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

City of Grand Prairie

July 2012

Project No. 11006.00

RPS Espey

RESOLUTION NO. 4574-2012

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

WHEREAS, the "City-Wide Drainage Master Plan for Cottonwood Creek" (the Plan) is about providing comprehensive, updated technical data for the management of the Cottonwood 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 Cottonwood 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 THAT:

SECTION 1. That the City of Grand Prairie, Texas, having developed the "City-Wide Drainage Master Plan for Cottonwood Creek" to cost-effectively manage flood or storm waters within budgeting constraints, approves and adopts the "City-Wide Drainage Master Plan for Cottonwood 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
TEXAS

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

Prepared for:
Public Works Engineering Department
City of Grand Prairie
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7-12-12

Project No. 11006

July 2012

TABLE OF CONTENTS

EXECUTIVE SUMMARY VI
I. INTRODUCTION I-1
A. ACKNOWLEDGEMENTS I-1
B. PURPOSE OF STUDY I-1
C. CITY ORDINANCES AND DEVELOPMENT REQUIREMENTS I-2
D. WATERSHED DESCRIPTION I-3
E. PRINCIPAL FLOODING PROBLEMS I-4
F. PERTINENT STUDY AND TECHNICAL DATA RELATED TO WATERSHED PRIOR TO COTTONWOOD CREEK DRAINAGE MASTER PLAN PREPARATION I-4
II. THE HYDROLOGIC STUDIES II-1
A. GENERAL II-1
B. WATERSHEDS II-1
C. LAND USE II-1
D. IMPERVIOUS COVERAGE II-1
E. SOIL TYPES II-5
F. LOSS RATES II-6
G. SYNTHETIC UNIT HYDROGRAPH METHODS II-9
H. RAINFALL II-11
I. FLOOD ROUTING II-12
J. DETENTION AND DIVERSIONS II-12
III. HYDRAULIC STUDIES III-1
A. HYDRAULIC ANALYSES III-1
IV. HYDROLOGIC AND HYDRAULIC STUDY RESULTS IV-1
A. HYDROLOGIC STUDY RESULTS IV-1
B. HYDRAULIC STUDY RESULTS IV-11
V. FLOODPLAIN MAPPING V-1
A. FEMA MAP REVISIONS V-1
VI. ROADWAY CROSSINGS VI-1
A. EVALUATION OF EXISTING ROADWAY CROSSINGS VI-1
B. EVALUATION OF PROPOSED AND FUTURE ROADWAY CROSSINGS VI-4
VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS VII-1
A. BELTLINE ROAD AT COTTONWOOD CREEK (STREAM STATION 53+20) VII-1
B. 3RD STREET AT COTTONWOOD CREEK (STREAM STATION 107+60) VII-2
C. CARRIER PARKWAY AT COTTONWOOD CREEK (STREAM STATION 8+59) AND CARRIER PARKWAY AT SOUTH FORK OF COTTONWOOD CREEK (STREAM STATION 9+05) VII-2
D. GREAT SOUTHWEST PARKWAY AT COTTONWOOD CREEK (STREAM STATION 105+50) VII-3
E. MARSHALL DRIVE AT SOUTH FORK OF COTTONWOOD CREEK (STREAM STATION 24+73) VII-4
F. ROBINSON ROAD AT SOUTH FORK OF COTTONWOOD CREEK (STREAM STATION 28+52) VII-5
G. PIONEER PARKWAY AT SOUTH FORK OF COTTONWOOD CREEK (STREAM STATION 145+82) VII-5
H. GREAT SOUTHWEST PARKWAY AT SOUTH FORK OF COTTONWOOD CREEK (STREAM STATION 166+85) VII-6
I. BELTLINE ROAD AT PLATTNER CREEK (STREAM STATION 65+17) VII-6
J. CORAL WAY AT PLATTNER CREEK (STREAM STATION 52+35) VII-7

VIII. STORM WATER INFRASTRUCTURE ANALYSIS VIII-1
A. OVERVIEW VIII-1
IX. CHANNEL STABILITY ASSESSMENT AND EROSION HAZARD ANALYSIS IX-1
A. INTRODUCTION IX-1
B. STANDARD EROSION PREVENTION MEASURES IX-2
C. NORTH FORK COTTONWOOD CREEK IX-4
D. SOUTH FORK COTTONWOOD CREEK IX-8
E. COTTONWOOD CREEK MAIN STEM IX-14
F. WARRIOR CREEK IX-16
G. PLATTNER CREEK IX-18
X. DAMS / LEVEES / DETENTION / DRAINAGE REVIEWS X-1
A. DAMS / LEVEES X-1
B. DETENTION PONDS X-1
C. DETENTION POND MAINTENANCE X-1
XI. STORM DRAIN OUTFALL ASSESSMENT XI-16
A. CONDITION AND CRITERIA XI-16
XII. PRELIMINARY QUANTITIES / ESTIMATES OF PROBABLE COST XII-1
XIII. EVALUATION AND PRIORITIZATION / PHASING AND IMPLEMENTATION XIII-1
A. EVALUATION AND PRIORITIZATION XIII-1
B. IMPLEMENTATION XIII-7
XIV. SHORT TERM PRIORITIES AND LONG TERM PLAN XIV-1
A. SHORT-TERM PRIORITIES IMPLEMENTATION XIV-1
B. LONG-TERM PLAN IMPLEMENTATION XIV-1
XV. MASTER PLAN STUDY WRAP-UP AND RECOMMENDATIONS XV-1
A. STREAMS AND OPEN CHANNELS XV-1
B. STREAM BANK STABILITY XV-1
C. MAINTENANCE XV-1
D. FUTURE STUDIES AND REPORT UPDATES XV-1
Appendix **A Figures** .... A
Appendix **B Tables** .... B
Appendix **C Hydrologic & Hydraulic Model Output** C
Appendix **D Storm Drain Model Output** .... D
Appendix **E Geomorphic Stream Assessment** .... E
Appendix **F Miscellaneous Documentation** .... F
Appendix **G CD-ROM** .... G

FIGURES

Figure II-1: Watersheds II-2
Figure II-2: Existing Land Use Map II-3
Figure II-3: Ultimate Landuse Map II-4
Figure II-4: Hydrologic Soils Map II-8
Figure II-5: NRCS Unit Graph II-9
Figure II-6: Average Velocities for Estimating Travel Time in Shallow Concentrated Flow Segments II-10
Figure V-1: Floodplain Work Map 1 of 6 .... V-2
Figure V-2: Floodplain Work Map 2 of 6 .... V-3
Figure V-3: Floodplain Work Map 3 of 6 .... V-4
Figure V-4: Floodplain Work Map 4 of 6 .... V-5
Figure V-5: Floodplain Work Map 5 of 6 .... V-6
Figure V-6: Floodplain Work Map 6 of 6 .... V-7
Figure VI-1: Existing Roadway Crossings VI-5

Figure IX-1: Erosion Hazard Setback Schematic IX-2
Figure IX-2: Typical Stacked Gabion Basket IX-3
Figure IX-3: Typical Drop Structure IX-3
Figure IX-4: Typical Drop Structure with Pipe Encasement IX-4
Figure IX-5: Location Map IX-5
Figure IX-6: Bank Erosion at Cross Section 111+07 .... IX-6
Figure IX-7: Undermining of Riprap/Shotcrete Upstream of Cross Section 105+50 .... IX-6
Figure IX-8: Right Bank Erosion D/S of Railroad Crossing IX-7
Figure IX-9: Channel Scour D/S of Railroad Crossing IX-7
Figure IX-10: Channel Scour D/S of Railroad Crossing IX-8
Figure IX-11: Channel Scour D/S of Great Southwest Parkway IX-9
Figure IX-12: Channel Incision near Cross Section 159+04 .... IX-10
Figure IX-13: Bank Erosion near Cross Section 151+93 .... IX-10
Figure IX-14: Culverts at 134+79 .... IX-11
Figure IX-15: Downstream of Low Water Crossing at 119+67 .... IX-11
Figure IX-16: Bank Erosion at Cross Section 100+47 .... IX-12
Figure IX-17: Channel Scour at Cross Section 77+65 .... IX-12
Figure IX-18: Channel Between Cross Sections 51+96 and 51+57 .... IX-13
Figure IX-20: Bank Erosion Near Cross Section 124+82 .... IX-15
Figure IX-21: Pedestrian Bridge Foundation Damage at Cross Section 110+42 .... IX-15
Figure IX-22: Gabion Wall in WARC-1 Creek Centerline IX-17
Figure IX-23: Bank Erosion and Sparse Vegetation at Cross Sections 13 and 14 .... IX-18
Figure IX-24: Bank Erosion Along PLAC-1 .... IX-19
Figure IX-25: Bank Erosion Along PLAC-2 .... IX-20
Figure X-2: CWC On-Channel Pond No. 1: South of Wheat Hill Drive X-2
Figure X-1: Detention Pond Location Map X-3
Figure X-3: CWC On-Channel Pond Outfall No. 1: South of Wheat Hill Drive X-4
Figure X-4: CWC On-Channel Pond Outfall No. 1: South of Wheat Hill Drive X-4
Figure X-5: CWC Detention Pond No. 2: Between Skyline Road & Avion Parkway X-5
Figure X-6: CWC Retention Pond No. 3: Between Beltline Road & Tampico Street X-5
Figure X-7: CWC Retention Pond Outfall No. 3: Between Beltline Road & Tampico Street X-6
Figure X-8: CWC Detention Pond No. 4: G.P. Family Church off Beltline Road X-6
Figure X-9: CWC Detention Pond No. 5: Mountain Creek Retirement Living off 12 Oaks Boulevard X-7
Figure X-10: CWC Detention Pond No. 6: Between Cranbrook Lane & Blueberry Lane X-7
Figure X-11: CWC Retention Pond No. 7: Off West Pioneer Parkway X-8
Figure X-12: CWC Detention Pond No. 8: Off West Pioneer Parkway Behind Long John Silvers X-8
Figure X-13: CWC Detention Pond No. 9: Off West Pioneer Parkway Behind QuikTrip X-9
Figure X-14: CWC Detention Pond No. 10: Off 161 & Arkansas Lane X-9
Figure X-15: CWC Detention Pond No. 11: Along Police Station X-10
Figure X-16: CWC Detention Pond No. 12 .... X-10
Figure X-17: CWC Detention Pond No. 13 .... X-11
Figure X-18: CWC Detention Pond No. 15 .... X-11
Figure X-19: CWC Detention Pond No. 15 .... X-12
Figure X-20: CWC Detention Pond No. 19: North of Osler Drive & Timber Oaks Lane X-12
Figure X-21: CWC Detention Pond No. 20: Apartments off Timber Oaks Lane X-13
Figure X-22: CWC Detention Pond Outfall No. 20: Apartments off Timber Oaks Lane X-13
Figure X-23: CWC Detention Pond Outfall No. 21: Tyre Park X-14
Figure X-24: CWC Detention Pond Outfall No. 23 .... X-14
Figure X-25: CWC Detention Pond Outfall No. 24 .... X-15
Figure X-26: CWC Detention Pond Outfall No. 25 .... X-15
Figure XI-1: Fair Conditions Location Map XI-18
Figure XI-2: Poor Conditions Location Map XI-20
Figure XIII-1: Capital Improvement Projects Cottonwood Creek XIII-6

TABLES

Table I-1: Study Streams I-3
Table II-1: Impervious Cover II-5
Table II-2: Watershed Soil Classification II-6
Table II-3: NRCS Curve Number Assumption II-7
Table II-4: City of Grand Prairie Depth–Duration Rainfall Data II-11
Table III-1: Manning's Roughness Coefficients by Type III-2
Table III-2: Summary of Manning's Roughness Coefficients by Stream III-2
Table III-3: Hydraulic Parameters III-3
Table IV-1: Summary of Soil Types & Curve Number IV-1
Table IV-2: Summary of Hydrologic Parameters IV-3
Table IV-3: Summary of Discharges from this Study IV-4
Table IV-4: FEMA Effective Discharges (1996) IV-6
Table IV-5: Comparison of Restudy Discharges and Effective Discharges (cfs) IV-7
Table IV-6: Cottonwood Creek Basin Peak Run-Off IV-8
Table IV-7: Comparison of Restudy Discharge (cfs) and Variations in Impervious Cover IV-9
Table IV-8: Steady Flow Data IV-11
Table VI-1: Existing Bridge Crossings VI-1
Table VI-2: Existing Roadway Proposed Alternatives VI-3
Table VI-3: Cottonwood Creek Basin Studied Tributaries with Future Thoroughfare Crossings VI-4
Table IX-1: North Fork Cottonwood Creek Segments IX-4
Table IX-2: NFCC Structural Measures Cost Summary IX-8
Table IX-3: South Fork Cottonwood Creek Segments IX-9
Table IX-4: SFCC Structural Measures Cost Summary IX-13
Table IX-5: Cottonwood Creek Main Stem Segments IX-14
Table IX-6: CCMS Structural Measures Cost Summary IX-16
Table IX-7: Warrior Creek Main Stem Segments IX-16
Table IX-8: WARC Structural Measures Cost Summary IX-18
Table IX-10: PLAC Structural Measures Cost Summary IX-20
Table X-1: Cottonwood Creek Detention Pond Maintenance Condition X-1
Table XI-1: Cottonwood Creek Structures – Fair Conditions XI-16
Table XI-2: Cottonwood Creek Structures – Poor Conditions XI-19
Table XII-1: Summary of Stream and Open Channel Improvements XII-1
Table XII-2 Summary of Stream Stability Improvements XII-7
Table XIII-1: Ranking Matrix XIII-1
Table XIII-2 : Roadway Classifications XIII-1
Table XIII-3: Citizens Protected XIII-2
Table XIII-4: Citizens Impacted XIII-2
Table XIII-5: Roadway Benefit XIII-3
Table XIII-6: Value of Benefitted Structures XIII-3
Table XIII-7: Roadway Level of Service Classifications XIII-4
Table XIII-8 : Project Priorities XIII-5

EXECUTIVE SUMMARY

The fundamental objective of this Cottonwood Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed historically for the Cottonwood 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 Cottonwood Creek watershed.

The Cottonwood Creek watershed is located south of Main Street (Highway 180) and north of Warrior Trail. Drainage generally travels from west to east from an area in Arlington west of SH360, traveling eastward under SH161 to Mountain Creek Lake on the east side of the City of Grand Prairie. The Cottonwood 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 approximately 80% urbanized and 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.

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

Project Priorities

City Wide Drainage Master Plan

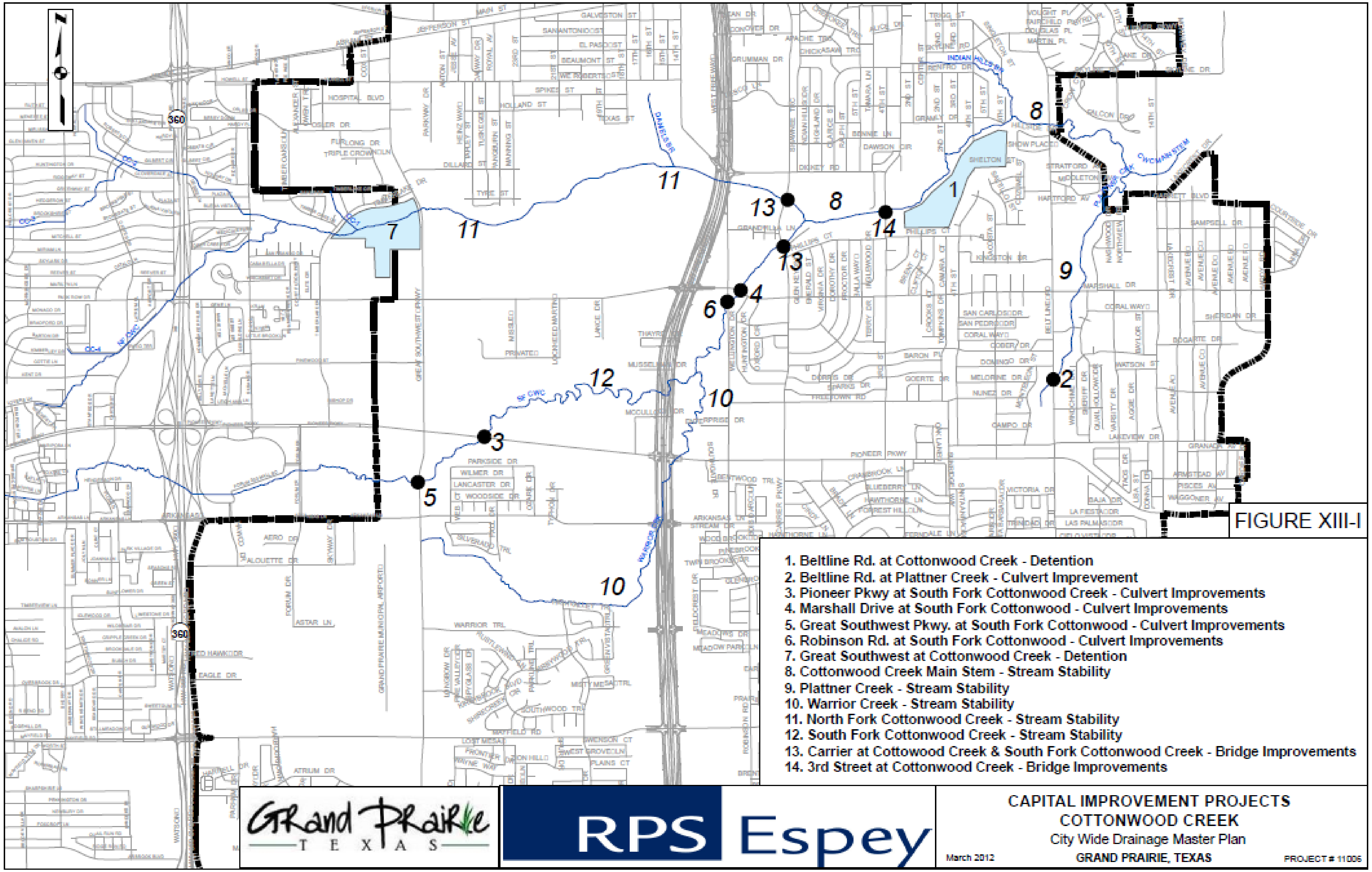
Cottonwood Creek

	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	Belt Line Road at Cottonwood Creek	Large/Long-Term	12	$4,719,000	3	P6D	5	35%	65%	7605	$620.51	6	$2,250,000	1	10	1	19,398		1
2	Belt Line Road at Plattner Creek	Small/Short-Term	0	$139,000	3	P6D	25	70%	30%	3510	$39.60	1	$0	20	24	2	1,981		2
3	Pioneer Parkway at SF Cottonwood	Small/Short-Term	0	$226,000	3	P6D	25	70%	30%	3510	$64.39	2	$0	20	25	3	3,987		3
4	Marshall Drive at SF Cottonwood	Medium/Long-Term	0	$814,000	4	M4U	2	15%	85%	5746	$141.66	3	$0	20	27	4	6,277	4	4
5	GSW Pkwy at SF Cottonwood	Small/Short-Term	0	$326,000	3	P4D	25	70%	30%	2340	$139.32	4	$0	20	27	4	4,010	5	5
6	Robinson Road at SF Cottonwood	Medium/Long-Term	0	$920,000	4	M4U	2	15%	85%	5746	$160.11	5	$0	20	29	6	6,197		6
11	North Fork Cottonwood Stream Stability	Small/Short-Term	0	$160,850	4	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	34	11	12,583	11	11
8	Cottonwood Creek Main Stem Stream Stability	Small/Short-Term	0	$259,720	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	19,398	8	8
7	GSW Pkwy at Cottonwood	Large/Long-Term	0	$4,937,000	5	P4D	2	15%	85%	6630	$744.65	7	$0	20	32	7	8,888		7
9	Plattner Creek Stream Stability	Small/Short-Term	0	$191,940	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	3,608	9	9
10	Warrior Creek Stream Stability	Small/Short-Term	0	$380,895	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	1,466	10	10
13	Carrier at SF Cottonwood/Cottonwood	X-Large/Long-Term	0	$6,486,000	8	M5U	2	15%	85%	7182.5	$903.03	8	$0	20	36	13	18,386		13
14	3rd Street at Cottonwood	X-Large/Long-Term	0	$8,469,000	8	C2U	2	15%	85%	2320.5	$3,649.64	9	$0	20	37	14	18,630		14
12	South Fork Cottonwood Stream Stability	Medium/Long-Term	0	$560,575	4	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	34	11	6,047	12	12

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, w ith 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 Roadw ay 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 Roadw ay # 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, w hen comparing projects betw een tw o different w atersheds: If tw o 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 low est cost estimate

Project Location Map



I. INTRODUCTION

A. Acknowledgements

Espey Consultants, Inc., dba RPS Espey, has completed the Cottonwood 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 Cottonwood 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 Cottonwood Creek City-Wide Drainage Master Plan project.

Romin Khavari, P.E., CFM, City Engineer
Gabe Johnson, P.E., CFM, Flood Plain 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 Cottonwood Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydraulic models that have been developed historically for the Cottonwood 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 Cottonwood Creek watershed.

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

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. Preform 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 Cottonwood drainage basin.

6. Preform 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 Cottonwood Creek watershed originates within the City of Arlington and continues downstream through the City of Grand Prairie. 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 December 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 Cottonwood 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 approximately 80% urbanized and 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 Cottonwood Creek watershed is located south of Main Street (Highway 180) and north of Warrior Trail. Drainage generally travels from west to east from an area in Arlington west of SH360, traveling eastward under SH161 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 Cottonwood 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 Cottonwood Creek encompassed the fourteen square mile drainage basin, of which 9.7 square miles are in the city limits of Grand Prairie. The Cottonwood Creek hydraulic analysis begins at Mountain Creek Lake and extends to the City of Grand Prairie's boundary with Arlington. This analysis encompassed 13.5 miles of stream and included South Fork of Cottonwood Creek, Warrior Creek, Plattner Creek, Henry Branch, Indian Hills Branch and Daniel's Branch.

Table I-1: Study Streams

Stream Name	Downstream Limit	Upstream Limit	Study Method	Hydrologic Model Used	Hydraulic Model Used	Length (mi)
Cottonwood Creek	Confluence with Mountain Creek	Approximately 350' downstream of Carrier Pkwy.	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	2.4
Daniels Branch	Confluence with North Fork of Cottonwood Creek	Approximately 1800' upstream of the confluence with North Fork of Cottonwood Creek	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	0.33
Henry Branch	Confluence with Indian Hills Branch	Just downstream of Dallas Street	Enhanced Approximate	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	0.89
Indian Hills Branch	Confluence with Cottonwood Creek	Just downstream of Center Street	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	0.6
North Fork of Cottonwood Creek	Confluence with Cottonwood Creek	Approximately 2300' upstream of Great Southwest Parkway	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	2.41
Plattner Creek	Confluence with Cottonwood Creek	Approximately 700' upstream of Beltline Road	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	1.35
South Fork of Cottonwood Creek	Confluence with Cottonwood Creek	Approximately 1400' upstream of Great Southwest Parkway	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	3.47

Stream Name	Downstream Limit	Upstream Limit	Study Method	Hydrologic Model Used	Hydraulic Model Used	Length (mi)
Warrior Creek	Confluence with South Fork of Cottonwood Creek	Near Fall Street, south of Arkansas Lane	Detailed	HEC-HMS (v. 3.5)	HEC-RAS (v. 4.1)	2.1
Total Length						**13.55**

2. Unique Attributes of the Watershed

Cottonwood 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. There are a total of twenty bridges and/or culverts in Cottonwood Creek and its tributaries.

There have been two recently completed hydraulic improvement projects, the floodplain reclamation project by Poly America and the Central Park Facilities constructed by the City. The Poly America project consisted of three on-channel lakes and four erosion control structures on Cottonwood Creek between S.H. 161 and Great Southwest Parkway, which allowed Poly America to reclaim 5.2 acres of land from the floodplain. The Central Park project constructed five off-channel ponds which serve as detention and water features for the Central Park complex which houses the Senior Center and Central Police Station. These facilities are located along Warrior Creek between Arkansas Lane and Warrior Trail.

E. Principal Flooding Problems

1. Drainage Complaint Database

The Drainage Complaint Database has five hundred and forty five (545) entries for the Cottonwood Creek Basin. This represents approximately twenty three percent (23%) of all the entries in the database. The complaints are categorized as follows: fourteen (14) erosion, eighty-six (86) property flooding, one hundred thirteen (113) street flooding and one hundred forty-three (143) structure flooding.

2. Hot Spot Locations

a. Tapley Street (along Tyre Branch – Erosion)
b. San Antonio, El Paso, and Beaumont Street (south of Jefferson Boulevard.)
c. Dallas Street to Clarice Drive (west of 5th Street)
d. Along Jefferson and Main Street (east of Carrier Parkway)
e. Along Indian Hills Branch (property flooding, erosion)
f. Gramley Street
g. Parkside Drive (east of Great Southwest Parkway)
h. Wellington Drive (east of Robinson Road)
i. Cober and 3rd Street, Freetown and 3rd Street
j. Along Powers Branch (property flooding, erosion)
k. Phillip's Court (east of 4th Street)
l. South of Stratford Drive (east of Beltline Road)
m. Texas and 18th Street

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

1. Existing Data

a. FEMA FY10 Risk MAP Project–Halff Associates, Espey Consultants Inc., AECOM, O'Brien Engineering Inc. (Oct. 2011)
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 watersheds in the City, Cedar Creek, Cottonwood Creek, Fish Creek and Johnson Creek. Relevant information from that study has been included this report.

b. Cottonwood and Fish Creek Flood Protection Plan – Espey Consultants Inc. (Jan. 2011)
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.

c. Letter of Map Revision Report for FEMA, Cottonwood Creek - Graham Associates, Inc. (Aug. 2009)
Floodplain reclamation project for Poly American along Cottonwood Creek between S.H. 161 and Great Southwest Parkway.

d. Central Park Drainage Design Analysis Warrior Creek – Halff Associates (Nov. 2008)

e. Watershed Technical Report – Freese & Nichols (Feb. 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.

f. Henry Branch Watershed Study – Halff Associates (Nov. 2005)
This is a supplement to the Main Street Drainage at Center Street (Y #200)

g. Cottonwood Creek Drainage Master Plan – Hutt-Zollars (April 1995)

h. Cottonwood Creek–HEC-2 to HEC-RAS Conversion for Cottonwood Creek and Tributaries— Halff Associates (February 2002)

i. Main Street Drainage at Center Street – Preliminary Report –Halff Associates (May 2003)
The purpose of this study was to analyze the existing storm drain system to identify problems and recommend alternatives. Alternatives include various culvert improvements.

j. Veteran's Park Conceptual Design Services Report – Halff Associates (Dec. 2006)

II. THE HYDROLOGIC STUDIES

A. General

The Cottonwood Creek Basin has a drainage area of 14.4 square miles. Cottonwood Creek has three major tributaries, South Fork of Cottonwood Creek, Warrior Creek and Plattner Creek as well as nine minor tributaries, Avion Branch, Henry Branch, Indian Hills Branch, Gray's Branch, Daniels Branch, Raine's Branch, Jackson Branch, Bostick Branch and Williamson Branch. 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 Cottonwood 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 hydrologic analysis of Cottonwood Creek encompassed the fourteen square mile drainage basin. The Cottonwood Creek hydraulic analysis begins at Mountain Creek Lake and extends to the City of Grand Prairie's boundary with Arlington. This analysis encompassed 10.5 miles of stream and included South Fork of Cottonwood Creek, Plattner Creek, Indian Hills Branch and Daniel's Branch.

The Cottonwood Creek watershed is located south of Main Street (Highway 180) and north of Warrior Trail. Drainage generally travels from west to east from an area in Arlington west of SH360, traveling eastward under SH161 to Mountain Creek Lake on the east side of the City of Grand Prairie. **Figure II-1** is a detailed map of the watershed and its subbasins.

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**.

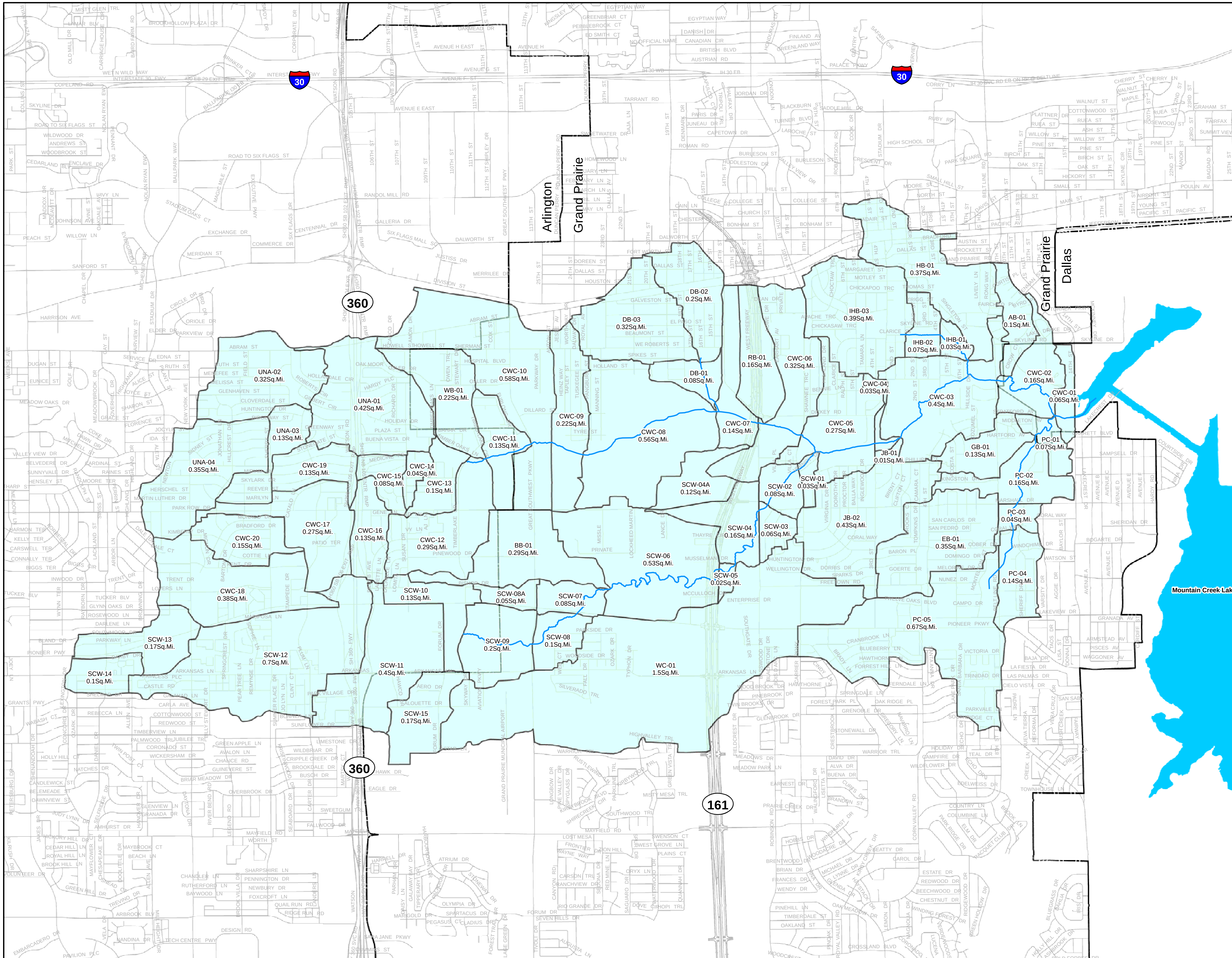
The ultimate development conditions (fully-developed conditions) analysis included modifications to the impervious cover percentages to represent full development. For the purposes of this analysis, full development was assumed to be equivalent to the estimated level by the year 2030 for City of Grand 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
CottonWood Creek



KEY TO FEATURES

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

0 1,500 3,000 6,000

Scale in Feet

N W E S

RPS Espey

Grand Prairie TEXAS

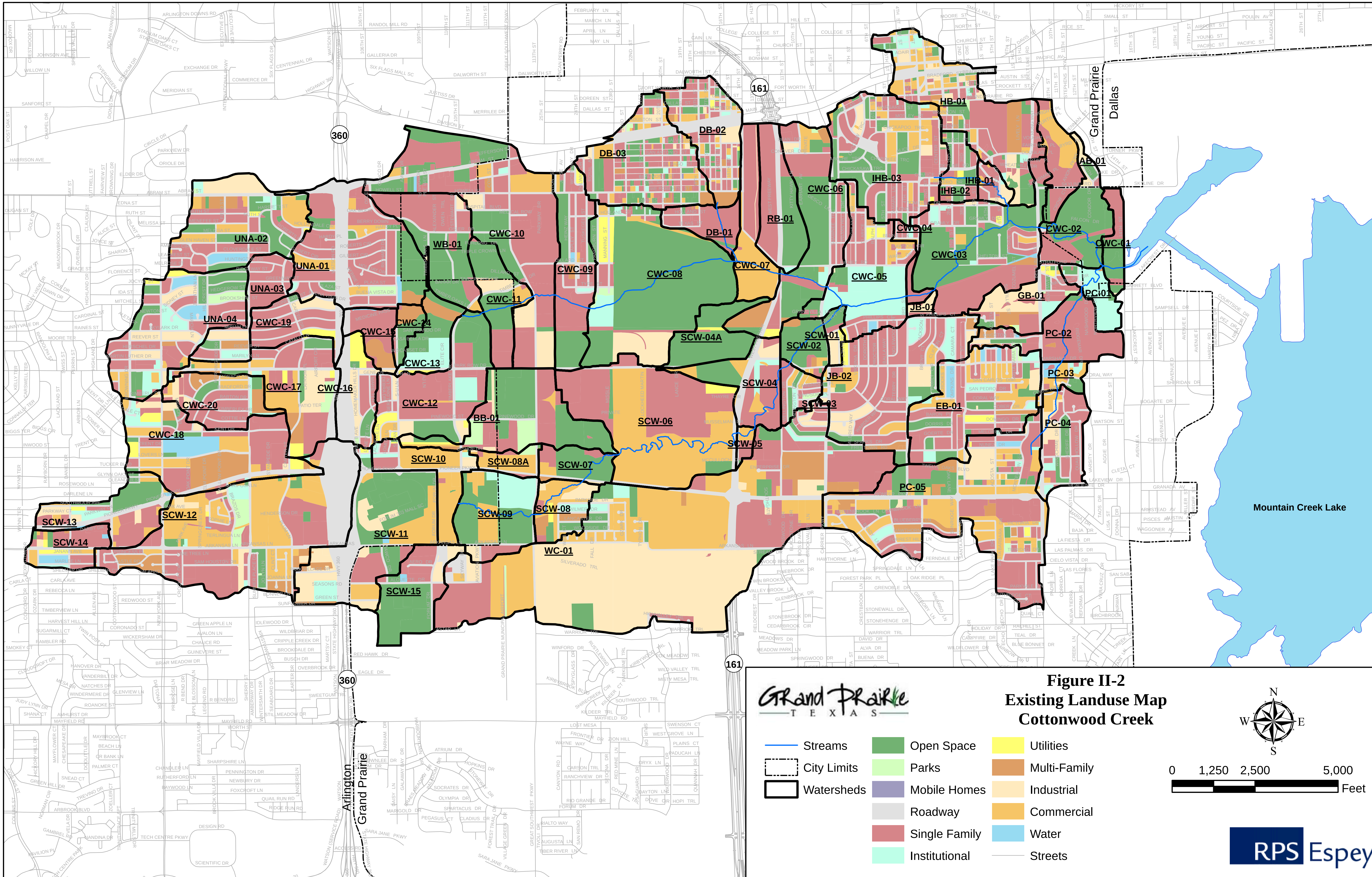


Figure II-2
Existing Landuse Map
Cottonwood Creek
Grand Prairie
TEXAS
Streams
City Limits
Watersheds
Open Space
Parks
Mobile Homes
Roadway
Single Family
Institutional
Utilities
Multi-Family
Industrial
Commercial
Water
Streets
N
S
E
W
0
1,250
2,500
5,000
Feet
RPS Espey
Mountain Creek Lake
Grand Prairie
Dallas
Arlington
Grand Prairie
360
161
HB-01
DB-02
DB-03
AB-01
IHB-01
IHB-02
IHB-03
CWC-06
RB-01
DB-01
CWC-04
CWC-02
CWC-01
CWC-03
CWC-05
CWC-07
CWC-08
CWC-09
CWC-10
WB-01
UNA-02
UNA-01
UNA-03
UNA-04
CWC-19
CWC-15
CWC-14
CWC-11
GB-01
PC-01
JB-01
SCW-04A
SCW-01
SCW-02
PC-02
CWC-13
JB-02
PC-03
CWC-17
CWC-16
CWC-20
CWC-12
SCW-04
SCW-03
EB-01
BB-01
SCW-06
PC-04
CWC-18
SCW-05
SCW-10
SCW-08A
SCW-07
PC-05
SCW-12
SCW-13
SCW-14
SCW-09
SCW-08
SCW-11
WC-01
SCW-15

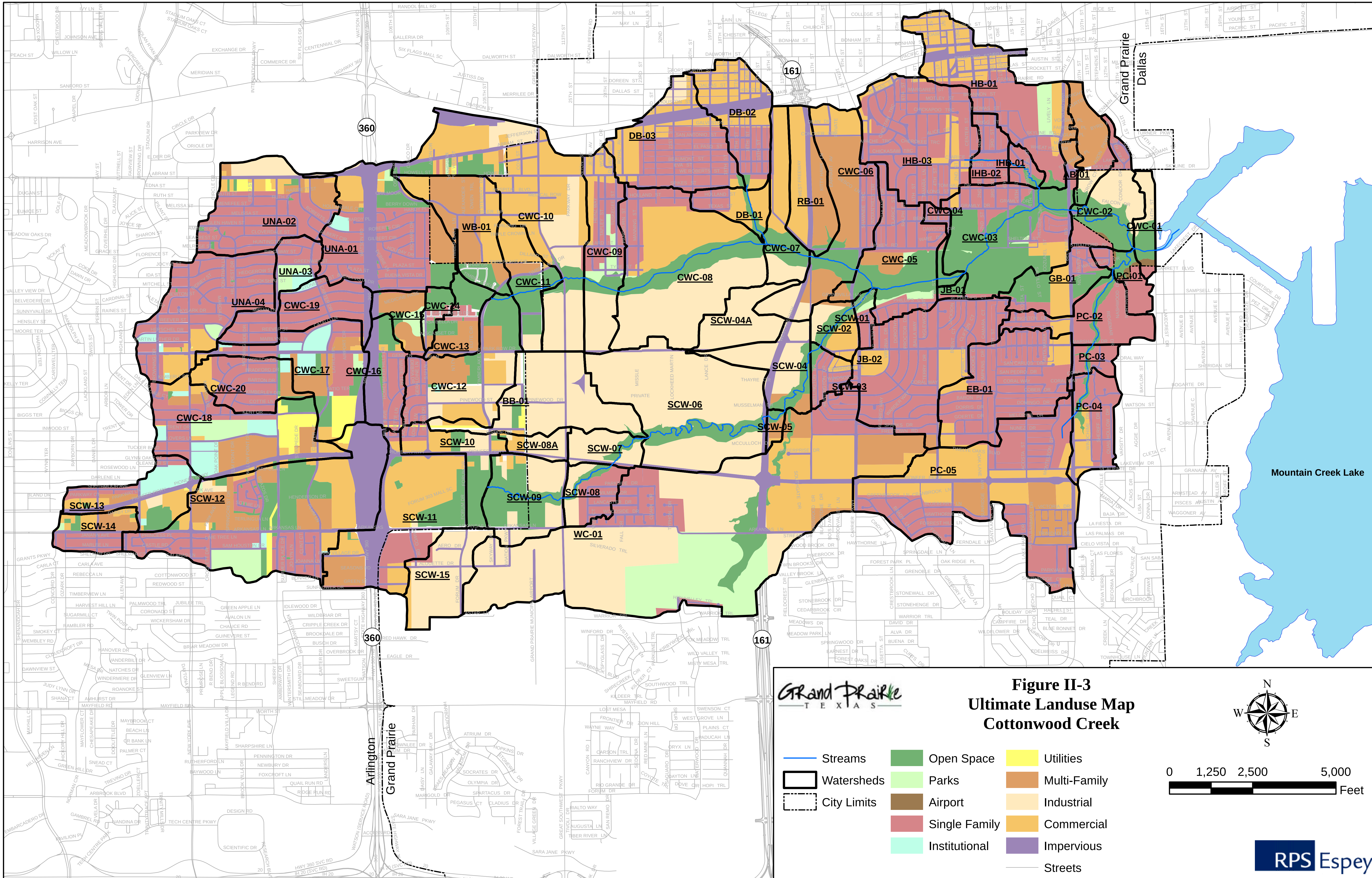


Figure II-3
Ultimate Landuse Map
Cottonwood Creek

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) postprocessed 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)

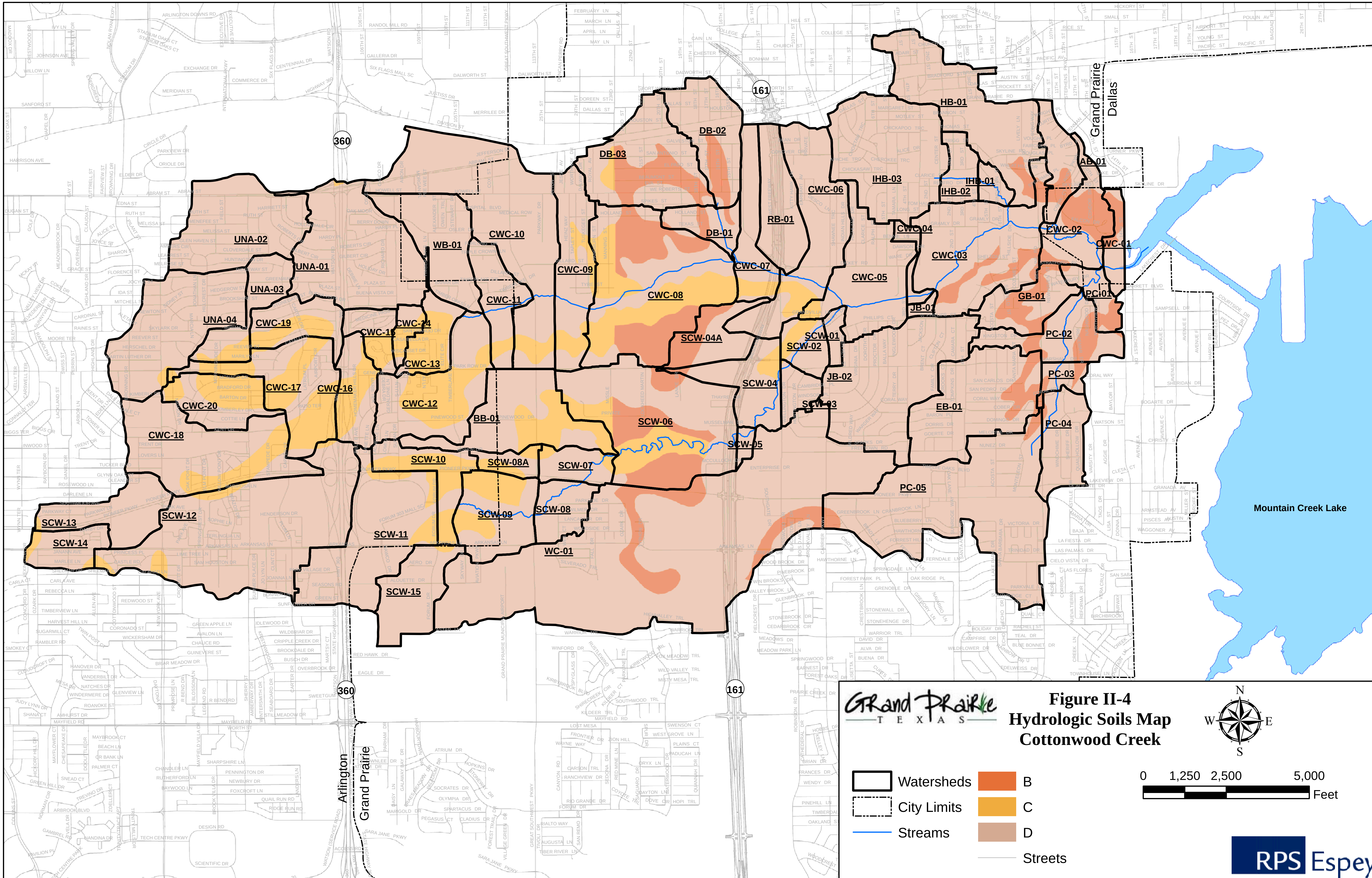


Figure II-4
Hydrologic Soils Map
Cottonwood Creek

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).

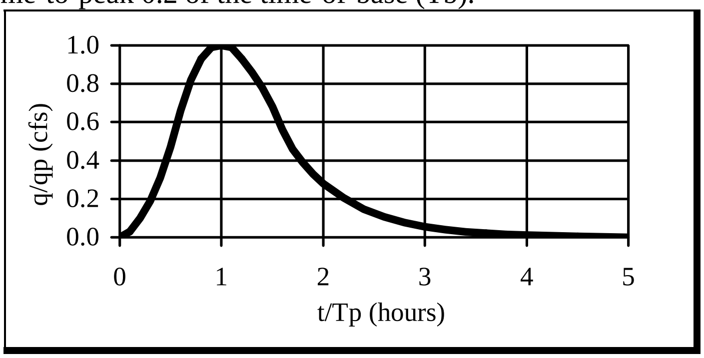


Figure II-5: NRCS Unit Graph

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).

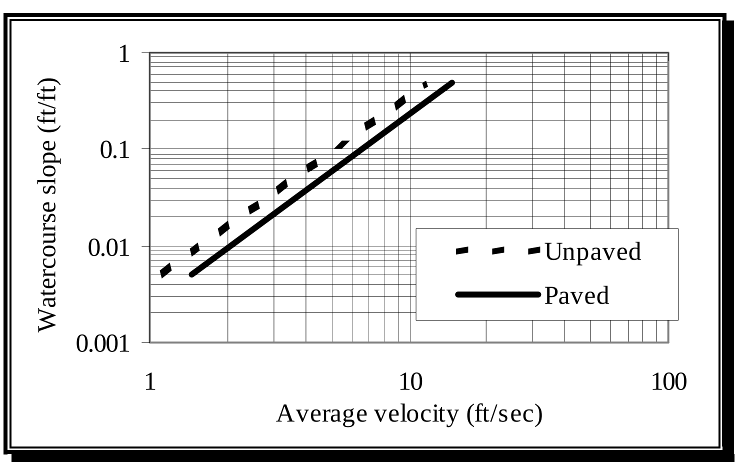


Figure II-6: Average Velocities for Estimating Travel Time in Shallow Concentrated Flow Segments

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 Cottonwood Creek Basin. All of these locations were visited to verify the existence and condition of the ponds. There are twenty-three (23) ponds designed to provide detention, one (1) small on-channel lake on Henry Branch and two (2) off-channel stock tanks.

The on-channel ponds on Cottonwood Creek upstream of S.H. 161 and the on-channel lake on Henry Branch were included in the hydrology model as Modified Puls routing data, the ponds located in the Central Park Complex along Warrior Creek were modeled in Unsteady RAS by Halff Associates, Inc. (*FEMA FY10 Risk MAP Project–Halff Associates, October 2011*). Hydrographs from the unsteady model were incorporated in the HEC-HMS model for the Cottonwood Creek Basin.

There were no diversions identified in the Cottonwood Creek Basin.

III. HYDRAULIC STUDIES

A. Hydraulic Analyses

A hydraulic analysis of the Cottonwood Creek Basin was performed as part of the FEMA FY10 Risk MAP Project. The Cottonwood 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 Cottonwood Creek Basin, "Cottonwood Creek" which includes South Fork of Cottonwood Creek, Plattner Creek, Indian Hills Branch and Daniel's Branch, "Henry Branch" and "Warrior Creek."

1. Cottonwood 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 "Cottonwood 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 Cottonwood Creek Basin contains five named creeks, Cottonwood Creek, South Fork of Cottonwood Creek, Plattner Creek, Indian Hills Branch and Daniels Branch. Cottonwood Creek is divided into two river segments Cottonwood Creek (CWC) Main Stem with three reaches, and North Fork Cottonwood Creek (NF CWC) with two reaches. South Cottonwood is divided into two reaches and the remaining streams all have one reach each. The flows for the various storms and the corresponding cross-section where these flows were applied to the Cottonwood 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
Cottonwood Creek	0.015 - 0.040	0.035 - 0.080
South Fork Cottonwood Creek	0.035 - 0.060	0.035 - 0.080
Plattner Creek	0.015 - 0.040	0.035 - 0.080
Daniels Branch	0.045	0.035
Indian Hills Branch	0.015 - 0.055	0.030 - 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 Cottonwood 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

2. Henry Branch, FEMA FY10 Risk MAP Project, Halff Associates, (October 2011)

Half Associates prepared a Hydraulic model for Henry 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 Skyline Drive and Grand Prairie Road as well as the outlet to a small lake were surveyed in July 2011. 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 and at the approach section as well as at cross sections 2809 and 3831.

The coefficients were increased to 0.6 and 0.8 at cross section 2708. Manning's roughness coefficients (n-values) were selected based on standard references, engineering judgment, aerial and field photographs, and field observations of the streams and floodplain areas. Channel n-values ranged from 0.020 to 0.080 and overbank values from 0.060 to 0.100.

3. Warrior Creek, FEMA FY10 Risk MAP Project, Halff Associates, (October 2011)

Half Associates prepared an unsteady HEC-RAS model for Warrior Creek in conjunction with the Central Park Drainage Design Analysis, (Nov. 2008). The original analysis only addressed the 1 percent chance event. In the FEMA FY10 Risk MAP Project this model was modified to include the 10-, 4-, 2-, 1-, and 0.2-percent annual-chance-flood events. Unsteady modeling was necessary to accurately model the series of ponds that were constructed in Central Park. These ponds function as both water features for the park and detention for the creek. Cross-sections developed from the Grand Prairie 2009 LiDAR data previously discussed. Road crossings at Pioneer Parkway (SH 303), Arkansas Lane (SH 161), three (3) driveway crossings and two (2) pedestrian bridges within the Central Park Development were included in the model. 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 and at the approach section. Channel n-values ranged from 0.035to 0.075 and overbank values from 0.025 to 0.030. Warrior Creek has two lateral weirs located near river stations 10787 and 10066 to divert flow from the main channel of Warrior Creek to a series of six detention ponds in the Central Park Development**.**

Locations of hydraulic cross-sections for each of the studies are shown on the Floodplain Workmaps included in this report. Floodway models have been developed for the Cottonwood Creek and Warrior Creek models. 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.

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
AB-01	0.10	0%	18%	0%	82%	76.6
BB-01	0.29	0%	0%	32%	68%	78.1
CWC-01	0.06	0%	41%	0%	59%	72.1
CWC-02	0.16	0%	41%	0%	59%	72.3
CWC-03	0.40	0%	14%	0%	86%	77.3
CWC-04	0.03	0%	0%	0%	100%	80.0
CWC-05	0.27	0%	0%	2%	98%	79.9
CWC-06	0.32	0%	0%	10%	90%	79.4
CWC-07	0.14	0%	0%	14%	86%	79.2
CWC-08	0.56	0%	33%	35%	32%	71.6
CWC-09	0.22	0%	0%	19%	81%	78.9
CWC-10	0.58	0%	0%	4%	96%	79.7
CWC-11	0.13	0%	0%	13%	87%	79.2
CWC-12	0.29	0%	0%	39%	61%	77.7
CWC-13	0.10	0%	0%	65%	35%	76.1
CWC-14	0.04	0%	0%	59%	41%	76.5
CWC-15	0.08	0%	0%	37%	63%	77.8
CWC-16	0.13	0%	0%	47%	53%	77.2
CWC-17	0.27	0%	0%	61%	39%	76.4
CWC-18	0.38	0%	0%	19%	81%	78.8
CWC-19	0.13	0%	0%	36%	64%	77.9
CWC-20	0.15	0%	0%	52%	48%	76.9
DB-01	0.08	0%	19%	0%	81%	76.4
DB-02	0.20	0%	18%	0%	82%	76.6
DB-03	0.32	0%	28%	4%	68%	74.4
EB-01	0.35	0%	10%	0%	90%	78.0
GB-01	0.13	0%	38%	0%	62%	72.9

Sub-basin	Total Area (sq.mi)	Percent of Soil Type				Weighted Curve Number
		%A	%B	%C	%D	AMC II
IHB-01	0.03	0%	0%	0%	100%	80.0
IHB-02	0.07	0%	0%	0%	100%	80.0
JB-01	0.39	0%	1%	0%	99%	79.8
JB-02	0.01	0%	0%	0%	100%	80.0
PC-01	0.43	0%	30%	0%	70%	74.4
PC-02	0.07	0%	27%	0%	73%	74.9
PC-03	0.16	0%	23%	0%	77%	75.7
PC-04	0.04	0%	5%	0%	95%	79.0
PC-05	0.14	0%	2%	0%	98%	79.5
RB-01	0.67	0%	0%	0%	100%	80.0
SCW-01	0.16	0%	0%	0%	100%	80.0
SCW-02	0.03	0%	0%	26%	74%	78.4
SCW-03	0.08	0%	0%	1%	99%	80.0
SCW-04	0.06	0%	3%	11%	86%	78.7
SCW-05	0.16	0%	0%	0%	100%	80.0
SCW-06	0.12	0%	28%	21%	51%	73.4
SCW-07	0.02	0%	0%	12%	88%	79.3
SCW-08	0.53	0%	0%	15%	85%	79.1
SCW-09	0.08	0%	0%	40%	60%	77.6
SCW-10	0.10	0%	0%	76%	24%	75.5
SCW-11	0.05	0%	0%	12%	88%	79.3
SCW-12	0.20	0%	0%	5%	95%	79.7
SCW-13	0.13	0%	0%	2%	98%	79.9
SCW-14	0.40	0%	0%	11%	89%	79.3
SCW-15	0.70	0%	0%	2%	98%	79.9
SWC-04A	0.17	0%	38%	1%	61%	72.7
UNA-01	0.10	0%	0%	0%	100%	80.0
UNA-02	0.17	0%	0%	0%	100%	80.0
UNA-03	0.42	0%	0%	18%	82%	78.9
UNA-04	0.32	0%	0%	2%	98%	79.9
WB-01	0.13	0%	0%	0%	100%	80.0

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
AB-01	0.10	27.4	76.6	22.9%	38.0%
BB-01	0.29	17.9	77.9	56.8%	84.7%
CWC-01	0.06	12.2	72.1	25.5%	52.3%
CWC-02	0.16	29	72.3	18.6%	25.9%
CWC-03	0.40	24.5	77.3	15.5%	26.5%
CWC-04	0.03	21.9	80	26.4%	26.4%
CWC-05	0.27	24	79.9	30.2%	32.3%
CWC-06	0.32	8.7	79.4	46.5%	62.4%
CWC-07	0.14	10.6	79.2	37.9%	75.0%
CWC-08	0.56	19.9	70.9	21.1%	75.0%
CWC-09	0.22	13	78.6	48.1%	65.5%
CWC-10	0.58	27.3	79.7	58.2%	84.9%
CWC-11	0.13	20.1	79.2	17.8%	48.0%
CWC-12	0.29	22.3	77.7	64.7%	67.3%
CWC-13	0.10	15.1	76.1	44.2%	44.2%
CWC-14	0.04	8.2	76.5	26.4%	26.4%
CWC-15	0.08	7.1	77.8	49.4%	56.8%
CWC-16	0.13	13.3	77.2	32.3%	63.9%
CWC-17	0.27	14.6	76.4	45.4%	56.2%
CWC-18	0.38	26	78.8	46.1%	57.7%
CWC-19	0.13	10.3	77.9	37.5%	38.0%
CWC-20	0.15	14.7	76.9	45.9%	55.7%
DB-01	0.08	20.9	76.4	11.6%	75.4%
DB-02	0.20	13.5	76.6	41.1%	41.1%
DB-03	0.32	13	74.4	38.6%	38.6%
EB-01	0.35	28.9	78	39.2%	46.7%
GB-01	0.13	26.3	72.9	21.3%	38.0%
IHB-01	0.03	9.3	80	24.3%	35.1%
IHB-02	0.07	18.2	80	39.2%	43.9%
IHB-03	0.39	21.6	80	40.9%	41.0%
JB-01	0.01	14.8	79.8	11.5%	14.7%
JB-02	0.43	36.2	80	39.9%	46.9%
PC-01	0.07	42.4	74.4	9.4%	35.9%
PC-02	0.16	50	74.9	13.4%	56.9%
PC-03	0.04	14.5	75.7	30.0%	56.0%
PC-04	0.14	23.3	79	35.2%	53.7%
PC-05	0.67	26.7	79.5	45.5%	60.9%

Sub-basin Name	Drainage Area (sq. mi.)	Lag Time (minutes)	AMC II CN	Existing Impervious Cover	Future Impervious Cover
RB-01	0.16	10.5	80	70.7%	83.7%
SCW-01	0.03	10.1	80	25.3%	25.3%
SCW-02	0.08	16.3	78.4	19.2%	31.2%
SCW-03	0.06	8.9	80	37.1%	42.0%
SCW-04	0.16	18.3	78.7	43.9%	87.1%
SCW-04A	0.12	5.8	72.7	61.1%	61.1%
SCW-05	0.02	10	80	29.5%	71.0%
SCW-06	0.53	36.7	73.4	33.6%	90.0%
SCW-07	0.08	24.4	77.9	1.1%	90.0%
SCW-08	0.10	20.6	80	41.6%	64.7%
SCW-08A	0.05	12.3	77.8	78.2%	90.5%
SCW-09	0.20	30	77.6	44.8%	49.9%
SCW-10	0.13	8.7	75.5	33.7%	46.6%
SCW-11	0.40	15.4	79.3	63.1%	75.1%
SCW-12	0.70	35.3	79.7	43.3%	61.2%
SCW-13	0.17	14.2	79.9	49.5%	64.1%
SCW-14	0.10	17.3	79.3	56.2%	65.2%
SCW-15	0.17	11.6	79.9	72.2%	88.9%
UNA-01	0.42	19.1	80	39.5%	39.6%
UNA-2	0.32	14	80	49.9%	49.9%
UNA-3	0.13	20.4	78.9	37.7%	37.7%
UNA-4	0.35	14.9	79.9	43.3%	43.3%
WB-01	0.22	15.7	80	31.4%	75.3%

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
Cottonwood Creek					
Great Southwest Parkway	10,550	5,301	7,911	8,850	11,468

Flooding Source and Location	XS ID	Peak Discharges (cfs)			
		10% Flood	2% Flood	1% Flood	0.20% Flood
Cottonwood Creek					
Confluence with Daniels Branch	3,546	6,869	10,069	11,584	15,006
Upstream of South Cottonwood	701	10,025	16,233	19,136	26,973
Confluence with South Cottonwood	12,482	10,313	15,300	17,668	23,465
Confluence with Indian Creek	5,978	10,469	15,859	18,248	25,045
Downstream of SE 14th Street	914	10,025	16,233	19,136	26,973
South Fork of Cottonwood Creek					
At upstream end of study	18,296	2,147	3,029	3,528	4,599
Great Southwest Parkway	16,685	2,322	3,328	3,876	5,162
Pioneer Parkway	14,301	2,258	3,212	3,819	5,313
Upstream of Cottonwood	761	3,507	5,236	6,047	8,485
Plattner Creek					
Beltline Road	6,517	1,253	1,743	1,959	2,498
Marshall Road	4,062	2,066	2,856	3,163	4,062
Upstream of Cottonwood	364	2,253	3,225	3,608	4,741
Daniels Branch					
Upstream Limit of Study	1,718	1,226	1,705	1,916	2,401
Upstream of Cottonwood	684	1,345	1,883	2,121	2,674
Indian Hills Branch					
S. Center Street	3,183	802	1,111	1,248	1,579
S.E. 4th Street	2,140	948	1,317	1,478	1,872
Upstream of Cottonwood	778	962	1,321	1,459	1,847
Warrior Creek					
Upstream Limit of Study	11,031	735	997	1,117	1,402
Arkansas Parkway	4,942	476	654	726	906
Pioneer Parkway	3,286	1,139	1,556	1,739	2,146
Upstream of Cottonwood	246	1,896	2,597	2,908	3,597

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 sown on **Table IV-4**.

Table IV-4: FEMA Effective Discharges (1996)

Flooding Source and Location	**XS ID**	**Peak Discharges (cfs)**			
		10% Flood	**2% Flood**	**1% Flood**	**0.20% Flood**
Cottonwood Creek					
Great Southwest Parkway	27,658	8,400	10,400	11,310	14,470
Confluence with Daniels Branch	18,700	9,760	11,980	12,900	17,840
Upstream of South Cottonwood	17160	14,500	18,610	20,380	28,250
Confluence with South Cottonwood	15,640	14,500	18,740	20,490	28,190
Confluence with Indian Hills Branch	10,140	14,530	18,900	21,170	28,150
Downstream of SE 14th Street	4950	15,900	20,180	22,900	29,980
South Fork of Cottonwood Creek					
At upstream end of study	18,120	3,340	4,220	4,570	5,630
Great Southwest Parkway	16,610	3,070	4,110	4,540	5,800
Pioneer Parkway	15,200	3,070	3,980	4,360	5,600
Upstream of Cottonwood	940	5,300	7,300	8,050	10,780
Plattner Creek					
Beltline Road	5,590	No Data	No Data	1,180	No Data
Marshall Road	3,820	No Data	No Data	3,740	No Data
Upstream of Cottonwood	700	No Data	No Data	4,120	No Data
Daniels Branch					
Upstream Limit of Study	1,718	1,900	2,430	2,670	3,600
Upstream of Cottonwood	684	1,900	2,430	2,670	3,600
Indian Hills Branch					
S. Center Street	3,183	1,200	1,520	1,670	2,220
S.E. 4th Street	2,140	1,200	1,520	1,670	2,220
Upstream of Cottonwood	778	1,200	1,520	1,670	2,220
Warrior Creek					
Upstream Limit of Study	11,031	No Data	No Data	No Data	No Data
Arkansas Pkwy.	4,942	No Data	No Data	2,020	No Data
Pioneer Pkwy.	3,286	No Data	No Data	3,050	No Data
Upstream of Cottonwood	246	No Data	No Data	3,210	No Data

4. Comparison with Revised Discharges

The results of this model were compared to the effective model prepared by Huitt Zollar Inc. in 1996. The peak flows in this study are lower than the flows in the effective model. The City of Grand Prairie has constructed detention facilities in Warrior Creek which is a tributary of Cottonwood Creek and a private developer has constructed some improvements on the main channel of Cottonwood Creek. These improvements would be expected reduce the magnitude of any flooding; however, they do not fully explain these reductions in flow. An additional comparison was made of the current study against the original FIS study in May of 1997. Along the main stem of Cottonwood Creek, the current study produces flows that are higher than the original FIS study but lower than the flows in the current effective model. In reviewing the previous flows, there seems to be a number of inconsistences between the two previous models. It would normally be expected that continued urbanization would result in an increase in flows; so, in order to estimate the sensitivity of the model to development, a simulation was made assuming an increase of impervious cover by 50% from today's conditions. The results from this sensitivity analysis are presented below in **Table IV-7** and indicate that an increase in impervious cover of 50% for the entire watershed resulted in a change in peak flow rate of only 12% at the downstream end of the study area. The restudy utilized the most recent topographic and storm sewer data producing a more detailed and accurate basin model. The restudy peak discharges are show on **Table IV-6,** 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 1% Flood Discharge	Effective FIS 1% Flood Discharge	Percent Change
Cottonwood Creek			
Great Southwest Parkway	8850	11310	-24%
Confluence with Daniels Branch	11584	12900	-11%
Upstream of South Cottonwood	19136	20380	-6%
Confluence with South Cottonwood	17668	20490	-15%
Confluence with Indian Creek	18248	21170	-15%
Downstream of S.E. 14th Street	19136	22900	-18%
South Fork of Cottonwood Creek			
At Upstream End of Study	3528	4570	-26%
Great Southwest Parkway	3876	4540	-16%
Pioneer Parkway	3819	4360	-13%
Upstream of Cottonwood	6047	8050	-28%
Plattner Creek			
Beltline Road	1959	1180	50%
Marshall Road	3163	3740	-17%
Upstream of Cottonwood	3608	4120	-13%
Daniels Branch			
Upstream Limit of Study	1,916	2,670	-33%

Discharge Location	Restudy 1% Flood Discharge	Effective FIS 1% Flood Discharge	Percent Change
Daniels Branch continued			
Upstream of Cottonwood	2,121	2,670	-23%
Indian Hills Branch			
S. Center Street	1,248	1,670	-29%
S.E. 4th Street	1,478	1,670	-12%
Upstream of Cottonwood	1,459	1,670	-13%
Warrior Creek			
Arkansas Parkway	726	2,020	-94%
Pioneer Parkway	1,739	3,050	-123%
Upstream of Cottonwood	2,908	3,210	-59%

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: Cottonwood 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
NF CWC	SECTION_02	10,550	5,301	7,911	8,850	11,468
NF CWC	SECTION_02	10,386	6,278	9,359	10,459	13,472
NF CWC	SECTION_02	8,394	6,376	9,409	10,603	13,470
NF CWC	SECTION_02	5,702	6,686	9,823	11,199	14,349
NF CWC	SECTION_03	3,546	6,869	10,069	11,584	15,006
NF CWC	SECTION_03	2,634	6,951	10,155	11,700	15,219
NF CWC	SECTION_03	1,291	7,019	10,246	11,816	15,422
CWC MAIN STEM	SECTION_01	12,689	10,313	15,300	17,668	23,465
CWC MAIN STEM	SECTION_01	10,760	10,382	15,447	17,865	23,781
CWC MAIN STEM	SECTION_01	10,345	10,391	15,464	17,890	23,807
CWC MAIN STEM	SECTION_01	9,744	10,768	16,083	18,608	24,803
CWC MAIN STEM	SECTION_02	5,978	10,469	15,859	18,248	25,045
CWC MAIN STEM	SECTION_02	4,663	10,092	15,270	17,541	24,592
CWC MAIN STEM	SECTION_02	3,081	10,057	15,277	17,576	24,645
CWC MAIN STEM	SECTION_03	1,288	10,113	16,233	19,161	26,985

HEC-RAS Location			**Peak Flows**			
River	Reach	RS	Existing 10 yr	Existing 50 yr	Existing 100 yr	Existing 500 yr
CWC MAIN STEM	SECTION_03	1,075	10,025	16,233	19,136	26,973
SF CWC	SECTION_01	18,296	2,147	3,029	3,528	4,599
SF CWC	SECTION_01	16,685	2,322	3,328	3,876	5,162
SF CWC	SECTION_01	14,582	2,249	3,189	3,771	5,151
SF CWC	SECTION_01	14,301	2,258	3,212	3,819	5,313
SF CWC	SECTION_01	13,479	2,284	3,244	3,857	5,437
SF CWC	SECTION_01	12,822	2,373	3,370	4,038	5,806
SF CWC	SECTION_01	9,021	2,653	3,692	4,452	6,611
SF CWC	SECTION_01	5,765	2,638	3,654	4,377	6,473
SF CWC	SECTION_02	5,157	3,407	5,054	5,843	8,293
SF CWC	SECTION_02	2,852	3,458	5,142	5,948	8,375
SF CWC	SECTION_02	2,723	3,493	5,218	6,032	8,463
SF CWC	SECTION_02	905	3,507	5,236	6,047	8,485
DANIELS BR	DANIELS BR	1,718	1,226	1,705	1,916	2,401
DANIELS BR	DANIELS BR	1,159	1,345	1,883	2,121	2,674
INDIAN HILLS BR	INDIAN HILLS BR	3,183	802	1,111	1,248	1,579
INDIAN HILLS BR	INDIAN HILLS BR	2,328	948	1,317	1,478	1,872
INDIAN HILLS BR	INDIAN HILLS BR	1,086	962	1,321	1,459	1,847
PLATTNER CRK	PLATTNER CRK	7,131	1,253	1,743	1,959	2,498
PLATTNER CRK	PLATTNER CRK	5,235	1,461	2,003	2,204	2,849
PLATTNER CRK	PLATTNER CRK	4,284	2,066	2,856	3,163	4,062
PLATTNER CRK	PLATTNER CRK	1,654	2,298	3,201	3,556	4,616
PLATTNER CRK	PLATTNER CRK	642	2,253	3,225	3,608	4,741

Table IV-7: Comparison of Restudy Discharge (cfs) and Variations in Impervious Cover

HEC- RAS Location			**HMS-Node**	**Peak Flows**		
River	Reach	RS		Existing I.C.	150% I.C.	Percent Increase
NF CWC	SECTION_02	12725	CWC J-12A	8,106	8,460	4.3%
NF CWC	SECTION_02	12079	CWC J-12	8,629	8,999	4.2%
NF CWC	SECTION_02	10550	CWC J-11	8,850	9,223	4.1%
NF CWC	SECTION_02	10386	CWC J-10	10,459	10,912	4.2%
NF CWC	SECTION_02	8394	CWC J-09	10,603	11,059	4.2%

HEC- RAS Location			HMS-Node	Peak Flows		
River	Reach	RS		Existing I.C.	150% I.C.	Percent Increase
NF CWC	SECTION_02	5702	CWC J-08A	11,199	11,691	4.3%
NF CWC	SECTION_03	3546	CWC J-08	11,584	12,102	4.4%
NF CWC	SECTION_03	2634	CWC J-07	11,700	12,229	4.4%
NF CWC	SECTION_03	1291	CWC J-06	11,816	12,358	4.5%
CWC MAIN STEM	SECTION_01	12689	CWC J-05	17,668	18,510	4.7%
CWC MAIN STEM	SECTION_01	10760	CWC J-04	17,865	18,725	4.7%
CWC MAIN STEM	SECTION_01	10345	CWC J-03A	17,890	18,743	4.7%
CWC MAIN STEM	SECTION_01	9744	CWC J-03	18,608	19,505	4.7%
CWC MAIN STEM	SECTION_02	5978	CWC J-02A	18,248	20,173	10.0%
CWC MAIN STEM	SECTION_02	4663	CWC J-02	17,541	19,660	11.4%
CWC MAIN STEM	SECTION_02	3081	CWC J-01A	17,576	19,698	11.4%
CWC MAIN STEM	SECTION_03	1288	CWC J-01	19,161	21,584	11.9%
CWC MAIN STEM	SECTION_03	1075	Mountain Creek Lake	19,136	21,583	12.0%
DANIELS BR	DANIELS BR	1718	DB J-2	1,916	2,005	4.5%
DANIELS BR	DANIELS BR	1159	DB J-1	2,121	2,211	4.1%
INDIAN HILLS BR	INDIAN HILLS BR	3183	IHB-03	1,248	1,290	3.3%
INDIAN HILLS BR	INDIAN HILLS BR	2328	IHB J-2	1,478	1,530	3.4%
INDIAN HILLS BR	INDIAN HILLS BR	1086	IHB J-1	1,459	1,499	2.8%
PLATTNER CRK	PLATTNER CRK	7131	PC-05	1,959	2,033	3.7%
PLATTNER CRK	PLATTNER CRK	5235	PC J-3	2,204	2,271	3.0%
PLATTNER CRK	PLATTNER CRK	4284	PC J-2	3,163	3,262	3.1%
PLATTNER CRK	PLATTNER CRK	1654	PC J-1	3,556	3,662	2.9%
PLATTNER CRK	PLATTNER CRK	642	PC J-1A	3,608	3,716	2.9%
SF CWC	SECTION_01	18295 6	SCW J-08	3,528	3,707	4.9%
SF CWC	SECTION_01	16685	SCW J-07	3,876	4,115	6.0%
SF CWC	SECTION_01	14582	SCW J-06A	3,771	4,005	6.0%
SF CWC	SECTION_01	14301	SCW J-06	3,819	4,075	6.5%

HEC- RAS Location			HMS-Node	Peak Flows		
River	Reach	RS		Existing I.C.	150% I.C.	Percent Increase
SF CWC	SECTION_01	13479	SCW J-05A	3,857	4,122	6.7%
SF CWC	SECTION_01	12822	SCW J-05	4,038	4,332	7.0%
SF CWC	SECTION_01	9021	SCW J-04	4,452	4,799	7.5%
SF CWC	SECTION_01	5765	SCW J-03A	4,377	4,714	7.4%
SF CWC	SECTION_02	5157	SCW J-03	5,843	6,159	5.3%
SF CWC	SECTION_02	2852	SCW J-02A	5,948	6,258	5.1%
SF CWC	SECTION_02	2723	SCW J-02	6,032	6,350	5.1%
SF CWC	SECTION_02	905	SCW J-01	6,047	6,358	5.0%

B. Hydraulic Study Results

There are three hydraulic models for the Cottonwood Creek Basin, Cottonwood Creek, Warrior Creek, and Henry Branch. The Cottonwood Creek model contains five named creeks, Cottonwood Creek, South Fork of Cottonwood Creek, Plattner Creek, Indian Hills Branch and Daniels Branch. Cottonwood Creek is divided into two river segments Cottonwood Creek (CWC) Main Stem with three reaches, and North Fork Cottonwood Creek (NF CWC) with two reaches. The South Fork of Cottonwood is divided into two reaches and the remaining streams all have one reach each. Warrior Creek is a separate un-steady RAS model which begins at the confluence of Warrior Creek and the South Fork of Cottonwood Creek and extends to a point upstream of the Central Park Complex.

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 4% greater than existing, but this does not translate to a significant increase in depth. The calculated water surface elevations are an average of 0.19 ft. higher in the ultimate conditions, with the largest increase being 0.52 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-8** shows the water surface elevations for the various events at selected locations.

Table IV-8: Steady Flow Data

COTTONWOOD 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
Great Southwest Parkway	10,550	520.24	523.58	524.41	525.12	525.82	526.22	528.38	526.3
Confluence with Daniels Branch	3,546	487.72	489.67	490.39	491.07	491.73	492.29	493.48	492.44
Upstream of South Cottonwood	701	481.14	482.37	482.95	483.51	483.99	484.45	485.43	484.61
Confluence with South Cottonwood	12,482	479.86	481.03	481.75	482.36	482.85	483.3	484.28	483.47
Confluence with Indian Creek	5,978	466.94	468.77	469.88	470.88	471.56	471.97	473.77	472.29
Confluence with Plattner Creek	1,288	459.99	462.71	463.53	464.36	465.16	465.80	467.30	466.07
Downstream of SE 14th Street	914	457.89	458.81	459.93	461.39	462.73	463.88	466.63	464.40

SOUTH FORK OF COTTONWOOD 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
Great Southwest Parkway	16,685	545.75	548.29	549.70	551.24	552.18	552.63	553.31	552.72
Pioneer Parkway	14,301	533.56	534.57	534.99	535.37	535.80	536.22	537.11	536.31
Confluence with Warrior Creek	5,157	499.10	500.52	501.12	501.64	502.06	502.48	503.73	502.72
Upstream of Cottonwood	761	481.40	482.57	483.24	483.78	484.23	484.67	485.69	484.85

PLATTNER 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
Beltline Road	6,517	485.71	487.7	489.56	492.21	494.64	495.42	496.23	495.42
Marshall Road	4,062	470.34	472.19	473.19	474.41	475.61	476.75	479.17	476.99
Upstream of Cottonwood	364	460.23	462.8	463.63	464.47	465.27	465.93	467.46	466.2

DANIELS BRANCH									
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
Upstream Limit of Study	1,718	502.76	503.38	503.69	504.00	504.25	504.46	504.47	504.47
Upstream of Cottonwood	684	492.95	493.42	493.70	494.01	494.25	494.47	495.02	494.52

INDIAN HILLS BRANCH									
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. Center Street	3,183	479.07	480.05	480.61	481.14	481.56	481.93	482.67	481.92
S.E. 4th Street	2,140	471.49	472.37	472.97	473.65	474.21	474.73	476.38	474.81
Upstream of Cottonwood	778	467.20	468.93	470.01	471.00	465.90	472.11	473.91	472.43

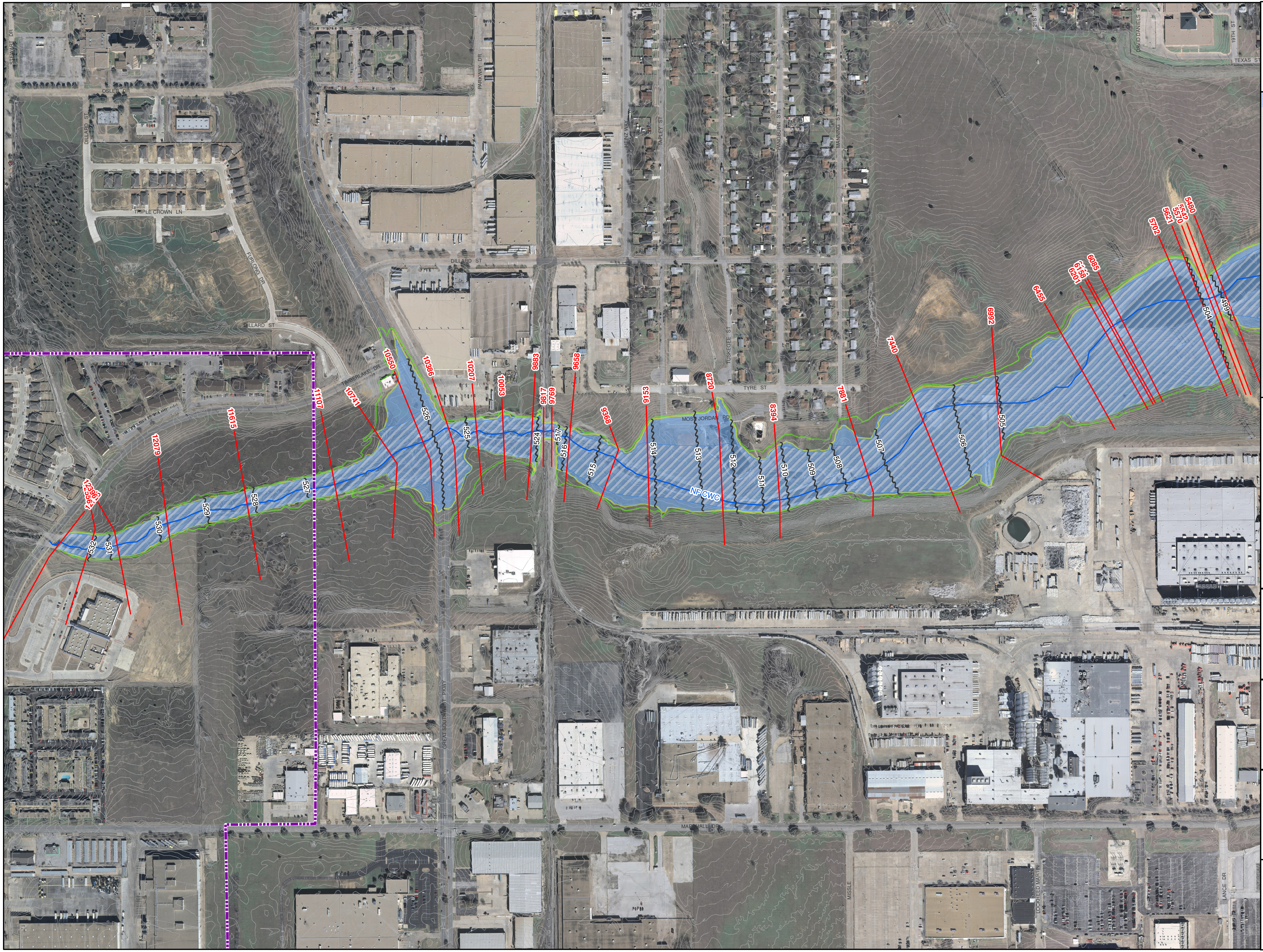
WARRIOR CREEK									
Location	XS River Sta.	2-YR (ft)	5-YR (ft)	10-YR (ft)	25-YR (ft)	50-YR (ft)	100-YR (ft)	500-YR (ft)	Ultimate 100-YR
Upstream Limit of Study	11,031	561.76	562.62	562.62	562.84	563.02	563.17	563.45	563.24
Arkansas Parkway	4,942	529.86	530.74	531.28	531.76	532.21	532.70	533.49	532.92
Pioneer Parkway.	3,286	518.07	519.67	520.99	521.53	522.27	522.93	525.28	523.20
Upstream of Cottonwood	246	502.87	504.19	504.94	505.57	506.08	506.54	507.44	506.79

V. FLOODPLAIN MAPPING

RPS Espey re-mapped Cottonwood Creek, South Fork of Cottonwood Creek, Plattner Creek, Indian Hills Branch and Daniels Branch. 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).

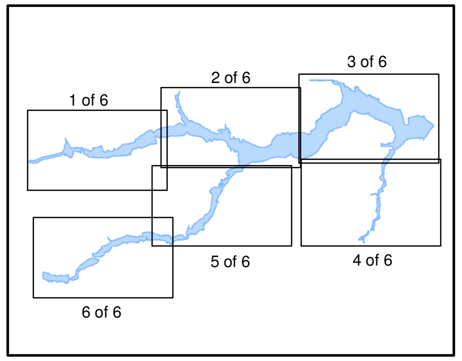


FLOODPLAIN WORK MAPS
COTTONWOOD - 1 OF 6

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



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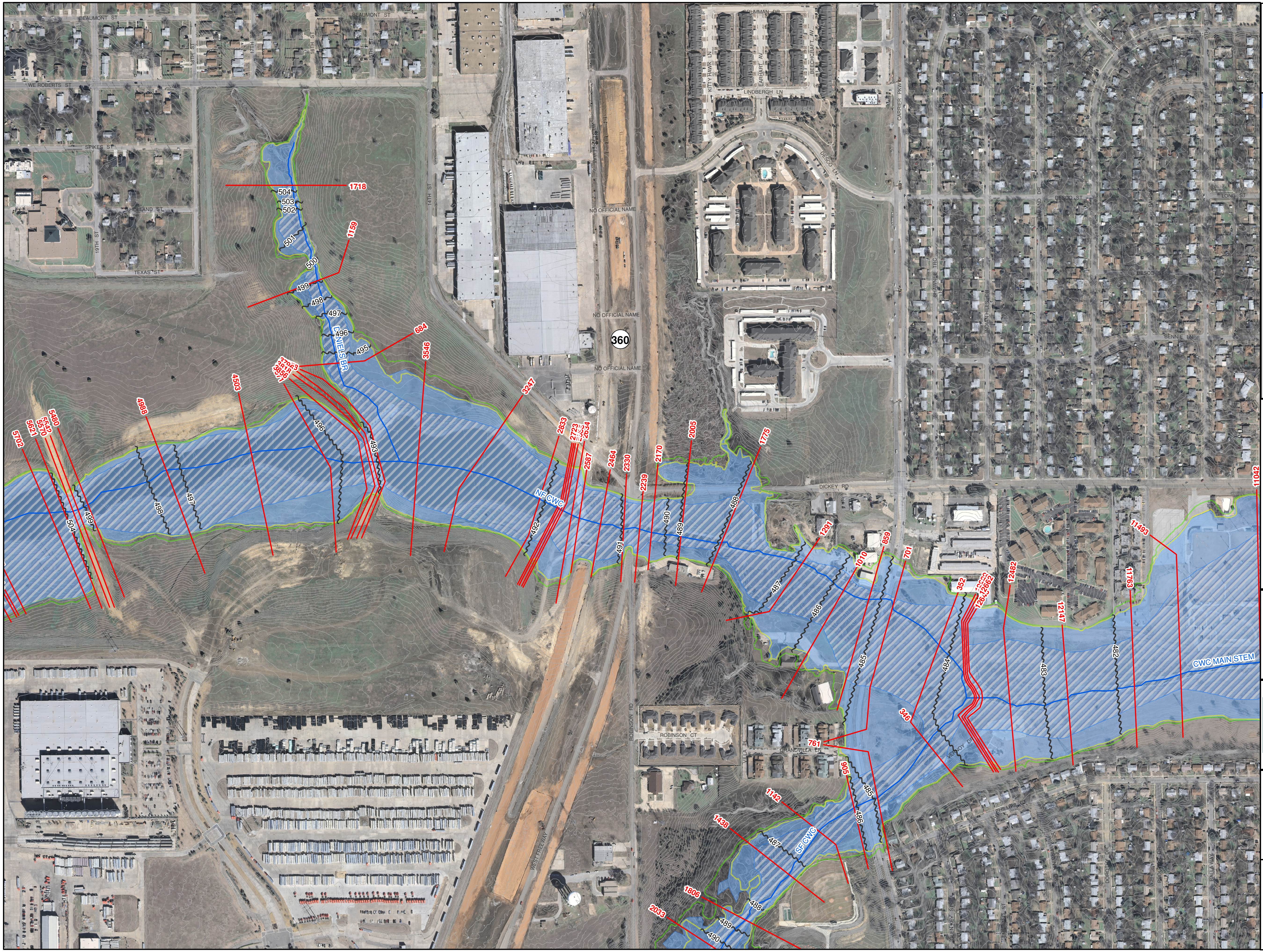
Scale in Feet

RPS Espey

FEMA

Grand Prairie TEXAS



FLOODPLAIN WORK MAPS

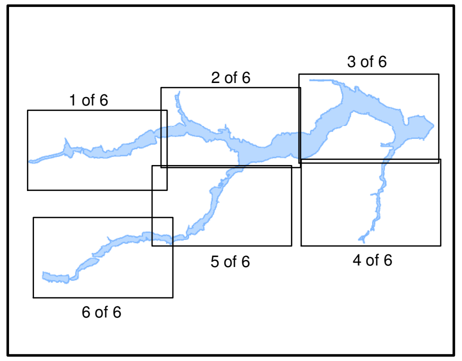
COTTONWOOD - 2 OF 6

KEY TO FEATURES

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

N E S W

MAP INDEX



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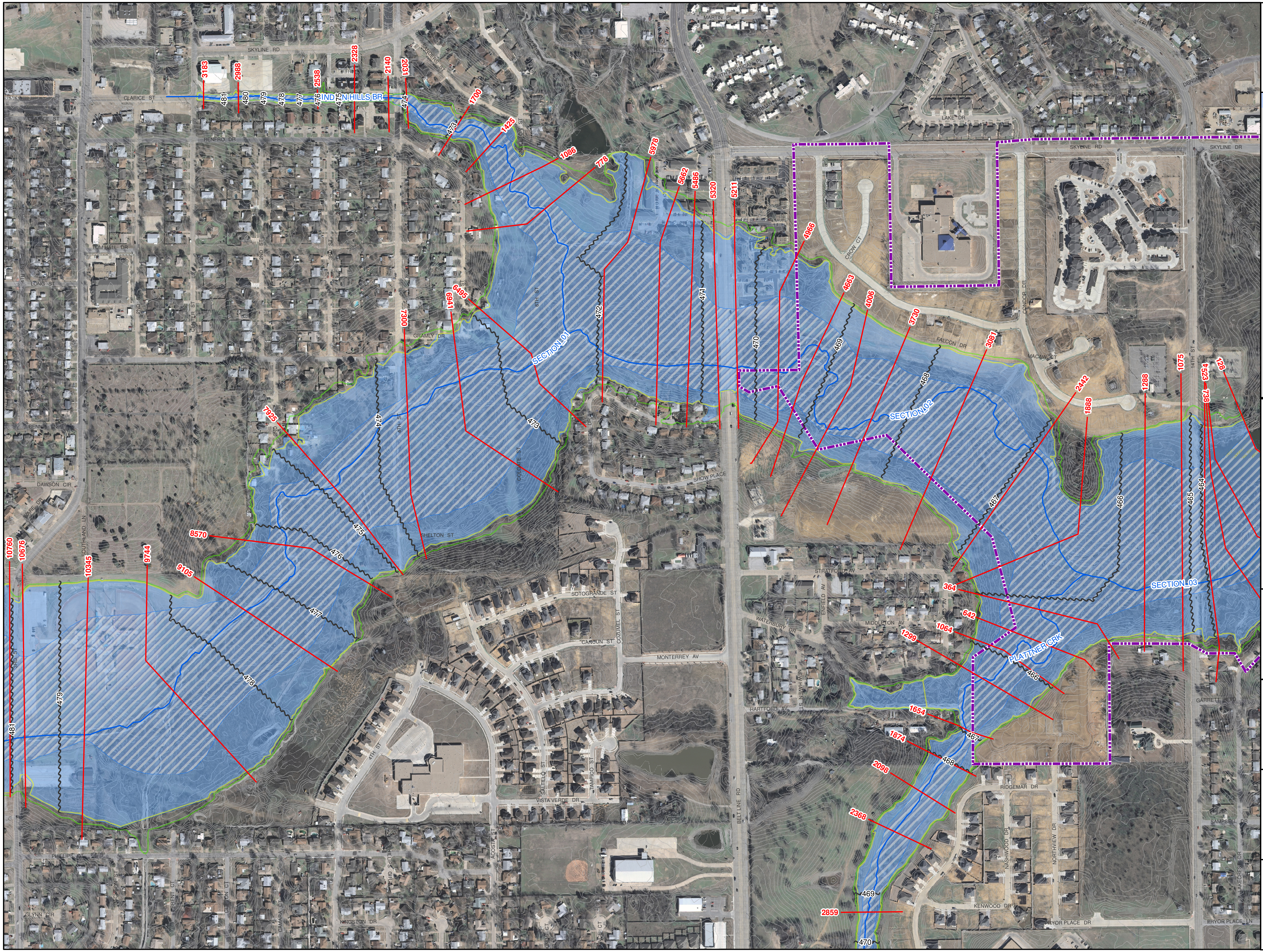
Scale in Feet

RPS Espey

FEMA

Grand Prairie TEXAS



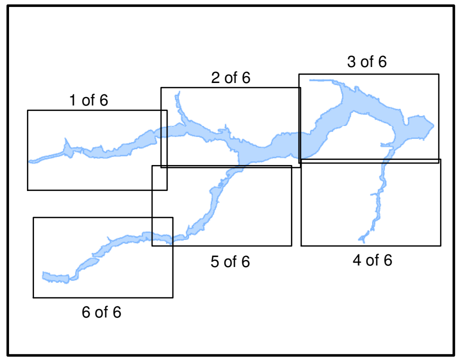
FLOODPLAIN WORK MAPS
COTTONWOOD - 3 OF 6

KEY TO FEATURES

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

N E S W

MAP INDEX



0 250 500 1,000

Scale in Feet

RPS Espey

U.S. DEPARTMENT OF HOMELAND SECURITY FEMA

Grand Prairie TEXAS

FLOODPLAIN WORK MAPS

COTTONWOOD - 4 OF 6

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
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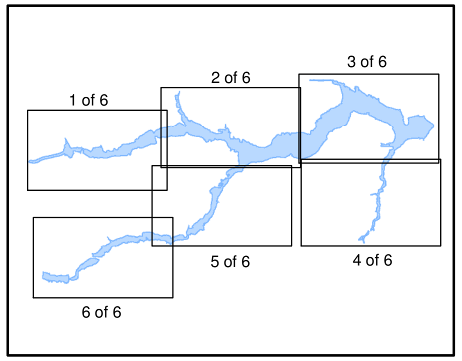
MAP INDEX



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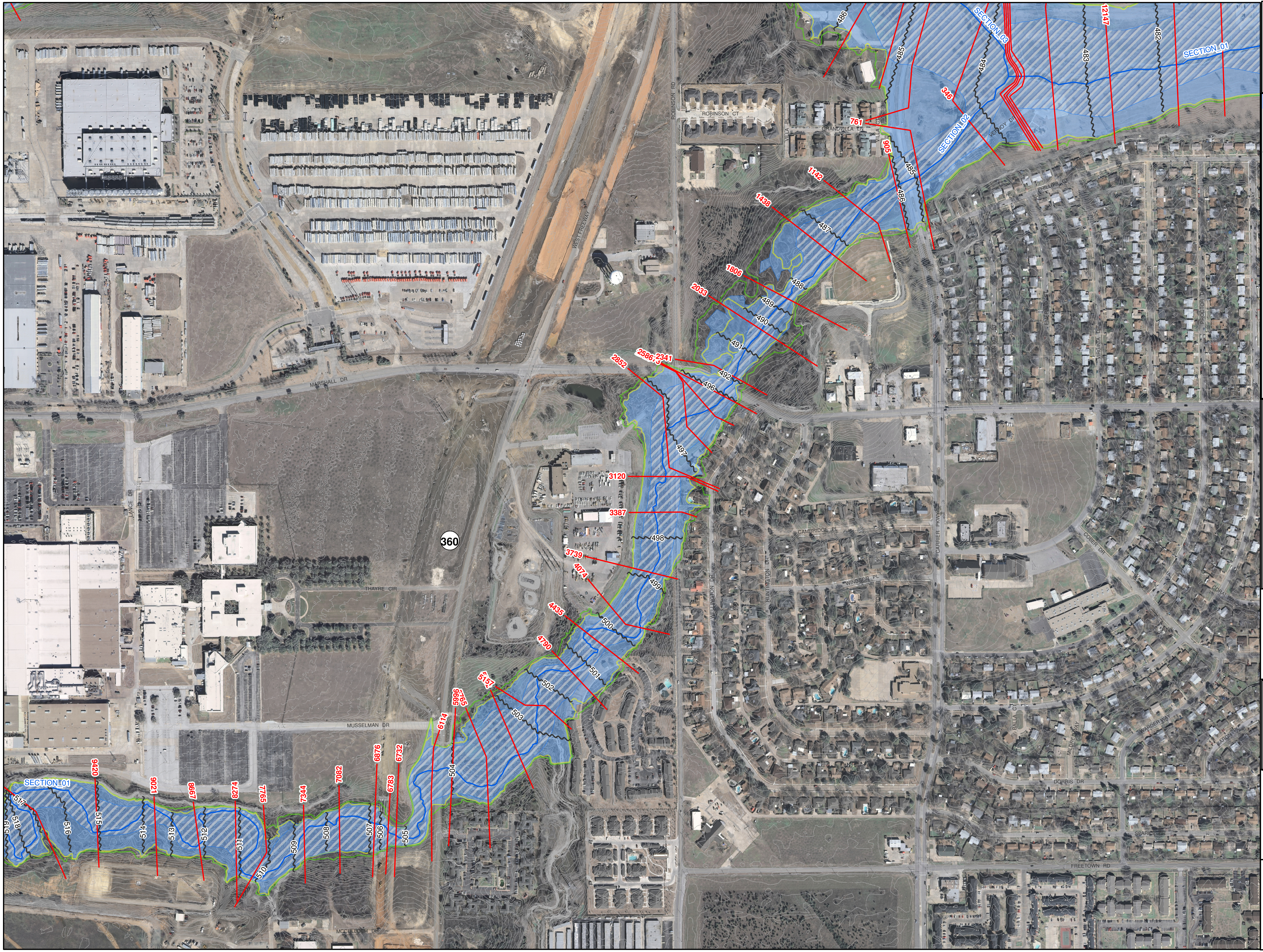
Scale in Feet

RPS Espey

FEMA

Grand Prairie
TEXAS

FLOODPLAIN WORK MAPS
COTTONWOOD - 5 OF 6



KEY TO FEATURES

- Mapping XS
- BFE
- 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

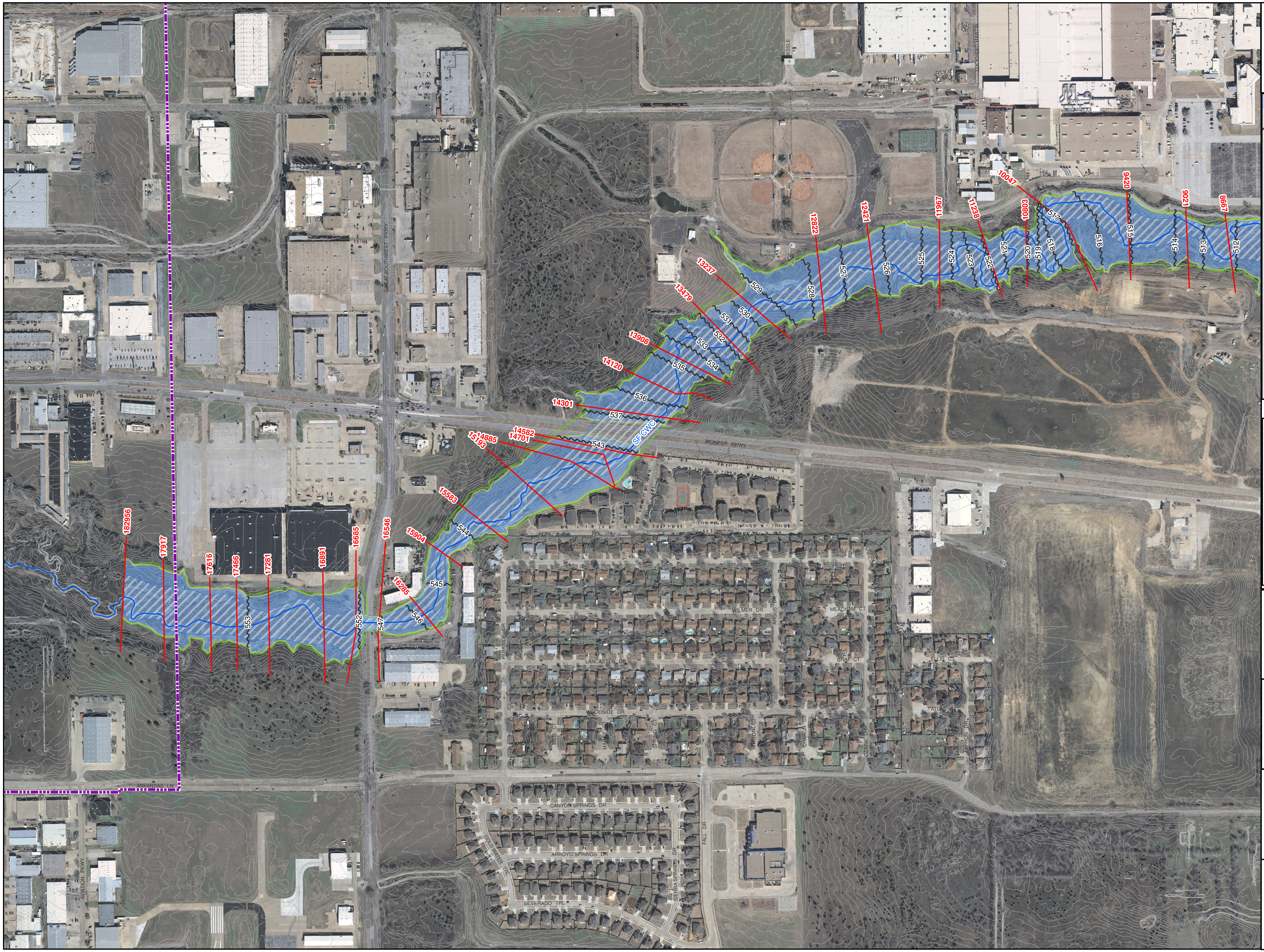
RPS Espey

FEMA

Grand Prairie TEXAS

FLOODPLAIN WORK MAPS

COTTONWOOD - 6 OF 6



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
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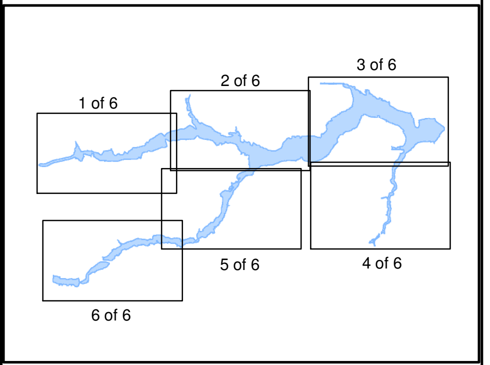
MAP INDEX



0 250 500 1,000

Scale in Feet

RPS Espey

FEMA

Grand Prairie TEXAS

VI. ROADWAY CROSSINGS

A. Evaluation of Existing Roadway Crossings

The 20 existing roadway crossings within the Cottonwood 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. Please refer to **Figure VI-1**, located at the end of this section, for the existing roadway crossings.

