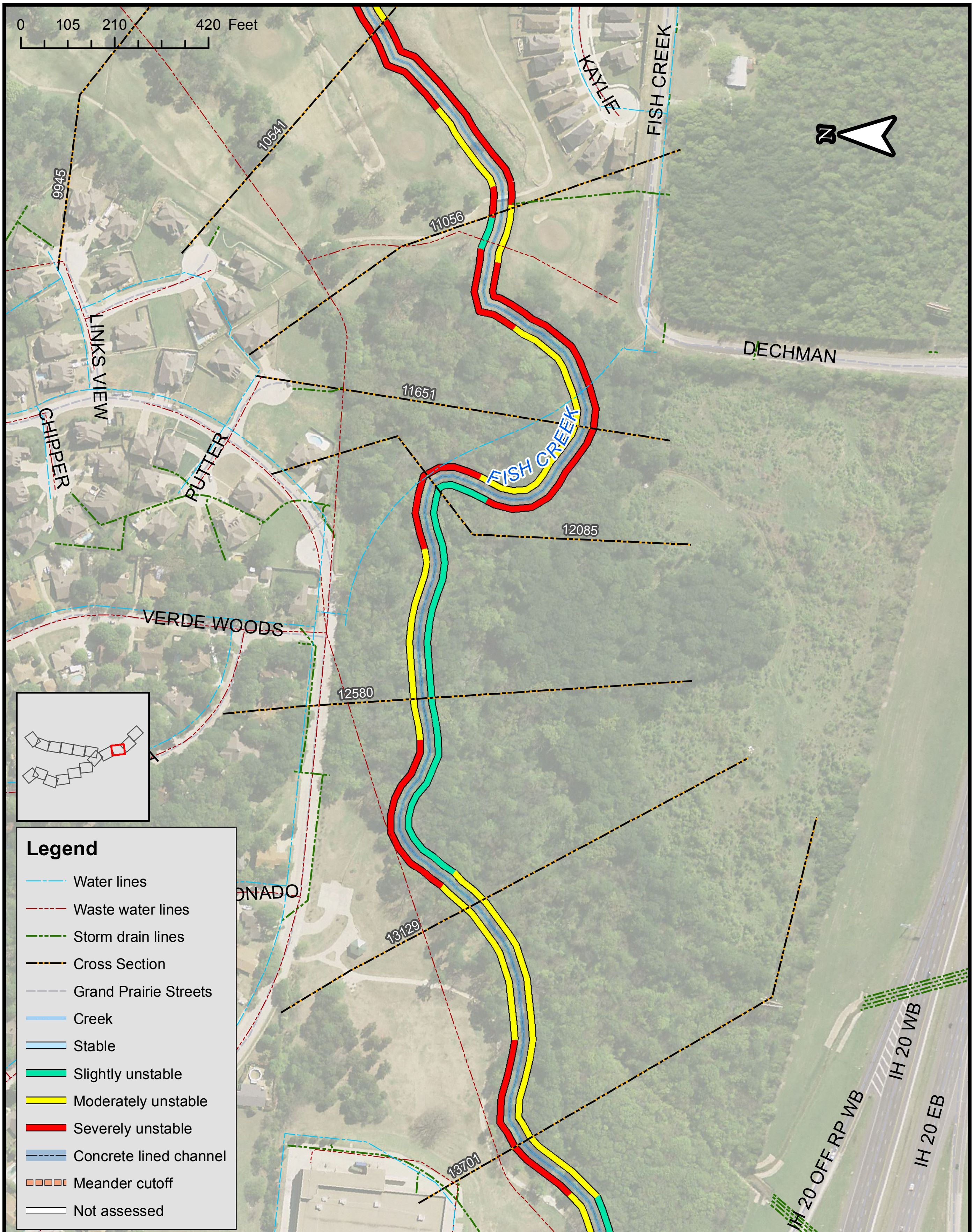

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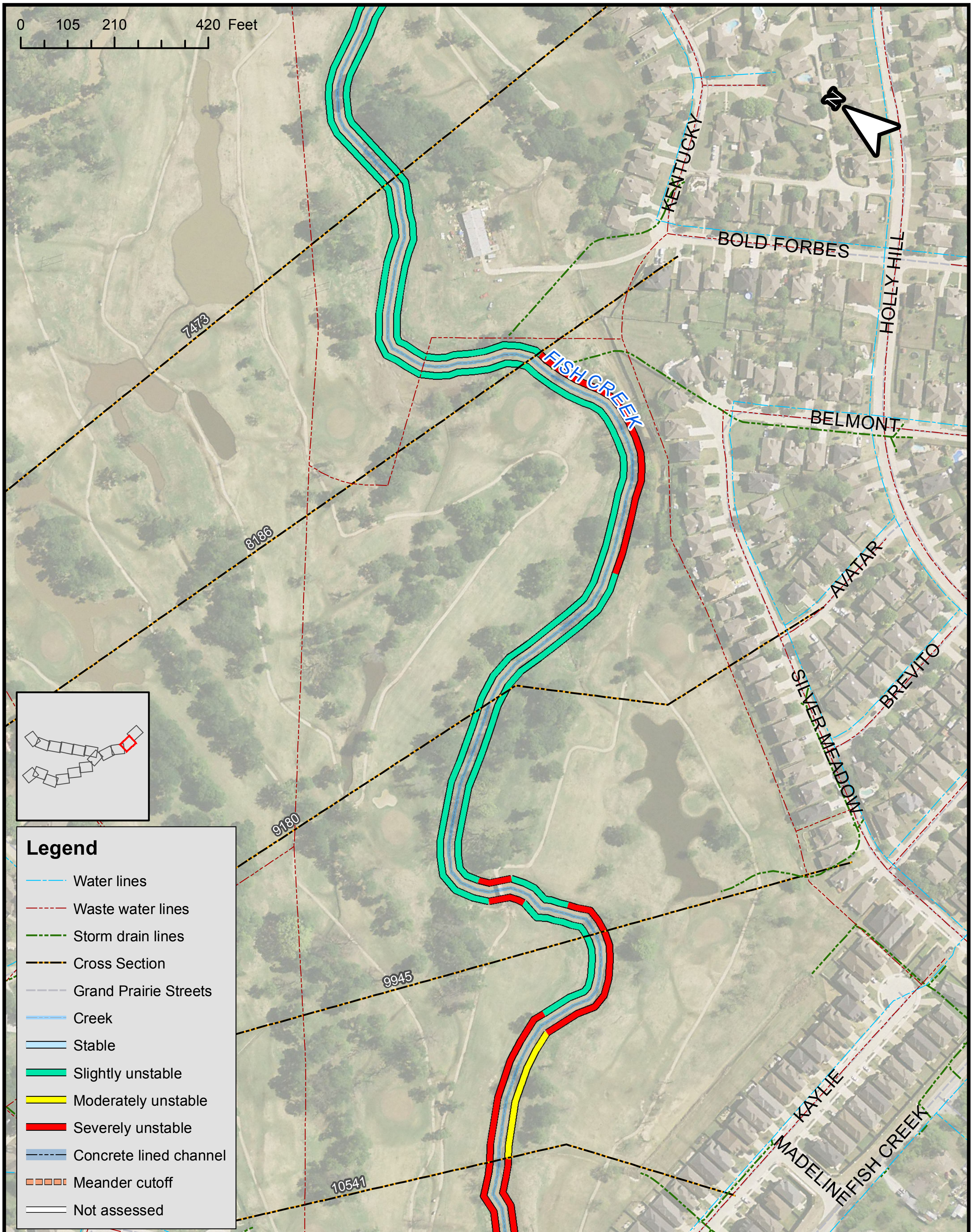