Table VI-1: Existing Bridge Crossings

Stream: Cottonwood Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
1	5320	Beltline Road *340' Bridge*	469.00	No WSEL = 465.69	No WSEL = 467.61	No WSEL = 468.72	Yes WSEL = 469.86	Yes WSEL = 470.49	Yes WSEL = 470.75
2	10760	3rd Street *130' Bridge*	478.00	No WSEL = 477.71	Yes WSEL = 478.47	Yes WSEL = 479.96	Yes WSEL = 480.52	Yes WSEL = 480.95	Yes WSEL = 481.33
3	859	Carrier Parkway *5-10'x5' MBC*	481.00	Yes WSEL = 482.74	Yes WSEL = 483.86	Yes WSEL = 484.36	Yes WSEL = 484.79	Yes WSEL = 485.19	Yes WSEL = 485.51
4	10550	Great Southwest Parkway *5-10'x8' MBC*	523.67	No WSEL = 520.24	No WSEL = 523.58	Yes WSEL = 524.41	Yes WSEL = 525.12	Yes WSEL = 525.82	Yes WSEL = 526.22
13	2587	S.H. 161 S. Bound *430' Bridge*	502.00	No WSEL = 487.28	No WSEL = 489.32	No WSEL = 490.00	No WSEL = 490.63	No WSEL = 491.24	No WSEL = 491.76
14	2239	S.H. 161 N. Bound *320' Bridge*	497.16	No WSEL = 486.68	No WSEL = 488.86	No WSEL = 489.49	No WSEL = 490.06	No WSEL = 490.60	No WSEL = 491.08

Stream: South Fork of Cottonwood Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
5	905	Carrier Parkway *4-9'x6' MBC*	482.00	Yes WSEL = 482.64	Yes WSEL = 484.39	Yes WSEL = 484.97	Yes WSEL = 485.42	Yes WSEL = 485.78	Yes WSEL = 486.12
6	2473	Marshall Drive *4-9'x6' MBC*	493.57	No WSEL = 489.62	Yes WSEL = 493.71	Yes WSEL = 494.45	Yes WSEL = 495.29	Yes WSEL = 495.78	Yes WSEL = 496.18
7	2852	Robinson Road *4-10'x6' MBC*	494.67	No WSEL = 491.75	Yes WSEL = 495.57	Yes WSEL = 496.00	Yes WSEL = 496.42	Yes WSEL = 496.70	Yes WSEL = 496.97
8	14582	Pioneer Parkway *3-8'x8' MBC*	542.00	No WSEL = 534.57	No WSEL = 537.38	No WSEL = 539.38	No WSEL = 541.63	Yes WSEL = 542.81	Yes WSEL = 543.45

Stream: South Fork of Cottonwood Creek										
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**						
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
9	16685	Great Southwest Parkway *3-10'x8' MBC*	551.39	No WSEL = 545.75	No WSEL = 548.29	No WSEL = 549.70	No WSEL = 551.24	Yes WSEL = 552.18	Yes WSEL = 552.63
15	6876	S.H. 161 S. Bound *295' Bridge*	514.95	No WSEL = 502.92	No WSEL = 504.53	No WSEL = 505.24	No WSEL = 505.67	No WSEL = 506.33	No WSEL = 506.92
16	6114	S.H. 161 N. Bound *420' Bridge*	514.78	No WSEL = 501.10	No WSEL = 502.47	No WSEL = 503.07	No WSEL = 503.54	No WSEL = 504.03	No WSEL = 504.54

Stream: Plattner Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
10	6517	Beltline Road *3-6'x6' MBC*	494.33	No WSEL = 485.71	No WSEL = 487.70	No WSEL = 489.56	No WSEL = 492.21	Yes WSEL = 494.64	Yes WSEL = 495.42
11	5235	Coral Way *3-12'x5' MBC*	479.00	No WSEL = 475.89	No WSEL = 477.19	No WSEL = 478.78	Yes WSEL = 480.50	Yes WSEL = 481.51	Yes WSEL = 482.31
19	4062	Marshall Drive *3-10'x8' MBC*	478.01	No WSEL = 470.34	No WSEL = 472.19	No WSEL = 473.19	No WSEL = 474.41	No WSEL = 475.61	No WSEL = 476.75

Stream: Indian Hills Branch									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
12	2140	4th Street *3-10'x7' MBC*	476.69	No WSEL = 471.36	No WSEL = 472.26	No WSEL = 472.87	No WSEL = 473.57	No WSEL = 474.14	No WSEL = 474.67

Stream: Warrior Creek									
River Station		**Roadway Crossing *Existing Structure***	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
				50%	**20%**	**10%**	**4%**	**2%**	**1%**
17	3,286	Pioneer Parkway *3-8'x8' MBC*	526.00	No WSEL = 518.07	No WSEL = 519.67	No WSEL = 520.99	No WSEL = 521.53	No WSEL = 522.27	No WSEL = 522.93
18	4,942	Arkansas Lane *3-8'x4' MBC*	532.80	No WSEL = 529.86	No WSEL = 530.74	No WSEL = 531.28	No WSEL = 531.76	No WSEL = 532.21	No WSEL = 532.70

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	Existing Crossing	Minimum Top of Road Elevation		Proposed Improvement	100-Year Ultimate WSEL	Change in WSEL
		(cfs)	(ft)	Existing	Proposed		(ft)	(ft)
Cottonwood	Beltline Road	19,398	340' Bridge	469.00	469.00	375 ac-ft Detention Pond	468.40	-2.42
Cottonwood	3rd Street	18,630	130' Bridge	478.00	479.00	Lengthen Bridge to 240' Extend 150' Channel from Beltline	478.84	-2.53
Cottonwood	Carrier Parkway	12,276	5-10'x5' MBC	481.00	485.50	Lengthen Bridge to 140'	485.27	-0.22
Cottonwood	Great Southwest Parkway	8,888	5-10'x8' MBC	523.67	523.67	350 ac-ft Detention Pond	-	-
South Cottonwood	Carrier Parkway	6,290	4-9'x6' MBC	482.00	485.50	Lengthen Bridge to 160' Widen Channel to 190'	485.33	-0.96
South Cottonwood	Marshall Drive	6,277	4-9'x6' MBC	493.57	494.25	10-10'x10' MBC	493.18	-3.27
South Cottonwood	Robinson Road	6,197	4-10'x6' MBC	494.67	494.67	Widen Channel to 100' 10-10'x10' MBC	494.35	-2.82
South Cottonwood	Pioneer Parkway	3,913	3-8'x8' MBC	542.00	542.00	Add 10'x10' BC	541.99	-1.46
South Cottonwood	Great Southwest Parkway	3,886	3-10'x8' MBC	551.39	551.39	4-10'x10' MBC	551.02	-1.61
Plattner	Beltline Road	1,981	3-6'x6' MBC	494.33	494.33	Add 6'x6' BC	492.63	-2.79
Plattner	Coral Way	2,261	3-12'x5' MBC	479.00	479.00	-	482.47	-

B. Evaluation of Proposed and Future Roadway Crossings

According to the 2010 City of Grand Prairie's Master Thoroughfare Plan, there are only two planned thoroughfares crossings within the Cottonwood Creek Basin including Highway 161 and the extension of Fall Drive, an undivided two lane collector. 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: Cottonwood Creek Basin Studied Tributaries with Future Thoroughfare Crossings

Tributary Name	Master Thoroughfare Crossing
Cottonwood Creek	Highway 161[1]
South Fork of Cottonwood Creek	Highway 161[1]
Warrior Creek	Fall Drive

[1] Currently under construction.

1. Design of Future Thoroughfare Crossings

Future thoroughfare crossings within the Cottonwood 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 Cottonwood Creek and the South Fork of Cottonwood 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.

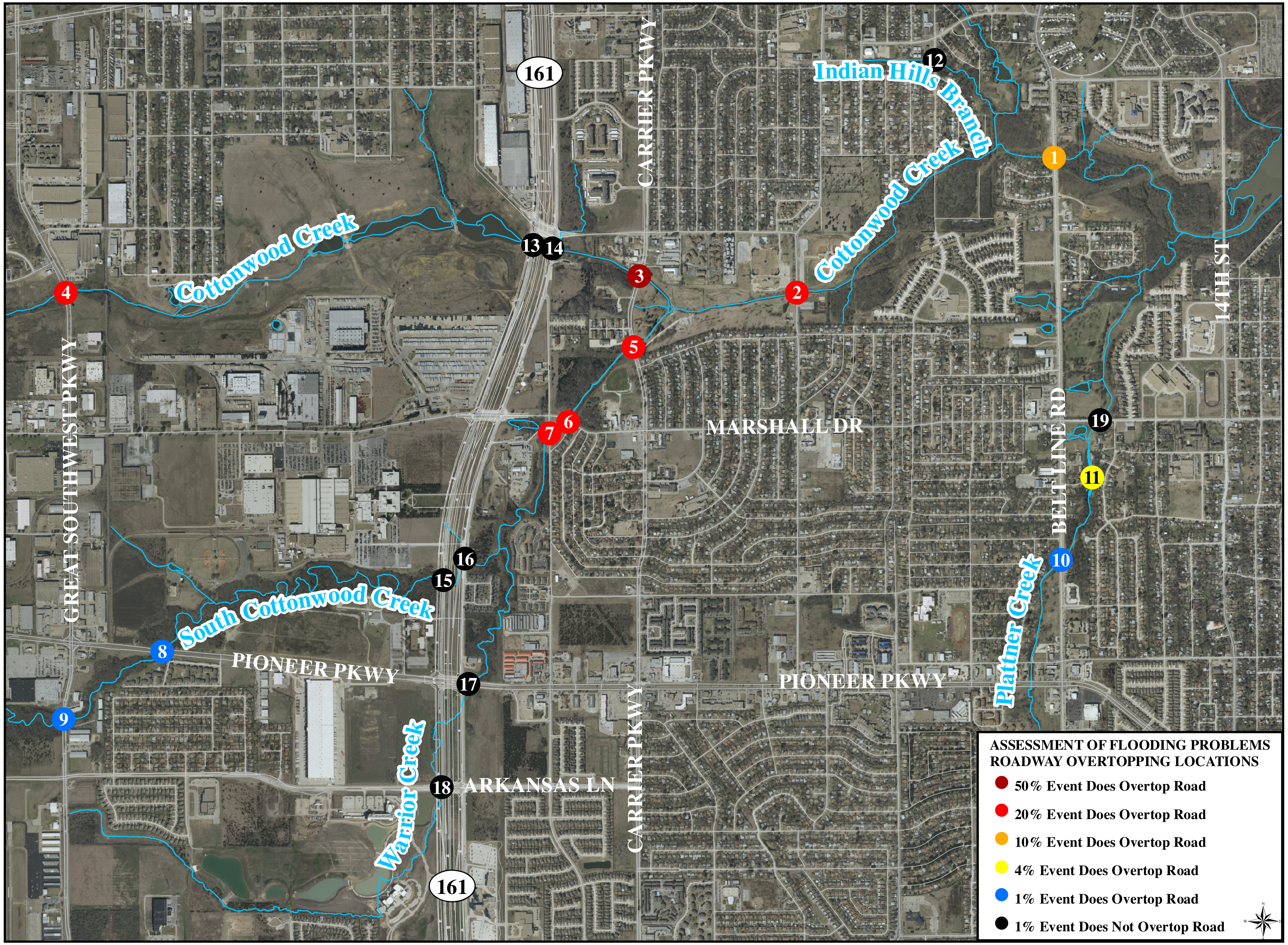


Figure VI-1: Existing Roadway Crossings

VII. ALTERNATIVES FOR STREAMS AND OPEN CHANNELS

Three types of mitigation were evaluated for the areas within the Cottonwood Creek Basin subjected to flooding damage: buy-outs, storage, and structural modifications. RPS Espey Consultants 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 Cottonwood Creek Basin. In addition to the residential buildings discussed below, there are eleven road crossings which are overtopped by a 100-yr storm.

Proposed bridge alternatives were considered for all existing roadway crossings modeled within the Cottonwood 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 Cottonwood Creek. 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 Cottonwood Creek Basin. Refer to **Table VI-2** for a summary of proposed conceptual existing bridge crossing improvements.

A. Beltline Road at Cottonwood Creek (Stream Station 53+20)

The existing bridge on Beltline Road is approximately 340' long and is overtopped by the 10-year storm event with the ultimate 100-year storm event overtopping the roadway by more than two feet. This location has two types of flooding: apartments that are located in the floodplain and roadway overtopping.

There is a group of apartments along this section of Cottonwood Creek on both sides of Beltline Road. There are twelve buildings which are subject to flooding up to three and a half feet deep during a 100-yr flood event. None of these structures appear on the City's list of repetitive loss structures.

Stream: Cottonwood Creek								
River Station	**Roadway Crossing**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
5320	Beltline Road	469.00	No WSEL = 465.69	No WSEL = 467.61	Yes WSEL = 468.72	Yes WSEL = 469.86	Yes WSEL = 470.49	Yes WSEL = 470.75

Proposed Improvements

- Construct a 375 ac-ft detention pond upstream from Beltline Road to McFalls Park

Statement of Probable Cost - 2012	
Construction Cost	$3,867,700
Non-Construction Cost * (22%)	$851,000
TOTAL	**$4,719,000**

* Engineering, Survey, Geotechnical, etc.

Refer to **Section XII** of this report for a detailed breakdown of the preliminary cost estimate. If the proposed improvements at Beltline Road were implemented, the roadway would not be overtopped by the ultimate 100-year storm event, and the flood levels downstream would also be reduced. The implementation of the proposed improvements would not require the relocation of any residents, and all of the construction will be located within the city limits of Grand Prairie.

B. 3rd Street at Cottonwood Creek (Stream Station 107+60)

The existing bridge at 3rd Street is approximately 130' long and is overtopped by the 10-year storm event with the ultimate 100-year storm event overtopping the roadway by more than three feet.

Stream: Cottonwood Creek								
River Station	Roadway	Existing Roadway Elevation	% Chance Flood Event Overtops Road					
			50%	20%	10%	4%	2%	1%
10760	3rd Street	478.00	No WSEL = 477.71	Yes WSEL = 478.47	Yes WSEL = 479.96	Yes WSEL = 480.52	Yes WSEL = 480.95	Yes WSEL = 481.33

Proposed Improvements

- Raise the roadway by approximately one foot
- Extend the 150-foot flat bottom channel from Beltline Road to 3rd Street
- Lengthen the bridge to 240 feet to match the proposed channel width

Statement of Probable Cost - 2012	
Construction Cost	$6,942,000
Non-Construction Cost* (22%)	$1,527,000
TOTAL	**$8,469,000**

* Engineering, Survey, Geotechnical, etc.

Refer to **Section XII** of this report for a detailed breakdown of the preliminary cost estimate. If the proposed improvements at 3rd Street were implemented, the roadway would not be overtopped by the ultimate 100-year storm event.

C. Carrier Parkway at Cottonwood Creek (Stream Station 8+59) and Carrier Parkway at South Fork of Cottonwood Creek (Stream Station 9+05)

The existing crossing at Carrier Parkway and Cottonwood Creek consists of a five barrel 10' x 5' multiple box culvert that is overtopped by a 2-year storm event with the ultimate 100-year storm event overtopping the roadway by more than four feet.

Stream: Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
859	Carrier Parkway	481.00	Yes WSEL = 482.74	Yes WSEL = 483.86	Yes WSEL = 484.36	Yes WSEL = 484.79	Yes WSEL = 485.19	Yes WSEL = 485.51

The existing crossing at Carrier Parkway and South Fork of Cottonwood Creek consists of a four barrel 9’ x 6’ multiple box culvert that is overtopped by a 5-year storm event with the ultimate 100-year storm event overtopping the roadway by more than four feet.

Stream: South Fork of Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
905	Carrier Parkway	482.00	No WSEL = 482.64	Yes WSEL = 484.39	Yes WSEL = 484.97	Yes WSEL = 485.42	Yes WSEL = 485.78	Yes WSEL = 486.12

Proposed Improvements

- Raise the roadway to an elevation of approximately 485.50
- Replace the existing Cottonwood Creek crossing with a 140-foot bridge
- Replace the existing South Fork of Cottonwood Creek crossing with a 160-foot bridge

These proposed culvert and roadway improvements will allow access to the apartment buildings located on the west side of Carrier Parkway between Cottonwood and South Fork Cottonwood Creeks during the 1% event. Currently these apartments are isolated by the 20% event. The small dam located at the confluence of Cottonwood and South Fork Cottonwood Creeks, in McFalls Park, restricts flow downstream; therefore, improvements at Carrier should not produce any negative effects downstream; conversely any of the proposed downstream improvements will have minimal effect on Carrier Parkway culvert improvements. The proposed detention pond upstream of Great Southwest Parkway could serve to reduce the magnitude of these improvements.

Statement of Probable Cost - 2012	
Construction Cost	$5,316,000
Non-Construction Cost* (22%)	$1,170,000
TOTAL	**$6,486,000**

* Engineering, Survey, Geotechnical, etc.

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

D. Great Southwest Parkway at Cottonwood Creek (Stream Station 105+50)

The existing crossing at Great Southwest Parkway consists of a five barrel 10’ x 8’ multiple box culvert that is overtopped by a 10-year storm event with the ultimate 100-year storm event overtopping the roadway by more than three feet.

Stream: Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
10550	Great Southwest Parkway	523.67	No WSEL = 520.24	No WSEL = 523.58	Yes WSEL = 524.41	Yes WSEL = 525.12	Yes WSEL = 525.82	Yes WSEL = 526.22

Proposed Improvements

- Construct a 350 ac-ft detention pond upstream of Great Southwest Parkway

Statement of Probable Cost - 2012	
Construction Cost	$4,047,000
Non-Construction Cost* (22%)	$890,000
TOTAL	**$4,937,000**

* Engineering, Survey, Geotechnical, etc.

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 as well as reducing the peak flow through the culvert at Carrier Parkway and other structures downstream, providing additional benefits by reducing the cost of their improvements.

E. Marshall Drive at South Fork of Cottonwood Creek (Stream Station 24+73)

The existing crossing at Marshall Drive consists of a four barrel 9' x 6' multiple box culvert that is overtopped by a 5-year storm event with the ultimate 100-year storm event overtopping the roadway by more than three feet.

Stream: South Fork of Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
2473	Marshall Drive	493.57	No WSEL = 489.62	Yes WSEL = 493.71	Yes WSEL = 494.45	Yes WSEL = 495.29	Yes WSEL = 495.78	Yes WSEL = 496.18

Proposed Improvements

- Raise the elevation of Marshall Drive by three quarters of a foot
- Replace the existing culvert with a ten barrel 10' x 10' multiple box culvert

Statement of Probable Cost - 2012	
Construction Cost	$667,000
Non-Construction Cost* (22%)	$147,000
TOTAL	**$814,000**

* Engineering, Survey, Geotechnical, etc.

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

F. Robinson Road at South Fork of Cottonwood Creek (Stream Station 28+52)

The existing crossing at Robinson Road consists of a four barrel 10' x 6' multiple box culvert that is overtopped by a 5-year storm event with the ultimate 100-year storm event overtopping the roadway by more than two feet.

Stream: South Fork of Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
2852	Robinson Road	494.67	No WSEL = 491.75	Yes WSEL = 495.57	Yes WSEL = 496.00	Yes WSEL = 496.42	Yes WSEL = 496.70	Yes WSEL = 496.97

Proposed Improvements

- Widen the channel between Marshall Drive and Robinson Road to 100'
- Replace the existing culvert at Robinson Road with a ten barrel 10' x 10' multiple box culvert

Statement of Probable Cost - 2012	
Construction Cost	$754,000
Non-Construction Cost* (22%)	$166,000
TOTAL	**$920,000**

* Engineering, Survey, Geotechnical, etc.

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

G. Pioneer Parkway at South Fork of Cottonwood Creek (Stream Station 145+82)

The existing crossing at Pioneer Parkway consists of a three barrel 8' x 8' multiple box culvert that is overtopped by a 50-year storm event with the ultimate 100-year storm event overtopping the roadway by one and a half feet.

Stream: South Fork of Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
14582	Pioneer Parkway	542.00	No WSEL = 534.57	No WSEL = 537.38	No WSEL = 539.38	No WSEL = 541.63	Yes WSEL = 542.81	Yes WSEL = 543.45

Proposed Improvements

- Add an additional 10'x10' barrel to the existing box culvert

Statement of Probable Cost - 2012	
Construction Cost	$185,000
Non-Construction Cost* (22%)	$41,000
TOTAL	**$226,000**

* Engineering, Survey, Geotechnical, etc.

Refer to **Section XII** of this report for a detailed breakdown of the preliminary cost estimate. If the Alternative 1 improvements at Pioneer Parkway were implemented, the roadway would not be overtopped by the ultimate 100-year storm event.

H. Great Southwest Parkway at South Fork of Cottonwood Creek (Stream Station 166+85)

The existing crossing at Great Southwest Parkway consists of a three barrel 10' x 8' multiple box culvert that is overtopped by a 50-year storm event with the ultimate 100-year storm event overtopping the roadway by one and a half feet.

Stream: South Fork of Cottonwood Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
16685	Great Southwest Parkway	551.39	No WSEL = 545.75	No WSEL = 548.29	No WSEL = 549.70	No WSEL = 551.24	Yes WSEL = 552.18	Yes WSEL = 552.63

Proposed Improvements

- Replace the existing crossing with a four barrel 10'x10' multiple box culvert

Statement of Probable Cost - 2012	
Construction Cost	$267,000
Non-Construction Cost* (22%)	$59,000
TOTAL	**$326,000**

* Engineering, Survey, Geotechnical, etc.

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.

I. Beltline Road at Plattner Creek (Stream Station 65+17)

The existing crossing at Beltline Road consists of a three barrel 6'x6' multiple box culvert and is overtopped by a 50-year storm event with the ultimate 100-year storm event overtopping the roadway by over one foot.

Stream: Plattner Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
6517	Beltline Road	494.33	No WSEL = 485.71	No WSEL = 487.70	No WSEL = 489.56	No WSEL = 492.21	Yes WSEL = 494.64	Yes WSEL = 495.42

Proposed Improvements

- Add an additional 6' x 6' barrel to the existing culvert.

Statement of Probable Cost - 2012	
Construction Cost	$114,000
Non-Construction Cost* (22%)	$25,000
TOTAL	**$139,000**

* Engineering, Survey, Geotechnical, etc.

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

J. Coral Way at Plattner Creek (Stream Station 52+35)

The existing crossing at Coral Way consists of a three barrel 12' x 5' multiple box culvert and is overtopped by a 25-year storm event with the ultimate 100-year storm event overtopping the roadway by over two and a half feet.

Stream: Plattner Creek								
River Station	**Roadway**	**Existing Roadway Elevation**	**% Chance Flood Event Overtops Road**					
			50%	**20%**	**10%**	**4%**	**2%**	**1%**
5235	Coral Way	479.00	No WSEL = 475.89	No WSEL = 477.19	No WSEL = 478.78	Yes WSEL = 480.50	Yes WSEL = 481.51	Yes WSEL = 482.31

No improvements were proposed to Coral Way. This culvert is 660 feet long and appears to have originally been designed to be overtopped by the 1% event. There is a large swell located above the culvert to carry the overtopping flow and no structures are permitted in this drainage area. Coral Way is a minor arterial street and there is another access route into the subdivision.

VIII. STORM WATER INFRASTRUCTURE ANALYSIS

A. Overview

No storm water infrastructure analysis was performed as a part of the FEMA CTP and Road Map Drainage Master Plan Study (Y#0881) contract; however at the time of this writing, the City of Grand Prairie had issued several contracts for the analysis of the storm water infrastructure in five "Hot Spots" located in the Cottonwood Creek Basin. These analyses will be added to the Drainage Master Plan as they become available.

IX. CHANNEL STABILITY ASSESSMENT AND EROSION HAZARD ANALYSIS

A. Introduction

As part of the FEMA CTP and Road Map 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 Cottonwood Creek Geomorphic Stream Assessment that was prepared by Freese and Nichols, Inc. (FNI) included in **Appendix E** to this report. 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 stream bed 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 stream bed 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.

From a geomorphic standpoint, the key element to stabilizing the Cottonwood 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.

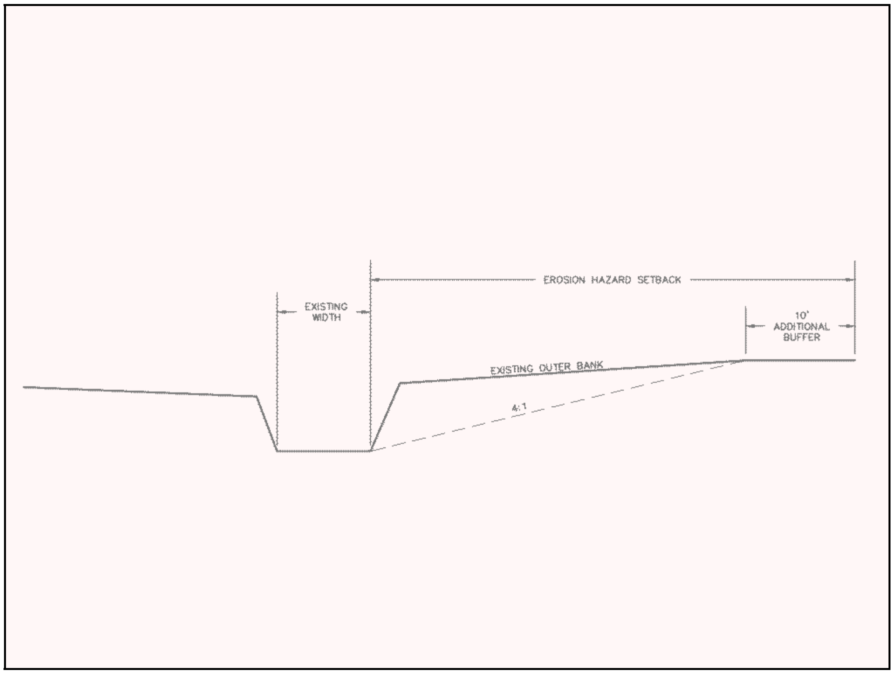


Figure IX-1: Erosion Hazard Setback Schematic

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.

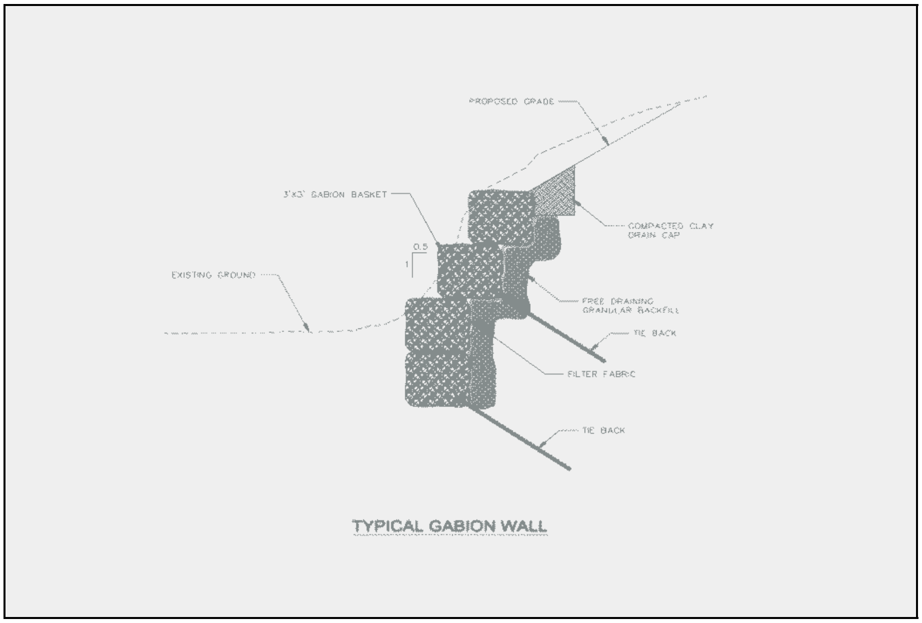


Figure IX-2: Typical Stacked Gabion Basket

b. **Drop structures** (DS) will be utilized at locations along the channel reach where 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.

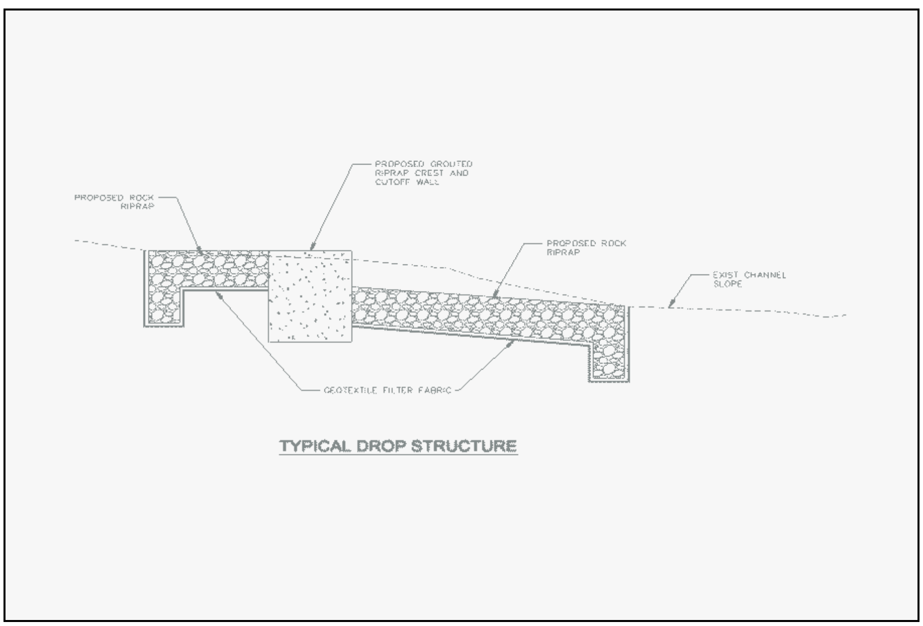


Figure IX-3: Typical Drop Structure

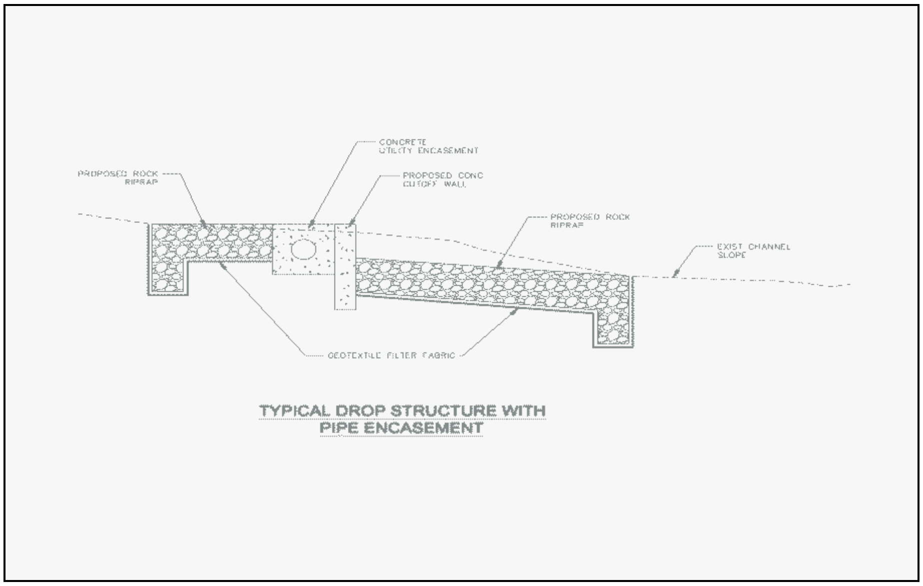


Figure IX-4: Typical Drop Structure with Pipe Encasement

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. North Fork Cottonwood Creek

For this analysis, the North Fork Cottonwood Creek (NFCC) project area extends from just upstream of Carrier Parkway to just upstream of Great Southwest Parkway. The existing slope for NFCC is 0.004 (ft/ft). The FNI recommended stable slope is 0.0012. The FNI report segments NFCC by hydraulic model cross section. For this analysis, RPSE has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure 1** within **Appendix A** shows the extents of the NFCC project area.

Table IX-1: North Fork Cottonwood Creek Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
NFCC-1	11107-10550	5.13	1 - 5 ft	EHS, DS
NFCC-2	10386-9817	0	0	DRR
NFCC-3	9769-8720	0.85	1 - 1 ft	EHS, DS, DRR
NFCC-4	7881-7440	0	0	EHS
NFCC-5	7440-6992	2.08	1 - 2 ft	EHS, DS
NFCC-6	6992-6201	1.06	1 - 1 ft	EHS, DRR
NFCC-7	2170-859	0	0	STABLE
NFCC-8	701-0	0	0	STABLE

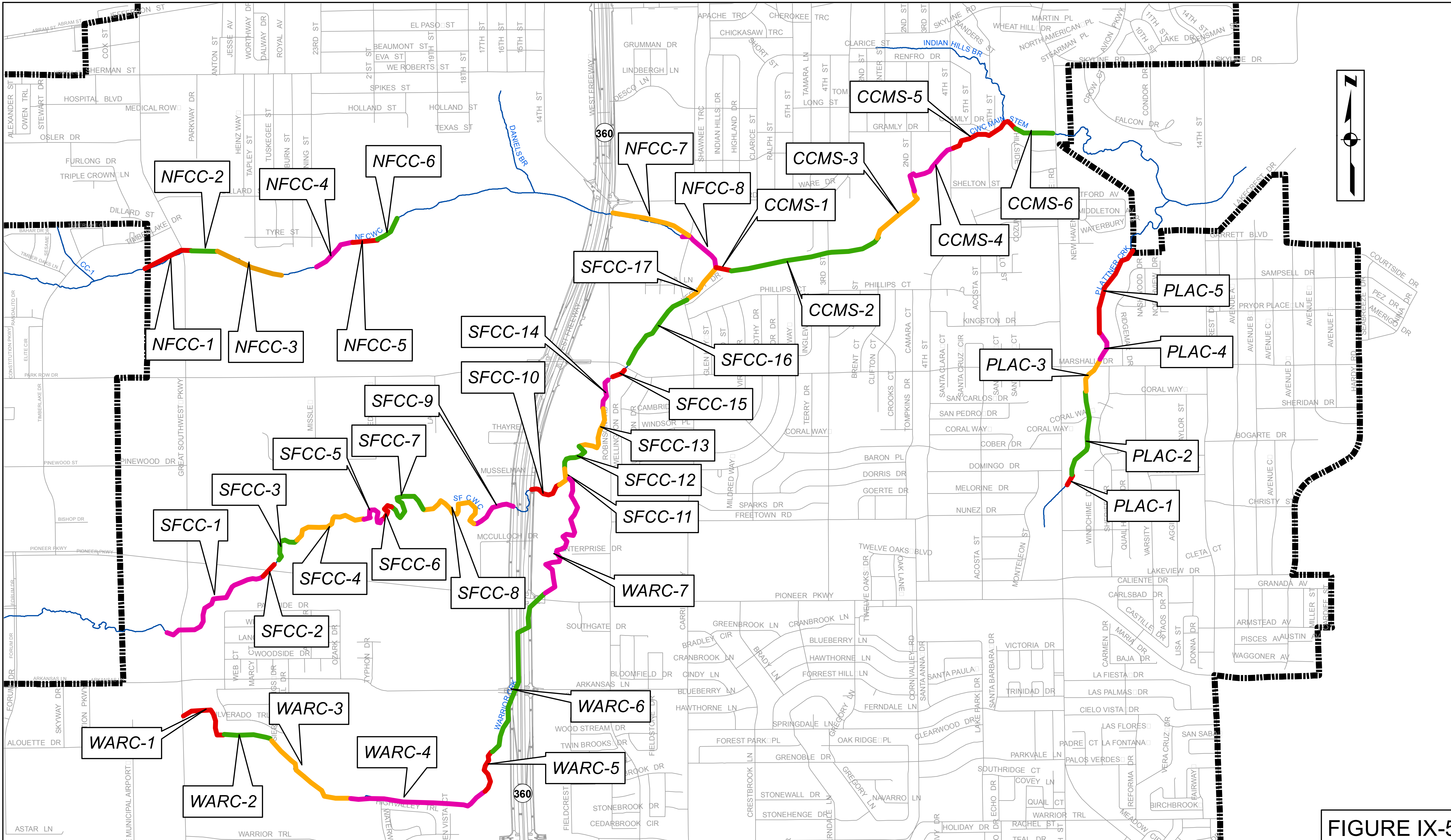


FIGURE IX-5

Grand Prairie TEXAS

RPS Espey

March 2012

STREAM STABILITY SEGMENTS
COTTONWOOD CREEK
City Wide Drainage Master Plan
GRAND PRAIRIE, TEXAS

PROJECT # 11006

1. **NFCC-1**
   a. As shown in **Figure IX-6**, the right bank near cross section 111+07 is experiencing severe bank erosion. No development or City infrastructure exists at this location so it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure. **Figure IX-6** below shows the above mentioned location.

Figure IX-6: Bank Erosion at Cross Section 111+07

   b. **Figure IX-7**, which is located just upstream of cross section 105+50 (upstream of Great Southwest Parkway) shows where riprap/shotcrete at the road culvert is being undermined. A five foot drop structure is proposed for just upstream of this riprap/shotcrete.

Figure IX-7: Undermining of Riprap/Shotcrete Upstream of Cross Section 105+50

2. **NFCC-2**
   a. Based on photos provided by FNI, it appears that dry rock riprap is currently being placed downstream of Great Southwest Parkway.
   b. Further downstream, near the railroad crossing, at cross section 98+17 it is recommended that further dry rock riprap be placed at various scour locations.

3. **NFCC-3**
   a. NFCC suffers from bank erosion and channel scour just downstream of the railroad crossing. **Figures IX-8** through **IX-10** show the conditions just downstream of the railroad crossing.

Figure IX-8: Right Bank Erosion D/S of Railroad Crossing

Figure IX-9: Channel Scour D/S of Railroad Crossing

Figure IX-10: Channel Scour D/S of Railroad Crossing

It is recommended that dry rock riprap be placed along the channel. It is also recommended that a one-foot drop structure be constructed at cross section 87+20. 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.

4. **NFCC-4**
   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.

5. **NFCC-5 and NFCC-6**
   Similar to the section above, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place. A minor drop structure is recommended at cross section 69+92 (two-foot drop) and placement of dry rock riprap be placed just upstream of cross section 62+01.

6. **NFCC-7 and NFCC-8**
   No erosion control measures are recommended for these portions of NFCC.

   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: NFCC Structural Measures Cost Summary

Construction Subtotal	$ 111,895
Approximate Contigency (25%)	$ 27,975
Construction Total	$ 139,870
Approximate Engineering and Survey (15%)	$ 20,980
Total	$ 160,850

D. South Fork Cottonwood Creek

For this analysis, the South Fork Cottonwood Creek (SFCC) project area extends from 1,000 feet upstream of Carrier Parkway to 1,000 feet upstream of Great Southwest Parkway. The existing slope for NFCC is 0.004 (ft/ft). The FNI recommended stable slope is 0.0014. The FNI report segments SFCC by hydraulic model cross section. For this analysis, RPSE has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure 2** within **Appendix A** shows the extents of the SFCC project area.

Table IX-3: South Fork Cottonwood Creek Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
SFCC-1	16546-145885	8.6	2 - 4.5 ft	EHS, DS, DRR
SFCC-2	14885-14582	3.71	1 - 4 ft	DS
SFCC-3	14301-13479	0	0	EHS
SFCC-4	13479-11967	5.88	2 - 3 ft	EHS, DS
SFCC-5	11967-11238	6.52	2 - 3.5 ft	EHS, DS
SFCC-6	11238-10803	0	0	EHS
SFCC-7	10803-9420	6.06	2 - 3 ft	EHS, DS
SFCC-8	9420-7765	2.68	1 - 3 ft	EHS, DS
SFCC-9	7765-6876	2.84	1 - 3 ft	EHS, DS
SFCC-10	5994-5502	0.11	0	DRR
SFCC-11	5502-5175	0	0	STABLE
SFCC-12	5175-4435	1.77	1 - 2 ft	DRR
SFCC-13	4435-3387	2.93	1 - 3 ft	DS
SFCC-14	3387-2852	0	0	none
SFCC-15	2723-2473	0.15	0	DRR
SFCC-16	2341-905	5.56	2 - 3 ft	DS, EHS
SFCC-17	761-0	0	0	none

1. **SFCC-1**
   a. As shown in **Figure IX-11**, severe channel scour is occurring just downstream of Great Southwest Parkway. Two 4.5-foot drop structures are proposed for this location.

Figure IX-5: Channel Scour D/S of Great Southwest Parkway

b. **Figures IX-12** and **IX-13**, which are located between cross sections 159+04 and 148+85 show where the channel is experiencing incision and slumping. It is recommended that an erosion hazard setback be established along the left bank where no existing development of city infrastructure exists. Dry rock riprap should be placed where channel incision is occurring.

Figure IX-6: Channel Incision near Cross Section 159+04

Figure IX-7: Bank Erosion near Cross Section 151+93

2. **SFCC-2**
It is recommended that a four-foot drop structure be placed just downstream of 148+85.

3. **SFCC-3**
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. **SFCC-4 AND SFCC-5**

It is recommended that the existing culvert just downstream of cross section 134+79 be replaced by two 3-foot drop structures in series. In addition, the low water crossing just downstream of cross section 119+67 should be replaced by two 3.5-foot drop structures in series. Currently, the channel suffers from severe erosion and scour which in turn have blocked the culverts. **Figures IX-14** and **IX-15** are pictures of the culverts looking upstream from the downstream side.

Figure IX-8: Culverts at 134+79

Figure IX-9: Downstream of Low Water Crossing at 119+67

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.

5. **SFCC-6**

Similar to the section above, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

6. SFCC-7, SFCC-8, SFCC-9

It is recommended that a 3-foot drop structures be placed in series at cross section 108+03. This drop structure will have to be placed with a utility crossing as part of the design. Two more 3-foot drop structures should be placed near cross section 77+65 and 73+44. **Figures IX-16** and **IX-17** are examples of the above mentioned locations.

Figure IX-10: Bank Erosion at Cross Section 100+47

Figure IX-11: Channel Scour at Cross Section 77+65

It is recommended that dry rock riprap be placed along the channel between cross sections. Similar to the section above, it is recommended that an erosion hazard setback be established before any planned development or placement of future City infrastructure take place.

7. **SFCC-10**
Dry rock riprap should also be placed downstream of the concrete-protected pipeline between cross section 59+96 and 57+65.

Figure IX-12: Channel Between Cross Sections 51+96 and 51+57

8. **SFCC-11**
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.

9. **SFCC-12 AND SFCC-13**
It is recommended that dry rock riprap should be placed at various channel scour locations along this segment as well. A 3-foot drop structure is proposed just upstream of cross section 37+39.

10. **SFCC-14 AND SFCC-15**
To prevent channel scour, additional dry rock riprap should be placed downstream of the culverts at Robinson Road.

11. **SFCC-16**
It is recommended that two 3-foot drop structures be placed in series starting at cross section 23+41. If no further development is planned along the left bank, an erosion hazard setback should be established.

12. **SFCC-17**
There are no recommendations for this section of SFCC.

Table IX-4 is an estimated cost summary for the recommended structural measures within SFCC. A more detailed cost estimate is included in **Section XII** of this report.

Table IX-4: SFCC Structural Measures Cost Summary

Construction Subtotal	$ 389,965
Approximate Contigency (25%)	$ 97,490
Construction Total	$ 487,455
Approximate Engineering and Survey (15%)	$ 73,120
Total	$ 560,575

E. Cottonwood Creek Main Stem

For this analysis, the Cottonwood Creek Main Stem (CCMS) project area extends from Beltline Road to the confluence of North and South Fork Cottonwood Creek. The existing slope for NFCC is 0.002 (ft/ft). The FNI recommended stable slope is 0.001. The FNI report segments CCMS by hydraulic model cross section. For this analysis, RPS Espey has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure 3** within **Appendix A** shows the extents of the CCMS project area.

Table IX-5: Cottonwood Creek Main Stem Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
CCMS-1	12645-12482	0.84	1 - 1 ft	EHS, DS
CCMS-2	12482-9774	0.77	1 - 1 ft	DRR
CCMS-3	9774-8750	4.32	1 - 4 ft	EHS, DS, DRR
CCMS-4	8750-7300	0.73	1 - 1 ft	EHS
CCMS-5	7300-5978	0	0	EHS, DS
CCMS-6	5978-5211	1.84	1 - 2 ft	EHS, DRR

1. CCMS-1

As seen in **Figure IX-19**, the dam structure at cross section 126+45 is experiencing structural damage at the downstream end. Grouted rock riprap should be applied to damaged areas.

Figure IX-13: Dam Structure Damage at Cross Section 126+45

It is also recommended that a one-foot drop structure be placed near cross section 124+82.

2. CCMS-2

Figure IX-20 shows significant bank erosion near an aerial walking path downstream of cross section 124+82.

Figure IX-20: Bank Erosion Near Cross Section 124+82

It is recommended that an erosion hazard setback should be established starting downstream of cross section 117+63 to cross section 107+60.

Similar to the aerial walking path near cross section 124+82, the aerial walking path downstream of cross section 110+42 is also suffering from bank erosion near its foundation along with foundation damage. **Figure IX-21** is a picture of the foundation damage along the right bank.

Figure IX-14: Pedestrian Bridge Foundation Damage at Cross Section 110+42

A cracked outfall pipe just downstream of cross section 106+76 also needs to be repaired. It is also recommended that a one-foot drop structure be placed upstream of cross section 97+44.

3. **CCMS-3**
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. It is also recommended that a 4-foot drop structure be placed just upstream of cross section 85+70.

4. **CCMS-4**
Similar to CCMS-3, an erosion hazard setback should be established along this portion of CCMS. It is recommended that one 1-foot drop structure be placed just upstream of SE 4th Street.

5. **CCMS-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.

6. **CCMS-6**
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. A 2-foot drop structure with pipeline encasement should be placed at the pipe crossing just downstream of cross section 59+78.

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

Table IX-6: CCMS Structural Measures Cost Summary

Construction Subtotal	$ 180,675
Approximate Contigency (25%)	$ 45,170
Construction Total	$ 225,845
Approximate Engineering and Survey (15%)	$ 33,875
Total	$ 259,720

F. Warrior Creek

For this analysis, the Warrior Creek (WARC) project area extends from its confluence with CCMS to just downstream of Great Southwest Parkway at the Grand Prairie Municipal Airport. The existing slope for NFCC is 0.006 (ft/ft). The FNI recommended stable slope is 0.0021. The FNI report segments WARC by hydraulic model cross section. For this analysis, RPS Espey has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure 4** within **Appendix A** shows the extents of the WARC project area.

Table IX-7: Warrior Creek Main Stem Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control Measures
WARC-1	1-3	1.05	1 - 1ft	DS, EHS
WARC-2	3-4	0	1 - 1ft	STABLE
WARC-3	4-6	7.38	2 - 3.5ft	DS, EHS
WARC-4	6-10	6.68	2 - 3.5ft	DS
WARC-5	10-12	1.27	1 - 1ft	DS
WARC-6	12-3079	1.96	1 - 2ft	DS
WARC-7	3079-182	12.14	3 - 4ft	DS, SGB, EHS

1. **WARC-1**
   As shown in **Figure IX-22** (upstream looking downstream), a gabion structure has been placed across the creek centerline. It is recommended that the purpose of this wall be investigated.

Figure IX-15: Gabion Wall in WARC-1 Creek Centerline

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

2. **WARC-3**
   It is recommended that two 3.5-foot drop structures be placed near cross section 5 and 6 along with the establishment of an erosion hazard setback.

3. **WARC-4**
   It is recommended that two 3.5-foot drop structures be placed near cross section 7 and 8.

4. **WARC-5**
   It is recommended that one 1-foot drop structure be placed near cross section 12.

5. **WARC-6**
   It is recommended that hydromulch in combination with a soil retention blanket be placed along the right bank of WARC between cross sections 13 and 14. **Figure IX-23** shows the current bank erosion and sparse vegetation.

Figure IX-16: Bank Erosion and Sparse Vegetation at Cross Sections 13 and 14

It is also recommended that a 2-foot drop structure be placed just upstream of cross section 35+10.

6. WARC-7

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.

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

Table IX-8: WARC Structural Measures Cost Summary

Construction Subtotal	$ 180,675
Approximate Contigency (25%)	$ 45,170
Construction Total	$ 225,845
Approximate Engineering and Survey (15%)	$ 33,875
Total	$ 259,720

G. Plattner Creek

For this analysis, the Plattner Creek (PLAC) project area extends from its confluence with CCMS to just upstream of S. Beltline Road. The existing slope for PLAC is 0.0055 (ft/ft). The FNI recommended stable slope is 0.0016. The FNI report segments PLAC by hydraulic model cross section. For this analysis, RPS Espey has added additional columns to the FNI tables that provide the City with recommended erosion control measures per section. **Figure 5** within **Appendix A** shows the extents of the PLAC project area.

Table IX-9: Plattner Creek Main Stem Segments

Section	Cross Section ID	Downcut (ft)	Number of Drops	Recommended Erosion Control
PLAC-1	6287-6104	1.25	1 - 1 ft	DS
PLAC-2	6104-4510	7.55	2 - 4 ft	DS
PLAC-3	4510-3878	0.73	1 - 1 ft	DS
PLAC-4	3878-3306	0	0	EHS
PLAC-5	3306-1654	2.52	1 - 3 ft	DS, EHS

1. **PLAC-1**
   As shown in **Figure IX-24,** the channel banks along PLAC-1 are severely eroded. It is recommended that a one-foot drop structure be placed near cross section 62+87.

Figure IX-17: Bank Erosion Along PLAC-1

2. **PLAC-2**
   Similar to PLAC-1, the channel banks along PLAC-2 (**Figure IX-25**) are severely eroded as it traverses through developed land. It is recommended that two 4-foot drop structures be placed near cross section 61+04 and 54+55.

Figure IX-18: Bank Erosion Along PLAC-2

3. **PLAC-3**
   It is recommended that one 1-foot drop structure be placed near cross section 45+10.

4. **PLAC-4**
   It is recommended that an erosion hazard setback be established along the left bank of the PLAC-4 segment.

5. **PLAC-5**
   It is recommended that a 3-foot drop structure be placed near cross section 23+68. It is also recommended that an erosion hazard setback be established along the left bank of the PLAC-5 segment.

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

Table IX-10: PLAC Structural Measures Cost Summary

Construction Subtotal	$ 133,525
Approximate Contigency (25%)	$ 33,380
Construction Total	$ 166,905
Approximate Engineering and Survey (15%)	$ 25,035
Total	$ 191,940

X. DAMS / LEVEES / DETENTION / DRAINAGE REVIEWS

A. Dams / Levees

Three small lakes are located in the Cottonwood Creek watershed, one is located on Henry Branch and the other two are off-channel stock tanks. The spillway of the dam on Henry Branch located just southwest of the Beltline Road and Sunnybrook Street intersection, designated as Pond #1on **Figure X-1**, was rated as being poor and requires immediate corrective maintenance. The pond was rated poor as a result of heavy erosion occurring around the concrete spillway outlet. This erosion is undercutting the concrete spillways subgrade; without corrective action, erosion will continue and will ultimately lead to complete failure.

B. Detention Ponds

The City of Grand Prairie's GIS database indicated twenty-nine (29) possible detention ponds within the Cottonwood Creek Basin. All of these locations were visited to verify the existence and condition of the ponds. There are twenty-three (23) ponds designed to provide detention, one (1) small on-channel lake on Henry Branch and two (2) off-channel stock tanks. 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: four (4) of the twenty-nine (29) ponds were rated as fair due to their need of mowing, particularly around the headwalls. **Table X-1** describes the condition assigned to each detention pond. Each entries' pond number correlates with **Figure X-1.**

Table X-1: Cottonwood Creek Detention Pond Maintenance Condition

Pond No.	City Plan ID	Type	Condition
1	72	On Channel Pond	**Poor** – Heavy Erosion at Spillway Outlet
2	159	Detention	Fair – Needs Mowing
3	68	Retention	Good
4	66	Detention	Good
5	144	Detention	Good
6	156	Detention	Fair – Needs Mowing
7	346	Retention	Good
8	331	Detention	Good
9	345	Detention	Good
10	335	Detention	Good
11	336	Detention	Good
12	337	Detention	Good
13	338	Detention	Good
14	339	Detention	Good

Pond No.	City Plan ID	Type	Condition
15	340	Detention	Good
16	235	Does Not Exist	Removed due to Construction of SH-161
17	64	Natural	Good
18	62	Detention	Good
19	329	Detention	Fair – Needs Mowing
20	328	Detention	Fair – Needs Mowing
21	157	Detention	Good
22	67	Detention	Good
23	69	Detention	Good
24	71	Detention	Good
25	70	Detention	Good
26	234	Wetlands	Area is a Wetland
27	180	Does Not Exist	No Pond Exists in this Location
28	65	Off Channel Pond	Private Stock Tank
29	63	Off Channel Pond	Private Stock Tank

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-2: CWC On-Channel Pond No. 1: South of Wheat Hill Drive

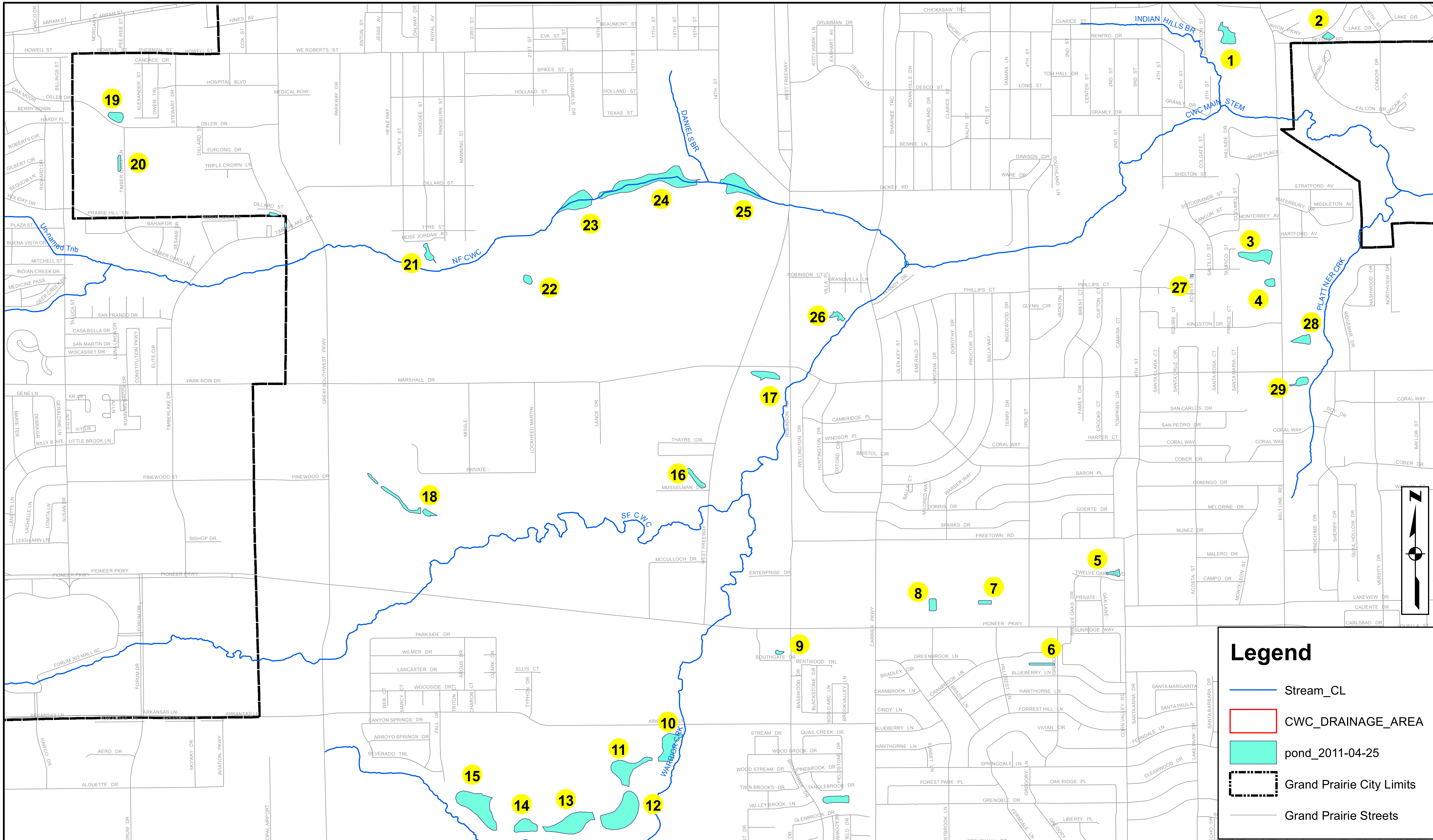


FIGURE X-1
DETENTION PONDS
COTTONWOOD CREEK
City Wide Drainage Master Plan
GRAND PRAIRIE, TEXAS

MARCH 2012

PROJECT # 11006

Figure X-3: CWC On-Channel Pond Outfall No. 1: South of Wheat Hill Drive

Figure X-4: CWC On-Channel Pond Outfall No. 1: South of Wheat Hill Drive

Figure X-5: CWC Detention Pond No. 2: Between Skyline Road & Avion Parkway

Figure X-6: CWC Retention Pond No. 3: Between Beltline Road & Tampico Street

Figure X-7: CWC Retention Pond Outfall No. 3: Between Beltline Road & Tampico Street

Figure X-8: CWC Detention Pond No. 4: G.P. Family Church off Beltline Road

Figure X-9: CWC Detention Pond No. 5: Mountain Creek Retirement Living off 12 Oaks Boulevard

Figure X-10: CWC Detention Pond No. 6: Between Cranbrook Lane & Blueberry Lane

Figure X-11: CWC Retention Pond No. 7: Off West Pioneer Parkway

Figure X-12: CWC Detention Pond No. 8: Off West Pioneer Parkway Behind Long John Silvers

Figure X-13: CWC Detention Pond No. 9: Off West Pioneer Parkway Behind QuikTrip

Figure X-14: CWC Detention Pond No. 10: Off 161 & Arkansas Lane

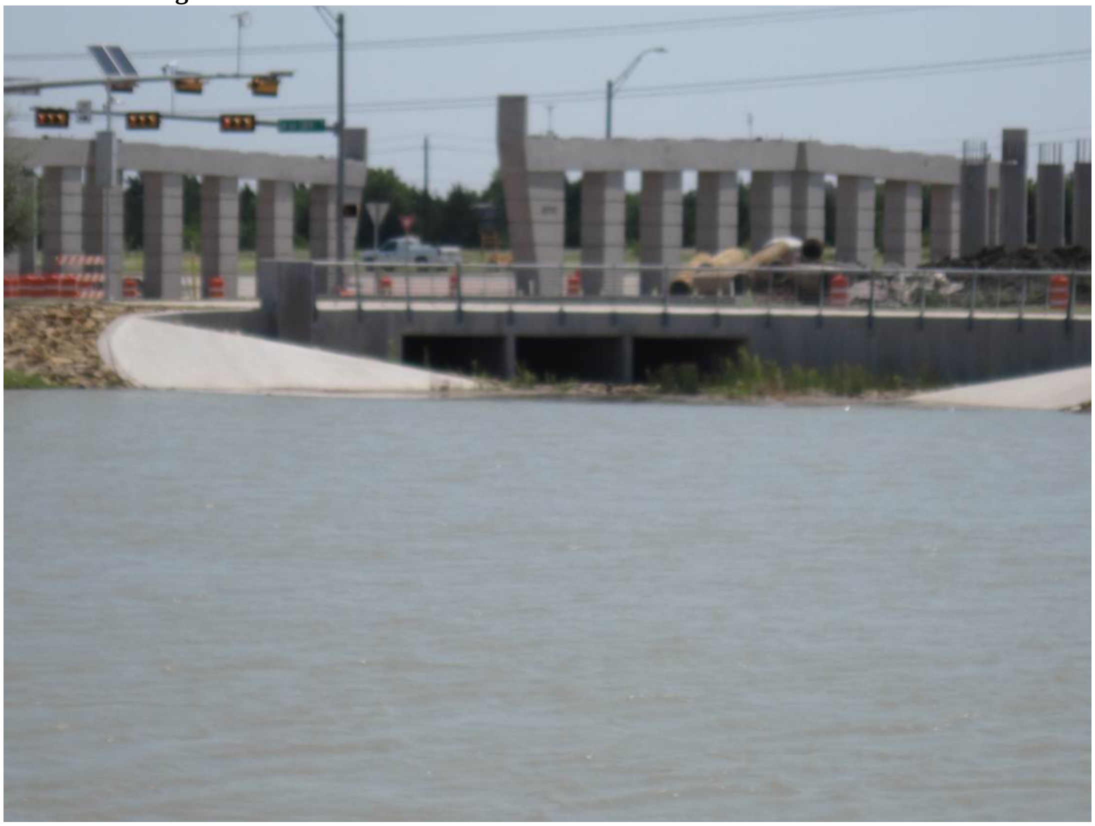


Figure X-15: CWC Detention Pond No. 11: Along Police Station

Figure X-16: CWC Detention Pond No. 12

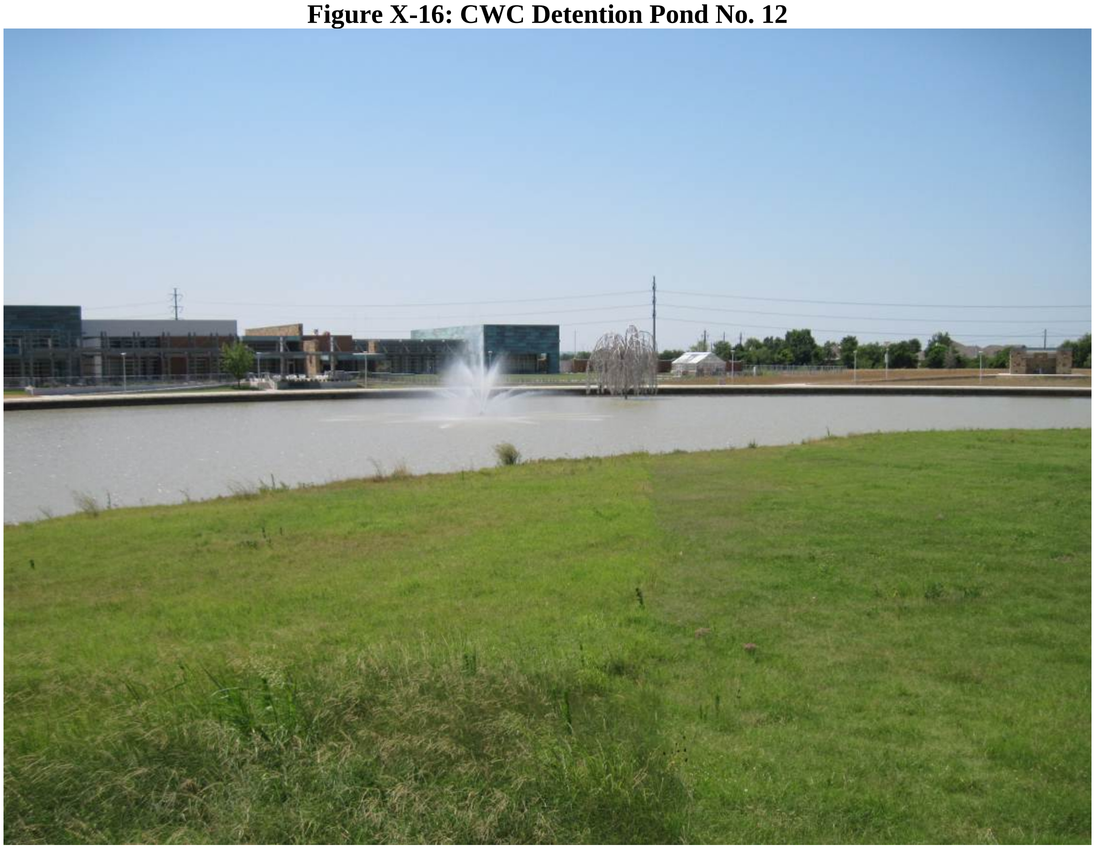


Figure X-17: CWC Detention Pond No. 13

Figure X-18: CWC Detention Pond No. 15

Figure X-19: CWC Detention Pond No. 15

Figure X-20: CWC Detention Pond No. 19: North of Osler Drive & Timber Oaks Lane

Figure X-21: CWC Detention Pond No. 20: Apartments off Timber Oaks Lane

Figure X-22: CWC Detention Pond Outfall No. 20: Apartments off Timber Oaks Lane

Figure X-23: CWC Detention Pond Outfall No. 21: Tyre Park

Figure X-24: CWC Detention Pond Outfall No. 23

Figure X-25: CWC Detention Pond Outfall No. 24

Figure X-26: CWC Detention Pond Outfall No. 25

XI. STORM DRAIN OUTFALL ASSESSMENT

The City of Grand Prairie provided photographs of each storm drain outfall as well as a GIS shape file 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 Cottonwood Creek watershed, there were 216 structures in the City of Grand Prairie's database.

The structures were assigned one of the four following conditions:

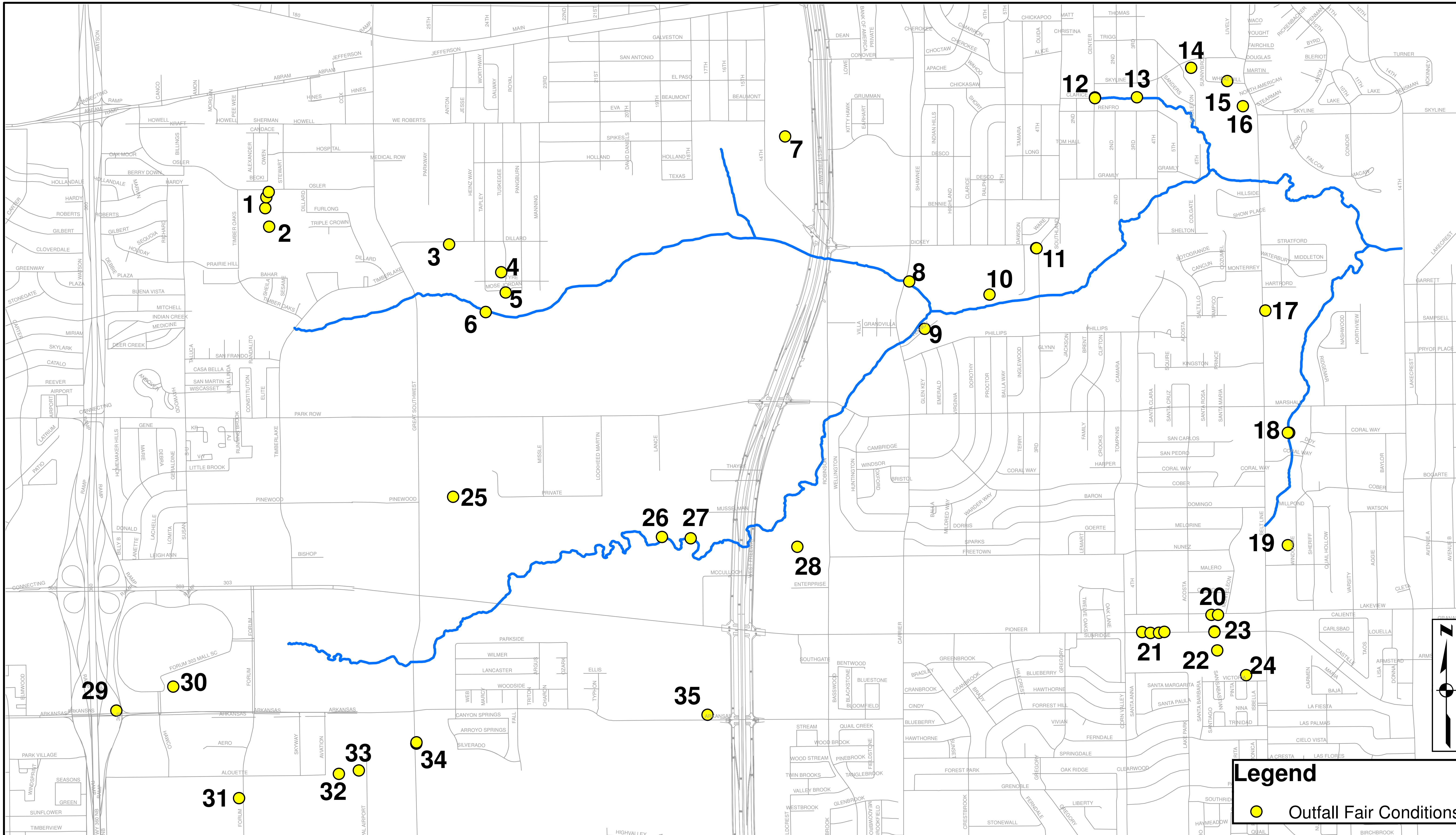
1. **Good –** Requires no corrective maintenance, continued normal inspections.
2. **Fair –** Requires some corrective maintenance, not immediate.
3. **Poor –** Requires immediate corrective maintenance.
4. **Failure –** Requires immediate assistance beyond corrective maintenance.

Most of the structures are in good condition – 154 of 216 rated Good (71%). Forty-seven (47) 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 Cottonwood Creek Structure Locations – Fair Conditions Map – **Figure XI-1**.

Table XI-1: Cottonwood Creek Structures – Fair Conditions

Map No.	SDD_ID_N	TYPE	COMMENTS
1	887	OUTFALL	Fair – Vegetation Needs Clearing
1	1476	OUTFALL	Fair – Vegetation Needs to be Cleared. Needs Rip Rap
1	880	OUTFALL	Fair – Vegetation Needs Clearing
2	879	OUTFALL	Fair – Vegetation Needs Clearing
3	525	OUTFALL	Fair – Silt/Vegetation Needs Clearing
4	1558	OUTFALL	Fair – Needs Grouted Rip Rap
5	1294	OUTFALL	Fair – Erosion Behind Wing Wall Will Lead to Erosion Behind Headwall. Needs to be Filled/Compacted
6	1591	OUTFALL	Fair – Bank Eroding Around Pipe. Headwall Needed
7	1289	OUTFALL	Fair – High Silt and Vegetation Needs Clearing
8	899	OUTFALL	Fair – Erosion Behind Headwall and Wingwalls
9	1749	INTAKE	Fair – Siltation Needs to be Removed
10	912	OUTFALL	Fair – Large Trees in Flowline of Outfall Need to be Removed. Heavy Siltation at Outfall
11	758	OUTFALL	Fair – Erosion Behind Wing Walls. Needs to be Filled/Compacted
11	1119	OUTFALL	Fair – Erosion Behind Wing Walls. Needs to be Filled/Compacted
12	761	OUTFALL	Fair – Erosion Protection Needed on Banks
12	762	OUTFALL	Fair – Erosion Protection Needed on Banks
13	760	OUTFALL	Fair – Structure Needs Toe Wall and Wing Wall Before Further Erosion Undercuts Outfall
14	801	OUTFALL	Fair – Heavy Siltation Blocking West Box. Needs to be Cleared

Map No.	SDD_ID_N	TYPE	COMMENTS
15	408	OUTFALL	Fair – Heavy Silt/Vegetation Needs Clearing
16	1291	OUTFALL	Fair – Silt/Vegetation Needs Clearing
17	304	OUTFALL	Fair – Heavy Brush Needs Clearing
18	1373	OUTFALL	Fair–Heavy Erosion at Bank Beyond Wingwalls. Debris Needs Clearing at Outfall.
18	1396	OUTFALL	Fair–Heavy Erosion at Bank Beyond Wingwalls. Debris Needs Clearing at Outfall.
18	1397	OUTFALL	Fair–Heavy Erosion at Bank Beyond Wingwalls. Debris Needs Clearing at Outfall.
19	491	OUTFALL	Fair – Silt/Vegetation Needs Clearing
20	323	OUTFALL	Fair – Silt/Vegetation Needs Clearing
20	324	OUTFALL	Fair – Silt/Vegetation Needs Clearing
21	1307	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
21	1312	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
21	1313	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
21	1314	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
22	1315	OUTFALL	Fair – Pipe Needs Erosion Control All Around Outfall. Needs Clearing
23	1318	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
23	1319	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
24	754	OUTFALL	Fair – Slight Erosion Around Outfall. Debris Needs Clearing
25	909	OUTFALL	Fair – Structure Covered with Heavy Brush. Needs Clearing
26	658	OUTFALL	Fair – Bank Behind Wingwall Needs to be Filled
27	1301	OUTFALL	Fair – Bank Erosion Starting to Undercut Pipe
28	288	OUTFALL	Fair – Bank Overtopping Wingwall
29	1320	OUTFALL	Fair – Monitor Cracks in Concrete Channel Linings
30	1205	OUTFALL	Fair – Vegetation Needs Clearing
31	416	OUTFALL	Fair – Vegetation Needs Clearing
32	1130	OUTFALL	Fair – Erosion Around Headwall
33	1208	OUTFALL	Fair – Vegetation Needs Clearing. Erosion North and South Banks of Structure
34	750	OUTFALL	Fair – Erosion Starting to Cut Behind Headwall. Needs to be Filled/Compacted
34	805	OUTFALL	Fair – Erosion Starting to Cut Behind Headwall. Needs to be Filled/Compacted
35	833	OUTFALL	Fair – Heavy Vegetation Needs to be Cleared



Grand Prairie TEXAS

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MARCH 2012

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

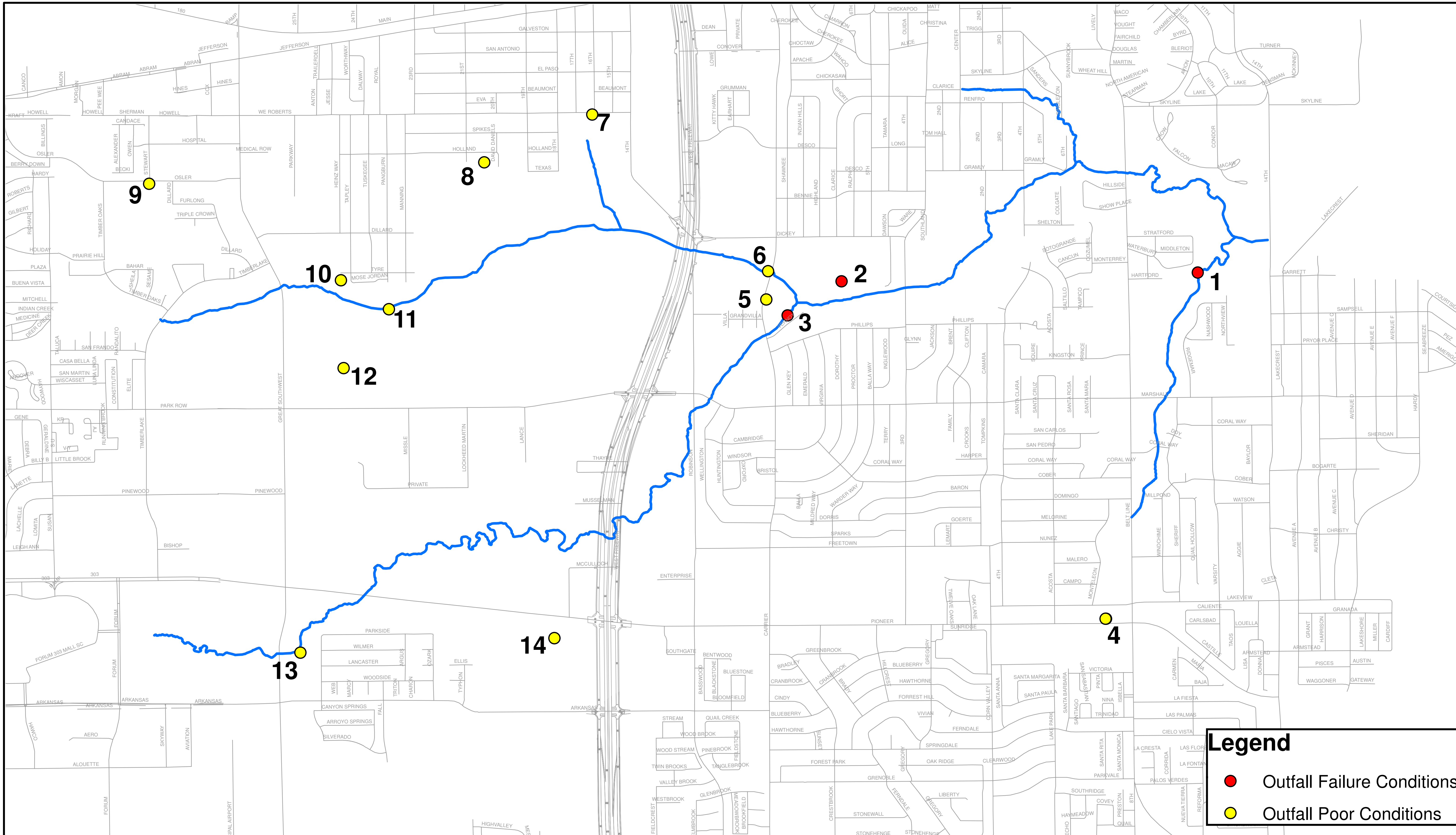
PROJECT # 10060

There were twelve (12) 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.

There were three (3) structures rated as failures. These structures have completely separated and washed out, requiring immediate assistance. **Table XI-2** lists the structures assigned as having a poor/failure condition. Each entries map number correlates with the Cottonwood Creek Structure Locations – Poor/Failure Conditions Map – **Figure XI-2**.

Table XI-2: Cottonwood Creek Structures – Poor Conditions

Map No.	SDD_ID_N	TYPE	COMMENTS
1	1120	OUTFALL	**Failure –** Pipe Separated. Needs Repair. Erosion Control Outfall Bedding Needed
2	910	OUTFALL	**Failure** – Pipe is Separated. Needs Repair
3	1750	OUTFALL	**Failure –** Erosion has Undercut Pipe. Entire Joint has come Apart. Needs Toewall and Rip Rap around Outfall
4	1316	OUTFALL	**Poor** – Erosion under Structure. Undercutting will Occur. Erosion Control Bedding Needed
4	1317	OUTFALL	**Poor** – Erosion under Structure. Undercutting will Occur. Erosion Control Bedding Needed
5	1748	OUTFALL	**Poor** – Heavy Erosion Around Outfall Backing Towards Road. Wingwalls and Rip Rap Needed
6	1201	OUTFALL	**Poor** – Heavy Vegetation. Needs to be Cleared
7	280	OUTFALL	**Poor** – Erosion Behind Headwall
8	923	OUTFALL	**Poor** – Needs Erosion Control Outfall Bedding at the Minimum. Siltation Needs to be Cleared.
9	415	OUTFALL	**Poor** – Flume Cracked/Separated from Top of Pipe. Cracked Wingwalls. Heavy Vegetation Needs Clearing
10	501	OUTFALL	**Poor** – Pipe Cracked/Separating. Erosion at Outflow
11	1117	OUTFALL	**Poor** – Needs Erosion Control Outfall Bedding at the Minimum. Outfall Spilling into Earthen Channel Causing Undercutting
12	1121	OUTFALL	**Poor** – Heavy Erosion on Banks. Pipe Needs Erosion Control all Around Outfall. Needs Clearing
13	282	OUTFALL	**Poor** – Siltation at Outflow. Flume Cracked. Erosion at Edges of Flume
14	675	OUTFALL	**Poor** – Heavy Siltation Fully Blocking Outlet; Needs Clearing



Grand Prairie TEXAS

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

MARCH 2012

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
Beltline Road at Cottonwood Creek	Construct a 375 ac-ft detention pond upstream from Beltline Road to McFalls Park.	$4,719,000
3rd Street at Cottonwood Creek	Raise the roadway by approximately one foot; extend the 150-foot flat bottom channel from Beltline Road to 3rd Street; lengthen the bridge to 240 feet to match the proposed channel width.	$8,469,000
Carrier Parkway at Cottonwood Creek and Carrier Parkway at South Fork of Cottonwood Creek	Raise the roadway to an elevation of approximately 485.50; replace the existing Cottonwood Creek crossing with a 140-foot bridge; replace the existing South Fork of Cottonwood Creek crossing with a 160-foot bridge.	$6,486,000
Great Southwest Parkway at Cottonwood Creek	Construct a 350 ac-ft detention pond upstream of Great Southwest Parkway.	$4,937,000
Marshall Drive at South Fork of Cottonwood Creek	Raise the elevation of Marshall Drive by three quarters of a foot; replace the existing culvert with a ten barrel 10’ x 10’ multiple box culvert.	$814,000
Robinson Road at South Fork of Cottonwood Creek	Widen the channel between Marshall Drive and Robinson Road to 150’; replace the existing culvert at Robinson Road with a ten barrel 10’ x 10’ multiple box culvert.	$920,000
Pioneer Parkway at South Fork of Cottonwood Creek	Add an additional 10’x10’ barrel to the existing box culvert.	$226,000
Great Southwest Parkway at South Fork of Cottonwood Creek	Replace the existing crossing with a four barrel 10’x10’ multiple box culvert.	$326,000
Beltline Road at Plattner Creek	Add an additional 6’ x 6’ barrel to the existing culvert.	$139,000

Beltline Road at Cottonwood Creek				
375 ac-ft Detention Pond				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Land	50	ac	$10,000.00	$500,000.00
Clearing	50	ac	$5,000.00	$250,000.00
Tree Planting	50	ac	$1,000.00	$50,000.00
Excavation & Embankment	268,000	cy	$10.00	$2,680,000.00
Topsoil	50,000	sy	$2.40	$120,000.00
Seed & Fertilize	50	ac	$2,000.00	$100,000.00
Inlet Structure	1	ls	$80,000.00	$80,000.00
Outlet Structure	1	ls	$88,000.00	$88,000.00
			Construction Cost	$3,868,000.00
			Construction Cost	$3,868,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$851,000.00
			Total Project	**$4,719,000.00**

3rd Street at Cottonwood				
Raise the roadway 1' , lengthen bridge to 240', 150' channel DS to Beltline				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Land	24	ac	$10,000.00	$240,000.00
Clearing	24	ac	$5,000.00	$120,000.00
Tree Planting	24	ac	$1,000.00	$24,000.00
Channel Excavation	249,000	cy	$10.00	$2,490,000.00
Hauling	200,000	cy	$3.00	$600,000.00
Topsoil	4,000	sy	$2.40	$9,600.00
Seed & Fertilize	1	ac	$2,000.00	$2,000.00
Embankment	49,000	cy	$10.00	$490,000.00
Road Demolition	6,400	sy	$6.40	$40,960.00
Pavement	1,200	lf	$114.00	$136,800.00
Bridge Demolition	100	lf	$250.00	$25,000.00
24" Rock Riprap	2,000	cy	$120.00	$ 240,000
Filter Fabric	3,000	sy	$2.40	$ 16,000
Bridge Abutments	2	ea	$42,000.00	$84,000.00
Bridge	240	lf	$10,100.00	$2,424,000.00
			Construction Cost	$6,942,360.00
			Construction Cost	$6,942,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$1,527,000.00
			Total Project	**$8,469,000.00**

Carrier Parkway at Cottonwood Creek				
Raise the roadway to 485.5 and lengthen Cottonwood Bridge to 140' & South Cottonwood to 160'				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Excavation & Embankment	70,000	cy	$10.00	$700,000.00
Road Demolition	11,000	sy	$6.40	$70,400.00
Pavement	1,700	lf	$144.00	$244,800.00
Culvert Demolition	275	lf	$31.00	$8,525.00
24" Rock Riprap	3,000	cy	$120.00	$ 360,000
Filter Fabric	4,500	sy	$2.40	$ 16,000
Bridge Abutments	4	ea	$53,000.00	$212,000.00
Bridge	300	lf	$12,346.00	$3,703,800.00
			Construction Cost	$5,315,525.00
			Construction Cost	$5,316,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$1,170,000.00
			Total Project	**$6,486,000.00**

Great Southwest Parkway at Cottonwood Creek				
350 ac-ft Detention Pond				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Land	50	ac	$22,000.00	$1,100,000.00
Clearing	10	ac	$5,000.00	$50,000.00
Tree Planting	10	ac	$1,000.00	$10,000.00
Excavation & Embankment	285,000	cy	$10.00	$2,850,000.00
Topsoil	7,000	sy	$2.40	$16,800.00
Seed & Fertilize	10	ac	$2,000.00	$20,000.00
			Construction Cost	$4,046,800.00
			Construction Cost	$4,047,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$890,000.00
			Total Project	**$4,937,000.00**

Marshall Drive at South Fork Cottonwood				
Raise the roadway 1', 10-10x10 MBC				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Excavation & Embankment	1,800	cy	$10.00	$18,000.00
Pavement	250	lf	$144.00	$36,000.00
Road Demolition	700	sy	$6.40	$4,480.00
Culvert Demolition	200	lf	$31.00	$6,200.00
10x10 Box Culvert	720	lf	$650.00	$468,000.00
Headwall	2	ea	$25,000.00	$50,000.00
Riprap	700	cy	$120.00	$84,000.00
			Construction Cost	$666,680.00
			Construction Cost	$667,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$147,000.00
			Total Project	**$814,000.00**

Robinson Road at South Fork Cottonwood				
10-10x10 MBC, 100' flat bottom channel				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Pavement	120	lf	$114.00	$13,680.00
Road Demolition	600	sy	$6.40	$3,840.00
Culvert Demolition	120	lf	$31.00	$3,720.00
10x10 Box Culvert	610	lf	$650.00	$396,500.00
Headwall	2	ea	$25,000.00	$50,000.00
Riprap	700	cy	$120.00	$84,000.00
Excavation & Embankment	16,000	cy	$10.00	$160,000.00
Hauling	14,000	cy	$3.00	$42,000.00
			Construction Cost	$753,740.00
			Construction Cost	$754,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$166,000.00
			Total Project	**$920,000.00**

Pioneer Parkway at South Fork Cottonwood				
1-10x10 RCB				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Pavement	120	lf	$114.00	$13,680.00
Road Demolition	700	sy	$6.40	$4,480.00
Culvert Demolition	200	lf	$31.00	$6,200.00
10x10 Box Culvert	200	lf	$650.00	$130,000.00
Headwall	2	ea	$10,000.00	$20,000.00
Riprap	70	cy	$120.00	$8,400.00
Channel Excavation	200	cy	$10.00	$2,000.00
Hauling	200	cy	$3.00	$600.00
			Construction Cost	$185,360.00
			Construction Cost	$185,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$41,000.00
			Total Project	**$226,000.00**

Great Southwest Parkway at South Fork Cottonwood				
4-10x10 MBC				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Pavement	160	lf	$114.00	$18,240.00
Road Demolition	800	sy	$6.40	$5,120.00
Culvert Demolition	200	lf	$31.00	$6,200.00
10x10 Box Culvert	312	lf	$650.00	$202,800.00
Headwall	2	ea	$12,000.00	$24,000.00
Riprap	70	cy	$120.00	$8,400.00
Channel Excavation	200	cy	$10.00	$2,000.00
Hauling	200	cy	$3.00	$600.00
			Construction Cost	$267,360.00
			Construction Cost	$267,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$59,000.00
			Total Project	**$326,000.00**

Beltline at Plattner				
1-6x6 MBC				
Description	**Quantity**	**Units**	**Unit Price**	**Cost**
Pavement	175	lf	$200.00	$35,000.00
Road Demolition	850	sy	$6.40	$5,440.00
6x6 Box Culvert	144	lf	$510.00	$73,440.00
Headwall Demolition	1	ls	$6,000.00	$6,000.00
Headwall	2	ea	$10,000.00	$20,000.00
Riprap	70	cy	$120.00	$8,400.00
Channel Excavation	200	cy	$10.00	$2,000.00
Hauling	200	cy	$3.00	$600.00
			Construction Cost	$113,880.00
			Construction Cost	$114,000.00
Non-Construction Cost – Engineering, Survey, Geotechnical, Legal, etc. (22%)				$25,000.00
			Total Project	**$139,000.00**

B. Stream Bank Stability

Table XII-2 Summary of Stream Stability Improvements

Location	Probable Cost
Cottonwood Creek Main Stem	$ 259,720
North Fork Cottonwood Creek	$ 160,850
South Fork Cottonwood Creek	$ 560,575
Plattner Creek	$ 191,940
Warrior Creek	$ 380,895

COTTONWOOD CREEK MAIN STEM PROBABLE COST

Item Description	Qty	Unit	Unit Cost	Amount
Site Preparation	1,456	STA	$50.00	$ 72,800
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	5	EA	$5,000.00	$ 25,000
Unclassified Channel Excavation	533	CY	$10.40	$ 5,545
Grouted Riprap (24" thick)	67	CY	$150.00	$ 10,050
Loose Riprap (D50 = 12", 24" thick)	519	CY	$120.00	$ 62,280
Approximate 25% Contingency				$45,170
			SUBTOTAL	**$225,845**
Engineering and Surveying (15%)				$33,875
			TOTAL ESTIMATED COST	**$259,720**

Construction Subtotal	$ 180,675
Approximate Contingency (25%)	$ 45,170
Construction Total	$ 225,845
Approximate Engineering and Survey (15%)	$ 33,875
Total	**$ 259,720**

NORTH FORK COTTONWOOD CREEK PROBABLE COST

Item Description	Qty	Unit	Unit Cost	Amount
Site Preparation	430	STA	$50.00	$ 21,500
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	4	EA	$5,000.00	$ 20,000
Unclassified Channel Excavation	533	CY	$10.40	$ 5,545
Grouted Riprap (24" thick)	67	CY	$150.00	$ 10,050
Loose Riprap (D50 = 12", 24" thick)	415	CY	$120.00	$ 49,800
Approximate 25% Contingency				$ 27,975
			SUBTOTAL	**$ 139,870**
Engineering and Surveying (15%)				$ 20,980
			TOTAL ESTIMATED COST	**$ 160,850**

Construction Subtotal	$111,895
Approximate Contingency (25%)	$ 27,975
Construction Total	$139,870
Approximate Engineering and Survey (15%)	$ 20,980
Total	**$160,850**

SOUTH FORK COTTONWOOD CREEK PROBABLE COST

Item Description	Qty	Unit	Unit Cost	Amount
Site Preparation	644	STA	$50.00	$ 32,200
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	17	EA	$5,000.00	$ 85,000
Unclassified Channel Excavation	2,785	CY	$10.40	$ 28,965
Grouted Riprap (24" thick)	348	CY	$150.00	$ 52,200
Loose Riprap (D50 = 12", 24" thick)	1,555	CY	$120.00	$ 186,600
Approximate 25% Contingency				$ 97,490
			SUBTOTAL	**$ 487,455**
Engineering and Surveying (15%)				$ 73,120
			TOTAL ESTIMATED COST	**$ 560,575**

Construction Subtotal	$ 389,965
Approximate Contingency (25%)	$ 97,490
Construction Total	$ 487,455
Approximate Engineering and Survey (15%)	$ 73,120
Total	**$ 560,575**

PLATTNER CREEK PROBABLE COST

Item Description	Qty	Unit	Unit Cost	Amount
Site Preparation	613	STA	$50.00	$ 30,650
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	4	EA	$5,000.00	$ 20,000
Unclassified Channel Excavation	533	CY	$10.40	$ 5,545
Grouted Riprap (24" thick)	67	CY	$150.00	$ 10,050
Loose Riprap (D50 = 12", 24" thick)	519	CY	$120.00	$ 62,280
Approximate 25% Contingency				$ 33,380
			SUBTOTAL	**$ 166,905**
Engineering and Surveying (15%)				$ 25,035
			TOTAL ESTIMATED COST	**$ 191,940**

Construction Subtotal	$ 133,525
Approximate Contingency (25%)	$ 33,380
Construction Total	$ 166,905
Approximate Engineering and Survey (15%)	$ 25,035
Total	**$ 191,940**

WARRIOR CREEK PROBABLE COST

Item Description	Qty	Unit	Unit Cost	Amount
Site Preparation	1,108	STA	$50.00	$ 55,400
Joint Stormwater Pollution Prevention Plan	1	LS	$5,000.00	$ 5,000
Construction Entrance	6	EA	$5,000.00	$ 30,000
Unclassified Channel Excavation	1,719	CY	$10.40	$ 17,880
Grouted Riprap (24" thick)	215	CY	$150.00	$ 32,250
Loose Riprap (D50 = 12", 24" thick)	1,037	CY	$120.00	$ 124,440
Approximate 25% Contingency				$ 66,245
			SUBTOTAL	**$ 331,215**
Engineering and Surveying (15%)				$ 49,680
			TOTAL ESTIMATED COST	**$ 380,895**

Construction Subtotal	$ 264,970
Approximate Contingency (25%)	$ 66,245
Construction Total	$ 331,215
Approximate Engineering and Survey (15%)	$ 49,680
Total	**$ 380,895**

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.

Sub-Step 1 – Determine Existing Roadway Type

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* Roadway Capacity LOS E	LOS D	LOS C	Current UDC "LOS C" Traffic Volume
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
≥ $ 600,000	15

Total Tax Value of Properties with Structures Benefitted	Third Ranking Factor
≥ $ 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, Phase 1 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

Cottonwood Creek

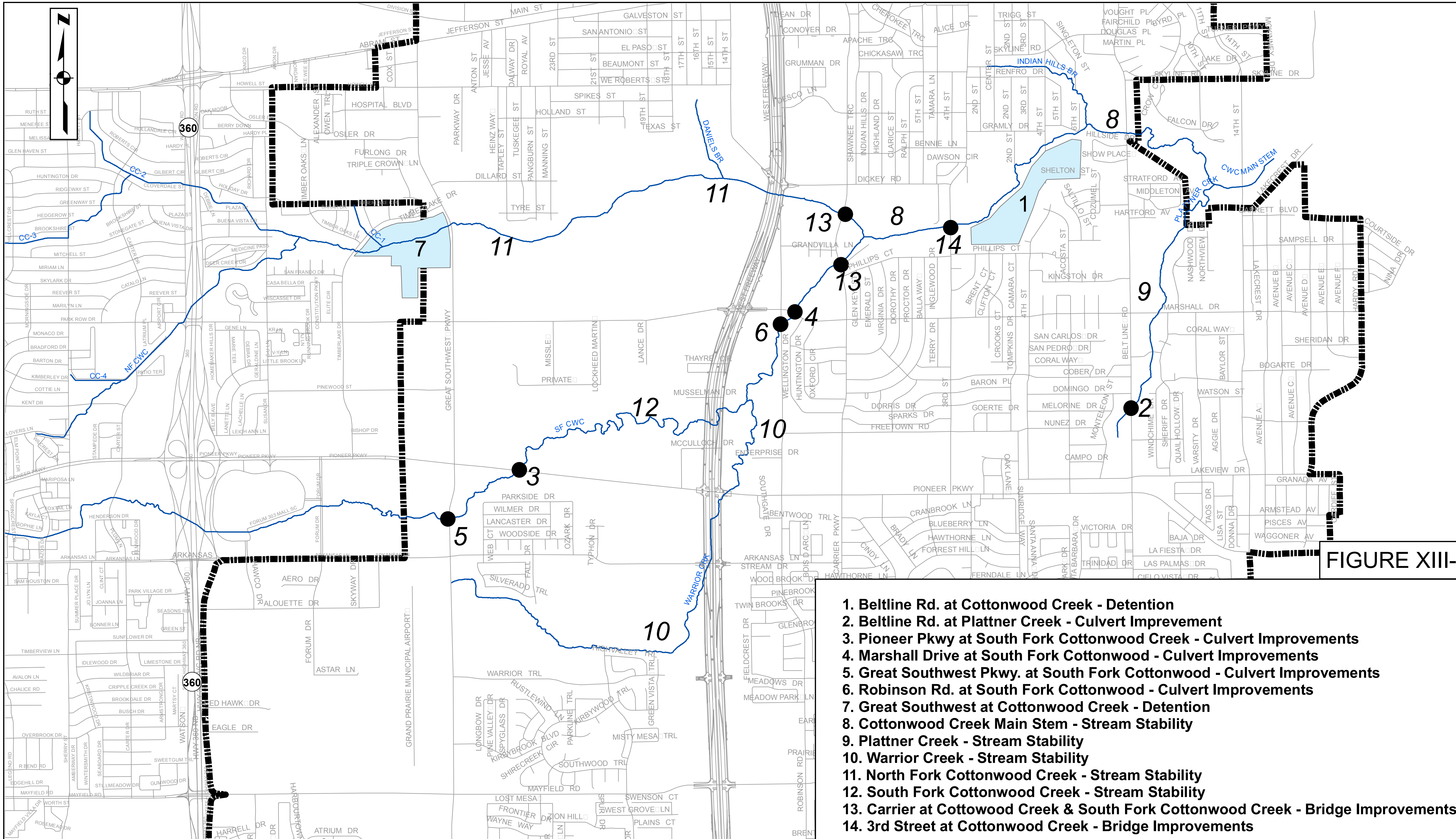
	Capital Improvement Project Alternative	Project Size & Short-Term/Long-Term	Step 1 - Initial Ranking Factor - Estimate of Probable Cost vs. # Structures Benefited [1]			Step 2 - Second Ranking Factor - Cost to Benefit of Roadway Number of Citizens Impacted [2]							Step 3 - Tax Value of Benefited Property 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	Belt Line Road at Cottonwood Creek	Large/Long-Term	12	$4,719,000	3	P6D	5	35%	65%	7605	$620.51	6	$2,250,000	1	10	1	19,398		1
2	Belt Line Road at Plattner Creek	Small/Short-Term	0	$139,000	3	P6D	25	70%	30%	3510	$39.60	1	$0	20	24	2	1,981		2
3	Pioneer Parkway at SF Cottonwood	Small/Short-Term	0	$226,000	3	P6D	25	70%	30%	3510	$64.39	2	$0	20	25	3	3,987		3
4	Marshall Drive at SF Cottonwood	Medium/Long-Term	0	$814,000	4	M4U	2	15%	85%	5746	$141.66	3	$0	20	27	4	6,277	4	4
5	GSW Pkwy at SF Cottonwood	Small/Short-Term	0	$326,000	3	P4D	25	70%	30%	2340	$139.32	4	$0	20	27	4	4,010	5	5
6	Robinson Road at SF Cottonwood	Medium/Long-Term	0	$920,000	4	M4U	2	15%	85%	5746	$160.11	5	$0	20	29	6	6,197		6
11	North Fork Cottonwood Stream Stability	Small/Short-Term	0	$160,850	4	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	34	11	12,583	11	11
8	Cottonwood Creek Main Stem Stream Stability	Small/Short-Term	0	$259,720	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	19,398	8	8
7	GSW Pkwy at Cottonwood	Large/Long-Term	0	$4,937,000	5	P4D	2	15%	85%	6630	$744.65	7	$0	20	32	7	8,888		7
9	Plattner Creek Stream Stability	Small/Short-Term	0	$191,940	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	3,608	9	9
10	Warrior Creek Stream Stability	Small/Short-Term	0	$380,895	3	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	33	8	1,466	10	10
13	Carrier at SF Cottonwood/Cottonwood	X-Large/Long-Term	0	$6,486,000	8	M5U	2	15%	85%	7182.5	$903.03	8	$0	20	36	13	18,386		13
14	3rd Street at Cottonwood	X-Large/Long-Term	0	$8,469,000	8	C2U	2	15%	85%	2320.5	$3,649.64	9	$0	20	37	14	18,630		14
12	South Fork Cottonwood Stream Stability	Medium/Long-Term	0	$560,575	4	N/A	N/A	N/A	N/A	N/A	N/A	10	$0	20	34	11	6,047	12	12

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



1. Beltline Rd. at Cottonwood Creek - Detention
2. Beltline Rd. at Plattner Creek - Culvert Imprevement
3. Pioneer Pkwy at South Fork Cottonwood Creek - Culvert Improvements
4. Marshall Drive at South Fork Cottonwood - Culvert Improvements
5. Great Southwest Pkwy. at South Fork Cottonwood - Culvert Improvements
6. Robinson Rd. at South Fork Cottonwood - Culvert Improvements
7. Great Southwest at Cottonwood Creek - Detention
8. Cottonwood Creek Main Stem - Stream Stability
9. Plattner Creek - Stream Stability
10. Warrior Creek - Stream Stability
11. North Fork Cottonwood Creek - Stream Stability
12. South Fork Cottonwood Creek - Stream Stability
13. Carrier at Cottowood Creek & South Fork Cottonwood Creek - Bridge Improvements
14. 3rd Street at Cottonwood Creek - Bridge Improvements

Grand Prairie TEXAS

RPS Espey

CAPITAL IMPROVEMENT PROJECTS
COTTONWOOD 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 Cottonwood Creek 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 are seven short-term projects in the Cottonwood Creek Basin. Three of these are culvert modification projects: Beltline Road at Plattner Creek, Pioneer Parkway at South Fork of Cottonwood Creek and Great Southwest Parkway at South Fork of Cottonwood, and four are stream stability projects: Upper Cottonwood Creek, Lower Cottonwood Creek, Plattner Creek and Warrior Creek. The majority of the culvert modification projects' construction should occur within existing street Right-of-Way, minimizing the requirements for obtaining easements. The Beltline Road and Pioneer Parkway Projects involve TxDOT roadways and will require TxDOT's participation. These projects 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. Construction access will have a significant bearing on the stream stabilization projects, and permanent easements will be required at all locations where the City does not have drainage easements or property ownership. These stream stabilization projects 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.

B. Long-Term Plan Implementation

The remaining seven projects are classified as long-term projects, requiring longer lead times to allow the City to develop funding alternatives for these projects.

One of these is the South Fork Cottonwood Creek Stream Stability; the construction access and permitting requirements discussed above will also apply to this project.

There are two storage type projects, Beltline Road at Cottonwood Creek and Great Southwest Parkway at Cottonwood Creek. These projects are off-channel detention ponds. The excavation of the ponds themselves should not require Corps permitting; however, the inlet and outlet structures will. It is anticipated that these will qualify for a nationwide permit. The minimum requirements for these projects would be a wetlands delineation and pre-construction conference with the Corps. The City would have to purchase the property for the pond sites as well as an access route for construction and maintenance.

The remaining projects are large culvert improvements or bridge lengthening projects. The majority of the construction should occur within existing street Right-of-Way, minimizing the requirements for obtaining easements; and as with the culverts discussed in the short-term implementation, they are expected to qualify for a Nationwide Corps of Engineer Permit.

XV. MASTER PLAN STUDY WRAP-UP AND RECOMMENDATIONS

The fundamental objective of this Cottonwood Creek Drainage Master Planning effort was to comprehensively integrate and update the various hydrologic and hydrologic models that have been developed for the Cottonwood 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 Cottonwood Creek watershed.

A. Streams and Open Channels

There are nine stream improvement projects, of these only one project serves to mitigate flooding of homes or businesses. The remaining eight projects are designed to mitigate roadway flooding at bridges and culverts. These projects should be included in the evaluation future Capital Improvement Projects for the City.

B. Stream Bank Stability

Cottonwood Creek Main Stem varied from severely to moderately unstable with a section classified as slightly unstable, and five project areas have been identified along this reach of Cottonwood Creek. Cottonwood Creek, upstream of the confluence with the South Fork Cottonwood Creek, was generally considered slightly unstable with some sections of severe instability; five project areas have also been identified along this reach. South Fork Cottonwood Creek varied from severely to slightly unstable; fourteen project areas have been determined along this reach. In general, the majority of Warrior Creek was slightly unstable with a few moderately to severely unstable areas; six project areas have been identified for this creek. Four project areas have been identified for Plattner Creek, which is generally classified as slightly unstable with localized bank scour. The projects in the severely unstable reaches of the creek should be given higher priorities as the stream will continue to degrade until they have been stabilized.

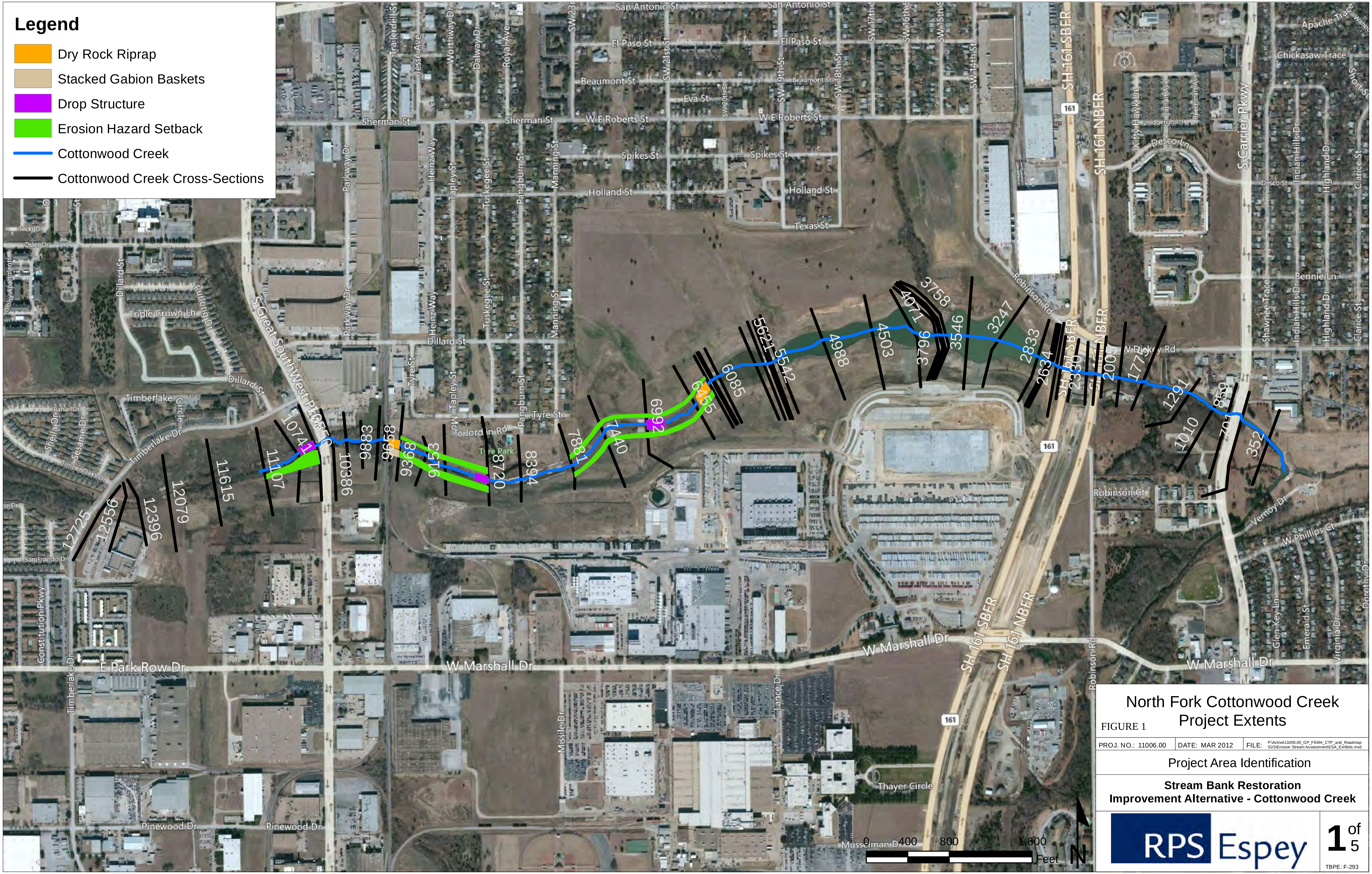
C. Maintenance

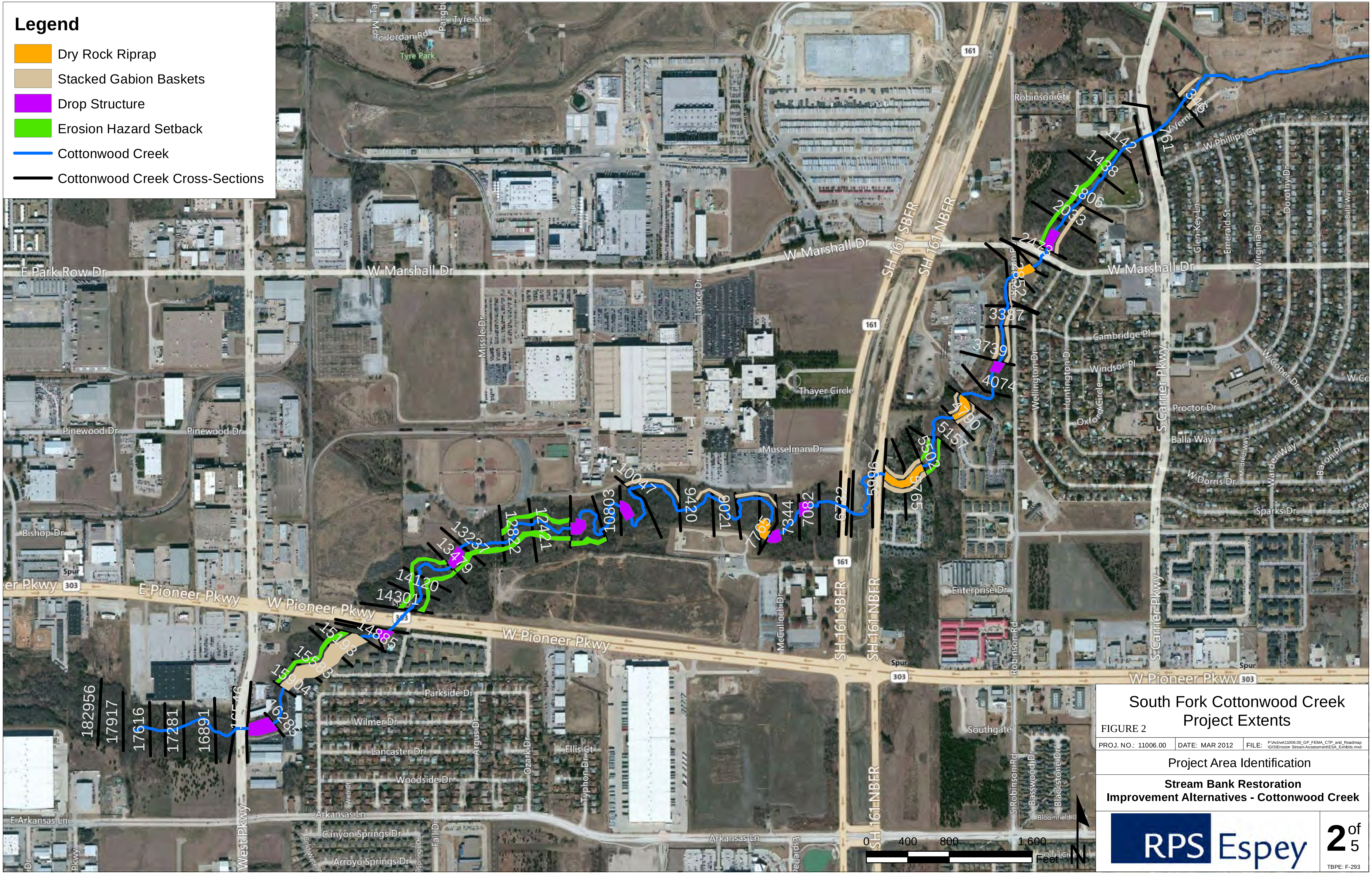
The storm drain outfalls and detention ponds rated as poor or worse should be scheduled for maintenance as soon as budget allows. Maintenance is an ongoing task, and it is recommended that the City establish a program of regular inspection of storm drain outlets, bridge abutment and piers, culverts, 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 discuss in **Section VIII**, there are several stormwater infrastructure modeling projects currently in progress for this basin. The results of these analyses should be included in this report as they become available.

Appendix A
Figures


Legend
Dry Rock Riprap
Stacked Gabion Baskets
Drop Structure
Erosion Hazard Setback
Cottonwood Creek
Cottonwood Creek Cross-Sections
North Fork Cottonwood Creek
Project Extents
FIGURE 1
PROJ. NO.: 11006.00
DATE: MAR 2012
Project Area Identification
Stream Bank Restoration
Improvement Alternative - Cottonwood Creek
RPS Espey
1 of 5
TBPE: F-293
0 400 800 1,600
Feet
N
W Marshall Dr
E Park Row Dr
S Great Southwest Pkwy
SH 161 SBFR
SH 161 NBFR
S Carrier Pkwy
W Dickey Rd
Robinson Rd
Timberlake Dr
Tyre Park



South Fork Cottonwood Creek
Project Extents

FIGURE 2

PROJ. NO.: 11006.00 | DATE: MAR 2012 | FILE: P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\GIS\Erosion Stream Assessment\ESA_Exhibits.mxd

Project Area Identification

Stream Bank Restoration
Improvement Alternatives - Cottonwood Creek

RPS Espey

2 of 5

TBPE: F-293

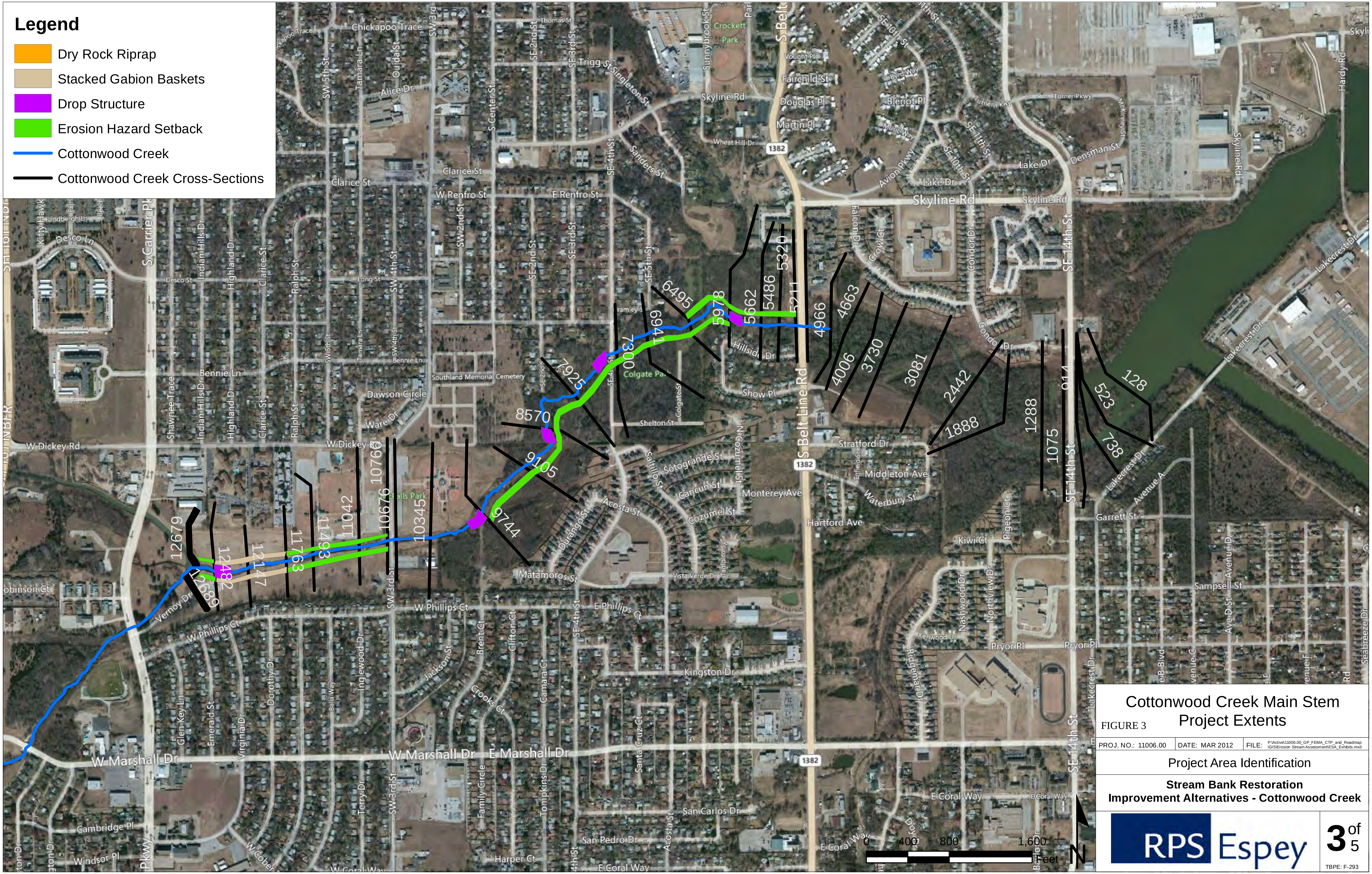


FIGURE 3

Cottonwood Creek Main Stem Project Extents

PROJ. NO.: 11006.00 | DATE: MAR 2012 | FILE:

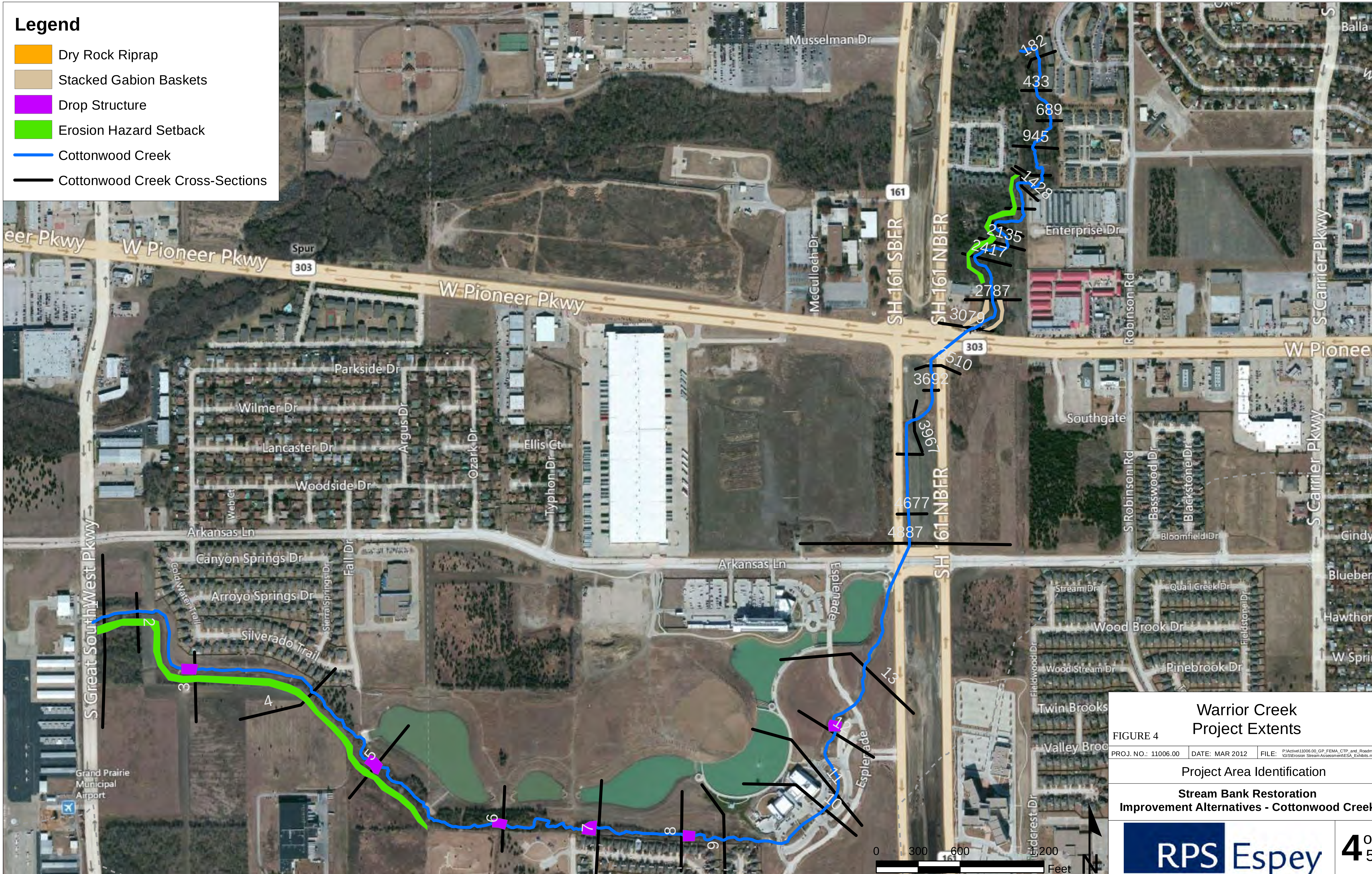
Project Area Identification

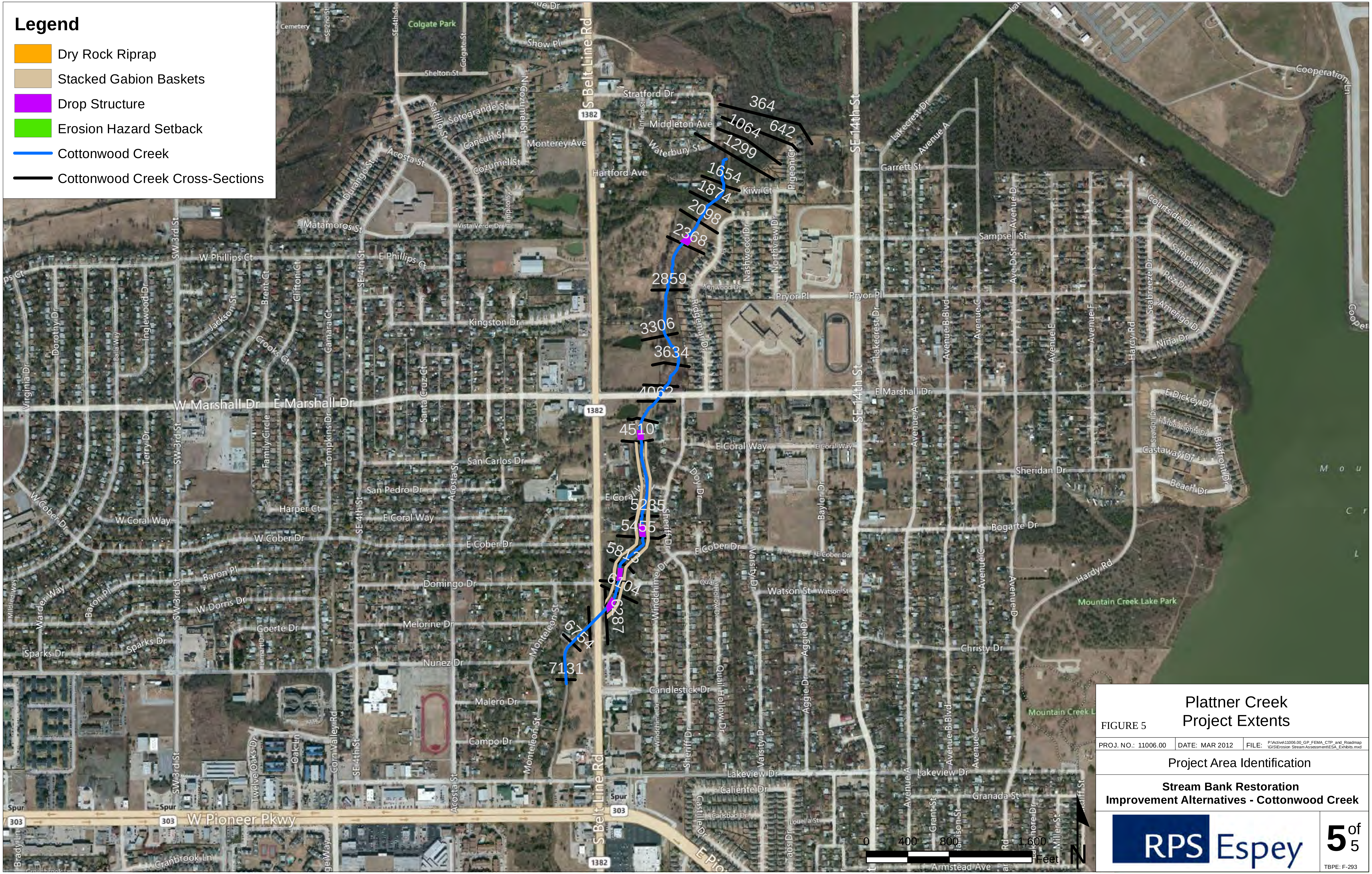
Stream Bank Restoration
Improvement Alternatives - Cottonwood Creek

RPS Espey

3 of 5

TBPE: F-293


Legend
Dry Rock Riprap
Stacked Gabion Baskets
Drop Structure
Erosion Hazard Setback
Cottonwood Creek
Cottonwood Creek Cross-Sections
Musselman Dr
W Pioneer Pkwy
Spur 303
161
SH 161 SBFR
SH 161 NBFR
McCulloch Dr
Enterprise Dr
Robinson Rd
S Carrier Pkwy
Balla W
Parkside Dr
Wilmer Dr
Lancaster Dr
Woodside Dr
Argus Dr
Ozark Dr
Ellis Ct
Typhon Dr
Arkansas Ln
Canyon Springs Dr
Arroyo Springs Dr
Silverado Trail
Fall Dr
S Great Southwest Pkwy
Grand Prairie Municipal Airport
Southgate
Basswood Dr
Blackstone Dr
Bloomfield Dr
Cindy L
Blueberry
Stream Dr
Quail Creek Dr
Wood Brook Dr
Wood Stream Dr
Pinebrook Dr
Hawthorne
W Spring
Twin Brooks
Valley Broo
Esplenade
182
433
689
945
1428
2135
2417
2787
3070
3510
3692
3961
4677
4887
0 300 600 1,200 Feet
N
Warrior Creek
Project Extents
FIGURE 4
PROJ. NO.: 11006.00
DATE: MAR 2012
FILE: P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap \GIS\Erosion Stream Assessment\ESA_Exhibits.mxd
Project Area Identification
Stream Bank Restoration
Improvement Alternatives - Cottonwood Creek
RPS Espey
4 of 5
TBPE: F-293


Legend
Dry Rock Riprap
Stacked Gabion Baskets
Drop Structure
Erosion Hazard Setback
Cottonwood Creek
Cottonwood Creek Cross-Sections
364
642
1064
1299
1654
1874
2098
2368
2859
3306
3634
4062
4510
5235
5455
5843
6104
6287
6754
7131
S. Belt Line Rd
SE 14th St
W Marshall Dr
E Marshall Dr
W Pioneer Pkwy
Mountain Creek Lake Park
0 400 800 1,600 Feet
N
FIGURE 5
Plattner Creek
Project Extents
PROJ. NO.: 11006.00
DATE: MAR 2012
FILE:
Project Area Identification
Stream Bank Restoration
Improvement Alternatives - Cottonwood Creek
RPS Espey
5 of 5
TBPE: F-293

Appendix B
Tables

EXISTING CONDITIONS

TR-55 Method of Computing the Time of Concentration

	variable	units	AB_01	BB_01	CWC_01	CWC_02	CWC_03	CWC_04	CWC_04A	CWC_05
Sheet Flow										
Manning's roughness coef.	n	n/a	0.240	0.013	0.013	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	50	20	60	60	60	60	20	50
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0020	0.0050	0.0050	0.0382	0.0189	0.0100	0.0129	0.0100
Travel time	Tt	hours	0.333	0.011	0.026	0.118	0.157	0.202	0.076	0.175
Shallow Concentrated Flow		min.	20.0	0.6	1.6	7.1	9.4	12.1	4.5	10.5
Flow Length	L	feet	665	1,820	1,450	140	390	1,105	145	670
Slope	s	ft/ft	0.007	0.010	0.018	0.027	0.074	0.005	0.012	0.005
Surface (1=paved or 2=unpaved)		n/a	2	1	2	2	2	1	1	1
Velocity	V	ft/sec	1.36	2.06	2.16	2.69	4.41	1.42	2.23	1.46
Travel time	Tt	hours	0.136	0.246	0.186	0.014	0.025	0.216	0.018	0.128
Manning's Equation		min.	8.2	14.7	11.2	0.9	1.5	13.0	1.1	7.7
1 Flow Length	L	feet	2,520	2,230	830	1,250	4,560	1,375	1,495	1,848
Slope	S	ft/ft	0.0135	0.0110	0.0156	0.0232	0.0029	0.0240	0.0123	0.0029
roughness	n	n/a	0.04	0.04	0.05	0.013	0.06	0.04	0.013	0.04
Open Channel										
Bottom Width	BW	feet	20	10	3	0	25	3	0	2
Side Slopes (H:1)	H	feet	20	15	5	0	15	5	0	3
Depth	d	feet	1.5	3	2	0	4.5	1.5	0	1.5
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	2.00	0.00	0.00	2.50	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	75.00	165.00	26.00	3.14	416.25	15.75	4.91	9.75
Flow Rate	Q	cfs	310.78	898.22	103.67	34.51	1059.16	82.24	45.66	17.57
Velocity	V	ft/sec	4.14	5.44	3.99	10.99	2.54	5.22	9.30	1.80
Travel time	Tt	hours	0.169	0.114	0.058	0.032	0.498	0.073	0.045	0.285
2 Flow Length	L	feet	753	1,420	640	2,854	-	801	587	1,579
Slope	S	ft/ft	0.0125	0.0094	0.0064	0.0011	0.0000	0.0041	0.0088	0.0177
roughness	n	n/a	0.05	0.013	0.06	0.06	0	0.05	0.013	0.013
Open Channel										
Bottom Width	BW	feet	25	0	100	100	0	25	0	0
Side Slopes (H:1)	H	feet	12	0	25	25	0	15	0	0
Depth	d	feet	2	0	2	2.5	0	1.5	0	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	3.50	0.00	0.00	0.00	0.00	5.00	4.50
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	98.00	9.62	300.00	406.25	0.00	71.25	19.63	15.90
Flow Rate	Q	cfs	395.97	98.02	782.49	503.24	0.00	136.71	245.41	238.56
Velocity	V	ft/sec	4.04	10.19	2.61	1.24	0.00	1.92	12.50	15.00
Travel time	Tt	hours	0.052	0.039	0.068	0.640	-	0.116	0.013	0.029
3 Flow Length	L	feet	-	1,953	-	-	-	-	464	866
Slope	S	ft/ft	0.0000	0.0131	0.0000	0.0000	0.0000	0.0000	0.0176	0.0126
roughness	n	n/a	0	0.05	0	0	0	0	0.013	0.06
Open Channel										
Bottom Width	BW	feet	0	25	0	0	0	0	0	20
Side Slopes (H:1)	H	feet	0	5	0	0	0	0	0	15
Depth	d	feet	0	3.5	0	0	0	0	0	4
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	6.33	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	148.75	0.00	0.00	0.00	0.00	31.50	320.00
Flow Rate	Q	cfs	0.00	923.14	0.00	0.00	0.00	0.00	472.55	1545.64
Velocity	V	ft/sec	0.00	6.21	0.00	0.00	0.00	0.00	15.00	4.83
Travel time	Tt	hours	-	0.087	-	-	-	-	0.009	0.050
Total Travel Time	TC	hours	0.690	0.496	0.338	0.804	0.679	0.608	0.160	0.667
	TC	min.	41.4	29.8	20.3	48.3	40.8	36.5	9.6	40.0
Lag Time	TL	hours	0.4139	0.2978	0.2029	0.4827	0.4076	0.3646	0.0961	0.4000
	TL	min.	24.8	17.9	12.2	29.0	24.5	21.9	5.8	24.0

EXISTING CONDITIONS

TR-55 Method of Computing the Time of Concentration

			CWC_06	CWC_07	CWC_08	CWC_09	CWC_10	CWC_11	CWC_12	CWC_13
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.013	0.240	0.013	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	20	60	50	20	20	60	50	60
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0050	0.0412	0.0050	0.0103	0.0090	0.0054	0.0100	0.0100
Travel time	Tt	hours	0.011	0.115	0.022	0.083	0.088	0.258	0.175	0.202
Shallow Concentrated Flow		min.	0.6	6.9	1.3	5.0	5.3	15.5	10.5	12.1
Flow Length	L	feet	620	600	320	1,557	390	1,676	1,110	1,100
Slope	s	ft/ft	0.016	0.048	0.016	0.015	0.006	0.030	0.006	0.025
Surface (1=paved or 2=unpaved)		n/a	1	2	1	1	2	2	1	2
Velocity	V	ft/sec	2.59	3.56	2.63	2.53	1.21	2.79	1.61	2.58
Travel time	Tt	hours	0.066	0.047	0.034	0.171	0.090	0.167	0.192	0.118
Manning's Equation		min.	4.0	2.8	2.0	10.2	5.4	10.0	11.5	7.1
1 Flow Length	L	feet	1,583	740	2,590	2,890	3,955	1,537	4,880	1,350
Slope	S	ft/ft	0.0061	0.0392	0.0232	0.0201	0.0047	0.0054	0.0137	0.0242
roughness	n	n/a	0.013	0.06	0.04	0.013	0.04	0.05	0.04	0.04
Open Channel										
Bottom Width	BW	feet	0	6	3	0	3	35	3	3
Side Slopes (H:1)	H	feet	0	5	5	0	5	10	5	5
Depth	d	feet	0	3	3	0	1.5	2.5	3	2
...or Closed Conduit										
Rise / Diameter	R / D	feet	3.00	0.00	0.00	2.75	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	63.00	54.00	5.94	15.75	150.00	54.00	26.00
Flow Rate	Q	cfs	52.05	445.02	420.38	75.12	36.23	480.94	322.50	161.59
Velocity	V	ft/sec	7.36	7.06	7.78	12.65	2.30	3.21	5.97	6.22
Travel time	Tt	hours	0.060	0.029	0.092	0.063	0.478	0.133	0.227	0.060
2 Flow Length	L	feet	894	1,100	4,528	555	1,995	-	643	466
Slope	S	ft/ft	0.0023	0.0209	0.0042	0.0039	0.0113	0.0000	0.0238	0.0165
roughness	n	n/a	0.013	0.06	0.06	0.05	0.013	0	0.05	0.04
Open Channel										
Bottom Width	BW	feet	0	6	35	25	0	0	35	5
Side Slopes (H:1)	H	feet	0	5	15	10	0	0	10	5
Depth	d	feet	0	4	4.5	4.25	0	0	2.5	2
...or Closed Conduit										
Rise / Diameter	R / D	feet	4.00	0.00	0.00	0.00	3.50	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	12.57	104.00	461.25	286.88	9.62	0.00	150.00	30.00
Flow Rate	Q	cfs	69.09	636.54	1438.77	1007.49	107.41	0.00	1005.45	160.64
Velocity	V	ft/sec	5.50	6.12	3.12	3.51	11.16	0.00	6.70	5.35
Travel time	Tt	hours	0.045	0.050	0.403	0.044	0.050	-	0.027	0.024
3 Flow Length	L	feet	3,169	1,007	-	-	2,889	-	-	235
Slope	S	ft/ft	0.0110	0.0157	0.0000	0.0000	0.0181	0.0000	0.0000	0.0190
roughness	n	n/a	0.013	0.06	0	0	0.013	0	0	0.05
Open Channel										
Bottom Width	BW	feet	0	6	0	0	0	0	0	35
Side Slopes (H:1)	H	feet	0	6	0	0	0	0	0	15
Depth	d	feet	0	4	0	0	0	0	0	2
...or Closed Conduit										
Rise / Diameter	R / D	feet	7.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	38.48	120.00	0.00	0.00	19.63	0.00	0.00	130.00
Flow Rate	Q	cfs	577.27	630.55	0.00	0.00	294.52	0.00	0.00	656.95
Velocity	V	ft/sec	15.00	5.25	0.00	0.00	15.00	0.00	0.00	5.05
Travel time	Tt	hours	0.059	0.053	-	-	0.053	-	-	0.013
Total Travel Time	TC	hours	0.241	0.294	0.552	0.361	0.758	0.558	0.621	0.418
	TC	min.	14.4	17.6	33.1	21.7	45.5	33.5	37.2	25.1
Lag Time	TL	hours	0.1444	0.1763	0.3311	0.2166	0.4548	0.3348	0.3723	0.2509
	TL	min.	8.7	10.6	19.9	13.0	27.3	20.1	22.3	15.1

EXISTING CONDITIONS

TR-55 Method of Computing the Time of Concentration

	variable	units	CWC_14	CWC_15	CWC_16	CWC_17	CWC_18	CWC_19	CWC_20	DB_01
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.240	0.013	0.240	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	20	20	20	20	50	50	20	60
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0181	0.0050	0.0210	0.0150	0.0100	0.0231	0.0038	0.0035
Travel time	Tt	hours	0.066	0.011	0.062	0.071	0.175	0.125	0.123	0.308
Shallow Concentrated Flow		min.	4.0	0.6	3.7	4.3	10.5	7.5	7.4	18.5
Flow Length	L	feet	1,061	1,168	1,098	1,480	1,430	161	780	1,427
Slope	s	ft/ft	0.039	0.028	0.018	0.015	0.005	0.023	0.011	0.028
Surface (1=paved or 2=unpaved)		n/a	1	2	2	2	1	1	1	2
Velocity	V	ft/sec	4.07	2.71	2.15	2.01	1.46	3.13	2.21	2.72
Travel time	Tt	hours	0.072	0.120	0.142	0.205	0.273	0.014	0.098	0.146
Manning's Equation		min.	4.3	7.2	8.5	12.3	16.4	0.9	5.9	8.7
1 Flow Length	L	feet	1,160	1,066	2,070	2,184	3,300	2,500	2,138	1,695
Slope	S	ft/ft	0.0179	0.0184	0.0206	0.0096	0.0102	0.0120	0.0190	0.0106
roughness	n	n/a	0.06	0.05	0.04	0.05	0.04	0.04	0.04	0.05
Open Channel										
Bottom Width	BW	feet	30	30	2	10	10	2	2	30
Side Slopes (H:1)	H	feet	10	10	3	15	15	5	3	15
Depth	d	feet	1.5	1.5	1.5	3.75	3	3	1.5	2
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	67.50	67.50	9.75	248.44	165.00	51.00	9.75	120.00
Flow Rate	Q	cfs	242.17	294.80	46.69	1161.27	865.41	280.29	44.93	444.98
Velocity	V	ft/sec	3.59	4.37	4.79	4.67	5.24	5.50	4.61	3.71
Travel time	Tt	hours	0.090	0.068	0.120	0.130	0.175	0.126	0.129	0.127
2 Flow Length	L	feet	-	-	607	-	1,869	761	926	-
Slope	S	ft/ft	0.0000	0.0000	0.0060	0.0000	0.0108	0.0121	0.0130	0.0000
roughness	n	n/a	0	0	0.05	0	0.05	0.013	0.05	0
Open Channel										
Bottom Width	BW	feet	0	0	30	0	25	0	15	0
Side Slopes (H:1)	H	feet	0	0	5	0	10	0	15	0
Depth	d	feet	0	0	2.75	0	3.5	0	2.5	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	120.31	0.00	210.00	7.07	131.25	0.00
Flow Rate	Q	cfs	0.00	0.00	450.85	0.00	1102.32	73.62	572.10	0.00
Velocity	V	ft/sec	0.00	0.00	3.75	0.00	5.25	10.42	4.36	0.00
Travel time	Tt	hours	-	-	0.045	-	0.099	0.020	0.059	-
3 Flow Length	L	feet	-	-	-	-	-	-	-	-
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
roughness	n	n/a	0	0	0	0	0	0	0	0
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Rate	Q	cfs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Velocity	V	ft/sec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Travel time	Tt	hours	-	-	-	-	-	-	-	-
Total Travel Time	TC	hours	0.228	0.198	0.369	0.406	0.721	0.286	0.409	0.580
	TC	min.	13.7	11.9	22.2	24.4	43.3	17.2	24.6	34.8
Lag Time	TL	hours	0.1371	0.1189	0.2216	0.2436	0.4327	0.1716	0.2457	0.3480
	TL	min.	8.2	7.1	13.3	14.6	26.0	10.3	14.7	20.9

EXISTING CONDITIONS

TR-55 Method of Computing the Time of Concentration

			DB_02	DB_03	EB_01	GB_01	IHB_01	IHB_02	JB_01	JB_02
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	50	50	60	50	50	60	50	50
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0112	0.0060	0.0040	0.0068	0.0211	0.0017	0.0080	0.0017
Travel time	Tt	hours	0.167	0.215	0.292	0.204	0.130	0.412	0.191	0.354
Shallow Concentrated Flow		min.	10.0	12.9	17.5	12.3	7.8	24.7	11.5	21.2
Flow Length	L	feet	691	400	1,440	1,861	1,050	303	450	1,363
Slope	s	ft/ft	0.009	0.015	0.004	0.006	0.032	0.009	0.003	0.009
Surface (1=paved or 2=unpaved)		n/a	1	1	2	2	2	2	2	1
Velocity	V	ft/sec	1.92	2.51	1.04	1.24	2.92	1.56	0.89	1.94
Travel time	Tt	hours	0.100	0.044	0.386	0.418	0.100	0.054	0.141	0.195
Manning's Equation		min.	6.0	2.7	23.1	25.1	6.0	3.2	8.5	11.7
1 Flow Length	L	feet	2,068	1,882	3,402	851	682	1,507	732	2,613
Slope	S	ft/ft	0.0118	0.0165	0.0041	0.0277	0.0079	0.0062	0.0075	0.0034
roughness	n	n/a	0.013	0.013	0.013	0.04	0.04	0.013	0.05	0.04
Open Channel										
Bottom Width	BW	feet	0	0	0	130	20	0	30	3
Side Slopes (H:1)	H	feet	0	0	0	50	10	0	20	5
Depth	d	feet	0	0	0	1.5	5	0	1.5	1.5
...or Closed Conduit										
Rise / Diameter	R / D	feet	3.00	3.00	5.50	0.00	0.00	2.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	7.07	23.76	307.50	350.00	3.14	90.00	15.75
Flow Rate	Q	cfs	72.65	86.02	214.69	2029.92	2360.04	17.93	231.96	30.92
Velocity	V	ft/sec	10.28	12.17	9.04	6.60	6.74	5.71	2.58	1.96
Travel time	Tt	hours	0.056	0.043	0.105	0.036	0.028	0.073	0.079	0.370
2 Flow Length	L	feet	1,587	2,059	1,174	441	-	1,334	-	2,312
Slope	S	ft/ft	0.0130	0.0117	0.0102	0.0127	0.0000	0.0084	0.0000	0.0074
roughness	n	n/a	0.013	0.013	0.013	0.013	0.05	0.013	0	0.013
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	0
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	0
Depth	d	feet	0	0	0	0	0	0	0	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	5.00	5.00	6.50	2.00	0.00	4.50	0.00	4.50
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	19.63	19.63	33.18	3.14	0.00	15.90	0.00	15.90
Flow Rate	Q	cfs	294.52	281.91	497.75	25.58	0.00	180.20	0.00	169.80
Velocity	V	ft/sec	15.00	14.36	15.00	8.14	0.00	11.33	0.00	10.68
Travel time	Tt	hours	0.029	0.040	0.022	0.015	-	0.033	-	0.060
3 Flow Length	L	feet	483	349	-	546	-	1,404	-	1,443
Slope	S	ft/ft	0.0147	0.0156	0.0000	0.0054	0.0000	0.0103	0.0000	0.0130
roughness	n	n/a	0.04	0.05	0	0.05	0	0.013	0	0.013
Open Channel										
Bottom Width	BW	feet	20	20	0	35	0	0	0	3
Side Slopes (H:1)	H	feet	15	20	0	20	0	0	0	5
Depth	d	feet	2.5	3	0	2	0	0	0	3
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	143.75	240.00	0.00	150.00	0.00	23.76	0.00	54.00
Flow Rate	Q	cfs	856.12	1280.21	0.00	393.10	0.00	342.01	0.00	810.00
Velocity	V	ft/sec	5.96	5.33	0.00	2.62	0.00	14.40	0.00	15.00
Travel time	Tt	hours	0.023	0.018	-	0.058	-	0.027	-	0.027
Total Travel Time	TC	hours	0.375	0.360	0.804	0.731	0.258	0.599	0.411	1.005
	TC	min.	22.5	21.6	48.2	43.9	15.5	35.9	24.7	60.3
Lag Time	TL	hours	0.2250	0.2159	0.4823	0.4387	0.1547	0.3592	0.2466	0.6032
	TL	min.	13.5	13.0	28.9	26.3	9.3	21.6	14.8	36.2

EXISTING CONDITIONS										
TR-55 Method of Computing the Time of Concentration										
			PC_01	**PC_02**	**PC_03**	**PC_04**	**PC_05**	**RB_01**	**SCW_01**	**SCW_02**
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	100	50	50	50	50	20	20	60
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0007	0.0004	0.0029	0.0020	0.0026	0.0214	0.0091	0.0045
Travel time	Tt	hours	0.882	0.612	0.286	0.333	0.300	0.062	0.087	0.278
Shallow Concentrated Flow		min.	52.9	36.7	17.1	20.0	18.0	3.7	5.2	16.7
Flow Length	L	feet	257	1,210	396	376	822	300	1,222	874
Slope	s	ft/ft	0.008	0.001	0.009	0.002	0.014	0.016	0.050	0.035
Surface (1=paved or 2=unpaved)		n/a	2	1	1	2	1	2	1	2
Velocity	V	ft/sec	1.46	0.61	1.93	0.72	2.44	2.02	4.58	3.03
Travel time	Tt	hours	0.049	0.552	0.057	0.144	0.094	0.041	0.074	0.080
Manning's Equation		min.	2.9	33.1	3.4	8.6	5.6	2.5	4.4	4.8
1 Flow Length	L	feet	1,300	1,367	550	2,357	3,769	4,466	873	1,410
Slope	S	ft/ft	0.0278	0.0149	0.0522	0.0102	0.0021	0.0136	0.0054	0.0083
roughness	n	n/a	0.013	0.013	0.05	0.013	0.013	0.04	0.05	0.05
Open Channel										
Bottom Width	BW	feet	0	0	10	0	0	5	20	15
Side Slopes (H:1)	H	feet	0	0	10	0	0	8	25	5
Depth	d	feet	0	0	1.5	0	0	3.5	1.5	2.75
...or Closed Conduit										
Rise / Diameter	R / D	feet	3.50	2.25	0.00	3.00	3.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	9.62	3.98	37.50	7.07	7.07	115.50	86.25	79.06
Flow Rate	Q	cfs	144.32	37.91	244.00	67.44	30.45	763.98	176.47	321.14
Velocity	V	ft/sec	15.00	9.53	6.51	9.54	4.31	6.61	2.05	4.06
Travel time	Tt	hours	0.024	0.040	0.023	0.069	0.243	0.188	0.119	0.096
2 Flow Length	L	feet	420	2,468	531	717	2,087	-	-	-
Slope	S	ft/ft	0.0142	0.0097	0.0125	0.0076	0.0032	0.0000	0.0000	0.0000
roughness	n	n/a	0.04	0.05	0.05	0.05	0.013	0	0	0
Open Channel										
Bottom Width	BW	feet	10	20	15	10	0	0	0	0
Side Slopes (H:1)	H	feet	12	25	7	7	0	0	0	0
Depth	d	feet	2	2.5	2	3.5	0	0	0	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	5	0	0	0
Cross-Sectional Area	X-A	feet^2	68.00	206.25	58.00	120.75	40.00	0.00	0.00	0.00
Flow Rate	Q	cfs	335.26	766.59	235.32	504.33	344.19	0.00	0.00	0.00
Velocity	V	ft/sec	4.93	3.72	4.06	4.18	8.60	0.00	0.00	0.00
Travel time	Tt	hours	0.024	0.184	0.036	0.048	0.067	-	-	-
3 Flow Length	L	feet	1,084	-	-	648	2,035	-	-	-
Slope	S	ft/ft	0.0021	0.0000	0.0000	0.0060	0.0118	0.0000	0.0000	0.0000
roughness	n	n/a	0.05	0	0	0.06	0.013	0	0	0
Open Channel										
Bottom Width	BW	feet	20	0	0	6	0	0	0	0
Side Slopes (H:1)	H	feet	30	0	0	6	0	0	0	0
Depth	d	feet	2	0	0	4	0	0	0	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	160.00	0.00	0.00	120.00	50.27	0.00	0.00	0.00
Flow Rate	Q	cfs	240.84	0.00	0.00	391.41	753.98	0.00	0.00	0.00
Velocity	V	ft/sec	1.51	0.00	0.00	3.26	15.00	0.00	0.00	0.00
Travel time	Tt	hours	0.200	-	-	0.055	0.038	-	-	-
Total Travel Time	TC	hours	1.179	1.389	0.402	0.649	0.741	0.291	0.280	0.454
	TC	min.	70.7	83.3	24.1	38.9	44.5	17.4	16.8	27.2
Lag Time	TL	hours	0.7074	0.8333	0.2415	0.3891	0.4447	0.1744	0.1680	0.2725
	TL	min.	42.4	50.0	14.5	23.3	26.7	10.5	10.1	16.3

EXISTING CONDITIONS										
TR-55 Method of Computing the Time of Concentration										
			SCW_03	**SCW_04**	**SCW_05**	**SCW_06**	**SCW_07**	**SCW_08**	**SCW_09**	**SCW_10**
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.240	0.011	0.240	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	50	20	60	20	300	60	60	20
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0164	0.0117	0.0398	0.0070	0.0316	0.0050	0.0027	0.0060
Travel time	Tt	hours	0.144	0.007	0.116	0.097	0.463	0.267	0.342	0.103
Shallow Concentrated Flow		min.	8.6	0.4	7.0	5.8	27.8	16.0	20.5	6.2
Flow Length	L	feet	990	650	650	1,344	100	590	460	564
Slope	s	ft/ft	0.036	0.012	0.035	0.007	0.034	0.005	0.007	0.018
Surface (1=paved or 2=unpaved)		n/a	1	1	2	2	2	2	1	1
Velocity	V	ft/sec	3.89	2.28	3.03	1.32	2.98	1.19	1.70	2.76
Travel time	Tt	hours	0.071	0.079	0.060	0.282	0.009	0.138	0.075	0.057
Manning's Equation		min.	4.2	4.8	3.6	16.9	0.6	8.3	4.5	3.4
1 Flow Length	L	feet	710	3,160	696	2,325	750	1,084	1,650	1,020
Slope	S	ft/ft	0.0183	0.0145	0.0042	0.0167	0.0093	0.0301	0.0227	0.0111
roughness	n	n/a	0.013	0.04	0.05	0.04	0.05	0.013	0.04	0.013
Open Channel										
Bottom Width	BW	feet	0	2	20	3	15	0	3	0
Side Slopes (H:1)	H	feet	0	3	15	5	20	0	5	0
Depth	d	feet	0	1.5	1.5	2	2	0	2	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	3.00	0.00	0.00	0.00	0.00	2.00	0.00	3.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	7.07	9.75	63.75	26.00	110.00	3.14	26.00	7.07
Flow Rate	Q	cfs	90.48	39.16	121.71	134.39	348.39	39.36	156.56	70.35
Velocity	V	ft/sec	12.80	4.02	1.91	5.17	3.17	12.53	6.02	9.95
Travel time	Tt	hours	0.015	0.219	0.101	0.125	0.066	0.024	0.076	0.028
2 Flow Length	L	feet	255	2,632	-	5,925	1,386	1,791	2,462	522
Slope	S	ft/ft	0.0080	0.0061	0.0000	0.0038	0.0059	0.0045	0.0032	0.0295
roughness	n	n/a	0.05	0.05	0	0.05	0.05	0.05	0.06	0.04
Open Channel										
Bottom Width	BW	feet	15	25	0	20	30	20	30	2
Side Slopes (H:1)	H	feet	5	11	0	15	15	15	30	3
Depth	d	feet	2.5	3	0	4	2	4	3	1.5
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	68.75	174.00	0.00	320.00	120.00	320.00	360.00	9.75
Flow Rate	Q	cfs	260.79	623.16	0.00	1023.42	332.91	1106.56	723.07	55.94
Velocity	V	ft/sec	3.79	3.58	0.00	3.20	2.77	3.46	2.01	5.74
Travel time	Tt	hours	0.019	0.204	-	0.515	0.139	0.144	0.340	0.025
3 Flow Length	L	feet	-	-	-	-	-	-	-	366
Slope	S	ft/ft	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0070
roughness	n	n/a	0	0	0	0	0	0	0	0.05
Open Channel										
Bottom Width	BW	feet	0	0	0	0	0	0	0	20
Side Slopes (H:1)	H	feet	0	0	0	0	0	0	0	10
Depth	d	feet	0	0	0	0	0	0	0	2.75
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	130.63
Flow Rate	Q	cfs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	469.70
Velocity	V	ft/sec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
Travel time	Tt	hours	-	-	-	-	-	-	-	0.028
Total Travel Time	TC	hours	0.248	0.509	0.277	1.019	0.677	0.573	0.833	0.242
	TC	min.	14.9	30.5	16.6	61.1	40.6	34.4	50.0	14.5
Lag Time	TL	hours	0.1490	0.3051	0.1664	0.6112	0.4060	0.3439	0.5000	0.1451
	TL	min.	8.9	18.3	10.0	36.7	24.4	20.6	30.0	8.7

EXISTING CONDITIONS										
TR-55 Method of Computing the Time of Concentration										
			SCW_11	**SCW_12**	**SCW_13**	**SCW_14**	**SCW_15**	**UNA_01**	**UNA_02**	**UNA_03**
Sheet Flow	variable	units								
Manning's roughness coef.	n	n/a	0.011	0.240	0.240	0.240	0.240	0.240	0.240	0.240
Flow Length	L	feet	20	50	50	50	20	20	20	50
2-year, 24-hour rainfall	P2	inches	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Slope	s	ft/ft	0.0010	0.0043	0.0100	0.0040	0.0045	0.0090	0.0100	0.0036
Travel time	Tt	hours	0.018	0.244	0.175	0.251	0.115	0.088	0.084	0.264
Shallow Concentrated Flow		min.	1.1	14.6	10.5	15.1	6.9	5.3	5.0	15.9
Flow Length	L	feet	911	982	700	1,378	136	1,853	480	1,700
Slope	s	ft/ft	0.008	0.013	0.015	0.010	0.014	0.009	0.006	0.011
Surface (1=paved or 2=unpaved)		n/a	1	1	2	1	2	1	1	1
Velocity	V	ft/sec	1.90	2.35	1.97	2.03	1.89	1.98	1.56	2.13
Travel time	Tt	hours	0.133	0.116	0.099	0.188	0.020	0.260	0.085	0.222
Manning's Equation		min.	8.0	7.0	5.9	11.3	1.2	15.6	5.1	13.3
1 Flow Length	L	feet	1,440	2,853	2,794	1,373	2,412	2,450	1,775	1,920
Slope	S	ft/ft	0.0247	0.0100	0.0090	0.0077	0.0030	0.0151	0.0114	0.0125
roughness	n	n/a	0.013	0.04	0.013	0.013	0.013	0.013	0.04	0.013
Open Channel										
Bottom Width	BW	feet	0	3	0	0	0	0	3	0
Side Slopes (H:1)	H	feet	0	5	0	0	0	0	5	0
Depth	d	feet	0	1.5	0	0	0	0	1.5	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	4.50	0.00	2.50	3.50	3.00	3.50	0.00	3.50
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	15.90	15.75	4.91	9.62	7.07	9.62	15.75	9.62
Flow Rate	Q	cfs	238.56	53.18	39.02	88.46	36.76	123.82	56.76	112.86
Velocity	V	ft/sec	15.00	3.38	7.95	9.19	5.20	12.87	3.60	11.73
Travel time	Tt	hours	0.027	0.235	0.098	0.041	0.129	0.053	0.137	0.045
2 Flow Length	L	feet	1,407	2,695	654	-	1,466	2,730	613	868
Slope	S	ft/ft	0.0077	0.0067	0.0058	0.0000	0.0081	0.0093	0.0176	0.0234
roughness	n	n/a	0.04	0.05	0.013	0	0.013	0.05	0.013	0.05
Open Channel										
Bottom Width	BW	feet	10	15	0	0	0	10	0	10
Side Slopes (H:1)	H	feet	5	8	0	0	0	5	0	5
Depth	d	feet	3	3	0	0	0	5	0	3
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	3.50	0.00	6.50	0.00	4.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	4	0	0	0
Cross-Sectional Area	X-A	feet^2	75.00	117.00	9.62	0.00	26.00	175.00	12.57	75.00
Flow Rate	Q	cfs	369.10	430.02	76.72	0.00	308.84	1013.94	188.50	514.27
Velocity	V	ft/sec	4.92	3.68	7.97	0.00	11.88	5.79	15.00	6.86
Travel time	Tt	hours	0.079	0.204	0.023	-	0.034	0.131	0.011	0.035
3 Flow Length	L	feet	2,463	3,059	-	-	1,008	-	1,752	-
Slope	S	ft/ft	0.0055	0.0062	0.0000	0.0000	0.0045	0.0000	0.0201	0.0000
roughness	n	n/a	0.05	0.05	0	0	0.013	0	0.05	0
Open Channel										
Bottom Width	BW	feet	15	20	0	0	5	0	15	0
Side Slopes (H:1)	H	feet	15	10	0	0	5	0	10	0
Depth	d	feet	4.5	4.75	0	0	3.5	0	3.5	0
...or Closed Conduit										
Rise / Diameter	R / D	feet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Span (0 if circular)	S	feet	0	0	0	0	0	0	0	0
Cross-Sectional Area	X-A	feet^2	371.25	320.63	0.00	0.00	78.75	0.00	175.00	0.00
Flow Rate	Q	cfs	1494.89	1487.71	0.00	0.00	940.06	0.00	1194.37	0.00
Velocity	V	ft/sec	4.03	4.64	0.00	0.00	11.94	0.00	6.82	0.00
Travel time	Tt	hours	0.170	0.183	-	-	0.023	-	0.071	-
Total Travel Time	TC	hours	0.427	0.982	0.394	0.481	0.322	0.531	0.389	0.567
	TC	min.	25.6	58.9	23.6	28.8	19.3	31.9	23.3	34.0
Lag Time	TL	hours	0.2564	0.5890	0.2362	0.2884	0.1932	0.3189	0.2334	0.3401
	TL	min.	15.4	35.3	14.2	17.3	11.6	19.1	14.0	20.4

EXISTING CONDITIONS				
TR-55 Method of Computing the Time of Concentration				
			UNA_04	**WB_01**
Sheet Flow	variable	units		
Manning's roughness coef.	n	n/a	0.240	0.011
Flow Length	L	feet	50	20
2-year, 24-hour rainfall	P2	inches	3.4	3.4
Slope	s	ft/ft	0.0127	0.0129
Travel time	Tt	hours	0.159	0.006
Shallow Concentrated Flow		min.	9.5	0.4
Flow Length	L	feet	850	1,730
Slope	s	ft/ft	0.013	0.012
Surface (1=paved or 2=unpaved)		n/a	1	1
Velocity	V	ft/sec	2.39	2.29
Travel time	Tt	hours	0.099	0.210
Manning's Equation		min.	5.9	12.6
1 Flow Length	L	feet	2,120	1,350
Slope	S	ft/ft	0.0134	0.0114
roughness	n	n/a	0.04	0.04
Open Channel				
Bottom Width	BW	feet	3	10
Side Slopes (H:1)	H	feet	5	15
Depth	d	feet	2	3
...or Closed Conduit				
Rise / Diameter	R / D	feet	0.00	0.00
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	26.00	165.00
Flow Rate	Q	cfs	120.23	914.53
Velocity	V	ft/sec	4.62	5.54
Travel time	Tt	hours	0.127	0.068
2 Flow Length	L	feet	880	2,790
Slope	S	ft/ft	0.0130	0.0169
roughness	n	n/a	0.013	0.05
Open Channel				
Bottom Width	BW	feet	0	20
Side Slopes (H:1)	H	feet	0	15
Depth	d	feet	0	2.5
...or Closed Conduit				
Rise / Diameter	R / D	feet	5.00	0.00
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	19.63	143.75
Flow Rate	Q	cfs	294.52	732.53
Velocity	V	ft/sec	15.00	5.10
Travel time	Tt	hours	0.016	0.152
3 Flow Length	L	feet	326	-
Slope	S	ft/ft	0.0255	0.0000
roughness	n	n/a	0.05	0
Open Channel				
Bottom Width	BW	feet	15	0
Side Slopes (H:1)	H	feet	15	0
Depth	d	feet	3.25	0
...or Closed Conduit				
Rise / Diameter	R / D	feet	0.00	0.00
Span (0 if circular)	S	feet	0	0
Cross-Sectional Area	X-A	feet^2	207.19	0.00
Flow Rate	Q	cfs	1478.19	0.00
Velocity	V	ft/sec	7.13	0.00
Travel time	Tt	hours	0.013	-
Total Travel Time	TC	hours	0.414	0.436
	TC	min.	24.9	26.2
Lag Time	TL	hours	0.2486	0.2618
	TL	min.	14.9	15.7

Appendix C
Hydrologic & Hydraulic Model Output

Cottonwood Creek 10% Chance Event

HEC-HMS 3.5 [P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\HEC_HMS\C...

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	160.5	01Jan2006, 12:32	4.25
BB-01	0.29	666.6	01Jan2006, 12:20	5.28
CWC-01	0.06	131.6	01Jan2006, 12:14	4.12
CWC-02	0.16	225.8	01Jan2006, 12:34	3.87
CWC-03	0.40	678.0	01Jan2006, 12:28	4.19
CWC-04	0.03	58.6	01Jan2006, 12:26	4.68
CWC-05	0.27	510.1	01Jan2006, 12:28	4.75
CWC-06	0.32	945.8	01Jan2006, 12:10	5.11
CWC-07	0.14	375.5	01Jan2006, 12:12	4.88
CWC-08	0.56	950.7	01Jan2006, 12:24	3.87
CWC-09	0.22	558.7	01Jan2006, 12:16	5.06
CWC-10	0.58	1118.3	01Jan2006, 12:30	5.40
CWC-11	0.13	256.8	01Jan2006, 12:24	4.49
CWC-12	0.29	608.1	01Jan2006, 12:26	5.35
CWC-13	0.10	230.1	01Jan2006, 12:18	4.84
CWC-14	0.04	108.0	01Jan2006, 12:10	4.42
CWC-15	0.08	248.1	01Jan2006, 12:08	5.08
CWC-16	0.13	306.1	01Jan2006, 12:16	4.62
CWC-17	0.27	635.1	01Jan2006, 12:18	4.90
CWC-18	0.38	715.2	01Jan2006, 12:30	5.06
CWC-19	0.13	345.9	01Jan2006, 12:12	4.79
CWC-20	0.15	354.9	01Jan2006, 12:18	4.94
CWC J-01	14.43	10136.1	01Jan2006, 14:10	4.94
CWC J-01A	12.87	10084.5	01Jan2006, 13:58	4.97
CWC J-02	12.71	10117.1	01Jan2006, 13:52	4.98
CWC J-02A	12.61	10496.0	01Jan2006, 13:42	4.99
CWC J-03	11.35	10799.2	01Jan2006, 13:18	4.99
CWC J-03A	10.91	10421.3	01Jan2006, 13:18	5.00
CWC J-04	10.88	10411.3	01Jan2006, 13:18	5.00
CWC J-05	10.61	10343.1	01Jan2006, 13:12	5.00
CWC J-06	5.72	7022.3	01Jan2006, 13:04	4.90
CWC J-07	5.40	6952.9	01Jan2006, 13:02	4.89
CWC J-08	5.10	6871.1	01Jan2006, 12:56	4.86
CWC J-08A	4.50	6687.7	01Jan2006, 12:48	4.90
CWC J-09	3.94	6371.5	01Jan2006, 12:42	5.04
CWC J-10	3.72	6274.7	01Jan2006, 12:40	5.04
CWC J-11	3.14	5296.5	01Jan2006, 12:40	4.98

Cottonwood Creek 10% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	5166.8	01Jan2006, 12:36	5.00
CWC J-12A	2.79	4882.7	01Jan2006, 12:38	5.01
CWC J-13	2.50	4482.9	01Jan2006, 12:34	4.97
CWC J-14	2.40	4674.9	01Jan2006, 12:28	4.98
CWC J-15	1.18	2196.0	01Jan2006, 12:26	4.91
CWC J-15A	1.14	2288.7	01Jan2006, 12:20	4.93
CWC J-16	1.06	2144.6	01Jan2006, 12:20	4.91
CWC J-17	0.93	1856.7	01Jan2006, 12:20	4.96
CWC J-18	0.53	1004.6	01Jan2006, 12:24	5.02
CWC R-01	14.43	10049.8	01Jan2006, 14:16	4.94
CWC R-01A	12.87	9664.7	01Jan2006, 14:12	4.97
CWC R-02	12.71	10051.5	01Jan2006, 13:58	4.98
CWC R-02A	12.61	10094.7	01Jan2006, 13:52	4.99
CWC R-03	11.35	10123.7	01Jan2006, 13:42	4.99
CWC R-03A	10.91	10411.6	01Jan2006, 13:20	5.00
CWC R-04	10.88	10408.6	01Jan2006, 13:18	5.00
CWC R-05	10.61	10283.9	01Jan2006, 13:18	5.00
CWC R-06	5.72	6919.0	01Jan2006, 13:10	4.90
CWC R-07	5.40	6907.7	01Jan2006, 13:06	4.89
CWC R-08	5.10	6831.4	01Jan2006, 13:02	4.86
CWC R-08A	4.50	6526.2	01Jan2006, 12:58	4.90
CWC R-09	3.94	6225.1	01Jan2006, 12:52	5.04
CWC R-10	3.72	6186.1	01Jan2006, 12:44	5.04
CWC R-11	3.14	5275.8	01Jan2006, 12:42	4.98
CWC R-12	3.01	5120.9	01Jan2006, 12:40	5.00
CWC R-12A	2.79	4882.5	01Jan2006, 12:38	5.01
CWC R-13	2.50	4402.5	01Jan2006, 12:40	4.97
CWC R-14	2.40	4348.4	01Jan2006, 12:36	4.98
CWC R-15	1.18	2132.9	01Jan2006, 12:30	4.91
CWC R-15A	1.14	2143.3	01Jan2006, 12:26	4.93
CWC R-16	1.06	2139.5	01Jan2006, 12:20	4.91
CWC R-17	0.93	1855.3	01Jan2006, 12:20	4.96
CWC R-18	0.53	1001.8	01Jan2006, 12:26	5.02
DB-01	0.08	140.8	01Jan2006, 12:24	4.01
DB-02	0.20	479.3	01Jan2006, 12:16	4.80
DB-03	0.32	746.3	01Jan2006, 12:16	4.60
DB J-1	0.60	1344.2	01Jan2006, 12:18	4.59
DB J-2	0.52	1225.7	01Jan2006, 12:16	4.68

Cottonwood Creek 10% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	1340.4	01Jan2006, 12:18	4.59
DB R-2	0.52	1218.4	01Jan2006, 12:16	4.68
EB-01	0.35	603.6	01Jan2006, 12:32	4.84
GB-01	0.13	197.6	01Jan2006, 12:30	3.96
Henry Branch	0.37	729.4	01Jan2006, 12:28	5.59
IHB-01	0.03	81.4	01Jan2006, 12:12	4.62
IHB-02	0.07	154.5	01Jan2006, 12:20	4.97
IHB-03	0.39	801.7	01Jan2006, 12:24	5.01
IHB J-1	0.49	962.6	01Jan2006, 12:30	4.98
IHB J-2	0.46	947.9	01Jan2006, 12:24	5.00
IHB R-1	0.49	880.2	01Jan2006, 12:44	4.98
IHB R-2	0.46	926.4	01Jan2006, 12:30	5.00
IHB R-3	0.39	800.0	01Jan2006, 12:26	5.01
JB-01	0.01	22.1	01Jan2006, 12:18	4.33
JB-02	0.43	676.4	01Jan2006, 12:40	4.99
JB R-1	0.43	664.9	01Jan2006, 12:46	4.99
Mountain Creek L...	14.49	10059.0	01Jan2006, 14:16	4.94
PC-01	0.07	79.7	01Jan2006, 12:48	3.76
PC-02	0.16	171.7	01Jan2006, 12:56	3.96
PC-03	0.04	86.7	01Jan2006, 12:18	4.40
PC-04	0.14	271.5	01Jan2006, 12:26	4.85
PC-05	0.67	1252.1	01Jan2006, 12:30	5.07
PC J-1	1.49	2297.3	01Jan2006, 12:44	4.76
PC J-1A	1.56	2252.6	01Jan2006, 12:54	4.72
PC J-2	1.20	2065.5	01Jan2006, 12:36	4.96
PC J-3	0.81	1461.9	01Jan2006, 12:34	5.03
PC R-01	1.49	2174.5	01Jan2006, 12:54	4.76
PC R-01A	1.56	2084.5	01Jan2006, 13:06	4.72
PC R-02	1.20	1979.6	01Jan2006, 12:46	4.96
PC R-03	0.81	1428.4	01Jan2006, 12:38	5.03
PC R-04	0.67	1211.4	01Jan2006, 12:36	5.07
RB-01	0.16	476.9	01Jan2006, 12:12	5.68
SCW-01	0.03	79.6	01Jan2006, 12:12	4.63
SCW-02	0.08	168.5	01Jan2006, 12:20	4.37
SCW-03	0.06	170.7	01Jan2006, 12:10	4.86
SCW-04	0.16	352.4	01Jan2006, 12:20	5.02
SCW-04A	0.12	390.6	01Jan2006, 12:08	5.18
SCW-05	0.02	55.3	01Jan2006, 12:12	4.91

Cottonwood Creek 10% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	728.7	01Jan2006, 12:42	4.38
SCW-07	0.08	145.6	01Jan2006, 12:28	4.57
SCW-08	0.10	210.1	01Jan2006, 12:24	5.01
SCW-08A	0.05	142.8	01Jan2006, 12:14	5.83
SCW-09	0.20	342.3	01Jan2006, 12:34	4.93
SCW-10	0.13	365.1	01Jan2006, 12:10	4.85
SCW-11	0.40	1006.9	01Jan2006, 12:18	5.47
SCW-12	0.70	1123.2	01Jan2006, 12:38	5.04
SCW-13	0.17	427.6	01Jan2006, 12:16	5.19
SCW-14	0.10	235.4	01Jan2006, 12:20	5.32
SCW-15	0.17	490.0	01Jan2006, 12:14	5.70
SCW J-01	4.86	3530.3	01Jan2006, 13:20	5.13
SCW J-02	4.78	3516.9	01Jan2006, 13:16	5.14
SCW J-02A	4.60	3481.4	01Jan2006, 13:14	5.14
SCW J-03	4.44	3429.3	01Jan2006, 13:10	5.15
SCW J-03A	2.94	2648.3	01Jan2006, 13:34	5.04
SCW J-04	2.92	2662.4	01Jan2006, 13:20	5.04
SCW J-05	2.39	2380.2	01Jan2006, 13:20	5.19
SCW J-05A	2.10	2290.8	01Jan2006, 13:22	5.18
SCW J-06	2.02	2262.3	01Jan2006, 13:18	5.20
SCW J-06A	1.92	2253.8	01Jan2006, 13:12	5.21
SCW J-07	1.87	2326.8	01Jan2006, 12:50	5.20
SCW J-08	1.67	2154.8	01Jan2006, 12:24	5.23
SCW J-08A	1.50	1962.3	01Jan2006, 12:44	5.17
SCW J-09	1.37	1921.6	01Jan2006, 12:40	5.21
SCW J-10	0.97	1539.9	01Jan2006, 12:38	5.10
SCW J-11	0.27	472.1	01Jan2006, 12:18	5.24
SCW R-01	4.86	3524.1	01Jan2006, 13:24	5.13
SCW R-02	4.78	3507.6	01Jan2006, 13:20	5.14
SCW R-02A	4.60	3479.9	01Jan2006, 13:16	5.14
SCW R-03	4.44	3419.2	01Jan2006, 13:16	5.15
SCW R-03A	2.94	2645.5	01Jan2006, 13:38	5.04
SCW R-04	2.92	2644.9	01Jan2006, 13:34	5.04
SCW R-05	2.39	2359.0	01Jan2006, 13:32	5.19
SCW R-05A	2.10	2288.7	01Jan2006, 13:24	5.18
SCW R-06	2.02	2257.3	01Jan2006, 13:22	5.20
SCW R-06A	1.92	2224.1	01Jan2006, 13:20	5.21
SCW R-07	1.87	2237.4	01Jan2006, 13:14	5.20

Cottonwood Creek 10% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	2081.4	01Jan2006, 12:56	5.23
SCW R-08A	1.50	1957.1	01Jan2006, 12:46	5.17
SCW R-09	1.37	1889.3	01Jan2006, 12:46	5.21
SCW R-10	0.97	1511.0	01Jan2006, 12:46	5.10
SCW R-11	0.27	416.8	01Jan2006, 12:38	5.24
SCW R-12	0.10	235.4	01Jan2006, 12:52	5.32
SCW R-13	0.17	490.0	01Jan2006, 12:20	5.70
UNA-01	0.42	910.3	01Jan2006, 12:22	4.98
UNA-2	0.32	811.5	01Jan2006, 12:16	5.21
UNA-3	0.13	267.6	01Jan2006, 12:24	4.86
UNA-4	0.35	847.7	01Jan2006, 12:18	5.05
UNA J-01	1.22	2791.5	01Jan2006, 12:20	5.05
UNA J-2	0.80	1899.7	01Jan2006, 12:18	5.08
UNA J-3	0.48	1100.7	01Jan2006, 12:18	5.00
UNA R-1	1.22	2577.2	01Jan2006, 12:26	5.05
UNA R-2	0.80	1891.4	01Jan2006, 12:18	5.08
UNA R-3	0.48	1096.1	01Jan2006, 12:18	5.00
Warriior Creek	1.50	1754.9	01Jan2006, 12:36	5.35
WB-01	0.22	505.5	01Jan2006, 12:18	4.79

Cottonwood Creek 4% Chance Event

HEC-HMS 3.5 [P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\HEC_HMS\C...

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	199.7	01Jan2006, 12:32	5.31
BB-01	0.29	800.1	01Jan2006, 12:20	6.39
CWC-01	0.06	163.3	01Jan2006, 12:14	5.16
CWC-02	0.16	285.5	01Jan2006, 12:34	4.89
CWC-03	0.40	844.2	01Jan2006, 12:28	5.25
CWC-04	0.03	71.6	01Jan2006, 12:24	5.78
CWC-05	0.27	622.8	01Jan2006, 12:28	5.85
CWC-06	0.32	1133.9	01Jan2006, 12:10	6.22
CWC-07	0.14	453.4	01Jan2006, 12:12	5.99
CWC-08	0.56	1196.5	01Jan2006, 12:24	4.90
CWC-09	0.22	672.2	01Jan2006, 12:16	6.17
CWC-10	0.58	1343.8	01Jan2006, 12:30	6.52
CWC-11	0.13	315.4	01Jan2006, 12:24	5.58
CWC-12	0.29	730.5	01Jan2006, 12:26	6.47
CWC-13	0.10	279.2	01Jan2006, 12:18	5.93
CWC-14	0.04	132.2	01Jan2006, 12:10	5.49
CWC-15	0.08	297.9	01Jan2006, 12:08	6.19
CWC-16	0.13	373.2	01Jan2006, 12:16	5.70
CWC-17	0.27	768.9	01Jan2006, 12:16	6.00
CWC-18	0.38	866.9	01Jan2006, 12:30	6.16
CWC-19	0.13	418.8	01Jan2006, 12:12	5.89
CWC-20	0.15	429.0	01Jan2006, 12:18	6.04
CWC J-01	14.43	13825.7	01Jan2006, 13:54	6.14
CWC J-01A	12.87	13190.2	01Jan2006, 13:50	6.18
CWC J-02	12.71	13194.2	01Jan2006, 13:46	6.19
CWC J-02A	12.61	13637.1	01Jan2006, 13:34	6.20
CWC J-03	11.35	13841.2	01Jan2006, 13:14	6.19
CWC J-03A	10.91	13323.6	01Jan2006, 13:14	6.19
CWC J-04	10.88	13311.1	01Jan2006, 13:12	6.20
CWC J-05	10.61	13180.9	01Jan2006, 13:08	6.20
CWC J-06	5.72	8599.0	01Jan2006, 13:02	5.99
CWC J-07	5.40	8503.0	01Jan2006, 13:00	5.98
CWC J-08	5.10	8401.1	01Jan2006, 12:56	5.96
CWC J-08A	4.50	8191.2	01Jan2006, 12:48	5.99
CWC J-09	3.94	7864.9	01Jan2006, 12:42	6.15
CWC J-10	3.72	7775.3	01Jan2006, 12:40	6.15
CWC J-11	3.14	6600.3	01Jan2006, 12:38	6.08

Cottonwood Creek 4% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	6505.1	01Jan2006, 12:36	6.10
CWC J-12A	2.79	6187.4	01Jan2006, 12:36	6.12
CWC J-13	2.50	5584.1	01Jan2006, 12:32	6.08
CWC J-14	2.40	5807.5	01Jan2006, 12:26	6.08
CWC J-15	1.18	2774.1	01Jan2006, 12:24	6.01
CWC J-15A	1.14	2783.6	01Jan2006, 12:20	6.03
CWC J-16	1.06	2606.6	01Jan2006, 12:20	6.01
CWC J-17	0.93	2254.7	01Jan2006, 12:20	6.06
CWC J-18	0.53	1218.9	01Jan2006, 12:24	6.13
CWC R-01	14.43	13795.5	01Jan2006, 13:58	6.14
CWC R-01A	12.87	12998.3	01Jan2006, 13:58	6.18
CWC R-02	12.71	13142.3	01Jan2006, 13:50	6.19
CWC R-02A	12.61	13162.3	01Jan2006, 13:46	6.20
CWC R-03	11.35	13064.4	01Jan2006, 13:36	6.19
CWC R-03A	10.91	13312.1	01Jan2006, 13:14	6.19
CWC R-04	10.88	13306.1	01Jan2006, 13:14	6.20
CWC R-05	10.61	13125.8	01Jan2006, 13:14	6.20
CWC R-06	5.72	8505.2	01Jan2006, 13:08	5.99
CWC R-07	5.40	8459.1	01Jan2006, 13:04	5.98
CWC R-08	5.10	8352.1	01Jan2006, 13:00	5.96
CWC R-08A	4.50	7964.7	01Jan2006, 12:58	5.99
CWC R-09	3.94	7598.3	01Jan2006, 12:50	6.15
CWC R-10	3.72	7619.9	01Jan2006, 12:42	6.15
CWC R-11	3.14	6558.8	01Jan2006, 12:40	6.08
CWC R-12	3.01	6368.7	01Jan2006, 12:38	6.10
CWC R-12A	2.79	6136.5	01Jan2006, 12:36	6.12
CWC R-13	2.50	5566.3	01Jan2006, 12:36	6.08
CWC R-14	2.40	5407.4	01Jan2006, 12:34	6.08
CWC R-15	1.18	2678.4	01Jan2006, 12:28	6.01
CWC R-15A	1.14	2700.8	01Jan2006, 12:24	6.03
CWC R-16	1.06	2602.0	01Jan2006, 12:20	6.01
CWC R-17	0.93	2253.6	01Jan2006, 12:20	6.06
CWC R-18	0.53	1215.7	01Jan2006, 12:26	6.13
DB-01	0.08	176.3	01Jan2006, 12:24	5.06
DB-02	0.20	581.5	01Jan2006, 12:16	5.89
DB-03	0.32	910.7	01Jan2006, 12:16	5.68
DB J-1	0.60	1642.0	01Jan2006, 12:18	5.66
DB J-2	0.52	1492.2	01Jan2006, 12:16	5.76

Cottonwood Creek 4% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	1637.2	01Jan2006, 12:18	5.66
DB R-2	0.52	1484.9	01Jan2006, 12:16	5.76
EB-01	0.35	737.2	01Jan2006, 12:32	5.93
GB-01	0.13	248.7	01Jan2006, 12:30	5.00
Henry Branch	0.37	1007.7	01Jan2006, 12:28	7.73
IHB-01	0.03	98.8	01Jan2006, 12:12	5.72
IHB-02	0.07	187.0	01Jan2006, 12:20	6.08
IHB-03	0.39	970.9	01Jan2006, 12:24	6.12
IHB J-1	0.49	1164.5	01Jan2006, 12:30	6.09
IHB J-2	0.46	1150.2	01Jan2006, 12:24	6.11
IHB R-1	0.49	1056.5	01Jan2006, 12:46	6.09
IHB R-2	0.46	1119.8	01Jan2006, 12:30	6.11
IHB R-3	0.39	969.3	01Jan2006, 12:26	6.12
JB-01	0.01	27.1	01Jan2006, 12:18	5.41
JB-02	0.43	823.7	01Jan2006, 12:40	6.09
JB R-1	0.43	811.0	01Jan2006, 12:46	6.10
Mountain Creek L...	14.49	13807.7	01Jan2006, 13:58	6.13
PC-01	0.07	101.5	01Jan2006, 12:48	4.79
PC-02	0.16	216.9	01Jan2006, 12:56	5.00
PC-03	0.04	106.6	01Jan2006, 12:18	5.46
PC-04	0.14	330.6	01Jan2006, 12:26	5.95
PC-05	0.67	1517.2	01Jan2006, 12:30	6.18
PC J-1	1.49	2800.3	01Jan2006, 12:46	5.85
PC J-1A	1.56	2805.9	01Jan2006, 12:52	5.81
PC J-2	1.20	2504.8	01Jan2006, 12:36	6.06
PC J-3	0.81	1777.7	01Jan2006, 12:34	6.14
PC R-01	1.49	2705.6	01Jan2006, 12:52	5.85
PC R-01A	1.56	2667.6	01Jan2006, 13:00	5.81
PC R-02	1.20	2399.5	01Jan2006, 12:46	6.06
PC R-03	0.81	1728.6	01Jan2006, 12:38	6.14
PC R-04	0.67	1471.7	01Jan2006, 12:34	6.18
RB-01	0.16	564.0	01Jan2006, 12:12	6.81
SCW-01	0.03	96.8	01Jan2006, 12:12	5.72
SCW-02	0.08	207.4	01Jan2006, 12:20	5.44
SCW-03	0.06	206.1	01Jan2006, 12:10	5.96
SCW-04	0.16	426.1	01Jan2006, 12:20	6.13
SCW-04A	0.12	467.0	01Jan2006, 12:08	6.28
SCW-05	0.02	66.6	01Jan2006, 12:12	6.02

Cottonwood Creek 4% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	905.3	01Jan2006, 12:40	5.44
SCW-07	0.08	178.9	01Jan2006, 12:28	5.66
SCW-08	0.10	254.3	01Jan2006, 12:24	6.12
SCW-08A	0.05	168.5	01Jan2006, 12:14	6.97
SCW-09	0.20	417.1	01Jan2006, 12:34	6.03
SCW-10	0.13	441.3	01Jan2006, 12:10	5.94
SCW-11	0.40	1200.6	01Jan2006, 12:18	6.60
SCW-12	0.70	1365.6	01Jan2006, 12:38	6.15
SCW-13	0.17	512.9	01Jan2006, 12:16	6.31
SCW-14	0.10	282.1	01Jan2006, 12:20	6.44
SCW-15	0.17	579.4	01Jan2006, 12:14	6.84
SCW J-01	4.86	4695.2	01Jan2006, 13:10	6.45
SCW J-02	4.78	4680.6	01Jan2006, 13:04	6.47
SCW J-02A	4.60	4616.2	01Jan2006, 13:04	6.48
SCW J-03	4.44	4542.9	01Jan2006, 12:58	6.50
SCW J-03A	2.94	3114.6	01Jan2006, 13:30	6.15
SCW J-04	2.92	3113.6	01Jan2006, 13:16	6.15
SCW J-05	2.39	2802.5	01Jan2006, 13:28	6.31
SCW J-05A	2.10	2712.8	01Jan2006, 13:30	6.29
SCW J-06	2.02	2683.5	01Jan2006, 13:28	6.32
SCW J-06A	1.92	2689.3	01Jan2006, 13:20	6.33
SCW J-07	1.87	2838.3	01Jan2006, 12:52	6.31
SCW J-08	1.67	2627.6	01Jan2006, 12:38	6.35
SCW J-08A	1.50	2395.2	01Jan2006, 12:44	6.29
SCW J-09	1.37	2346.9	01Jan2006, 12:40	6.32
SCW J-10	0.97	1876.1	01Jan2006, 12:38	6.21
SCW J-11	0.27	568.1	01Jan2006, 12:18	6.36
SCW R-01	4.86	4686.0	01Jan2006, 13:12	6.45
SCW R-02	4.78	4656.5	01Jan2006, 13:10	6.47
SCW R-02A	4.60	4613.0	01Jan2006, 13:06	6.48
SCW R-03	4.44	4512.2	01Jan2006, 13:06	6.50
SCW R-03A	2.94	3113.4	01Jan2006, 13:34	6.15
SCW R-04	2.92	3109.8	01Jan2006, 13:30	6.15
SCW R-05	2.39	2785.0	01Jan2006, 13:40	6.31
SCW R-05A	2.10	2710.8	01Jan2006, 13:32	6.29
SCW R-06	2.02	2679.5	01Jan2006, 13:30	6.32
SCW R-06A	1.92	2646.0	01Jan2006, 13:28	6.33
SCW R-07	1.87	2673.3	01Jan2006, 13:20	6.31

Cottonwood Creek 4% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	2546.1	01Jan2006, 12:58	6.35
SCW R-08A	1.50	2389.1	01Jan2006, 12:46	6.29
SCW R-09	1.37	2303.9	01Jan2006, 12:46	6.32
SCW R-10	0.97	1842.3	01Jan2006, 12:46	6.21
SCW R-11	0.27	510.4	01Jan2006, 12:38	6.36
SCW R-12	0.10	282.1	01Jan2006, 12:52	6.44
SCW R-13	0.17	579.4	01Jan2006, 12:20	6.84
UNA-01	0.42	1101.7	01Jan2006, 12:22	6.08
UNA-2	0.32	973.0	01Jan2006, 12:16	6.33
UNA-3	0.13	325.3	01Jan2006, 12:24	5.96
UNA-4	0.35	1021.1	01Jan2006, 12:18	6.16
UNA J-01	1.22	3368.0	01Jan2006, 12:20	6.16
UNA J-2	0.80	2288.0	01Jan2006, 12:18	6.20
UNA J-3	0.48	1329.4	01Jan2006, 12:18	6.11
UNA R-1	1.22	3141.7	01Jan2006, 12:26	6.16
UNA R-2	0.80	2278.9	01Jan2006, 12:18	6.20
UNA R-3	0.48	1324.4	01Jan2006, 12:18	6.11
Warrior Creek	1.50	2414.7	01Jan2006, 12:36	7.18
WB-01	0.22	613.7	01Jan2006, 12:18	5.90

Cottonwood Creek 2% Chance Event

HEC-HMS 3.5 [P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\HEC_HMS\C...