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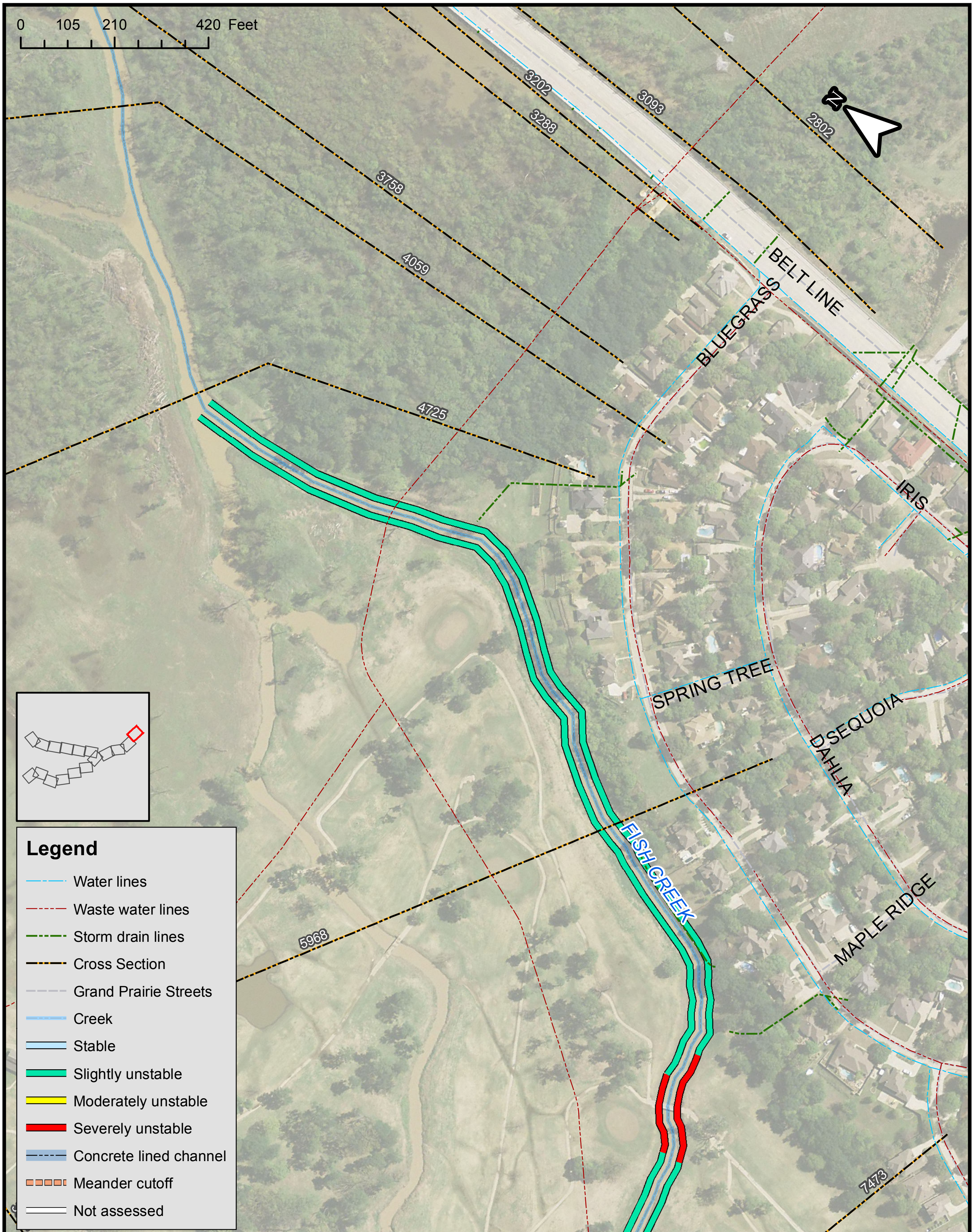

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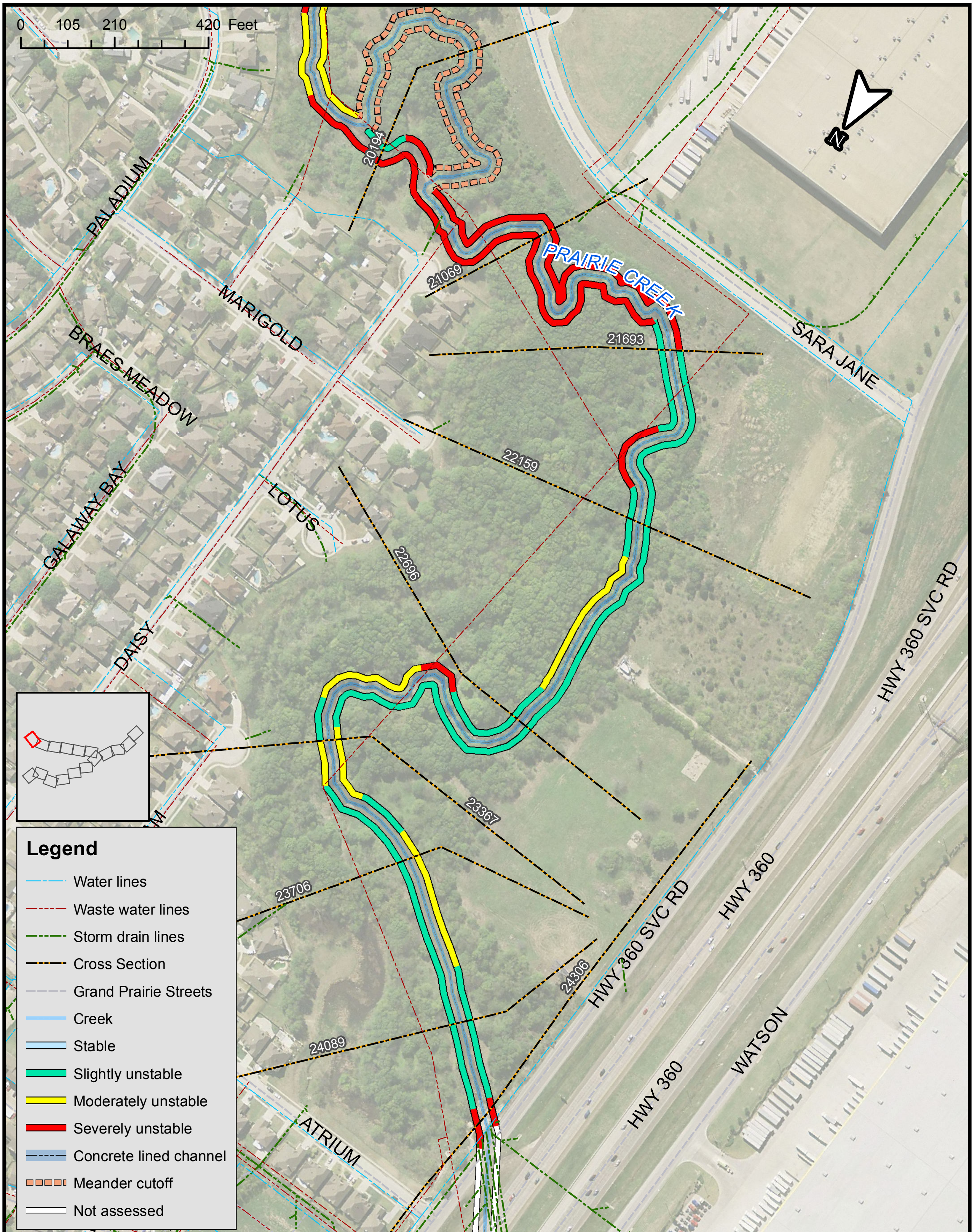