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	233.3	01Jan2006, 12:32	6.26
BB-01	0.29	908.8	01Jan2006, 12:20	7.38
CWC-01	0.06	188.5	01Jan2006, 12:14	6.10
CWC-02	0.16	337.4	01Jan2006, 12:34	5.81
CWC-03	0.40	983.0	01Jan2006, 12:28	6.20
CWC-04	0.03	82.6	01Jan2006, 12:26	6.75
CWC-05	0.27	718.0	01Jan2006, 12:28	6.83
CWC-06	0.32	1274.8	01Jan2006, 12:10	7.21
CWC-07	0.14	513.1	01Jan2006, 12:12	6.96
CWC-08	0.56	1405.1	01Jan2006, 12:24	5.81
CWC-09	0.22	761.7	01Jan2006, 12:16	7.15
CWC-10	0.58	1534.7	01Jan2006, 12:30	7.52
CWC-11	0.13	364.2	01Jan2006, 12:24	6.54
CWC-12	0.29	832.8	01Jan2006, 12:26	7.46
CWC-13	0.10	318.7	01Jan2006, 12:18	6.90
CWC-14	0.04	150.5	01Jan2006, 12:10	6.45
CWC-15	0.08	334.6	01Jan2006, 12:08	7.17
CWC-16	0.13	426.6	01Jan2006, 12:16	6.66
CWC-17	0.27	876.2	01Jan2006, 12:18	6.97
CWC-18	0.38	995.7	01Jan2006, 12:30	7.15
CWC-19	0.13	474.7	01Jan2006, 12:12	6.86
CWC-20	0.15	488.7	01Jan2006, 12:18	7.02
CWC J-01	14.43	16261.1	01Jan2006, 13:48	6.98
CWC J-01A	12.87	15300.7	01Jan2006, 13:46	7.01
CWC J-02	12.71	15293.4	01Jan2006, 13:42	7.03
CWC J-02A	12.61	15882.1	01Jan2006, 13:30	7.03
CWC J-03	11.35	16111.6	01Jan2006, 13:10	7.04
CWC J-03A	10.91	15492.2	01Jan2006, 13:10	7.04
CWC J-04	10.88	15474.7	01Jan2006, 13:10	7.04
CWC J-05	10.61	15327.1	01Jan2006, 13:06	7.04
CWC J-06	5.72	10250.2	01Jan2006, 13:00	6.97
CWC J-07	5.40	10158.3	01Jan2006, 12:58	6.95
CWC J-08	5.10	10071.8	01Jan2006, 12:54	6.93
CWC J-08A	4.50	9826.2	01Jan2006, 12:46	6.97
CWC J-09	3.94	9405.0	01Jan2006, 12:40	7.13
CWC J-10	3.72	9355.4	01Jan2006, 12:36	7.13
CWC J-11	3.14	7906.2	01Jan2006, 12:36	7.06

Cottonwood Creek 2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	7772.3	01Jan2006, 12:30	7.08
CWC J-12A	2.79	7208.1	01Jan2006, 12:34	7.10
CWC J-13	2.50	6500.7	01Jan2006, 12:32	7.06
CWC J-14	2.40	6685.5	01Jan2006, 12:26	7.06
CWC J-15	1.18	3239.5	01Jan2006, 12:22	6.98
CWC J-15A	1.14	3193.9	01Jan2006, 12:20	7.00
CWC J-16	1.06	2989.7	01Jan2006, 12:20	6.99
CWC J-17	0.93	2586.4	01Jan2006, 12:20	7.03
CWC J-18	0.53	1399.9	01Jan2006, 12:24	7.11
CWC R-01	14.43	16245.8	01Jan2006, 13:50	6.98
CWC R-01A	12.87	15102.9	01Jan2006, 13:52	7.01
CWC R-02	12.71	15238.9	01Jan2006, 13:46	7.03
CWC R-02A	12.61	15252.4	01Jan2006, 13:42	7.03
CWC R-03	11.35	15189.9	01Jan2006, 13:32	7.04
CWC R-03A	10.91	15474.3	01Jan2006, 13:12	7.04
CWC R-04	10.88	15470.3	01Jan2006, 13:10	7.04
CWC R-05	10.61	15254.7	01Jan2006, 13:10	7.04
CWC R-06	5.72	10120.6	01Jan2006, 13:04	6.97
CWC R-07	5.40	10093.2	01Jan2006, 13:00	6.95
CWC R-08	5.10	9990.4	01Jan2006, 12:58	6.93
CWC R-08A	4.50	9524.7	01Jan2006, 12:54	6.97
CWC R-09	3.94	9079.5	01Jan2006, 12:48	7.13
CWC R-10	3.72	9097.4	01Jan2006, 12:42	7.13
CWC R-11	3.14	7877.3	01Jan2006, 12:38	7.06
CWC R-12	3.01	7617.1	01Jan2006, 12:36	7.08
CWC R-12A	2.79	7231.4	01Jan2006, 12:30	7.10
CWC R-13	2.50	6456.9	01Jan2006, 12:34	7.06
CWC R-14	2.40	6279.5	01Jan2006, 12:32	7.06
CWC R-15	1.18	3110.1	01Jan2006, 12:28	6.98
CWC R-15A	1.14	3142.7	01Jan2006, 12:22	7.00
CWC R-16	1.06	2981.6	01Jan2006, 12:20	6.99
CWC R-17	0.93	2583.9	01Jan2006, 12:20	7.03
CWC R-18	0.53	1397.1	01Jan2006, 12:26	7.11
DB-01	0.08	206.1	01Jan2006, 12:24	6.00
DB-02	0.20	662.6	01Jan2006, 12:16	6.86
DB-03	0.32	1041.9	01Jan2006, 12:16	6.63
DB J-1	0.60	1882.1	01Jan2006, 12:18	6.62
DB J-2	0.52	1704.5	01Jan2006, 12:16	6.72

Cottonwood Creek 2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	1873.7	01Jan2006, 12:18	6.62
DB R-2	0.52	1697.1	01Jan2006, 12:16	6.72
EB-01	0.35	849.7	01Jan2006, 12:32	6.90
GB-01	0.13	292.7	01Jan2006, 12:30	5.92
Henry Branch	0.37	1007.7	01Jan2006, 12:28	7.73
IHB-01	0.03	112.1	01Jan2006, 12:12	6.69
IHB-02	0.07	213.3	01Jan2006, 12:20	7.06
IHB-03	0.39	1111.5	01Jan2006, 12:24	7.10
IHB J-1	0.49	1321.0	01Jan2006, 12:30	7.07
IHB J-2	0.46	1317.1	01Jan2006, 12:24	7.09
IHB R-1	0.49	1200.6	01Jan2006, 12:48	7.07
IHB R-2	0.46	1272.2	01Jan2006, 12:32	7.09
IHB R-3	0.39	1110.3	01Jan2006, 12:26	7.10
JB-01	0.01	31.2	01Jan2006, 12:18	6.37
JB-02	0.43	950.7	01Jan2006, 12:40	7.08
JB R-1	0.43	936.1	01Jan2006, 12:46	7.08
Mountain Creek L...	14.49	16261.2	01Jan2006, 13:50	6.98
PC-01	0.07	120.6	01Jan2006, 12:48	5.72
PC-02	0.16	256.5	01Jan2006, 12:56	5.94
PC-03	0.04	122.8	01Jan2006, 12:18	6.41
PC-04	0.14	380.1	01Jan2006, 12:26	6.93
PC-05	0.67	1741.7	01Jan2006, 12:30	7.17
PC J-1	1.49	3201.2	01Jan2006, 12:46	6.82
PC J-1A	1.56	3224.2	01Jan2006, 12:52	6.77
PC J-2	1.20	2856.4	01Jan2006, 12:36	7.04
PC J-3	0.81	2004.2	01Jan2006, 12:34	7.13
PC R-01	1.49	3105.3	01Jan2006, 12:54	6.82
PC R-01A	1.56	3111.2	01Jan2006, 13:00	6.77
PC R-02	1.20	2727.9	01Jan2006, 12:48	7.04
PC R-03	0.81	1962.5	01Jan2006, 12:40	7.13
PC R-04	0.67	1659.3	01Jan2006, 12:36	7.17
RB-01	0.16	629.9	01Jan2006, 12:12	7.81
SCW-01	0.03	109.9	01Jan2006, 12:12	6.70
SCW-02	0.08	239.3	01Jan2006, 12:20	6.40
SCW-03	0.06	232.8	01Jan2006, 12:10	6.94
SCW-04	0.16	486.4	01Jan2006, 12:22	7.11
SCW-04A	0.12	522.7	01Jan2006, 12:08	7.25
SCW-05	0.02	75.2	01Jan2006, 12:12	7.00

Cottonwood Creek 2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	1059.5	01Jan2006, 12:40	6.38
SCW-07	0.08	207.1	01Jan2006, 12:28	6.62
SCW-08	0.10	291.0	01Jan2006, 12:24	7.10
SCW-08A	0.05	188.2	01Jan2006, 12:14	7.98
SCW-09	0.20	481.3	01Jan2006, 12:34	7.00
SCW-10	0.13	498.9	01Jan2006, 12:10	6.91
SCW-11	0.40	1355.3	01Jan2006, 12:18	7.59
SCW-12	0.70	1574.1	01Jan2006, 12:38	7.14
SCW-13	0.17	580.4	01Jan2006, 12:16	7.30
SCW-14	0.10	320.0	01Jan2006, 12:20	7.43
SCW-15	0.17	648.0	01Jan2006, 12:14	7.84
SCW J-01	4.86	5258.7	01Jan2006, 13:08	7.13
SCW J-02	4.78	5240.5	01Jan2006, 13:04	7.14
SCW J-02A	4.60	5164.6	01Jan2006, 13:04	7.14
SCW J-03	4.44	5077.2	01Jan2006, 12:58	7.14
SCW J-03A	2.94	3664.1	01Jan2006, 13:40	7.13
SCW J-04	2.92	3702.5	01Jan2006, 13:28	7.13
SCW J-05	2.39	3379.9	01Jan2006, 13:18	7.29
SCW J-05A	2.10	3251.6	01Jan2006, 13:18	7.28
SCW J-06	2.02	3218.1	01Jan2006, 13:14	7.31
SCW J-06A	1.92	3194.3	01Jan2006, 13:10	7.32
SCW J-07	1.87	3333.5	01Jan2006, 12:48	7.30
SCW J-08	1.67	3033.0	01Jan2006, 12:34	7.33
SCW J-08A	1.50	2744.3	01Jan2006, 12:42	7.28
SCW J-09	1.37	2696.7	01Jan2006, 12:38	7.31
SCW J-10	0.97	2150.6	01Jan2006, 12:40	7.19
SCW J-11	0.27	644.4	01Jan2006, 12:18	7.35
SCW R-01	4.86	5246.6	01Jan2006, 13:10	7.13
SCW R-02	4.78	5214.0	01Jan2006, 13:08	7.14
SCW R-02A	4.60	5163.5	01Jan2006, 13:04	7.14
SCW R-03	4.44	5047.7	01Jan2006, 13:04	7.14
SCW R-03A	2.94	3657.1	01Jan2006, 13:42	7.13
SCW R-04	2.92	3658.5	01Jan2006, 13:40	7.13
SCW R-05	2.39	3299.2	01Jan2006, 13:32	7.29
SCW R-05A	2.10	3243.1	01Jan2006, 13:20	7.28
SCW R-06	2.02	3199.6	01Jan2006, 13:18	7.31
SCW R-06A	1.92	3156.5	01Jan2006, 13:14	7.32
SCW R-07	1.87	3171.0	01Jan2006, 13:10	7.30

Cottonwood Creek 2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	2960.7	01Jan2006, 12:54	7.33
SCW R-08A	1.50	2736.3	01Jan2006, 12:46	7.28
SCW R-09	1.37	2638.8	01Jan2006, 12:46	7.31
SCW R-10	0.97	2115.1	01Jan2006, 12:48	7.19
SCW R-11	0.27	578.5	01Jan2006, 12:42	7.35
SCW R-12	0.10	320.0	01Jan2006, 12:52	7.43
SCW R-13	0.17	648.0	01Jan2006, 12:20	7.84
UNA-01	0.42	1259.1	01Jan2006, 12:22	7.07
UNA-2	0.32	1100.4	01Jan2006, 12:16	7.31
UNA-3	0.13	373.2	01Jan2006, 12:24	6.94
UNA-4	0.35	1160.0	01Jan2006, 12:18	7.15
UNA J-01	1.22	3835.3	01Jan2006, 12:20	7.14
UNA J-2	0.80	2600.0	01Jan2006, 12:18	7.18
UNA J-3	0.48	1514.0	01Jan2006, 12:18	7.09
UNA R-1	1.22	3579.4	01Jan2006, 12:26	7.14
UNA R-2	0.80	2588.9	01Jan2006, 12:18	7.18
UNA R-3	0.48	1509.1	01Jan2006, 12:20	7.09
Warrior Creek	1.50	2414.7	01Jan2006, 12:36	7.18
WB-01	0.22	700.7	01Jan2006, 12:18	6.87

Cottonwood Creek 1% Chance Event

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Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	265.9	01Jan2006, 12:32	7.23
BB-01	0.29	1015.4	01Jan2006, 12:20	8.38
CWC-01	0.06	213.8	01Jan2006, 12:14	7.06
CWC-02	0.16	388.1	01Jan2006, 12:34	6.75
CWC-03	0.40	1119.9	01Jan2006, 12:28	7.17
CWC-04	0.03	93.1	01Jan2006, 12:26	7.74
CWC-05	0.27	810.0	01Jan2006, 12:28	7.82
CWC-06	0.32	1417.3	01Jan2006, 12:10	8.21
CWC-07	0.14	573.2	01Jan2006, 12:12	7.96
CWC-08	0.56	1610.2	01Jan2006, 12:24	6.76
CWC-09	0.22	850.8	01Jan2006, 12:16	8.15
CWC-10	0.58	1718.6	01Jan2006, 12:30	8.52
CWC-11	0.13	411.8	01Jan2006, 12:24	7.53
CWC-12	0.29	932.0	01Jan2006, 12:26	8.46
CWC-13	0.10	357.9	01Jan2006, 12:18	7.89
CWC-14	0.04	169.1	01Jan2006, 12:10	7.42
CWC-15	0.08	371.9	01Jan2006, 12:08	8.17
CWC-16	0.13	479.8	01Jan2006, 12:16	7.65
CWC-17	0.27	982.6	01Jan2006, 12:18	7.96
CWC-18	0.38	1119.9	01Jan2006, 12:30	8.14
CWC-19	0.13	531.0	01Jan2006, 12:12	7.85
CWC-20	0.15	547.6	01Jan2006, 12:18	8.01
CWC J-01	14.43	19198.5	01Jan2006, 13:44	7.97
CWC J-01A	12.87	17601.1	01Jan2006, 13:44	7.99
CWC J-02	12.71	17566.1	01Jan2006, 13:40	8.01
CWC J-02A	12.61	18276.2	01Jan2006, 13:28	8.02
CWC J-03	11.35	18636.1	01Jan2006, 13:08	8.02
CWC J-03A	10.91	17917.8	01Jan2006, 13:08	8.02
CWC J-04	10.88	17892.0	01Jan2006, 13:08	8.02
CWC J-05	10.61	17695.0	01Jan2006, 13:04	8.02
CWC J-06	5.72	11820.9	01Jan2006, 12:58	7.96
CWC J-07	5.40	11704.4	01Jan2006, 12:56	7.94
CWC J-08	5.10	11587.8	01Jan2006, 12:52	7.92
CWC J-08A	4.50	11203.0	01Jan2006, 12:46	7.96
CWC J-09	3.94	10599.1	01Jan2006, 12:40	8.13
CWC J-10	3.72	10455.7	01Jan2006, 12:36	8.13
CWC J-11	3.14	8845.1	01Jan2006, 12:36	8.05

Cottonwood Creek 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	8622.3	01Jan2006, 12:34	8.08
CWC J-12A	2.79	8099.2	01Jan2006, 12:34	8.09
CWC J-13	2.50	7334.1	01Jan2006, 12:32	8.05
CWC J-14	2.40	7511.1	01Jan2006, 12:26	8.06
CWC J-15	1.18	3663.8	01Jan2006, 12:22	7.97
CWC J-15A	1.14	3595.1	01Jan2006, 12:20	7.99
CWC J-16	1.06	3364.7	01Jan2006, 12:20	7.98
CWC J-17	0.93	2910.9	01Jan2006, 12:20	8.03
CWC J-18	0.53	1575.2	01Jan2006, 12:24	8.10
CWC R-01	14.43	19154.2	01Jan2006, 13:46	7.97
CWC R-01A	12.87	17477.5	01Jan2006, 13:48	7.99
CWC R-02	12.71	17530.7	01Jan2006, 13:44	8.01
CWC R-02A	12.61	17519.6	01Jan2006, 13:40	8.02
CWC R-03	11.35	17465.8	01Jan2006, 13:30	8.02
CWC R-03A	10.91	17886.7	01Jan2006, 13:10	8.02
CWC R-04	10.88	17891.1	01Jan2006, 13:08	8.02
CWC R-05	10.61	17624.3	01Jan2006, 13:08	8.02
CWC R-06	5.72	11692.6	01Jan2006, 13:02	7.96
CWC R-07	5.40	11632.5	01Jan2006, 12:58	7.94
CWC R-08	5.10	11500.6	01Jan2006, 12:56	7.92
CWC R-08A	4.50	10939.4	01Jan2006, 12:54	7.96
CWC R-09	3.94	10321.9	01Jan2006, 12:48	8.13
CWC R-10	3.72	10251.1	01Jan2006, 12:42	8.13
CWC R-11	3.14	8825.6	01Jan2006, 12:38	8.05
CWC R-12	3.01	8517.0	01Jan2006, 12:36	8.08
CWC R-12A	2.79	8093.0	01Jan2006, 12:34	8.09
CWC R-13	2.50	7266.4	01Jan2006, 12:36	8.05
CWC R-14	2.40	7084.6	01Jan2006, 12:34	8.06
CWC R-15	1.18	3527.4	01Jan2006, 12:26	7.97
CWC R-15A	1.14	3553.5	01Jan2006, 12:22	7.99
CWC R-16	1.06	3355.2	01Jan2006, 12:20	7.98
CWC R-17	0.93	2907.6	01Jan2006, 12:20	8.03
CWC R-18	0.53	1571.9	01Jan2006, 12:26	8.10
DB-01	0.08	235.3	01Jan2006, 12:24	6.96
DB-02	0.20	743.5	01Jan2006, 12:16	7.84
DB-03	0.32	1172.7	01Jan2006, 12:16	7.61
DB J-1	0.60	2120.5	01Jan2006, 12:18	7.60
DB J-2	0.52	1916.2	01Jan2006, 12:16	7.70

Cottonwood Creek 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	2111.8	01Jan2006, 12:18	7.60
DB R-2	0.52	1908.8	01Jan2006, 12:16	7.70
EB-01	0.35	959.7	01Jan2006, 12:32	7.89
GB-01	0.13	335.6	01Jan2006, 12:30	6.87
Henry Branch	0.37	1127.6	01Jan2006, 12:28	8.75
IHB-01	0.03	125.4	01Jan2006, 12:12	7.68
IHB-02	0.07	239.3	01Jan2006, 12:20	8.06
IHB-03	0.39	1248.2	01Jan2006, 12:24	8.10
IHB J-1	0.49	1458.7	01Jan2006, 12:32	8.07
IHB J-2	0.46	1478.4	01Jan2006, 12:24	8.09
IHB R-1	0.49	1323.5	01Jan2006, 12:50	8.07
IHB R-2	0.46	1406.1	01Jan2006, 12:34	8.09
IHB R-3	0.39	1246.8	01Jan2006, 12:26	8.10
JB-01	0.01	35.3	01Jan2006, 12:18	7.35
JB-02	0.43	1072.6	01Jan2006, 12:40	8.07
JB R-1	0.43	1056.7	01Jan2006, 12:44	8.07
Mountain Creek L...	14.49	19171.6	01Jan2006, 13:46	7.96
PC-01	0.07	139.2	01Jan2006, 12:48	6.67
PC-02	0.16	295.3	01Jan2006, 12:56	6.89
PC-03	0.04	138.8	01Jan2006, 12:18	7.38
PC-04	0.14	428.1	01Jan2006, 12:26	7.92
PC-05	0.67	1958.4	01Jan2006, 12:30	8.17
PC J-1	1.49	3556.1	01Jan2006, 12:48	7.81
PC J-1A	1.56	3608.3	01Jan2006, 12:54	7.76
PC J-2	1.20	3163.2	01Jan2006, 12:36	8.03
PC J-3	0.81	2205.1	01Jan2006, 12:34	8.12
PC R-01	1.49	3472.6	01Jan2006, 12:54	7.81
PC R-01A	1.56	3527.8	01Jan2006, 13:00	7.76
PC R-02	1.20	3019.2	01Jan2006, 12:48	8.03
PC R-03	0.81	2160.7	01Jan2006, 12:40	8.12
PC R-04	0.67	1825.7	01Jan2006, 12:38	8.17
RB-01	0.16	696.4	01Jan2006, 12:12	8.83
SCW-01	0.03	123.0	01Jan2006, 12:12	7.69
SCW-02	0.08	270.6	01Jan2006, 12:20	7.38
SCW-03	0.06	259.7	01Jan2006, 12:10	7.93
SCW-04	0.16	545.5	01Jan2006, 12:22	8.10
SCW-04A	0.12	579.7	01Jan2006, 12:08	8.24
SCW-05	0.02	83.9	01Jan2006, 12:12	7.99

Cottonwood Creek 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	1209.0	01Jan2006, 12:40	7.35
SCW-07	0.08	234.3	01Jan2006, 12:28	7.61
SCW-08	0.10	326.6	01Jan2006, 12:24	8.10
SCW-08A	0.05	208.1	01Jan2006, 12:14	8.99
SCW-09	0.20	543.0	01Jan2006, 12:34	8.00
SCW-10	0.13	557.2	01Jan2006, 12:10	7.90
SCW-11	0.40	1508.0	01Jan2006, 12:18	8.60
SCW-12	0.70	1774.6	01Jan2006, 12:38	8.13
SCW-13	0.17	647.3	01Jan2006, 12:16	8.30
SCW-14	0.10	357.2	01Jan2006, 12:20	8.43
SCW-15	0.17	716.9	01Jan2006, 12:14	8.86
SCW J-01	4.86	6070.8	01Jan2006, 13:06	8.10
SCW J-02	4.78	6056.5	01Jan2006, 13:02	8.12
SCW J-02A	4.60	5972.2	01Jan2006, 13:02	8.12
SCW J-03	4.44	5870.3	01Jan2006, 12:58	8.12
SCW J-03A	2.94	4389.9	01Jan2006, 13:30	8.12
SCW J-04	2.92	4464.2	01Jan2006, 13:20	8.12
SCW J-05	2.39	4048.0	01Jan2006, 13:10	8.29
SCW J-05A	2.10	3866.3	01Jan2006, 13:08	8.28
SCW J-06	2.02	3826.3	01Jan2006, 13:04	8.31
SCW J-06A	1.92	3777.2	01Jan2006, 13:00	8.32
SCW J-07	1.87	3881.1	01Jan2006, 12:46	8.30
SCW J-08	1.67	3531.5	01Jan2006, 12:34	8.34
SCW J-08A	1.50	3147.3	01Jan2006, 12:38	8.28
SCW J-09	1.37	3022.6	01Jan2006, 12:38	8.31
SCW J-10	0.97	2406.2	01Jan2006, 12:40	8.19
SCW J-11	0.27	721.9	01Jan2006, 12:18	8.35
SCW R-01	4.86	6057.4	01Jan2006, 13:10	8.10
SCW R-02	4.78	6016.8	01Jan2006, 13:08	8.12
SCW R-02A	4.60	5967.7	01Jan2006, 13:04	8.12
SCW R-03	4.44	5830.4	01Jan2006, 13:04	8.12
SCW R-03A	2.94	4377.6	01Jan2006, 13:32	8.12
SCW R-04	2.92	4383.8	01Jan2006, 13:30	8.12
SCW R-05	2.39	3891.7	01Jan2006, 13:22	8.29
SCW R-05A	2.10	3848.9	01Jan2006, 13:10	8.28
SCW R-06	2.02	3786.3	01Jan2006, 13:08	8.31
SCW R-06A	1.92	3730.7	01Jan2006, 13:04	8.32
SCW R-07	1.87	3743.0	01Jan2006, 13:00	8.30

Cottonwood Creek 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	3426.6	01Jan2006, 12:50	8.34
SCW R-08A	1.50	3142.4	01Jan2006, 12:40	8.28
SCW R-09	1.37	3003.2	01Jan2006, 12:42	8.31
SCW R-10	0.97	2362.2	01Jan2006, 12:48	8.19
SCW R-11	0.27	634.2	01Jan2006, 12:44	8.35
SCW R-12	0.10	357.2	01Jan2006, 12:52	8.43
SCW R-13	0.17	716.9	01Jan2006, 12:20	8.86
UNA-01	0.42	1412.8	01Jan2006, 12:22	8.06
UNA-2	0.32	1226.9	01Jan2006, 12:16	8.32
UNA-3	0.13	419.9	01Jan2006, 12:24	7.93
UNA-4	0.35	1297.0	01Jan2006, 12:18	8.15
UNA J-01	1.22	4294.3	01Jan2006, 12:20	8.14
UNA J-2	0.80	2907.6	01Jan2006, 12:18	8.18
UNA J-3	0.48	1695.8	01Jan2006, 12:18	8.09
UNA R-1	1.22	3983.7	01Jan2006, 12:26	8.14
UNA R-2	0.80	2896.4	01Jan2006, 12:18	8.18
UNA R-3	0.48	1690.8	01Jan2006, 12:20	8.09
Warrior Creek	1.50	2708.4	01Jan2006, 12:36	8.11
WB-01	0.22	786.5	01Jan2006, 12:18	7.87

Cottonwood Creek 0.2% Chance Event

HEC-HMS 3.5 [P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\HEC_HMS\C...

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	347.0	01Jan2006, 12:32	9.58
BB-01	0.29	1268.5	01Jan2006, 12:20	10.78
CWC-01	0.06	270.9	01Jan2006, 12:14	9.38
CWC-02	0.16	515.1	01Jan2006, 12:34	9.04
CWC-03	0.40	1455.8	01Jan2006, 12:28	9.51
CWC-04	0.03	118.9	01Jan2006, 12:26	10.12
CWC-05	0.27	1036.1	01Jan2006, 12:28	10.20
CWC-06	0.32	1723.5	01Jan2006, 12:10	10.60
CWC-07	0.14	705.4	01Jan2006, 12:12	10.34
CWC-08	0.56	2107.0	01Jan2006, 12:24	9.05
CWC-09	0.22	1053.9	01Jan2006, 12:16	10.54
CWC-10	0.58	2177.1	01Jan2006, 12:30	10.93
CWC-11	0.13	526.3	01Jan2006, 12:24	9.90
CWC-12	0.29	1175.2	01Jan2006, 12:26	10.86
CWC-13	0.10	449.0	01Jan2006, 12:18	10.26
CWC-14	0.04	208.8	01Jan2006, 12:10	9.77
CWC-15	0.08	450.4	01Jan2006, 12:08	10.56
CWC-16	0.13	601.1	01Jan2006, 12:16	10.01
CWC-17	0.27	1230.2	01Jan2006, 12:18	10.34
CWC-18	0.38	1428.3	01Jan2006, 12:30	10.54
CWC-19	0.13	654.7	01Jan2006, 12:12	10.22
CWC-20	0.15	684.8	01Jan2006, 12:18	10.39
CWC J-01	14.43	27012.4	01Jan2006, 13:32	10.33
CWC J-01A	12.87	24676.6	01Jan2006, 13:36	10.35
CWC J-02	12.71	24624.9	01Jan2006, 13:32	10.37
CWC J-02A	12.61	25081.8	01Jan2006, 13:24	10.38
CWC J-03	11.35	24830.5	01Jan2006, 13:06	10.38
CWC J-03A	10.91	23833.7	01Jan2006, 13:06	10.37
CWC J-04	10.88	23807.3	01Jan2006, 13:06	10.37
CWC J-05	10.61	23491.8	01Jan2006, 13:02	10.38
CWC J-06	5.72	15428.3	01Jan2006, 12:56	10.34
CWC J-07	5.40	15225.0	01Jan2006, 12:54	10.32
CWC J-08	5.10	15011.3	01Jan2006, 12:52	10.29
CWC J-08A	4.50	14353.7	01Jan2006, 12:46	10.34
CWC J-09	3.94	13467.7	01Jan2006, 12:42	10.52
CWC J-10	3.72	13469.6	01Jan2006, 12:38	10.52
CWC J-11	3.14	11463.2	01Jan2006, 12:36	10.44

Cottonwood Creek 0.2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	11251.8	01Jan2006, 12:34	10.47
CWC J-12A	2.79	10545.4	01Jan2006, 12:34	10.48
CWC J-13	2.50	9524.9	01Jan2006, 12:32	10.44
CWC J-14	2.40	9617.8	01Jan2006, 12:26	10.45
CWC J-15	1.18	4691.6	01Jan2006, 12:22	10.35
CWC J-15A	1.14	4566.2	01Jan2006, 12:20	10.37
CWC J-16	1.06	4269.4	01Jan2006, 12:20	10.36
CWC J-17	0.93	3697.9	01Jan2006, 12:20	10.41
CWC J-18	0.53	2008.1	01Jan2006, 12:24	10.49
CWC R-01	14.43	26975.4	01Jan2006, 13:36	10.33
CWC R-01A	12.87	24523.9	01Jan2006, 13:40	10.35
CWC R-02	12.71	24556.4	01Jan2006, 13:36	10.37
CWC R-02A	12.61	24545.8	01Jan2006, 13:32	10.38
CWC R-03	11.35	23757.7	01Jan2006, 13:26	10.38
CWC R-03A	10.91	23815.5	01Jan2006, 13:08	10.37
CWC R-04	10.88	23796.4	01Jan2006, 13:06	10.37
CWC R-05	10.61	23432.3	01Jan2006, 13:06	10.38
CWC R-06	5.72	15342.9	01Jan2006, 13:00	10.34
CWC R-07	5.40	15181.9	01Jan2006, 12:58	10.32
CWC R-08	5.10	14954.9	01Jan2006, 12:56	10.29
CWC R-08A	4.50	14167.5	01Jan2006, 12:54	10.34
CWC R-09	3.94	13205.5	01Jan2006, 12:50	10.52
CWC R-10	3.72	13039.2	01Jan2006, 12:44	10.52
CWC R-11	3.14	11400.9	01Jan2006, 12:38	10.44
CWC R-12	3.01	11032.4	01Jan2006, 12:36	10.47
CWC R-12A	2.79	10553.6	01Jan2006, 12:34	10.48
CWC R-13	2.50	9467.1	01Jan2006, 12:34	10.44
CWC R-14	2.40	9194.5	01Jan2006, 12:32	10.45
CWC R-15	1.18	4552.2	01Jan2006, 12:26	10.35
CWC R-15A	1.14	4544.4	01Jan2006, 12:22	10.37
CWC R-16	1.06	4254.1	01Jan2006, 12:22	10.36
CWC R-17	0.93	3689.5	01Jan2006, 12:20	10.41
CWC R-18	0.53	2006.9	01Jan2006, 12:26	10.49
DB-01	0.08	305.6	01Jan2006, 12:24	9.29
DB-02	0.20	928.3	01Jan2006, 12:16	10.22
DB-03	0.32	1472.1	01Jan2006, 12:16	9.96
DB J-1	0.60	2673.3	01Jan2006, 12:18	9.96
DB J-2	0.52	2400.4	01Jan2006, 12:16	10.06

Cottonwood Creek 0.2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	2655.4	01Jan2006, 12:20	9.96
DB R-2	0.52	2391.7	01Jan2006, 12:16	10.06
EB-01	0.35	1234.4	01Jan2006, 12:32	10.27
GB-01	0.13	442.2	01Jan2006, 12:30	9.17
Henry Branch	0.37	1431.7	01Jan2006, 12:30	11.18
IHB-01	0.03	154.5	01Jan2006, 12:10	10.06
IHB-02	0.07	301.4	01Jan2006, 12:22	10.45
IHB-03	0.39	1579.4	01Jan2006, 12:24	10.49
IHB J-1	0.49	1846.9	01Jan2006, 12:34	10.46
IHB J-2	0.46	1872.4	01Jan2006, 12:24	10.49
IHB R-1	0.49	1672.8	01Jan2006, 12:50	10.46
IHB R-2	0.46	1778.6	01Jan2006, 12:34	10.49
IHB R-3	0.39	1579.8	01Jan2006, 12:26	10.49
JB-01	0.01	44.6	01Jan2006, 12:18	9.72
JB-02	0.43	1382.6	01Jan2006, 12:40	10.47
JB R-1	0.43	1364.5	01Jan2006, 12:44	10.47
Mountain Creek L...	14.49	27003.1	01Jan2006, 13:36	10.32
PC-01	0.07	186.7	01Jan2006, 12:48	8.97
PC-02	0.16	394.9	01Jan2006, 12:54	9.22
PC-03	0.04	176.0	01Jan2006, 12:18	9.72
PC-04	0.14	545.4	01Jan2006, 12:26	10.31
PC-05	0.67	2496.9	01Jan2006, 12:30	10.56
PC J-1	1.49	4616.1	01Jan2006, 12:46	10.18
PC J-1A	1.56	4740.7	01Jan2006, 12:52	10.13
PC J-2	1.20	4062.0	01Jan2006, 12:38	10.42
PC J-3	0.81	2849.7	01Jan2006, 12:36	10.52
PC R-01	1.49	4556.4	01Jan2006, 12:52	10.18
PC R-01A	1.56	4688.4	01Jan2006, 12:56	10.13
PC R-02	1.20	3895.3	01Jan2006, 12:48	10.42
PC R-03	0.81	2778.9	01Jan2006, 12:40	10.52
PC R-04	0.67	2361.4	01Jan2006, 12:38	10.56
RB-01	0.16	842.7	01Jan2006, 12:12	11.25
SCW-01	0.03	151.8	01Jan2006, 12:12	10.06
SCW-02	0.08	344.2	01Jan2006, 12:20	9.74
SCW-03	0.06	317.6	01Jan2006, 12:10	10.32
SCW-04	0.16	686.9	01Jan2006, 12:22	10.49
SCW-04A	0.12	698.2	01Jan2006, 12:08	10.62
SCW-05	0.02	102.9	01Jan2006, 12:12	10.38

Cottonwood Creek 0.2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	1589.4	01Jan2006, 12:42	9.68
SCW-07	0.08	301.2	01Jan2006, 12:28	9.98
SCW-08	0.10	412.9	01Jan2006, 12:24	10.49
SCW-08A	0.05	252.8	01Jan2006, 12:14	11.42
SCW-09	0.20	698.2	01Jan2006, 12:34	10.38
SCW-10	0.13	683.1	01Jan2006, 12:10	10.27
SCW-11	0.40	1864.1	01Jan2006, 12:18	11.01
SCW-12	0.70	2284.0	01Jan2006, 12:40	10.53
SCW-13	0.17	800.8	01Jan2006, 12:16	10.70
SCW-14	0.10	445.3	01Jan2006, 12:20	10.84
SCW-15	0.17	871.1	01Jan2006, 12:14	11.28
SCW J-01	4.86	8505.2	01Jan2006, 13:24	10.43
SCW J-02	4.78	8484.2	01Jan2006, 13:20	10.44
SCW J-02A	4.60	8394.9	01Jan2006, 13:20	10.44
SCW J-03	4.44	8312.5	01Jan2006, 13:16	10.44
SCW J-03A	2.94	6487.3	01Jan2006, 13:18	10.51
SCW J-04	2.92	6625.6	01Jan2006, 13:06	10.51
SCW J-05	2.39	5820.7	01Jan2006, 12:56	10.69
SCW J-05A	2.10	5446.9	01Jan2006, 12:56	10.68
SCW J-06	2.02	5317.7	01Jan2006, 12:54	10.71
SCW J-06A	1.92	5155.1	01Jan2006, 12:52	10.72
SCW J-07	1.87	5166.6	01Jan2006, 12:42	10.70
SCW J-08	1.67	4604.1	01Jan2006, 12:30	10.74
SCW J-08A	1.50	4120.9	01Jan2006, 12:42	10.68
SCW J-09	1.37	4122.4	01Jan2006, 12:38	10.71
SCW J-10	0.97	3006.1	01Jan2006, 12:40	10.59
SCW J-11	0.27	905.4	01Jan2006, 12:18	10.75
SCW R-01	4.86	8498.5	01Jan2006, 13:26	10.43
SCW R-02	4.78	8457.0	01Jan2006, 13:24	10.44
SCW R-02A	4.60	8390.5	01Jan2006, 13:20	10.44
SCW R-03	4.44	8280.2	01Jan2006, 13:20	10.44
SCW R-03A	2.94	6452.6	01Jan2006, 13:20	10.51
SCW R-04	2.92	6476.1	01Jan2006, 13:18	10.51
SCW R-05	2.39	5583.6	01Jan2006, 13:10	10.69
SCW R-05A	2.10	5427.0	01Jan2006, 12:58	10.68
SCW R-06	2.02	5288.7	01Jan2006, 12:56	10.71
SCW R-06A	1.92	5136.2	01Jan2006, 12:54	10.72
SCW R-07	1.87	5097.3	01Jan2006, 12:52	10.70

Cottonwood Creek 0.2% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	4516.6	01Jan2006, 12:46	10.74
SCW R-08A	1.50	4105.9	01Jan2006, 12:42	10.68
SCW R-09	1.37	3944.6	01Jan2006, 12:42	10.71
SCW R-10	0.97	3021.2	01Jan2006, 12:42	10.59
SCW R-11	0.27	730.1	01Jan2006, 13:18	10.75
SCW R-12	0.10	445.3	01Jan2006, 12:52	10.84
SCW R-13	0.17	871.1	01Jan2006, 12:20	11.28
UNA-01	0.42	1780.3	01Jan2006, 12:22	10.46
UNA-2	0.32	1516.6	01Jan2006, 12:16	10.72
UNA-3	0.13	532.7	01Jan2006, 12:24	10.32
UNA-4	0.35	1615.4	01Jan2006, 12:18	10.54
UNA J-01	1.22	5378.1	01Jan2006, 12:20	10.54
UNA J-2	0.80	3625.4	01Jan2006, 12:18	10.58
UNA J-3	0.48	2121.7	01Jan2006, 12:18	10.48
UNA R-1	1.22	5065.6	01Jan2006, 12:26	10.54
UNA R-2	0.80	3611.6	01Jan2006, 12:20	10.58
UNA R-3	0.48	2120.7	01Jan2006, 12:20	10.48
Warrior Creek	1.50	3365.0	01Jan2006, 12:36	10.30
WB-01	0.22	986.0	01Jan2006, 12:18	10.25

Cottonwood Creek Ultimate Development 1% Chance Event

HEC-HMS 3.5 [P:\Active\11006.00_GP_FEMA_CTP_and_Roadmap\HEC_HMS\C...

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
AB-01	0.10	277.4	01Jan2006, 12:30	7.76
BB-01	0.29	1067.6	01Jan2006, 12:20	9.13
CWC-01	0.06	228.3	01Jan2006, 12:14	7.90
CWC-02	0.16	398.2	01Jan2006, 12:34	7.00
CWC-03	0.40	1147.4	01Jan2006, 12:28	7.49
CWC-04	0.03	93.1	01Jan2006, 12:26	7.74
CWC-05	0.27	813.2	01Jan2006, 12:28	7.88
CWC-06	0.32	1452.8	01Jan2006, 12:10	8.60
CWC-07	0.14	609.8	01Jan2006, 12:12	8.91
CWC-08	0.56	1891.3	01Jan2006, 12:22	8.65
CWC-09	0.22	878.1	01Jan2006, 12:16	8.64
CWC-10	0.58	1791.8	01Jan2006, 12:30	9.17
CWC-11	0.13	430.7	01Jan2006, 12:22	8.22
CWC-12	0.29	944.4	01Jan2006, 12:26	8.65
CWC-13	0.10	358.5	01Jan2006, 12:18	7.90
CWC-14	0.04	168.9	01Jan2006, 12:10	7.42
CWC-15	0.08	377.1	01Jan2006, 12:08	8.37
CWC-16	0.13	510.6	01Jan2006, 12:16	8.53
CWC-17	0.27	1005.2	01Jan2006, 12:16	8.27
CWC-18	0.38	1142.9	01Jan2006, 12:30	8.45
CWC-19	0.13	531.5	01Jan2006, 12:12	7.86
CWC-20	0.15	558.5	01Jan2006, 12:18	8.29
CWC J-01	14.43	20386.8	01Jan2006, 13:42	8.39
CWC J-01A	12.87	18596.6	01Jan2006, 13:40	8.41
CWC J-02	12.71	18564.7	01Jan2006, 13:36	8.43
CWC J-02A	12.61	19195.9	01Jan2006, 13:26	8.43
CWC J-03	11.35	19487.0	01Jan2006, 13:08	8.47
CWC J-03A	10.91	18731.5	01Jan2006, 13:08	8.48
CWC J-04	10.88	18718.2	01Jan2006, 13:06	8.48
CWC J-05	10.61	18503.2	01Jan2006, 13:04	8.50
CWC J-06	5.72	12226.5	01Jan2006, 12:58	8.44
CWC J-07	5.40	12095.0	01Jan2006, 12:56	8.43
CWC J-08	5.10	11965.9	01Jan2006, 12:52	8.40
CWC J-08A	4.50	11548.8	01Jan2006, 12:46	8.47
CWC J-09	3.94	10823.5	01Jan2006, 12:40	8.44
CWC J-10	3.72	10674.5	01Jan2006, 12:36	8.43
CWC J-11	3.14	8993.6	01Jan2006, 12:36	8.30

Cottonwood Creek Ultimate Development 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
CWC J-12	3.01	8755.9	01Jan2006, 12:34	8.30
CWC J-12A	2.79	8204.3	01Jan2006, 12:34	8.25
CWC J-13	2.50	7424.2	01Jan2006, 12:32	8.20
CWC J-14	2.40	7600.6	01Jan2006, 12:26	8.22
CWC J-15	1.18	3752.8	01Jan2006, 12:22	8.29
CWC J-15A	1.14	3682.8	01Jan2006, 12:20	8.32
CWC J-16	1.06	3448.1	01Jan2006, 12:20	8.32
CWC J-17	0.93	2967.4	01Jan2006, 12:20	8.29
CWC J-18	0.53	1608.4	01Jan2006, 12:24	8.40
CWC R-01	14.43	20371.1	01Jan2006, 13:44	8.39
CWC R-01A	12.87	18468.1	01Jan2006, 13:44	8.41
CWC R-02	12.71	18518.8	01Jan2006, 13:40	8.43
CWC R-02A	12.61	18512.5	01Jan2006, 13:36	8.43
CWC R-03	11.35	18328.2	01Jan2006, 13:28	8.47
CWC R-03A	10.91	18699.4	01Jan2006, 13:08	8.48
CWC R-04	10.88	18704.9	01Jan2006, 13:08	8.48
CWC R-05	10.61	18431.6	01Jan2006, 13:06	8.50
CWC R-06	5.72	12102.6	01Jan2006, 13:02	8.44
CWC R-07	5.40	12035.8	01Jan2006, 12:58	8.43
CWC R-08	5.10	11887.0	01Jan2006, 12:56	8.40
CWC R-08A	4.50	11283.6	01Jan2006, 12:52	8.47
CWC R-09	3.94	10539.9	01Jan2006, 12:48	8.44
CWC R-10	3.72	10458.5	01Jan2006, 12:40	8.43
CWC R-11	3.14	8971.5	01Jan2006, 12:38	8.30
CWC R-12	3.01	8653.2	01Jan2006, 12:36	8.30
CWC R-12A	2.79	8198.7	01Jan2006, 12:34	8.25
CWC R-13	2.50	7355.2	01Jan2006, 12:36	8.20
CWC R-14	2.40	7173.2	01Jan2006, 12:32	8.22
CWC R-15	1.18	3616.8	01Jan2006, 12:26	8.29
CWC R-15A	1.14	3642.6	01Jan2006, 12:22	8.32
CWC R-16	1.06	3440.5	01Jan2006, 12:20	8.32
CWC R-17	0.93	2964.2	01Jan2006, 12:20	8.29
CWC R-18	0.53	1605.0	01Jan2006, 12:26	8.40
DB-01	0.08	270.9	01Jan2006, 12:24	8.83
DB-02	0.20	743.9	01Jan2006, 12:16	7.85
DB-03	0.32	1172.5	01Jan2006, 12:16	7.61
DB J-1	0.60	2158.2	01Jan2006, 12:18	7.85
DB J-2	0.52	1916.4	01Jan2006, 12:16	7.70

Cottonwood Creek Ultimate Development 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
DB R-1	0.60	2149.2	01Jan2006, 12:18	7.85
DB R-2	0.52	1909.1	01Jan2006, 12:16	7.70
EB-01	0.35	974.5	01Jan2006, 12:32	8.10
GB-01	0.13	354.5	01Jan2006, 12:30	7.47
Henry Branch	0.37	1127.6	01Jan2006, 12:28	8.75
IHB-01	0.03	127.7	01Jan2006, 12:10	7.95
IHB-02	0.07	241.0	01Jan2006, 12:20	8.17
IHB-03	0.39	1248.1	01Jan2006, 12:24	8.10
IHB J-1	0.49	1460.6	01Jan2006, 12:32	8.10
IHB J-2	0.46	1479.9	01Jan2006, 12:24	8.11
IHB R-1	0.49	1324.8	01Jan2006, 12:50	8.10
IHB R-2	0.46	1407.3	01Jan2006, 12:34	8.11
IHB R-3	0.39	1246.7	01Jan2006, 12:26	8.10
JB-01	0.01	35.4	01Jan2006, 12:18	7.43
JB-02	0.43	1085.0	01Jan2006, 12:40	8.24
JB R-1	0.43	1069.1	01Jan2006, 12:44	8.24
Mountain Creek L...	14.49	20389.0	01Jan2006, 13:44	8.39
PC-01	0.07	150.0	01Jan2006, 12:46	7.52
PC-02	0.16	329.8	01Jan2006, 12:54	8.21
PC-03	0.04	148.5	01Jan2006, 12:16	8.23
PC-04	0.14	440.0	01Jan2006, 12:26	8.35
PC-05	0.67	2010.6	01Jan2006, 12:30	8.56
PC J-1	1.49	3663.0	01Jan2006, 12:48	8.29
PC J-1A	1.56	3725.3	01Jan2006, 12:54	8.26
PC J-2	1.20	3226.6	01Jan2006, 12:36	8.39
PC J-3	0.81	2253.1	01Jan2006, 12:34	8.53
PC R-01	1.49	3579.8	01Jan2006, 12:54	8.29
PC R-01A	1.56	3650.4	01Jan2006, 13:00	8.26
PC R-02	1.20	3079.3	01Jan2006, 12:48	8.39
PC R-03	0.81	2207.7	01Jan2006, 12:40	8.53
PC R-04	0.67	1866.0	01Jan2006, 12:38	8.56
RB-01	0.16	710.1	01Jan2006, 12:12	9.15
SCW-01	0.03	123.2	01Jan2006, 12:12	7.71
SCW-02	0.08	277.0	01Jan2006, 12:20	7.72
SCW-03	0.06	262.9	01Jan2006, 12:10	8.12
SCW-04	0.16	586.9	01Jan2006, 12:20	9.21
SCW-04A	0.12	579.9	01Jan2006, 12:08	8.23
SCW-05	0.02	88.4	01Jan2006, 12:12	8.84

Cottonwood Creek Ultimate Development 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW-06	0.53	1409.1	01Jan2006, 12:40	9.22
SCW-07	0.08	261.4	01Jan2006, 12:28	9.28
SCW-08	0.10	339.0	01Jan2006, 12:24	8.68
SCW-08A	0.05	212.3	01Jan2006, 12:14	9.29
SCW-09	0.20	549.5	01Jan2006, 12:34	8.17
SCW-10	0.13	557.9	01Jan2006, 12:10	7.93
SCW-11	0.40	1537.9	01Jan2006, 12:18	8.92
SCW-12	0.70	1829.3	01Jan2006, 12:38	8.58
SCW-13	0.17	662.4	01Jan2006, 12:16	8.66
SCW-14	0.10	362.6	01Jan2006, 12:20	8.66
SCW-15	0.17	735.0	01Jan2006, 12:14	9.27
SCW J-01	4.86	6466.5	01Jan2006, 13:04	8.57
SCW J-02	4.78	6461.1	01Jan2006, 13:00	8.59
SCW J-02A	4.60	6374.4	01Jan2006, 13:00	8.60
SCW J-03	4.44	6267.3	01Jan2006, 12:54	8.58
SCW J-03A	2.94	4637.6	01Jan2006, 13:28	8.82
SCW J-04	2.92	4709.4	01Jan2006, 13:18	8.82
SCW J-05	2.39	4210.5	01Jan2006, 13:08	8.74
SCW J-05A	2.10	4013.3	01Jan2006, 13:06	8.68
SCW J-06	2.02	3959.0	01Jan2006, 13:02	8.66
SCW J-06A	1.92	3893.6	01Jan2006, 12:58	8.66
SCW J-07	1.87	4008.8	01Jan2006, 12:46	8.64
SCW J-08	1.67	3631.0	01Jan2006, 12:34	8.69
SCW J-08A	1.50	3226.7	01Jan2006, 12:38	8.63
SCW J-09	1.37	3106.2	01Jan2006, 12:38	8.70
SCW J-10	0.97	2473.2	01Jan2006, 12:38	8.60
SCW J-11	0.27	738.7	01Jan2006, 12:18	8.66
SCW R-01	4.86	6454.8	01Jan2006, 13:08	8.57
SCW R-02	4.78	6410.4	01Jan2006, 13:06	8.59
SCW R-02A	4.60	6367.8	01Jan2006, 13:02	8.60
SCW R-03	4.44	6214.3	01Jan2006, 13:00	8.58
SCW R-03A	2.94	4621.2	01Jan2006, 13:30	8.82
SCW R-04	2.92	4631.2	01Jan2006, 13:28	8.82
SCW R-05	2.39	4034.8	01Jan2006, 13:20	8.74
SCW R-05A	2.10	3992.9	01Jan2006, 13:08	8.68
SCW R-06	2.02	3921.5	01Jan2006, 13:06	8.66
SCW R-06A	1.92	3854.1	01Jan2006, 13:02	8.66
SCW R-07	1.87	3856.9	01Jan2006, 12:58	8.64

Cottonwood Creek Ultimate Development 1% Chance Event

Hydrologic Element	Drainage Area (MI2)	Peak Discha... (CFS)	Time of Peak	Volume (IN)
SCW R-08	1.67	3534.1	01Jan2006, 12:48	8.69
SCW R-08A	1.50	3222.5	01Jan2006, 12:40	8.63
SCW R-09	1.37	3076.2	01Jan2006, 12:42	8.70
SCW R-10	0.97	2413.7	01Jan2006, 12:50	8.60
SCW R-11	0.27	643.9	01Jan2006, 12:38	8.66
SCW R-12	0.10	362.6	01Jan2006, 12:52	8.66
SCW R-13	0.17	735.0	01Jan2006, 12:20	9.27
UNA-01	0.42	1412.8	01Jan2006, 12:22	8.06
UNA-2	0.32	1227.0	01Jan2006, 12:16	8.32
UNA-3	0.13	419.9	01Jan2006, 12:24	7.93
UNA-4	0.35	1297.1	01Jan2006, 12:18	8.15
UNA J-01	1.22	4294.2	01Jan2006, 12:20	8.14
UNA J-2	0.80	2907.8	01Jan2006, 12:18	8.18
UNA J-3	0.48	1695.9	01Jan2006, 12:18	8.09
UNA R-1	1.22	3983.8	01Jan2006, 12:26	8.14
UNA R-2	0.80	2896.2	01Jan2006, 12:18	8.18
UNA R-3	0.48	1690.9	01Jan2006, 12:20	8.09
Warrior Creek	1.50	2708.4	01Jan2006, 12:36	8.11
WB-01	0.22	842.1	01Jan2006, 12:18	8.94

HEC-RAS Plan: Jul11 Locations: User Defined

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)	
CWC MAIN STEM	SECTION_01	12689	10 yr	10313.00	475.00	482.13	479.94	482.46	0.000858	10.37	3308.99	953.01	0.70
CWC MAIN STEM	SECTION_01	12689	50 yr	15300.00	475.00	483.24	481.34	483.60	0.000815	11.17	4399.00	1009.52	0.70
CWC MAIN STEM	SECTION_01	12689	100 yr	17668.00	475.00	483.70	481.34	484.08	0.000803	11.51	4867.97	1029.51	0.70
CWC MAIN STEM	SECTION_01	12689	500 yr	23465.00	475.00	484.68	482.36	485.11	0.000801	12.37	5897.12	1072.26	0.71
CWC MAIN STEM	SECTION_01	12689	Ultimate 100 yr	18503.00	475.00	483.85	481.71	484.24	0.000801	11.63	5025.48	1035.73	0.70
CWC MAIN STEM	SECTION_01	12679	10 yr	10313.00	475.92	481.99	480.85	482.44	0.001324	11.32	2826.18	913.43	0.84
CWC MAIN STEM	SECTION_01	12679	50 yr	15300.00	475.92	483.11	481.73	483.58	0.001146	11.90	3896.43	985.86	0.81
CWC MAIN STEM	SECTION_01	12679	100 yr	17668.00	475.92	483.58	482.03	484.06	0.001088	12.13	4362.75	1005.47	0.80
CWC MAIN STEM	SECTION_01	12679	500 yr	23465.00	475.92	484.56	482.57	485.08	0.001029	12.85	5373.40	1048.25	0.79
CWC MAIN STEM	SECTION_01	12679	Ultimate 100 yr	18503.00	475.92	483.73	482.12	484.22	0.001075	12.23	4517.67	1012.29	0.80
CWC MAIN STEM	SECTION_01	12662	10 yr	10313.00	474.77	481.62	481.22	482.39	0.001268	11.43	2590.69	872.47	0.83
CWC MAIN STEM	SECTION_01	12662	50 yr	15300.00	474.77	482.79	481.92	483.54	0.001080	11.91	3658.31	947.03	0.79
CWC MAIN STEM	SECTION_01	12662	100 yr	17668.00	474.77	483.25	482.22	484.02	0.001056	12.28	4100.03	981.61	0.79
CWC MAIN STEM	SECTION_01	12662	500 yr	23465.00	474.77	484.24	482.78	485.04	0.001000	12.98	5096.53	1028.90	0.79
CWC MAIN STEM	SECTION_01	12662	Ultimate 100 yr	18503.00	474.77	483.40	482.33	484.17	0.001045	12.39	4251.63	990.47	0.79
CWC MAIN STEM	SECTION_01	12645	10 yr	10313.00	471.00	481.89	478.69	482.26	0.000446	9.48	3755.73	883.15	0.53
CWC MAIN STEM	SECTION_01	12645	50 yr	15300.00	471.00	482.99	478.51	483.44	0.000524	11.02	4774.90	975.26	0.59
CWC MAIN STEM	SECTION_01	12645	100 yr	17668.00	471.00	483.44	481.29	483.92	0.000547	11.56	5219.90	1001.86	0.60
CWC MAIN STEM	SECTION_01	12645	500 yr	23465.00	471.00	484.42	482.04	484.95	0.000581	12.58	6218.16	1035.52	0.63
CWC MAIN STEM	SECTION_01	12645	Ultimate 100 yr	18503.00	471.00	483.59	481.41	484.08	0.000553	11.72	5372.27	1008.71	0.61
CWC MAIN STEM	SECTION_01	12482	10 yr	10313.00	470.00	481.77	480.45	482.11	0.001508	6.30	2566.46	756.60	0.36
CWC MAIN STEM	SECTION_01	12482	50 yr	15300.00	470.00	482.89	481.14	483.26	0.001440	6.62	3440.96	800.99	0.35
CWC MAIN STEM	SECTION_01	12482	100 yr	17668.00	470.00	483.34	481.39	483.73	0.001441	6.81	3804.52	822.31	0.36
CWC MAIN STEM	SECTION_01	12482	500 yr	23465.00	470.00	484.31	481.98	484.76	0.001446	7.20	4623.94	864.12	0.36
CWC MAIN STEM	SECTION_01	12482	Ultimate 100 yr	18503.00	470.00	483.49	481.49	483.89	0.001443	6.87	3928.50	830.44	0.36
CWC MAIN STEM	SECTION_01	12147	10 yr	10313.00	467.00	481.30	479.74	481.65	0.001305	6.49	2537.76	669.24	0.34
CWC MAIN STEM	SECTION_01	12147	50 yr	15300.00	467.00	482.38	480.45	482.79	0.001392	7.11	3280.15	698.83	0.35
CWC MAIN STEM	SECTION_01	12147	100 yr	17668.00	467.00	482.81	480.78	483.26	0.001431	7.37	3582.83	706.67	0.36
CWC MAIN STEM	SECTION_01	12147	500 yr	23465.00	467.00	483.73	481.47	484.27	0.001514	7.93	4238.35	715.08	0.37
CWC MAIN STEM	SECTION_01	12147	Ultimate 100 yr	18503.00	467.00	482.95	480.85	483.41	0.001442	7.45	3685.04	707.98	0.36
CWC MAIN STEM	SECTION_01	11763	10 yr	10313.00	467.00	480.28	479.56	480.97	0.002368	9.05	1966.47	600.23	0.46
CWC MAIN STEM	SECTION_01	11763	50 yr	15300.00	467.00	481.33	480.43	482.08	0.002492	9.82	2626.19	656.14	0.48
CWC MAIN STEM	SECTION_01	11763	100 yr	17668.00	467.00	481.74	480.74	482.53	0.002559	10.15	2897.97	675.82	0.49
CWC MAIN STEM	SECTION_01	11763	500 yr	23465.00	467.00	482.59	481.42	483.49	0.002748	10.96	3496.09	722.82	0.51
CWC MAIN STEM	SECTION_01	11763	Ultimate 100 yr	18503.00	467.00	481.88	480.85	482.68	0.002575	10.25	2992.86	682.31	0.49
CWC MAIN STEM	SECTION_01	11493	10 yr	10313.00	467.73	480.23	477.56	480.36	0.000573	4.04	3805.60	928.04	0.22
CWC MAIN STEM	SECTION_01	11493	50 yr	15300.00	467.73	481.26	478.18	481.43	0.000653	4.59	4785.34	978.00	0.24
CWC MAIN STEM	SECTION_01	11493	100 yr	17668.00	467.73	481.66	478.45	481.86	0.000692	4.84	5183.62	997.88	0.25
CWC MAIN STEM	SECTION_01	11493	500 yr	23465.00	467.73	482.51	478.89	482.76	0.000777	5.37	6051.34	1037.43	0.26

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
CWC MAIN STEM	SECTION_01	11493	Ultimate 100 yr	18503.00	467.73	481.80	478.47	482.00	0.000703	4.91	5322.68	1004.76	0.25
CWC MAIN STEM	SECTION_01	11042	10 yr	10313.00	467.00	480.10	477.03	480.15	0.000230	2.70	5687.88	1224.48	0.14
CWC MAIN STEM	SECTION_01	11042	50 yr	15300.00	467.00	481.11	477.46	481.19	0.000270	3.10	6938.83	1241.82	0.16
CWC MAIN STEM	SECTION_01	11042	100 yr	17668.00	467.00	481.51	477.62	481.60	0.000289	3.27	7432.28	1247.75	0.16
CWC MAIN STEM	SECTION_01	11042	500 yr	23465.00	467.00	482.35	478.04	482.47	0.000334	3.67	8482.00	1257.88	0.18
CWC MAIN STEM	SECTION_01	11042	Ultimate 100 yr	18503.00	467.00	481.64	477.71	481.74	0.000295	3.33	7603.51	1249.84	0.16
CWC MAIN STEM	SECTION_01	10760	10 yr	10382.00	465.37	479.98	474.77	480.08	0.000303	3.18	4843.13	1089.08	0.17
CWC MAIN STEM	SECTION_01	10760	50 yr	15447.00	465.37	480.97	476.52	481.10	0.000369	3.71	5927.66	1110.25	0.19
CWC MAIN STEM	SECTION_01	10760	100 yr	17865.00	465.37	481.35	477.31	481.50	0.000407	3.98	6358.04	1143.56	0.20
CWC MAIN STEM	SECTION_01	10760	500 yr	23781.00	465.37	482.16	479.21	482.35	0.000492	4.56	7295.79	1177.64	0.22
CWC MAIN STEM	SECTION_01	10760	Ultimate 100 yr	18718.00	465.37	481.49	477.58	481.63	0.000417	4.06	6510.91	1156.44	0.20
CWC MAIN STEM	SECTION_01	10721		Bridge									
CWC MAIN STEM	SECTION_01	10676	10 yr	10382.00	465.31	477.70	477.30	478.24	0.002712	7.85	2229.22	894.73	0.47
CWC MAIN STEM	SECTION_01	10676	50 yr	15447.00	465.31	478.78	477.85	479.25	0.002222	7.69	3231.13	976.87	0.44
CWC MAIN STEM	SECTION_01	10676	100 yr	17865.00	465.31	479.26	478.05	479.72	0.002013	7.56	3706.26	1003.36	0.42
CWC MAIN STEM	SECTION_01	10676	500 yr	23781.00	465.31	480.43	478.57	480.86	0.001593	7.23	4965.72	1150.38	0.38
CWC MAIN STEM	SECTION_01	10676	Ultimate 100 yr	18718.00	465.31	479.44	478.13	479.89	0.001926	7.48	3886.39	1012.48	0.41
CWC MAIN STEM	SECTION_01	10345	10 yr	10391.00	468.57	477.10	475.63	477.34	0.001697	5.26	2806.81	930.60	0.36
CWC MAIN STEM	SECTION_01	10345	50 yr	15464.00	468.57	478.29	476.16	478.54	0.001289	5.13	3922.00	944.66	0.33
CWC MAIN STEM	SECTION_01	10345	100 yr	17890.00	468.57	478.81	476.39	479.07	0.001179	5.13	4413.44	950.78	0.32
CWC MAIN STEM	SECTION_01	10345	500 yr	23807.00	468.57	480.10	476.93	480.35	0.000892	4.92	6218.08	1351.16	0.28
CWC MAIN STEM	SECTION_01	10345	Ultimate 100 yr	18732.00	468.57	479.01	476.47	479.27	0.001132	5.11	4600.28	954.28	0.31
CWC MAIN STEM	SECTION_01	9744	10 yr	10768.00	466.49	476.57	474.46	476.69	0.000984	3.61	4560.47	1210.91	0.22
CWC MAIN STEM	SECTION_01	9744	50 yr	16083.00	466.49	477.90	474.89	478.04	0.000824	3.65	6186.98	1246.10	0.21
CWC MAIN STEM	SECTION_01	9744	100 yr	18608.00	466.49	478.45	475.08	478.61	0.000784	3.70	6880.55	1258.78	0.21
CWC MAIN STEM	SECTION_01	9744	500 yr	24803.00	466.49	479.80	475.51	479.98	0.000680	3.75	8598.39	1284.00	0.20
CWC MAIN STEM	SECTION_01	9744	Ultimate 100 yr	19487.00	466.49	478.66	475.14	478.82	0.000760	3.70	7147.77	1263.48	0.21
CWC MAIN STEM	SECTION_01	9105	10 yr	10768.00	463.14	475.52	473.55	475.76	0.002914	6.44	3550.91	796.14	0.35
CWC MAIN STEM	SECTION_01	9105	50 yr	16083.00	463.14	476.97	474.21	477.23	0.002800	6.88	4733.51	832.42	0.35
CWC MAIN STEM	SECTION_01	9105	100 yr	18608.00	463.14	477.55	474.48	477.82	0.002788	7.08	5221.01	842.44	0.35
CWC MAIN STEM	SECTION_01	9105	500 yr	24803.00	463.14	478.99	475.07	479.29	0.002604	7.36	6453.39	866.49	0.35
CWC MAIN STEM	SECTION_01	9105	Ultimate 100 yr	19487.00	463.14	477.79	474.57	478.06	0.002731	7.10	5419.57	846.38	0.35
CWC MAIN STEM	SECTION_01	8570	10 yr	10768.00	461.00	474.22	471.49	474.42	0.002525	5.85	3578.93	707.73	0.33
CWC MAIN STEM	SECTION_01	8570	50 yr	16083.00	461.00	475.68	472.21	475.93	0.002561	6.46	4623.73	721.48	0.34
CWC MAIN STEM	SECTION_01	8570	100 yr	18608.00	461.00	476.23	472.52	476.51	0.002668	6.81	5024.98	731.76	0.35
CWC MAIN STEM	SECTION_01	8570	500 yr	24803.00	461.00	477.67	473.16	478.00	0.002743	7.45	6118.49	794.26	0.36
CWC MAIN STEM	SECTION_01	8570	Ultimate 100 yr	19487.00	461.00	476.49	472.62	476.77	0.002633	6.86	5212.67	739.91	0.35

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
CWC MAIN STEM	SECTION_01	7925	10 yr	10768.00	460.00	472.62	470.59	472.97	0.003693	7.14	2921.12	774.06	0.40
CWC MAIN STEM	SECTION_01	7925	50 yr	16083.00	460.00	474.23	471.40	474.56	0.003298	7.47	4506.46	878.87	0.39
CWC MAIN STEM	SECTION_01	7925	100 yr	18608.00	460.00	474.79	471.69	475.13	0.003266	7.68	4998.30	891.49	0.39
CWC MAIN STEM	SECTION_01	7925	500 yr	24803.00	460.00	476.36	472.50	476.70	0.002934	7.90	6529.60	1021.22	0.38
CWC MAIN STEM	SECTION_01	7925	Ultimate 100 yr	19487.00	460.00	475.04	471.81	475.40	0.003336	7.87	5228.70	949.33	0.40
CWC MAIN STEM	SECTION_01	7300	10 yr	10768.00	459.00	471.48	468.25	471.60	0.001081	4.39	5162.41	1000.10	0.23
CWC MAIN STEM	SECTION_01	7300	50 yr	16083.00	459.00	473.20	468.92	473.33	0.001045	4.73	6938.65	1073.71	0.23
CWC MAIN STEM	SECTION_01	7300	100 yr	18608.00	459.00	473.75	469.18	473.89	0.001104	5.00	7536.06	1095.24	0.24
CWC MAIN STEM	SECTION_01	7300	500 yr	24803.00	459.00	475.43	469.79	475.58	0.001042	5.24	9452.11	1184.22	0.23
CWC MAIN STEM	SECTION_01	7300	Ultimate 100 yr	19487.00	459.00	474.00	469.29	474.14	0.001093	5.03	7812.28	1105.15	0.24
CWC MAIN STEM	SECTION_01	6941	10 yr	10768.00	459.00	471.21	464.99	471.27	0.000715	3.35	6047.77	962.54	0.18
CWC MAIN STEM	SECTION_01	6941	50 yr	16083.00	459.00	472.92	467.37	473.00	0.000778	3.85	7775.25	1047.78	0.19
CWC MAIN STEM	SECTION_01	6941	100 yr	18608.00	459.00	473.45	467.62	473.54	0.000844	4.12	8334.45	1061.26	0.20
CWC MAIN STEM	SECTION_01	6941	500 yr	24803.00	459.00	475.14	468.15	475.25	0.000832	4.44	10166.33	1111.44	0.20
CWC MAIN STEM	SECTION_01	6941	Ultimate 100 yr	19487.00	459.00	473.70	467.70	473.79	0.000839	4.17	8604.01	1066.45	0.20
CWC MAIN STEM	SECTION_01	6495	10 yr	10768.00	458.51	470.53	467.20	470.75	0.002406	6.13	3596.33	722.55	0.33
CWC MAIN STEM	SECTION_01	6495	50 yr	16083.00	458.51	472.21	468.44	472.45	0.002266	6.55	4847.40	765.09	0.33
CWC MAIN STEM	SECTION_01	6495	100 yr	18608.00	458.51	472.67	468.78	472.95	0.002459	7.00	5205.12	774.42	0.34
CWC MAIN STEM	SECTION_01	6495	500 yr	24803.00	458.51	474.39	469.54	474.68	0.002241	7.26	6580.42	827.70	0.34
CWC MAIN STEM	SECTION_01	6495	Ultimate 100 yr	19487.00	458.51	472.93	468.91	473.21	0.002415	7.03	5406.52	781.30	0.34
CWC MAIN STEM	SECTION_02	5978	10 yr	10469.00	457.91	469.85	465.03	469.91	0.000659	3.32	6255.64	1073.17	0.18
CWC MAIN STEM	SECTION_02	5978	50 yr	15859.00	457.91	471.55	465.72	471.63	0.000724	3.85	8137.79	1170.84	0.19
CWC MAIN STEM	SECTION_02	5978	100 yr	18248.00	457.91	471.96	466.00	472.05	0.000809	4.15	8617.17	1184.02	0.20
CWC MAIN STEM	SECTION_02	5978	500 yr	25045.00	457.91	473.73	466.73	473.83	0.000816	4.55	10851.17	1316.23	0.21
CWC MAIN STEM	SECTION_02	5978	Ultimate 100 yr	19196.00	457.91	472.23	466.09	472.32	0.000806	4.20	8939.47	1197.10	0.21
CWC MAIN STEM	SECTION_02	5662	10 yr	10469.00	457.00	469.58	464.78	469.66	0.000990	4.15	5447.14	1016.41	0.22
CWC MAIN STEM	SECTION_02	5662	50 yr	15859.00	457.00	471.26	465.71	471.36	0.001011	4.60	7196.37	1086.53	0.22
CWC MAIN STEM	SECTION_02	5662	100 yr	18248.00	457.00	471.63	466.01	471.75	0.001152	5.00	7601.63	1110.19	0.24
CWC MAIN STEM	SECTION_02	5662	500 yr	25045.00	457.00	473.41	467.68	473.54	0.001091	5.29	9652.48	1189.98	0.24
CWC MAIN STEM	SECTION_02	5662	Ultimate 100 yr	19196.00	457.00	471.90	466.20	472.02	0.001142	5.04	7906.76	1125.83	0.24
CWC MAIN STEM	SECTION_02	5486	10 yr	10469.00	457.63	469.20	466.69	469.39	0.002200	6.05	3809.42	900.32	0.32
CWC MAIN STEM	SECTION_02	5486	50 yr	15859.00	457.63	470.90	467.51	471.10	0.002024	6.39	5617.78	1042.13	0.32
CWC MAIN STEM	SECTION_02	5486	100 yr	18248.00	457.63	471.22	467.80	471.45	0.002257	6.86	5956.36	1050.85	0.34
CWC MAIN STEM	SECTION_02	5486	500 yr	25045.00	457.63	473.03	468.56	473.26	0.002044	7.12	7948.20	1216.63	0.33
CWC MAIN STEM	SECTION_02	5486	Ultimate 100 yr	19196.00	457.63	471.51	467.91	471.73	0.002156	6.81	6258.09	1056.61	0.33
CWC MAIN STEM	SECTION_02	5320	10 yr	10469.00	455.58	468.69	464.61	469.03	0.002085	6.01	2715.14	823.11	0.32
CWC MAIN STEM	SECTION_02	5320	50 yr	15859.00	455.58	470.49	466.04	470.77	0.001832	6.23	5060.13	926.57	0.31
CWC MAIN STEM	SECTION_02	5320	100 yr	18248.00	455.58	470.73	466.47	471.07	0.002166	6.86	5279.11	943.59	0.33
CWC MAIN STEM	SECTION_02	5320	500 yr	25045.00	455.58	472.57	467.59	472.91	0.002061	7.30	7208.47	1094.55	0.33

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
CWC MAIN STEM	SECTION_02	5320	Ultimate 100 yr	19196.00	455.58	471.03	466.63	471.37	0.002095	6.85	5550.46	968.84	0.33
CWC MAIN STEM	SECTION_02	5269		Bridge									
CWC MAIN STEM	SECTION_02	5211	10 yr	10469.00	455.30	467.86	465.31	468.39	0.004264	7.96	2167.17	611.57	0.44
CWC MAIN STEM	SECTION_02	5211	50 yr	15859.00	455.30	469.57	466.45	470.18	0.004603	9.19	3639.05	986.70	0.47
CWC MAIN STEM	SECTION_02	5211	100 yr	18248.00	455.30	470.21	466.81	470.81	0.004366	9.27	4218.20	1009.64	0.46
CWC MAIN STEM	SECTION_02	5211	500 yr	25045.00	455.30	471.89	468.11	472.40	0.003486	9.02	5766.13	1063.15	0.42
CWC MAIN STEM	SECTION_02	5211	Ultimate 100 yr	19196.00	455.30	470.47	467.19	471.05	0.004175	9.19	4457.54	1019.07	0.46
CWC MAIN STEM	SECTION_02	4966	10 yr	10469.00	455.10	467.34	463.53	467.47	0.001753	5.24	4349.02	888.91	0.29
CWC MAIN STEM	SECTION_02	4966	50 yr	15859.00	455.10	469.06	464.49	469.20	0.001640	5.61	5930.12	958.31	0.28
CWC MAIN STEM	SECTION_02	4966	100 yr	18248.00	455.10	469.72	464.77	469.87	0.001606	5.75	6571.74	981.23	0.28
CWC MAIN STEM	SECTION_02	4966	500 yr	25045.00	455.10	471.47	465.64	471.64	0.001488	6.03	8329.28	1028.18	0.28
CWC MAIN STEM	SECTION_02	4966	Ultimate 100 yr	19196.00	455.10	470.00	464.84	470.15	0.001576	5.78	6845.15	990.17	0.28
CWC MAIN STEM	SECTION_02	4663	10 yr	10092.00	454.90	466.95	463.55	467.10	0.001679	5.04	3952.55	747.07	0.28
CWC MAIN STEM	SECTION_02	4663	50 yr	15270.00	454.90	468.67	464.34	468.84	0.001664	5.57	5278.96	795.36	0.29
CWC MAIN STEM	SECTION_02	4663	100 yr	17541.00	454.90	469.33	464.64	469.52	0.001659	5.77	5809.77	811.90	0.29
CWC MAIN STEM	SECTION_02	4663	500 yr	24592.00	454.90	471.06	465.43	471.29	0.001694	6.36	7252.07	850.75	0.30
CWC MAIN STEM	SECTION_02	4663	Ultimate 100 yr	18565.00	454.90	469.60	464.76	469.80	0.001662	5.86	6034.75	818.71	0.29
CWC MAIN STEM	SECTION_02	4006	10 yr	10092.00	454.40	466.24	462.29	466.38	0.001620	4.73	3978.66	751.23	0.27
CWC MAIN STEM	SECTION_02	4006	50 yr	15270.00	454.40	467.99	463.00	468.16	0.001554	5.20	5327.77	795.28	0.28
CWC MAIN STEM	SECTION_02	4006	100 yr	17541.00	454.40	468.66	463.29	468.84	0.001535	5.37	5865.79	812.13	0.28
CWC MAIN STEM	SECTION_02	4006	500 yr	24592.00	454.40	470.39	464.10	470.61	0.001571	5.96	7310.83	861.10	0.29
CWC MAIN STEM	SECTION_02	4006	Ultimate 100 yr	18565.00	454.40	468.94	463.44	469.12	0.001538	5.46	6090.89	819.94	0.28
CWC MAIN STEM	SECTION_02	3730	10 yr	10092.00	454.20	465.88	462.08	466.02	0.001774	4.47	3868.58	711.60	0.28
CWC MAIN STEM	SECTION_02	3730	50 yr	15270.00	454.20	467.65	462.82	467.81	0.001687	4.97	5157.67	743.92	0.28
CWC MAIN STEM	SECTION_02	3730	100 yr	17541.00	454.20	468.32	463.13	468.50	0.001674	5.18	5661.80	755.03	0.28
CWC MAIN STEM	SECTION_02	3730	500 yr	24592.00	454.20	470.03	463.95	470.26	0.001718	5.80	6968.49	780.39	0.29
CWC MAIN STEM	SECTION_02	3730	Ultimate 100 yr	18565.00	454.20	468.59	463.27	468.78	0.001674	5.27	5869.96	757.70	0.28
CWC MAIN STEM	SECTION_02	3081	10 yr	10057.00	453.70	465.14	460.55	465.22	0.001125	3.62	4543.42	751.02	0.22
CWC MAIN STEM	SECTION_02	3081	50 yr	15277.00	453.70	466.91	461.22	467.03	0.001187	4.23	5930.69	810.94	0.23
CWC MAIN STEM	SECTION_02	3081	100 yr	17576.00	453.70	467.58	461.48	467.71	0.001204	4.45	6482.36	828.11	0.24
CWC MAIN STEM	SECTION_02	3081	500 yr	24645.00	453.70	469.26	462.22	469.43	0.001306	5.10	7907.56	868.71	0.25
CWC MAIN STEM	SECTION_02	3081	Ultimate 100 yr	18597.00	453.70	467.85	461.60	467.99	0.001217	4.55	6709.04	835.30	0.24
CWC MAIN STEM	SECTION_02	2442	10 yr	10057.00	453.30	464.57	459.85	464.67	0.001202	3.55	4360.99	755.36	0.23
CWC MAIN STEM	SECTION_02	2442	50 yr	15277.00	453.30	466.30	460.57	466.44	0.001282	4.20	5745.46	843.07	0.24
CWC MAIN STEM	SECTION_02	2442	100 yr	17576.00	453.30	466.97	460.86	467.12	0.001294	4.42	6320.36	881.96	0.25
CWC MAIN STEM	SECTION_02	2442	500 yr	24645.00	453.30	468.61	461.65	468.80	0.001368	5.02	7816.35	948.17	0.26
CWC MAIN STEM	SECTION_02	2442	Ultimate 100 yr	18597.00	453.30	467.24	460.99	467.39	0.001300	4.51	6558.13	892.54	0.25

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
CWC MAIN STEM	SECTION_02	1888	10 yr	10057.00	452.90	463.99	459.87	464.10	0.001353	4.26	4229.66	729.12	0.25
CWC MAIN STEM	SECTION_02	1888	50 yr	15277.00	452.90	465.69	460.55	465.83	0.001431	4.91	5507.01	776.46	0.26
CWC MAIN STEM	SECTION_02	1888	100 yr	17576.00	452.90	466.34	460.55	466.51	0.001454	5.15	6022.74	793.56	0.27
CWC MAIN STEM	SECTION_02	1888	500 yr	24645.00	452.90	467.91	461.79	468.13	0.001641	5.96	7306.12	846.90	0.29
CWC MAIN STEM	SECTION_02	1888	Ultimate 100 yr	18597.00	452.90	466.60	461.15	466.77	0.001474	5.26	6230.23	800.84	0.27
CWC MAIN STEM	SECTION_03	1288	10 yr	10113.00	452.40	463.48	458.71	463.52	0.000502	2.57	6800.26	1088.43	0.15
CWC MAIN STEM	SECTION_03	1288	50 yr	16233.00	452.40	465.13	459.32	465.19	0.000610	3.18	8615.60	1111.68	0.17
CWC MAIN STEM	SECTION_03	1288	100 yr	19161.00	452.40	465.77	459.57	465.84	0.000669	3.46	9329.53	1136.09	0.18
CWC MAIN STEM	SECTION_03	1288	500 yr	26985.00	452.40	467.26	460.16	467.37	0.000781	4.07	11052.33	1164.00	0.20
CWC MAIN STEM	SECTION_03	1288	Ultimate 100 yr	20387.00	452.40	466.02	459.66	466.10	0.000690	3.57	9613.69	1143.33	0.19
CWC MAIN STEM	SECTION_03	1075	10 yr	10025.00	452.27	463.33	459.48	463.39	0.000555	2.70	6005.41	1142.01	0.16
CWC MAIN STEM	SECTION_03	1075	50 yr	16233.00	452.27	464.96	461.00	465.05	0.000611	3.18	8381.79	1168.61	0.17
CWC MAIN STEM	SECTION_03	1075	100 yr	19136.00	452.27	465.58	461.62	465.68	0.000661	3.43	9113.09	1189.67	0.18
CWC MAIN STEM	SECTION_03	1075	500 yr	26973.00	452.27	467.05	462.50	467.18	0.000766	4.02	10885.59	1224.00	0.20
CWC MAIN STEM	SECTION_03	1075	Ultimate 100 yr	20389.00	452.27	465.83	461.88	465.93	0.000683	3.54	9403.06	1198.26	0.19
CWC MAIN STEM	SECTION_03	1005		Bridge									
CWC MAIN STEM	SECTION_03	914	10 yr	10025.00	449.00	459.86	455.62	460.73	0.003741	7.63	1459.86	937.82	0.42
CWC MAIN STEM	SECTION_03	914	50 yr	16233.00	449.00	462.69	458.08	462.86	0.000986	4.61	6367.44	1086.05	0.23
CWC MAIN STEM	SECTION_03	914	100 yr	19136.00	449.00	463.82	459.00	463.99	0.000866	4.57	7463.01	1157.98	0.21
CWC MAIN STEM	SECTION_03	914	500 yr	26973.00	449.00	466.57	461.37	466.72	0.000665	4.51	11280.79	1338.40	0.19
CWC MAIN STEM	SECTION_03	914	Ultimate 100 yr	20389.00	449.00	464.29	459.37	464.44	0.000792	4.47	8434.41	1170.90	0.21
CWC MAIN STEM	SECTION_03	738	10 yr	10025.00	449.00	459.76	457.38	459.92	0.001509	4.64	4299.75	995.95	0.26
CWC MAIN STEM	SECTION_03	738	50 yr	16233.00	449.00	462.56	458.20	462.68	0.000906	4.26	7189.33	1071.38	0.21
CWC MAIN STEM	SECTION_03	738	100 yr	19136.00	449.00	463.71	458.55	463.82	0.000785	4.20	8440.14	1100.58	0.20
CWC MAIN STEM	SECTION_03	738	500 yr	26973.00	449.00	466.48	459.25	466.59	0.000635	4.28	11607.47	1204.17	0.19
CWC MAIN STEM	SECTION_03	738	Ultimate 100 yr	20389.00	449.00	464.18	458.64	464.29	0.000745	4.19	8964.03	1109.37	0.20
CWC MAIN STEM	SECTION_03	523	10 yr	10025.00	449.00	459.52	453.78	459.69	0.000913	3.77	4147.97	863.71	0.21
CWC MAIN STEM	SECTION_03	523	50 yr	16233.00	449.00	462.37	455.54	462.52	0.000687	3.86	6689.71	918.49	0.19
CWC MAIN STEM	SECTION_03	523	100 yr	19136.00	449.00	463.53	456.27	463.69	0.000632	3.92	7769.83	940.08	0.18
CWC MAIN STEM	SECTION_03	523	500 yr	26973.00	449.00	466.31	458.44	466.48	0.000563	4.17	10491.37	1039.10	0.18
CWC MAIN STEM	SECTION_03	523	Ultimate 100 yr	20389.00	449.00	464.01	456.56	464.16	0.000613	3.95	8221.30	949.30	0.18
CWC MAIN STEM	SECTION_03	128	10 yr	10025.00	449.00	459.38	451.52	459.43	0.000253	1.81	5617.41	700.33	0.11
CWC MAIN STEM	SECTION_03	128	50 yr	16233.00	449.00	462.25	452.45	462.33	0.000253	2.19	7718.86	768.31	0.11
CWC MAIN STEM	SECTION_03	128	100 yr	19136.00	449.00	463.42	452.84	463.50	0.000253	2.33	8634.44	802.53	0.11
CWC MAIN STEM	SECTION_03	128	500 yr	26973.00	449.00	466.20	453.82	466.31	0.000253	2.66	11031.29	915.69	0.12
CWC MAIN STEM	SECTION_03	128	Ultimate 100 yr	20389.00	449.00	463.90	453.01	463.98	0.000253	2.39	9022.67	817.66	0.12
DANIELS BR	DANIELS BR	1718	10 yr	1226.00	498.00	503.66	503.18	504.16	0.006379	6.45	232.35	117.45	0.57
DANIELS BR	DANIELS BR	1718	50 yr	1705.00	498.00	504.22	503.65	504.78	0.006318	7.00	302.09	137.29	0.58

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
DANIELS BR	DANIELS BR	1718	100 yr	1916.00	498.00	504.43	503.82	505.02	0.006292	7.21	332.87	147.28	0.58
DANIELS BR	DANIELS BR	1718	500 yr	2401.00	498.00	504.83	504.22	505.48	0.006434	7.70	395.91	165.41	0.60
DANIELS BR	DANIELS BR	1718	Ultimate 100 yr	1916.00	498.00	504.44	503.82	505.02	0.006234	7.19	334.12	147.67	0.58
DANIELS BR	DANIELS BR	1159	10 yr	1345.00	495.00	498.72	498.62	499.25	0.012532	7.07	235.40	175.12	0.72
DANIELS BR	DANIELS BR	1159	50 yr	1883.00	495.00	499.00	498.96	499.70	0.013972	7.93	287.49	189.14	0.78
DANIELS BR	DANIELS BR	1159	100 yr	2121.00	495.00	499.10	499.10	499.87	0.014636	8.29	306.54	192.37	0.80
DANIELS BR	DANIELS BR	1159	500 yr	2674.00	495.00	499.37	499.37	500.26	0.014464	8.67	359.59	201.11	0.80
DANIELS BR	DANIELS BR	1159	Ultimate 100 yr	2158.00	495.00	499.12	499.12	499.90	0.014719	8.34	309.52	192.88	0.80
DANIELS BR	DANIELS BR	684	10 yr	1345.00	491.00	493.68	493.19	494.01	0.008865	4.69	293.74	178.54	0.61
DANIELS BR	DANIELS BR	684	50 yr	1883.00	491.00	494.23	493.52	494.57	0.006747	4.87	428.04	287.58	0.55
DANIELS BR	DANIELS BR	684	100 yr	2121.00	491.00	494.45	493.65	494.77	0.005823	4.80	494.14	302.62	0.52
DANIELS BR	DANIELS BR	684	500 yr	2674.00	491.00	494.99	494.18	495.27	0.004086	4.55	669.56	348.15	0.45
DANIELS BR	DANIELS BR	684	Ultimate 100 yr	2158.00	491.00	494.50	493.66	494.81	0.005571	4.75	508.82	306.26	0.51
INDIAN HILLS BR	INDIAN HILLS BR	3183	10 yr	802.00	473.94	480.61	479.70	481.62	0.012193	8.09	99.15	25.46	0.72
INDIAN HILLS BR	INDIAN HILLS BR	3183	50 yr	1111.00	473.94	481.56	480.60	482.80	0.012454	8.92	124.60	27.90	0.74
INDIAN HILLS BR	INDIAN HILLS BR	3183	100 yr	1248.00	473.94	481.93	480.96	483.26	0.012569	9.23	135.16	28.85	0.75
INDIAN HILLS BR	INDIAN HILLS BR	3183	500 yr	1579.00	473.94	482.68	481.75	484.24	0.013248	10.03	157.46	30.76	0.78
INDIAN HILLS BR	INDIAN HILLS BR	3183	Ultimate 100 yr	1248.00	473.94	481.93	480.96	483.26	0.012582	9.24	135.11	28.84	0.75
INDIAN HILLS BR	INDIAN HILLS BR	2988	10 yr	802.00	473.00	479.15	477.45	479.73	0.005869	6.12	130.97	31.44	0.53
INDIAN HILLS BR	INDIAN HILLS BR	2988	50 yr	1111.00	473.00	480.08	478.25	480.82	0.006312	6.88	161.42	34.03	0.56
INDIAN HILLS BR	INDIAN HILLS BR	2988	100 yr	1248.00	473.00	480.44	478.57	481.24	0.006515	7.18	173.80	35.12	0.57
INDIAN HILLS BR	INDIAN HILLS BR	2988	500 yr	1579.00	473.00	481.01	479.27	482.03	0.007755	8.12	194.43	37.15	0.63
INDIAN HILLS BR	INDIAN HILLS BR	2988	Ultimate 100 yr	1248.00	473.00	480.43	478.57	481.24	0.006536	7.19	173.60	35.10	0.57
INDIAN HILLS BR	INDIAN HILLS BR	2538	10 yr	802.00	469.52	475.02	474.49	475.97	0.013926	7.85	102.11	33.75	0.80
INDIAN HILLS BR	INDIAN HILLS BR	2538	50 yr	1111.00	469.52	475.72	475.22	476.92	0.013221	8.79	127.27	37.23	0.80
INDIAN HILLS BR	INDIAN HILLS BR	2538	100 yr	1248.00	469.52	476.03	475.51	477.30	0.012735	9.09	138.86	38.64	0.80
INDIAN HILLS BR	INDIAN HILLS BR	2538	500 yr	1579.00	469.52	477.13	476.14	478.31	0.008697	8.82	184.31	44.06	0.69
INDIAN HILLS BR	INDIAN HILLS BR	2538	Ultimate 100 yr	1248.00	469.52	476.04	475.51	477.31	0.012608	9.06	139.31	38.70	0.79
INDIAN HILLS BR	INDIAN HILLS BR	2328	10 yr	948.00	469.00	472.70	472.70	474.19	0.002651	9.78	96.94	33.12	1.01
INDIAN HILLS BR	INDIAN HILLS BR	2328	50 yr	1317.00	469.00	473.68	473.44	475.28	0.002084	10.14	129.90	34.05	0.91
INDIAN HILLS BR	INDIAN HILLS BR	2328	100 yr	1478.00	469.00	474.25	473.75	475.77	0.001719	9.89	149.42	34.61	0.84
INDIAN HILLS BR	INDIAN HILLS BR	2328	500 yr	1872.00	469.00	476.14	474.42	477.30	0.000875	8.66	217.49	37.95	0.62
INDIAN HILLS BR	INDIAN HILLS BR	2328	Ultimate 100 yr	1480.00	469.00	474.34	473.75	475.80	0.001622	9.71	152.48	34.69	0.82
INDIAN HILLS BR	INDIAN HILLS BR	2140	10 yr	948.00	467.70	472.84	470.81	473.37	0.000551	5.86	161.90	32.78	0.46
INDIAN HILLS BR	INDIAN HILLS BR	2140	50 yr	1317.00	467.70	474.10	471.56	474.75	0.000538	6.47	203.57	33.32	0.46
INDIAN HILLS BR	INDIAN HILLS BR	2140	100 yr	1478.00	467.70	474.61	471.85	475.31	0.000534	6.69	220.79	33.53	0.46
INDIAN HILLS BR	INDIAN HILLS BR	2140	500 yr	1872.00	467.70	476.34	472.56	477.04	0.000436	6.68	280.42	38.12	0.42
INDIAN HILLS BR	INDIAN HILLS BR	2140	Ultimate 100 yr	1480.00	467.70	474.68	471.87	475.36	0.000520	6.63	223.08	33.56	0.45

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
INDIAN HILLS BR	INDIAN HILLS BR	2088		Culvert									
INDIAN HILLS BR	INDIAN HILLS BR	2031	10 yr	948.00	465.00	472.63	467.66	472.72	0.000626	2.44	389.31	90.67	0.16
INDIAN HILLS BR	INDIAN HILLS BR	2031	50 yr	1317.00	465.00	473.58	468.23	473.72	0.000788	2.98	442.65	127.40	0.19
INDIAN HILLS BR	INDIAN HILLS BR	2031	100 yr	1478.00	465.00	473.92	468.46	474.08	0.000862	3.20	461.75	148.24	0.20
INDIAN HILLS BR	INDIAN HILLS BR	2031	500 yr	1872.00	465.00	475.04	468.94	475.15	0.000784	2.59	786.46	179.42	0.18
INDIAN HILLS BR	INDIAN HILLS BR	2031	Ultimate 100 yr	1480.00	465.00	473.99	468.46	474.15	0.000841	3.18	465.60	151.86	0.19
INDIAN HILLS BR	INDIAN HILLS BR	1700	10 yr	948.00	465.00	471.68	470.31	472.20	0.008297	5.92	183.07	86.21	0.52
INDIAN HILLS BR	INDIAN HILLS BR	1700	50 yr	1317.00	465.00	472.60	471.05	473.13	0.006880	6.18	275.93	113.45	0.49
INDIAN HILLS BR	INDIAN HILLS BR	1700	100 yr	1478.00	465.00	472.93	471.44	473.46	0.006559	6.30	314.31	121.32	0.48
INDIAN HILLS BR	INDIAN HILLS BR	1700	500 yr	1872.00	465.00	474.26	472.19	474.64	0.003779	5.55	504.36	159.08	0.38
INDIAN HILLS BR	INDIAN HILLS BR	1700	Ultimate 100 yr	1480.00	465.00	473.07	471.45	473.56	0.005855	6.06	331.98	125.70	0.46
INDIAN HILLS BR	INDIAN HILLS BR	1425	10 yr	948.00	465.00	470.38	469.41	470.56	0.003174	4.22	391.53	205.17	0.37
INDIAN HILLS BR	INDIAN HILLS BR	1425	50 yr	1317.00	465.00	471.82	469.79	471.92	0.001308	3.32	715.85	241.91	0.25
INDIAN HILLS BR	INDIAN HILLS BR	1425	100 yr	1478.00	465.00	472.22	469.93	472.32	0.001164	3.28	814.40	249.37	0.24
INDIAN HILLS BR	INDIAN HILLS BR	1425	500 yr	1872.00	465.00	473.93	470.24	473.98	0.000555	2.68	1258.98	271.97	0.17
INDIAN HILLS BR	INDIAN HILLS BR	1425	Ultimate 100 yr	1480.00	465.00	472.47	469.94	472.55	0.000957	3.05	875.63	253.08	0.22
INDIAN HILLS BR	INDIAN HILLS BR	1086	10 yr	962.00	461.00	470.00	466.09	470.02	0.000177	1.31	1009.11	330.48	0.09
INDIAN HILLS BR	INDIAN HILLS BR	1086	50 yr	1321.00	461.00	471.68	466.84	471.70	0.000098	1.14	1608.02	377.37	0.07
INDIAN HILLS BR	INDIAN HILLS BR	1086	100 yr	1459.00	461.00	472.10	466.96	472.12	0.000092	1.15	1768.14	387.41	0.07
INDIAN HILLS BR	INDIAN HILLS BR	1086	500 yr	1847.00	461.00	473.87	467.22	473.88	0.000058	1.04	2488.53	422.67	0.06
INDIAN HILLS BR	INDIAN HILLS BR	1086	Ultimate 100 yr	1461.00	461.00	472.37	466.96	472.38	0.000079	1.09	1872.35	393.12	0.07
INDIAN HILLS BR	INDIAN HILLS BR	778	10 yr	962.00	459.79	469.98	465.67	469.99	0.000047	0.73	1654.86	434.00	0.05
INDIAN HILLS BR	INDIAN HILLS BR	778	50 yr	1321.00	459.79	471.67	465.92	471.68	0.000029	0.66	2473.57	516.91	0.04
INDIAN HILLS BR	INDIAN HILLS BR	778	100 yr	1459.00	459.79	472.09	466.01	472.10	0.000028	0.66	2693.30	530.91	0.04
INDIAN HILLS BR	INDIAN HILLS BR	778	500 yr	1847.00	459.79	473.87	466.21	473.87	0.000019	0.61	3698.48	614.28	0.03
INDIAN HILLS BR	INDIAN HILLS BR	778	Ultimate 100 yr	1461.00	459.79	472.36	466.01	472.37	0.000024	0.63	2837.06	540.51	0.04
NF CWC	SECTION_02	12725	10 yr	4889.00	523.08	531.06	529.43	532.39	0.004082	9.25	528.71	96.87	0.65
NF CWC	SECTION_02	12725	50 yr	7215.00	523.08	532.49	530.87	534.16	0.004425	10.38	695.00	103.59	0.68
NF CWC	SECTION_02	12725	100 yr	8106.00	523.08	532.91	531.36	534.79	0.004669	11.02	735.78	105.91	0.70
NF CWC	SECTION_02	12725	500 yr	10551.00	523.08	533.93	532.46	536.41	0.005313	12.64	834.85	111.63	0.76
NF CWC	SECTION_02	12725	Ultimate 100 yr	8204.00	523.08	532.95	531.42	534.86	0.004697	11.09	740.05	106.14	0.71
NF CWC	SECTION_02	12556	10 yr	4889.00	523.00	530.33	529.21	531.54	0.005559	8.82	554.46	117.97	0.72
NF CWC	SECTION_02	12556	50 yr	7215.00	523.00	531.72	530.50	533.25	0.005598	9.91	728.00	130.70	0.74
NF CWC	SECTION_02	12556	100 yr	8106.00	523.00	532.18	530.96	533.82	0.005447	10.29	788.49	134.76	0.74
NF CWC	SECTION_02	12556	500 yr	10551.00	523.00	533.29	532.01	535.26	0.005221	11.28	944.38	146.88	0.74
NF CWC	SECTION_02	12556	Ultimate 100 yr	8204.00	523.00	532.23	531.01	533.89	0.005435	10.33	794.90	135.18	0.74
NF CWC	SECTION_02	12396	10 yr	4889.00	522.00	528.60	528.28	530.37	0.009254	10.67	458.23	107.40	0.91
NF CWC	SECTION_02	12396	50 yr	7215.00	522.00	530.21	529.61	532.17	0.007671	11.24	641.77	120.55	0.86

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_02	12396	100 yr	8106.00	522.00	530.69	530.05	532.77	0.007601	11.57	700.72	125.21	0.86
NF CWC	SECTION_02	12396	500 yr	10551.00	522.00	532.10	531.20	534.30	0.006728	11.90	886.95	138.57	0.83
NF CWC	SECTION_02	12396	Ultimate 100 yr	8204.00	522.00	530.77	530.10	532.84	0.007504	11.55	710.19	125.95	0.86
NF CWC	SECTION_02	12079	10 yr	5174.00	519.00	527.54	524.63	528.24	0.002162	6.69	773.41	121.34	0.47
NF CWC	SECTION_02	12079	50 yr	7780.00	519.00	529.35	526.01	530.28	0.002313	7.77	1001.09	131.57	0.50
NF CWC	SECTION_02	12079	100 yr	8629.00	519.00	529.86	526.42	530.87	0.002357	8.07	1069.35	134.61	0.50
NF CWC	SECTION_02	12079	500 yr	11258.00	519.00	531.38	527.61	532.58	0.002242	8.82	1290.27	160.67	0.51
NF CWC	SECTION_02	12079	Ultimate 100 yr	8756.00	519.00	529.94	526.48	530.96	0.002358	8.11	1080.14	135.17	0.51
NF CWC	SECTION_02	11615	10 yr	5174.00	517.45	526.08	523.95	527.01	0.003262	7.72	670.00	115.65	0.57
NF CWC	SECTION_02	11615	50 yr	7780.00	517.45	527.69	525.41	528.95	0.003551	9.00	864.75	126.21	0.61
NF CWC	SECTION_02	11615	100 yr	8629.00	517.45	528.15	525.83	529.51	0.003625	9.34	923.38	129.24	0.62
NF CWC	SECTION_02	11615	500 yr	11258.00	517.45	529.82	527.03	531.31	0.003304	9.81	1149.65	152.81	0.60
NF CWC	SECTION_02	11615	Ultimate 100 yr	8756.00	517.45	528.23	525.89	529.60	0.003613	9.37	934.02	129.78	0.62
NF CWC	SECTION_02	11107	10 yr	5174.00	516.00	524.76	522.01	525.52	0.002400	6.98	741.20	118.07	0.49
NF CWC	SECTION_02	11107	50 yr	7780.00	516.00	526.08	523.46	527.24	0.003084	8.63	901.49	125.82	0.57
NF CWC	SECTION_02	11107	100 yr	8629.00	516.00	526.45	523.88	527.73	0.003283	9.10	948.24	128.03	0.59
NF CWC	SECTION_02	11107	500 yr	11258.00	516.00	528.36	525.04	529.72	0.002808	9.36	1202.81	137.99	0.56
NF CWC	SECTION_02	11107	Ultimate 100 yr	8756.00	516.00	526.54	523.94	527.83	0.003262	9.12	960.16	128.57	0.59
NF CWC	SECTION_02	10741	10 yr	5174.00	516.00	524.43	521.25	524.75	0.001151	4.55	1155.51	229.89	0.34
NF CWC	SECTION_02	10741	50 yr	7780.00	516.00	525.79	522.31	526.25	0.001246	5.47	1483.46	267.38	0.36
NF CWC	SECTION_02	10741	100 yr	8629.00	516.00	526.18	522.58	526.68	0.001269	5.72	1586.30	284.55	0.37
NF CWC	SECTION_02	10741	500 yr	11258.00	516.00	528.35	523.40	528.79	0.000831	5.49	2339.28	361.83	0.31
NF CWC	SECTION_02	10741	Ultimate 100 yr	8756.00	516.00	526.29	522.64	526.78	0.001243	5.72	1615.69	291.60	0.37
NF CWC	SECTION_02	10550	10 yr	5301.00	510.20	524.44	516.49	524.56	0.000227	2.95	2419.17	559.21	0.16
NF CWC	SECTION_02	10550	50 yr	7911.00	510.20	525.86	518.14	526.01	0.000266	3.48	3330.13	694.99	0.18
NF CWC	SECTION_02	10550	100 yr	8850.00	510.20	526.27	518.62	526.43	0.000278	3.64	3617.80	713.04	0.19
NF CWC	SECTION_02	10550	500 yr	11468.00	510.20	528.47	519.84	528.60	0.000195	3.41	5386.11	860.46	0.16
NF CWC	SECTION_02	10550	Ultimate 100 yr	8994.00	510.20	526.38	518.70	526.54	0.000274	3.63	3695.82	717.72	0.18
NF CWC	SECTION_02	10464		Culvert									
NF CWC	SECTION_02	10386	10 yr	6278.00	508.30	521.87	514.96	522.42	0.000708	5.96	1054.08	155.41	0.30
NF CWC	SECTION_02	10386	50 yr	9359.00	508.30	524.70	516.70	525.21	0.000573	5.97	1988.01	384.61	0.27
NF CWC	SECTION_02	10386	100 yr	10459.00	508.30	525.66	517.26	526.12	0.000512	5.89	2367.02	409.81	0.26
NF CWC	SECTION_02	10386	500 yr	13472.00	508.30	528.20	518.68	528.55	0.000364	5.48	3568.45	513.07	0.23
NF CWC	SECTION_02	10386	Ultimate 100 yr	10675.00	508.30	525.84	517.37	526.30	0.000501	5.87	2442.73	414.73	0.26
NF CWC	SECTION_02	10207	10 yr	6278.00	509.42	520.53	519.27	521.96	0.003294	10.96	726.83	125.81	0.61
NF CWC	SECTION_02	10207	50 yr	9359.00	509.42	523.56	520.75	524.82	0.002177	10.64	1145.07	152.78	0.52
NF CWC	SECTION_02	10207	100 yr	10459.00	509.42	524.50	521.29	525.75	0.001992	10.66	1294.33	165.51	0.50
NF CWC	SECTION_02	10207	500 yr	13472.00	509.42	526.81	522.45	528.15	0.001831	11.32	1778.72	299.46	0.50

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_02	10207	Ultimate 100 yr	10675.00	509.42	524.68	521.39	525.92	0.001960	10.66	1324.57	168.27	0.50
NF CWC	SECTION_02	10053	10 yr	6278.00	509.00	520.88	515.95	521.35	0.000908	6.33	1273.56	192.69	0.33
NF CWC	SECTION_02	10053	50 yr	9359.00	509.00	523.91	518.03	524.36	0.000677	6.42	1894.09	218.57	0.30
NF CWC	SECTION_02	10053	100 yr	10459.00	509.00	524.85	518.65	525.31	0.000637	6.50	2105.54	229.91	0.30
NF CWC	SECTION_02	10053	500 yr	13472.00	509.00	527.24	520.04	527.71	0.000554	6.68	2690.06	261.34	0.28
NF CWC	SECTION_02	10053	Ultimate 100 yr	10675.00	509.00	525.03	518.76	525.49	0.000630	6.51	2147.27	232.13	0.29
NF CWC	SECTION_02	9883	10 yr	6278.00	505.96	520.83	514.85	521.19	0.000597	5.43	1472.56	206.90	0.27
NF CWC	SECTION_02	9883	50 yr	9359.00	505.96	523.88	517.47	524.24	0.000479	5.60	2124.61	224.03	0.25
NF CWC	SECTION_02	9883	100 yr	10459.00	505.96	524.82	517.88	525.20	0.000471	5.77	2344.52	242.18	0.25
NF CWC	SECTION_02	9883	500 yr	13472.00	505.96	527.22	519.21	527.60	0.000417	5.92	2948.25	261.57	0.24
NF CWC	SECTION_02	9883	Ultimate 100 yr	10675.00	505.96	525.00	517.99	525.38	0.000466	5.78	2388.70	243.56	0.25
NF CWC	SECTION_02	9817	10 yr	6278.00	508.24	519.60	516.49	521.02	0.002595	10.41	687.06	79.47	0.56
NF CWC	SECTION_02	9817	50 yr	9359.00	508.24	522.18	518.54	524.04	0.002620	12.07	899.99	86.11	0.58
NF CWC	SECTION_02	9817	100 yr	10459.00	508.24	522.97	519.20	524.98	0.002641	12.60	968.83	87.98	0.59
NF CWC	SECTION_02	9817	500 yr	13472.00	508.24	524.94	520.91	527.35	0.002711	13.93	1147.72	93.75	0.61
NF CWC	SECTION_02	9817	Ultimate 100 yr	10675.00	508.24	523.12	519.33	525.16	0.002644	12.70	982.16	88.33	0.59
NF CWC	SECTION_02	9797		Bridge									
NF CWC	SECTION_02	9769	10 yr	6278.00	507.00	515.33	515.33	518.50	0.008657	15.24	460.93	75.49	0.97
NF CWC	SECTION_02	9769	50 yr	9359.00	507.00	517.42	517.42	521.30	0.007901	17.11	627.54	84.98	0.97
NF CWC	SECTION_02	9769	100 yr	10459.00	507.00	518.15	518.15	522.19	0.007545	17.54	690.74	88.81	0.96
NF CWC	SECTION_02	9769	500 yr	13472.00	507.00	519.81	519.81	524.35	0.007132	18.83	844.05	95.47	0.95
NF CWC	SECTION_02	9769	Ultimate 100 yr	10675.00	507.00	518.28	518.28	522.35	0.007478	17.62	703.13	89.39	0.96
NF CWC	SECTION_02	9658	10 yr	6278.00	505.02	514.23	512.36	515.46	0.003964	8.90	708.05	124.59	0.63
NF CWC	SECTION_02	9658	50 yr	9359.00	505.02	515.06	513.93	517.14	0.005804	11.62	833.30	181.89	0.77
NF CWC	SECTION_02	9658	100 yr	10459.00	505.02	515.32	514.47	517.70	0.006398	12.47	883.18	208.83	0.82
NF CWC	SECTION_02	9658	500 yr	13472.00	505.02	516.58	516.58	519.02	0.005601	12.92	1205.44	290.31	0.78
NF CWC	SECTION_02	9658	Ultimate 100 yr	10675.00	505.02	515.36	514.60	517.81	0.006511	12.63	893.27	213.87	0.82
NF CWC	SECTION_02	9368	10 yr	6278.00	504.00	513.77	510.71	514.48	0.001740	6.99	1040.46	263.22	0.44
NF CWC	SECTION_02	9368	50 yr	9359.00	504.00	514.52	512.27	515.65	0.002578	9.04	1243.80	276.34	0.54
NF CWC	SECTION_02	9368	100 yr	10459.00	504.00	514.77	513.29	516.04	0.002826	9.64	1313.26	279.29	0.57
NF CWC	SECTION_02	9368	500 yr	13472.00	504.00	515.37	514.56	517.03	0.003468	11.16	1485.70	289.04	0.64
NF CWC	SECTION_02	9368	Ultimate 100 yr	10675.00	504.00	514.81	513.37	516.12	0.002876	9.76	1326.04	280.02	0.57
NF CWC	SECTION_02	9153	10 yr	6278.00	505.00	512.81	512.60	513.90	0.004558	8.92	890.03	374.80	0.67
NF CWC	SECTION_02	9153	50 yr	9359.00	505.00	513.81	513.52	514.96	0.004315	9.69	1292.08	427.02	0.67
NF CWC	SECTION_02	9153	100 yr	10459.00	505.00	514.12	513.79	515.29	0.004218	9.88	1427.03	440.09	0.67
NF CWC	SECTION_02	9153	500 yr	13472.00	505.00	514.89	514.32	516.11	0.004025	10.36	1780.23	479.84	0.66
NF CWC	SECTION_02	9153	Ultimate 100 yr	10675.00	505.00	514.17	513.84	515.35	0.004223	9.94	1449.95	442.40	0.67

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_02	8720	10 yr	6278.00	505.00	511.38	511.38	512.64	0.001251	10.88	1257.91	506.98	0.81
NF CWC	SECTION_02	8720	50 yr	9359.00	505.00	512.30	512.30	513.74	0.001306	12.30	1745.71	557.49	0.85
NF CWC	SECTION_02	8720	100 yr	10459.00	505.00	512.54	512.54	514.07	0.001355	12.84	1881.73	565.10	0.87
NF CWC	SECTION_02	8720	500 yr	13472.00	505.00	513.12	513.12	514.89	0.001484	14.20	2212.50	578.74	0.93
NF CWC	SECTION_02	8720	Ultimate 100 yr	10675.00	505.00	512.60	512.60	514.13	0.001345	12.88	1918.01	566.99	0.87
NF CWC	SECTION_02	8394	10 yr	6376.00	501.44	508.12	508.12	510.29	0.001603	12.18	663.18	201.89	0.91
NF CWC	SECTION_02	8394	50 yr	9409.00	501.44	509.65	509.65	512.08	0.001420	13.23	1032.38	286.00	0.89
NF CWC	SECTION_02	8394	100 yr	10603.00	501.44	510.29	510.29	512.67	0.001270	13.27	1241.15	355.06	0.85
NF CWC	SECTION_02	8394	500 yr	13470.00	501.44	511.30	511.30	513.85	0.001213	14.09	1614.17	389.32	0.85
NF CWC	SECTION_02	8394	Ultimate 100 yr	10824.00	501.44	510.38	510.38	512.77	0.001262	13.33	1272.05	357.87	0.85
NF CWC	SECTION_02	7881	10 yr	6376.00	497.00	505.69	503.89	506.70	0.003176	8.23	824.74	170.88	0.57
NF CWC	SECTION_02	7881	50 yr	9409.00	497.00	506.79	505.27	508.31	0.003915	10.16	1049.04	255.96	0.65
NF CWC	SECTION_02	7881	100 yr	10603.00	497.00	507.15	505.75	508.86	0.004182	10.83	1156.39	347.52	0.68
NF CWC	SECTION_02	7881	500 yr	13470.00	497.00	508.07	508.07	509.85	0.004006	11.41	1536.35	470.79	0.68
NF CWC	SECTION_02	7881	Ultimate 100 yr	10824.00	497.00	507.21	505.81	508.95	0.004212	10.93	1179.14	362.35	0.68
NF CWC	SECTION_02	7440	10 yr	6376.00	496.66	504.61	502.70	505.41	0.002458	7.62	1062.82	424.36	0.51
NF CWC	SECTION_02	7440	50 yr	9409.00	496.66	506.18	503.90	506.81	0.001754	7.37	1834.03	547.89	0.45
NF CWC	SECTION_02	7440	100 yr	10603.00	496.66	506.67	503.91	507.27	0.001606	7.33	2112.14	577.05	0.43
NF CWC	SECTION_02	7440	500 yr	13470.00	496.66	507.59	505.83	508.17	0.001446	7.42	2660.99	606.43	0.42
NF CWC	SECTION_02	7440	Ultimate 100 yr	10824.00	496.66	506.75	503.95	507.35	0.001586	7.33	2160.24	581.90	0.43
NF CWC	SECTION_02	6992	10 yr	6376.00	494.00	503.12	501.05	504.19	0.002930	8.49	846.76	227.94	0.56
NF CWC	SECTION_02	6992	50 yr	9409.00	494.00	504.51	502.97	505.78	0.002978	9.63	1239.63	344.78	0.58
NF CWC	SECTION_02	6992	100 yr	10603.00	494.00	505.01	503.77	506.30	0.002887	9.85	1427.38	401.84	0.58
NF CWC	SECTION_02	6992	500 yr	13470.00	494.00	506.15	504.92	507.32	0.002460	9.84	1931.53	475.03	0.54
NF CWC	SECTION_02	6992	Ultimate 100 yr	10824.00	494.00	505.13	503.89	506.39	0.002814	9.81	1476.04	411.70	0.57
NF CWC	SECTION_02	6455	10 yr	6376.00	493.00	501.78	499.98	502.65	0.002624	8.67	1055.23	322.65	0.54
NF CWC	SECTION_02	6455	50 yr	9409.00	493.00	503.85	501.57	504.38	0.001435	7.47	1978.51	500.47	0.42
NF CWC	SECTION_02	6455	100 yr	10603.00	493.00	504.47	502.61	504.95	0.001247	7.25	2298.95	522.91	0.39
NF CWC	SECTION_02	6455	500 yr	13470.00	493.00	505.74	503.23	506.17	0.001019	7.07	2991.38	571.94	0.36
NF CWC	SECTION_02	6455	Ultimate 100 yr	10824.00	493.00	504.62	502.68	505.09	0.001191	7.16	2377.61	528.06	0.38
NF CWC	SECTION_02	6201	10 yr	6376.00	491.91	501.64	499.00	502.04	0.001224	6.06	1566.66	482.57	0.37
NF CWC	SECTION_02	6201	50 yr	9409.00	491.91	503.79	500.53	504.05	0.000671	5.23	2718.93	583.04	0.29
NF CWC	SECTION_02	6201	100 yr	10603.00	491.91	504.42	501.26	504.66	0.000602	5.16	3094.95	606.40	0.27
NF CWC	SECTION_02	6201	500 yr	13470.00	491.91	505.69	501.86	505.93	0.000522	5.16	3898.85	658.66	0.26
NF CWC	SECTION_02	6201	Ultimate 100 yr	10824.00	491.91	504.57	501.32	504.81	0.000579	5.10	3187.44	611.46	0.27
NF CWC	SECTION_02	6158	10 yr	6376.00	494.30	501.66	499.60	501.96	0.001251	5.04	1674.81	505.74	0.36
NF CWC	SECTION_02	6158	50 yr	9409.00	494.30	503.80	500.70	504.00	0.000636	4.38	2840.34	583.41	0.27
NF CWC	SECTION_02	6158	100 yr	10603.00	494.30	504.43	500.95	504.63	0.000570	4.36	3213.54	604.26	0.26
NF CWC	SECTION_02	6158	500 yr	13470.00	494.30	505.70	501.48	505.90	0.000491	4.42	4006.50	645.37	0.24