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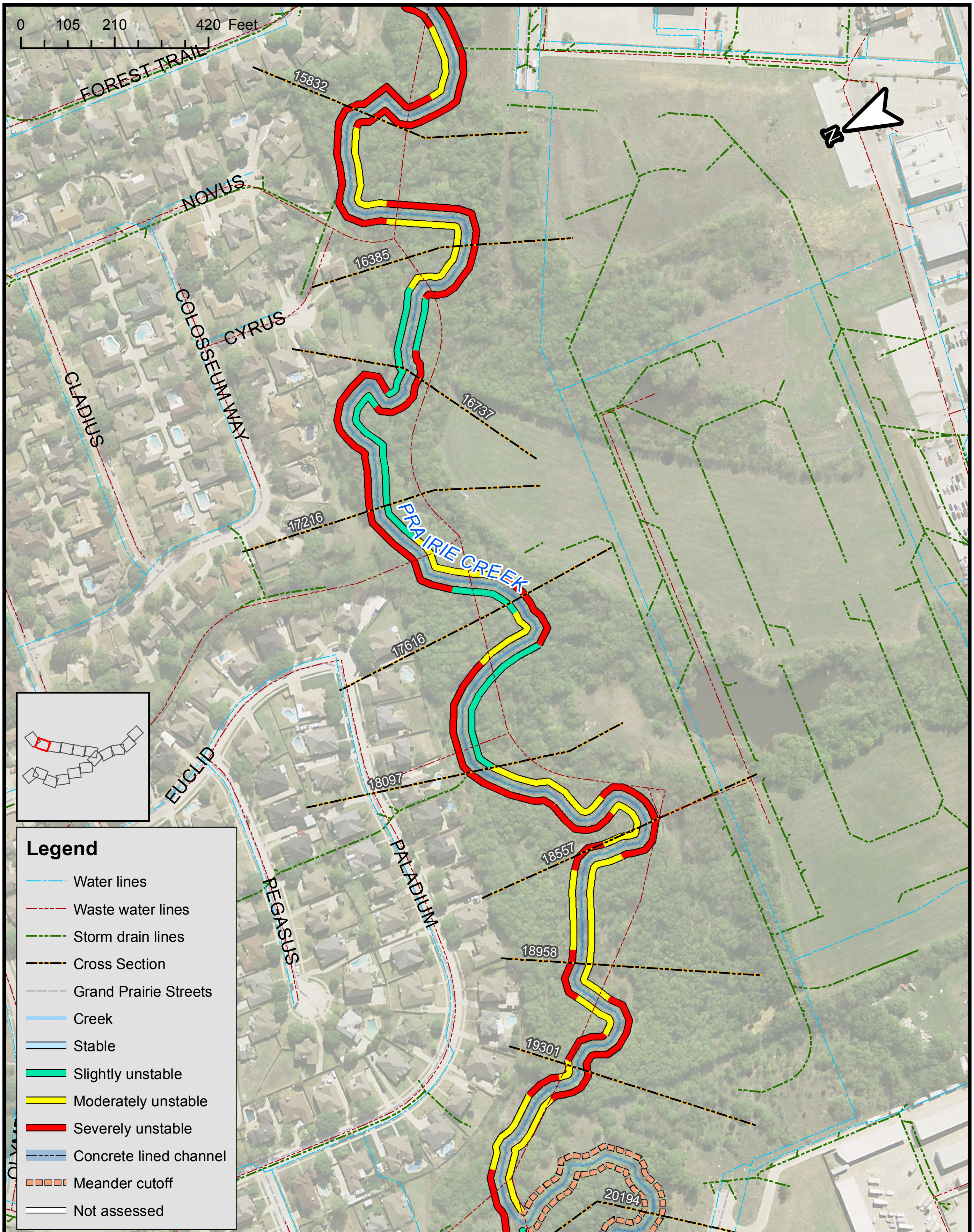

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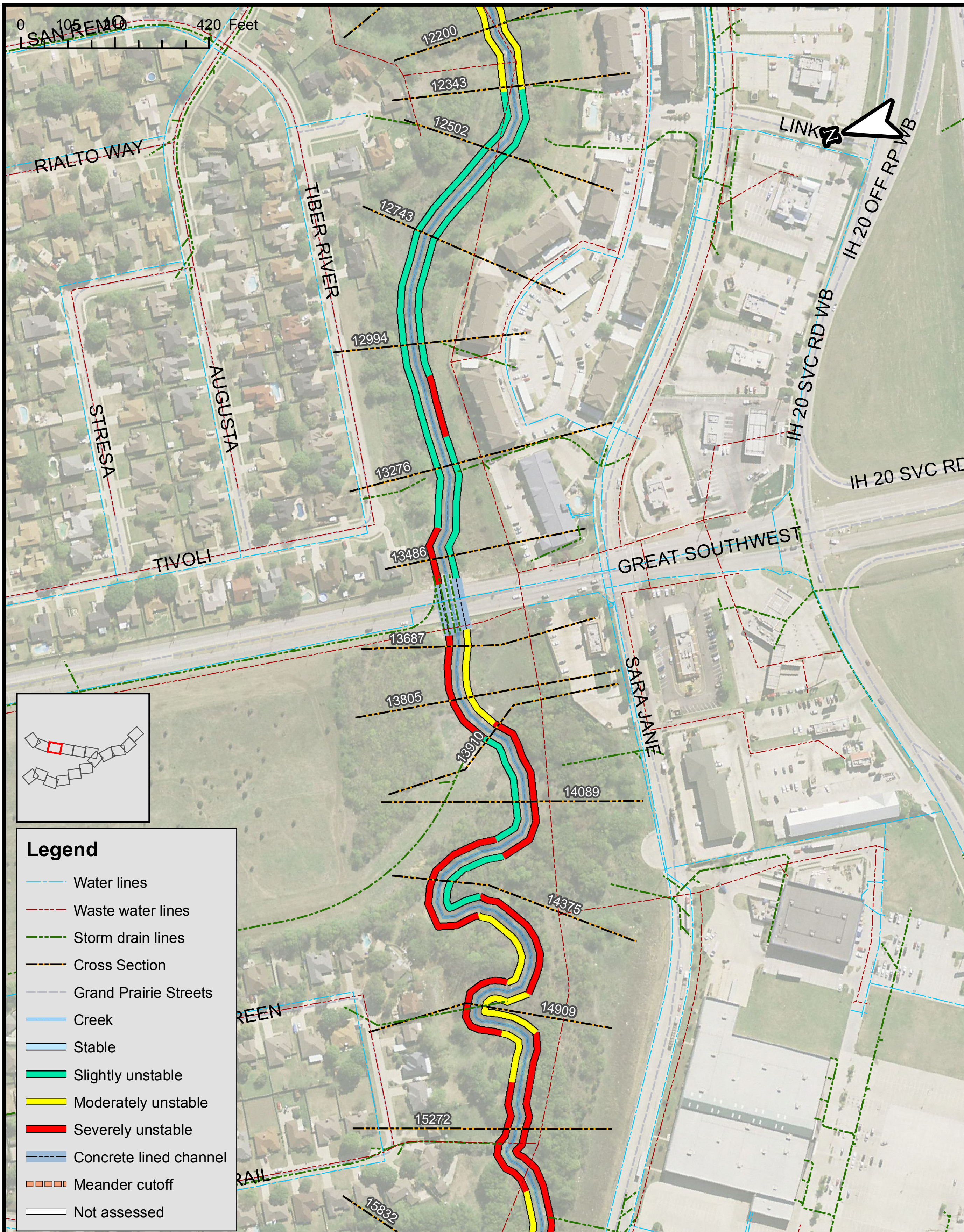

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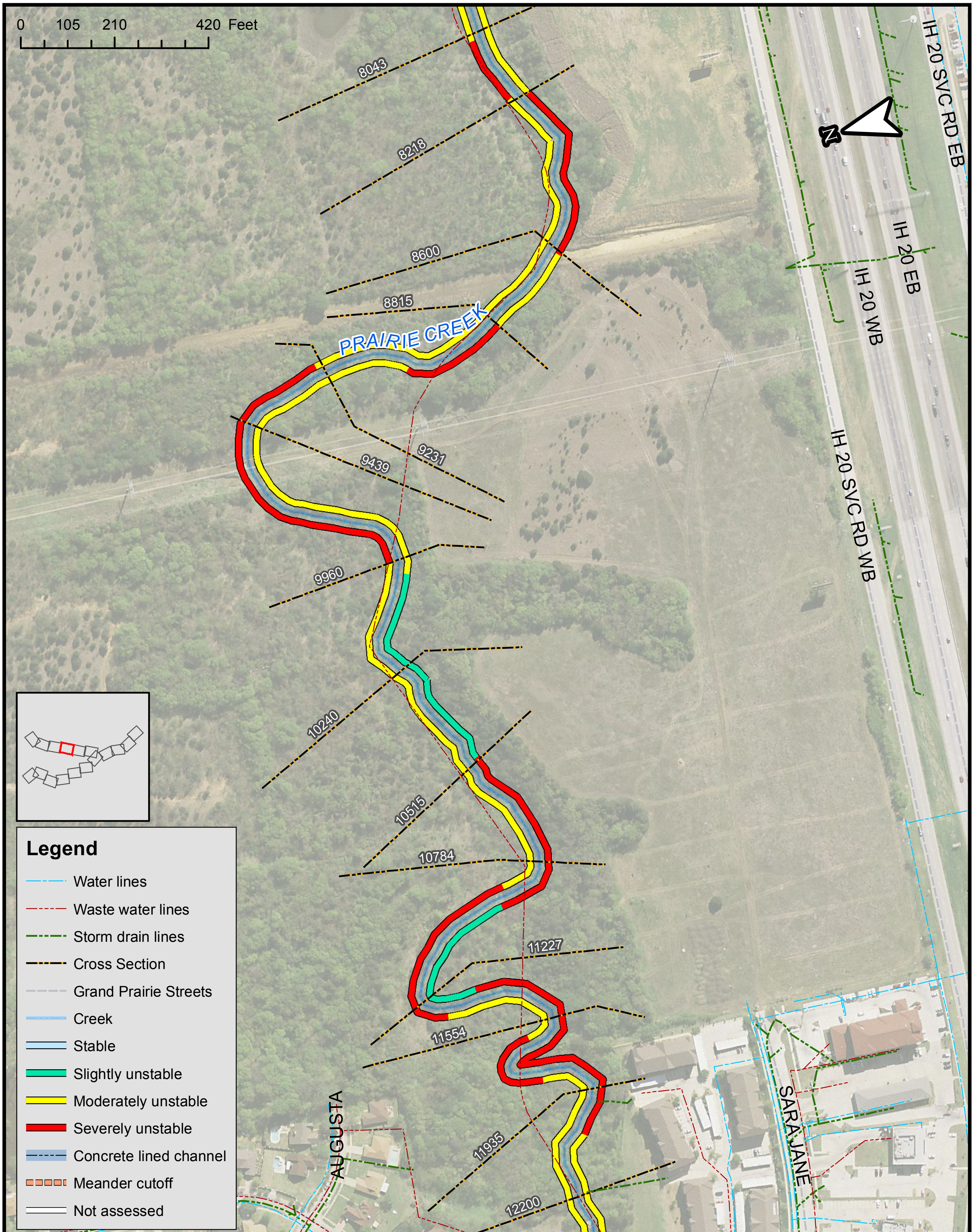