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_02	6158	Ultimate 100 yr	10824.00	494.30	504.58	500.98	504.77	0.000548	4.32	3304.78	609.15	0.25
NF CWC	SECTION_02	6144	10 yr	6376.00	494.52	501.66	499.15	501.93	0.001079	4.79	1739.43	510.53	0.33
NF CWC	SECTION_02	6144	50 yr	9409.00	494.52	503.79	500.06	503.99	0.000578	4.25	2911.53	585.33	0.26
NF CWC	SECTION_02	6144	100 yr	10603.00	494.52	504.42	500.49	504.62	0.000523	4.24	3285.88	605.89	0.25
NF CWC	SECTION_02	6144	500 yr	13470.00	494.52	505.69	501.30	505.89	0.000458	4.33	4080.97	645.96	0.24
NF CWC	SECTION_02	6144	Ultimate 100 yr	10824.00	494.52	504.57	500.56	504.76	0.000505	4.21	3377.42	610.72	0.24
NF CWC	SECTION_02	6085	10 yr	6376.00	488.57	501.73	494.21	501.85	0.000209	3.16	2718.97	519.00	0.16
NF CWC	SECTION_02	6085	50 yr	9409.00	488.57	503.82	495.59	503.95	0.000191	3.37	3882.13	590.02	0.16
NF CWC	SECTION_02	6085	100 yr	10603.00	488.57	504.44	496.12	504.58	0.000193	3.48	4256.50	611.97	0.16
NF CWC	SECTION_02	6085	500 yr	13470.00	488.57	505.71	497.19	505.86	0.000201	3.75	5058.76	656.31	0.17
NF CWC	SECTION_02	6085	Ultimate 100 yr	10824.00	488.57	504.59	496.21	504.73	0.000191	3.48	4348.16	617.55	0.16
NF CWC	SECTION_02	5702	10 yr	6686.00	490.00	501.74	492.85	501.77	0.000055	1.59	4993.31	683.98	0.08
NF CWC	SECTION_02	5702	50 yr	9823.00	490.00	503.83	493.57	503.88	0.000058	1.83	6470.86	729.54	0.09
NF CWC	SECTION_02	5702	100 yr	11199.00	490.00	504.46	493.85	504.50	0.000062	1.95	6929.49	743.63	0.09
NF CWC	SECTION_02	5702	500 yr	14349.00	490.00	505.72	494.46	505.78	0.000071	2.21	7886.61	771.70	0.10
NF CWC	SECTION_02	5702	Ultimate 100 yr	11549.00	490.00	504.60	493.92	504.65	0.000063	1.98	7039.85	746.93	0.09
NF CWC	SECTION_02	5621	10 yr	6686.00	490.00	501.64	494.18	501.76	0.000040	3.03	3349.52	580.39	0.16
NF CWC	SECTION_02	5621	50 yr	9823.00	490.00	503.71	495.30	503.86	0.000042	3.50	4643.22	655.82	0.17
NF CWC	SECTION_02	5621	100 yr	11199.00	490.00	504.31	495.75	504.49	0.000045	3.74	5045.44	668.27	0.18
NF CWC	SECTION_02	5621	500 yr	14349.00	490.00	505.54	496.75	505.76	0.000052	4.26	5887.66	712.26	0.20
NF CWC	SECTION_02	5621	Ultimate 100 yr	11549.00	490.00	504.46	495.85	504.64	0.000046	3.80	5142.04	671.24	0.18
NF CWC	SECTION_02	5570	10 yr	6686.00	489.00	498.61	498.61	501.48	0.001929	13.61	491.36	86.06	1.00
NF CWC	SECTION_02	5570	50 yr	9823.00	489.00	501.22	501.22	503.63	0.002114	12.47	788.07	171.92	1.02
NF CWC	SECTION_02	5570	100 yr	11199.00	489.00	501.86	501.86	504.26	0.001969	12.44	903.57	195.63	1.00
NF CWC	SECTION_02	5570	500 yr	14349.00	489.00	502.79	502.79	505.50	0.001865	13.24	1104.51	232.23	0.99
NF CWC	SECTION_02	5570	Ultimate 100 yr	11549.00	489.00	501.98	501.98	504.41	0.002034	12.51	927.72	205.19	1.01
NF CWC	SECTION_02	5542	10 yr	6686.00	488.66	498.15	498.15	501.10	0.001921	13.77	485.63	83.28	1.00
NF CWC	SECTION_02	5542	50 yr	9823.00	488.66	500.77	500.77	503.34	0.001958	12.86	763.57	148.78	1.00
NF CWC	SECTION_02	5542	100 yr	11199.00	488.66	501.52	501.52	504.00	0.002018	12.63	886.94	182.42	1.01
NF CWC	SECTION_02	5542	500 yr	14349.00	488.66	502.47	502.47	505.28	0.001891	13.45	1080.15	231.34	1.00
NF CWC	SECTION_02	5542	Ultimate 100 yr	11549.00	488.66	501.66	501.66	504.15	0.001994	12.65	912.87	185.58	1.01
NF CWC	SECTION_02	5480	10 yr	6686.00	487.40	495.25	492.71	495.95	0.000378	6.91	1186.31	235.03	0.47
NF CWC	SECTION_02	5480	50 yr	9823.00	487.40	496.27	493.92	497.35	0.000497	8.70	1437.25	258.33	0.55
NF CWC	SECTION_02	5480	100 yr	11199.00	487.40	496.62	494.41	497.89	0.000554	9.45	1528.72	268.70	0.58
NF CWC	SECTION_02	5480	500 yr	14349.00	487.40	497.27	495.38	499.05	0.000701	11.20	1722.84	340.24	0.66
NF CWC	SECTION_02	5480	Ultimate 100 yr	11549.00	487.40	496.70	494.53	498.02	0.000568	9.64	1551.38	271.56	0.59
NF CWC	SECTION_02	4988	10 yr	6686.00	487.00	495.48	490.26	495.61	0.000311	2.98	2480.76	460.66	0.19
NF CWC	SECTION_02	4988	50 yr	9823.00	487.00	496.68	491.07	496.87	0.000386	3.65	3067.80	513.33	0.21

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_02	4988	100 yr	11199.00	487.00	497.12	491.39	497.33	0.000414	3.90	3299.09	528.74	0.22
NF CWC	SECTION_02	4988	500 yr	14349.00	487.00	498.05	492.07	498.31	0.000467	4.40	3801.74	557.66	0.24
NF CWC	SECTION_02	4988	Ultimate 100 yr	11549.00	487.00	497.23	491.47	497.45	0.000421	3.96	3355.88	532.11	0.22
NF CWC	SECTION_02	4503	10 yr	6686.00	488.00	494.80	492.28	495.31	0.001725	6.02	1318.47	441.22	0.42
NF CWC	SECTION_02	4503	50 yr	9823.00	488.00	495.93	493.31	496.52	0.001728	6.72	1884.16	538.91	0.43
NF CWC	SECTION_02	4503	100 yr	11199.00	488.00	496.38	493.77	496.98	0.001677	6.88	2128.67	556.39	0.43
NF CWC	SECTION_02	4503	500 yr	14349.00	488.00	497.33	495.33	497.93	0.001539	7.12	2673.40	585.51	0.42
NF CWC	SECTION_02	4503	Ultimate 100 yr	11549.00	488.00	496.49	493.86	497.09	0.001664	6.92	2189.07	560.01	0.43
NF CWC	SECTION_02	4071	10 yr	6686.00	487.00	494.69	489.93	494.77	0.000211	2.19	3292.01	680.37	0.15
NF CWC	SECTION_02	4071	50 yr	9823.00	487.00	495.85	490.50	495.95	0.000247	2.64	4113.33	724.87	0.17
NF CWC	SECTION_02	4071	100 yr	11199.00	487.00	496.31	490.74	496.42	0.000257	2.80	4443.81	732.75	0.17
NF CWC	SECTION_02	4071	500 yr	14349.00	487.00	497.27	491.24	497.41	0.000274	3.11	5158.76	745.86	0.18
NF CWC	SECTION_02	4071	Ultimate 100 yr	11549.00	487.00	496.42	490.80	496.53	0.000260	2.84	4524.35	734.26	0.17
NF CWC	SECTION_02	3856	10 yr	6686.00	488.00	494.01	492.45	494.65	0.000483	6.84	1534.97	621.66	0.51
NF CWC	SECTION_02	3856	50 yr	9823.00	488.00	495.10	493.79	495.83	0.000473	7.62	2235.54	660.40	0.52
NF CWC	SECTION_02	3856	100 yr	11199.00	488.00	495.53	494.19	496.29	0.000465	7.88	2525.56	673.88	0.52
NF CWC	SECTION_02	3856	500 yr	14349.00	488.00	496.47	494.86	497.27	0.000443	8.36	3174.73	708.05	0.52
NF CWC	SECTION_02	3856	Ultimate 100 yr	11549.00	488.00	495.64	494.26	496.40	0.000464	7.95	2595.53	678.07	0.52
NF CWC	SECTION_02	3818	10 yr	6686.00	489.20	493.22	493.22	494.55	0.002180	9.36	775.02	325.34	0.97
NF CWC	SECTION_02	3818	50 yr	9823.00	489.20	494.02	494.02	495.70	0.002007	10.58	1048.42	355.57	0.97
NF CWC	SECTION_02	3818	100 yr	11199.00	489.20	494.34	494.34	496.15	0.001956	11.03	1162.26	364.51	0.97
NF CWC	SECTION_02	3818	500 yr	14349.00	489.20	494.95	494.95	497.11	0.001956	12.12	1388.76	381.50	1.00
NF CWC	SECTION_02	3818	Ultimate 100 yr	11549.00	489.20	494.43	494.43	496.26	0.001920	11.10	1196.00	367.13	0.97
NF CWC	SECTION_02	3796	10 yr	6686.00	488.43	493.00	493.00	494.33	0.002287	9.68	844.13	353.44	1.00
NF CWC	SECTION_02	3796	50 yr	9823.00	488.43	493.82	493.82	495.47	0.002082	10.88	1144.79	378.55	0.99
NF CWC	SECTION_02	3796	100 yr	11199.00	488.43	494.12	494.12	495.92	0.002056	11.39	1260.97	386.20	1.00
NF CWC	SECTION_02	3796	500 yr	14349.00	488.43	494.79	494.79	496.87	0.001972	12.35	1524.69	404.75	1.00
NF CWC	SECTION_02	3796	Ultimate 100 yr	11549.00	488.43	494.19	494.19	496.03	0.002054	11.52	1288.99	388.22	1.00
NF CWC	SECTION_02	3758	10 yr	6686.00	481.00	490.30	484.86	490.48	0.000072	3.53	2323.70	353.88	0.21
NF CWC	SECTION_02	3758	50 yr	9823.00	481.00	491.59	485.79	491.88	0.000097	4.49	2852.77	467.91	0.25
NF CWC	SECTION_02	3758	100 yr	11199.00	481.00	492.13	486.15	492.46	0.000104	4.83	3124.78	530.65	0.26
NF CWC	SECTION_02	3758	500 yr	14349.00	481.00	493.26	486.94	493.68	0.000117	5.48	3775.89	644.09	0.28
NF CWC	SECTION_02	3758	Ultimate 100 yr	11549.00	481.00	492.27	486.24	492.61	0.000106	4.90	3197.02	538.30	0.27
NF CWC	SECTION_03	3546	10 yr	6869.00	481.67	490.37	484.11	490.42	0.000109	1.82	4106.39	637.11	0.11
NF CWC	SECTION_03	3546	50 yr	10069.00	481.67	491.72	484.69	491.79	0.000135	2.23	5018.59	714.05	0.13
NF CWC	SECTION_03	3546	100 yr	11584.00	481.67	492.28	484.94	492.36	0.000144	2.40	5431.63	753.75	0.13
NF CWC	SECTION_03	3546	500 yr	15006.00	481.67	493.46	485.48	493.56	0.000158	2.70	6354.62	813.48	0.14
NF CWC	SECTION_03	3546	Ultimate 100 yr	11966.00	481.67	492.42	485.01	492.50	0.000146	2.43	5537.63	762.12	0.13

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_03	3247	10 yr	6869.00	481.00	490.35	483.20	490.39	0.000068	1.52	4804.93	618.15	0.09
NF CWC	SECTION_03	3247	50 yr	10069.00	481.00	491.70	483.74	491.75	0.000089	1.91	5653.80	645.61	0.10
NF CWC	SECTION_03	3247	100 yr	11584.00	481.00	492.26	483.98	492.32	0.000097	2.07	6019.53	657.65	0.11
NF CWC	SECTION_03	3247	500 yr	15006.00	481.00	493.43	484.47	493.51	0.000113	2.38	6802.04	677.73	0.12
NF CWC	SECTION_03	3247	Ultimate 100 yr	11966.00	481.00	492.40	484.04	492.46	0.000099	2.11	6111.30	660.37	0.11
NF CWC	SECTION_03	2833	10 yr	6869.00	481.00	490.24	484.82	490.34	0.000242	2.81	2945.38	501.50	0.17
NF CWC	SECTION_03	2833	50 yr	10069.00	481.00	491.55	485.86	491.68	0.000286	3.35	3612.77	518.34	0.19
NF CWC	SECTION_03	2833	100 yr	11584.00	481.00	492.09	486.30	492.25	0.000302	3.56	3898.02	525.50	0.19
NF CWC	SECTION_03	2833	500 yr	15006.00	481.00	493.23	487.23	493.43	0.000329	3.98	4506.82	540.50	0.20
NF CWC	SECTION_03	2833	Ultimate 100 yr	11966.00	481.00	492.23	486.40	492.39	0.000305	3.61	3969.62	527.28	0.19
NF CWC	SECTION_03	2723	10 yr	6869.00	481.00	490.05	486.19	490.30	0.000133	4.73	2650.64	536.15	0.29
NF CWC	SECTION_03	2723	50 yr	10069.00	481.00	491.30	487.33	491.64	0.000159	5.68	3332.10	557.52	0.32
NF CWC	SECTION_03	2723	100 yr	11584.00	481.00	491.82	487.74	492.20	0.000170	6.06	3624.03	565.77	0.33
NF CWC	SECTION_03	2723	500 yr	15006.00	481.00	492.91	488.58	493.37	0.000186	6.80	4249.55	581.68	0.36
NF CWC	SECTION_03	2723	Ultimate 100 yr	11966.00	481.00	491.95	487.83	492.34	0.000172	6.15	3697.65	567.84	0.34
NF CWC	SECTION_03	2713	10 yr	6869.00	481.94	489.96	486.94	490.29	0.000228	5.69	2341.13	519.09	0.37
NF CWC	SECTION_03	2713	50 yr	10069.00	481.94	491.20	487.72	491.63	0.000258	6.70	3002.83	551.50	0.40
NF CWC	SECTION_03	2713	100 yr	11584.00	481.94	491.71	488.41	492.19	0.000269	7.11	3290.44	565.22	0.41
NF CWC	SECTION_03	2713	500 yr	15006.00	481.94	492.80	489.00	493.36	0.000282	7.85	3918.62	586.47	0.43
NF CWC	SECTION_03	2713	Ultimate 100 yr	11966.00	481.94	491.84	488.49	492.33	0.000270	7.20	3363.61	568.72	0.42
NF CWC	SECTION_03	2700	10 yr	6869.00	483.57	489.93	487.20	490.29	0.000312	5.81	2047.00	479.08	0.42
NF CWC	SECTION_03	2700	50 yr	10069.00	483.57	491.15	488.19	491.62	0.000338	6.83	2670.74	533.28	0.45
NF CWC	SECTION_03	2700	100 yr	11584.00	483.57	491.66	488.55	492.18	0.000344	7.21	2948.14	546.73	0.46
NF CWC	SECTION_03	2700	500 yr	15006.00	483.57	492.74	489.07	493.35	0.000349	7.93	3553.25	578.34	0.47
NF CWC	SECTION_03	2700	Ultimate 100 yr	11966.00	483.57	491.79	488.61	492.32	0.000344	7.30	3018.93	549.73	0.46
NF CWC	SECTION_03	2688	10 yr	6869.00	482.46	489.93	487.56	490.28	0.000653	9.24	2092.66	495.92	0.61
NF CWC	SECTION_03	2688	50 yr	10069.00	482.46	491.18	488.48	491.60	0.000661	10.37	2731.01	534.49	0.64
NF CWC	SECTION_03	2688	100 yr	11584.00	482.46	491.70	488.83	492.16	0.000672	10.89	3017.36	561.71	0.65
NF CWC	SECTION_03	2688	500 yr	15006.00	482.46	492.82	489.67	493.31	0.000652	11.62	3660.73	591.82	0.65
NF CWC	SECTION_03	2688	Ultimate 100 yr	11966.00	482.46	491.83	488.91	492.29	0.000670	10.98	3092.12	566.04	0.65
NF CWC	SECTION_03	2634	10 yr	6951.00	481.00	490.03	487.04	490.18	0.000658	3.86	2360.62	549.22	0.24
NF CWC	SECTION_03	2634	50 yr	10155.00	481.00	491.31	487.69	491.49	0.000651	4.23	3090.40	596.60	0.24
NF CWC	SECTION_03	2634	100 yr	11700.00	481.00	491.84	487.97	492.04	0.000655	4.39	3416.46	621.82	0.24
NF CWC	SECTION_03	2634	500 yr	15219.00	481.00	492.97	488.56	493.19	0.000631	4.63	4136.21	654.04	0.24
NF CWC	SECTION_03	2634	Ultimate 100 yr	12095.00	481.00	491.98	488.01	492.17	0.000654	4.43	3500.13	628.13	0.24
NF CWC	SECTION_03	2587	10 yr	6951.00	479.80	489.98	486.80	490.15	0.000652	3.96	2185.34	433.61	0.24
NF CWC	SECTION_03	2587	50 yr	10155.00	479.80	491.23	487.56	491.45	0.000702	4.50	2738.11	452.54	0.25
NF CWC	SECTION_03	2587	100 yr	11700.00	479.80	491.75	487.80	492.00	0.000729	4.74	2977.01	463.29	0.26
NF CWC	SECTION_03	2587	500 yr	15219.00	479.80	492.84	488.39	493.15	0.000821	5.37	3503.24	517.75	0.28

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_03	2587	Ultimate 100 yr	12095.00	479.80	491.88	487.87	492.14	0.000735	4.80	3037.67	466.19	0.26
NF CWC	SECTION_03	2543		Bridge									
NF CWC	SECTION_03	2464	10 yr	6951.00	479.09	489.95	484.96	490.05	0.000279	2.90	2820.79	424.88	0.16
NF CWC	SECTION_03	2464	50 yr	10155.00	479.09	491.19	485.66	491.33	0.000368	3.60	3377.44	468.71	0.19
NF CWC	SECTION_03	2464	100 yr	11700.00	479.09	491.71	485.92	491.88	0.000393	3.83	3621.83	473.09	0.19
NF CWC	SECTION_03	2464	500 yr	15219.00	479.09	492.80	486.59	493.01	0.000439	4.29	4141.32	482.20	0.21
NF CWC	SECTION_03	2464	Ultimate 100 yr	12095.00	479.09	491.84	485.98	492.01	0.000399	3.88	3683.33	474.18	0.20
NF CWC	SECTION_03	2330	10 yr	6951.00	480.00	489.34	487.64	489.86	0.002043	6.63	1327.83	321.93	0.42
NF CWC	SECTION_03	2330	50 yr	10155.00	480.00	490.45	488.59	491.10	0.002209	7.53	1699.67	342.34	0.44
NF CWC	SECTION_03	2330	100 yr	11700.00	480.00	490.92	488.95	491.63	0.002262	7.88	1861.22	348.99	0.45
NF CWC	SECTION_03	2330	500 yr	15219.00	480.00	491.91	489.69	492.73	0.002319	8.52	2214.52	363.28	0.46
NF CWC	SECTION_03	2330	Ultimate 100 yr	12095.00	480.00	491.04	489.04	491.76	0.002269	7.96	1902.70	350.71	0.45
NF CWC	SECTION_03	2239	10 yr	6951.00	477.30	489.47	484.68	489.64	0.000407	3.76	2182.80	296.17	0.19
NF CWC	SECTION_03	2239	50 yr	10155.00	477.30	490.60	485.51	490.86	0.000559	4.69	2519.49	302.61	0.23
NF CWC	SECTION_03	2239	100 yr	11700.00	477.30	491.06	485.84	491.38	0.000627	5.09	2661.73	305.28	0.25
NF CWC	SECTION_03	2239	500 yr	15219.00	477.30	492.05	486.59	492.47	0.000762	5.89	2965.33	311.00	0.28
NF CWC	SECTION_03	2239	Ultimate 100 yr	12095.00	477.30	491.18	485.92	491.51	0.000643	5.19	2697.86	305.95	0.25
NF CWC	SECTION_03	2204		Bridge									
NF CWC	SECTION_03	2170	10 yr	6951.00	474.45	489.41	484.26	489.57	0.000342	3.82	2289.77	295.81	0.17
NF CWC	SECTION_03	2170	50 yr	10155.00	474.45	490.50	485.25	490.75	0.000489	4.79	2615.19	302.05	0.21
NF CWC	SECTION_03	2170	100 yr	11700.00	474.45	490.95	485.62	491.25	0.000557	5.21	2751.61	304.61	0.23
NF CWC	SECTION_03	2170	500 yr	15219.00	474.45	491.89	486.33	492.30	0.000696	6.04	3041.62	310.07	0.26
NF CWC	SECTION_03	2170	Ultimate 100 yr	12095.00	474.45	491.06	485.71	491.37	0.000573	5.30	2786.25	305.26	0.23
NF CWC	SECTION_03	2005	10 yr	6951.00	478.77	487.69	487.69	489.09	0.005365	10.48	868.39	401.10	0.66
NF CWC	SECTION_03	2005	50 yr	10155.00	478.77	488.63	488.63	490.20	0.005692	11.65	1179.79	442.56	0.70
NF CWC	SECTION_03	2005	100 yr	11700.00	478.77	488.98	488.98	490.66	0.005905	12.18	1301.00	462.35	0.71
NF CWC	SECTION_03	2005	500 yr	15219.00	478.77	489.61	489.61	491.61	0.006668	13.54	1517.50	481.66	0.77
NF CWC	SECTION_03	2005	Ultimate 100 yr	12095.00	478.77	489.06	489.06	490.78	0.006007	12.36	1326.15	465.08	0.72
NF CWC	SECTION_03	1775	10 yr	6951.00	477.00	486.50	485.90	487.37	0.003777	8.78	1137.64	438.44	0.55
NF CWC	SECTION_03	1775	50 yr	10155.00	477.00	487.52	486.94	488.38	0.003472	9.13	1586.49	546.14	0.54
NF CWC	SECTION_03	1775	100 yr	11700.00	477.00	487.91	487.21	488.80	0.003476	9.40	1763.16	589.82	0.54
NF CWC	SECTION_03	1775	500 yr	15219.00	477.00	488.76	487.79	489.63	0.003250	9.64	2366.18	629.06	0.53
NF CWC	SECTION_03	1775	Ultimate 100 yr	12095.00	477.00	488.03	487.28	488.94	0.003581	9.62	1915.70	605.26	0.55
NF CWC	SECTION_03	1291	10 yr	7019.00	477.00	485.43	484.01	485.84	0.002262	6.67	1561.47	487.96	0.42
NF CWC	SECTION_03	1291	50 yr	10246.00	477.00	486.49	484.73	486.95	0.002265	7.27	2106.82	542.47	0.43
NF CWC	SECTION_03	1291	100 yr	11816.00	477.00	486.89	484.98	487.38	0.002227	7.43	2324.38	543.78	0.43
NF CWC	SECTION_03	1291	500 yr	15422.00	477.00	487.70	485.74	488.28	0.002277	7.96	2779.13	568.13	0.44

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
NF CWC	SECTION_03	1291	Ultimate 100 yr	12227.00	477.00	486.99	484.98	487.49	0.002215	7.46	2380.26	544.11	0.43
NF CWC	SECTION_03	1010	10 yr	7019.00	476.54	484.48	483.01	485.04	0.003451	7.32	1275.40	399.62	0.52
NF CWC	SECTION_03	1010	50 yr	10246.00	476.54	485.37	483.93	486.09	0.004050	8.65	1670.49	508.73	0.57
NF CWC	SECTION_03	1010	100 yr	11816.00	476.54	485.69	484.27	486.50	0.004377	9.27	1841.32	552.63	0.60
NF CWC	SECTION_03	1010	500 yr	15422.00	476.54	486.39	485.20	487.34	0.005017	10.53	2274.88	672.99	0.65
NF CWC	SECTION_03	1010	Ultimate 100 yr	12227.00	476.54	485.80	484.39	486.61	0.004359	9.34	1901.61	563.83	0.60
NF CWC	SECTION_03	859	10 yr	7019.00	473.60	484.35	482.01	484.54	0.000811	4.33	2184.71	530.17	0.25
NF CWC	SECTION_03	859	50 yr	10246.00	473.60	485.21	482.65	485.48	0.001048	5.23	2659.64	580.56	0.29
NF CWC	SECTION_03	859	100 yr	11816.00	473.60	485.48	482.91	485.83	0.001368	6.08	2836.74	698.97	0.34
NF CWC	SECTION_03	859	500 yr	15422.00	473.60	486.15	483.50	486.58	0.001519	6.69	3396.42	884.74	0.36
NF CWC	SECTION_03	859	Ultimate 100 yr	12227.00	473.60	485.59	483.01	485.95	0.001385	6.17	2912.52	716.39	0.34
NF CWC	SECTION_03	776		Culvert									
NF CWC	SECTION_03	701	10 yr	7019.00	473.50	482.97	482.19	483.32	0.001714	6.02	1963.80	962.74	0.37
NF CWC	SECTION_03	701	50 yr	10246.00	473.50	484.03	482.80	484.28	0.001196	5.46	3021.87	1023.44	0.32
NF CWC	SECTION_03	701	100 yr	11816.00	473.50	484.48	483.10	484.72	0.001060	5.30	3492.22	1043.65	0.30
NF CWC	SECTION_03	701	500 yr	15422.00	473.50	485.46	483.47	485.67	0.000851	5.07	4523.59	1078.68	0.27
NF CWC	SECTION_03	701	Ultimate 100 yr	12227.00	473.50	484.63	483.15	484.86	0.001005	5.22	3644.14	1049.19	0.29
NF CWC	SECTION_03	352	10 yr	7019.00	476.00	482.68	480.27	482.80	0.000723	3.30	2570.96	695.98	0.24
NF CWC	SECTION_03	352	50 yr	10246.00	476.00	483.77	480.78	483.92	0.000688	3.59	3353.47	730.47	0.24
NF CWC	SECTION_03	352	100 yr	11816.00	476.00	484.23	481.00	484.40	0.000692	3.76	3697.09	753.45	0.24
NF CWC	SECTION_03	352	500 yr	15422.00	476.00	485.22	481.49	485.41	0.000650	3.95	4446.78	759.33	0.24
NF CWC	SECTION_03	352	Ultimate 100 yr	12227.00	476.00	484.39	481.09	484.55	0.000671	3.75	3812.55	754.40	0.24
PLATTNER CRK	PLATTNER CRK	7131	10 yr	1253.00	494.36	499.97	499.97	501.64	0.002416	10.38	120.68	36.73	1.01
PLATTNER CRK	PLATTNER CRK	7131	50 yr	1743.00	494.36	500.86	500.86	502.84	0.002090	11.31	159.59	49.89	0.98
PLATTNER CRK	PLATTNER CRK	7131	100 yr	1959.00	494.36	501.20	501.20	503.32	0.002018	11.71	177.20	53.47	0.97
PLATTNER CRK	PLATTNER CRK	7131	500 yr	2498.00	494.36	501.99	501.99	504.40	0.001868	12.55	222.55	61.18	0.96
PLATTNER CRK	PLATTNER CRK	7131	Ultimate 100 yr	2011.00	494.36	501.28	501.28	503.43	0.001999	11.79	181.58	54.24	0.97
PLATTNER CRK	PLATTNER CRK	6754	10 yr	1253.00	484.00	489.80	489.80	491.60	0.002371	10.75	116.52	32.54	1.00
PLATTNER CRK	PLATTNER CRK	6754	50 yr	1743.00	484.00	490.78	490.78	492.87	0.002309	11.62	150.05	36.43	1.01
PLATTNER CRK	PLATTNER CRK	6754	100 yr	1959.00	484.00	491.96	491.18	493.51	0.001415	10.00	195.97	41.09	0.81
PLATTNER CRK	PLATTNER CRK	6754	500 yr	2498.00	484.00	494.98	492.04	495.83	0.000530	7.39	338.20	53.03	0.52
PLATTNER CRK	PLATTNER CRK	6754	Ultimate 100 yr	2011.00	484.00	492.51	491.27	493.82	0.001105	9.18	219.05	43.28	0.72
PLATTNER CRK	PLATTNER CRK	6517	10 yr	1253.00	479.80	487.63	483.96	487.91	0.000217	4.26	293.97	55.40	0.33
PLATTNER CRK	PLATTNER CRK	6517	50 yr	1743.00	479.80	491.09	484.83	491.27	0.000089	3.35	526.19	100.90	0.22
PLATTNER CRK	PLATTNER CRK	6517	100 yr	1959.00	479.80	492.77	485.17	492.91	0.000056	3.05	667.64	166.97	0.18
PLATTNER CRK	PLATTNER CRK	6517	500 yr	2498.00	479.80	495.42	485.96	495.55	0.000036	2.93	1084.97	192.37	0.15
PLATTNER CRK	PLATTNER CRK	6517	Ultimate 100 yr	2011.00	479.80	493.19	485.25	493.33	0.000050	2.99	703.71	175.64	0.17

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
PLATTNER CRK	PLATTNER CRK	6407		Culvert									
PLATTNER CRK	PLATTNER CRK	6287	10 yr	1253.00	479.30	485.41	482.94	485.72	0.003371	4.51	290.81	72.69	0.36
PLATTNER CRK	PLATTNER CRK	6287	50 yr	1743.00	479.30	486.42	483.62	486.81	0.003354	5.09	368.92	84.38	0.37
PLATTNER CRK	PLATTNER CRK	6287	100 yr	1959.00	479.30	486.79	483.90	487.21	0.003383	5.32	399.06	90.20	0.37
PLATTNER CRK	PLATTNER CRK	6287	500 yr	2498.00	479.30	487.61	484.54	488.11	0.003543	5.90	480.75	105.37	0.39
PLATTNER CRK	PLATTNER CRK	6287	Ultimate 100 yr	2011.00	479.30	486.88	483.95	487.30	0.003392	5.38	405.94	91.65	0.37
PLATTNER CRK	PLATTNER CRK	6104	10 yr	1253.00	477.70	483.50	482.59	484.52	0.013513	8.19	163.93	59.35	0.69
PLATTNER CRK	PLATTNER CRK	6104	50 yr	1743.00	477.70	484.56	483.60	485.66	0.011406	8.69	243.01	85.72	0.66
PLATTNER CRK	PLATTNER CRK	6104	100 yr	1959.00	477.70	485.00	484.14	486.09	0.010407	8.75	283.41	95.24	0.64
PLATTNER CRK	PLATTNER CRK	6104	500 yr	2498.00	477.70	486.12	484.96	487.09	0.007991	8.61	407.12	127.90	0.57
PLATTNER CRK	PLATTNER CRK	6104	Ultimate 100 yr	2011.00	477.70	485.11	484.20	486.19	0.010181	8.76	293.53	97.66	0.63
PLATTNER CRK	PLATTNER CRK	5994	10 yr	1253.00	474.34	482.80	481.25	483.35	0.005596	6.72	270.97	81.26	0.46
PLATTNER CRK	PLATTNER CRK	5994	50 yr	1743.00	474.34	484.09	482.12	484.63	0.004713	6.95	386.21	96.96	0.44
PLATTNER CRK	PLATTNER CRK	5994	100 yr	1959.00	474.34	484.60	482.42	485.13	0.004410	7.01	437.45	102.79	0.43
PLATTNER CRK	PLATTNER CRK	5994	500 yr	2498.00	474.34	485.82	483.11	486.33	0.003708	7.04	571.47	114.36	0.40
PLATTNER CRK	PLATTNER CRK	5994	Ultimate 100 yr	2011.00	474.34	484.72	482.50	485.25	0.004346	7.03	449.67	104.07	0.42
PLATTNER CRK	PLATTNER CRK	5813	10 yr	1253.00	474.00	481.97	479.25	482.45	0.004130	5.77	256.65	69.84	0.40
PLATTNER CRK	PLATTNER CRK	5813	50 yr	1743.00	474.00	483.35	480.33	483.87	0.003650	6.18	365.91	88.29	0.39
PLATTNER CRK	PLATTNER CRK	5813	100 yr	1959.00	474.00	483.89	480.68	484.42	0.003469	6.30	416.17	95.42	0.38
PLATTNER CRK	PLATTNER CRK	5813	500 yr	2498.00	474.00	485.20	481.57	485.72	0.002992	6.45	547.61	105.20	0.37
PLATTNER CRK	PLATTNER CRK	5813	Ultimate 100 yr	2011.00	474.00	484.02	480.76	484.55	0.003429	6.33	428.25	96.75	0.38
PLATTNER CRK	PLATTNER CRK	5455	10 yr	1253.00	472.51	479.51	477.80	480.37	0.009365	7.48	175.95	47.95	0.57
PLATTNER CRK	PLATTNER CRK	5455	50 yr	1743.00	472.51	481.79	478.81	482.41	0.004583	6.63	333.66	87.80	0.42
PLATTNER CRK	PLATTNER CRK	5455	100 yr	1959.00	472.51	482.55	479.29	483.12	0.003870	6.49	404.33	100.02	0.39
PLATTNER CRK	PLATTNER CRK	5455	500 yr	2498.00	472.51	484.22	480.41	484.69	0.002758	6.18	592.64	122.90	0.34
PLATTNER CRK	PLATTNER CRK	5455	Ultimate 100 yr	2011.00	472.51	482.71	479.40	483.27	0.003751	6.47	420.86	102.90	0.39
PLATTNER CRK	PLATTNER CRK	5235	10 yr	1461.00	468.59	478.78	473.76	478.99	0.001405	3.89	445.93	84.47	0.24
PLATTNER CRK	PLATTNER CRK	5235	50 yr	2003.00	468.59	481.50	474.53	481.68	0.000886	3.73	710.30	106.03	0.20
PLATTNER CRK	PLATTNER CRK	5235	100 yr	2204.00	468.59	482.31	474.80	482.49	0.000812	3.75	799.63	115.14	0.19
PLATTNER CRK	PLATTNER CRK	5235	500 yr	2849.00	468.59	484.03	475.59	484.22	0.000775	4.01	1013.95	133.88	0.19
PLATTNER CRK	PLATTNER CRK	5235	Ultimate 100 yr	2253.00	468.59	482.48	474.86	482.66	0.000801	3.76	819.53	117.08	0.19
PLATTNER CRK	PLATTNER CRK	4938		Culvert									
PLATTNER CRK	PLATTNER CRK	4510	10 yr	1461.00	468.60	475.95	471.92	476.20	0.000998	4.03	368.56	75.67	0.27
PLATTNER CRK	PLATTNER CRK	4510	50 yr	2003.00	468.60	477.06	472.65	477.36	0.001036	4.44	480.25	87.85	0.28
PLATTNER CRK	PLATTNER CRK	4510	100 yr	2204.00	468.60	477.76	472.89	478.05	0.000899	4.38	545.11	96.82	0.27
PLATTNER CRK	PLATTNER CRK	4510	500 yr	2849.00	468.60	479.72	473.62	479.97	0.000643	4.26	754.29	116.47	0.23
PLATTNER CRK	PLATTNER CRK	4510	Ultimate 100 yr	2253.00	468.60	477.94	472.95	478.22	0.000867	4.36	562.20	98.85	0.26

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
PLATTNER CRK	PLATTNER CRK	4284	10 yr	2066.00	466.66	473.54	473.54	475.33	0.009284	11.20	210.76	65.18	0.82
PLATTNER CRK	PLATTNER CRK	4284	50 yr	2856.00	466.66	475.57	474.62	476.72	0.004483	9.51	363.46	83.19	0.60
PLATTNER CRK	PLATTNER CRK	4284	100 yr	3163.00	466.66	476.72	474.97	477.57	0.002847	8.31	463.75	90.36	0.49
PLATTNER CRK	PLATTNER CRK	4284	500 yr	4062.00	466.66	479.05	475.75	479.66	0.001581	7.22	692.96	114.13	0.38
PLATTNER CRK	PLATTNER CRK	4284	Ultimate 100 yr	3227.00	466.66	476.97	475.03	477.77	0.002601	8.09	486.42	91.90	0.47
PLATTNER CRK	PLATTNER CRK	4062	10 yr	2066.00	464.20	473.16	468.51	473.41	0.000792	4.16	555.72	138.78	0.26
PLATTNER CRK	PLATTNER CRK	4062	50 yr	2856.00	464.20	475.69	469.44	475.89	0.000472	3.84	828.41	214.02	0.21
PLATTNER CRK	PLATTNER CRK	4062	100 yr	3163.00	464.20	476.83	469.80	477.02	0.000375	3.67	952.23	226.82	0.19
PLATTNER CRK	PLATTNER CRK	4062	500 yr	4062.00	464.20	479.22	470.75	479.31	0.000175	2.83	1860.73	253.82	0.13
PLATTNER CRK	PLATTNER CRK	4062	Ultimate 100 yr	3227.00	464.20	477.08	469.87	477.26	0.000358	3.63	978.75	229.38	0.18
PLATTNER CRK	PLATTNER CRK	3986		Culvert									
PLATTNER CRK	PLATTNER CRK	3878	10 yr	2066.00	463.25	471.36	467.69	471.67	0.000899	4.70	490.10	94.48	0.30
PLATTNER CRK	PLATTNER CRK	3878	50 yr	2856.00	463.25	472.25	468.57	472.69	0.001094	5.60	572.47	110.60	0.34
PLATTNER CRK	PLATTNER CRK	3878	100 yr	3163.00	463.25	472.56	468.87	473.04	0.001165	5.92	600.83	114.19	0.36
PLATTNER CRK	PLATTNER CRK	3878	500 yr	4062.00	463.25	473.30	469.67	473.98	0.001487	7.07	722.21	175.53	0.41
PLATTNER CRK	PLATTNER CRK	3878	Ultimate 100 yr	3227.00	463.25	472.62	468.93	473.11	0.001180	5.99	606.44	114.89	0.36
PLATTNER CRK	PLATTNER CRK	3634	10 yr	2066.00	464.00	470.81	468.80	471.31	0.002008	6.10	401.26	111.08	0.45
PLATTNER CRK	PLATTNER CRK	3634	50 yr	2856.00	464.00	471.66	469.73	472.28	0.002139	6.90	500.25	120.95	0.47
PLATTNER CRK	PLATTNER CRK	3634	100 yr	3163.00	464.00	471.96	470.14	472.62	0.002178	7.17	536.46	124.53	0.48
PLATTNER CRK	PLATTNER CRK	3634	500 yr	4062.00	464.00	472.74	470.87	473.52	0.002262	7.85	637.68	133.65	0.50
PLATTNER CRK	PLATTNER CRK	3634	Ultimate 100 yr	3227.00	464.00	472.02	470.19	472.69	0.002187	7.23	543.73	125.17	0.48
PLATTNER CRK	PLATTNER CRK	3306	10 yr	2066.00	463.00	470.08	468.66	470.61	0.002408	6.64	457.72	157.51	0.49
PLATTNER CRK	PLATTNER CRK	3306	50 yr	2856.00	463.00	471.00	469.48	471.56	0.002275	7.13	608.83	171.56	0.49
PLATTNER CRK	PLATTNER CRK	3306	100 yr	3163.00	463.00	471.31	469.71	471.89	0.002251	7.31	662.87	176.51	0.49
PLATTNER CRK	PLATTNER CRK	3306	500 yr	4062.00	463.00	472.13	470.47	472.76	0.002216	7.81	813.38	190.88	0.49
PLATTNER CRK	PLATTNER CRK	3306	Ultimate 100 yr	3227.00	463.00	471.37	469.81	471.95	0.002251	7.35	673.53	177.47	0.49
PLATTNER CRK	PLATTNER CRK	2859	10 yr	2066.00	460.45	468.00	467.68	469.13	0.004592	9.67	296.45	99.44	0.67
PLATTNER CRK	PLATTNER CRK	2859	50 yr	2856.00	460.45	468.80	468.46	470.10	0.004814	10.71	381.25	112.12	0.70
PLATTNER CRK	PLATTNER CRK	2859	100 yr	3163.00	460.45	469.11	468.72	470.44	0.004766	10.95	416.40	116.72	0.70
PLATTNER CRK	PLATTNER CRK	2859	500 yr	4062.00	460.45	469.99	469.40	471.36	0.004467	11.40	523.86	129.31	0.69
PLATTNER CRK	PLATTNER CRK	2859	Ultimate 100 yr	3227.00	460.45	469.20	468.77	470.52	0.004678	10.93	426.55	118.01	0.70
PLATTNER CRK	PLATTNER CRK	2368	10 yr	2066.00	460.81	467.24	465.96	467.46	0.001255	4.72	635.08	235.23	0.35
PLATTNER CRK	PLATTNER CRK	2368	50 yr	2856.00	460.81	468.18	466.45	468.39	0.001003	4.68	863.87	249.53	0.32
PLATTNER CRK	PLATTNER CRK	2368	100 yr	3163.00	460.81	468.55	466.58	468.75	0.000917	4.64	955.98	254.54	0.31
PLATTNER CRK	PLATTNER CRK	2368	500 yr	4062.00	460.81	469.57	466.97	469.77	0.000737	4.56	1223.99	268.93	0.29
PLATTNER CRK	PLATTNER CRK	2368	Ultimate 100 yr	3227.00	460.81	468.66	466.62	468.86	0.000877	4.58	984.51	256.08	0.30
PLATTNER CRK	PLATTNER CRK	2098	10 yr	2066.00	458.00	466.77	465.52	467.09	0.001492	5.65	553.25	197.49	0.38
PLATTNER CRK	PLATTNER CRK	2098	50 yr	2856.00	458.00	467.80	466.11	468.09	0.001211	5.60	770.79	224.04	0.35

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
PLATTNER CRK	PLATTNER CRK	2098	100 yr	3163.00	458.00	468.21	466.25	468.48	0.001099	5.52	862.60	233.07	0.34
PLATTNER CRK	PLATTNER CRK	2098	500 yr	4062.00	458.00	469.30	466.75	469.55	0.000860	5.31	1130.78	255.03	0.31
PLATTNER CRK	PLATTNER CRK	2098	Ultimate 100 yr	3227.00	458.00	468.34	466.28	468.60	0.001039	5.42	893.18	235.59	0.33
PLATTNER CRK	PLATTNER CRK	1874	10 yr	2066.00	457.57	466.57	464.31	466.73	0.001264	3.62	722.91	214.78	0.23
PLATTNER CRK	PLATTNER CRK	1874	50 yr	2856.00	457.57	467.62	464.80	467.80	0.001109	3.69	963.37	241.57	0.22
PLATTNER CRK	PLATTNER CRK	1874	100 yr	3163.00	457.57	468.04	464.99	468.21	0.001036	3.67	1064.67	251.30	0.21
PLATTNER CRK	PLATTNER CRK	1874	500 yr	4062.00	457.57	469.16	465.43	469.34	0.000870	3.64	1361.04	276.33	0.20
PLATTNER CRK	PLATTNER CRK	1874	Ultimate 100 yr	3227.00	457.57	468.17	465.04	468.35	0.000988	3.62	1099.55	254.66	0.21
PLATTNER CRK	PLATTNER CRK	1654	10 yr	2298.00	458.00	465.27	464.38	466.16	0.009594	8.29	387.46	132.23	0.61
PLATTNER CRK	PLATTNER CRK	1654	50 yr	3201.00	458.00	466.41	465.39	467.30	0.008178	8.63	547.61	148.20	0.58
PLATTNER CRK	PLATTNER CRK	1654	100 yr	3556.00	458.00	466.89	465.67	467.74	0.007456	8.61	619.74	155.65	0.56
PLATTNER CRK	PLATTNER CRK	1654	500 yr	4616.00	458.00	468.13	466.36	468.94	0.006142	8.67	830.97	184.85	0.52
PLATTNER CRK	PLATTNER CRK	1654	Ultimate 100 yr	3663.00	458.00	467.07	465.75	467.90	0.007093	8.53	647.86	159.04	0.55
PLATTNER CRK	PLATTNER CRK	1299	10 yr	2298.00	456.04	464.02	462.03	464.10	0.001614	3.65	1234.57	373.96	0.25
PLATTNER CRK	PLATTNER CRK	1299	50 yr	3201.00	456.04	465.51	462.37	465.57	0.001057	3.39	1819.37	418.77	0.21
PLATTNER CRK	PLATTNER CRK	1299	100 yr	3556.00	456.04	466.11	462.50	466.17	0.000908	3.30	2079.81	441.82	0.20
PLATTNER CRK	PLATTNER CRK	1299	500 yr	4616.00	456.04	467.58	462.85	467.64	0.000681	3.17	2755.29	476.65	0.18
PLATTNER CRK	PLATTNER CRK	1299	Ultimate 100 yr	3663.00	456.04	466.35	462.54	466.41	0.000835	3.22	2184.59	446.91	0.19
PLATTNER CRK	PLATTNER CRK	1064	10 yr	2298.00	456.00	463.76	461.04	463.81	0.001140	2.97	1544.67	467.97	0.20
PLATTNER CRK	PLATTNER CRK	1064	50 yr	3201.00	456.00	465.36	461.36	465.39	0.000646	2.59	2315.14	495.79	0.16
PLATTNER CRK	PLATTNER CRK	1064	100 yr	3556.00	456.00	465.98	461.47	466.02	0.000539	2.48	2629.02	504.42	0.15
PLATTNER CRK	PLATTNER CRK	1064	500 yr	4616.00	456.00	467.49	461.79	467.52	0.000414	2.42	3407.26	529.10	0.13
PLATTNER CRK	PLATTNER CRK	1064	Ultimate 100 yr	3663.00	456.00	466.23	461.51	466.26	0.000497	2.43	2753.75	508.61	0.14
PLATTNER CRK	PLATTNER CRK	642	10 yr	2253.00	457.00	463.61	460.39	463.64	0.000468	1.83	2057.40	528.97	0.14
PLATTNER CRK	PLATTNER CRK	642	50 yr	3225.00	457.00	465.27	460.70	465.29	0.000317	1.79	2962.50	559.83	0.12
PLATTNER CRK	PLATTNER CRK	642	100 yr	3608.00	457.00	465.91	460.80	465.93	0.000278	1.77	3324.39	568.27	0.11
PLATTNER CRK	PLATTNER CRK	642	500 yr	4741.00	457.00	467.43	461.09	467.46	0.000234	1.83	4212.38	593.86	0.11
PLATTNER CRK	PLATTNER CRK	642	Ultimate 100 yr	3725.00	457.00	466.16	460.83	466.19	0.000262	1.76	3467.95	574.65	0.11
PLATTNER CRK	PLATTNER CRK	364	10 yr	2253.00	456.93	463.57	458.55	463.58	0.000094	0.89	3902.31	741.02	0.06
PLATTNER CRK	PLATTNER CRK	364	50 yr	3225.00	456.93	465.24	458.75	465.25	0.000080	0.96	5169.07	773.73	0.06
PLATTNER CRK	PLATTNER CRK	364	100 yr	3608.00	456.93	465.89	458.84	465.90	0.000075	0.98	5671.53	783.63	0.06
PLATTNER CRK	PLATTNER CRK	364	500 yr	4741.00	456.93	467.42	459.05	467.42	0.000072	1.06	6886.69	812.65	0.06
PLATTNER CRK	PLATTNER CRK	364	Ultimate 100 yr	3725.00	456.93	466.14	458.86	466.15	0.000072	0.98	5870.27	787.55	0.06
SF CWC	SECTION_01	182956	10 yr	2147.00	546.00	552.31	550.93	552.47	0.004157	4.72	789.29	291.86	0.35
SF CWC	SECTION_01	182956	50 yr	3029.00	546.00	553.53	551.39	553.66	0.002679	4.32	1158.76	314.90	0.29
SF CWC	SECTION_01	182956	100 yr	3528.00	546.00	553.98	551.59	554.12	0.002549	4.40	1302.57	321.04	0.29
SF CWC	SECTION_01	182956	500 yr	4599.00	546.00	554.81	551.93	554.96	0.002456	4.64	1573.07	334.27	0.29
SF CWC	SECTION_01	182956	Ultimate 100 yr	3631.00	546.00	554.08	551.62	554.21	0.002522	4.42	1332.44	322.52	0.29

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	17917	10 yr	2147.00	545.36	551.41	549.68	551.50	0.003159	4.12	974.46	336.72	0.31
SF CWC	SECTION_01	17917	50 yr	3029.00	545.36	553.05	550.05	553.11	0.001539	3.43	1546.96	364.23	0.23
SF CWC	SECTION_01	17917	100 yr	3528.00	545.36	553.52	550.21	553.59	0.001498	3.53	1722.06	369.81	0.23
SF CWC	SECTION_01	17917	500 yr	4599.00	545.36	554.36	550.51	554.45	0.001513	3.81	2037.04	379.13	0.23
SF CWC	SECTION_01	17917	Ultimate 100 yr	3631.00	545.36	553.62	550.24	553.69	0.001487	3.55	1758.40	370.88	0.23
SF CWC	SECTION_01	17616	10 yr	2147.00	545.03	550.65	548.77	550.75	0.002349	3.51	984.87	298.50	0.28
SF CWC	SECTION_01	17616	50 yr	3029.00	545.03	552.69	549.10	552.76	0.001029	2.91	1613.62	317.82	0.19
SF CWC	SECTION_01	17616	100 yr	3528.00	545.03	553.17	549.29	553.24	0.001060	3.09	1766.12	322.82	0.20
SF CWC	SECTION_01	17616	500 yr	4599.00	545.03	553.99	549.62	554.08	0.001178	3.49	2034.10	332.52	0.21
SF CWC	SECTION_01	17616	Ultimate 100 yr	3631.00	545.03	553.27	549.31	553.34	0.001064	3.12	1798.00	324.04	0.20
SF CWC	SECTION_01	17466	10 yr	2147.00	544.00	550.42	547.22	550.48	0.001028	2.53	1242.78	279.70	0.19
SF CWC	SECTION_01	17466	50 yr	3029.00	544.00	552.58	547.58	552.63	0.000578	2.34	1863.10	293.62	0.15
SF CWC	SECTION_01	17466	100 yr	3528.00	544.00	553.05	547.76	553.11	0.000627	2.54	2001.83	296.36	0.15
SF CWC	SECTION_01	17466	500 yr	4599.00	544.00	553.85	548.12	553.93	0.000753	2.95	2240.91	302.11	0.17
SF CWC	SECTION_01	17466	Ultimate 100 yr	3631.00	544.00	553.15	547.79	553.21	0.000635	2.57	2030.80	296.92	0.16
SF CWC	SECTION_01	17281	10 yr	2147.00	541.13	550.19	546.62	550.27	0.001142	3.31	1073.10	223.63	0.20
SF CWC	SECTION_01	17281	50 yr	3029.00	541.13	552.44	547.09	552.51	0.000734	3.12	1646.12	285.44	0.17
SF CWC	SECTION_01	17281	100 yr	3528.00	541.13	552.89	547.35	552.97	0.000812	3.38	1778.69	297.61	0.18
SF CWC	SECTION_01	17281	500 yr	4599.00	541.13	553.66	547.81	553.76	0.001000	3.92	2013.37	317.12	0.20
SF CWC	SECTION_01	17281	Ultimate 100 yr	3631.00	541.13	552.99	547.40	553.07	0.000826	3.43	1807.09	300.51	0.18
SF CWC	SECTION_01	16891	10 yr	2147.00	541.40	549.88	545.46	549.93	0.000842	2.78	1328.02	281.27	0.18
SF CWC	SECTION_01	16891	50 yr	3029.00	541.40	552.25	545.90	552.29	0.000505	2.57	2080.22	345.90	0.14
SF CWC	SECTION_01	16891	100 yr	3528.00	541.40	552.69	546.08	552.73	0.000555	2.77	2232.42	350.71	0.15
SF CWC	SECTION_01	16891	500 yr	4599.00	541.40	553.39	546.61	553.46	0.000723	3.31	2492.72	377.34	0.17
SF CWC	SECTION_01	16891	Ultimate 100 yr	3631.00	541.40	552.78	546.13	552.82	0.000567	2.82	2264.48	353.65	0.15
SF CWC	SECTION_01	16685	10 yr	2322.00	538.68	549.69	541.93	549.79	0.000472	2.60	893.34	269.71	0.14
SF CWC	SECTION_01	16685	50 yr	3328.00	538.68	552.19	542.70	552.22	0.000168	1.34	2579.73	380.58	0.08
SF CWC	SECTION_01	16685	100 yr	3876.00	538.68	552.62	543.09	552.65	0.000192	1.48	2747.25	399.93	0.09
SF CWC	SECTION_01	16685	500 yr	5162.00	538.68	553.31	543.95	553.36	0.000263	1.82	3034.26	440.00	0.10
SF CWC	SECTION_01	16685	Ultimate 100 yr	4009.00	538.68	552.71	543.19	552.74	0.000199	1.51	2783.07	404.58	0.09
SF CWC	SECTION_01	16615		Culvert									
SF CWC	SECTION_01	16546	10 yr	2322.00	539.03	545.32	543.79	546.20	0.008213	7.53	308.39	67.11	0.60
SF CWC	SECTION_01	16546	50 yr	3328.00	539.03	546.43	544.86	547.62	0.008422	8.76	379.86	73.40	0.63
SF CWC	SECTION_01	16546	100 yr	3876.00	539.03	547.12	545.34	548.33	0.009068	8.81	439.89	77.29	0.65
SF CWC	SECTION_01	16546	500 yr	5162.00	539.03	548.28	546.37	549.74	0.009229	9.69	535.07	90.26	0.67
SF CWC	SECTION_01	16546	Ultimate 100 yr	4009.00	539.03	547.25	545.46	548.48	0.009113	8.91	449.94	78.01	0.65
SF CWC	SECTION_01	16285	10 yr	2322.00	537.34	543.52	542.19	543.87	0.007132	8.07	591.07	171.31	0.59
SF CWC	SECTION_01	16285	50 yr	3328.00	537.34	545.14	542.75	545.44	0.004502	7.55	879.99	185.45	0.49

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	16285	100 yr	3876.00	537.34	545.79	543.09	546.10	0.004123	7.64	1003.27	190.09	0.47
SF CWC	SECTION_01	16285	500 yr	5162.00	537.34	547.09	543.66	547.43	0.003736	8.02	1254.98	198.51	0.46
SF CWC	SECTION_01	16285	Ultimate 100 yr	4009.00	537.34	545.93	543.16	546.25	0.004072	7.68	1030.33	191.03	0.47
SF CWC	SECTION_01	15904	10 yr	2322.00	531.00	541.16	538.62	541.81	0.003713	7.17	472.86	105.61	0.44
SF CWC	SECTION_01	15904	50 yr	3328.00	531.00	543.58	540.08	544.12	0.002447	6.92	737.26	114.28	0.37
SF CWC	SECTION_01	15904	100 yr	3876.00	531.00	544.21	540.62	544.81	0.002602	7.41	810.26	118.02	0.39
SF CWC	SECTION_01	15904	500 yr	5162.00	531.00	545.28	541.72	546.09	0.003151	8.67	941.86	125.95	0.44
SF CWC	SECTION_01	15904	Ultimate 100 yr	4009.00	531.00	544.33	540.75	544.96	0.002665	7.55	824.44	118.96	0.39
SF CWC	SECTION_01	15583	10 yr	2322.00	531.00	540.49	537.99	540.77	0.002317	6.08	767.41	171.86	0.36
SF CWC	SECTION_01	15583	50 yr	3328.00	531.00	543.25	538.81	543.44	0.001294	5.43	1296.41	222.83	0.28
SF CWC	SECTION_01	15583	100 yr	3876.00	531.00	543.88	539.18	544.09	0.001359	5.76	1441.62	236.81	0.29
SF CWC	SECTION_01	15583	500 yr	5162.00	531.00	544.94	539.96	545.21	0.001615	6.63	1706.70	263.35	0.32
SF CWC	SECTION_01	15583	Ultimate 100 yr	4009.00	531.00	544.00	539.26	544.22	0.001389	5.86	1469.31	239.55	0.29
SF CWC	SECTION_01	15193	10 yr	2322.00	528.15	539.60	536.57	539.95	0.002100	5.78	733.86	193.60	0.33
SF CWC	SECTION_01	15193	50 yr	3328.00	528.15	542.88	537.91	543.05	0.000838	4.47	1548.44	302.94	0.22
SF CWC	SECTION_01	15193	100 yr	3876.00	528.15	543.51	538.42	543.68	0.000851	4.65	1741.92	313.42	0.22
SF CWC	SECTION_01	15193	500 yr	5162.00	528.15	544.52	539.25	544.72	0.000984	5.25	2065.99	331.57	0.24
SF CWC	SECTION_01	15193	Ultimate 100 yr	4009.00	528.15	543.62	538.55	543.80	0.000866	4.72	1776.45	315.26	0.23
SF CWC	SECTION_01	14885	10 yr	2322.00	528.10	539.42	534.57	539.48	0.000417	2.76	1693.94	350.27	0.15
SF CWC	SECTION_01	14885	50 yr	3328.00	528.10	542.82	535.42	542.86	0.000191	2.26	3048.33	448.81	0.11
SF CWC	SECTION_01	14885	100 yr	3876.00	528.10	543.45	535.69	543.48	0.000207	2.43	3336.46	474.12	0.11
SF CWC	SECTION_01	14885	500 yr	5162.00	528.10	544.44	536.32	544.49	0.000261	2.85	3825.82	509.99	0.13
SF CWC	SECTION_01	14885	Ultimate 100 yr	4009.00	528.10	543.56	535.77	543.59	0.000214	2.48	3388.10	478.13	0.12
SF CWC	SECTION_01	14701	10 yr	2322.00	528.31	539.38	534.63	539.43	0.000372	2.42	1736.93	393.26	0.14
SF CWC	SECTION_01	14701	50 yr	3328.00	528.31	542.81	536.03	542.83	0.000136	1.81	3235.80	478.42	0.09
SF CWC	SECTION_01	14701	100 yr	3876.00	528.31	543.43	536.31	543.46	0.000143	1.92	3538.89	492.69	0.09
SF CWC	SECTION_01	14701	500 yr	5162.00	528.31	544.42	536.92	544.46	0.000176	2.23	4039.13	518.10	0.10
SF CWC	SECTION_01	14701	Ultimate 100 yr	4009.00	528.31	543.54	536.38	543.57	0.000147	1.96	3592.26	495.34	0.09
SF CWC	SECTION_01	14582	10 yr	2249.00	523.97	539.33	529.30	539.39	0.000195	2.02	1157.35	387.17	0.11
SF CWC	SECTION_01	14582	50 yr	3189.00	523.97	542.80	530.29	542.82	0.000057	1.30	3991.01	475.33	0.06
SF CWC	SECTION_01	14582	100 yr	3771.00	523.97	543.43	530.82	543.45	0.000067	1.45	4284.97	497.94	0.07
SF CWC	SECTION_01	14582	500 yr	5151.00	523.97	544.41	531.93	544.44	0.000096	1.81	4768.84	534.92	0.08
SF CWC	SECTION_01	14582	Ultimate 100 yr	3894.00	523.97	543.53	530.92	543.56	0.000069	1.48	4336.81	501.41	0.07
SF CWC	SECTION_01	14444		Culvert									
SF CWC	SECTION_01	14301	10 yr	2258.00	524.70	534.98	528.88	535.18	0.001199	3.56	634.25	447.71	0.21
SF CWC	SECTION_01	14301	50 yr	3212.00	524.70	535.79	529.93	536.12	0.001819	4.65	691.46	461.44	0.26
SF CWC	SECTION_01	14301	100 yr	3819.00	524.70	536.20	530.46	536.25	0.000395	2.23	2720.86	478.75	0.12
SF CWC	SECTION_01	14301	500 yr	5313.00	524.70	537.09	531.64	537.16	0.000520	2.70	3150.27	495.95	0.14

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	14301	Ultimate 100 yr	3959.00	524.70	536.29	530.58	536.34	0.000407	2.27	2762.65	483.37	0.13
SF CWC	SECTION_01	14120	10 yr	2258.00	527.00	534.65	532.68	534.84	0.003185	4.85	879.45	302.92	0.33
SF CWC	SECTION_01	14120	50 yr	3212.00	527.00	535.39	533.39	535.61	0.003413	5.38	1108.22	317.12	0.35
SF CWC	SECTION_01	14120	100 yr	3819.00	527.00	535.82	533.64	536.05	0.003486	5.65	1244.56	325.13	0.35
SF CWC	SECTION_01	14120	500 yr	5313.00	527.00	536.60	534.52	536.90	0.004099	6.52	1512.24	360.32	0.39
SF CWC	SECTION_01	14120	Ultimate 100 yr	3959.00	527.00	535.90	533.75	536.13	0.003539	5.73	1270.30	326.90	0.36
SF CWC	SECTION_01	13908	10 yr	2258.00	529.00	533.79	532.03	534.03	0.005754	4.99	677.63	265.53	0.42
SF CWC	SECTION_01	13908	50 yr	3212.00	529.00	534.41	532.61	534.72	0.006610	5.85	847.34	338.80	0.46
SF CWC	SECTION_01	13908	100 yr	3819.00	529.00	534.76	532.93	535.13	0.007130	6.36	998.88	391.38	0.49
SF CWC	SECTION_01	13908	500 yr	5313.00	529.00	535.47	533.81	535.88	0.007366	7.03	1281.42	409.21	0.50
SF CWC	SECTION_01	13908	Ultimate 100 yr	3959.00	529.00	534.83	533.00	535.20	0.007159	6.43	1026.62	392.95	0.49
SF CWC	SECTION_01	13479	10 yr	2284.00	527.00	530.58	529.86	530.87	0.011256	5.61	546.79	277.59	0.56
SF CWC	SECTION_01	13479	50 yr	3244.00	527.00	531.28	530.24	531.58	0.008951	5.72	750.81	303.89	0.52
SF CWC	SECTION_01	13479	100 yr	3857.00	527.00	531.68	530.46	531.99	0.008086	5.81	874.10	317.12	0.50
SF CWC	SECTION_01	13479	500 yr	5437.00	527.00	532.51	530.98	532.87	0.007336	6.24	1153.89	352.25	0.49
SF CWC	SECTION_01	13479	Ultimate 100 yr	4013.00	527.00	531.77	530.52	532.09	0.007973	5.85	902.46	320.12	0.50
SF CWC	SECTION_01	13237	10 yr	2284.00	521.00	527.94	526.78	528.42	0.009189	7.16	492.87	163.72	0.54
SF CWC	SECTION_01	13237	50 yr	3244.00	521.00	528.84	527.50	529.40	0.009267	7.96	658.68	212.13	0.56
SF CWC	SECTION_01	13237	100 yr	3857.00	521.00	529.35	527.84	529.93	0.009123	8.32	776.31	245.77	0.56
SF CWC	SECTION_01	13237	500 yr	5437.00	521.00	530.41	528.69	531.01	0.008326	8.75	1064.33	296.41	0.55
SF CWC	SECTION_01	13237	Ultimate 100 yr	4013.00	521.00	529.46	527.92	530.05	0.009051	8.38	804.58	251.22	0.56
SF CWC	SECTION_01	12822	10 yr	2373.00	518.00	526.01	523.83	526.12	0.001641	3.40	1101.25	313.38	0.24
SF CWC	SECTION_01	12822	50 yr	3370.00	518.00	526.93	524.31	527.06	0.001684	3.76	1392.31	319.63	0.25
SF CWC	SECTION_01	12822	100 yr	4038.00	518.00	527.46	524.58	527.61	0.001717	3.98	1563.64	322.90	0.25
SF CWC	SECTION_01	12822	500 yr	5806.00	518.00	528.64	525.17	528.82	0.001842	4.53	1946.53	329.82	0.27
SF CWC	SECTION_01	12822	Ultimate 100 yr	4211.00	518.00	527.59	524.65	527.74	0.001727	4.04	1605.23	323.66	0.25
SF CWC	SECTION_01	12421	10 yr	2373.00	518.00	525.06	523.05	525.25	0.003982	4.57	758.10	211.08	0.35
SF CWC	SECTION_01	12421	50 yr	3370.00	518.00	525.92	523.55	526.16	0.004201	5.20	947.14	273.47	0.37
SF CWC	SECTION_01	12421	100 yr	4038.00	518.00	526.42	523.83	526.69	0.004301	5.54	1103.72	296.81	0.38
SF CWC	SECTION_01	12421	500 yr	5806.00	518.00	527.53	524.50	527.85	0.004430	6.24	1445.04	320.35	0.40
SF CWC	SECTION_01	12421	Ultimate 100 yr	4211.00	518.00	526.55	523.90	526.82	0.004315	5.62	1140.21	300.63	0.38
SF CWC	SECTION_01	11967	10 yr	2373.00	519.00	523.13	521.35	523.33	0.005779	4.54	730.00	247.42	0.41
SF CWC	SECTION_01	11967	50 yr	3370.00	519.00	524.01	521.84	524.24	0.005373	5.03	958.69	273.03	0.41
SF CWC	SECTION_01	11967	100 yr	4038.00	519.00	524.53	522.14	524.78	0.005167	5.30	1103.88	287.42	0.41
SF CWC	SECTION_01	11967	500 yr	5806.00	519.00	525.66	522.83	525.96	0.004910	5.90	1445.65	313.38	0.41
SF CWC	SECTION_01	11967	Ultimate 100 yr	4211.00	519.00	524.65	522.18	524.91	0.005130	5.37	1140.49	291.28	0.41
SF CWC	SECTION_01	11238	10 yr	2373.00	511.46	520.27	518.62	520.52	0.004481	5.68	731.84	212.15	0.38
SF CWC	SECTION_01	11238	50 yr	3370.00	511.46	521.28	519.15	521.57	0.004526	6.25	960.52	245.84	0.39

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	11238	100 yr	4038.00	511.46	521.88	519.47	522.18	0.004515	6.55	1111.34	274.73	0.40
SF CWC	SECTION_01	11238	500 yr	5806.00	511.46	523.10	520.16	523.45	0.004564	7.20	1452.55	312.42	0.41
SF CWC	SECTION_01	11238	Ultimate 100 yr	4211.00	511.46	522.01	519.55	522.32	0.004544	6.64	1146.11	279.97	0.40
SF CWC	SECTION_01	10803	10 yr	2373.00	514.00	518.53	516.58	518.77	0.006225	5.06	643.77	181.81	0.44
SF CWC	SECTION_01	10803	50 yr	3370.00	514.00	519.54	517.12	519.83	0.006090	5.78	835.93	203.71	0.45
SF CWC	SECTION_01	10803	100 yr	4038.00	514.00	520.15	517.46	520.47	0.005965	6.16	965.12	219.58	0.45
SF CWC	SECTION_01	10803	500 yr	5806.00	514.00	521.29	518.23	521.71	0.006250	7.11	1228.72	240.72	0.48
SF CWC	SECTION_01	10803	Ultimate 100 yr	4211.00	514.00	520.26	517.53	520.59	0.006042	6.28	990.07	221.90	0.46
SF CWC	SECTION_01	10047	10 yr	2373.00	506.00	515.16	513.60	515.45	0.005636	5.79	661.80	197.03	0.41
SF CWC	SECTION_01	10047	50 yr	3370.00	506.00	516.14	514.13	516.48	0.005949	6.57	872.92	241.34	0.43
SF CWC	SECTION_01	10047	100 yr	4038.00	506.00	516.76	514.47	517.13	0.006071	7.02	1041.16	293.21	0.44
SF CWC	SECTION_01	10047	500 yr	5806.00	506.00	518.05	515.14	518.43	0.005735	7.56	1501.53	402.24	0.44
SF CWC	SECTION_01	10047	Ultimate 100 yr	4211.00	506.00	516.90	514.54	517.27	0.005981	7.05	1081.52	297.75	0.44
SF CWC	SECTION_01	9420	10 yr	2373.00	506.00	513.42	511.40	513.50	0.001705	3.49	1222.77	355.35	0.24
SF CWC	SECTION_01	9420	50 yr	3370.00	506.00	514.40	511.78	514.49	0.001597	3.70	1574.80	363.74	0.24
SF CWC	SECTION_01	9420	100 yr	4038.00	506.00	515.04	512.01	515.14	0.001497	3.79	1809.87	368.81	0.23
SF CWC	SECTION_01	9420	500 yr	5806.00	506.00	516.45	512.50	516.57	0.001403	4.08	2339.15	379.72	0.23
SF CWC	SECTION_01	9420	Ultimate 100 yr	4211.00	506.00	515.22	512.06	515.32	0.001459	3.79	1875.32	370.16	0.23
SF CWC	SECTION_01	9021	10 yr	2653.00	504.00	512.16	510.55	512.51	0.005988	6.71	674.56	176.98	0.45
SF CWC	SECTION_01	9021	50 yr	3692.00	504.00	513.11	511.12	513.52	0.006452	7.58	854.05	203.21	0.47
SF CWC	SECTION_01	9021	100 yr	4452.00	504.00	513.73	511.48	514.20	0.006871	8.23	988.51	232.80	0.50
SF CWC	SECTION_01	9021	500 yr	6611.00	504.00	515.14	512.32	515.68	0.006882	9.11	1347.94	275.93	0.51
SF CWC	SECTION_01	9021	Ultimate 100 yr	4709.00	504.00	513.92	511.61	514.40	0.006880	8.35	1032.15	237.92	0.50
SF CWC	SECTION_01	8667	10 yr	2653.00	503.00	510.64	508.88	510.86	0.004100	5.23	836.28	234.97	0.37
SF CWC	SECTION_01	8667	50 yr	3692.00	503.00	511.55	509.36	511.81	0.004075	5.71	1057.95	251.90	0.37
SF CWC	SECTION_01	8667	100 yr	4452.00	503.00	512.12	509.66	512.41	0.004112	6.03	1205.15	262.78	0.38
SF CWC	SECTION_01	8667	500 yr	6611.00	503.00	513.56	510.45	513.90	0.004077	6.72	1601.67	288.30	0.39
SF CWC	SECTION_01	8667	Ultimate 100 yr	4709.00	503.00	512.31	509.76	512.60	0.004123	6.14	1254.29	266.81	0.38
SF CWC	SECTION_01	8274	10 yr	2653.00	502.00	510.02	506.27	510.06	0.000652	2.12	1833.03	370.92	0.15
SF CWC	SECTION_01	8274	50 yr	3692.00	502.00	510.95	506.69	511.00	0.000727	2.45	2178.28	375.45	0.16
SF CWC	SECTION_01	8274	100 yr	4452.00	502.00	511.52	506.89	511.58	0.000785	2.68	2394.19	379.43	0.17
SF CWC	SECTION_01	8274	500 yr	6611.00	502.00	512.97	507.40	513.06	0.000905	3.22	2953.48	393.66	0.18
SF CWC	SECTION_01	8274	Ultimate 100 yr	4709.00	502.00	511.71	506.96	511.77	0.000801	2.75	2464.87	380.76	0.17
SF CWC	SECTION_01	7765	10 yr	2653.00	501.00	508.65	507.56	509.51	0.009763	8.89	527.69	213.24	0.59
SF CWC	SECTION_01	7765	50 yr	3692.00	501.00	509.62	507.60	510.42	0.008697	9.14	750.81	246.16	0.57
SF CWC	SECTION_01	7765	100 yr	4452.00	501.00	510.20	509.36	510.97	0.008229	9.31	896.76	263.06	0.56
SF CWC	SECTION_01	7765	500 yr	6611.00	501.00	511.62	510.29	512.39	0.007651	9.93	1331.77	339.94	0.55
SF CWC	SECTION_01	7765	Ultimate 100 yr	4709.00	501.00	510.39	509.61	511.16	0.008134	9.39	946.47	278.18	0.56

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	7344	10 yr	2653.00	497.00	506.75	503.20	506.97	0.002004	4.40	866.85	195.69	0.27
SF CWC	SECTION_01	7344	50 yr	3692.00	497.00	507.86	504.46	508.13	0.002146	4.96	1094.18	212.51	0.29
SF CWC	SECTION_01	7344	100 yr	4452.00	497.00	508.46	504.89	508.77	0.002347	5.41	1224.78	225.50	0.30
SF CWC	SECTION_01	7344	500 yr	6611.00	497.00	509.81	506.01	510.25	0.002910	6.56	1550.53	258.49	0.35
SF CWC	SECTION_01	7344	Ultimate 100 yr	4709.00	497.00	508.64	504.94	508.97	0.002416	5.55	1265.66	229.36	0.31
SF CWC	SECTION_01	7082	10 yr	2653.00	496.64	506.20	502.20	506.46	0.002031	4.43	789.79	179.39	0.27
SF CWC	SECTION_01	7082	50 yr	3692.00	496.64	507.21	503.06	507.55	0.002404	5.21	991.00	217.56	0.30
SF CWC	SECTION_01	7082	100 yr	4452.00	496.64	507.72	503.57	508.13	0.002740	5.77	1105.61	233.37	0.33
SF CWC	SECTION_01	7082	500 yr	6611.00	496.64	508.81	504.75	509.42	0.003738	7.24	1382.26	279.78	0.39
SF CWC	SECTION_01	7082	Ultimate 100 yr	4709.00	496.64	507.87	503.74	508.30	0.002860	5.96	1140.47	237.96	0.34
SF CWC	SECTION_01	6876	10 yr	2653.00	497.00	505.18	503.81	505.91	0.003080	7.11	432.35	146.20	0.54
SF CWC	SECTION_01	6876	50 yr	3692.00	497.00	506.27	504.88	507.00	0.002628	7.44	648.72	235.14	0.52
SF CWC	SECTION_01	6876	100 yr	4452.00	497.00	506.86	505.13	507.57	0.002429	7.57	791.93	255.00	0.50
SF CWC	SECTION_01	6876	500 yr	6611.00	497.00	507.93	506.89	508.76	0.002535	8.51	1084.45	293.74	0.53
SF CWC	SECTION_01	6876	Ultimate 100 yr	4709.00	497.00	507.01	505.20	507.73	0.002427	7.68	830.76	259.55	0.51
SF CWC	SECTION_01	6835		Bridge									
SF CWC	SECTION_01	6783	10 yr	2653.00	497.00	503.63	502.25	504.51	0.003959	7.55	359.36	92.38	0.60
SF CWC	SECTION_01	6783	50 yr	3692.00	497.00	504.64	503.17	505.73	0.003876	8.48	464.03	118.46	0.62
SF CWC	SECTION_01	6783	100 yr	4452.00	497.00	505.18	503.87	506.44	0.004067	9.21	527.93	149.59	0.64
SF CWC	SECTION_01	6783	500 yr	6611.00	497.00	506.47	505.91	507.98	0.004083	10.43	774.26	214.58	0.66
SF CWC	SECTION_01	6783	Ultimate 100 yr	4709.00	497.00	505.36	504.12	506.67	0.004076	9.40	551.65	159.55	0.65
SF CWC	SECTION_01	6732	10 yr	2653.00	495.09	503.61	501.06	504.19	0.002473	6.14	432.38	85.17	0.48
SF CWC	SECTION_01	6732	50 yr	3692.00	495.09	504.62	502.08	505.39	0.002969	7.05	523.71	96.15	0.53
SF CWC	SECTION_01	6732	100 yr	4452.00	495.09	505.15	502.76	506.08	0.003397	7.72	576.60	103.46	0.57
SF CWC	SECTION_01	6732	500 yr	6611.00	495.09	506.32	504.39	507.69	0.004250	9.41	707.68	126.04	0.66
SF CWC	SECTION_01	6732	Ultimate 100 yr	4709.00	495.09	505.33	502.97	506.31	0.003485	7.91	595.46	105.95	0.58
SF CWC	SECTION_01	6114	10 yr	2653.00	493.00	503.00	498.17	503.20	0.000506	3.96	921.00	283.34	0.24
SF CWC	SECTION_01	6114	50 yr	3692.00	493.00	504.01	499.16	504.23	0.000520	4.31	1232.41	323.16	0.24
SF CWC	SECTION_01	6114	100 yr	4452.00	493.00	504.51	499.91	504.75	0.000561	4.64	1398.93	339.00	0.26
SF CWC	SECTION_01	6114	500 yr	6611.00	493.00	505.71	502.43	506.01	0.000648	5.37	1845.12	393.74	0.28
SF CWC	SECTION_01	6114	Ultimate 100 yr	4709.00	493.00	504.69	500.12	504.94	0.000578	4.76	1460.34	358.50	0.26
SF CWC	SECTION_01	6060		Bridge									
SF CWC	SECTION_01	5996	10 yr	2653.00	492.75	502.59	498.75	503.00	0.002464	5.52	627.83	193.06	0.33
SF CWC	SECTION_01	5996	50 yr	3692.00	492.75	503.49	500.00	503.98	0.002846	6.33	826.17	260.82	0.36
SF CWC	SECTION_01	5996	100 yr	4452.00	492.75	503.91	501.00	504.47	0.003216	6.93	942.39	293.98	0.39
SF CWC	SECTION_01	5996	500 yr	6611.00	492.75	505.04	503.00	505.70	0.003663	7.95	1365.41	445.85	0.42
SF CWC	SECTION_01	5996	Ultimate 100 yr	4709.00	492.75	504.09	501.32	504.66	0.003239	7.04	995.51	313.90	0.39

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	5765	10 yr	2638.00	491.85	502.20	500.45	502.39	0.002082	4.61	904.02	345.22	0.29
SF CWC	SECTION_01	5765	50 yr	3654.00	491.85	503.10	500.96	503.31	0.002033	4.89	1249.68	473.92	0.29
SF CWC	SECTION_01	5765	100 yr	4377.00	491.85	503.53	501.28	503.73	0.001943	4.94	1456.23	487.58	0.29
SF CWC	SECTION_01	5765	500 yr	6473.00	491.85	504.70	502.18	504.89	0.001686	4.98	2050.84	537.83	0.27
SF CWC	SECTION_01	5765	Ultimate 100 yr	4638.00	491.85	503.73	501.41	503.92	0.001836	4.87	1551.67	493.52	0.28
SF CWC	SECTION_01	5502	10 yr	2638.00	492.00	501.72	499.45	501.92	0.001896	4.62	938.96	390.19	0.28
SF CWC	SECTION_01	5502	50 yr	3654.00	492.00	502.73	500.62	502.89	0.001453	4.36	1350.29	425.55	0.25
SF CWC	SECTION_01	5502	100 yr	4377.00	492.00	503.17	500.86	503.33	0.001463	4.51	1539.26	438.19	0.25
SF CWC	SECTION_01	5502	500 yr	6473.00	492.00	504.37	501.80	504.55	0.001375	4.72	2086.40	473.91	0.25
SF CWC	SECTION_01	5502	Ultimate 100 yr	4638.00	492.00	503.38	501.29	503.54	0.001390	4.46	1634.05	442.82	0.25
SF CWC	SECTION_01	5157	10 yr	3407.00	492.00	501.08	498.89	501.27	0.002277	4.85	1126.86	357.57	0.31
SF CWC	SECTION_01	5157	50 yr	5054.00	492.00	502.15	499.70	502.36	0.002154	5.14	1524.14	389.21	0.31
SF CWC	SECTION_01	5157	100 yr	5843.00	492.00	502.58	500.12	502.81	0.002126	5.27	1697.45	401.90	0.31
SF CWC	SECTION_01	5157	500 yr	8293.00	492.00	503.81	500.71	504.06	0.002015	5.58	2208.87	432.36	0.30
SF CWC	SECTION_01	5157	Ultimate 100 yr	6267.00	492.00	502.81	500.24	503.04	0.002115	5.34	1787.33	408.33	0.31
SF CWC	SECTION_01	4790	10 yr	3407.00	490.00	499.79	497.98	500.30	0.004216	6.97	739.52	243.58	0.43
SF CWC	SECTION_01	4790	50 yr	5054.00	490.00	500.90	498.75	501.45	0.004197	7.57	1026.57	274.17	0.44
SF CWC	SECTION_01	4790	100 yr	5843.00	490.00	501.36	498.77	501.92	0.004146	7.76	1154.54	285.46	0.44
SF CWC	SECTION_01	4790	500 yr	8293.00	490.00	502.62	500.70	503.22	0.004075	8.34	1540.35	330.81	0.44
SF CWC	SECTION_01	4790	Ultimate 100 yr	6267.00	490.00	501.58	498.78	502.15	0.004129	7.87	1220.18	291.11	0.44
SF CWC	SECTION_01	4435	10 yr	3407.00	489.29	498.85	497.14	499.14	0.002728	5.44	879.29	242.04	0.33
SF CWC	SECTION_01	4435	50 yr	5054.00	489.29	499.97	497.84	500.31	0.002788	5.99	1168.47	283.26	0.34
SF CWC	SECTION_01	4435	100 yr	5843.00	489.29	500.44	498.13	500.80	0.002780	6.17	1306.54	300.61	0.35
SF CWC	SECTION_01	4435	500 yr	8293.00	489.29	501.74	498.93	502.16	0.002635	6.53	1729.84	342.19	0.34
SF CWC	SECTION_01	4435	Ultimate 100 yr	6267.00	489.29	500.67	498.30	501.05	0.002758	6.25	1378.33	306.61	0.35
SF CWC	SECTION_01	4074	10 yr	3407.00	488.77	498.12	496.49	498.38	0.002256	4.82	855.72	235.67	0.30
SF CWC	SECTION_01	4074	50 yr	5054.00	488.77	499.26	497.09	499.58	0.002080	5.06	1130.32	243.89	0.29
SF CWC	SECTION_01	4074	100 yr	5843.00	488.77	499.73	497.26	500.09	0.002053	5.19	1245.52	247.25	0.29
SF CWC	SECTION_01	4074	500 yr	8293.00	488.77	501.03	497.98	501.48	0.002001	5.58	1571.80	255.22	0.30
SF CWC	SECTION_01	4074	Ultimate 100 yr	6267.00	488.77	499.97	497.42	500.34	0.002044	5.27	1304.60	248.96	0.30
SF CWC	SECTION_01	3739	10 yr	3407.00	488.00	497.15	495.29	497.53	0.003923	6.15	821.91	193.24	0.40
SF CWC	SECTION_01	3739	50 yr	5054.00	488.00	498.26	496.12	498.76	0.004410	7.17	1040.26	202.82	0.44
SF CWC	SECTION_01	3739	100 yr	5843.00	488.00	498.69	496.45	499.25	0.004663	7.63	1129.27	206.84	0.45
SF CWC	SECTION_01	3739	500 yr	8293.00	488.00	499.90	497.36	500.63	0.005235	8.81	1386.06	218.16	0.49
SF CWC	SECTION_01	3739	Ultimate 100 yr	6267.00	488.00	498.91	496.61	499.50	0.004784	7.86	1175.05	208.63	0.46
SF CWC	SECTION_01	3387	10 yr	3407.00	485.00	496.29	492.82	496.53	0.001660	4.75	1154.76	264.24	0.27
SF CWC	SECTION_01	3387	50 yr	5054.00	485.00	497.22	493.86	497.56	0.002243	5.88	1412.42	287.77	0.32
SF CWC	SECTION_01	3387	100 yr	5843.00	485.00	497.57	494.06	497.97	0.002525	6.37	1514.05	296.00	0.34
SF CWC	SECTION_01	3387	500 yr	8293.00	485.00	498.59	495.63	499.13	0.003175	7.59	1829.80	320.69	0.39

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	3387	Ultimate 100 yr	6267.00	485.00	497.75	494.39	498.17	0.002671	6.63	1566.91	300.66	0.35
SF CWC	SECTION_01	3120	10 yr	3407.00	485.86	495.95	492.22	496.20	0.000859	4.66	941.73	224.20	0.27
SF CWC	SECTION_01	3120	50 yr	5054.00	485.86	496.72	493.49	497.11	0.001213	5.85	1126.81	250.87	0.33
SF CWC	SECTION_01	3120	100 yr	5843.00	485.86	496.99	493.89	497.45	0.001401	6.40	1194.78	259.29	0.36
SF CWC	SECTION_01	3120	500 yr	8293.00	485.86	497.79	495.33	498.46	0.001883	7.81	1418.50	302.44	0.42
SF CWC	SECTION_01	3120	Ultimate 100 yr	6267.00	485.86	497.12	494.07	497.62	0.001506	6.69	1229.01	265.68	0.37
SF CWC	SECTION_01	2852	10 yr	3458.00	484.90	495.96	490.18	495.99	0.000109	1.80	2753.12	613.91	0.10
SF CWC	SECTION_01	2852	50 yr	5142.00	484.90	496.77	491.36	496.81	0.000151	2.22	3263.30	650.58	0.12
SF CWC	SECTION_01	2852	100 yr	5948.00	484.90	497.05	491.86	497.10	0.000174	2.43	3447.85	664.70	0.13
SF CWC	SECTION_01	2852	500 yr	8375.00	484.90	497.90	493.28	497.98	0.000226	2.90	4035.10	710.17	0.15
SF CWC	SECTION_01	2852	Ultimate 100 yr	6374.00	484.90	497.19	492.13	497.25	0.000186	2.53	3541.04	671.92	0.13
SF CWC	SECTION_01	2797		Culvert									
SF CWC	SECTION_01	2723	10 yr	3493.00	483.67	494.62	489.91	495.02	0.001117	5.12	696.94	397.84	0.31
SF CWC	SECTION_01	2723	50 yr	5218.00	483.67	496.24	491.22	496.40	0.000516	3.70	1947.81	539.76	0.21
SF CWC	SECTION_01	2723	100 yr	6032.00	483.67	496.69	491.80	496.85	0.000512	3.80	2194.81	551.04	0.21
SF CWC	SECTION_01	2723	500 yr	8463.00	483.67	497.71	493.37	497.89	0.000553	4.21	2774.62	589.80	0.22
SF CWC	SECTION_01	2723	Ultimate 100 yr	6461.00	483.67	496.89	492.14	497.06	0.000518	3.87	2304.73	556.01	0.22
SF CWC	SECTION_01	2586	10 yr	3493.00	484.95	494.51	491.10	494.81	0.001330	4.62	900.85	306.62	0.32
SF CWC	SECTION_01	2586	50 yr	5218.00	484.95	495.99	492.48	496.27	0.001038	4.69	1417.61	381.42	0.29
SF CWC	SECTION_01	2586	100 yr	6032.00	484.95	496.42	493.16	496.72	0.001090	4.97	1602.95	447.28	0.30
SF CWC	SECTION_01	2586	500 yr	8463.00	484.95	497.41	494.21	497.75	0.001132	5.46	2063.75	484.35	0.32
SF CWC	SECTION_01	2586	Ultimate 100 yr	6461.00	484.95	496.62	493.39	496.92	0.001091	5.05	1691.52	451.66	0.30
SF CWC	SECTION_01	2473	10 yr	3493.00	483.20	494.42	489.14	494.67	0.000817	4.20	991.32	311.35	0.26
SF CWC	SECTION_01	2473	50 yr	5218.00	483.20	495.91	490.50	496.17	0.000765	4.54	1451.91	371.93	0.26
SF CWC	SECTION_01	2473	100 yr	6032.00	483.20	496.31	491.07	496.61	0.000865	4.96	1597.86	440.98	0.28
SF CWC	SECTION_01	2473	500 yr	8463.00	483.20	497.30	492.57	497.64	0.000917	5.44	2136.35	479.28	0.29
SF CWC	SECTION_01	2473	Ultimate 100 yr	6461.00	483.20	496.52	491.35	496.82	0.000828	4.92	1776.79	444.95	0.27
SF CWC	SECTION_01	2413		Culvert									
SF CWC	SECTION_01	2341	10 yr	3493.00	481.13	489.15	486.88	490.08	0.004029	7.73	451.71	81.91	0.55
SF CWC	SECTION_01	2341	50 yr	5218.00	481.13	490.94	488.41	492.13	0.004085	8.78	599.44	108.92	0.57
SF CWC	SECTION_01	2341	100 yr	6032.00	481.13	491.59	488.93	492.93	0.004081	9.29	662.91	120.91	0.58
SF CWC	SECTION_01	2341	500 yr	8463.00	481.13	493.17	490.62	494.63	0.003924	9.87	1054.44	284.64	0.58
SF CWC	SECTION_01	2341	Ultimate 100 yr	6461.00	481.13	491.92	489.26	493.33	0.004093	9.56	696.46	136.45	0.59
SF CWC	SECTION_01	2033	10 yr	3493.00	476.41	488.21	484.03	489.03	0.002457	7.31	501.58	88.90	0.44
SF CWC	SECTION_01	2033	50 yr	5218.00	476.41	489.84	485.98	491.05	0.002938	8.96	715.41	190.43	0.49
SF CWC	SECTION_01	2033	100 yr	6032.00	476.41	490.51	486.71	491.83	0.003025	9.48	902.64	332.81	0.50
SF CWC	SECTION_01	2033	500 yr	8463.00	476.41	492.21	489.10	493.51	0.002803	10.04	1577.75	440.66	0.50

HEC-RAS Plan: Jul11 Locations: User Defined (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)	
SF CWC	SECTION_01	2033	Ultimate 100 yr	6461.00	476.41	490.88	487.08	492.20	0.002957	9.58	1036.38	373.63	0.50
SF CWC	SECTION_01	1806	10 yr	3493.00	476.19	487.04	484.85	488.24	0.004976	8.82	397.53	78.86	0.60
SF CWC	SECTION_01	1806	50 yr	5218.00	476.19	487.99	486.61	490.02	0.007012	11.46	466.45	114.87	0.73
SF CWC	SECTION_01	1806	100 yr	6032.00	476.19	488.36	487.30	490.73	0.007784	12.46	552.05	181.37	0.78
SF CWC	SECTION_01	1806	500 yr	8463.00	476.19	490.04	490.04	492.49	0.006778	13.21	908.75	248.92	0.75
SF CWC	SECTION_01	1806	Ultimate 100 yr	6461.00	476.19	488.54	487.67	491.08	0.008161	12.95	585.53	186.64	0.80
SF CWC	SECTION_01	1438	10 yr	3493.00	477.00	485.82	484.00	486.57	0.003403	8.11	839.07	299.17	0.52
SF CWC	SECTION_01	1438	50 yr	5218.00	477.00	486.88	486.01	487.72	0.003616	9.14	1169.34	321.32	0.55
SF CWC	SECTION_01	1438	100 yr	6032.00	477.00	487.31	486.36	488.19	0.003690	9.53	1307.60	328.42	0.56
SF CWC	SECTION_01	1438	500 yr	8463.00	477.00	488.37	487.26	489.40	0.004058	10.77	1673.58	364.12	0.60
SF CWC	SECTION_01	1438	Ultimate 100 yr	6461.00	477.00	487.50	486.57	488.41	0.003771	9.78	1373.05	334.23	0.57
SF CWC	SECTION_01	1142	10 yr	3493.00	476.62	485.10	482.88	485.62	0.002540	6.10	719.18	243.79	0.44
SF CWC	SECTION_01	1142	50 yr	5218.00	476.62	486.01	484.53	486.70	0.002978	7.25	950.04	265.48	0.49
SF CWC	SECTION_01	1142	100 yr	6032.00	476.62	486.35	484.98	487.13	0.003238	7.81	1042.31	284.38	0.51
SF CWC	SECTION_01	1142	500 yr	8463.00	476.62	487.18	485.92	488.23	0.003898	9.21	1299.30	332.15	0.57
SF CWC	SECTION_01	1142	Ultimate 100 yr	6461.00	476.62	486.49	485.20	487.33	0.003413	8.12	1083.11	292.57	0.53
SF CWC	SECTION_01	905	10 yr	3507.00	473.85	484.96	479.37	485.15	0.000661	3.69	1131.42	299.29	0.23
SF CWC	SECTION_01	905	50 yr	5236.00	473.85	485.85	480.69	486.14	0.000902	4.62	1432.74	370.37	0.27
SF CWC	SECTION_01	905	100 yr	6047.00	473.85	486.19	481.22	486.51	0.000995	4.98	1560.31	386.17	0.29
SF CWC	SECTION_01	905	500 yr	8485.00	473.85	487.03	482.67	487.46	0.001241	5.89	1901.88	423.05	0.33
SF CWC	SECTION_01	905	Ultimate 100 yr	6467.00	473.85	486.33	481.48	486.67	0.001053	5.17	1615.04	392.76	0.30
SF CWC	SECTION_01	825		Culvert									
SF CWC	SECTION_01	761	10 yr	3507.00	473.30	483.25	479.09	483.57	0.001698	4.79	902.82	521.74	0.35
SF CWC	SECTION_01	761	50 yr	5236.00	473.30	484.29	480.73	484.59	0.001472	4.98	1356.44	544.17	0.34
SF CWC	SECTION_01	761	100 yr	6047.00	473.30	484.73	483.05	485.03	0.001371	5.01	1554.77	555.45	0.33
SF CWC	SECTION_01	761	500 yr	8485.00	473.30	485.73	483.77	486.06	0.001303	5.33	2019.53	579.25	0.33
SF CWC	SECTION_01	761	Ultimate 100 yr	6467.00	473.30	484.89	483.22	485.20	0.001385	5.11	1628.96	561.53	0.33
SF CWC	SECTION_01	346	10 yr	3507.00	476.79	482.70	480.76	482.90	0.001283	3.91	1020.32	308.74	0.31
SF CWC	SECTION_01	346	50 yr	5236.00	476.79	483.77	481.42	484.01	0.001214	4.32	1359.69	327.14	0.31
SF CWC	SECTION_01	346	100 yr	6047.00	476.79	484.22	481.67	484.49	0.001210	4.52	1512.11	351.27	0.31
SF CWC	SECTION_01	346	500 yr	8485.00	476.79	485.18	482.31	485.52	0.001290	5.11	1852.74	356.45	0.33
SF CWC	SECTION_01	346	Ultimate 100 yr	6467.00	476.79	484.36	481.78	484.65	0.001251	4.66	1564.03	352.07	0.32

Appendix D
Storm Drain Model Output

Appendix E
Geomorphic Stream Assessment

Innovative approaches
Practical results
Outstanding service

Cottonwood Creek

Geomorphic Stream Assessment

Prepared for:

City of Grand Prairie

June 21, 2012

Prepared by:

FREESE AND NICHOLS, INC.
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ESP11227

TABLE OF CONTENTS

Executive Summary 1
1.0 Introduction 1
1.1 Field Assessment Methodology 1
2.0 Watershed Characteristics 2
2.1 Geographic Setting 3
2.2 Climate 3
2.3 Topography 3
2.4 Geology and Soils 3
2.5 Stream Morphology 4
3.0 Results 12
3.1 Channel Forming Discharge 12
3.2 Bed and Bank Material Erosion and Armoring Potential 13
3.2.1 Bed Material Evaluation and Movement Analysis 13
3.2.2 Critical Shear Stress of Channel Bed and Bank Material 21
3.2.3 Shale Erosion by Slaking 29
3.3 Vertical Stability 30
3.3.1 Equilibrium Slope 30
3.3.2 Channel Evolution 33
3.3.3 Existing Condition Channel Geometry 38
3.3.4 Existing Condition Channel Erosion and Instability 50
3.4 Planform Stability 62
3.4.1 Meander Migration 62
3.4.2 Bank Stability 62
4.0 Design and Engineering Considerations 64
4.1 Channel Erosion and Instability 64
4.2 Critical Shear Stress of Channel Bed and Bank Material 64
4.3 Shale Erosion by Slaking 64
4.4 Equilibrium Slope 64
4.5 Channel Evolution 65

4.6 Planform Stability 65
5.0 References 66

LIST OF FIGURES

Figure 2.1 Aerial photograph of the Cottonwood Creek watershed study area 5
Figure 2.2 Historical aerial photographs of Cottonwood Creek watershed study reaches 7
Figure 2.3 A topographic map of the Cottonwood Creek study area 8
Figure 2.4 Geology map of the Cottonwood Creek study area 9
Figure 2.5 Soil survey map of the Cottonwood Creek study area 10
Figure 2.6 Channel geomorphic examples in Cottonwood Creek study area 11
Figure 3.1 Incipient motion analysis results for North Fork Cottonwood Creek study reach 16
Figure 3.2 Incipient motion analysis results for South Fork Cottonwood Creek study reach 17
Figure 3.3 Incipient motion analysis results for Cottonwood Creek study reach 18
Figure 3.4 Incipient motion analysis results for Warrior Creek study reach 19
Figure 3.5 Incipient motion analysis results for Plattner Creek study reach 20
Figure 3.6 North Fork Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material 24
Figure 3.7 South Fork Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material 25
Figure 3.8 Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material 26
Figure 3.9 Warrior Creek hydraulic shear stress and critical shear stress of bed and bank material . 27
Figure 3.10 Plattner Creek hydraulic shear stress and critical shear stress of bed and bank material . 28
Figure 3.11 Incised Channel Evolution Model 36
Figure 3.12 Channel evolution of Cottonwood Creek watershed study reaches 37
Figure 3.13 Graph of North Fork Cottonwood Creek bank height and active channel depth 40
Figure 3.14 Graph of North Fork Cottonwood Creek bottom width and active channel width 41
Figure 3.15 Graph of South Fork Cottonwood Creek bank height and active channel depth 42
Figure 3.16 Graph of South Fork Cottonwood Creek bottom width and active channel width 43
Figure 3.17 Graph of Cottonwood Creek bank height and active channel depth 44
Figure 3.18 Graph of Cottonwood Creek bottom width and active channel width 45

Figure 3.19 Graph of Warrior Creek bank height and active channel depth 46
Figure 3.20 Graph of Warrior Creek bottom width and active channel width 47
Figure 3.21 Graph of Plattner Creek bank height and active channel depth 48
Figure 3.22 Graph of Plattner Creek bottom width and active channel width..................................... 49
Figure 3.23 Photos of bank stability.. 53
Figure 3.24 Photographs of bank failures 63

LIST OF TABLES

Table 2.1 Factors affecting stream bank stability 2
Table 2.1 Study reach characteristics 6
Table 3.1 Results of bed material grain size analysis for the study reaches 13
Table 3.2 Results of shale slaking analysis... 29
Table 3.3 Results of North Fork Cottonwood Creek equilibrium slope analysis 31
Table 3.4 Results of South Fork Cottonwood Creek equilibrium slope analysis 31
Table 3.5 Results of Cottonwood Creek equilibrium slope analysis.. 32
Table 3.6 Results of Warrior Creek equilibrium slope analysis 32
Table 3.7 Results of Plattner Creek equilibrium slope analysis.. 32
Table 3.8 Descriptions of specific areas of interest and severe instability along North Fork Cottonwood Creek 54
Table 3.9 Descriptions of specific areas of interest and severe instability along South Fork Cottonwood Creek 55
Table 3.10 Descriptions of specific areas of interest and severe instability along Cottonwood Creek 57
Table 3.11 Descriptions of specific areas of interest and severe instability along Warrior Creek 58
Table 3.12 Descriptions of specific areas of interest and severe instability along Plattner Creek....... 60

APPENDICES

Appendix A	Field Sketches
Appendix B	Areas of Interest
Appendix C	Grain Size Analyses
Appendix D	Channel Erosion and Instability

ATTACHMENT

Attachment 1	DVD containing shapefiles, photographs and photo-shapefiles

EXECUTIVE SUMMARY

Bed	The bed material was highly variable consisting of clay alluvium, sandstone, shale, sand and gravels. In the creeks within the Cottonwood watershed had D_{50} that varied from 3 mm to 8 mm and the D_{90} from 13 mm to 19 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	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 the study reaches. It can be expected that the channel of the study reaches will experience approximately 1 to 6 inches of 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, Burleson, Ferris, Ferris-Heiden, Ferris-Urban, Heiden, Houston Black, Lewisville, Ovan and the Trinity-Urban.
Bank Stability	Slumps and rotational failures were common in the study area along segments where flood flows became ponded from debris jams and aerial pipelines, 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 the creeks 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 in the 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 North Fork of Cottonwood Creek is 0.0012 ft/ft, South Fork of Cottonwood Creek 0.0014 ft/ft, Cottonwood Creek is 0.0010 ft/ft, Warrior Creek is 0.0021 ft/ft and Plattner Creek is 0.0016 ft/ft.