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D15
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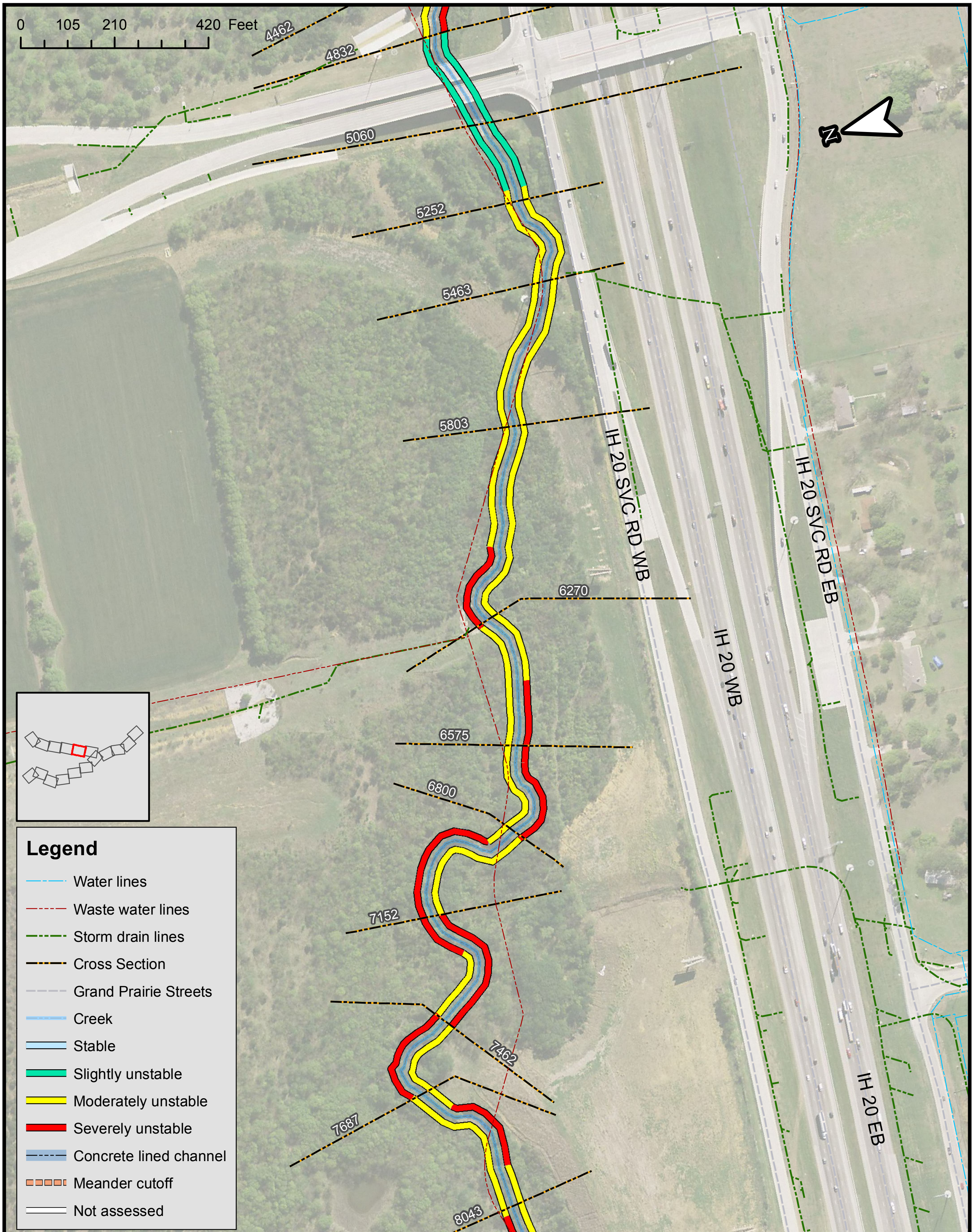

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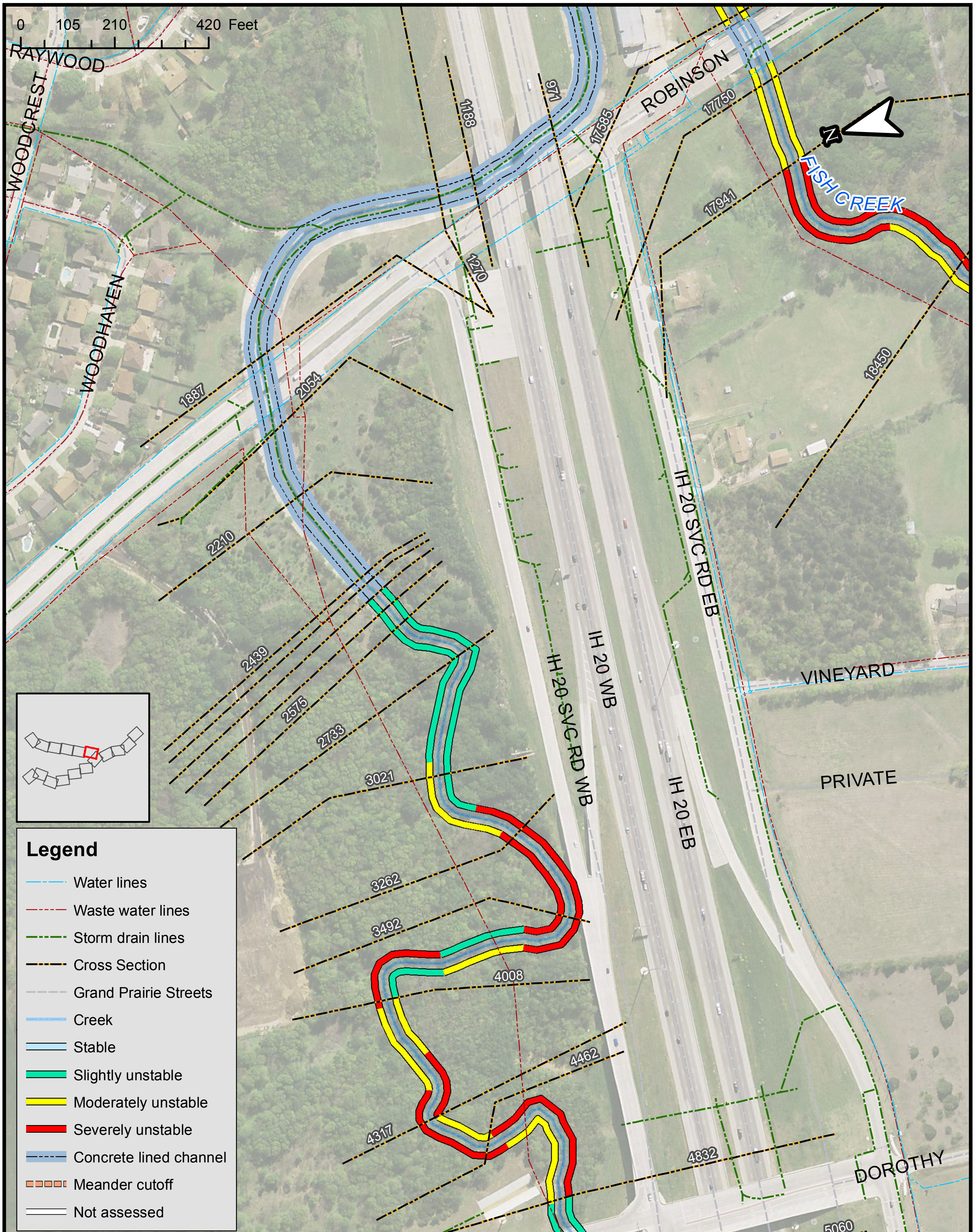
FIGURE