EXECUTIVE SUMMARY

Meander Migration	Meander migration rates were unable to be measured using aerial photographs as part of this study. Tree canopy density of the riparian corridor along the only remaining meandering study reach (South Fork Cottonwood Creek) was too dense to identify channel locations on sequential historical aerial photography. Field observations suggested that meanders of South Fork Cottonwood Creek may be migrating, but repeated site visits over a relatively long period of time would be necessary to measure a meander migration rate.
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 July 18 through July 28, 2011, FNI Hydrologists/Fluvial Geomorphologists performed a geomorphic stream assessment was performed on the channels of North Fork Cottonwood Creek, South Fork Cottonwood Creek, Cottonwood Creek, Warrior Creek, and Plattner 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 locations of erosive conditions, channel instability issues, and potential erosion threats to private property and infrastructure adjacent to the creek 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 channel protection, stabilization, and improvement projects.

1.1 Field Assessment Methodology

The stream assessment entailed a walking survey of the study reaches of North Fork Cottonwood Creek, South Fork Cottonwood Creek, Cottonwood Creek, Warrior Creek, and Plattner 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 reaches were divided into segments and numbered the same as the cross-sections in the hydrologic and hydraulic model of Cottonwood 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). 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. 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 2.1. 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 geographic setting, climate, topography, geology and soils, and stream morphology. 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 the study reaches 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 the study reaches 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 study reaches are all within the Cottonwood Creek watershed.

The Cottonwood Creek watershed is developed and landuse types include urban, single family residential, and industrial (accounts for approximately 80 percent). Plattner Creek confluences with Cottonwood Creek outside the boundaries of the study area, and Cottonwood Creek flow into Mountain Creek Lake which discharges to the West Fork Trinity River. Historically, the watersheds were agricultural from 1890's to 1950's. Residential development began in the 1950's and has continued until present (Figure 2.2).

2.2 Climate

The study reaches of the Cottonwood Creek watershed occupy the extreme northern part of the humid subtropical belt which extends inland from the Gulf of Mexico. Average annual temperatures range from 52°F to 77°F. Annual precipitation averages 41 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 455 ft msl (Figure 2.3). Average study reach channel slopes are listed in Table 3.1.

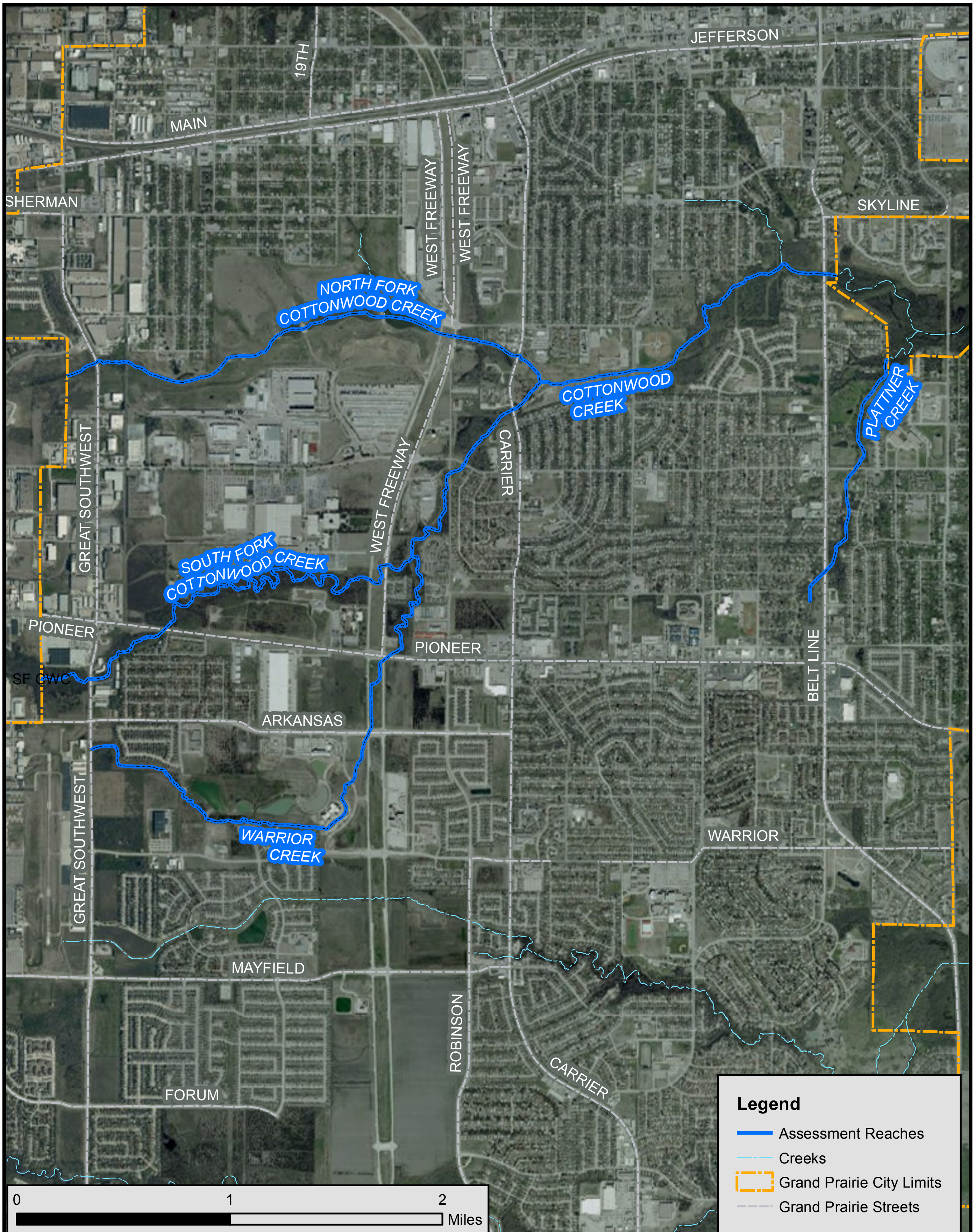
2.4 Geology and Soils

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). Stream valleys contain Quaternary Alluvium deposits (Figure 2.4). The Woodbine Formation, Eagle Ford Shale and Quaternary Alluvium were observed in the study area. The Woodbine Formation consists of interbedded sandstone, clay, and shale (Bureau of Economic Geology, 1988). The Woodbine geology observed in the study reaches was weathered clayey sandstone and silty shales. 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, Burleson, Ferris, Ferris-Heiden, Ferris-Urban, Heiden, Houston Black, Lewisville, Ovan and the Trinity-Urban by the Natural Resources Conservation Service (NRCS) (Figure 2.5). The Altoga and Ovan soils are classified as clay (CL) soils with low plasticity (liquid limit less than 50 percent). The Burleson, Ferris, Heiden, Houston Black, and Trinity soils are classified as fat clay (CH) soils with high plasticity (liquid limit greater than 50). The 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, Lewisville and Ovan soils are located.

2.5 Stream Morphology

The study reaches in the Cottonwood Creek watershed are part of a dynamic fluvial stream system. Historical aerial photographs and evidence from the field assessment show that the channels of the study reaches have historically migrated and meandered over the existing floodplain. Channel braiding, anabranches, and chute cutoffs are evidence of past and current channel adjustment and migration. The study reaches contain multiple geomorphic units including scour pools, pools, runs, riffles, bars, undercut banks, knickpoints, chute cutoffs, benches (formed of slumped material), ledges, large woody debris (LWD), and log jams (Figure 2.6). It was observed in the field that the five study reaches have floodplain connectivity along most of their length during the 1-year to 2-year peak discharge and greater, which allows flows to spread out and dissipate during high-flow events. However, there are segments of all the study reaches with entrenched channels that are only connected to the floodplain during flows greater than the 2-year peak discharge. The five study reaches are all characterized as sinuous, with sinuosity ratios between 1.01 and 1.31. Aerial photograph analysis and field observations suggest that segments of the five study reaches have been artificially straightened in the past, potentially for flood control purposes. Retention ponds have been constructed on the channels of North Fork Cottonwood Creek and Warrior Creek. There are areas along all the study reaches that have been altered for protection/stabilization purposes. Locations of existing channel protection/stabilization structures are presented in Appendix B.



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Cottonwood Creek Watershed Geomorphic Stream Assessment

Location Map

FN JOB NO	ESP11227
FILE	2.1_location.mxd
DATE	March 13 2012
SCALE	1:40,000
DESIGNED	SVC
DRAFTED	SVC

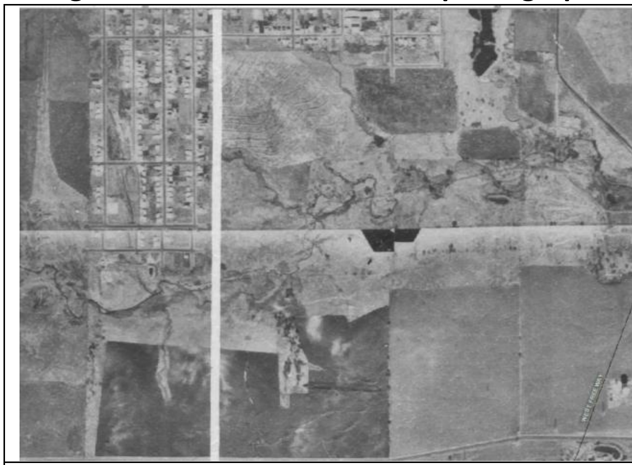
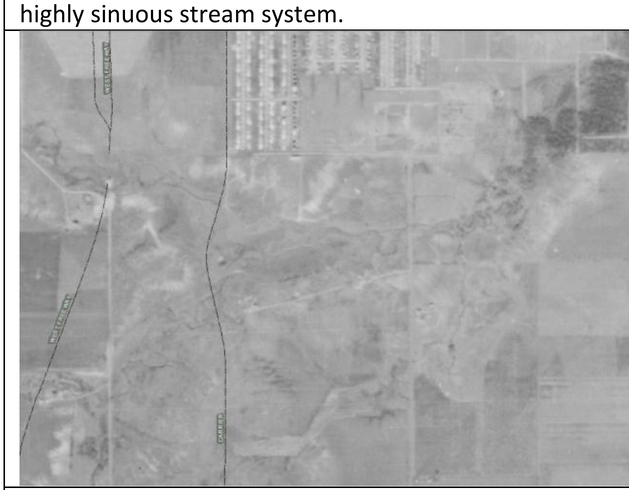
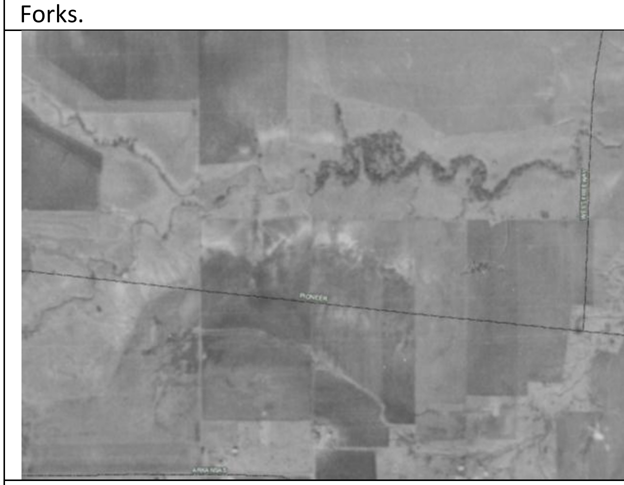
2.1

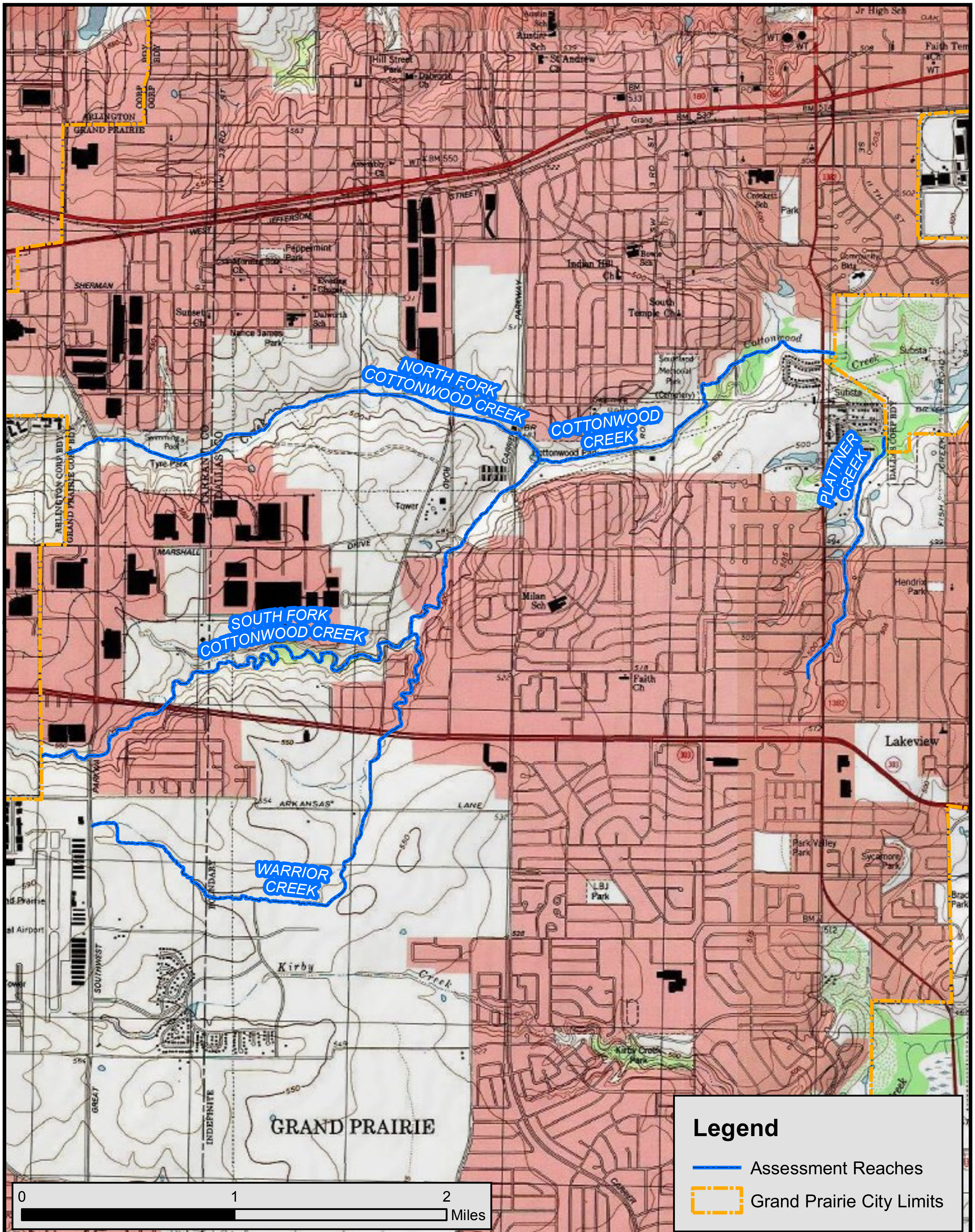
FIGURE

Table 2.1 Study reach characteristics

Creek	Drainage area (sq.mi.)	Reach length (mi.)	Upstream end of reach	Downstream end of reach	Comment
North Fork Cottonwood Creek	5.7	2.1	625 feet upstream of Great Southwest Parkway	Confluence of North Fork Cottonwood Creek and South Fork Cottonwood Creek, 650 feet downstream of Carrier Parkway	Channel stability was not assessed between cross-sections 6201 and 2170 because of a chain of retention ponds and construction at SH 161
South Fork Cottonwood Creek	4.6	3.4	1,100 feet upstream of Great Southwest Parkway	Confluence of North Fork Cottonwood Creek and South Fork Cottonwood Creek, 650 feet downstream of Carrier Parkway	Channel was not assessed between cross-sections 6730 and 5996 because of construction at SH 161
Cottonwood Creek	15.1	1.5	Confluence of North Fork Cottonwood Creek and South Fork Cottonwood Creek, 650 feet downstream of Carrier Parkway	230 feet downstream of Belt Line Road	
Warrior Creek	1.8	2.6	Culvert at Great Southwest Parkway	Confluence of Warrior Creek with South Fork Cottonwood Creek	Channel was not assessed between cross-sections 5343 and 3076 because of construction at SH 161
Plattner Creek	1.2	1.1	680 feet upstream of Belt Line Road	2,200 feet downstream of W. Marshall Drive	Creek was in a trapezoidal concrete channel from the start of the study reach to Belt Line Road. Channel was fully enclosed between cross-sections 5235 and 4510

Figure 2.2 Historical aerial photographs of Cottonwood Creek watershed study reaches

	
In 1964, the North Fork of Cottonwood Creek was a highly sinuous stream system.	Around 2001, retention ponds were placed on channel of the North Fork of Cottonwood Creek (photo 2009).
	
Cottonwood Creek in 1953 indicates straightening downstream of the confluence of the North and South Forks.	Cottonwood Creek in 2009 shows a straightened stream with severe erosion downstream of the confluence of the North and South Forks.
	
The South Fork of Cottonwood Creek in 1953 was a meandering stream with sparse riparian vegetation.	The South Fork of Cottonwood Creek is still a meandering stream with a dense riparian corridor.



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N W E S

Cottonwood Creek Watershed Geomorphic Stream Assessment

Topography

FN JOB NO	ESP11227
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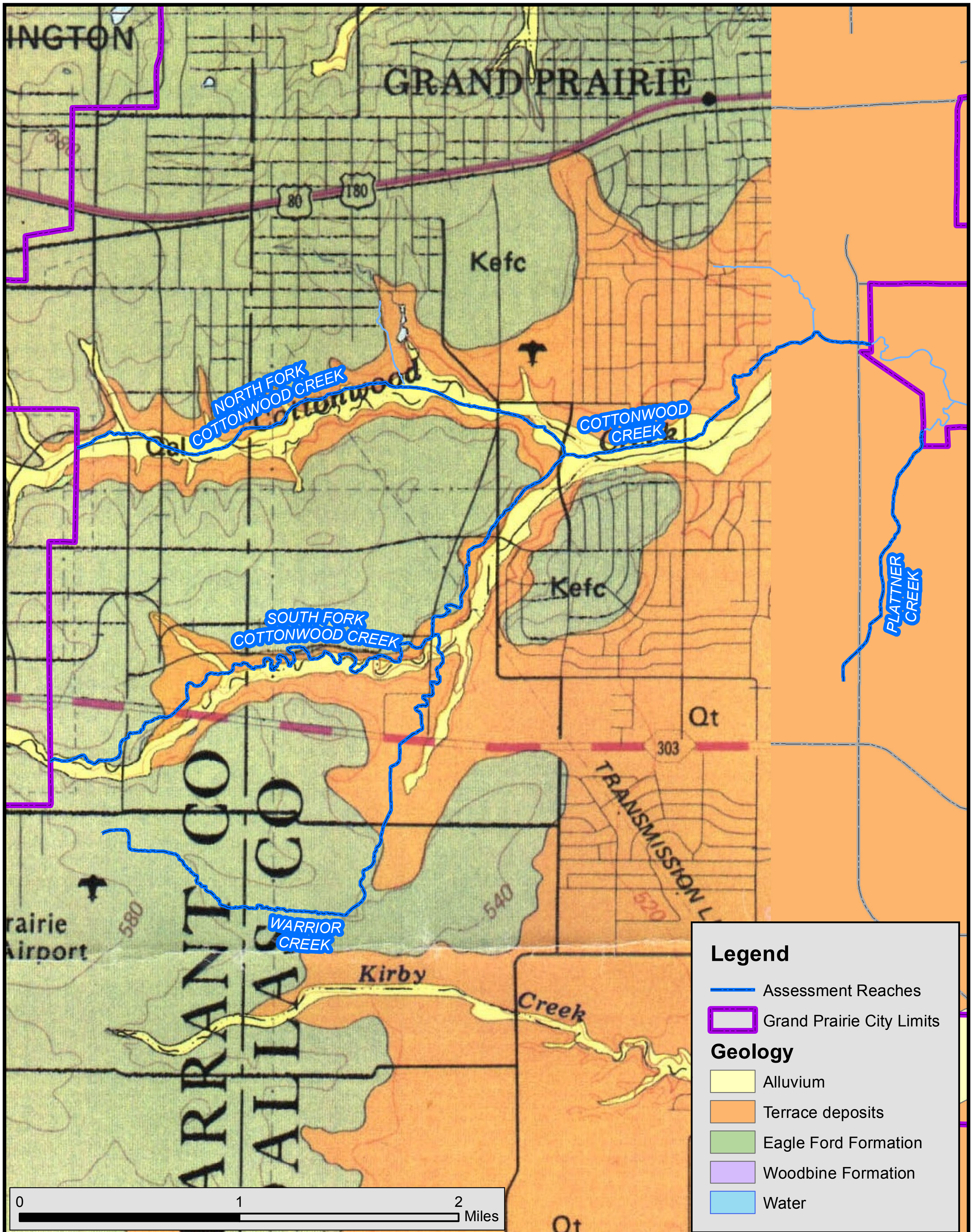
SCALE	1:40,000
DESIGNED	SVC
DRAFTED	SVC

2.3

FIGURE



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N
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Cottonwood Creek Watershed
Geomorphic Stream Assessment

Geology

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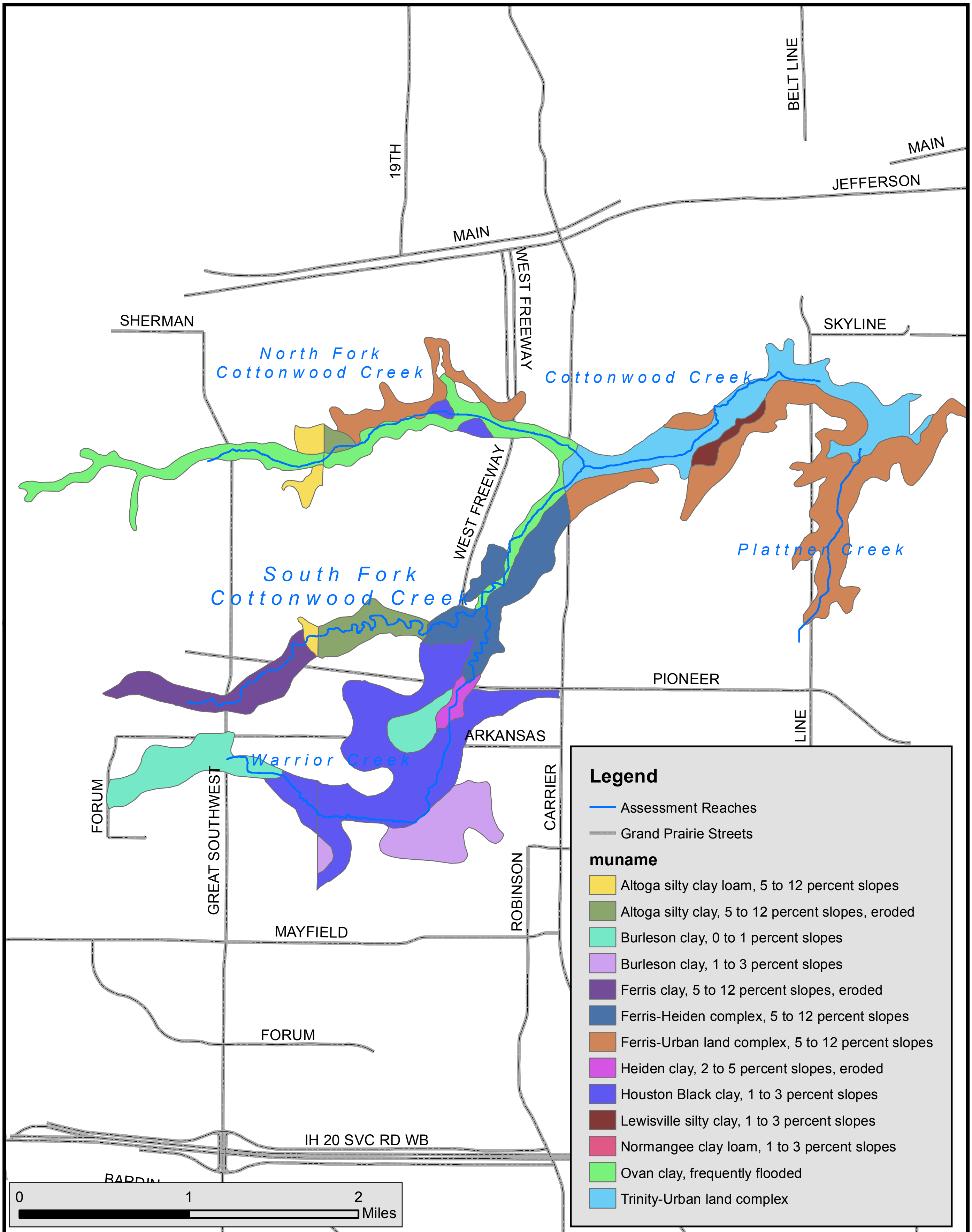
DESIGNED	SVC
DRAFTED	SVC

2.4
FIGURE



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Cottonwood Creek Watershed Geomorphic Stream Assessment

Soils

FN JOB NO	ESP11227
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DATE	March 13 2012
SCALE	1:50,000
DESIGNED	SVC
DRAFTED	SVC

2.5

FIGURE

Figure 2.6 Channel geomorphic examples in Cottonwood Creek study area

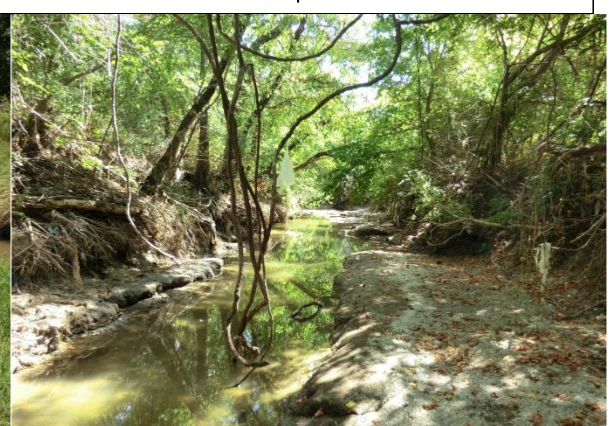
Undercut bank

Chute cutoff (left side of photos)

Scour pool

Knickpoint

Mid-channel bar



Ledge

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 determines particular channel parameters, such as cross-sectional capacity (Wolman and Leopold, 1957) and 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.

Based on field observations and review of the Cottonwood Creek hydrologic and hydraulic model (Espey Consultants, Inc., 2010), the modeled 1-year discharge appears to be approximately the active channel discharge in the majority of the modeled cross-sections in the study area.

The watersheds of five study reaches in the Cottonwood Creek watershed 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 higher in all the study reaches than existing modeled 100-year flood conditions. Future flow increases may cause channel instabilities and should be considered during any channel improvement projects. Hydrologic and hydraulic model results for Warrior Creek upstream of Arkansas Lane were provided by Espey Consultants in a separate study from the Cottonwood Creek watershed hydrologic and hydraulic model (Espey Consultants, Inc., 2010).

In summary (by creek):

North Fork Cottonwood Creek

- Modeled existing 1-year peak discharge from 1,899 cfs (upstream) to 2,506 cfs (downstream)
- Percent increase of modeled 100-year flows from 1.1% (upstream) to 3.6% (downstream)

South Fork Cottonwood Creek

- Modeled existing 1-year peak discharge from 817 cfs (upstream) to 1,275 cfs (downstream)
- Percent increase of modeled 100-year flows from 2.8% (upstream) to 8.4% (downstream)

Cottonwood Creek

- Modeled existing 1-year peak discharge from 3,429 cfs (upstream) to 3,605 cfs (downstream)
- Percent increase of modeled 100-year flows from 5.3% (upstream) to 7.2% (downstream)

Warrior Creek

- Modeled existing 1-year peak discharge from 207 cfs (upstream) to 692 cfs (downstream)
- Percent increase of modeled 100-year flows from 2.3% (upstream) to 7.0% (downstream)

Plattner Creek

- Modeled existing 1-year peak discharge from 475 cfs (upstream) to 842 cfs (downstream)
- Percent increase of modeled 100-year flows from 2.0% (upstream) to 3.5% (downstream)

The modeled 1-year flood discharge and associated hydrologic and hydraulic characteristics for the Cottonwood Creek watershed study reaches (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 the study reaches 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 the study reaches

	Cross-section	D_{50} (mm)	D_{90} (mm)
North Fork CWC	7881	5.3	19.5
North Fork CWC	701	3.6	13.0
South Fork CWC	346	2.1	7.9
Warrior Creek	8841	4.1	12.0
Warrior Creek	2417	5.3	19.0
Plattner Creek	2098	3.4	15.0

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} median grain size and D_{90} potential armoring grain size), depth, channel slope, flow velocity, and discharge. The depth and velocity variables were obtained from the modeled 1-year and future 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.

Bed material transport potential is generally higher for the future 100-year peak discharge than for the 1-year peak discharge. Exceptions to this generalization, when the transport potential for the 1-year peak discharge is greater than for the future 100-year peak discharge, typically occurred at cross-sections where the 1-year discharge was contained to a deep and narrow entrenched channel that generated high flow velocities.

The results of the incipient motion analysis for North Fork Cottonwood 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 high future 100-year peak discharge sediment transport potential at cross-section 9769 is caused by a decrease in channel cross-sectional area and an increase in slope where the channel is under a railroad bridge and is lined with riprap and concrete. Upstream and downstream of the railroad bridge the high flows are able to spread out onto a floodplain, which reduces stream power and erosion potential. Stream power and sediment transport potential are increased when high flows are constricted under the bridge. A grain size of approximately 400 mm (~16 inches) would be necessary to armor the creek bed at this location during the future 100-year peak discharge. Transport potential is also increased where the channel is lined with concrete (8720 – 7881) and at cross-section 2005 where the channel slope is relatively steep compared to upstream and downstream cross-sections. Incipient motion analysis results for the remaining study reaches are as follows:

South Fork Cottonwood Creek

- Future 100-year peak discharge sediment transport potential generally greater than 1-year peak discharge (Figure 3.2)
- No potential for natural armoring by existing bed material in majority of study reach
- High sediment transport potential at cross-section 1806 caused by steep slope and decreased channel cross-sectional area

Cottonwood Creek

- Future 100-year peak discharge sediment transport potential generally greater than 1-year peak discharge (Figure 3.3)
- No potential for natural armoring by existing bed material in majority of study reach
- High sediment transport potential at cross-sections 11763 and 5211 caused by steep slope and decreased channel cross-sectional area

Warrior Creek

- Future 100-year peak discharge sediment transport potential generally greater than 1-year peak discharge (Figure 3.4)
- No potential for natural armoring by existing bed material in majority of study reach
- High sediment transport potential downstream of W. Pioneer Parkway. The channel of Warrior Creek downstream of W. Pioneer Parkway is typically deep and narrow with limited floodplain connectivity during high flow conditions. High transport potential is caused by a series of knickpoints downstream of cross-section 689 that have steepened the channel slope to 0.01 ft/ft.

Plattner Creek

- Future 100-year peak discharge sediment transport potential generally greater than 1-year peak discharge (Figure 3.5)
- No potential for natural armoring by existing bed material in majority of study reach
- The steep channel slope and incised nature of the channel created high sediment transport potential at cross-section 2482 during the 1-year peak discharge.

The majority of the calculated peaks in sediment transport capacity in the study reaches were influenced primarily by steep modeled channel slopes relative to upstream and downstream cross-sections. There is potential that the minimum channel elevations used to calculate channel slope may not be representative of actual conditions, and surveyed channel cross-section measurements should be used to model hydraulic conditions prior to the design of any channel protection or stabilization structures.

Figure 3.1 Incipient motion analysis results for North Fork Cottonwood Creek study reach

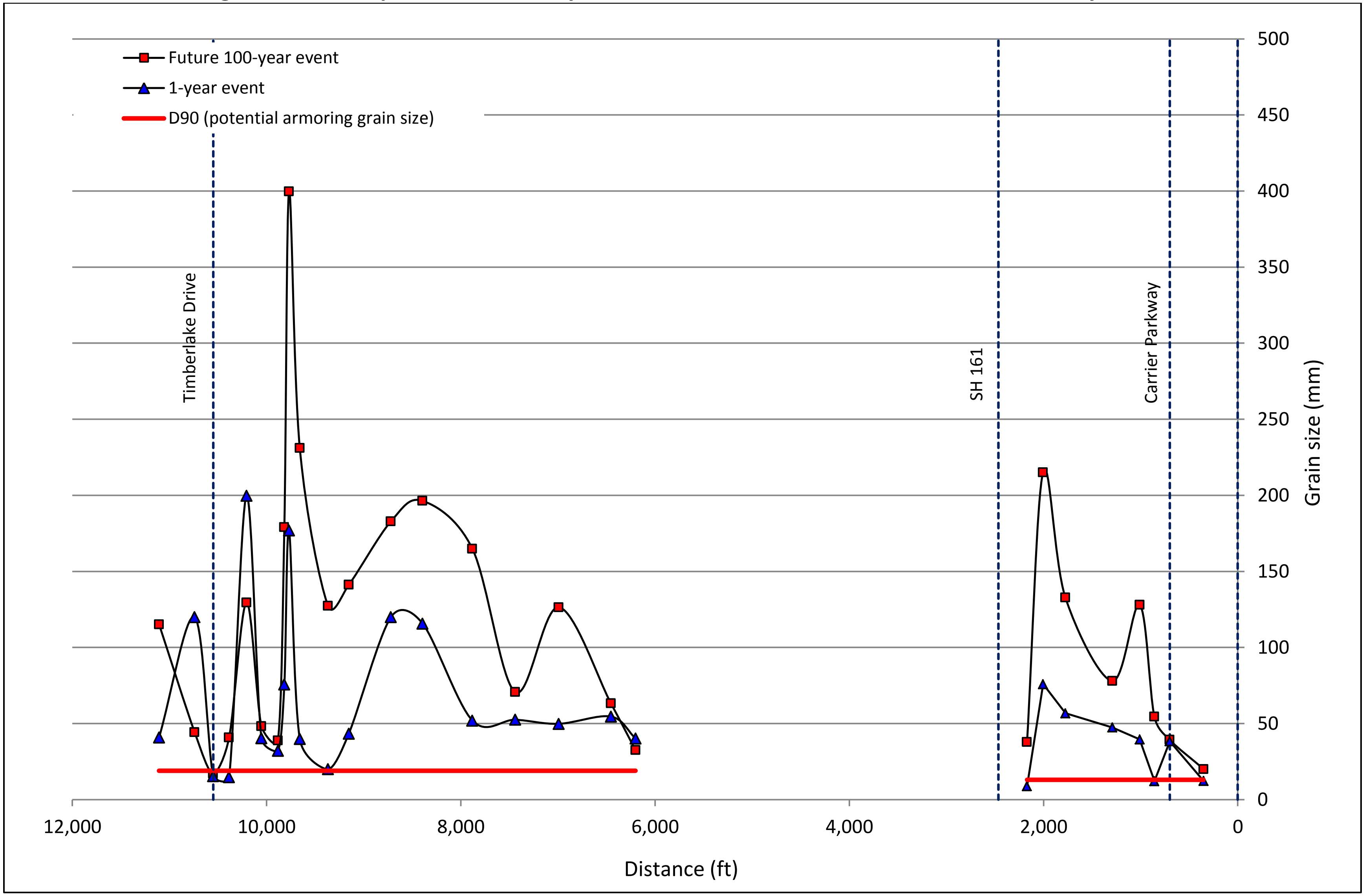


Figure 3.2 Incipient motion analysis results for South Fork Cottonwood Creek study reach

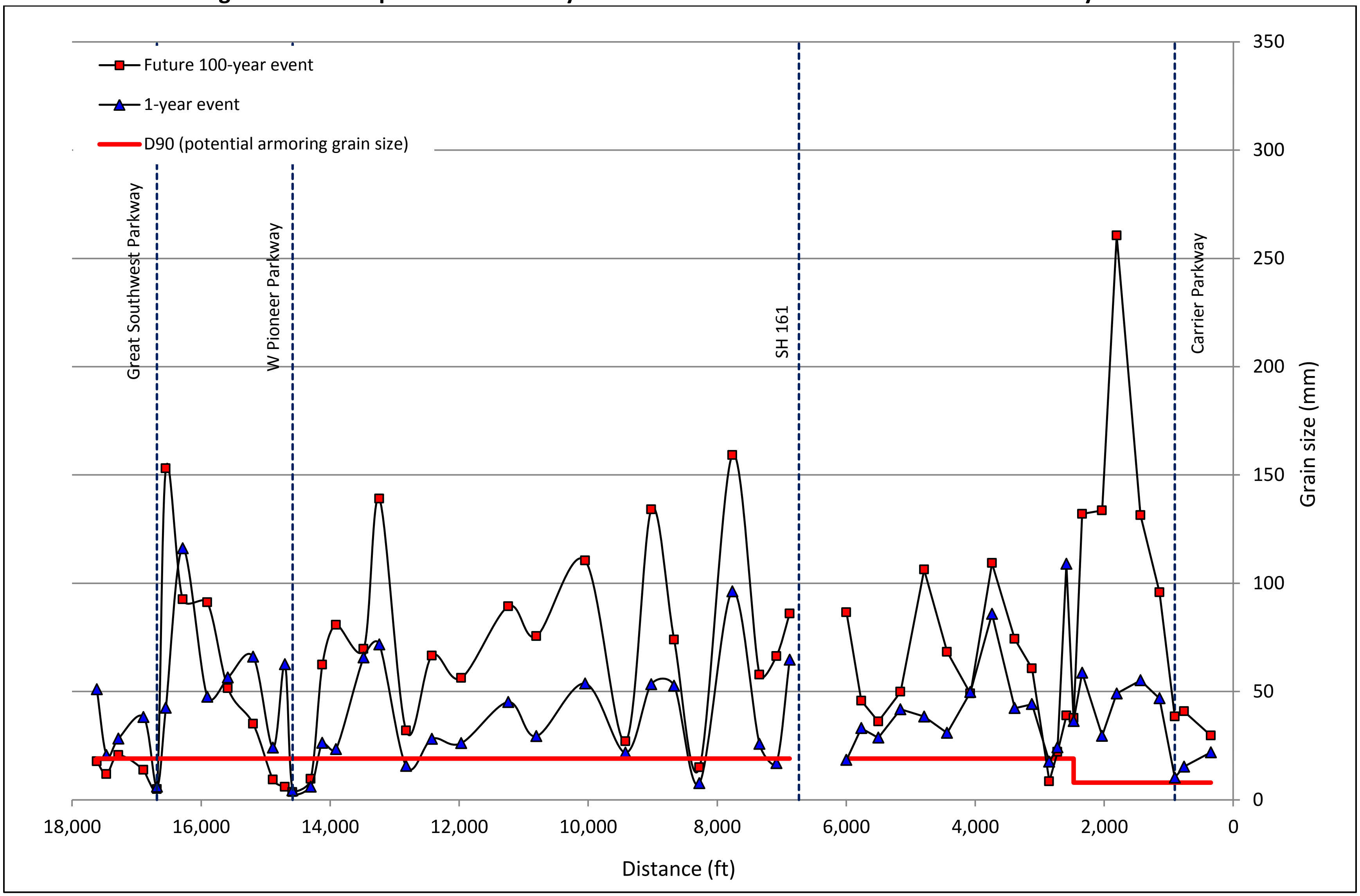


Figure 3.3 Incipient motion analysis results for Cottonwood Creek study reach

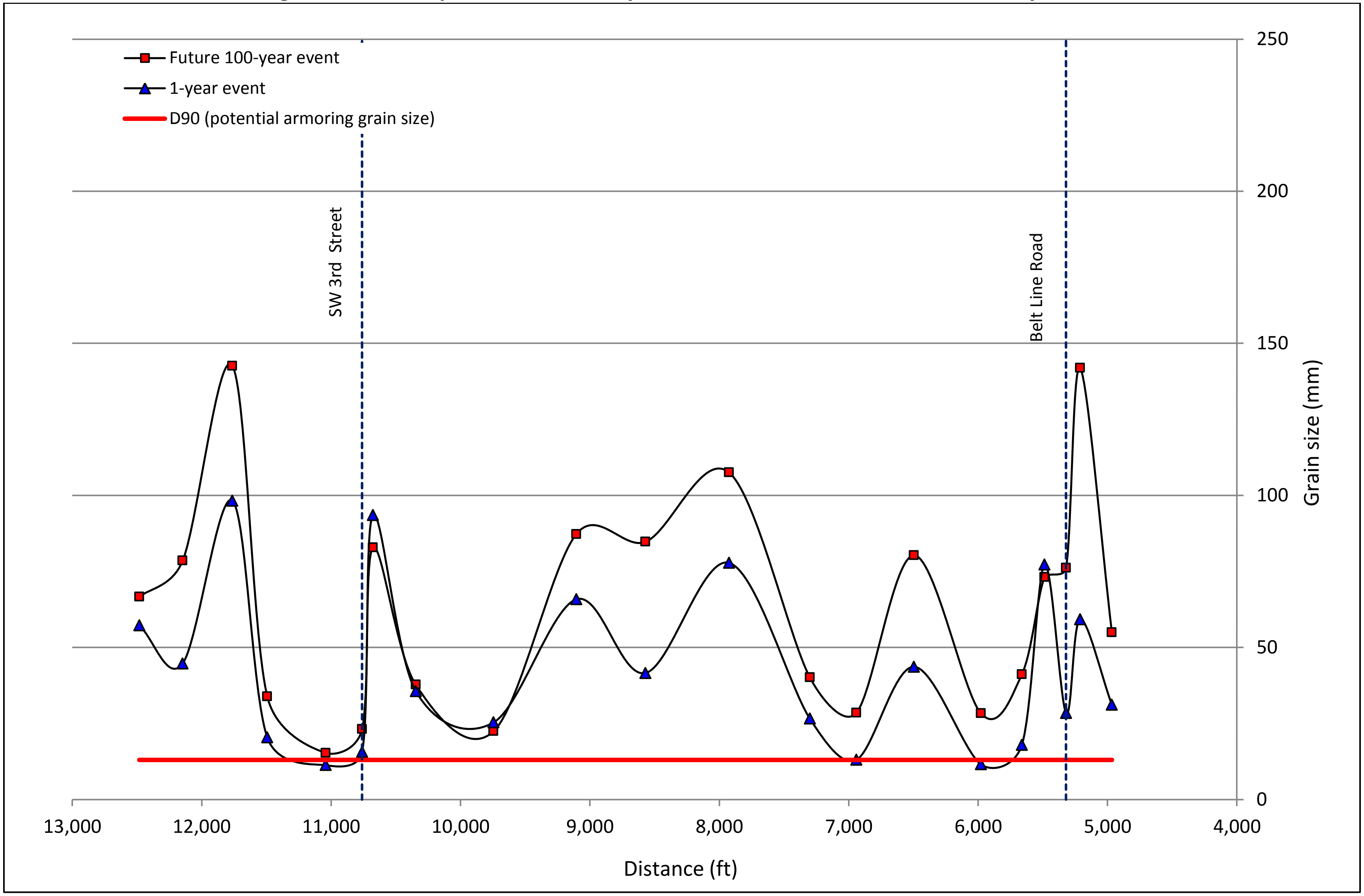


Figure 3.4 Incipient motion analysis results for Warrior Creek study reach

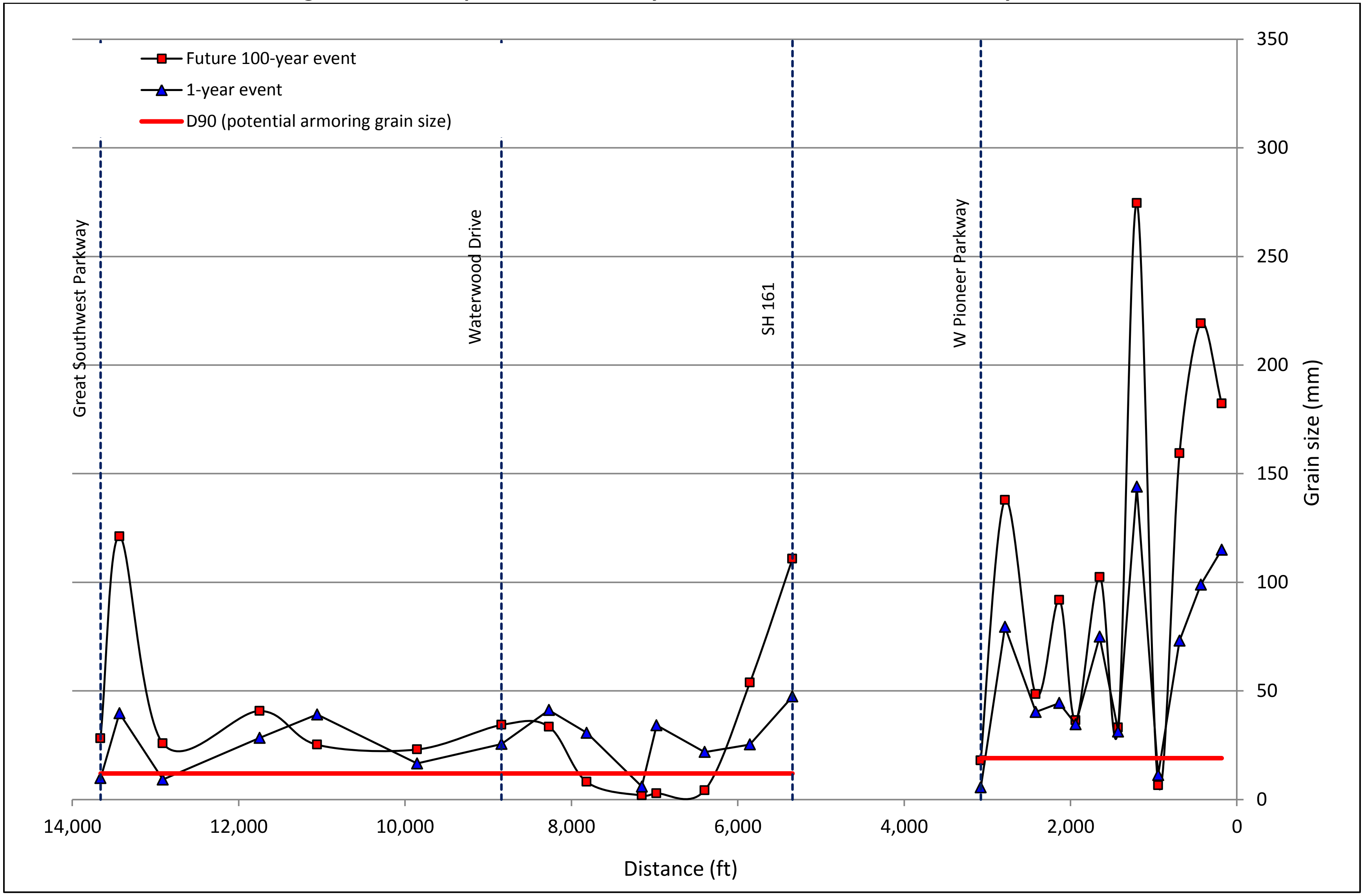
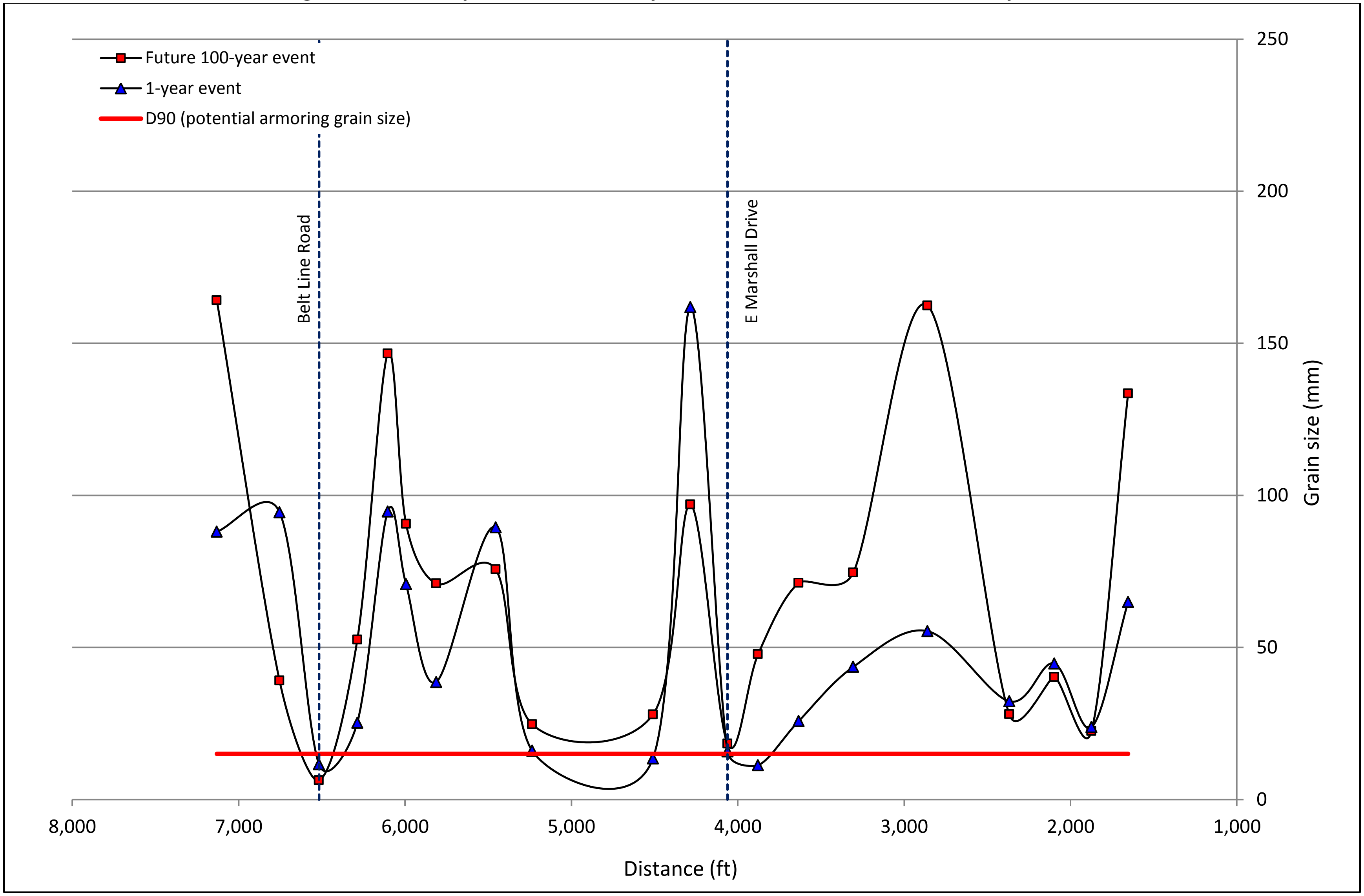


Figure 3.5 Incipient motion analysis results for Plattner Creek study reach



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 bed and bank 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 bed and bank 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 critical shear stress and critical velocity values for different types of channel bed and bank materials. The banks of the study reaches in the study area alternated between clay and shale, and the bed material was typically comprised of clay with shale and alluvial material (sand and gravel) present in some areas.

The critical shear stress and critical velocity values of the bed and bank materials in the study reaches of the Cottonwood Creek study area are (Fischenich, 2001):

- Clay shear stress – 0.26 pounds per square foot
- Shale shear stress– 0.67 pounds per square foot
- Gravel shear stress – 0.25 pounds per square foot

- Clay velocity – 3.0 to 4.5 feet per second
- Shale velocity – 6.0 feet per second
- Gravel velocity – 0.24 feet per second

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 3.6 through 3.10 show the hydraulic shear stresses in the Cottonwood Creek watershed study reaches in relation to the critical shear stresses of the channel bed and bank material. The critical shear stress for the 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 and the D_{90}, suggesting that the channel bed and banks composed these materials 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 current and future flow regimes.

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 the study reaches:

North Fork Cottonwood Creek

- Mean velocities from 0.87 to 11.64 feet per second (1-year peak discharge)
- Mean velocities from 1.99 to 17.57 feet per second (future 100-year peak discharge)

South Fork Cottonwood Creek

- Mean velocities from 1.5 to 8.03 feet per second (1-year peak discharge)
- Mean velocities from 1.48 to 12.75 feet per second (future 100-year peak discharge)

Cottonwood Creek

- Mean velocities from 2.54 to 9.27 feet per second (1-year peak discharge)
- Mean velocities from 2.67 to 12.37 feet per second (future 100-year peak discharge)

Warrior Creek

- Mean velocities from 1.65 to 9.14 feet per second (1-year peak discharge)
- Mean velocities from 1.19 to 13.49 feet per second (future 100-year peak discharge)

Plattner Creek

- Mean velocities from 1.08 to 9.51 feet per second (1-year peak discharge)
- Mean velocities from 2.37 to 11.75 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 critical velocity value of the bed material D_{90} as all the study sites. The modeled flow velocities exceed the critical velocity values for clay and shale at some sites, suggesting that the sections of the creeks that contain these materials are susceptible to erosion under the current flow regime and future flow regimes.

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), bank failures or localized scour. These results provide estimates of the relationship between applied shear stress and critical shear stress using published methods and available hydrologic and hydraulic model results (Espey Consultants, Inc., 2010). Detailed hydrologic and hydraulic modeling using surveyed cross-sections and geotechnical investigations are recommended to verity these initial estimates and prior to the design of any channel protection/stabilization feature.

Figure 3.6 North Fork Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material

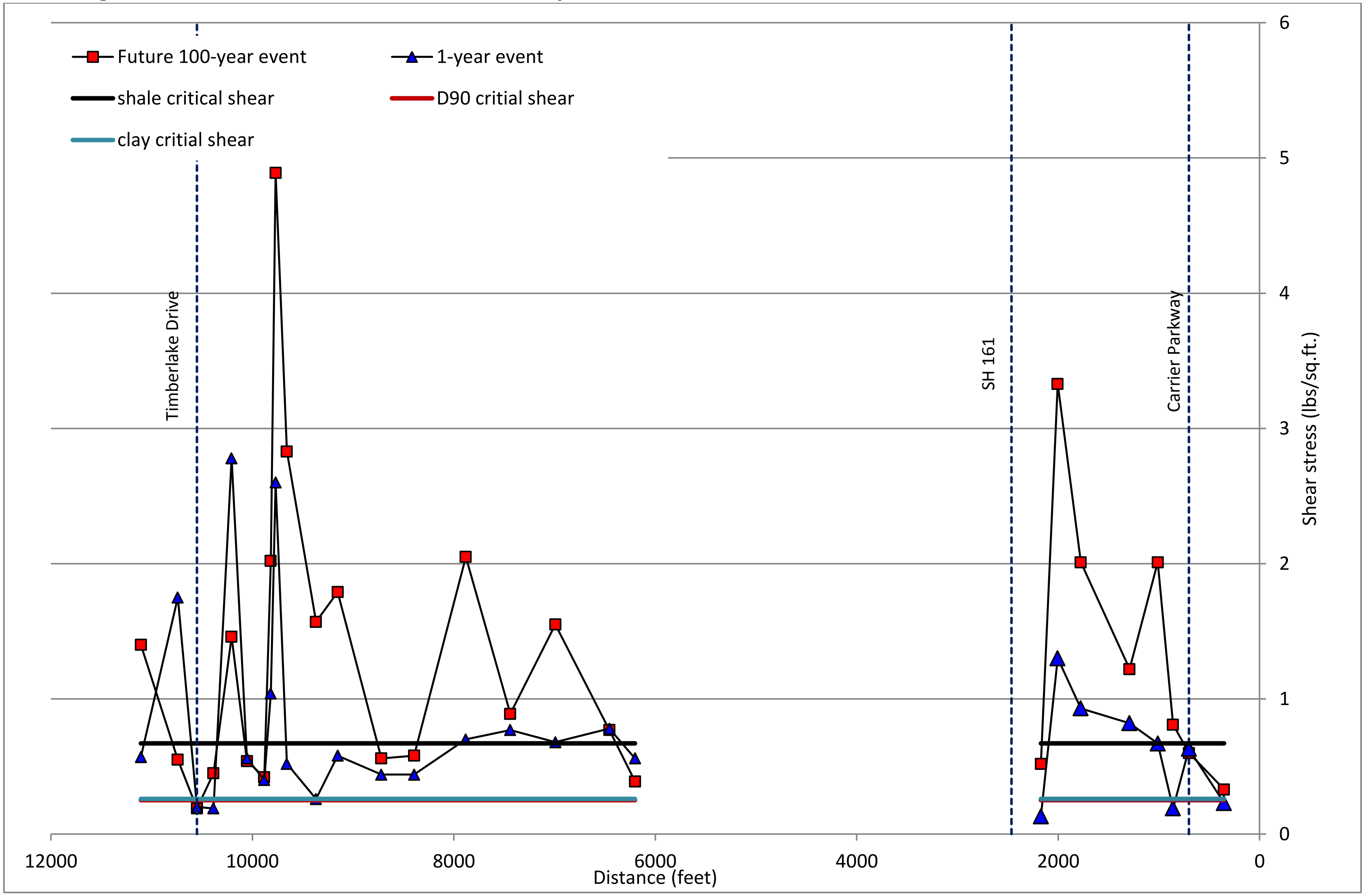


Figure 3.7 South Fork Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material

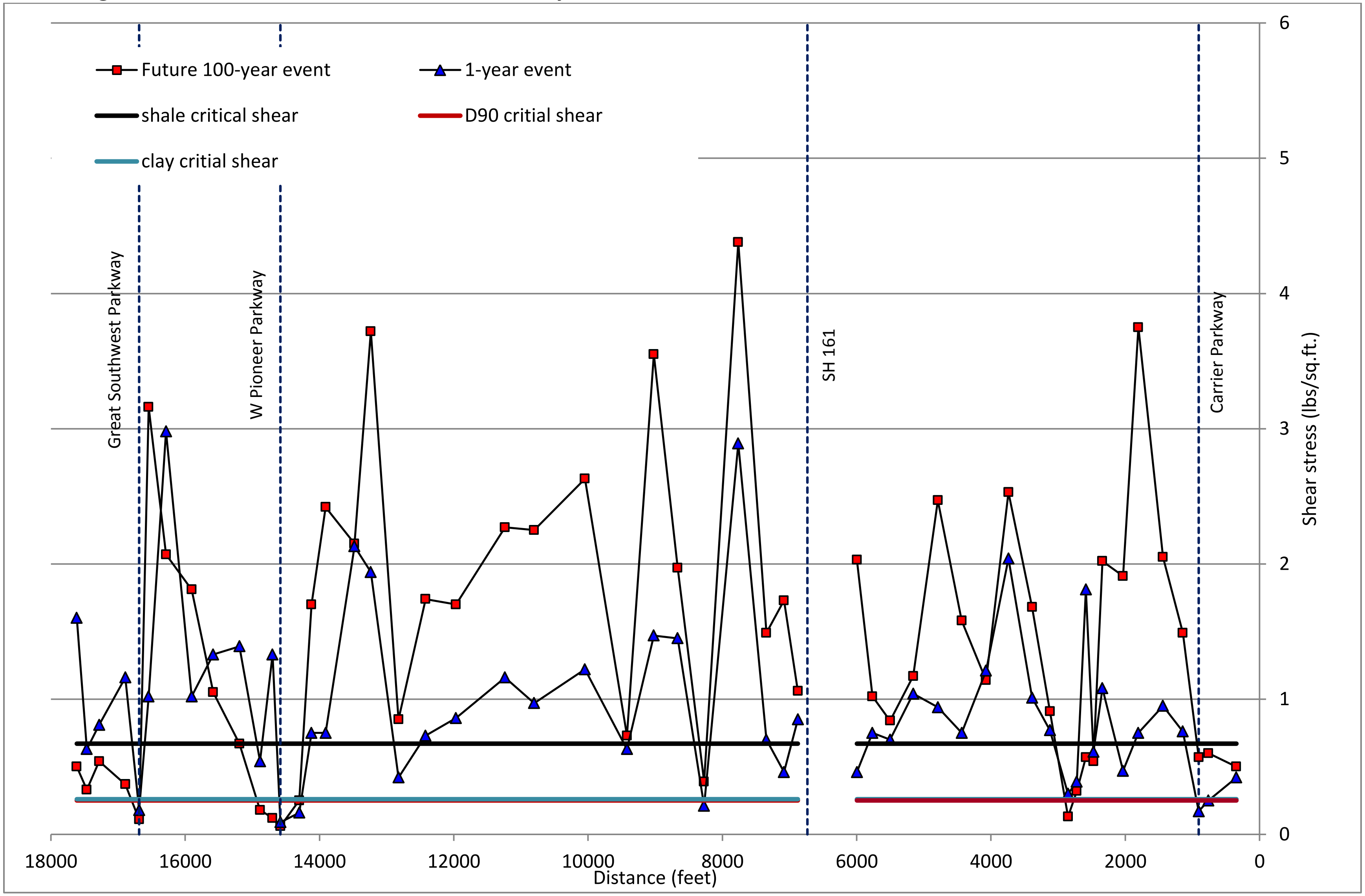


Figure 3.8 Cottonwood Creek hydraulic shear stress and critical shear stress of bed and bank material

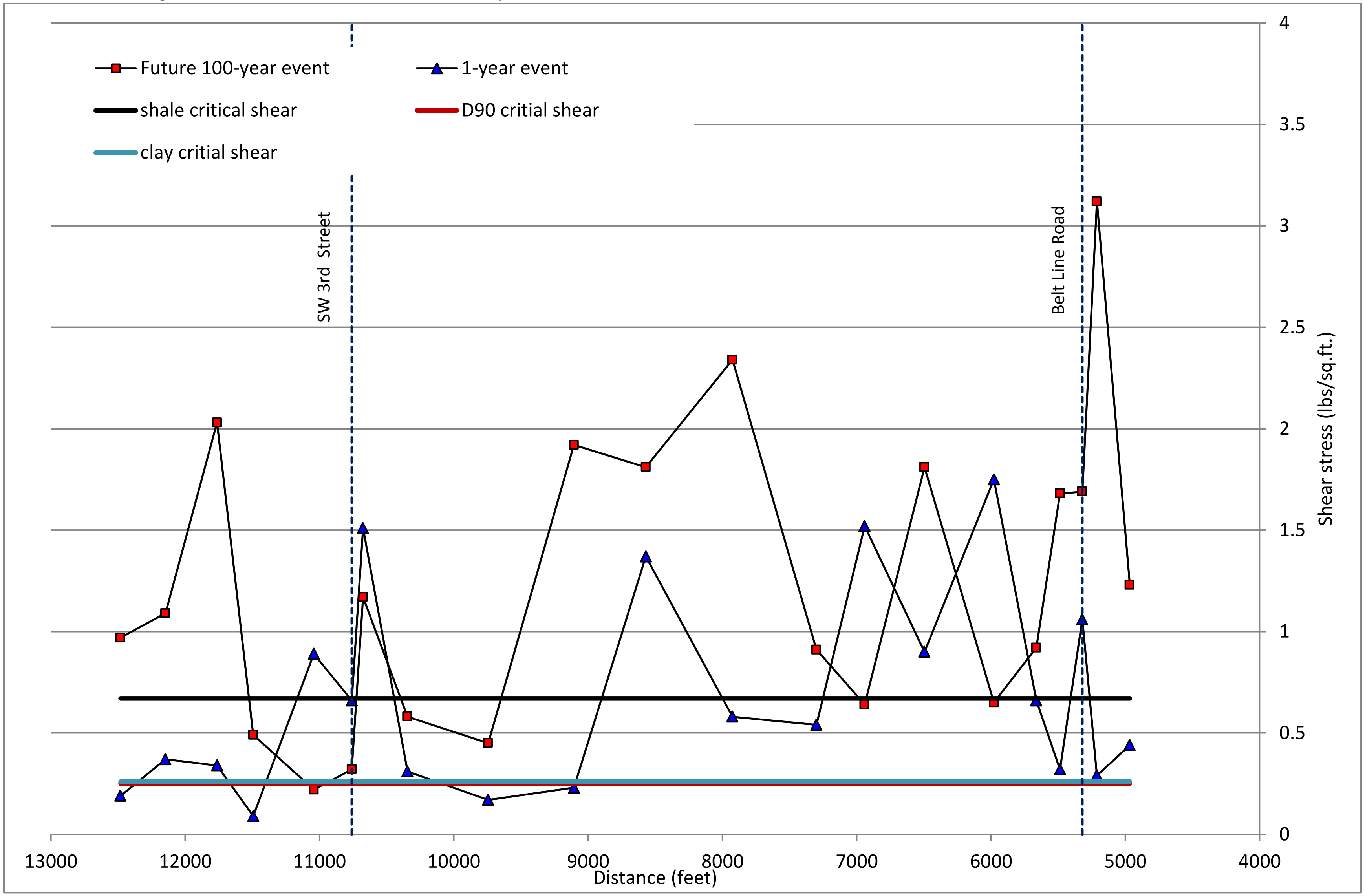


Figure 3.9 Warrior Creek hydraulic shear stress and critical shear stress of bed and bank material

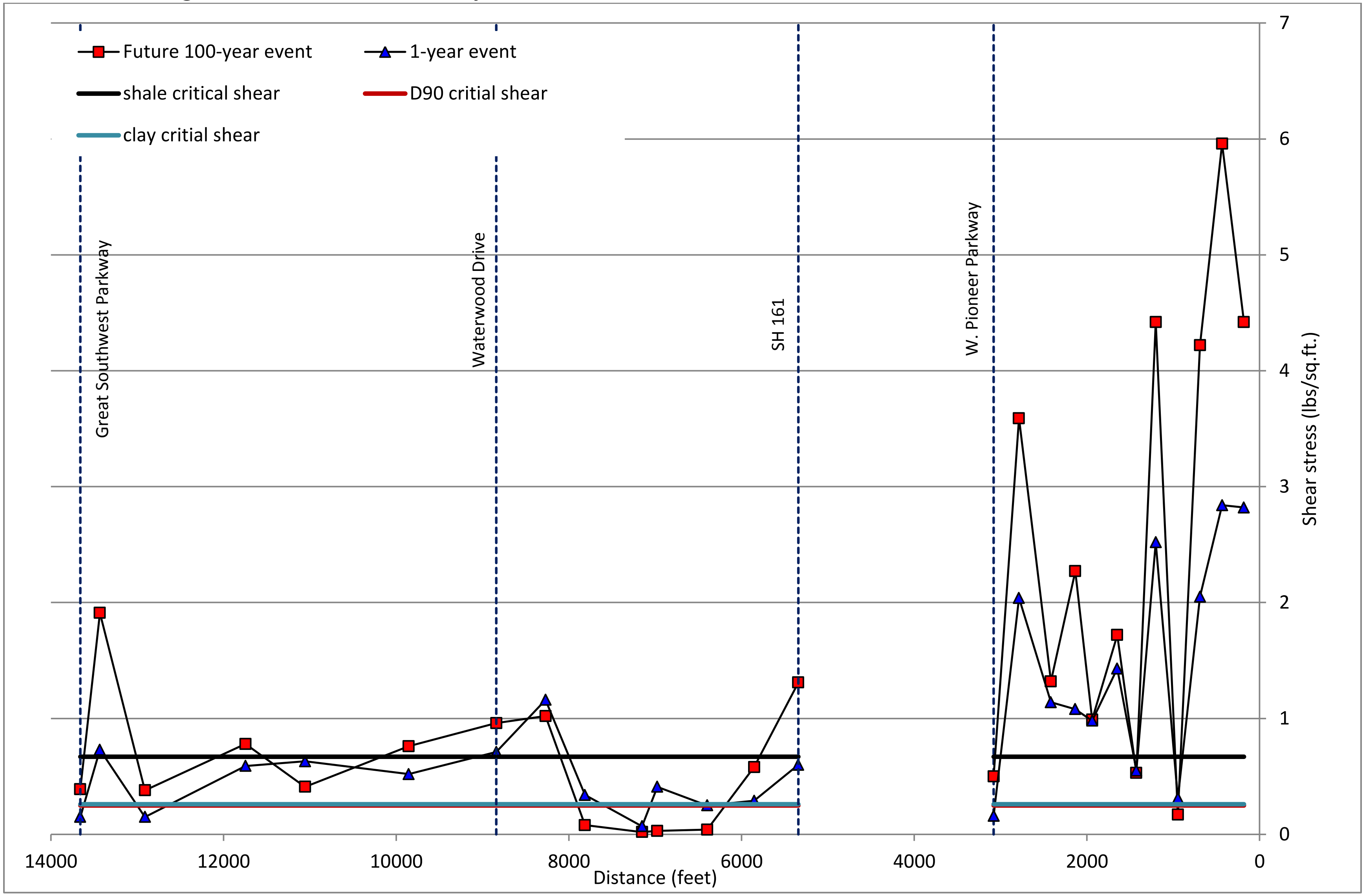
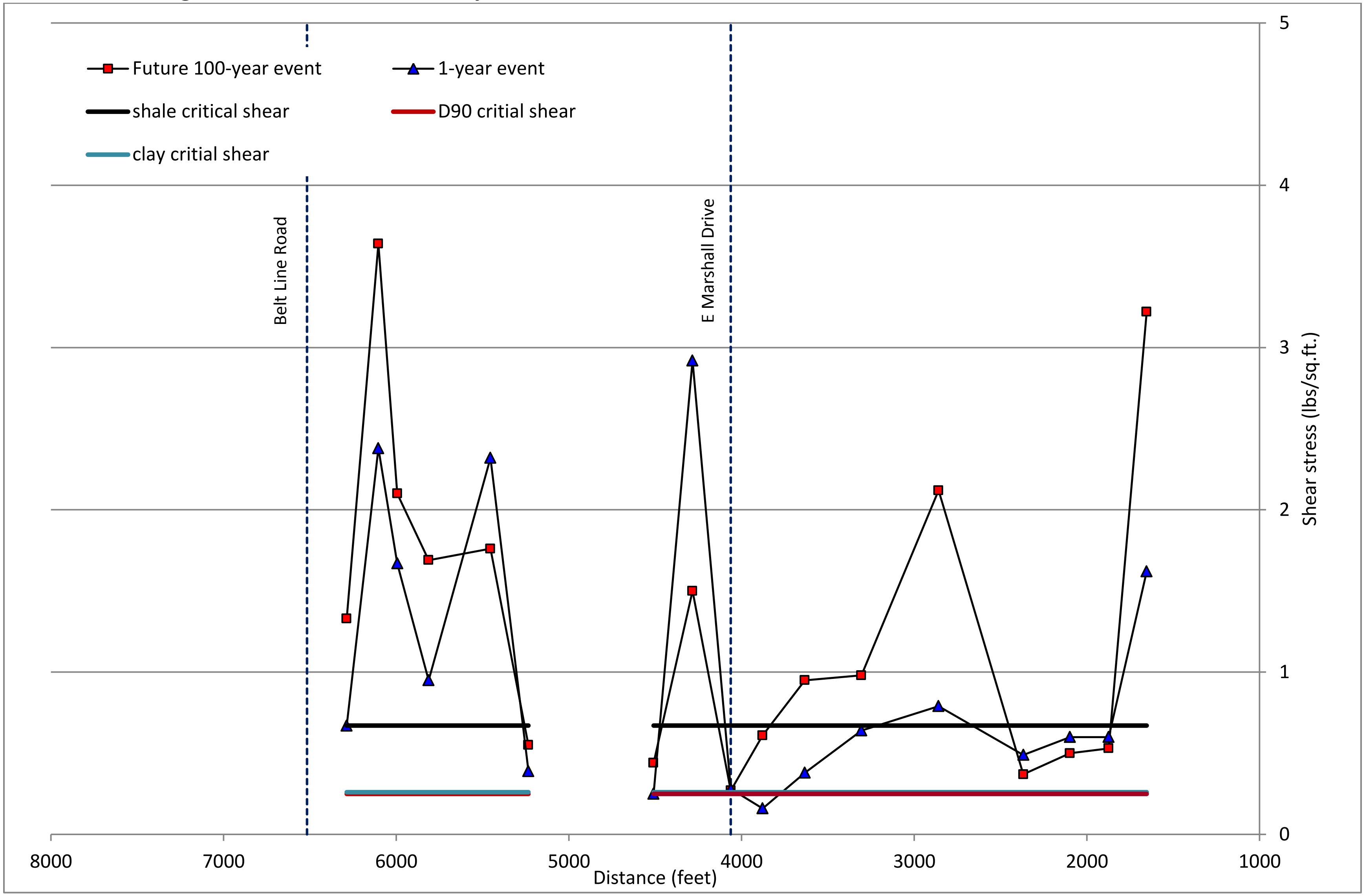


Figure 3.10 Plattner Creek hydraulic shear stress and critical shear stress of bed and bank material



3.2.3 Shale Erosion by Slaking

In areas where the Cottonwood Creek watershed study reaches have downcut into the Eagle Ford shale, widening and deepening 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. In the Dallas-Fort Worth area, the slake zone along the channel banks typically ranges in height from 0 to 5 feet (Allen et al, 2002). Field observations during this assessment noted that the slake zone extended up to approximately 5 feet on the cutbanks of some meanders in the study reaches.

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)
North Fork Cottonwood Creek	5.7	2	1.7
South Fork Cottonwood Creek	4.6	2	1.6
Cottonwood Creek	15.1	6	2.2
Warrior Creek	1.8	1	0.9
Plattner Creek	1.2	1	0.6

These results provide estimates of channel bed and bank loss due to slaking using published methods and available hydrologic and hydraulic model results (Espey Consultants, Inc., 2010). Detailed hydrologic and hydraulic modeling using surveyed cross-sections and geotechnical investigations are recommended to verity these initial estimates and prior to the design of any channel protection/stabilization feature. It can be expected that the North and South Fork of Cottonwood Creek and the main stem of Cottonwood Creek will experience approximately 2 inches of loss due to slaking. Warrior Creek and Plattner Creek will experience approximately 1 inch of loss. These loss rates are based on if number of floods 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 was used in addition to Meyer-Peter-Mueller, Lane's, and Schoklitsch equilibrium slopes methods (Pemberton and Lara, 1984) to estimate stable channel slopes for the study reaches in the Cottonwood Creek watershed.

The equilibrium or design slope, derived from the slope equations, will typically by lower than the existing channel slope. 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 or grade control 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 through 3.7 contain the results of the equilibrium slope analysis of the Cottonwood Creek watershed study reaches. 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. Segment lengths not listed in the tables are not expected to downcut because of current channel engineering structures. These results provide estimates of downcutting using published methods and available hydrologic and hydraulic model results (Espey Consultants, Inc., 2010). 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 3.7. 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 North Fork Cottonwood Creek equilibrium slope analysis

Segment (cross-section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
11107-10550	0.0012	1.0104	5.1	1.7
10386-9817	0.0012	0.0001	0	0
9769-8720	0.0012	0.0019	0.8	0.3
7881-7440	0.0012	0.0008	0	0
7440-6992	0.0012	0.0059	2.1	0.7
6992-6201	0.0012	0.0026	1.1	0.4
2170-859	0.0012	0.0006	0	0
701-0*	0.0012	0	0	0

*End of the reach is the dam at the confluence of North Fork Cottonwood Creek and South Fork Cottonwood Creek

Table 3.4 Results of South Fork Cottonwood Creek equilibrium slope analysis

Segment (cross-section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
16546-14885	0.0014	0.0066	8.6	2.9
14885-14582	0.0014	0.0136	3.7	1.2
14301-13479	0.0014	-0.0028	0	0
13479-11967	0.0014	0.0053	5.9	2.0
11967-11238	0.0014	0.0103	6.5	2.2
11238-10803	0.0014	-0.0058	0	0
10803-9420	0.0014	0.0058	6.1	2.0
9420-7765	0.0014	0.0030	2.7	0.9
7756-6876	0.0014	0.0045	2.8	0.9
5996-5502	0.0014	0.0015	0.1	0.0
5502-5175	0.0014	0.0000	0	0
5157-4435	0.0014	0.0038	1.7	0.6
4435-3387	0.0014	0.0041	2.8	0.9
3387-2852	0.0014	0.0002	0	0
2723-2473	0.0014	0.0019	0.1	0.0
2341-905	0.0014	0.0051	5.3	1.8
761-0*	0.0014	-0.0022	0	0

*End of the reach is the dam at the confluence of North Fork Cottonwood Creek and South Fork Cottonwood Creek

Table 3.5 Results of Cottonwood Creek equilibrium slope analysis

Segment (cross-section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
12645-12482	0.0010	0.0061	0.8	0.3
12482-9774	0.0010	0.0013	0.8	0.3
9774-8750	0.0010	0.0047	4.3	1.4
8570-7300	0.0010	0.0016	0.7	0.2
7300-5978	0.0010	0.0008	0	0
5978-5211	0.0010	0.0034	1.8	0.6

Table 3.6 Results of Warrior Creek equilibrium slope analysis

Segment (cross-section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
13661-12911	0.0021	0.0040	1.4	0.5
12911-11747	0.0021	0.0026	0.6	0.2
11747-9855	0.0021	0.0063	7.9	2.6
9855-7153	0.0021	0.0049	7.5	2.5
7153-6398	0.0021	0.0041	1.5	0.5
6398-3079	0.0021	0.0043	2.3	0.8
3079-182	0.0021	0.0059	11.0	3.7

Table 3.7 Results of Plattner Creek equilibrium slope analysis

Segment (cross-section ID)	Stable Slope (ft/ft)	Actual Slope (ft/ft)	Downcut (feet)	Number of Drops (3 ft.)
6287-6104	0.0016	0.0087	1.3	0.4
6104-4510	0.0016	0.0105	7.5	2.5
4510-3878	0.0016	0.0098	3.7	1.2
3878-3306	0.0016	0.0004	0	0
3306-1654	0.0016	0.0030	2.52	0.8

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 3.11). 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 the five study reaches was generally mobile, and the channels were generally in a state of downcutting and/or 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.

Some portions of the study reaches appeared to be in a state of widening. These included North Fork Cottonwood Creek downstream of SH 161, South Fork Cottonwood Creek downstream of W. Marshall Road, and the majority of the study reach of Cottonwood Creek. 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. 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.

Portions of the study reach that have been impacted by the construction of retention ponds or other channel stabilization measures no longer have the potential to evolve through the same predictable progression after urbanization. The retention ponds on North Fork Cottonwood Creek and Warrior Creek decrease peak discharges during high flow events, which decreases downstream flooding potential. Retention ponds, however, also trap sediment and increase downstream flow duration. Sediment trapped in a retention pond is no longer available for downstream sedimentation. This has the potential to create a hungry-water affect in which the sediment-starved water has higher potential to erode the channel bed and banks downstream of the retention pond (Kondolf, 1997). Prolonged flows downstream of a retention pond scour the lower banks of the channel for a longer period of time and can cause the upper banks to fail in the form of slumps. There was evidence of this scenario observed in the field downstream on North Fork Cottonwood Creek downstream of SH-161.

Stages I through III of the ICEM were observed in North Fork Cottonwood Creek, South Fork Cottonwood Creek, Cottonwood Creek, Warrior Creek and Plattner Creek (Figure 3.12).

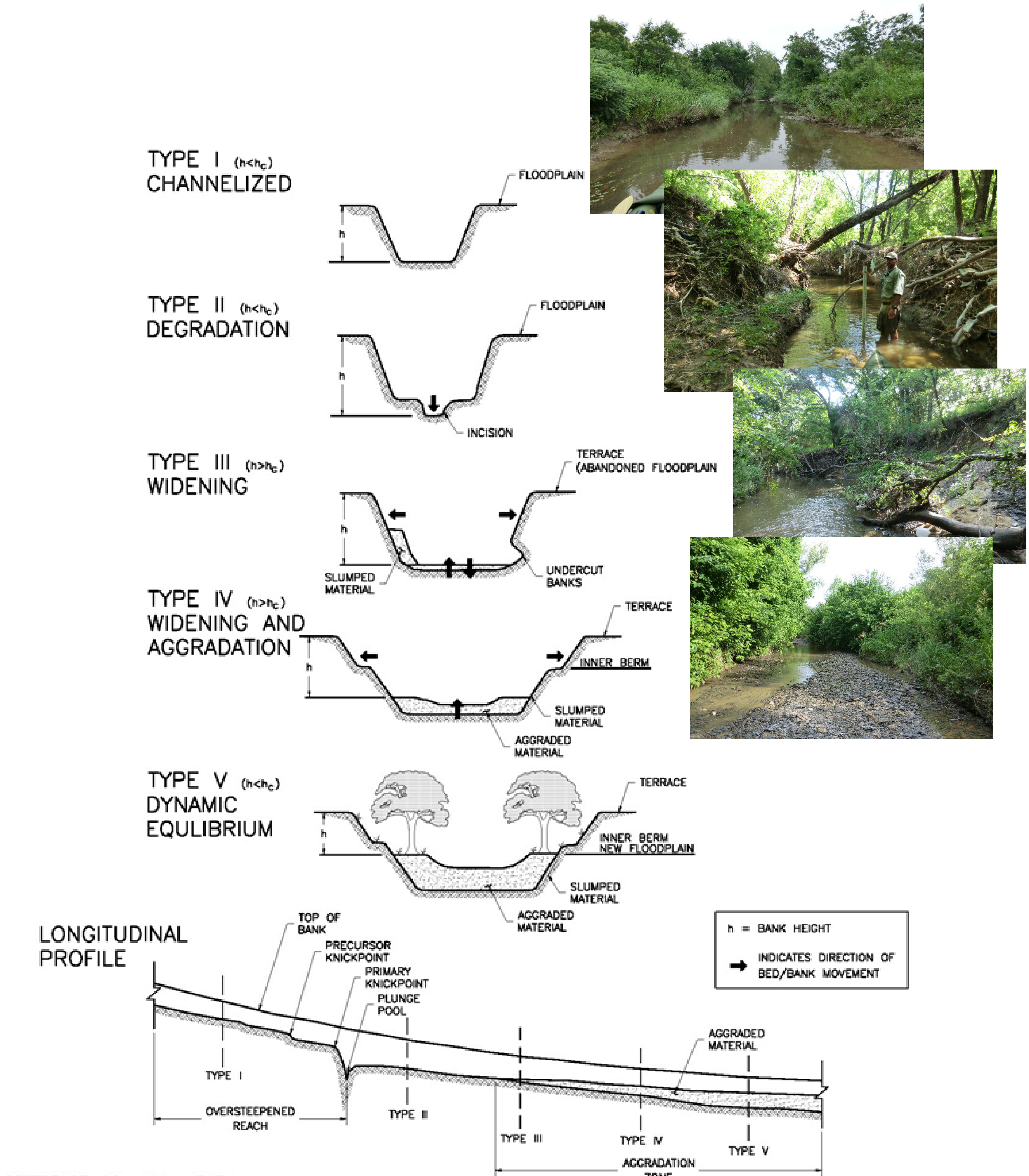
Field observations suggest that the beginning of the study reach for North Fork Cottonwood Creek is between Stage II and Stage III. Historically, North Fork Cottonwood Creek did not have a riparian corridor. Today there is sparse to no vegetative corridor along the creek. Approximately halfway through the study reach there are a series of retention ponds on the channel to help reduce the peak flows. These ponds have stabilized the segments of channel between each pond. Downstream of the ponds the channel is in Stage III. The cause of widening is likely triggered by the longer duration of flow. The creek is in Stage I between Carrier Parkway and the dam at the confluence of the North Fork and South Fork Cottonwood Creek.

Pre-urbanization, South Fork of Cottonwood Creek was a highly sinuous stream that meandered and migrated across the prairie floodplain. Currently, the creek has a dense riparian corridor that acts as a buffer along the stream. This buffer begins near the Grand Prairie's Cities limits and stops are the current construction of the SH 161. During the site assessment it was noted from cross sections 17917 to 17616 the creek was braided. There were approximately three channels that were identified, but only one contained pooled water. This channel was identified as the main channel. From the beginning of the study reach until SH 161 the creek between Stage I-II. Downstream of the construction at SH 161 the creek appears to be evolving to Stage II-III. The creek is in Stage I between Carrier Parkway and the dam at the confluence of the North Fork and South Fork Cottonwood Creek.

The main stem of Cottonwood Creek starts at the confluence of North Fork and South Fork Cottonwood Creek. The main stem of Cottonwood Creek was a meandering stream that was straightened around the early 1950's. The meander scars were erased from the landscape around the early 1960's. Currently the channel has remained relatively straight. The banks are steep and show signs of instability such as wedge failures, slumps, and tree falls. The channel shows that it is trying to regain some sinuosity. The creek is in Stage II-III upstream of SW 3rd Street and in Stage III downstream of SW 3rd Street to Beltline Road.

Warrior Creek was a meandering tributary that historically drained prairie land before it was altered to agricultural land. The channel has been altered many times in the past. The headwaters of the creek have been engineered and indicated signs of incision (Stage II). A segment of the creek has been bi-passed as flows above approximately the 1-year frequency are directed into a series of retention ponds. Downstream of the construction at SH 161 the channel is in Stage II, downcutting into the shale. This segment contains a series of knickpoints that will continue to migrate upstream until equilibrium slope is achieved.

Plattner Creek was also a tributary that migrated across the prairie. Historically this creek was a small drainage. Present day, most of the channel has been engineered to convey flow. Segments of this channel are within a concrete trapezoidal channel, complete enclosed in a culvert, and straightened. The segments that are not impacted by hard points appear to be in stage II-III.



REFERENCE: SCHUMM, HARVEY AND WATSON (1984)

Freese and Nichols
4055 International Plaza, Suite 200
Fort Worth, TX 76109 - 4895
Phone - (817) 735 - 7300

N W E S

Cottonwood Creek
Geomorphic Stream Assessment

Incised Channel Evolution Model

FN JOB NO	ESP11227
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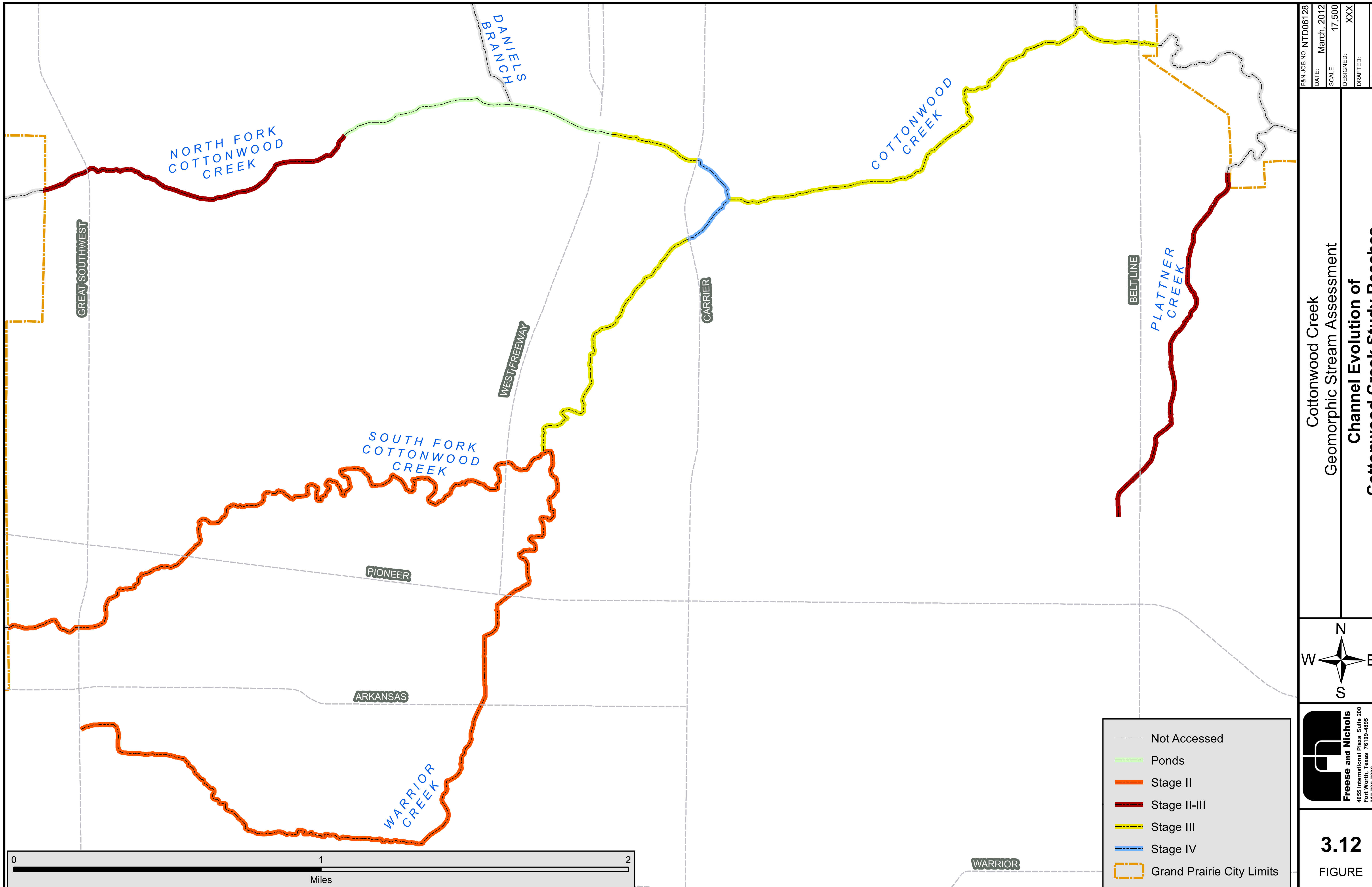
FIGURE


NORTH FORK COTTONWOOD CREEK
DANIELS BRANCH
COTTONWOOD CREEK
PLATTNER CREEK
SOUTH FORK COTTONWOOD CREEK
WARRIOR CREEK
GREAT SOUTHWEST
WEST FREEWAY
CARRIER
BELT LINE
PIONEER
ARKANSAS
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Cottonwood Creek
Geomorphic Stream Assessment
Channel Evolution of
Cottonwood Creek Study Reaches
Freese and Nichols
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
817-735-7300
3.12
FIGURE

3.3.3 Existing Condition Channel Geometry

The existing condition geometry assessment included measurement and evaluation of the channel morphology of the study reaches at each cross-section location. The bottom width, active channel width, active channel depth, left bank height and right bank heights were analyzed based on field measurements to identify where possible changes were occurring in the channel (Figures 3.13-3.22). The active channel contains the flow that is responsible for forming the channels of the study reaches. 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 five study reaches. Variation is likely due in part to past channel straightening in some locations with other locations along the reaches remaining in a more natural state. Creek valley morphology also affected channel dimensions. Generally, channel-floodplain connectivity was noted when the creek valleys were wide and channel depths were less than five feet. High flows are able to spread onto a floodplain, decreasing the erosive power of the stream. If discharges are increased as a result of future urbanization, the erosive power of the stream will increase and the creek channels may become larger. Results of measurements taken in the study area are summarized by creek:

North Fork Cottonwood Creek

- Active channel depth ranged from 2 to 7 feet
- Left bank heights ranged from 3 to 25 feet
- Right bank heights ranged from 4 to 27 feet
- Bottom width of the channel ranged from 13 to 73 feet
- Active channel width ranged from 27 to 75 feet

South Fork Cottonwood Creek

- Active channel depth ranged from 2 to 5.5 feet
- Left bank heights ranged from 3 to 34 feet
- Right bank heights ranged from 2 to 18 feet
- Bottom width of the channel ranged from 4 to 54 feet
- Active channel width ranged from 6 to 50 feet

Cottonwood Creek

- Active channel depth ranged from 2.5 to 6 feet
- Left bank heights ranged from 5 to 14 feet
- Right bank heights ranged from 5 to 14 feet
- Bottom width of the channel ranged from 12 to 40 feet
- Active channel width ranged from 22 to 45 feet

Warrior Creek

- Active channel depth ranged from 2 to 7 feet
- Left bank heights ranged from 4 to 14 feet
- Right bank heights ranged from 4 to 12 feet
- Bottom width of the channel ranged from 4 to 30 feet
- Active channel width ranged from 8 to 30 feet

Plattner Creek

- Active channel depth ranged from 2 to 5 feet
- Left bank heights ranged from 5 to 14 feet
- Right bank heights ranged from 5 to 14 feet
- Bottom width of the channel ranged from 5 to 42 feet
- Active channel width ranged from 11 to 32 feet

Figure 3.13 Graph of North Fork Cottonwood Creek bank height and active channel depth

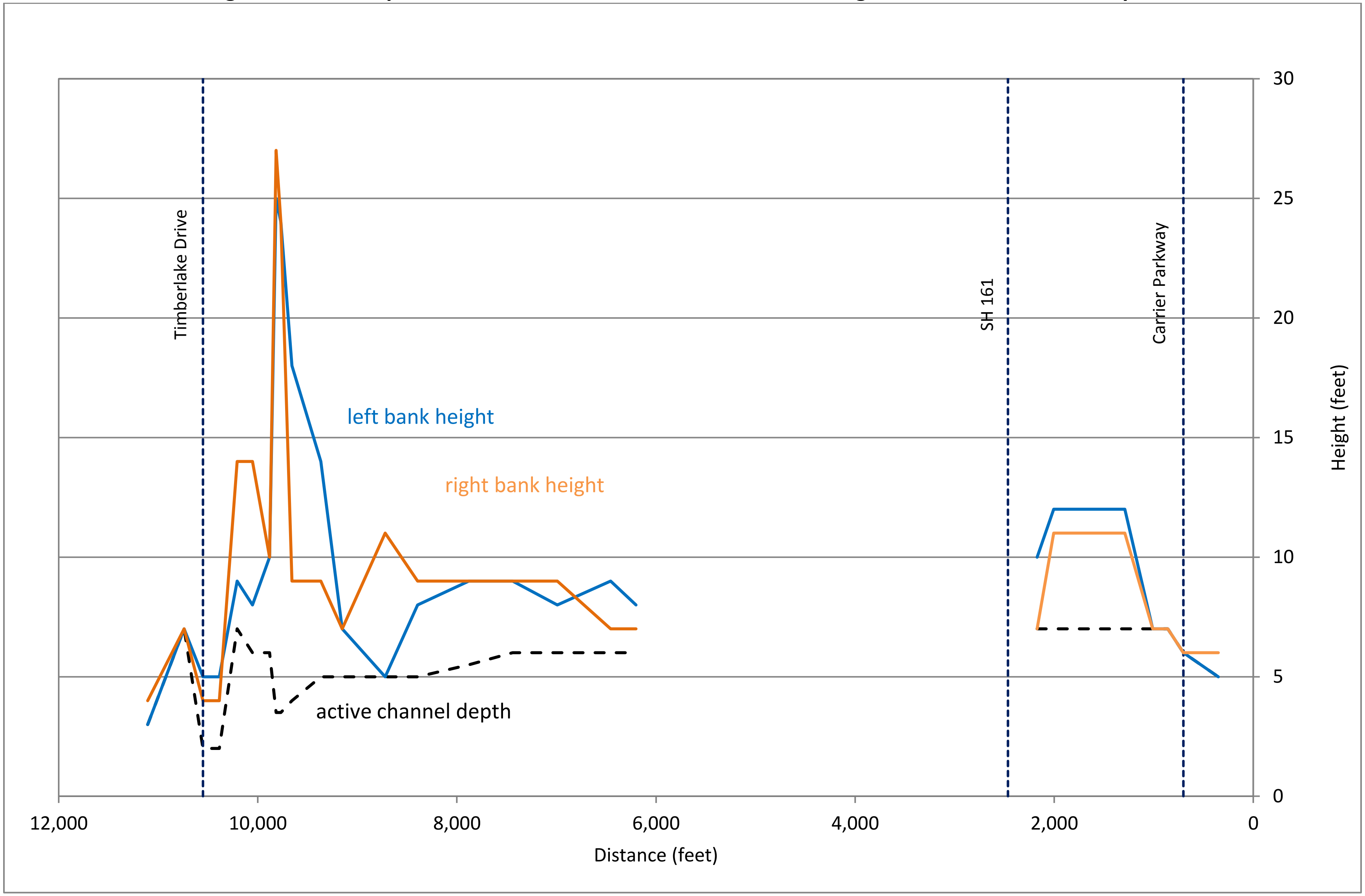


Figure 3.14 Graph of North Fork Cottonwood Creek bottom width and active channel width

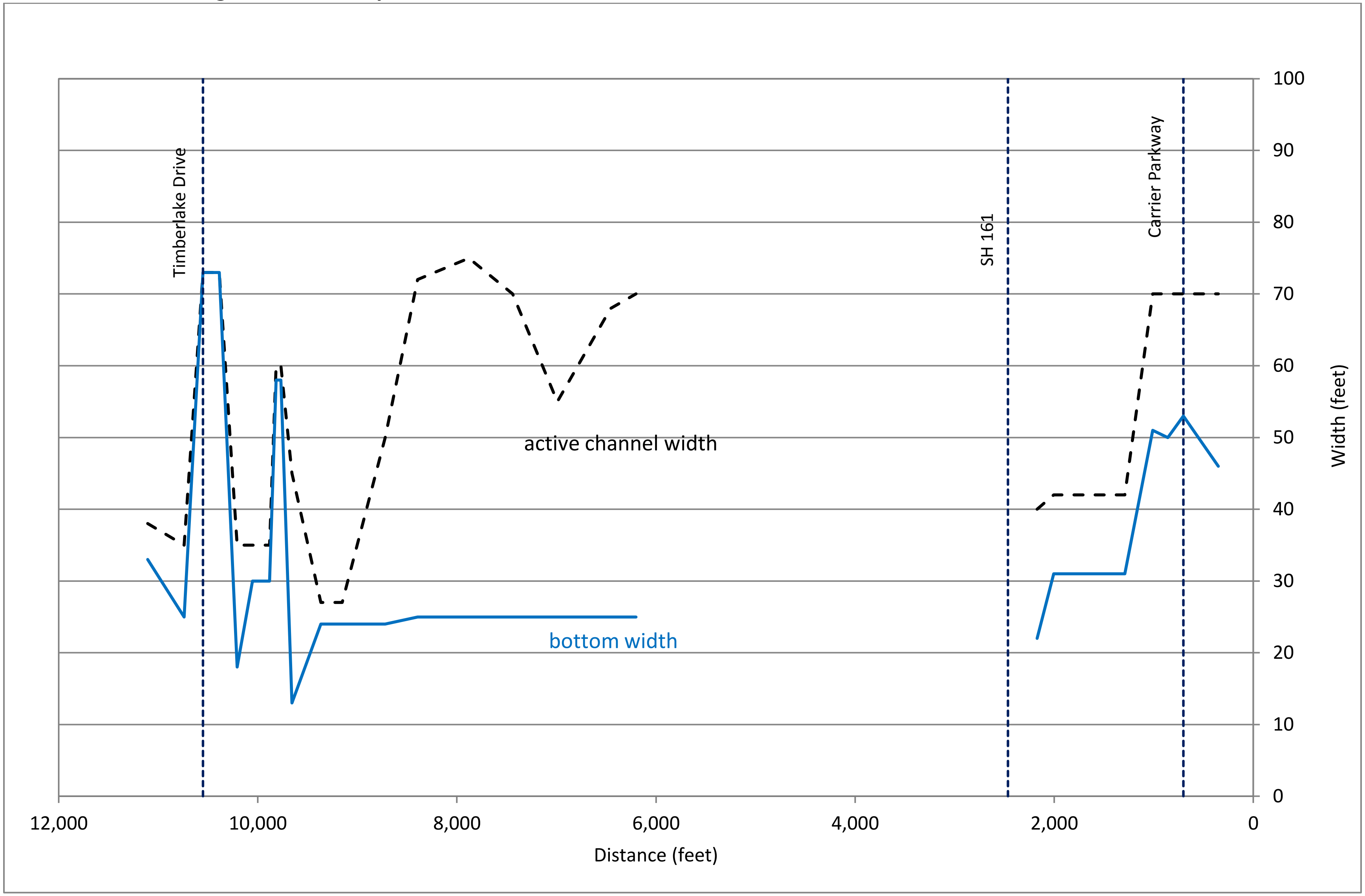


Figure 3.15 Graph of South Fork Cottonwood Creek bank height and active channel depth

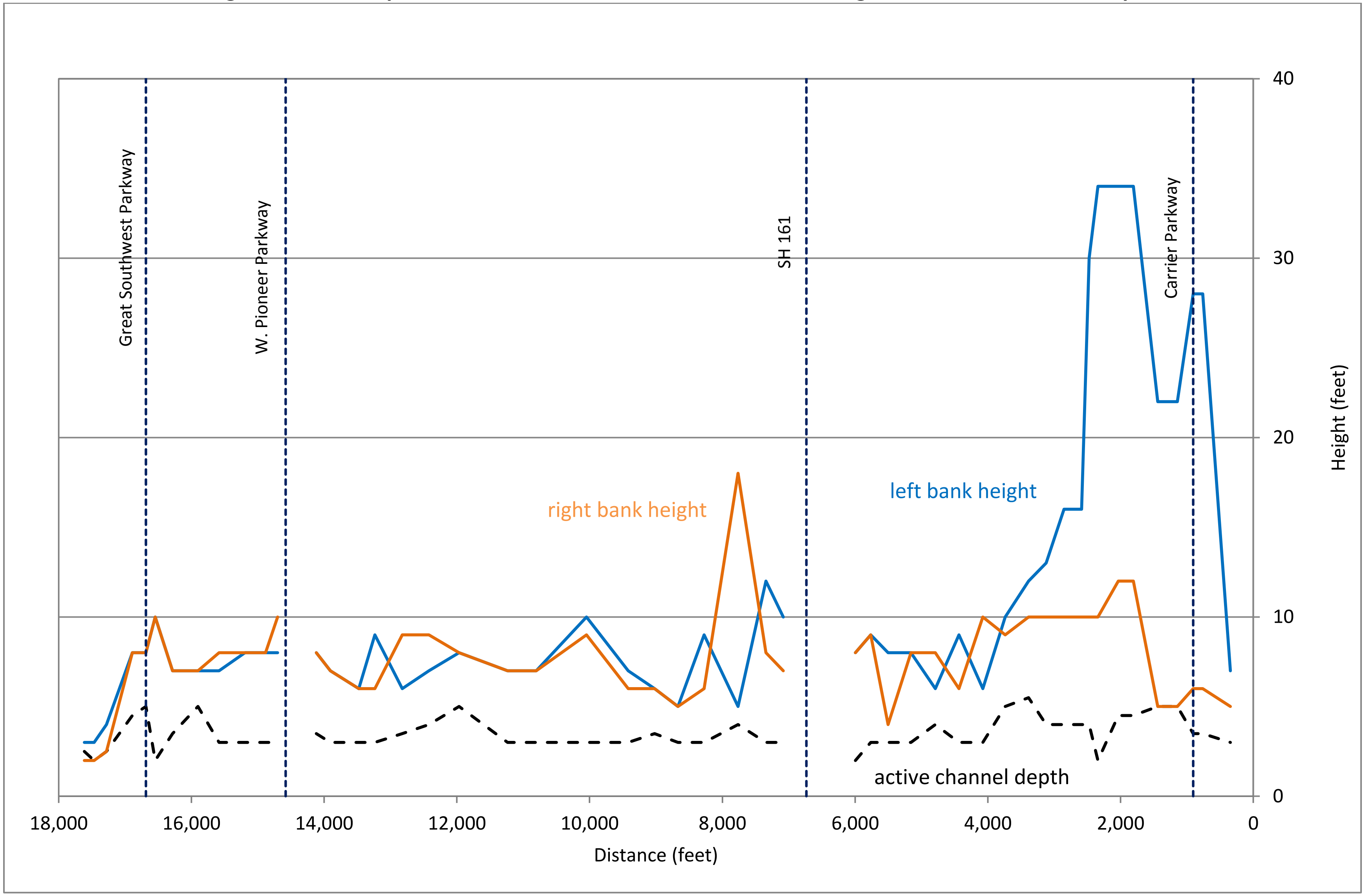


Figure 3.16 Graph of South Fork Cottonwood Creek bottom width and active channel width

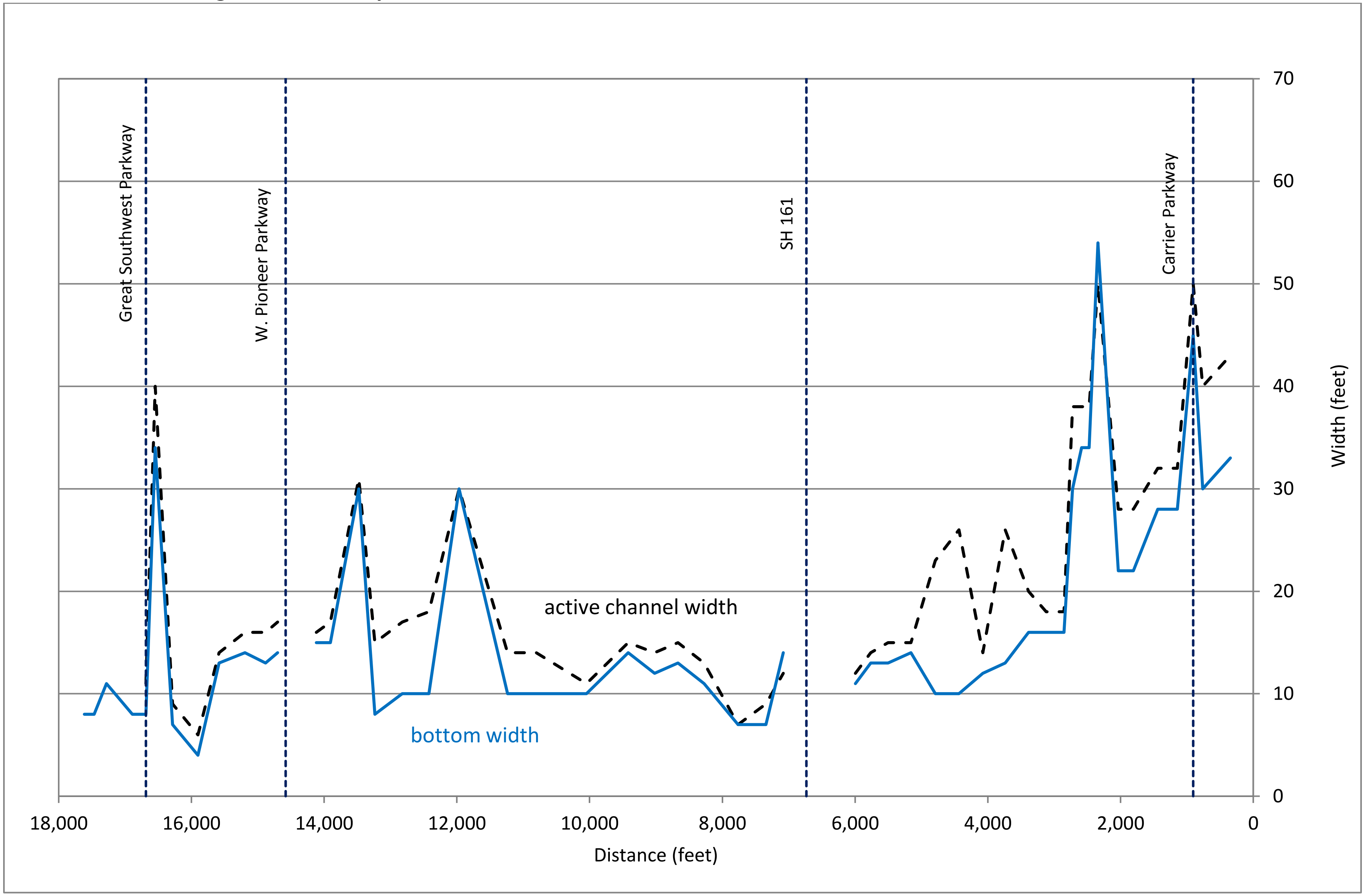


Figure 3.17 Graph of Cottonwood Creek bank height and active channel depth

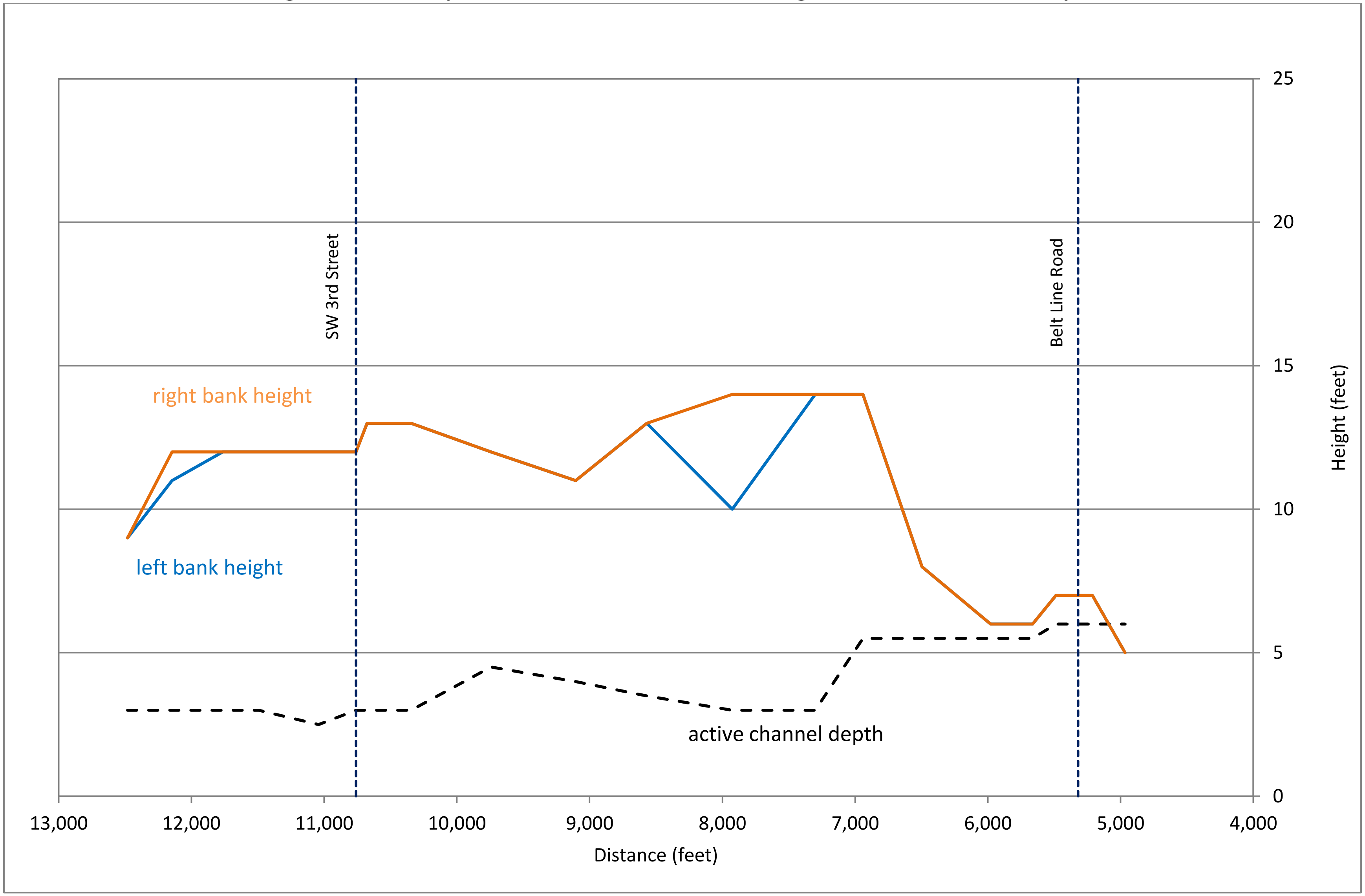


Figure 3.18 Graph of Cottonwood Creek bottom width and active channel width

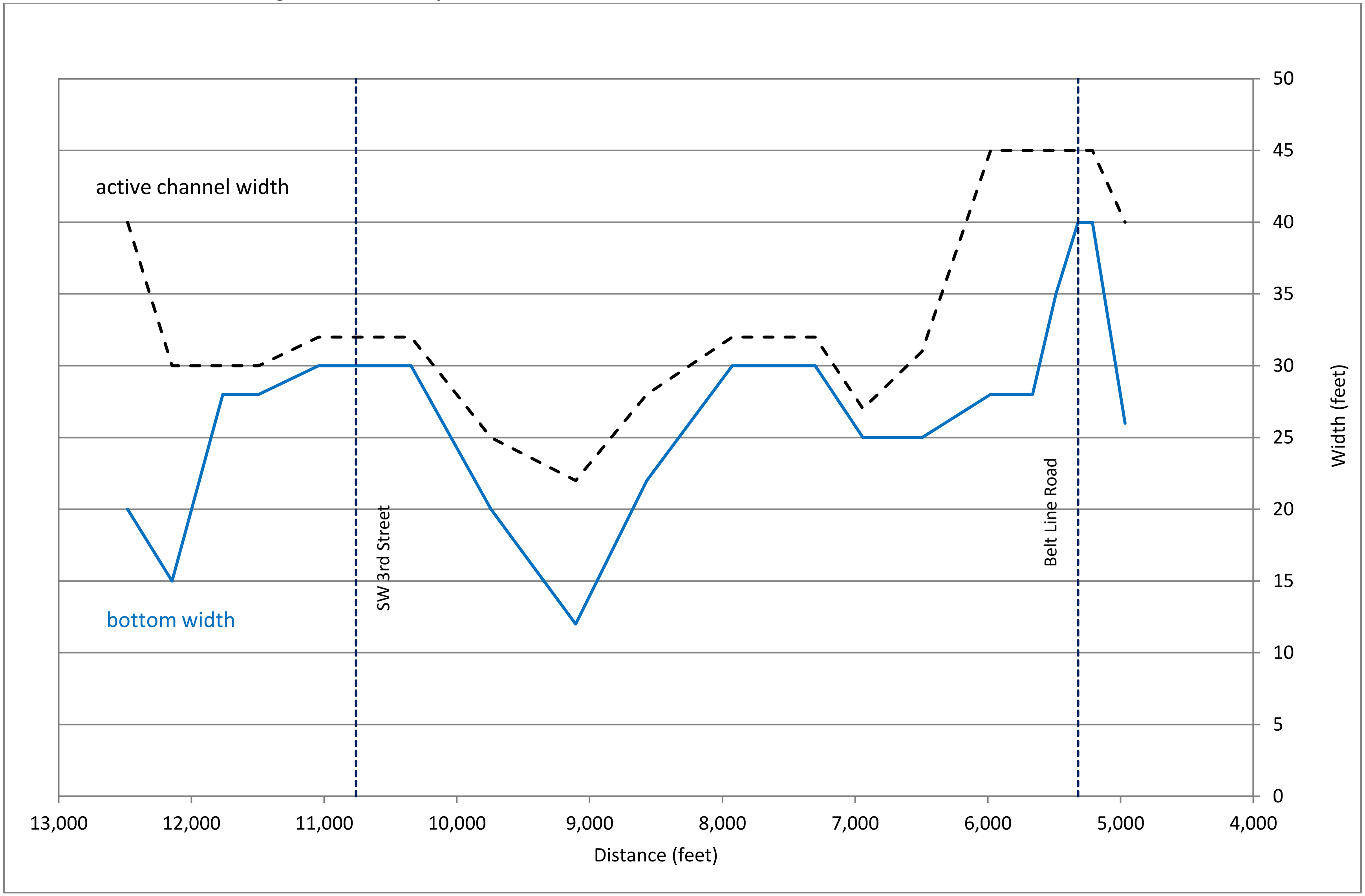


Figure 3.19 Graph of Warrior Creek bank height and active channel depth

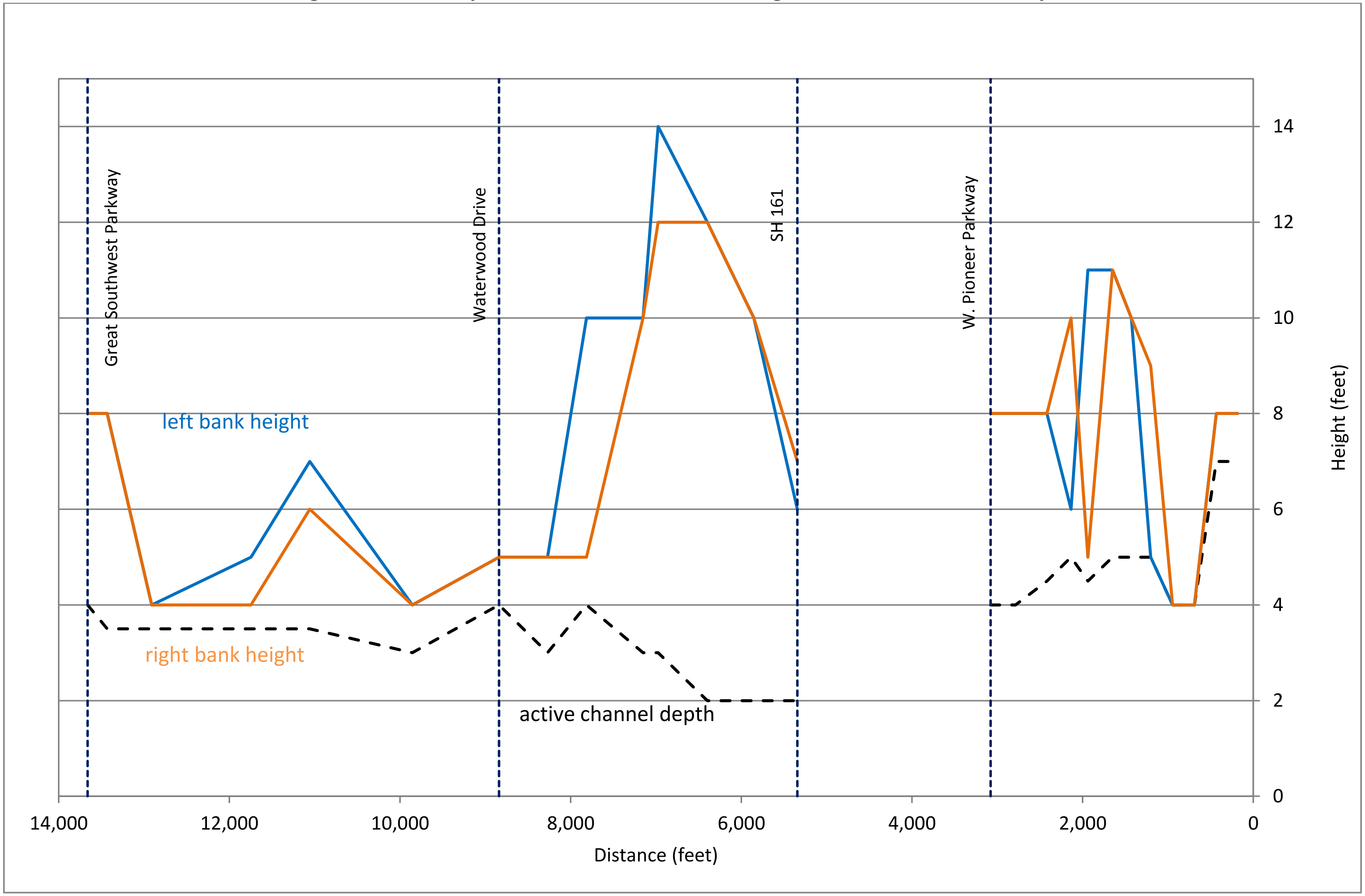


Figure 3.20 Graph of Warrior Creek bottom width and active channel width

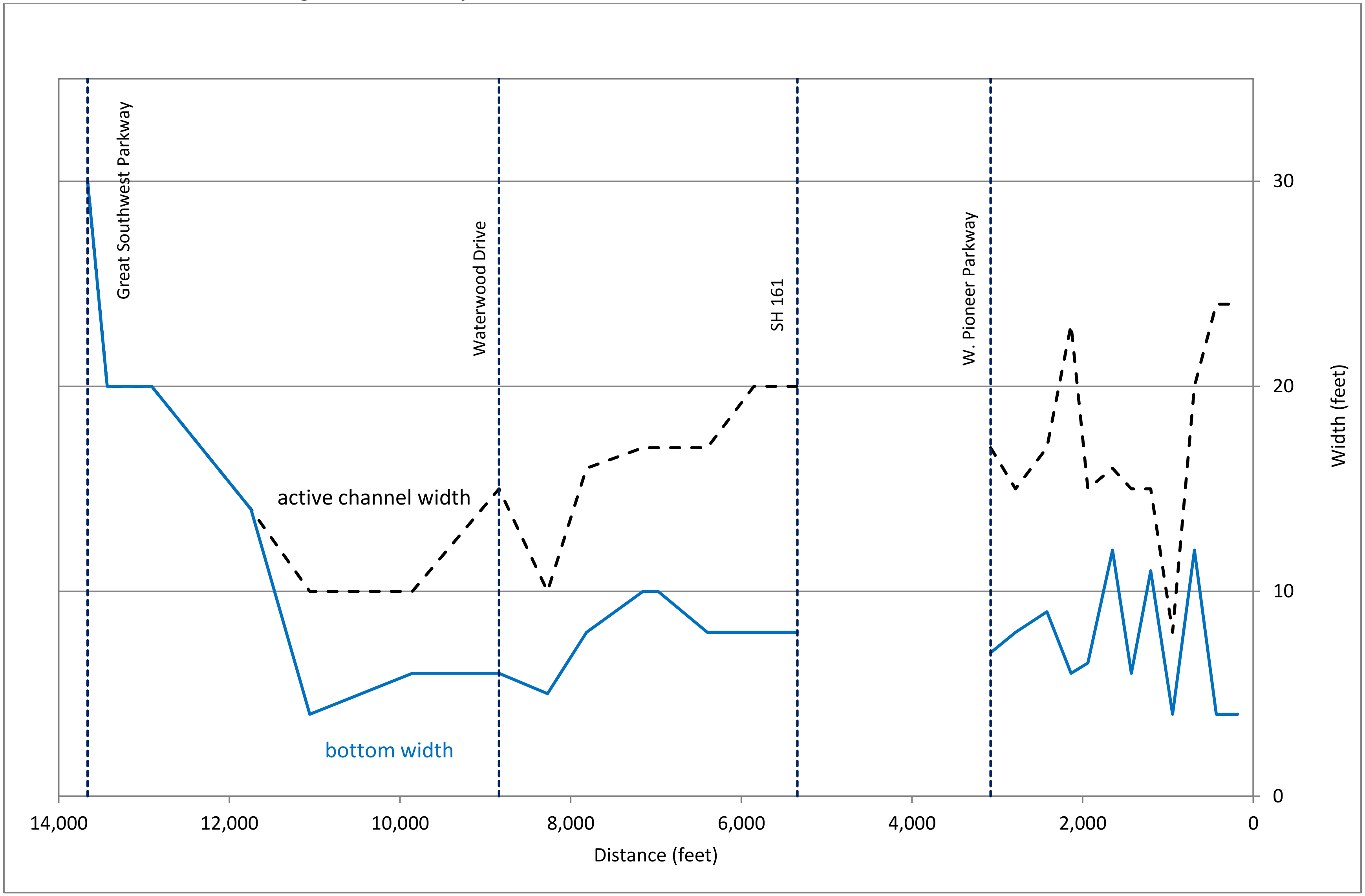


Figure 3.21 Graph of Plattner Creek bank height and active channel depth

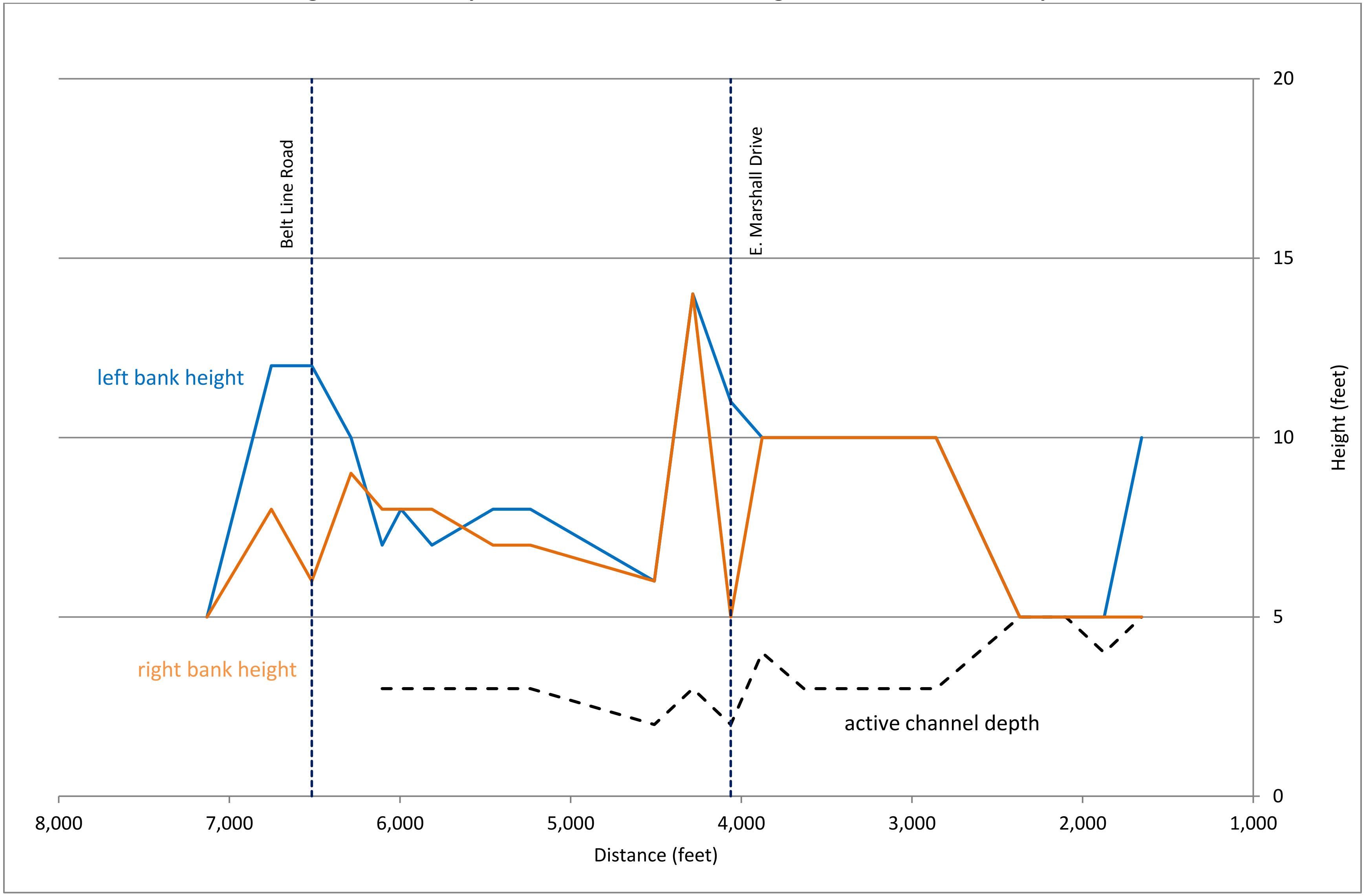
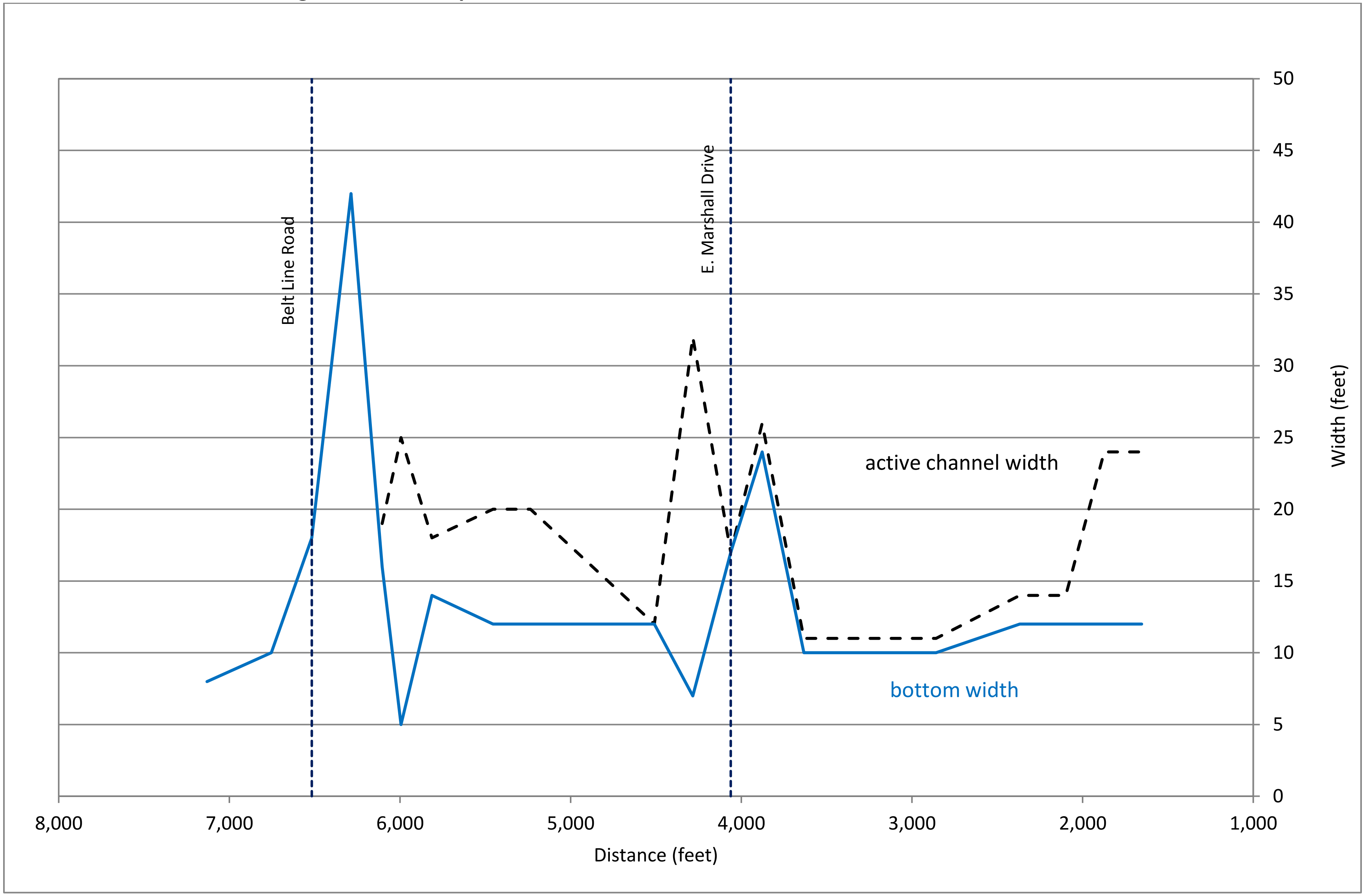


Figure 3.22 Graph of Plattner Creek bottom width and active channel width



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, culverts, and retention ponds)

Examples of stable, slightly unstable, moderately unstable, and severely unstable channels are shown in Figure 3.23. The existing condition channel stability of the Cottonwood Creek watershed study reaches 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. Tables 3.8 through 3.12 contain descriptions of specific areas of interest and severe instability along the Cottonwood Creek watershed study reaches shown in Appendix D.

In general, the upstream end of the North Fork Cottonwood Creek study reach (cross-sections 11107 to 7440) was slightly unstable. Within this segment of the channel there was an engineered channel from approximately cross-section 8720 to 7881. There were three locations within this segment that were classified are severely unstable: 1) downstream of cross-section 11107, 2) downstream of Great South West Parkway, and 3) at the railroad bridge crossing. The first two locations were undergoing severe scour and bank erosion; whereas the location near the railroad bridge crossing was undermining and scouring the in-channel protection. This was caused by the constriction of flow beneath the railroad bridge, steep banks, and additional runoff. Downstream of cross-section 7440 to cross-section 2713 the channel flowed through a series of retention ponds. Each pond contained a low water crossing at the upstream and downstream end and the segments of creek in between each low water crossing were stabilizing. It was noted during the field visit that gullies were forming on some of the banks of the ponds. Downstream of the construction at SH 161 (cross-section 2170 to 352), North Fork Cottonwood Creek appeared to be in a state of widening. There were undercut banks and bank failures such as slumps and rotational failures. This segment of channel has been straightened and appears to be ponded much of the year.

The channel erosion and stability of South Fork Cottonwood Creek varied between slightly unstable, moderately unstable, and severely unstable. There were a few locations that were lined with concrete and/or riprap protection. Some of these locations were acting as localized hardpoints in the stream. From cross-section 17616 to 6876 the creek flowed through a dense riparian corridor. The majority of the erosion and instabilities were noted on the outside of meanders and where the channel banks were composed of shale or silty shale. Downstream of the construction at SH 161, the channel flowed through a riparian area that was sparsely vegetated with early succession vegetation with shallow rooting depths. In addition, this segment of the channel flowed through the Woodbine-Eagle Ford contact boundary. The geology in this segment varied significantly from shales to weathered clayey sandstone. The majority of the erosion was located on the meanders. Near cross-section 3739 there were two pipelines where pipeline protection was severely compromised and needs repair. Downstream of W. Marshall Drive the channel had been straightened and was experiencing severe scour and bank erosion. The channel began to stabilize through McFalls Park downstream of Carrier Parkway.

The channel of Cottonwood Creek directly downstream of the low water crossing/dam (confluence of North Fork and South Fork Cottonwood Creeks) was severely unstable. The banks were severely eroding by mass wasting (excessive soil loss), bank failures (wedge and slumps) and tree falls. Tension cracks were noted at the top of each bank throughout the rest of the study reach. This segment appeared to be in Stage II (downcutting) of the channel evolution directly downstream of the dam and was transitioning into Stage III (widening) downstream of SW 3rd Street where the stream entered a grassy riparian corridor. The creek was most likely in Stage II because the dam effectively trapped the sediment causing the channel to downcut to satisfy the water-sediment balance. In addition, this segment of the channel did not have a vegetative buffer along the creek and the grass on the top banks is mowed to the edge of the channel. Mowing of the grass so close to the bank decreases rooting depth and structure, both of which are needed to aid in natural bank stability. There is a large scour hole located near cross-section 9744 downstream of a damaged gabion mattress that protects a pipeline crossing. The gabion mattress was being undermined and was collapsing into the scour hole at the time of the field assessment. The left bank was experiencing severe erosion at the location of the scour hole, and a wastewater pipeline (running parallel to the channel) was becoming exposed. Downstream of the sour hole, channel dimensions decreased as the creek flowed through a dense riparian corridor. The creek channel continued to be in a state of widening through the end of the study reach downstream of Belt Line Road.

In general, the majority of Warrior Creek was slightly unstable with a few moderately to severely unstable areas. Beginning at the headwaters this creek has been engineered and incorporated into a retention pond drainage system. The creek contains the flow of approximately the 1-year peak discharge before flowing into the ponds. The main creek channel was south of the series of retention ponds and flowed through another engineered channel. Present and potential future bank instabilities were noted between cross-sections 9 through 14 (Appendix B). Slight scour to the channel bed and tension cracks along the tops of the banks were observed during the field visit. Downstream of the construction at SH 161 the channel was in Stage II of channel evolution. The channel was downcutting into the Woodbine-Eagle Ford contact boundary, exposing clayey sandstone, silty shale and/or shale. This study reach contained a series of knickpoints that will continue to migrate upstream until the equilibrium slope is reached.

Plattner Creek is a tributary of Cottonwood Creek. This channel has been significantly altered from its original form. There were segments of the creek that were concrete protected with an engineered trapezoidal channel or fully enclosed in culverts that flowed underground. In general, Plattner Creek was slightly unstable with localized bank scour and minor undercutting of the base of the slope. Severely unstable locations were between cross-sections 6287 to 5455, where the channel was downcutting into the alluvium and causing severe bank scour. There was a sewer line exposed on the right bank in this location. Another severely unstable area was located near an aerial pipeline crossing at approximately cross-section 2098, where the banks were eroding and undermining the supports of the pipeline.

Figure 3.23 Photos of bank stability

STABLE SLIGHTLY UNSTABLE

MODERATELY UNSTABLE SEVERELY UNSTABLE

Table 3.8 Descriptions of specific areas of interest and severe instability along North Fork Cottonwood Creek

Nearest Cross-section	Description
South Fork Cottonwood Creek	
11107	Upstream of 11107 there is a concrete drop structure with a 4-foot drop, severe erosion and scour downstream.
10550	Upstream of 10550 there is riprap/shotcrete protection and flow is undermining the left side.
10376	Downstream of 10386 the area is under construction (adding more riprap).
10207	Downstream of 10207 there is severe bank erosion on the right bank.
10053	Downstream of 10053 the banks are slumping.
9883	Downstream of 9883 there is a gully on the right bank, scour and erosion to the stream.
9817	Near 9817 (railroad) the channel bed is armored with riprap/shotcrete, acting as a hard point.
9817	Right bank at 9817 bank heights increase, bank slopes steepen and there is a decrease in floodplain connection under the railroad.
9817	Left bank at 9817 in addition to flow, runoff is cutting a new channel around the channel armoring.
9817	Left bank at 9817, channel that has cut around the channel armoring, channel has been filled with additional riprap.
9769	Right bank near 9769 there is bank erosion.
9658	At 9658 the channel banks have early succession vegetation. The channel splits into two channels with a mid-channel bar.
9658	Downstream of 9658 the channel bed is shale.
9368	Downstream of 9368 there is a beaver dam ponding water keeping shale temporarily wet.
9368	Downstream of 9368 the banks are slumped and have early succession vegetation.
9153	Downstream of 9153 on the right bank there is erosion at the outfall and it is broken apart up into the field.
8720	Upstream of 8720 there is a beaver dam keeping the shale wet. Slaking on the banks, drying out, and no shade.
8720	Upstream of 8720 there is a concrete protected pipeline acting as a hard point.
8720	Downstream of 8720 there is a concrete channel with overflow into a retention pond.
8720	Between 8720 and upstream of 7881 the concrete is spalling in the channel bed.
7881	Upstream of 7881 there is deposition growing vegetation in the concrete channel.
7881	Upstream of 7881 there is a concrete drop with a 2.5-foot drop.
7881	Right and left bank near 7881, riprap and fabric are moved, water can flow behind wall.
7440	At 7440 the culverts are blocked with trash and woody debris.
5621	Slopes adjacent to the sting of ponds have some gully and rill erosion (5621).
2634	At 2634 concrete channel stops upstream of the construction of Hwy 161.
	At Hwy 161 there is erosion behind gabion baskets
	Hwy 161 bridge piers are in the channel bed.
	Under Hwy 161 there is gully erosion to some of the piers for the access road.
2170	At 2170 there is a pipeline with riprap/shotcrete protection. 4-foot drop acting as a hard point.

Table 3.8 (continued) Descriptions of specific areas of interest and severe instability along North Fork Cottonwood Creek

Nearest Cross-section	Description
North Fork Cottonwood Creek	
2170 - 859	Downstream of 2170 to 859 the channel is ponded and appears to have been straightened.
1775 – 1291	Downstream of 1775 to downstream of 1291 the base of the left bank slope is armored with riprap.
859	At 859, Carrier Parkway is acting as a hard point.
701	At 701, left bank, scour behind the wing walls at an outfall.
352	Upstream of 352 is a pipeline exposed in the channel bed.
352	At 352, right bank there are gabions exposed.

Table 3.9 Descriptions of specific areas of interest and severe instability along South Fork Cottonwood Creek

Nearest Cross-section	Description
South Fork Cottonwood Creek	
17616	Downstream of 17616 the creek is a braided system.
17466	Downstream of 17466 was the main channel at one time.
17281	Upstream of 17281, photo shows where GIS center line is. This location is not the main channel.
16891	Upstream of 16891 the channel is incising.
19685	At 16685, Great Southwest Parkway is a hard point made of riprap/shotcrete.
16546	Downstream of 16546 is severely scoured with a 4-foot drop. There is a siltstone/shale outcrop.
16285	Downstream of 16285 are two chute cutoff's in a row.
15904	Upstream of 15904 there is a 3-foot knickpoint.
15904	At 15904 the channel incision is about 5 feet deep and 3 feet wide.
15904	Downstream of 15904 there is light blue gray siltstone, stream flow is against the dip of the formation.
15583	At 15583 there is evidence of slumping and the fence line is 50 feet from bank.
15583	Downstream of 15583 the meanders expose siltstone/shale.
14885	Downstream of 14885 there is a concrete encased pipeline acting as a hard point.
14701	Near 14701 there are apartments on the right side of the creek.
14301	At 14301, Pioneer Parkway has 3 box culverts and 2 are clogged with sediment.
13908	Near 13908 there is evidence that the creek was ponded there are undercut banks and scour.
13479	At 13479 there is a chute cutoff that is used during higher flows.
13479	At 13479 water backs up behind this low water crossing.
13479	Downstream of 13479 there is severe erosion and scour and the culverts are blocked. The low water crossing is acting as a hard point.
13479	Downstream of 13479 there is a debris jam, tree falls and soil erosion.
13237	Near 13237 high water flows across the floodplain.

Table 3.9 (continued) Descriptions of specific areas of interest and severe instability along South Fork Cottonwood Creek

Nearest Cross-section	Description
South Fork Cottonwood Creek	
12882	Upstream of 12822 there is a sheet metal fence over the channel acting as a debris jam.
12882	Downstream of 12822 there is a chute cutoff.
12882	Downstream of 12822 there is a debris jam and a deep scour that is pool mining shale.
12421	Downstream of 12421 there is an aerial pipeline and the channel appears to be widening.
11967	Downstream of 11967 there is a low water crossing with a 3-foot drop in elevation.
11238	Upstream of 11238 there is a potential pipeline crossing under concrete protection.
10803	Upstream of 10803 there is a potential pipeline crossing under concrete protection.
10047	Near 10047 there is shale exposed, severe erosion (typical of areas with exposed shale).
10047	Downstream on the left bank near 10047 an outfall flows over exposed shale, 9-foot drop in elevation, and erosion at headwall.
9420	Downstream of 9420 there is a concrete encased pipeline being undermined.
9021	Upstream of 9021 there is an outfall with a scour pool that is undercutting the outfall.
9021	Downstream of 9021 there is a cutoff. Note 2-foot knickpoint migrating up the cutoff.
8274	Upstream, left bank near 8274, outfall with erosion behind the wing wall and 2 feet of scour.
7334	Upstream of 7344, severe erosion, concrete slab has shifted and the pier is exposed. There is a 4-foot drop in elevation on the downstream side.
7334	At 7344 the banks are slumping.
6876	At 6876 there is aerial pipeline. The channel bottom is protected with riprap and shotcrete.
6732	Downstream of 6732 looking at the temporary construction road over the creek.
6732	Downstream of 6732 there is erosion on the meander. Consider checking the riprap and fabric on the slope.
6114	Upstream of 6114 looking at the newly constructed piers in the channel.
6114	At 6114 there is a temporary road crossing.
5996	Upstream of 5996 under the Hwy 161 access road, there is gully erosion.
5996	Downstream of 5996 there is a concrete protected pipeline acting as a hard point.
5502	Downstream of 5502 is the confluence with Warrior Creek.
5157	Upstream of 5157 there is a concrete protected pipeline acting as a hard point.
4790	Downstream of 4790 there is a broken culvert and a 4-foot segment has fallen into the creek. Meander is migrating and the fence is 10 feet away.
4790	Downstream of 4790 there is a fence causing a debris jam and local scour. Consider removing.
4435	At 4435 exposed shaley silt stone from the Woodbine, it is erodible.
4435	Downstream of 4435 there is a concrete encased pipeline acting as a hard point.
3739	Downstream of 3739, potential high flow or abandoned channel.
3387	Upstream of 3387, severe erosion to gabion baskets and concrete pipeline protection.
3120	Upstream of 3120, there is an exposed pipeline. Severe bank erosion, wedge failures and soil loss.
3120	Downstream of 3120 the bank is slumping.
2852	Upstream of 2852 there is an aerial pipeline.

Table 3.9 (continued) Descriptions of specific areas of interest and severe instability along South Fork Cottonwood Creek

Nearest Cross-section	Description
South Fork Cottonwood Creek	
2852	At 2852, upstream of Robinson Road there is scour behind the wing wall from stormwater runoff.
2473	At 2473, upstream of Marshall Road the channel is armored with riprap/shotcrete. The bank are slumping between Robinson Rd and Marshall Rd.
2341	At 2341 the channel is protected with riprap/shotcrete.
2341	Downstream from 2341 there is severe bank erosion, scour and bank failures.
2341	Slumping banks typical of the reach 2341 to 1142.
761	Carrier Parkway near 761 is acting as a hard point, ponded upstream and downstream.
761	Downstream of 761 the water surface elevation used to be higher, note cypress knees.
346	The aerial walking path at 346 has erosion to the supports.
346	Downstream of 346 there is a broken outfall from local scour.
	Low water dam at the confluence of the North Fork and the South Fork of Cottonwood Creek (acting as a hard point).

Table 3.10 Descriptions of specific areas of interest and severe instability along Cottonwood Creek

Nearest Cross-section	Description
Cottonwood Creek	
	Low water dam at the confluence of the North Fork and the South Fork of Cottonwood Creek (acting as a hard point).
12645	Downstream of 12645 there is erosion to the dam structure.
12645	Downstream of 12645 there is severe erosion on both banks.
12645	Downstream of 12645 the gabion mattress on the left bank is exposed.
12482	Downstream of 12482 there is an aerial pipeline with erosion and scour to the bank protection.
12482	Downstream of 12482 there is severe erosion and failures on a bank near an aerial walking path.
12482	Downstream of 12482 there are tree falls and slumped banks.
12147	Upstream of 12147 there is an exposed pipeline and gravel bar formation on the upstream side.
12482 – 10760	From 12482 to 10760 the banks are eroding and slumping (worse on banks that are mowed with sparse vegetation).
11493	At 11493 a drainage gully is eroding.
11493	Near 11493 a drainage way protected with concrete is slightly undermined.
11042	Downstream of 11042 there is collapse of the bridge foundation.
10760	At 10760 a pipeline is exposed in the channel bed, crosses the creek diagonally.
10760	At 10760, Southwest 3rd bridge no sign of channel bed armoring.
10676	Downstream of 10676 there is a cracked outfall pipe on the left bank.
10676 – 9744	Between 10676 and 9744 the banks are undercut and slumping.
9744	Downstream of 9744 there is a collapsed gabion structure. Ponding upstream and scour hole downstream (a dumpster is in the scour hole).

Table 3.10 (continued) Descriptions of specific areas of interest and severe instability along Cottonwood Creek

Nearest Cross-section	Description
Cottonwood Creek	
9744	Downstream of the gabion structure the scour has exposed a pipeline that parallels the creek.
9744	Major transition in stream type downstream of scour pool (inset, meandering channel within riparian corridor).
8570	Upstream of 8570 there is riprap bank and bed protection, temporary hard point (severe bank erosion and a chute cutoff at this location).
8570	Downstream of 8570, typical view of creek with eroding banks, exposed roots and bank failures.
7300	Upstream of 7300 a pipeline crossing protected by concrete rubble.
7300	Upstream of 7300 use to be a road.
6495	Downstream of 6495 (confluence with a tributary) the creek transitions to a channel that has high connection to the floodplain.
5978	Downstream of 5978 there is two pipelines protected with concrete or gabions.
5978	Downstream of 5978 the concrete protection drops 3feet in elevation (scoured and undercut).
5320	Beltline Road at 5320, aggradation and debris jams under the bridge.
5211	Downstream of 5211 (Beltline Road) there is a hard point (potential pipeline protection) that drops 3 feet in elevation.
	End of City Limits (Study Area). Channel is pooled with undercut banks and flows have connection to the floodplain.

Table 3.11 Descriptions of specific areas of interest and severe instability along Warrior Creek

Nearest Cross-section	Description
Warrior Creek	
1	Great Southwest Parkway downstream of 1. Erosion from local scour.
1 – 2	Reach pools from 1 to just downstream of 2. Scour line on the banks with minor slumping.
2	Downstream of 2 there is a gully and rill erosion on the banks.
2	Downstream of 2 there is a gabion structure crossing the channel inducing local scour.
2	Downstream of 2 on the meander, near vertical bank, exposed erosion control, and 3 feet deep.
3	Upstream of 3 erosion control is exposed, stops abruptly, and erosion is evident around the brunch grass, mowed to short.
3	Upstream of 3 there is scour and knickpoint with a 6 inch drop in elevation.
3	Upstream of 3 is outfall on the left bank with riprap/shotcrete channel protection.
3 - 4	Typical view from 3 to 4, channel is filled with vegetation and flows have scoured the sides.

Table 3.11 (continued) Descriptions of specific areas of interest and severe instability along Warrior Creek

Nearest Cross-section	Description
Warrior Creek	
3 – 4	Between 3 and 4 is outfall on the left bank with riprap/shotcrete channel protection.
4	Upstream of 4 flows move around grade control check dam. Material is in place consider placement up the bank.
3 – 4	Between 3 and 4 there is an outfall on the left bank with riprap/shotcrete channel protection.
4	Upstream of 4 is grade control, flows have moved some of the material.
5	Upstream of 5 at the first pond, erosion to the bank downstream of the protection with minor bed scour.
5	Downstream of 5 there is grade control in the channel.
5	Downstream from 5, typical view of channel, narrow with undercut banks and vegetation.
6	Downstream of 6 the channel transitions into riparian corridor.
7	Downstream of 7 there is a black corrugated pipe in the channel.
7	Downstream of corrugated pipe, typical channel view.
8	Downstream of 8 there is a debris jam with a 1-foot knickpoint.
9	Downstream of 9 there is grade control with 1-foot drop in elevation. Neighborhood drains to this location.
9	Downstream of 9 there is channel protection upstream and downstream of the driveway.
10	Near 10 there is an aerial walking path, slopes in the creek are indicating signs of movement and footers are leaning.
10	Downstream of 10, driveway with two culverts and riprap bed and bank protection.
11	Downstream of 11 there is an aerial walking path, slopes in the creek are indicating signs of movement and footers are leaning.
11	Downstream of 11 there is about a 1-foot drop and soil erosion on the banks.
11	Downstream of 11, banks have tension cracks parallel to the creek.
12	Near 12 tension cracks indicating potential slope movement.
12	Downstream of 12 there is bank scour on the meander.
12	Downstream of 12 has been scoured.
12	Downstream of 12, right bank has severe gullies. Runoff from the parking area all drains to this location (undermining the bank protection).
13	Upstream of 13 gully formation water can flow under the riprap, and there is potential for undermining.
13	Upstream of 13 there is bank erosion, sparse vegetation and lacking topsoil.
14	Looking towards 14, upstream from Hwy 161. Creek joins retention ponds.
3079	Near 3079, left bank, employee expressed concern about the slope moving.
3079	Downstream of 3079 there is scour and undercutting.
3079	Downstream of 3079 there is erosion and cracks in the concrete structure.
3079	Downstream of 3079 there is an exposed pipeline crossing the creek diagonally.

Table 3.11 (continued) Descriptions of specific areas of interest and severe instability along Warrior Creek

Nearest Cross-section	Description
Warrior Creek	
3079	Downstream of 3079, more water enters the creek, local scour to the banks.
3079	Downstream of 3079 there is an exposed gas pipeline and severe bank erosion.
3079	Downstream of 3079 there is a drop in channel bed elevation.
2787	At 2787 there is a debris jam.
2787	Downstream of 2787 there is a 4-foot drop in elevation (knickpoint/scour pool).
2787	Downstream of 2787 there is a 2-foot drop in elevation.
2787	Downstream of 2787 there is a 1.5-foot drop in elevation (potential for grade control or drop structure).
1938	Downstream of 1938 there is severe erosion, scour, weathered shale/siltstone, and tree falls.
1649	Downstream of 1649 there is riprap that is possibly protecting a pipeline.
1428	Near 1428 the banks are undercut and houses are along the top of bank.
1428	Downstream of 1428 there is an air dam from a big rig in the channel blocking flow and inducing scour.
1202	Downstream of 1202 there is a severely eroding bank.
1202	Downstream of 1202 there is an illegal trash dumping site (recent-milk container dated 7/9/11).
1202	Downstream of 1202 there is a 2-foot knickpoint with debris jam.
945	Downstream of 945 there is a 3-foot knickpoint into shale.
945	Downstream of 945 there are large bank failures.
689	Upstream of 689 there is a man hole in channel potential leak water is back and smells. Water is ponded at the outfall upstream.
689	At 689 there are sandbags in the channel.
689	Downstream of 689 there is a broken outfall on the right bank.
433	Downstream of 433 the channel has cut into the shale forming knickpoints.
433	Downstream of 433 the channel is entrenched.
182	Downstream of 182 there is a hard point, concrete protected pipeline.

Table 3.12 Descriptions of specific areas of interest and severe instability along Plattner Creek

Nearest Cross-section	Description
Plattner Creek	
7131	At 7131 the channel is concrete.
6745	Upstream of 6517 there is a hole in the concrete with pooled water, potential leak.
6754	At 6754 the channel is concrete, looking towards Beltline Road.
6287	At 6287 a pipeline is protected with riprap and shotcrete.
6104	At 6104 flow has scoured the left bank of the channel.
6104	Downstream of 6104 the channel contains riprap on the right bank and in the bed.
6104	Downstream of 6104 there is severe erosion to the right bank. Runoff and flow have exposed a pipeline.

Table 3.12 (continued) Descriptions of specific areas of interest and severe instability along Plattner Creek

Nearest Cross-section	Description
Plattner Creek	
5994	Downstream of 5994 there is severe erosion and scour.
5813	Downstream of 5813 there is an old road crossing. The water smells and is black, potential leak.
5455	Upstream of 5455 erosion, scour and undermining to outfall runoff protection.
5455	Downstream of 5455 there is an aerial pipeline that is slightly bent.
6287	Downstream of 6287 the creek flows underground through culverts.
4510	Downstream of 4510 deposition and vegetation in the channel.
4510	Downstream of 4510 livestock access the creek, eroding banks and slumps.
4062	Upstream of 4062 there is deposition in the box culverts.
3878	Downstream of 3878 there is a pipeline that crossed the channel diagonally.
3306	Downstream of 3306 there is a grade control structures.
3306	Downstream of 3306 there is a grade control structure, potential low water crossing.
3306	Downstream of 3306 a pipeline parallels the creek.
2859	Downstream of 2859 there is an outfall with some erosion and scour.
2098	Downstream of 2098 there is an outfall where runoff enters the creek.
1874	At 1874 there is an aerial pipeline with severe erosion on the on the banks.
1654	Near 1654 there is temporary riprap hard point.
1654	At 1654 there is a 4-foot outfall where runoff enters the creek, scour and erosion downstream.

3.4 Planform Stability

3.4.1 Meander Migration

Meander migration rates were unable to be measured using aerial photographs as part of this study. In general, historical aerial photographs are the best way, aside from actual field data collection, to measure lateral channel movement. The majority of the study reaches have been straightened in the past, possibly in an attempt to increase drainage rates from agricultural fields or to increase flood conveyance. Tree canopy density of the riparian corridor along the only remaining meandering study reach (South Fork Cottonwood Creek) was too dense to identify channel locations on sequential historical aerial photography. Field observations suggested that meanders of South Fork Cottonwood Creek may be migrating, but repeated site visits over a relatively long period of time would be necessary to measure a meander migration rate. 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.

3.4.2 Bank Stability

Processes of bank erosion and instability 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 failures occur when bank material becomes unstable and falls or slides to the base of the bank. Different types of bank failures observed in the Cottonwood Creek watershed study reaches are shown in Figure 3.24. There were several types of failures and different failure mechanisms were 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 existing in-channel structures (low-water crossings and culverts) and were typically seen on bank slopes less than sixty degrees. Slumps occurred in the soil material on the upper banks of the channel. Where the soils material extended the entire bank height and clay or 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, wedge failures, and failure of non-cohesive bank material were common. Generally, bank failures along the channels of the study reaches were related to the depth of the bank material in relation to the top of the more resistant material composing the channel beds. The higher the more relatively resistant material (clay or shale) was exposed within the channel bank the more the channel was observed to fail by wedge failure and erosive scour. Wedge failures were noted to fail in locations where bank angles were steep (greater than 60 degrees) and tensions cracks had formed parallel to the tops of the banks. In addition, exposed shale was being 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 a complex process, geotechnical engineers should be consulted and a more detailed geotechnical analysis should be conducted to provide data for any stabilization designs.

Figure 3.24 Photographs of bank failures

CREEP SLUMP

UNDERCUT BANK WEDGE

4.0 DESIGN AND ENGINEERING CONSIDERATIONS

4.1 Channel Erosion and Instability

Stream bank protection and bank stabilization should be considered at all locations categorized as severely unstable and priority should be given to the areas in closest proximity to homes and infrastructure. Additionally, there were existing structures that were stabilizing portions of the study reaches. Structures used to protect and stabilize the study reaches should be permanently engineered. Appendix B and Tables 4.2 through 4.6 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 study reaches have evolved as a result of development in the Cottonwood 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. Future construction in the watershed 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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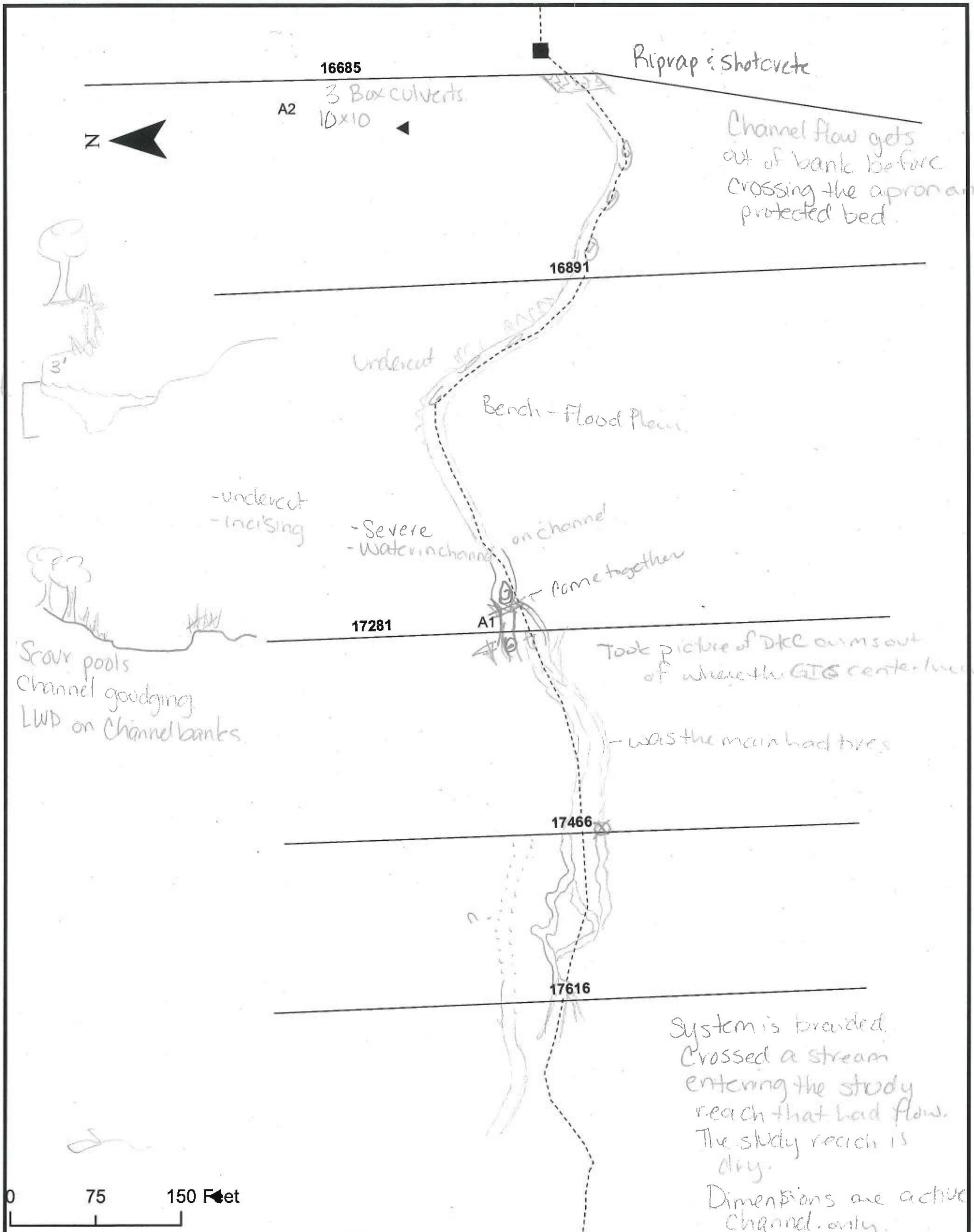
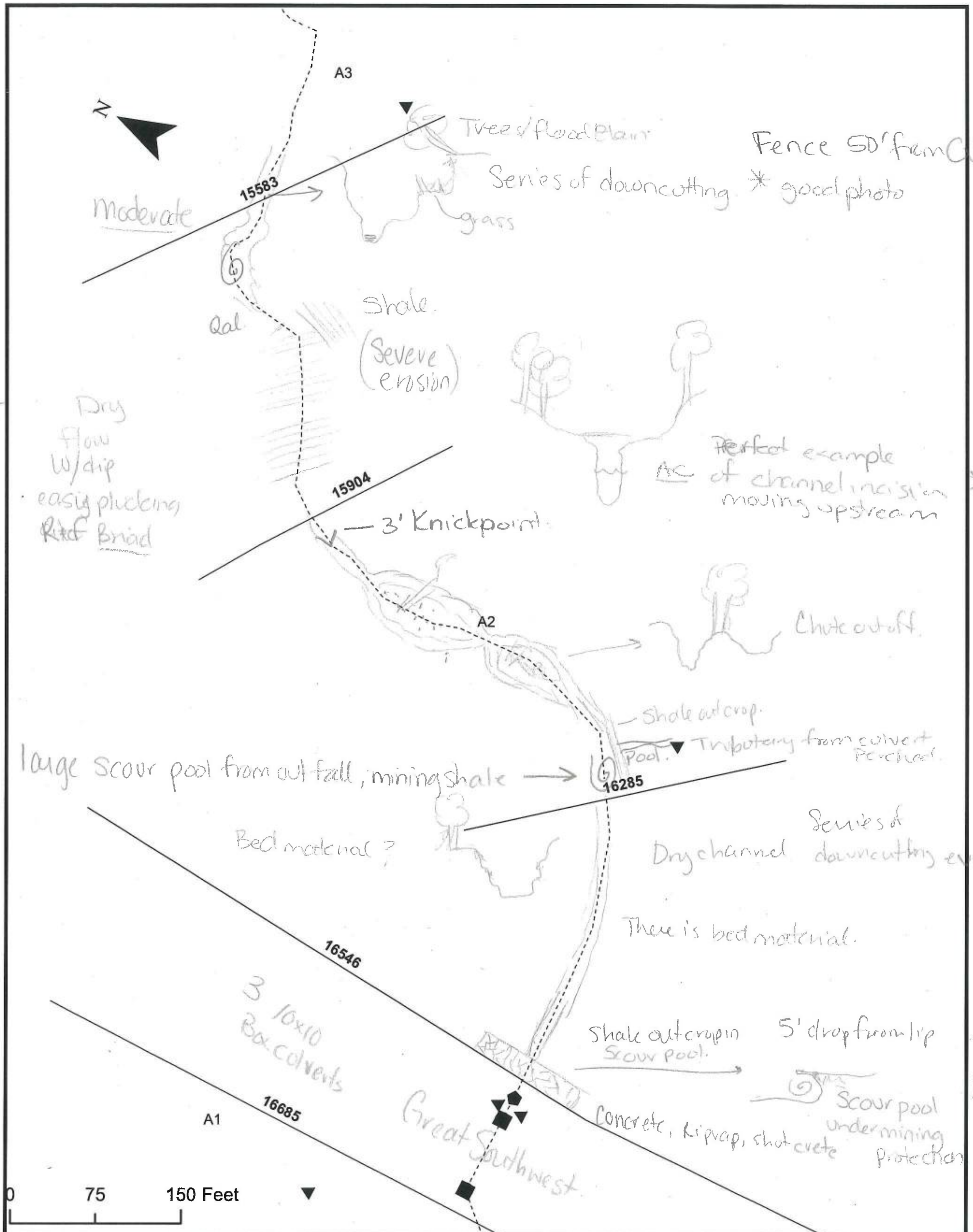
Appendix A

Hard point @ 16685

water depth 2'



Freese and Nichols 4055 International Plaza, Suite 200 Fort Worth, TX 76109 - 4895 Phone - (817) 735 - 7300	▲ Outfall ● WW ■ Pipeline ——— XS ⬟ Water ------ Creek	**Cottonwood Creek Geomorphic Assessment**	FN JOB NO ESP11227 DATE 7/19/11 STREAM Cottonwood Crk TEAM SVC, DKC	**A1** **FIGURE**



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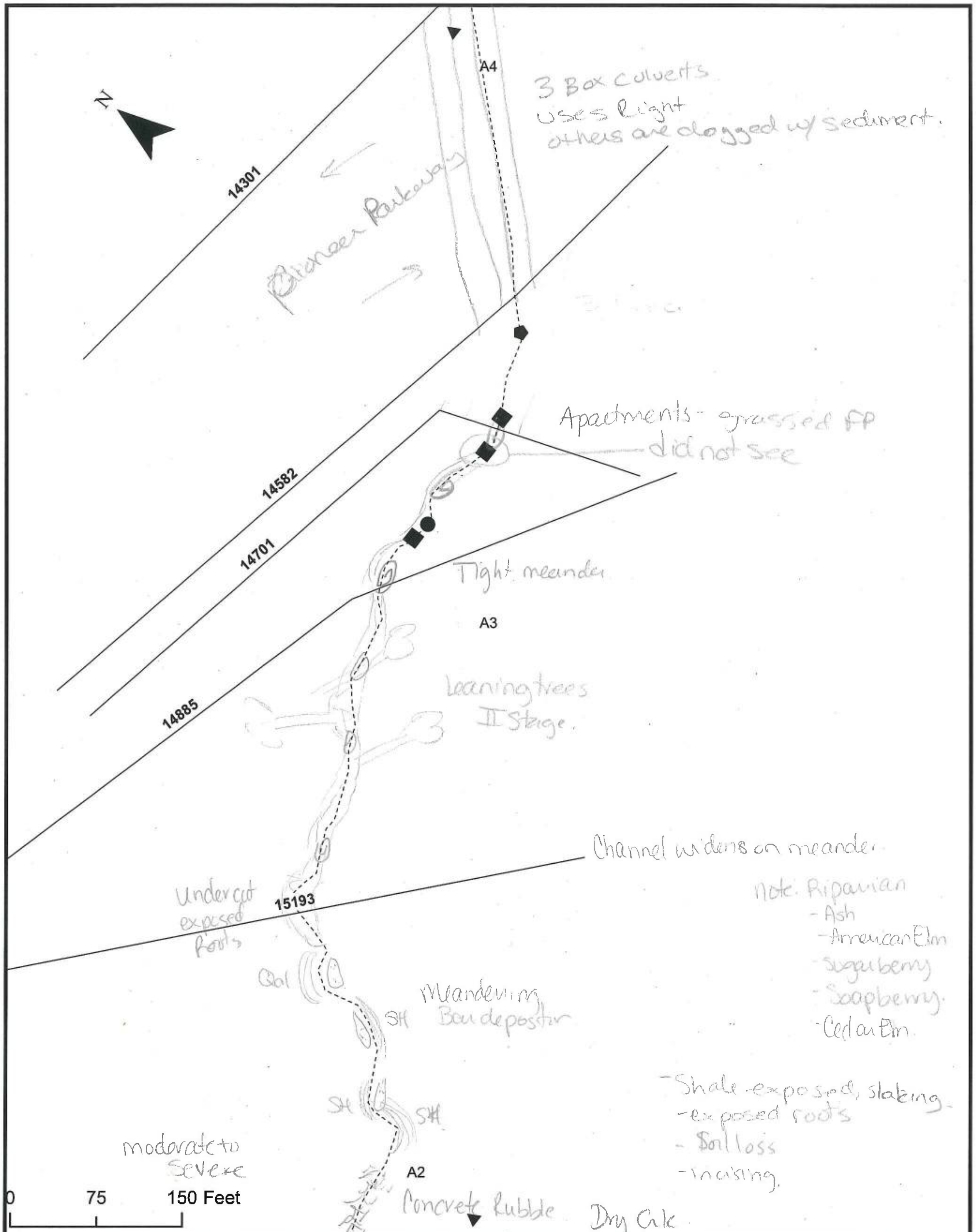
Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A2
DATE 7/19/11	
STREAM S. Cotton	FIGURE
TEAM SN, DKC	

Hard point
Concrete
Protected
Pipeline
near
14885



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Legend	
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

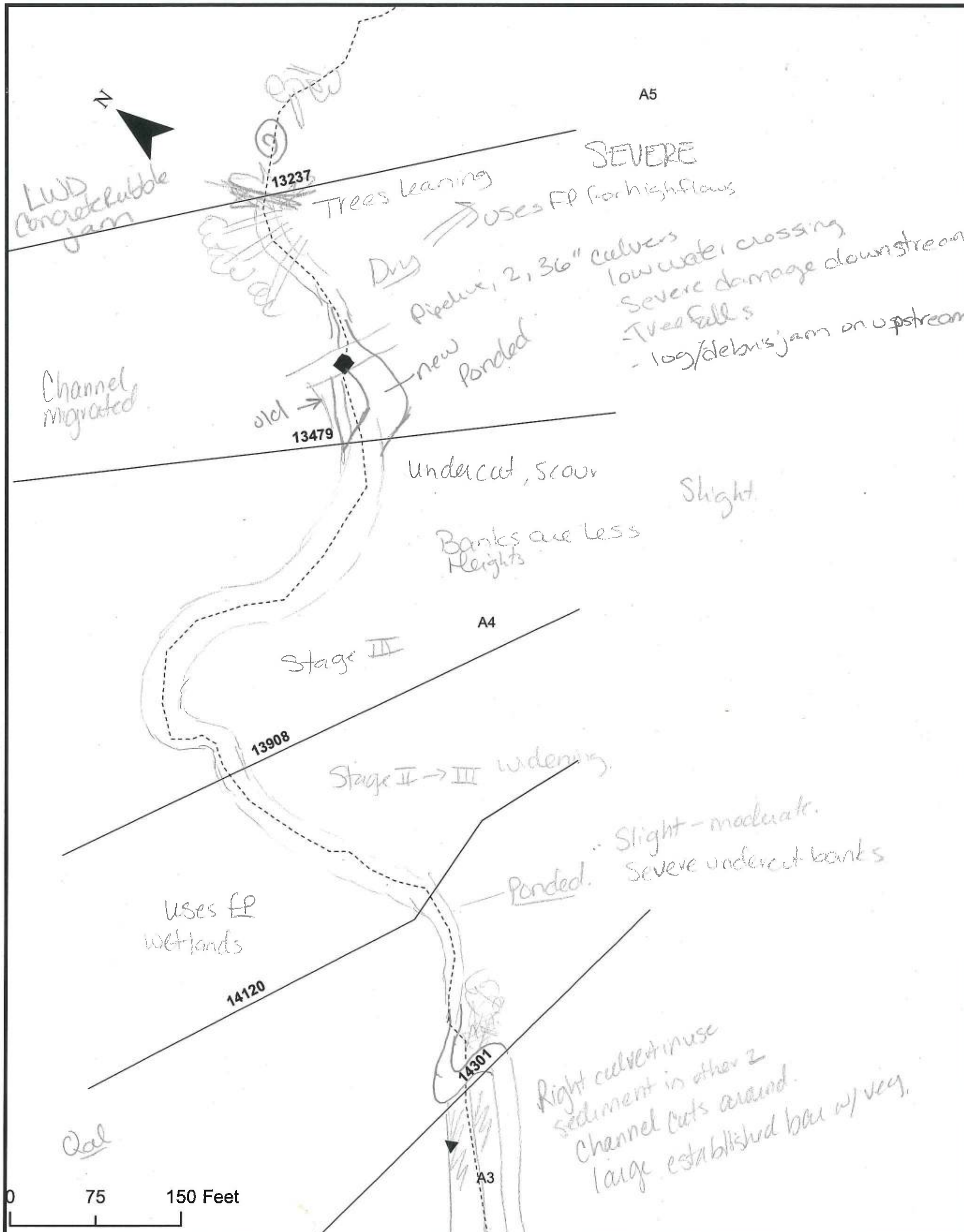
Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/19/11
STREAM	Cottonwood
TEAM	SVC, DKC

A3

FIGURE

* Hard point. near 13479



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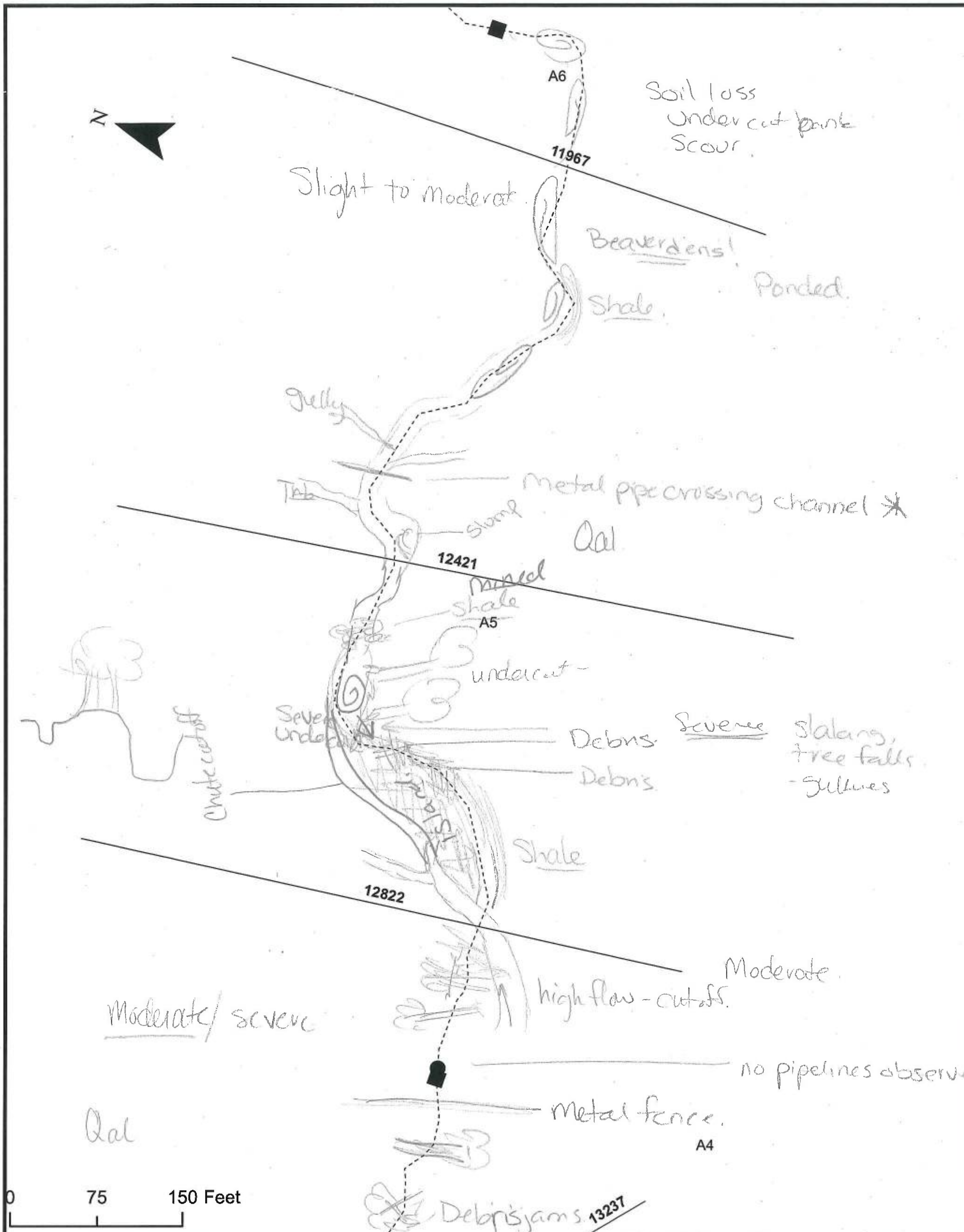
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO: ESP11227
DATE: 7-19-11
STREAM: S. Cottonwood
TEAM: SVC DKC

A4
FIGURE



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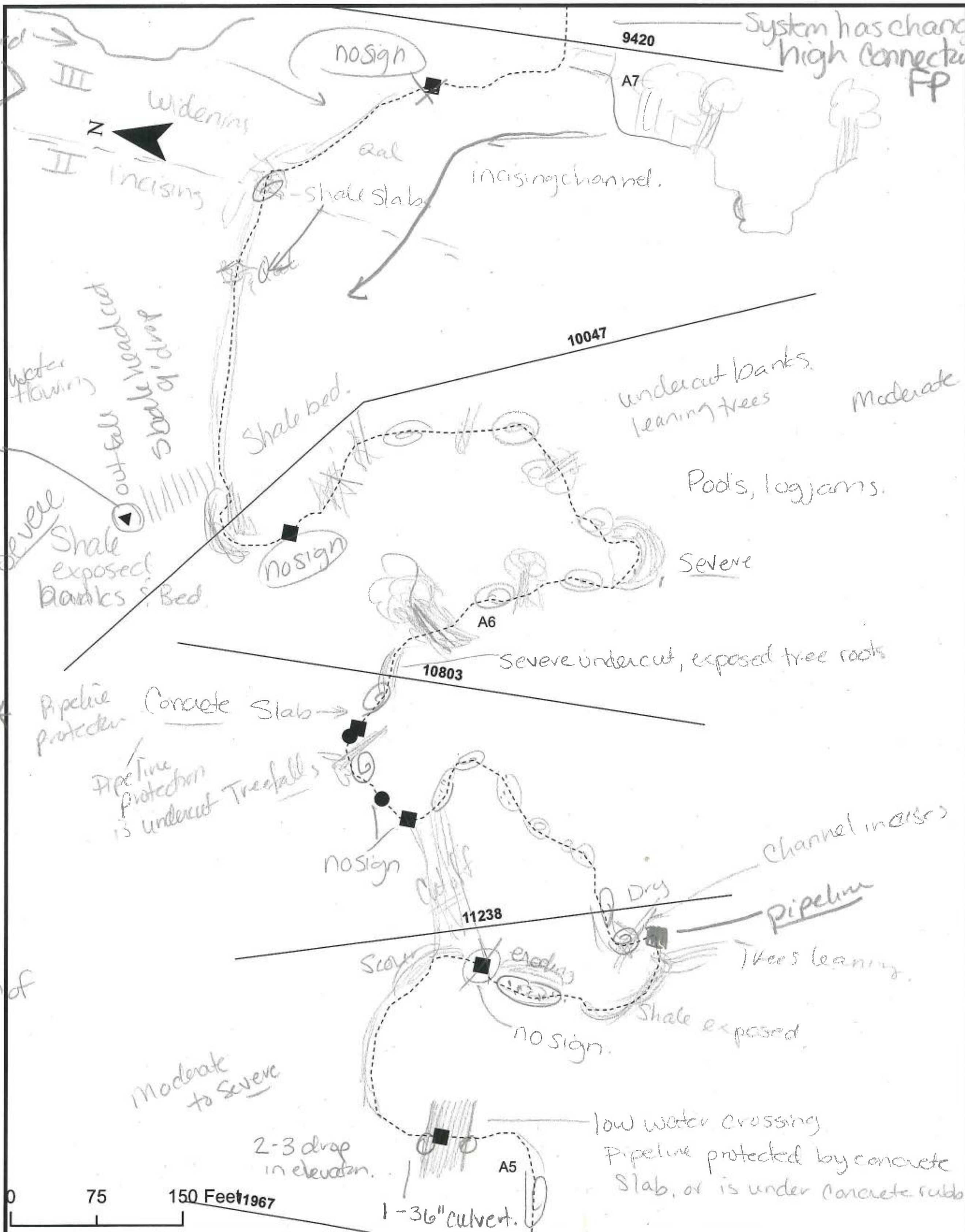
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A5
DATE 7-19-11	
STREAM S. Cottonwood	FIGURE
TEAM Sc, Dkc	



Banks slumped

Temporary Hardpoint @ 10803

Hardpoint upstream of 11238.

Hard point near 11967 There is a drop in streambed elevation

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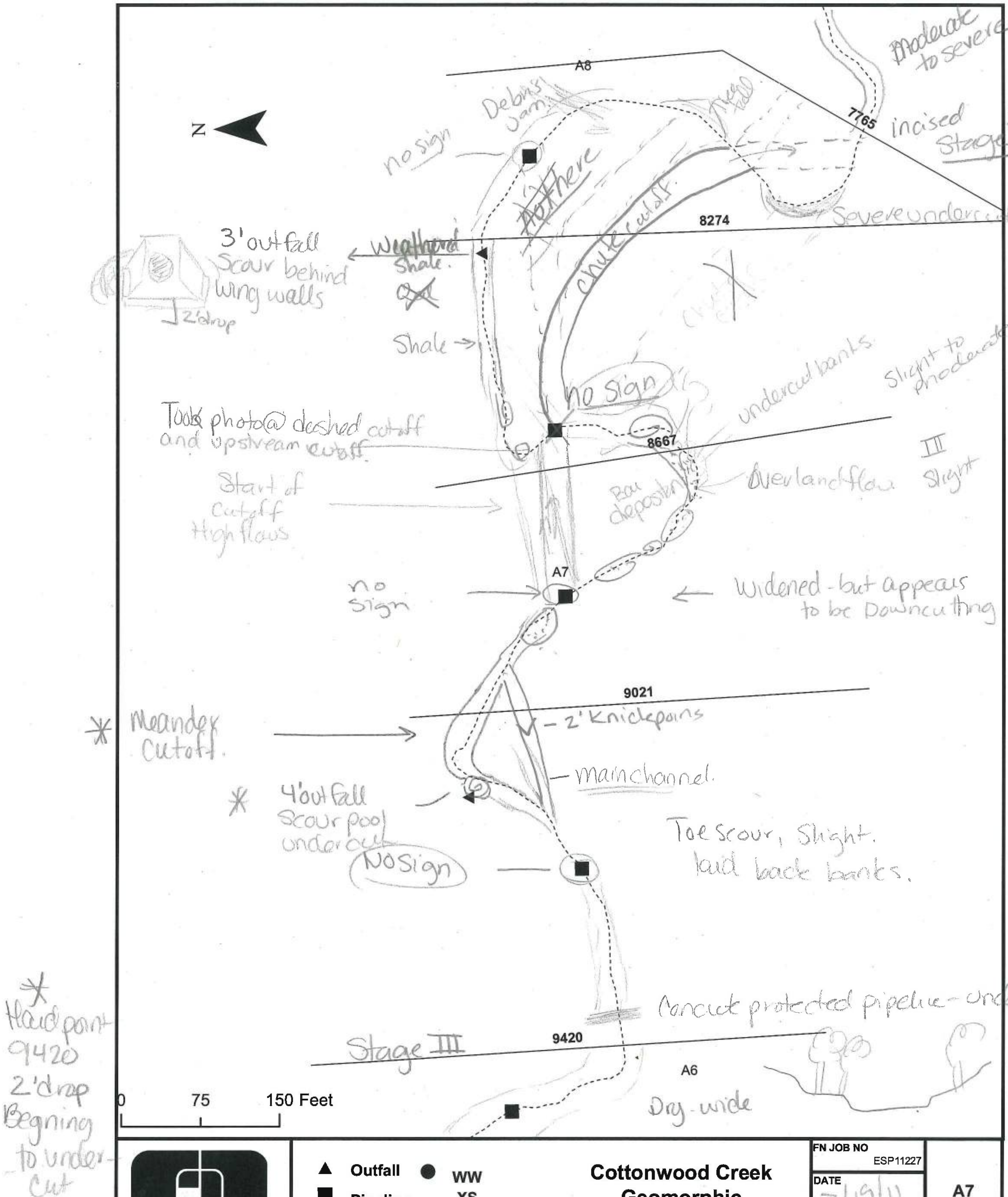
Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	
DATE 7/19/11	A6
STREAM S. CW Crk	FIGURE
TEAM SJC, DCC	



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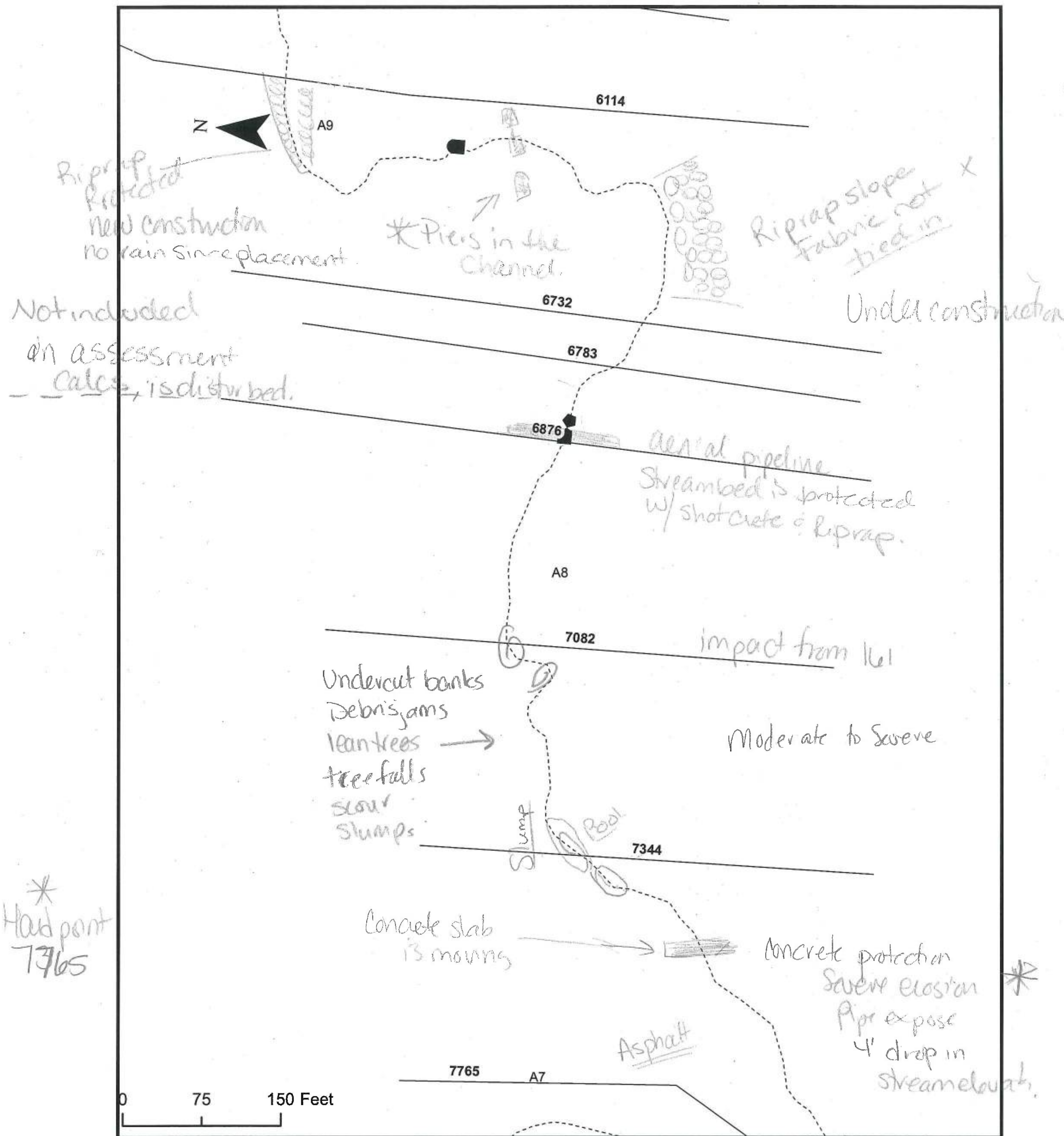
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/19/11
STREAM	Sirwark
TEAM	SVC, DKC

A7

FIGURE



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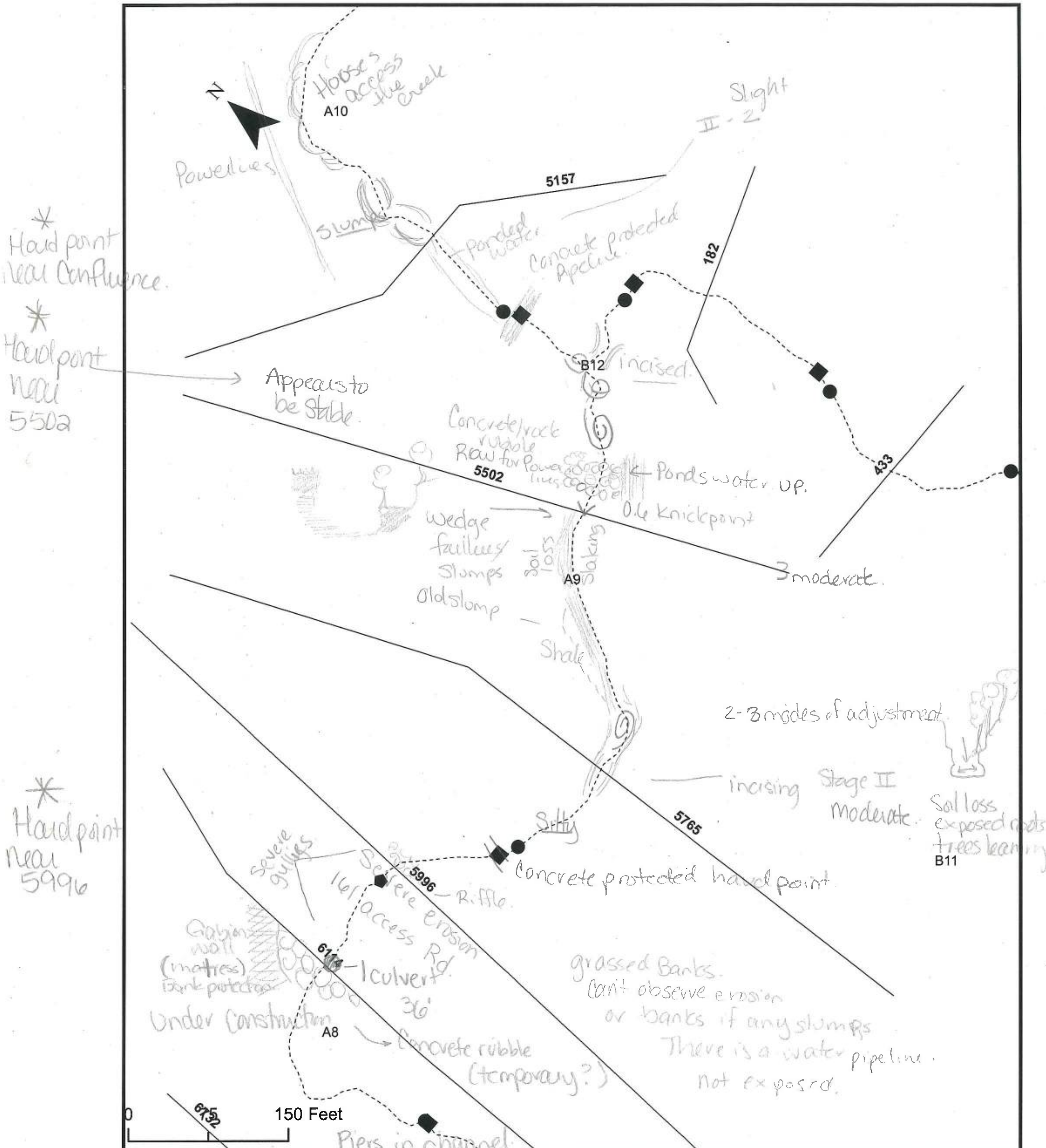
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A8
DATE 7-19-11	
STREAM Cottonwood	FIGURE
TEAM SK	



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■ Pipeline ——— XS
⬟ Water ------ Creek

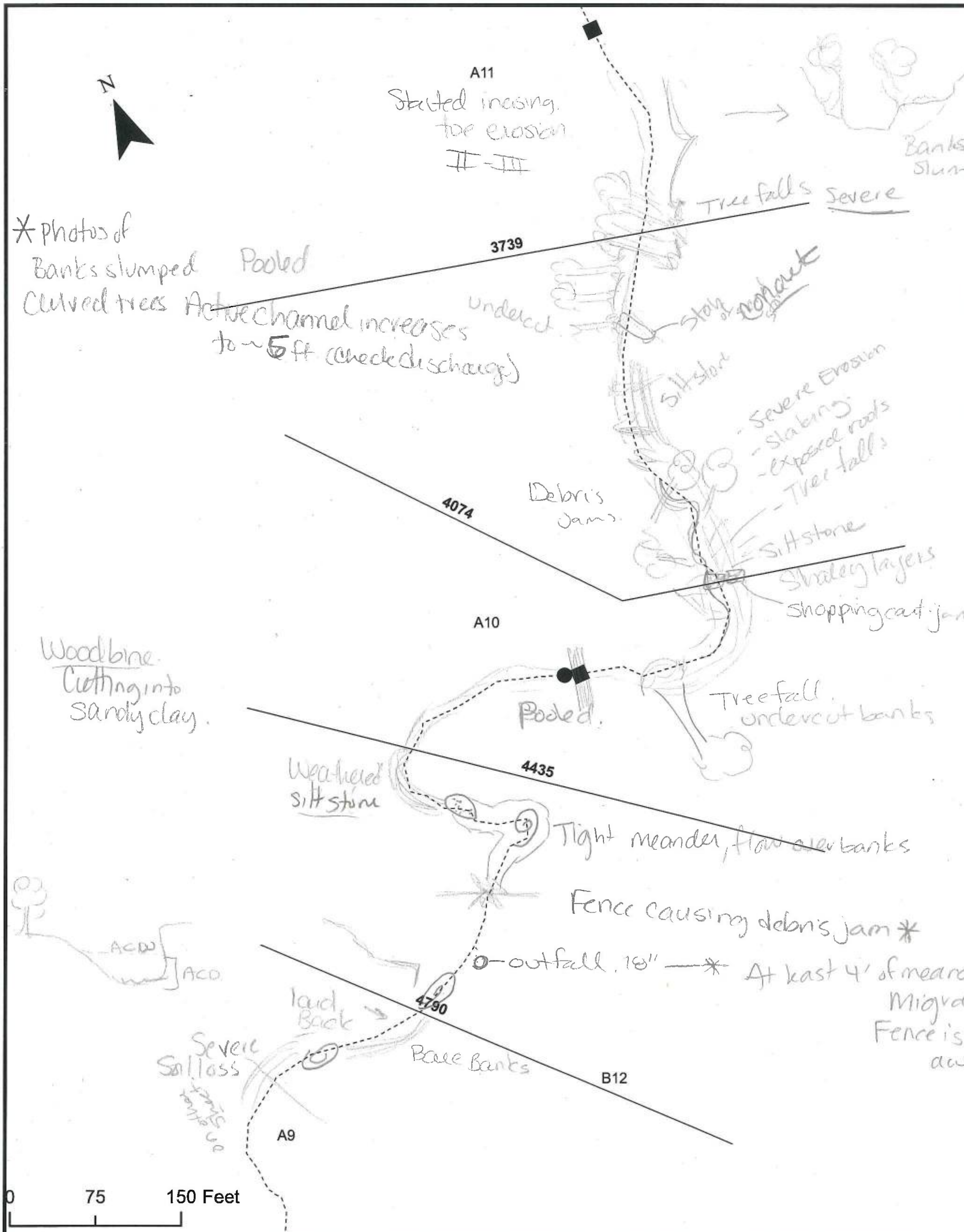
Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-20-11
STREAM	Cottonwood
TEAM	SVC, DKC