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D17
FIGURE

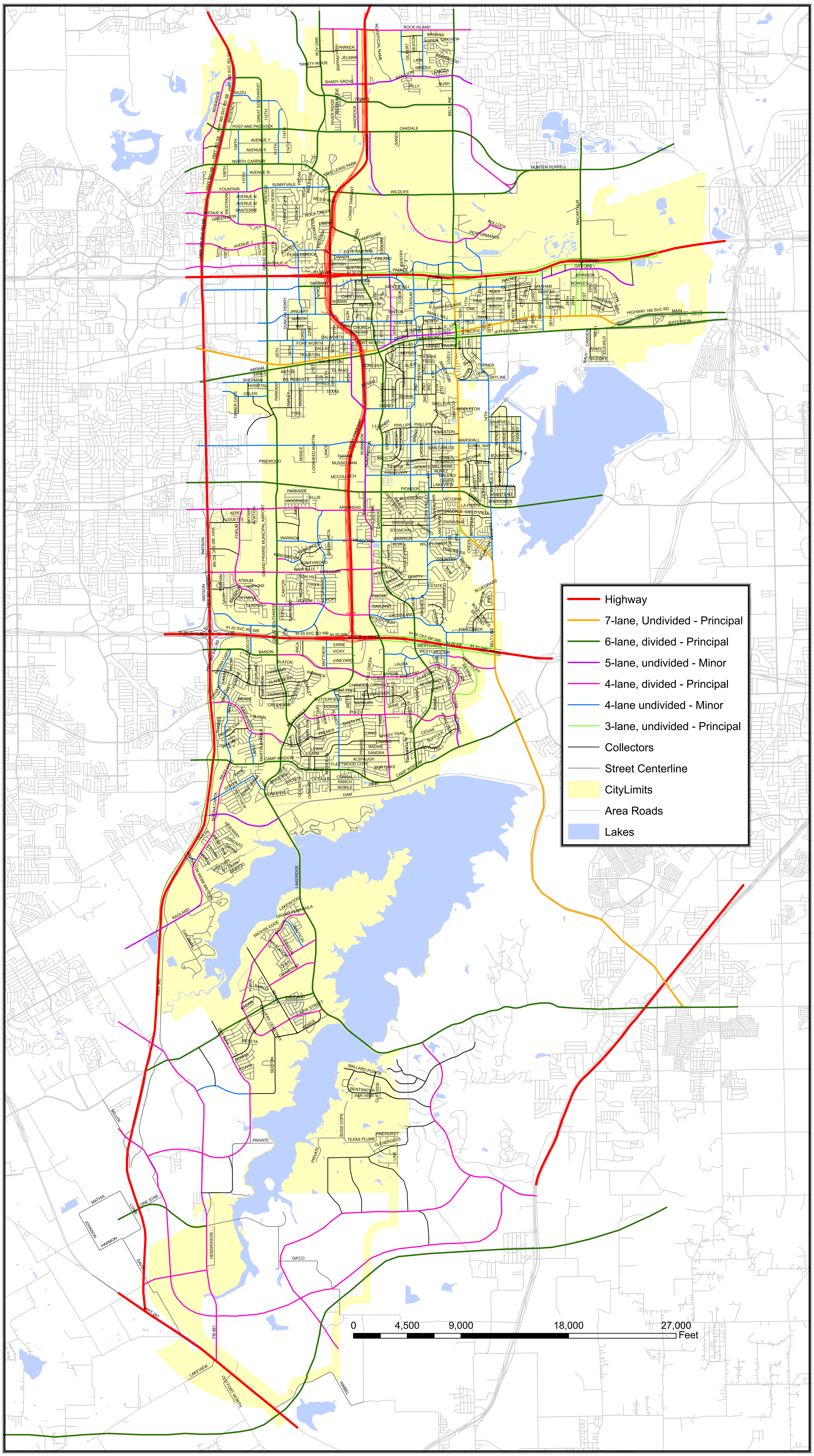
Attachment 1

Appendix F
Miscellaneous Documentation

City of Grand Prairie

Thoroughfare Plan Map

Current as of: October 4, 2005



REGULATORY COMPLIANCE

Prior to commencement of construction, it will be necessary to submit the project and appropriate permit applications to regulatory agencies. A detailed review and acquisition of the necessary permits for the construction of these projects exceeds the scope of this contract; however, a partial list and brief discussion of permits is included in the following subsections. This following list of agencies and corresponding permit activities is intended to be general in nature and is not intended to represent a definitive list of required permit acquisitions and agency coordination.

Federal Emergency Management Agency (FEMA)

The National Flood Insurance Act of 1968 was enacted by Title XIII of the Housing and Urban Development Act of 1968 (Public Law 90-448, August 1, 1968) to provide previously unavailable flood insurance protection to property owners in flood prone areas. FEMA administers the National Flood Insurance Program (NFIP); however, if a local community elects to participate in the NFIP, the local government is primarily responsible for enforcement. Participating communities are typically covered by a Flood Insurance Study which defines water surface profiles and floodplain boundaries through their communities.

If changes to the current effective FEMA floodplain map are desired as a result of improvements, a request for a Letter of Map Revision (LOMR) from FEMA will be required.

U. S. Army Corps of Engineers (USACE)

Pursuant to Section 404 of the Clean Water Act and the Rules and Regulations promulgated there under by the United States Environmental Protection Agency (USEPA) and the United States Army Corps of Engineers (USACE), the filling or excavation of waters of the United States, including wetlands, with dredged or fill material, requires the issuance of a permit from the USACE (33 CFR Parts 320-330). For purposes of administering the Section 404 permit program, the USACE defines wetlands as follows:

> *Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. (33 CFR 328.3)*

The Corps of Engineers Wetlands Delineation Manual (Technical Report Y-87-1), issued by the USACE in 1987 states that wetlands must possess three essential characteristics. These characteristics include, under normal circumstances: 1) the presence of hydrophytic vegetation, 2) hydric soils, and 3) wetland hydrology. If all three of these criteria are present on a particular property in areas larger than one-third acre in size, then a permit (general permit or nationwide permit) must be issued by the USACE in order to fill all or a portion of those areas. Exhibit 19 in Appendix A shows the known wetland areas within the 100-Year floodplain.

Section 404 (b)(1) guidelines (40 CFR Part 230), established by the USEPA, constitute the substantive environmental criteria used in the evaluating activities regulated under Section 404 of the Clean Water Act. The purpose of these guidelines is to restore and maintain the chemical physical and biological integrity of waters of the United States through the control of discharge of dredged or fill material. All property owners within the United States and its territories must adhere to the provisions of the Clean Water Act. If any contemplated activity might impact waters of the United States, including adjacent or isolated wetlands a permit application must be made. If jurisdictional waters and/or wetlands are found to exist, then any activity which would involve filling, excavating, or dredging these wetlands would require the issuance of a permit. The final authority to determine whether or not jurisdictional waters exist lies with USACE.

U.S. Fish and Wildlife Service (USFWS)

The U.S. Fish and Wildlife Service (USFWS), in the Department of the Interior, and the National Marine Fisheries Service (NMFS), in the Department of Commerce, share responsibility for administration of the Endangered Species Act (ESA). Generally, the USFWS is responsible for terrestrial and freshwater species and migratory birds, while the NMFS deals with those species occurring in marine environments and anadromous fish.

Section 9 of the ESA prohibits take of federally listed endangered or threatened species without appropriate authorization. Take is defined in the ESA, in part as "killing, harming, or harassment" of a federally listed species, while incidental take is take that is "incidental to, and not the purpose of, otherwise lawful activities".

Section 10 of the ESA provides a means for non-Federal projects resulting in take of listed species to be permitted subject to carefully prescribed conditions. Application for an incidental take permit is subject to a number of requirements, including preparation of a Habitat Conservation Plan by the applicant. In processing an incidental take permit application, the USFWS must comply with appropriate environmental laws, including the National Environmental Policy Act. Review of the application under Section 7 of the ESA is also required to ensure that permit issuance is not likely to jeopardize listed species. Section 10 issuance criteria require the USFWS to issue and incidental take permit if, after opportunity for public comment, it finds that:

1. the taking will be incidental;
2. the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of the taking;
3. the applicant will ensure that adequate funding and means to deal with unforeseen circumstances will be provided;
4. the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
5. the applicant will ensure that other measures that the USFWS may require as being necessary or appropriate will be provided.

The U.S. Fish and Wildlife Service should be contacted to determine the potential occurrence of and consequent impacts to any federal threatened and endangered species. In addition, the Corps of Engineers will require USFWS review of the project to ensure the project is in compliance with the Endangered Species Act prior to the issuance of a Section 404 permit.

Texas Commission on Environmental Quality (TCEQ)

The Texas Commission on Environmental Quality (TCEQ) has regulatory authority over: dam safety, water rights, Texas Pollutant Discharge Elimination System and Section 404(b)(1) guidelines for specification of disposal sites for dredged or fill material. The following sections briefly describe these regulations.

- Texas Pollutant Discharge Elimination System (TPDES)

On September 14, 1998, the USEPA authorized Texas to implement its Texas Pollutant Discharge Elimination System (TPDES) program. TPDES is the state program to carry out the National Pollutant

Discharge Elimination System (NPDES), a federal regulatory program to control discharges of pollutants to surface waters of the United States. The TCEQ administers the program, and a permit is required for any construction activity that disturbs one acre or more.

- Section 401 Water Quality Certification

Any activity requiring authorization under Section 404 of the Clean Water Act will also require a Section 401 water quality certification from the TCEQ. In Texas, these regulations are administered by the TCEQ.

- Texas Water Code Section 11.121 Water Right Permit

Use of surface water, including the diversion or storage of water, in the State of Texas requires a water right permit through the State of Texas pursuant to Texas Water Code Section 11.121. TCEQ requires the submission of the Water Rights Permit Package Application, TCEQ-10214 form. This application must be notarized and submitted with the water use permit application fees. Supplemental information may be required with the application.

- Texas Historical Commission

The Division of Antiquities Protection of the Texas Historical Commission coordinates the program by identifying and protecting important archeological and historic sites that may be threatened by public construction projects. This department coordinates the nomination of numerous sites as State Archeological Landmarks or for listing in the National Register of Historic Places. Designation is often sought by interested parties as the most effective way to protect archeological sites threatened by new development or vandalism. Applicable rules are found in the Texas Administrative Code, Title 13-Cultural Resources, Part II-Texas Historical Commission, Chapters 24-28.

The Corps of Engineers will require that the State Historical Preservation Officer (SHPO) review the project to ensure the project is in compliance with the National Historic Act prior to issuance of a Section 404 permit.

Appendix G
CD-ROM