A9

FIGURE

Handprint Wall 4435



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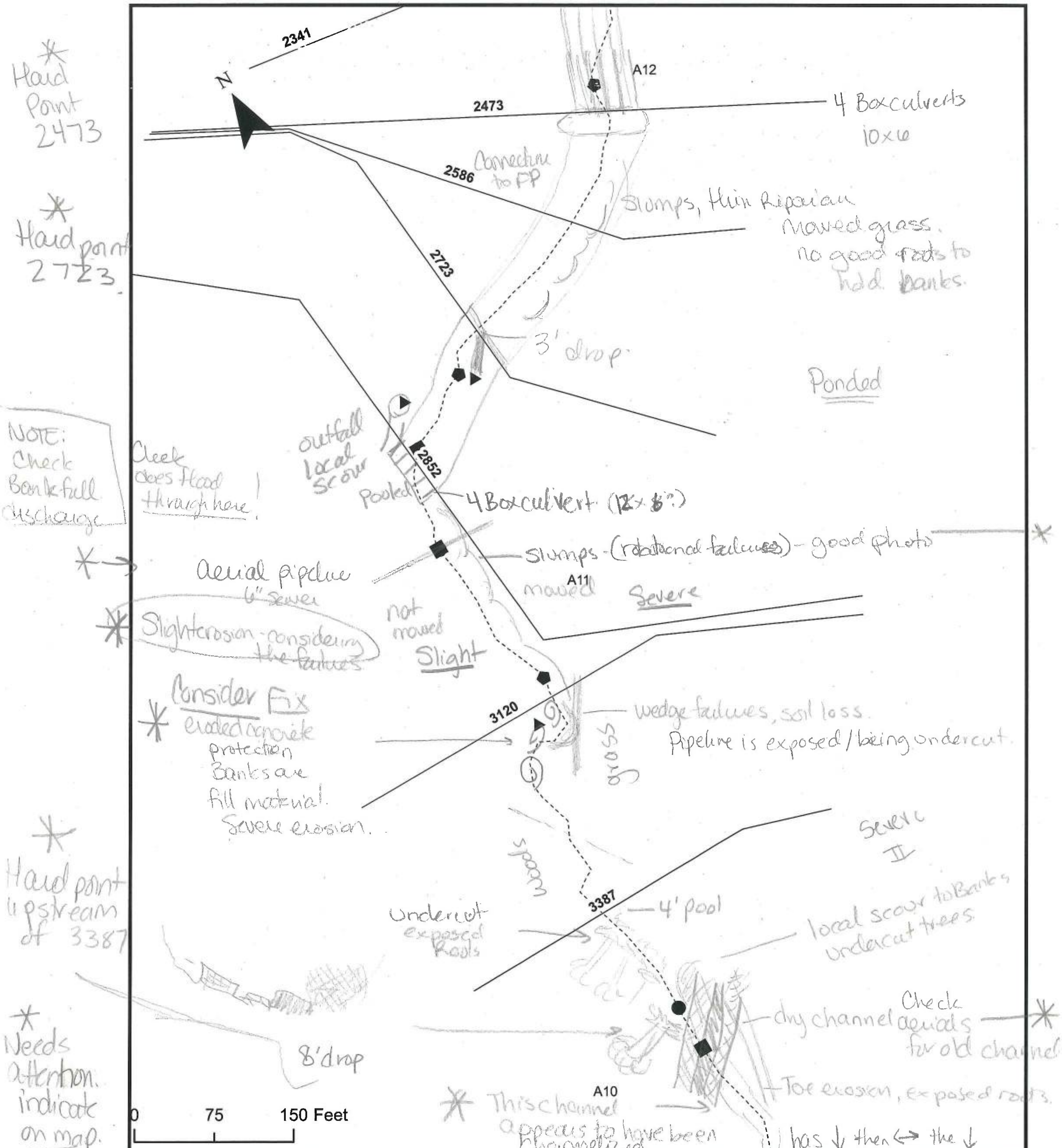
■ Pipeline ——— XS
⬟ Water - - - - - - Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A10
DATE 7/20/11	
STREAM CW	FIGURE
TEAM JC DKC	



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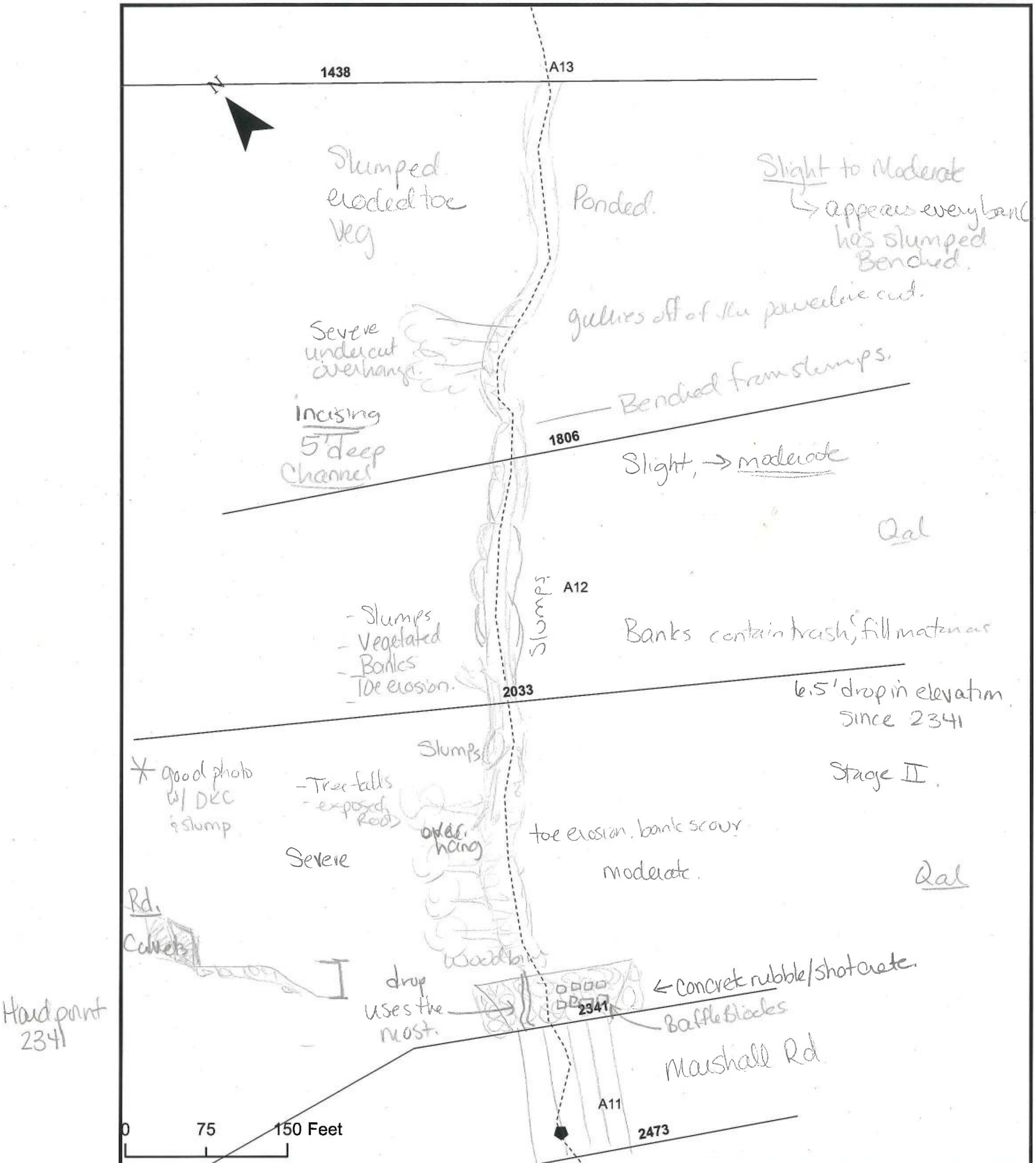
Legend	
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-20-11
STREAM	Cottonwood
TEAM	SK, DKC

A11

FIGURE



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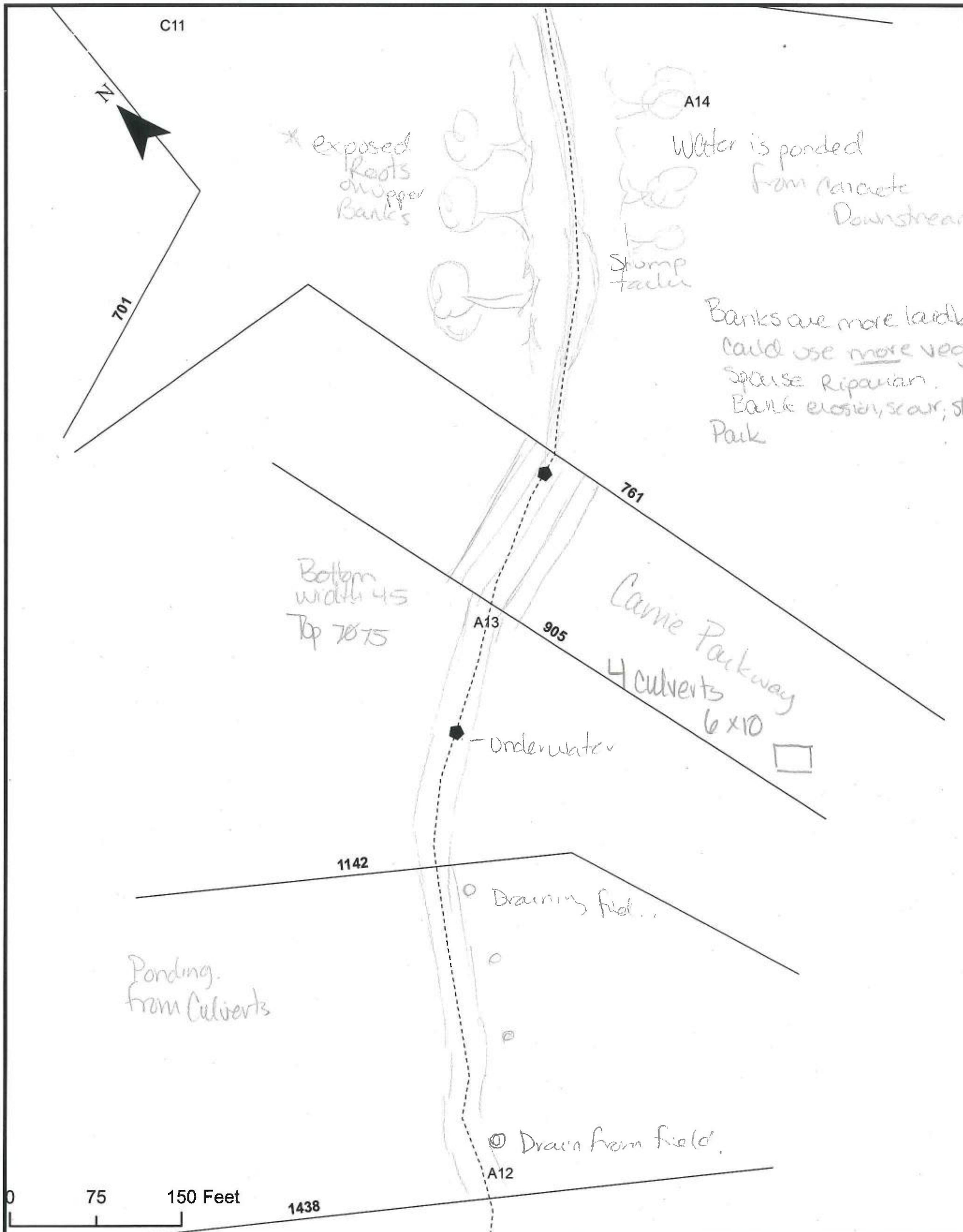
▲ Outfall
● WW
■ Pipeline
—— XS
⬟ Water
------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A12
DATE 7-20-11	
STREAM Cottonwood	FIGURE
TEAM SYC, DKC	



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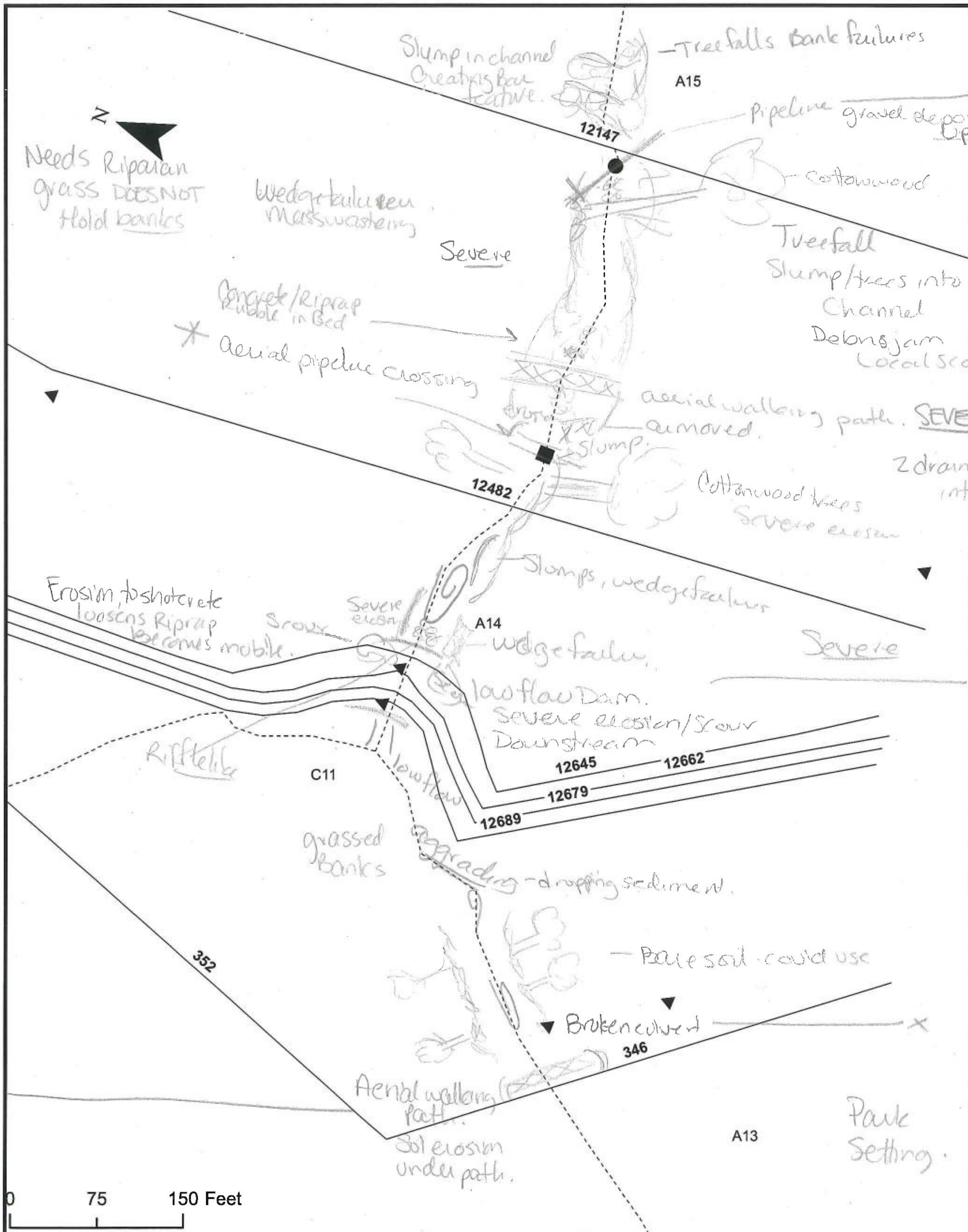
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A13
DATE 7-20-11	
STREAM Cottonwood	FIGURE
TEAM [illegible] , DKC	



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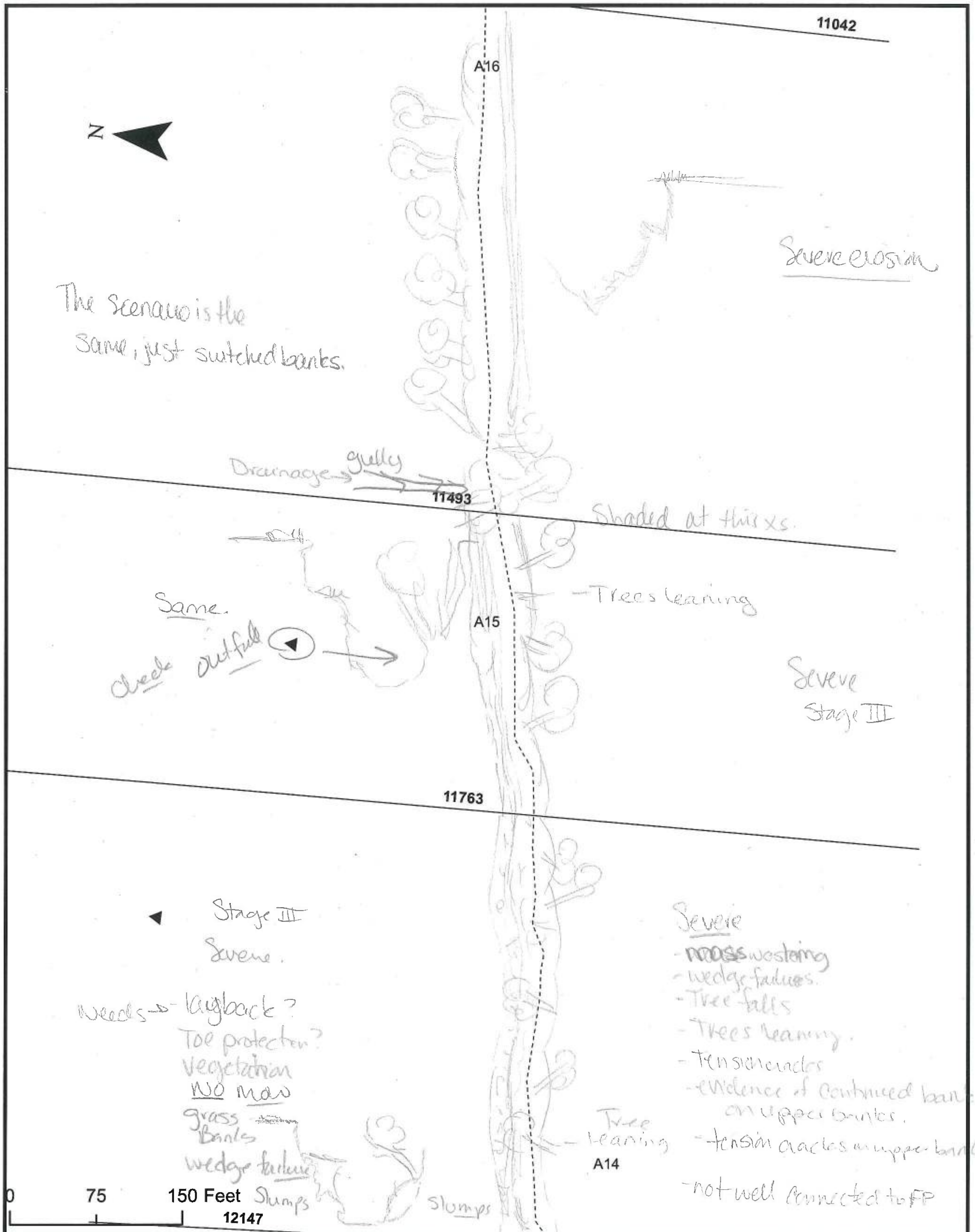

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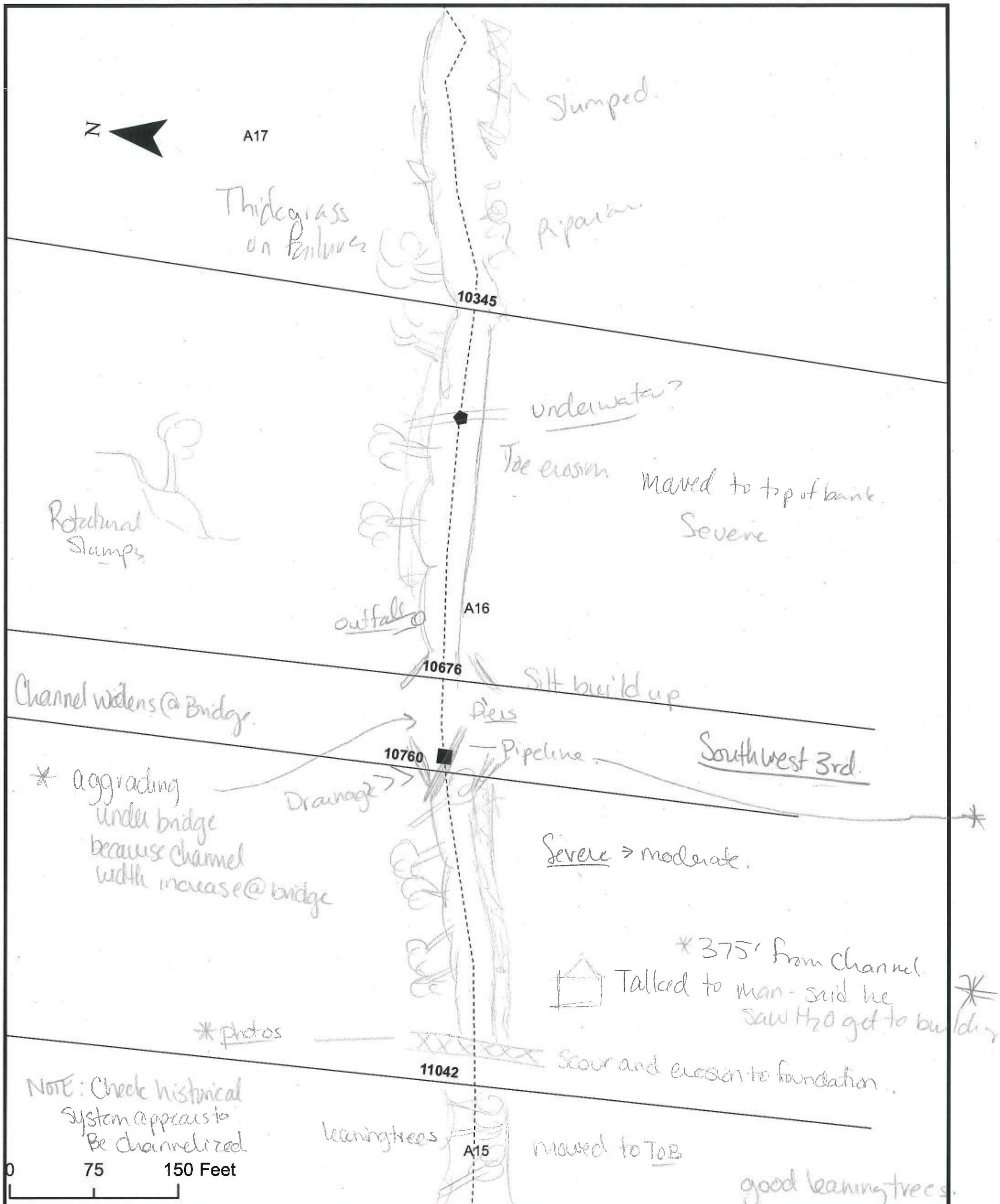
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-21-11
STREAM	Cottonwood
TEAM	SK DKC

A15
FIGURE



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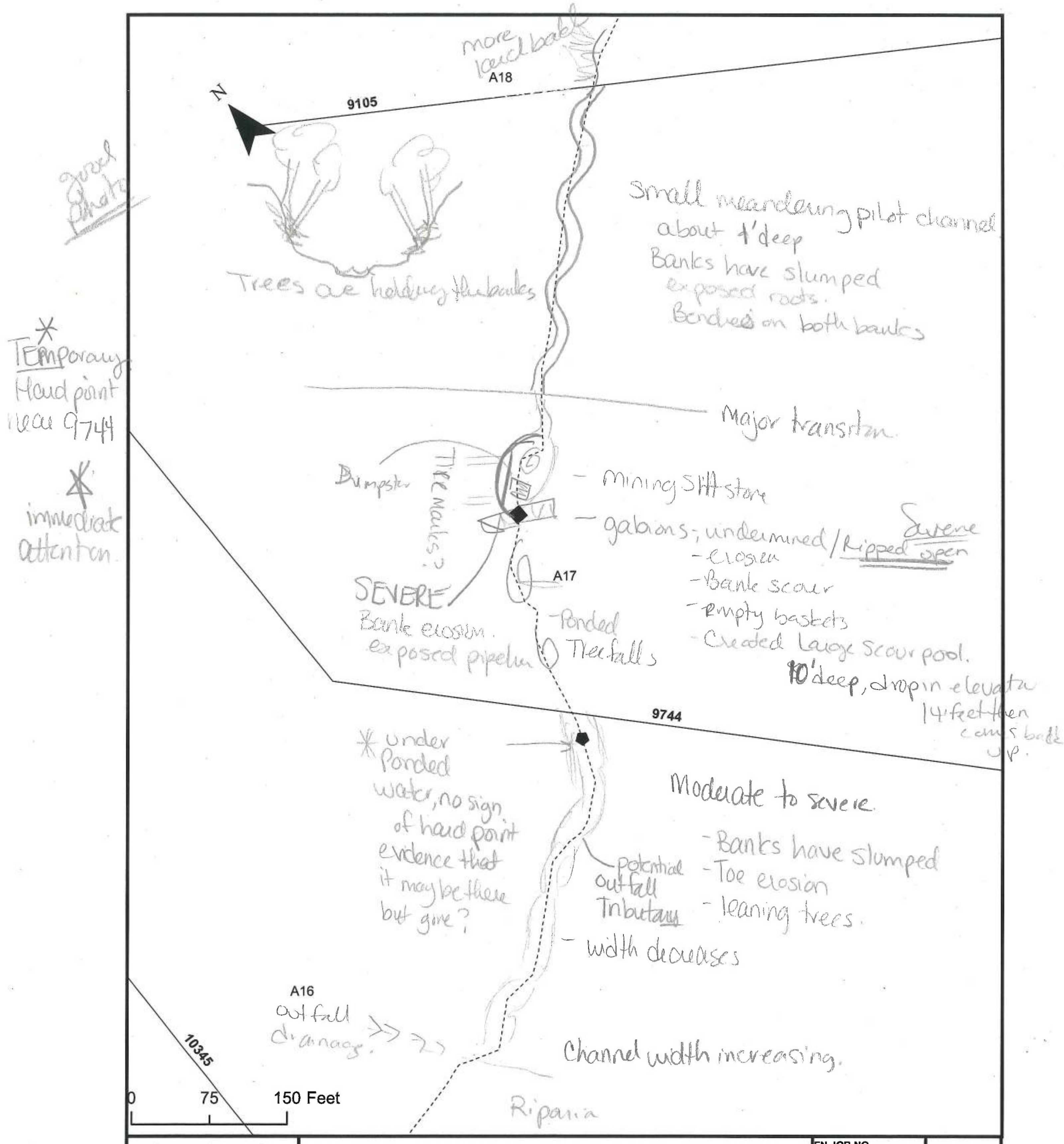
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227
DATE 7-21-11
STREAM Cottonwood
TEAM SIC DCC

A16
FIGURE



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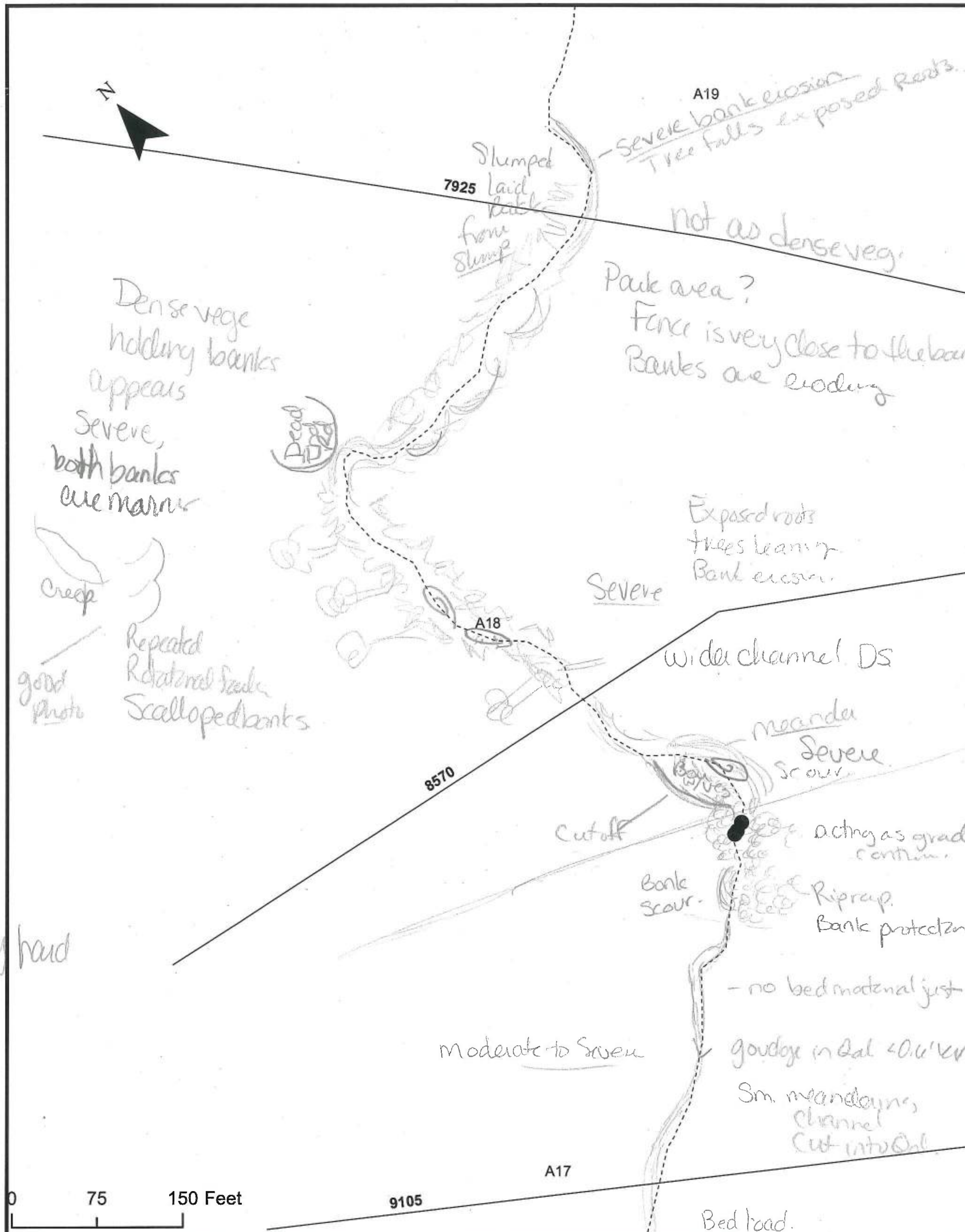
▲ Outfall ● WW
■ Pipeline ____ XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A17
DATE 7-21-11	
STREAM Cottonwood	FIGURE
TEAM SJC, DKC	



Temporary hand point Between 8570 & 9105

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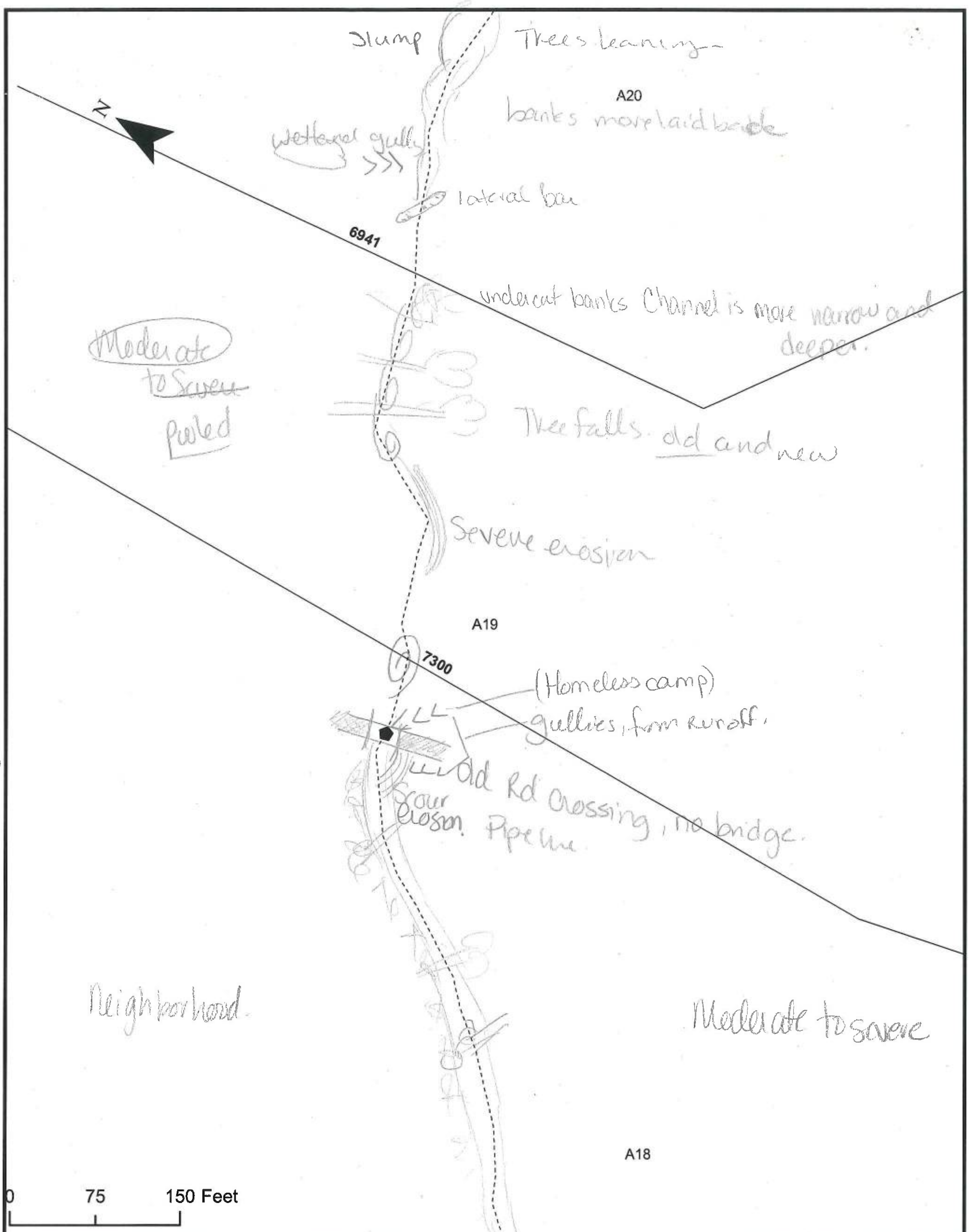
Hard point near 7300



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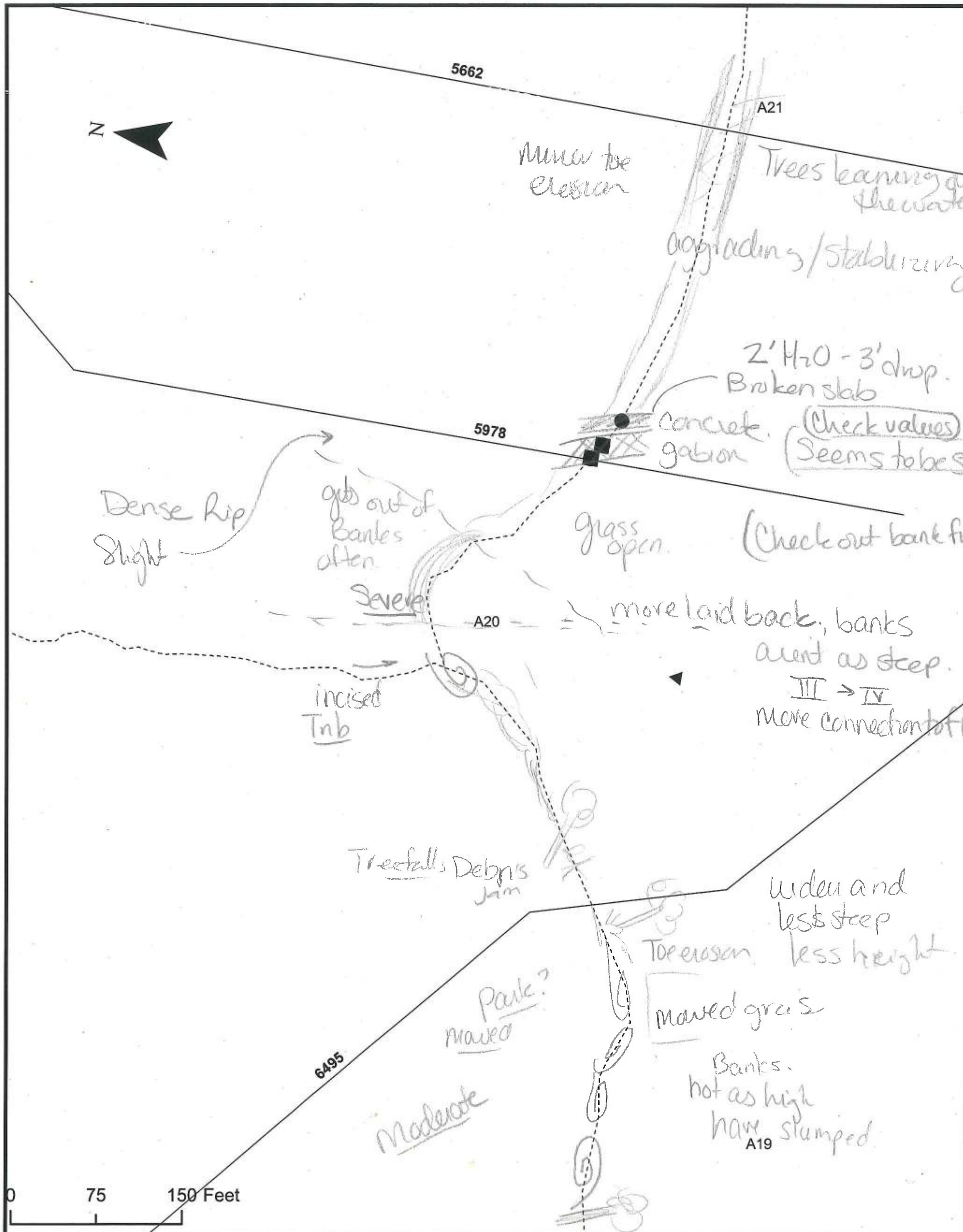
▲ Outfall ● WW
■ Pipeline ___ XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A19
DATE 7/21/14	
STREAM Cottonwood	FIGURE
TEAM SJC, DKC	

Hand point @ 5978



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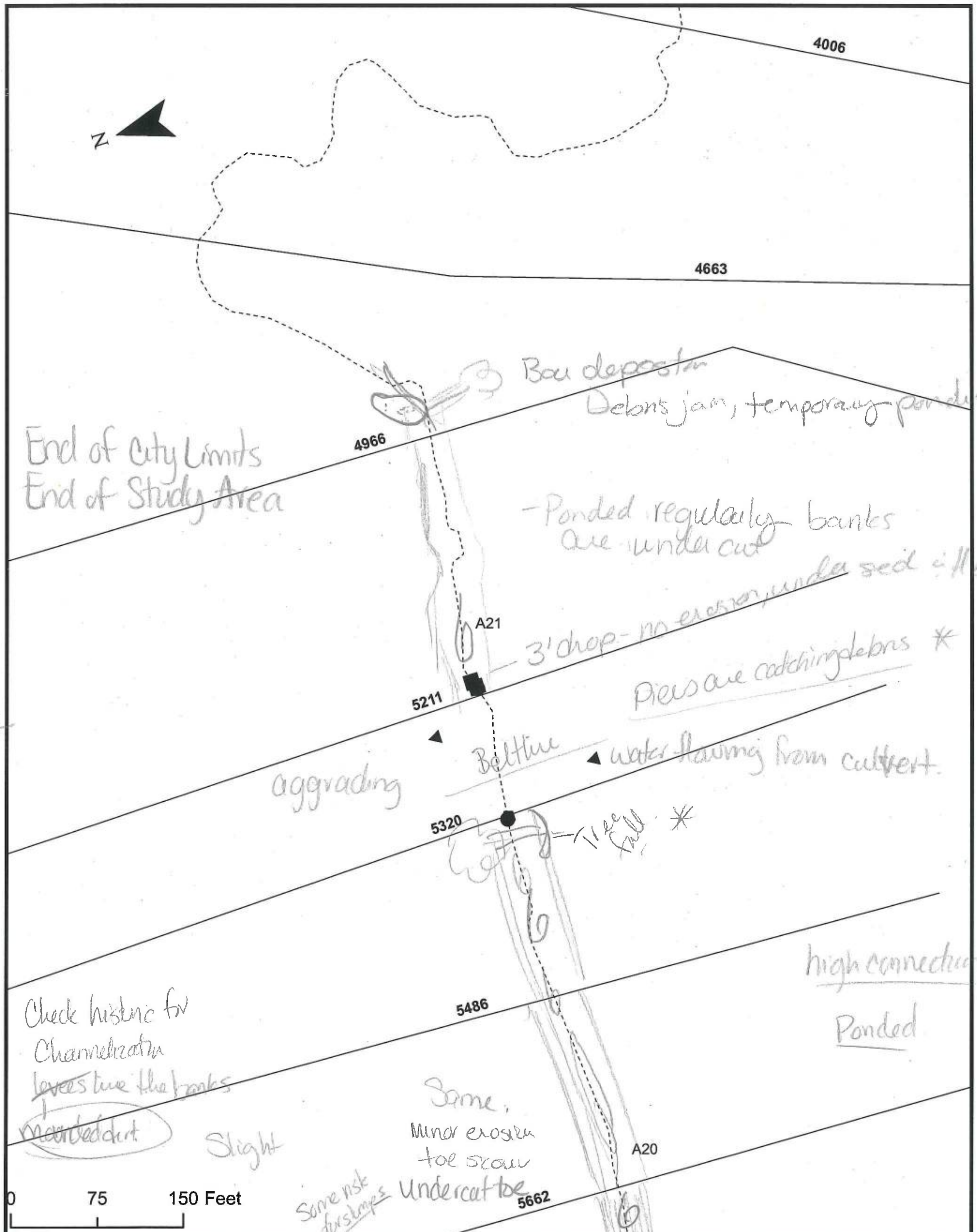
▲ Outfall	● WW		
■ Pipeline	——— XS		
⬟ Water	- - - - - Creek		

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A20
DATE 7/21/11	
STREAM Cottonwood	FIGURE
TEAM SVC, DKC	

Hardpoint @ 5211 Run analysis Starting here!



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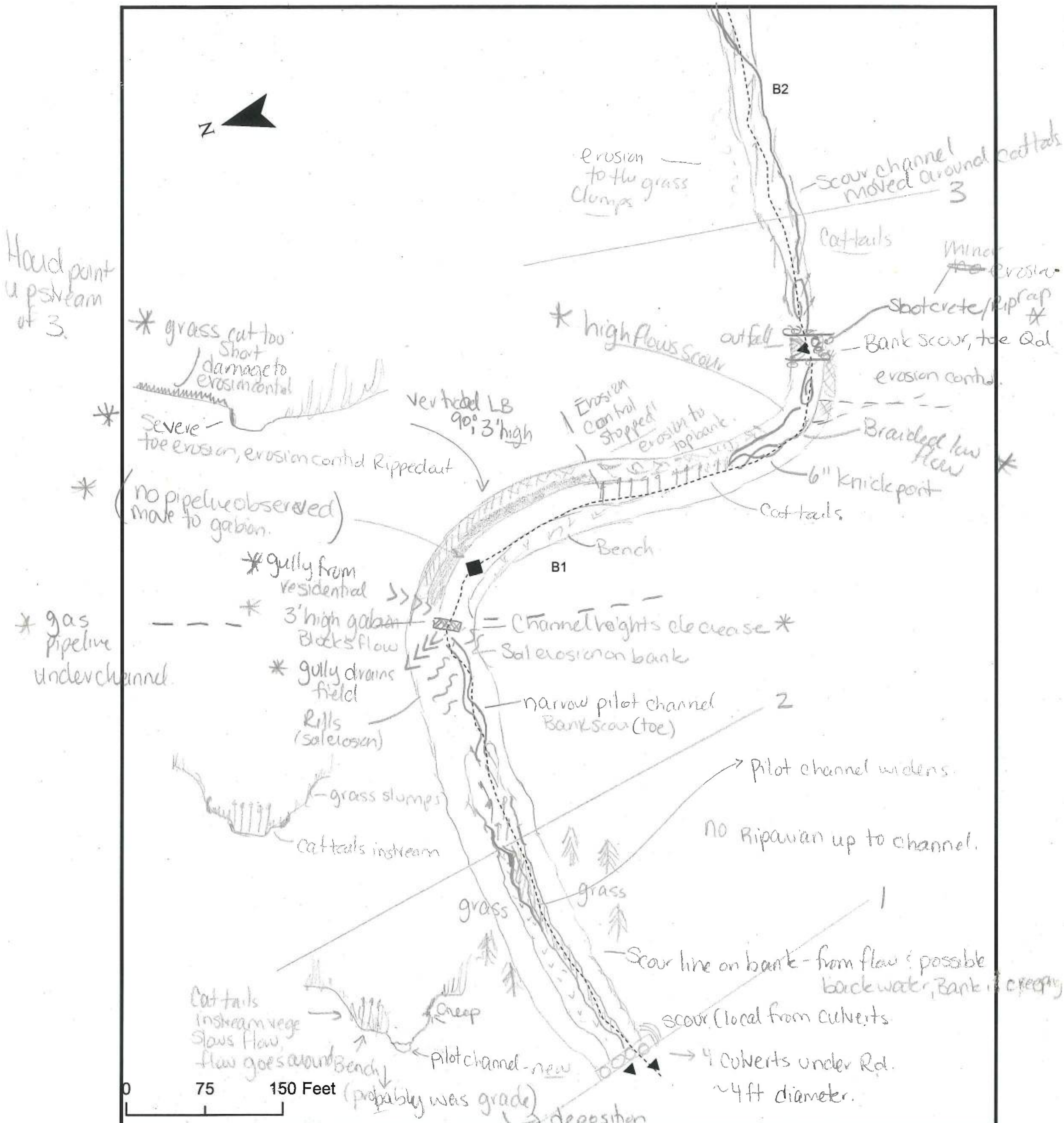
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	A21
DATE 7/21/11	
STREAM Cottonwood	FIGURE
TEAM SJC, DKC	



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▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227

DATE 7-25-11

STREAM Warrior

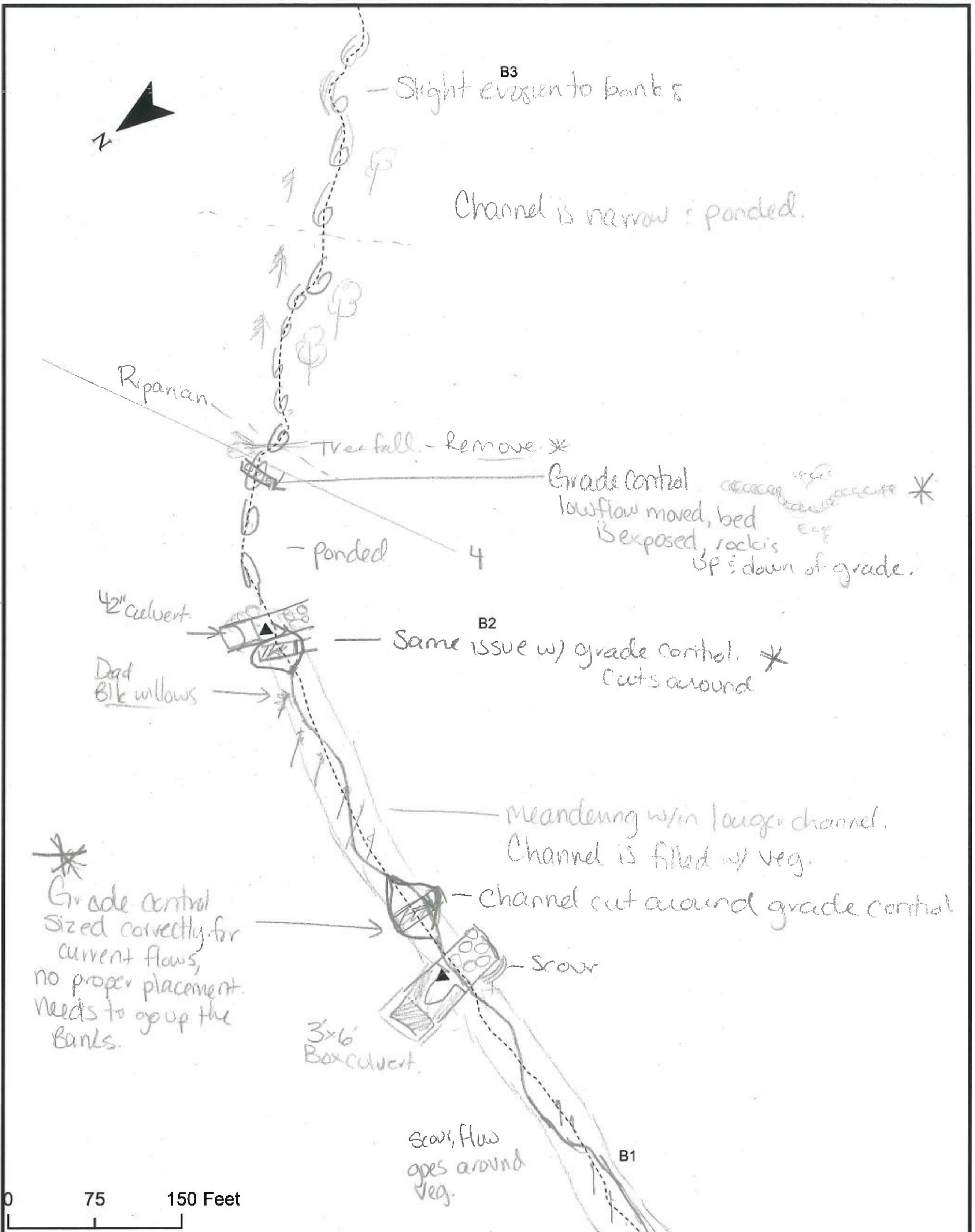
TEAM SVC, DKC

B1

FIGURE

hard point upstream of 4

Hard point Between 4 : 3



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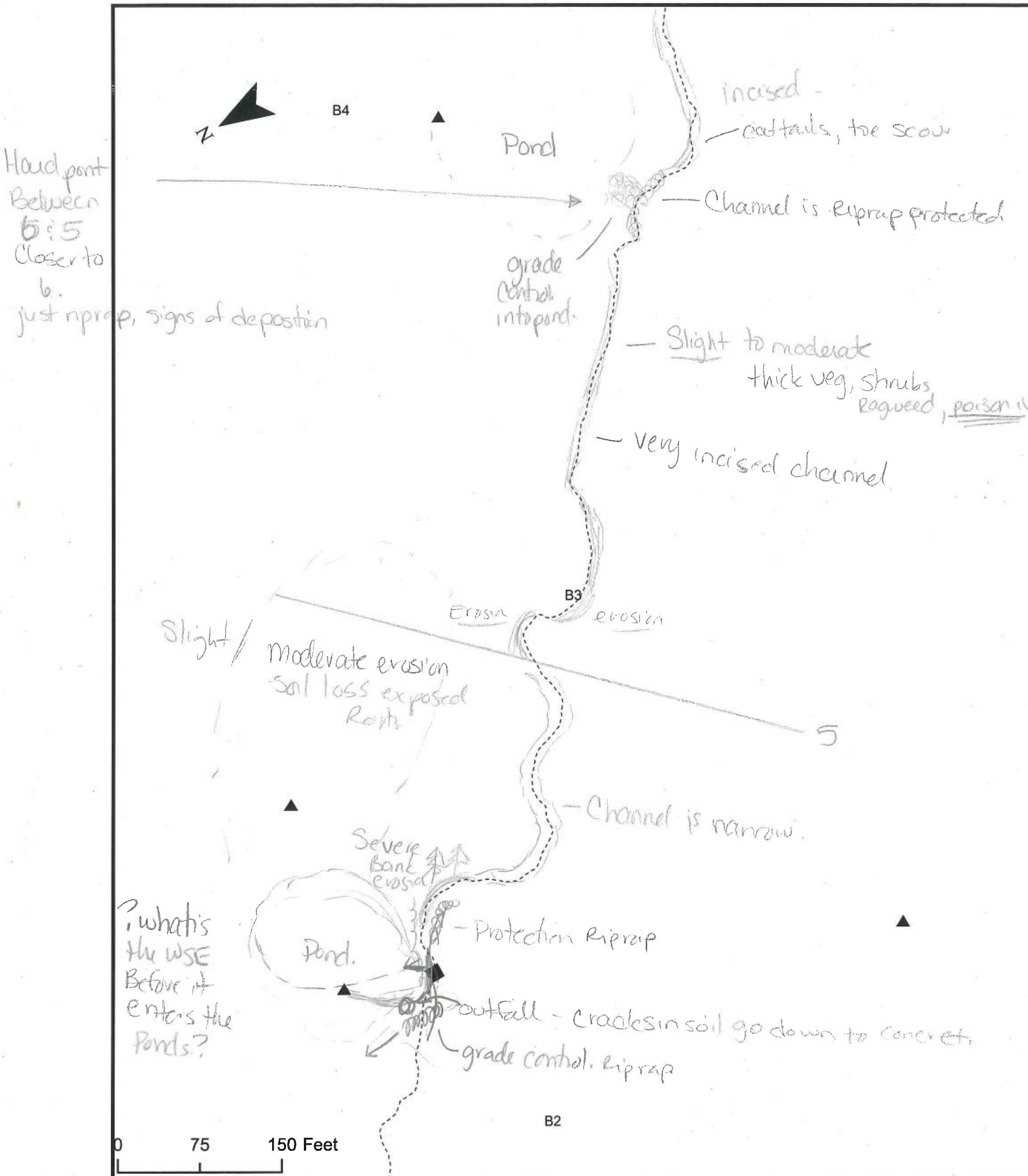
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/25/11
STREAM	Warrior Ck
TEAM	SVC, DKC

B2

FIGURE



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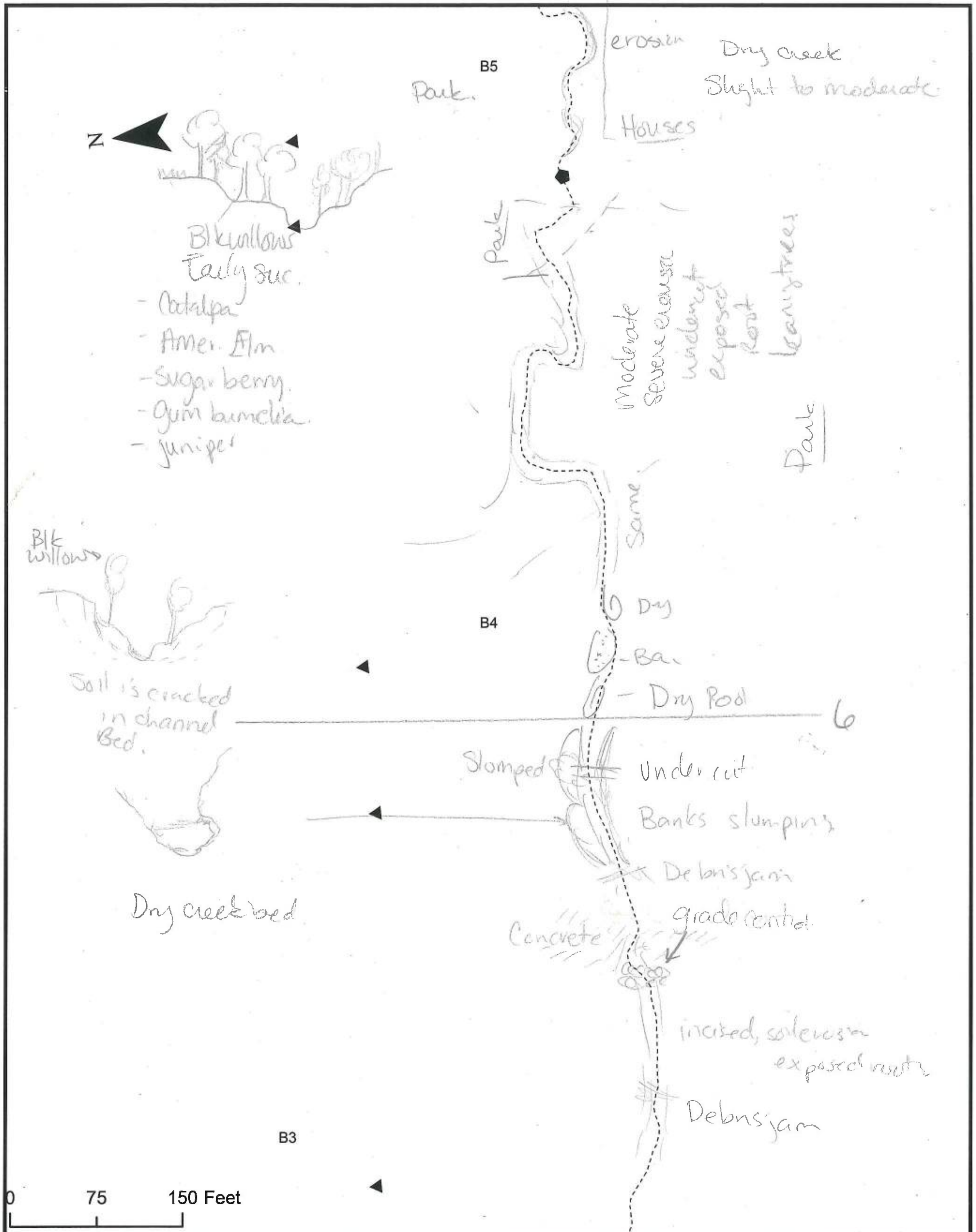
▲ Outfall	● WW
■ Pipeline	——— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/25/11
STREAM	Warner Crk
TEAM	SJC, DKC

B3

FIGURE



* hard Point d/s of 6.

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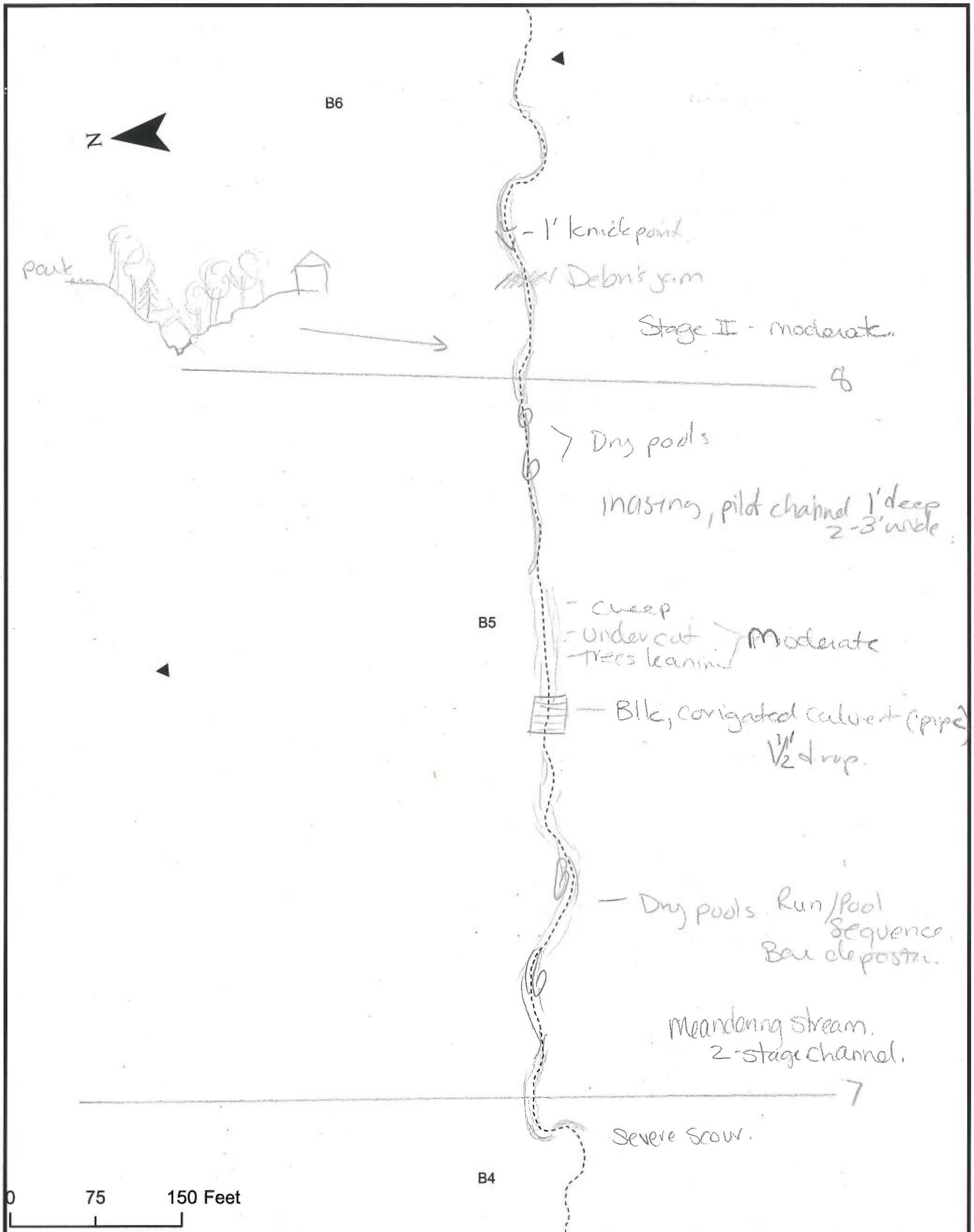
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	B4
DATE 7-25-11	
STREAM Warrior	FIGURE
TEAM SC, DKC	



▲ Outfall ● WW

■ Pipeline ——— XS

⬟ Water - - - - - - Creek

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Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227

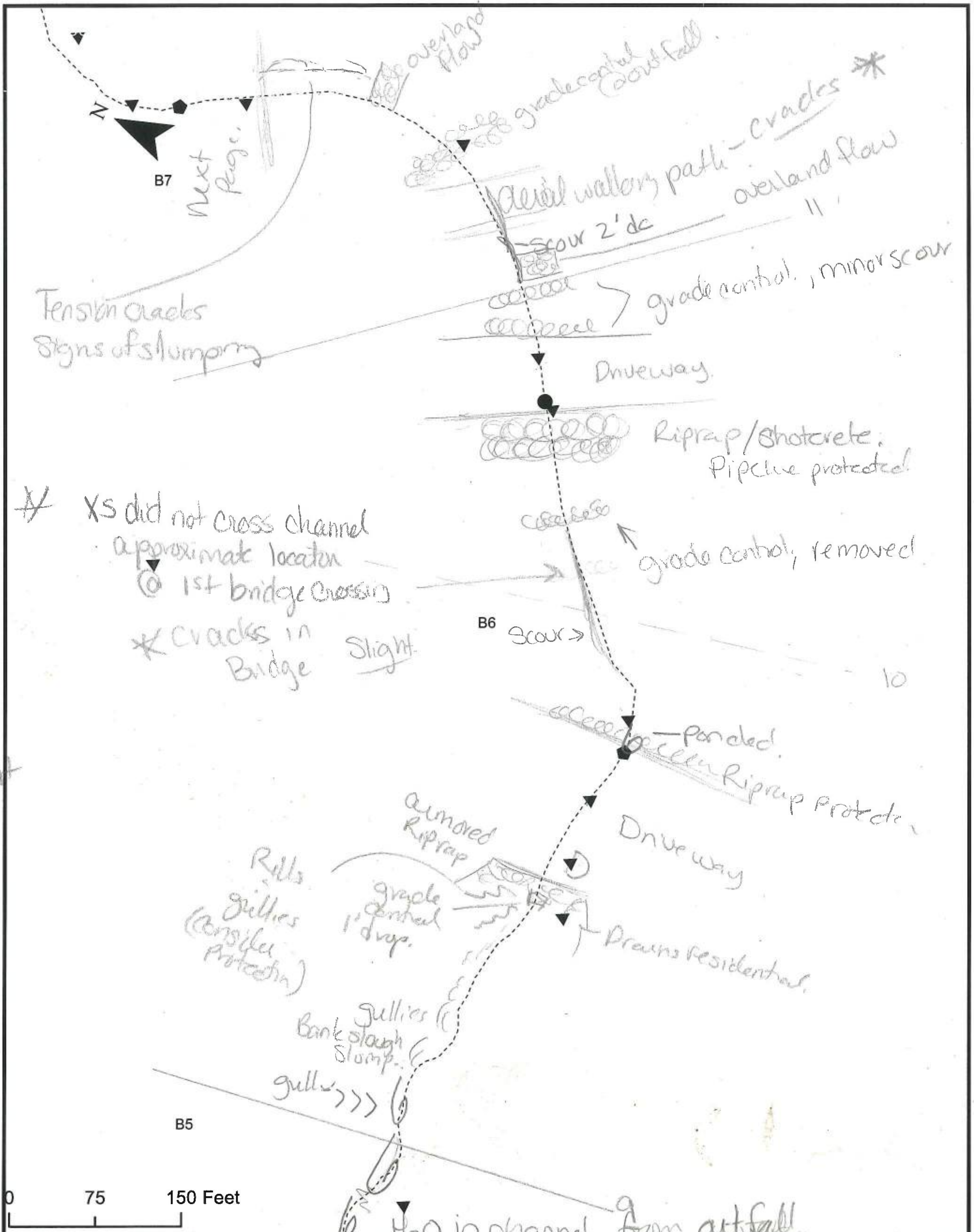
DATE 7/25/11

STREAM

TEAM

B5

FIGURE



Hardpoint
Between
10 & 9

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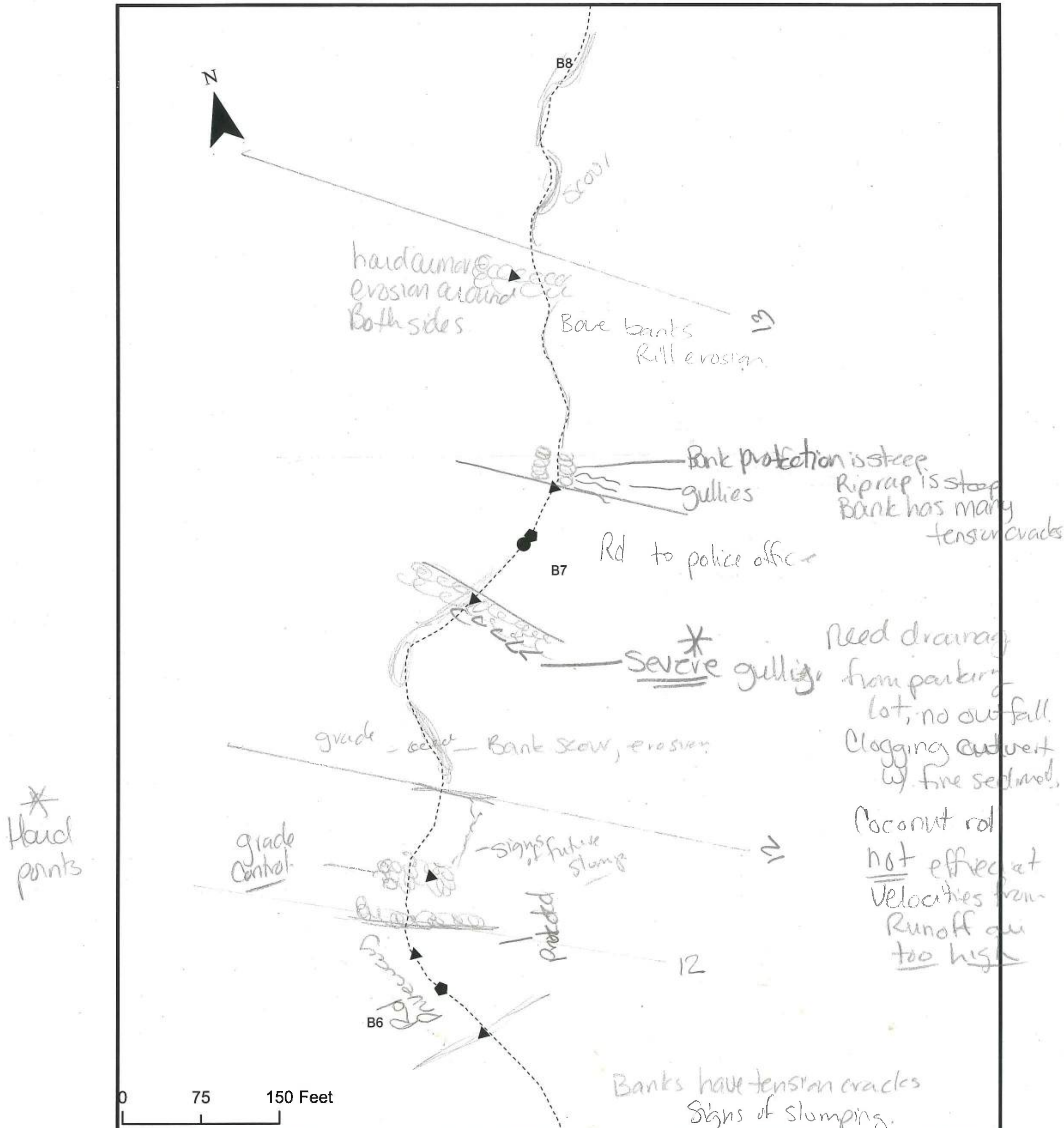

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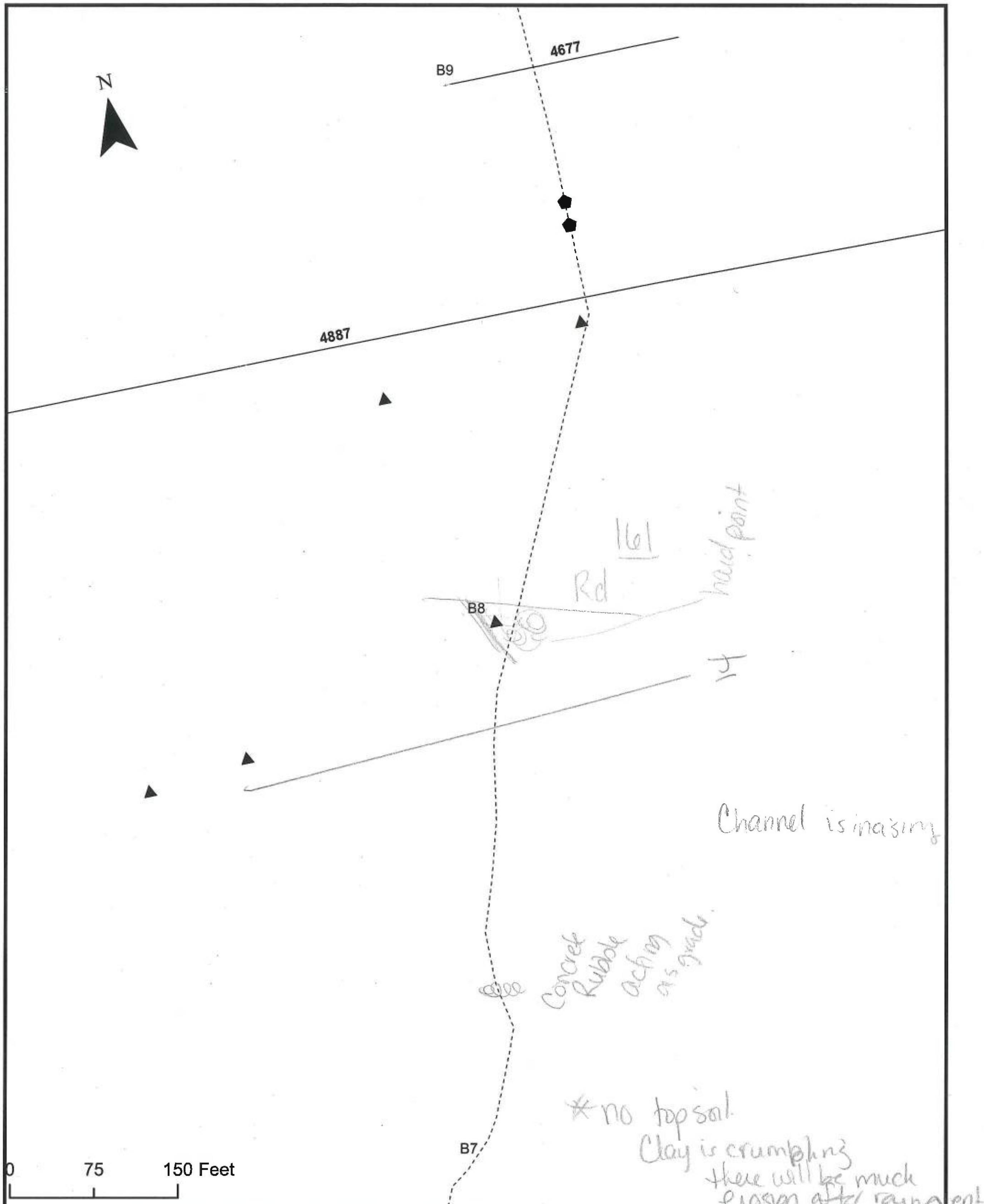
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-25-11
STREAM	Warrior
TEAM	[illegible]

B7

FIGURE



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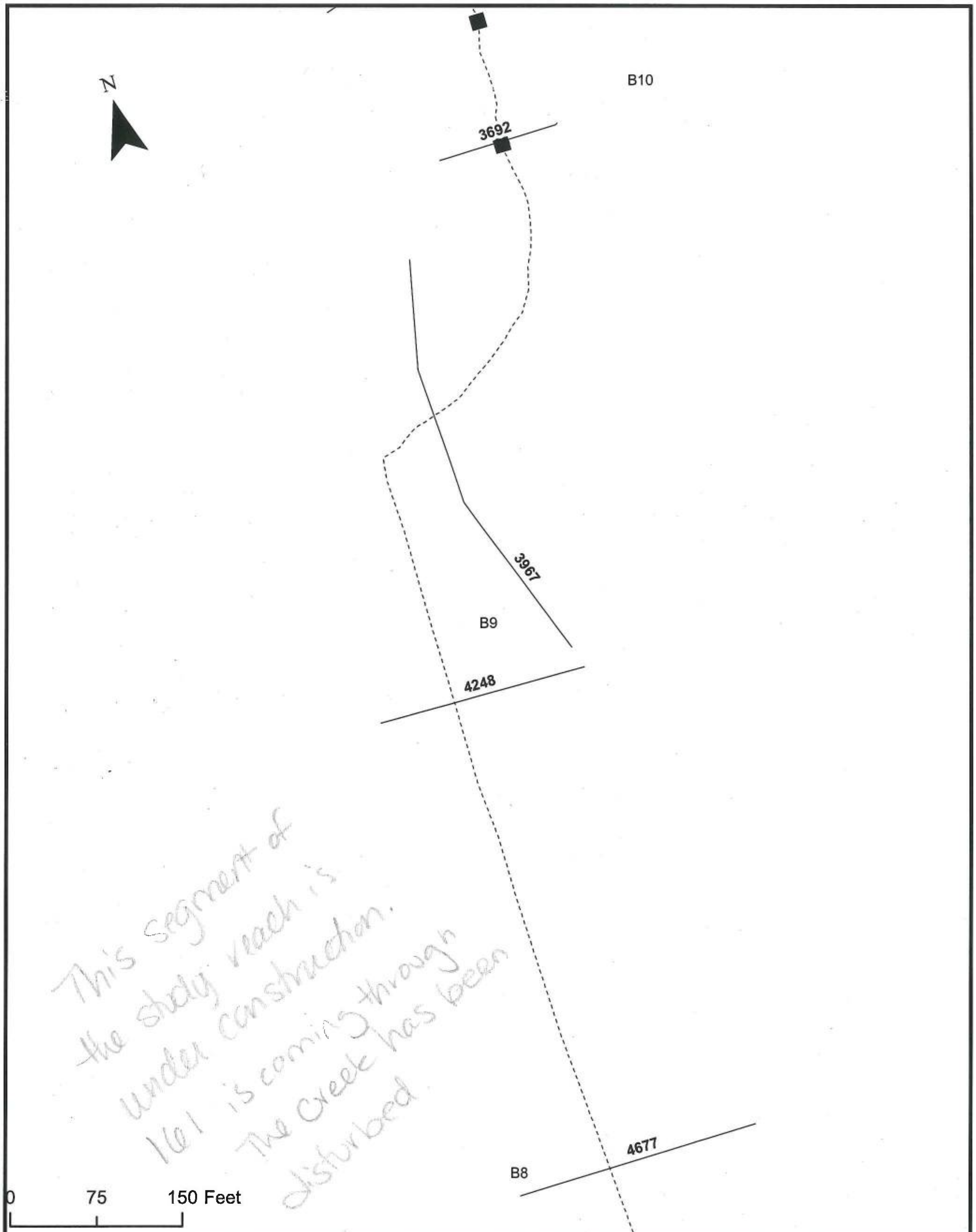
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	B8 FIGURE
DATE 7/25/11	
STREAM Warren	
TEAM	



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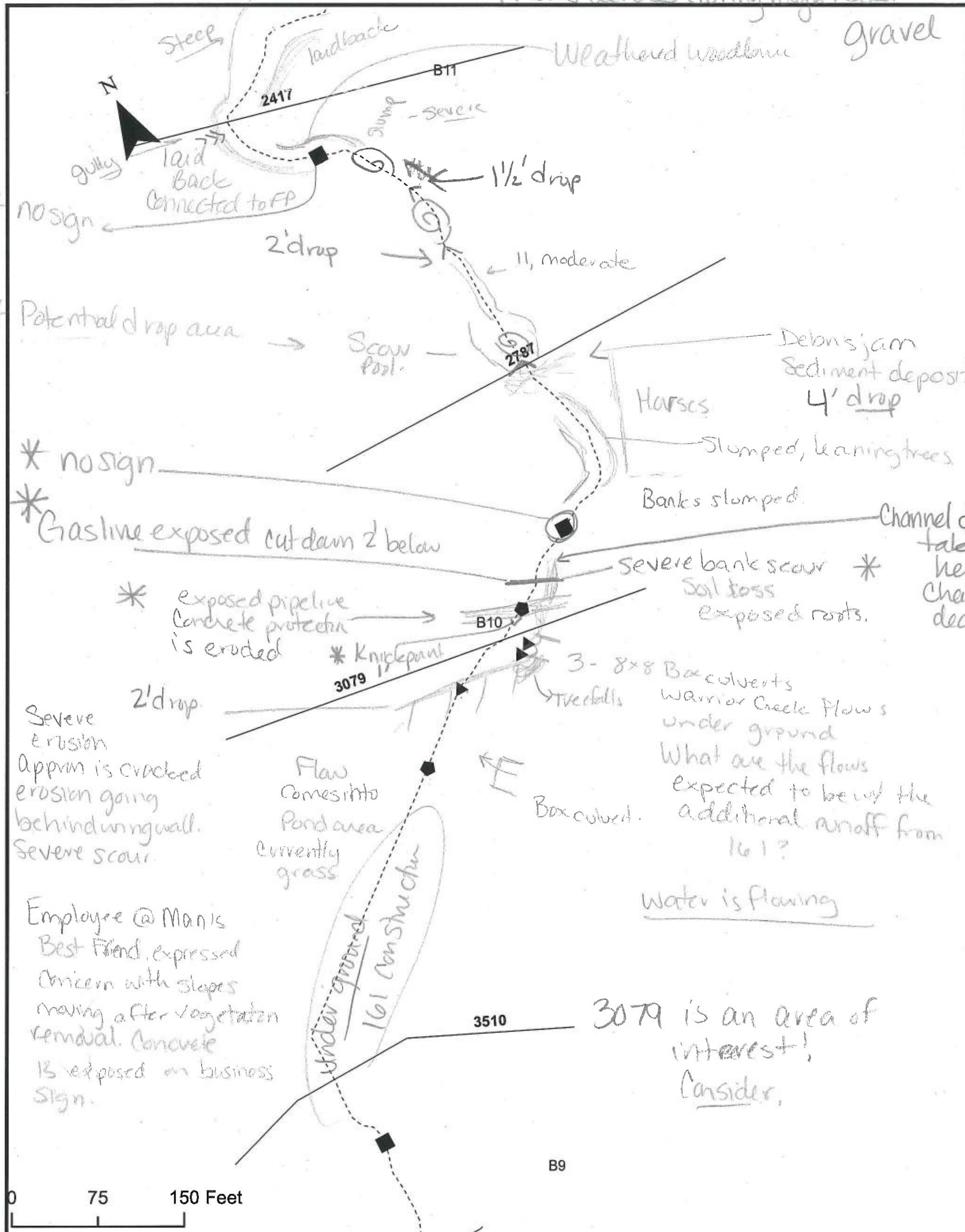
▲ Outfall ● WW
■ Pipeline ____ XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	B9
DATE 7-25-11	
STREAM	FIGURE
TEAM	

(Flows across during high flows.
gravel



Head Point 3079

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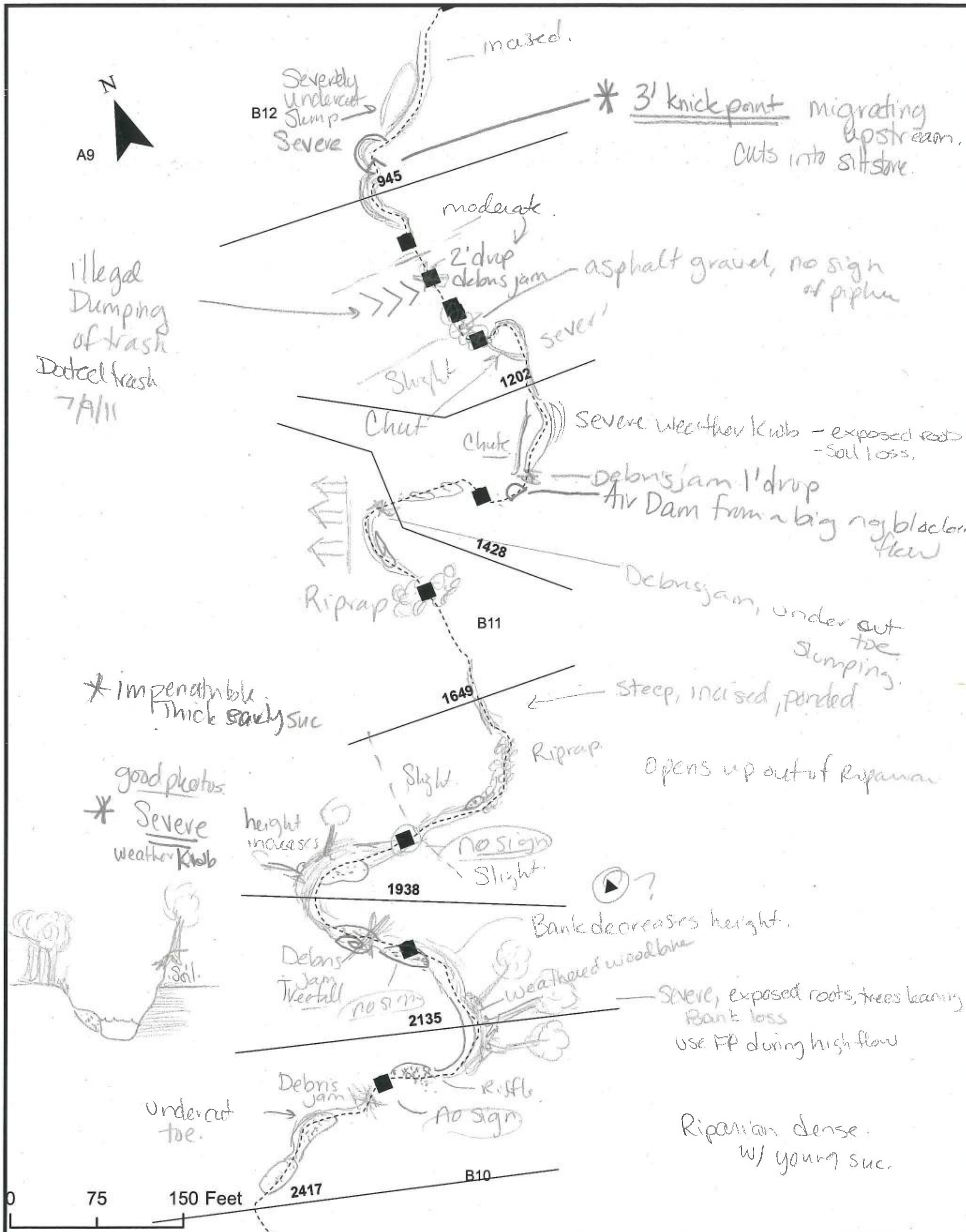
Legend	
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-27-11
STREAM	Warrior
TEAM	SYC, DKC

B10

FIGURE



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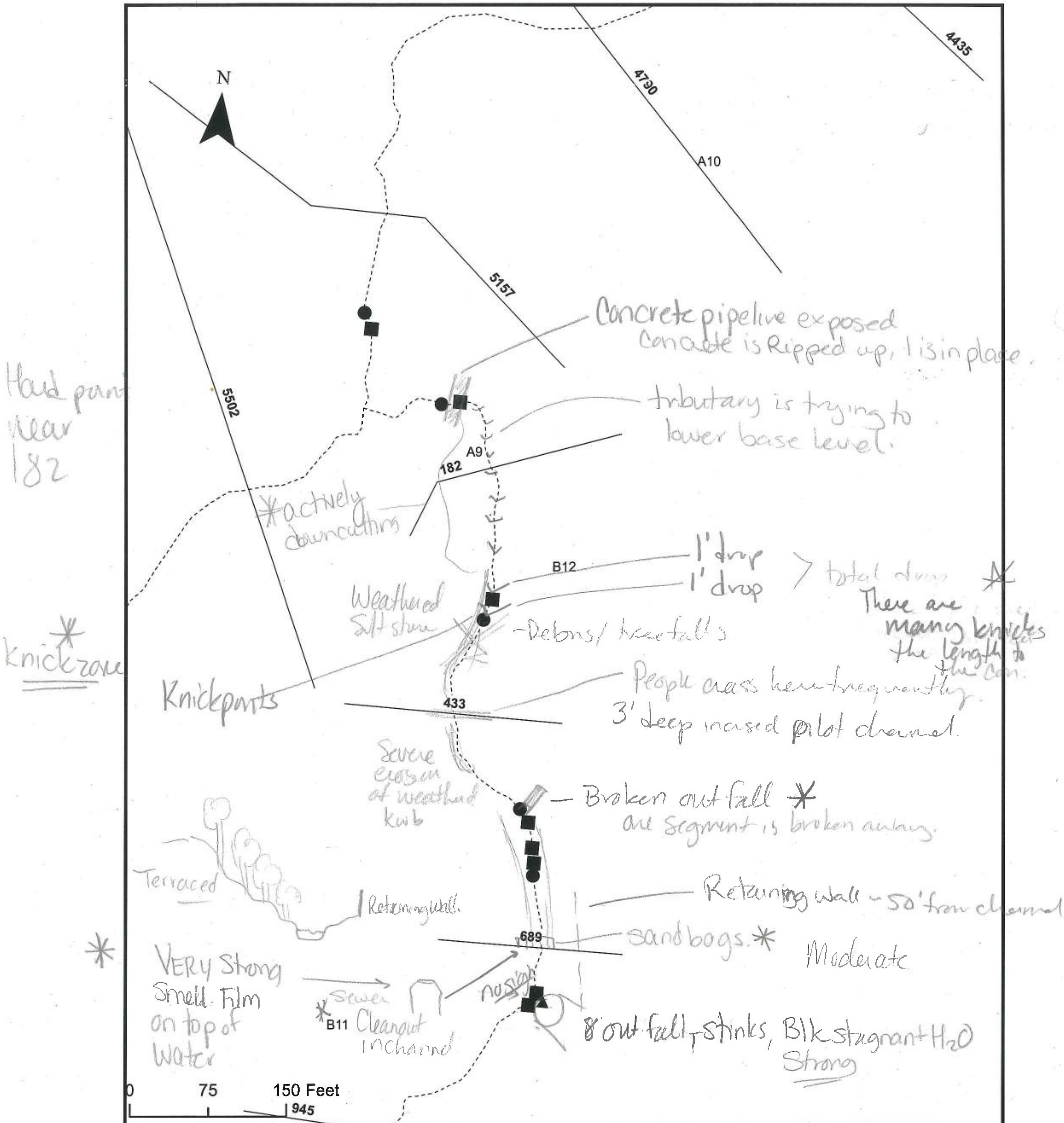
			B11 **FIGURE**



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Symbol	Legend
▲	Outfall
●	WW
■	Pipeline
——	XS
⬟	Water
- - - - -	Creek

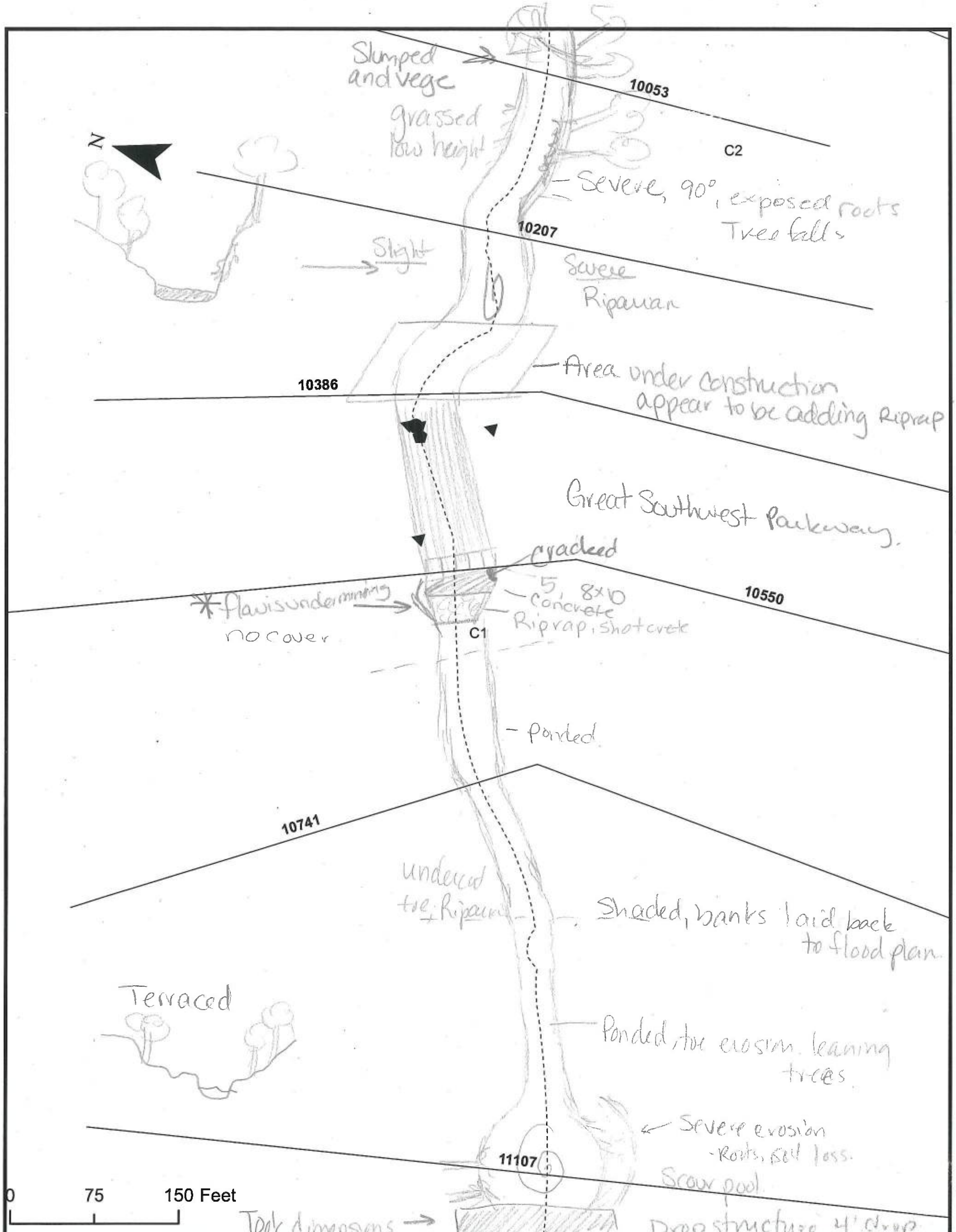
Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/27/11
STREAM	Warrior
TEAM	SVC, DKC

B12

FIGURE

Hardpoint 10386 to 10550



Hardpoint 11107

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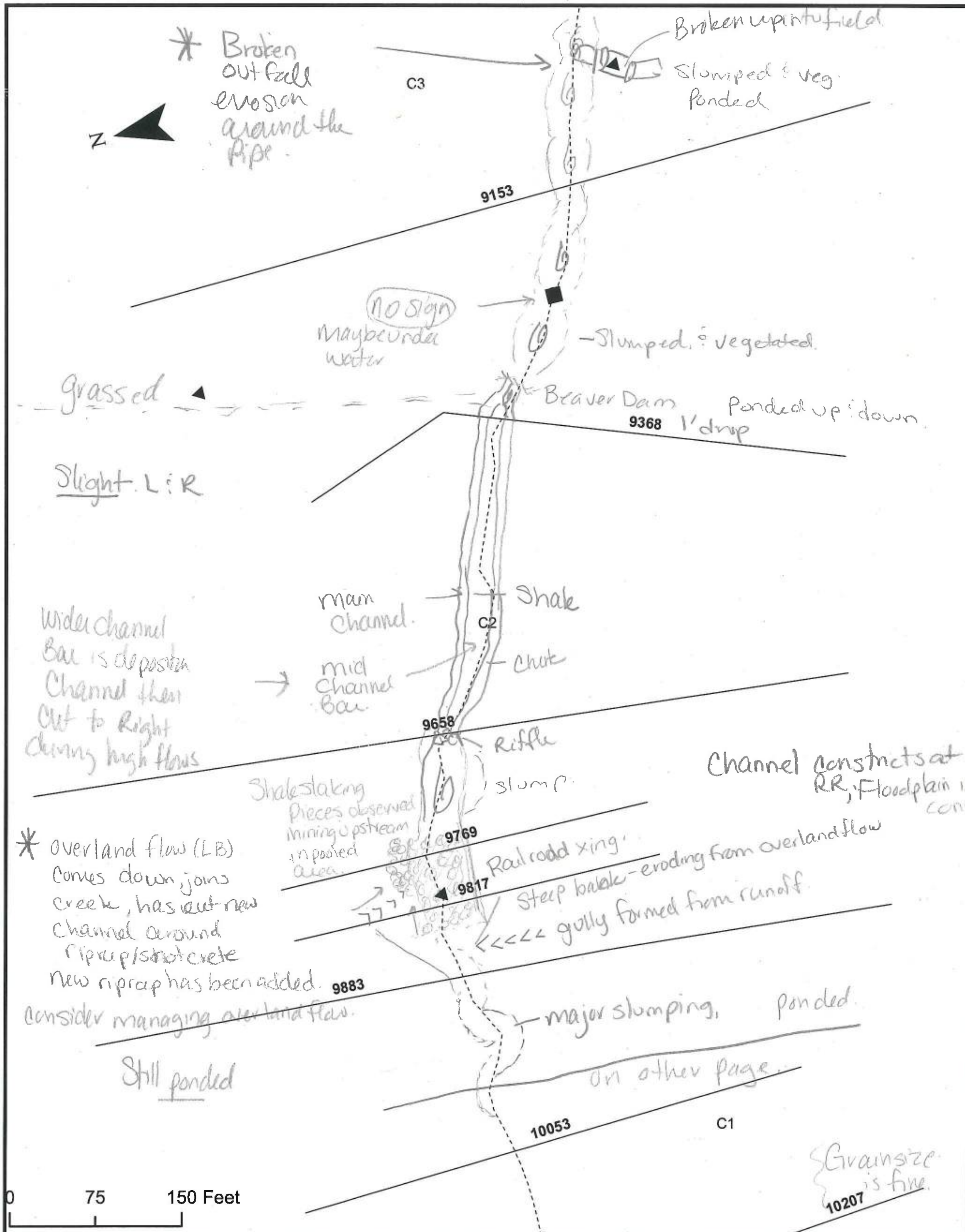

Haul point 9769 to 9817

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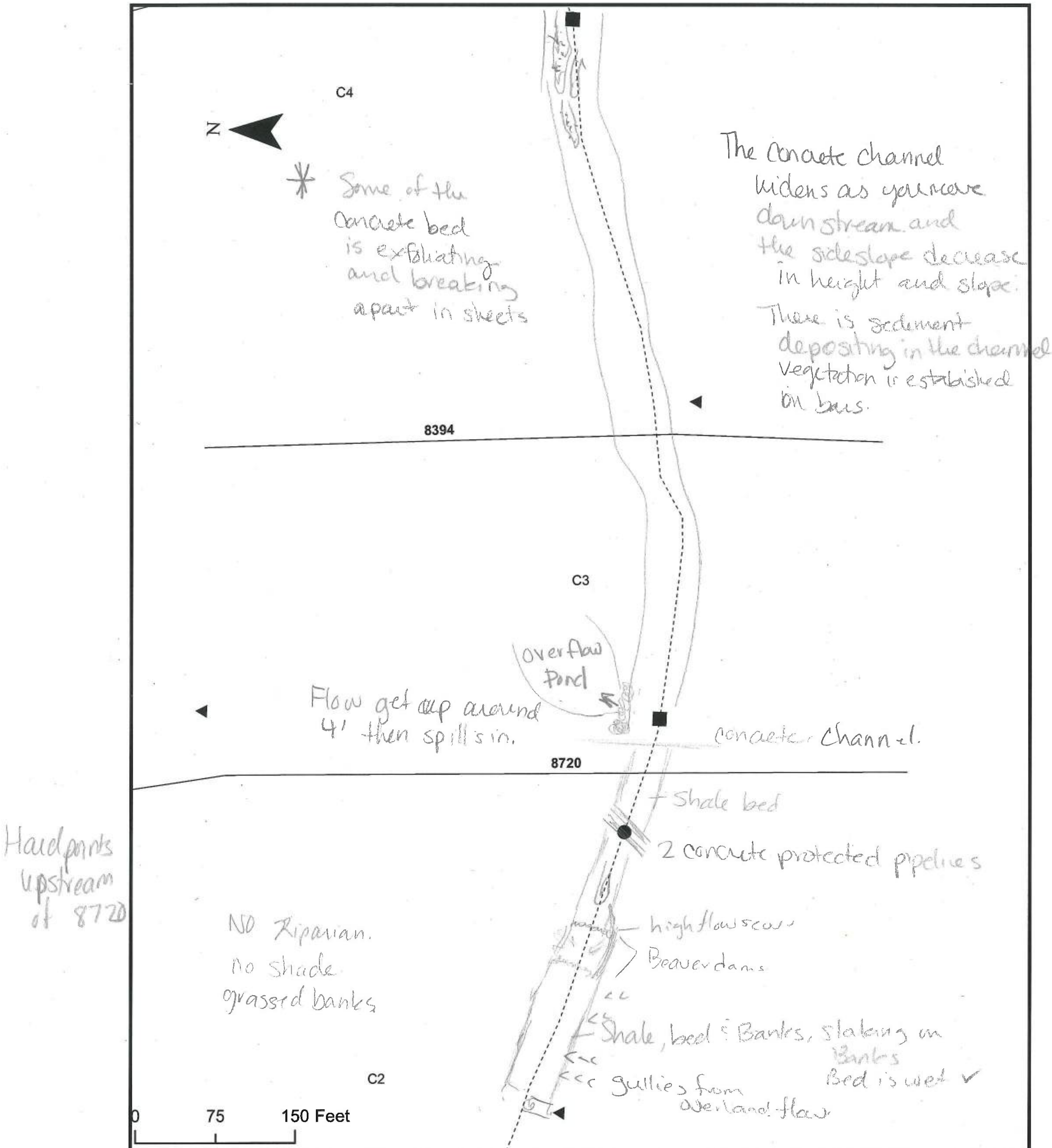
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C2
DATE 7-28-11	
STREAM N Fork of CW	FIGURE
TEAM SJC, DRC	



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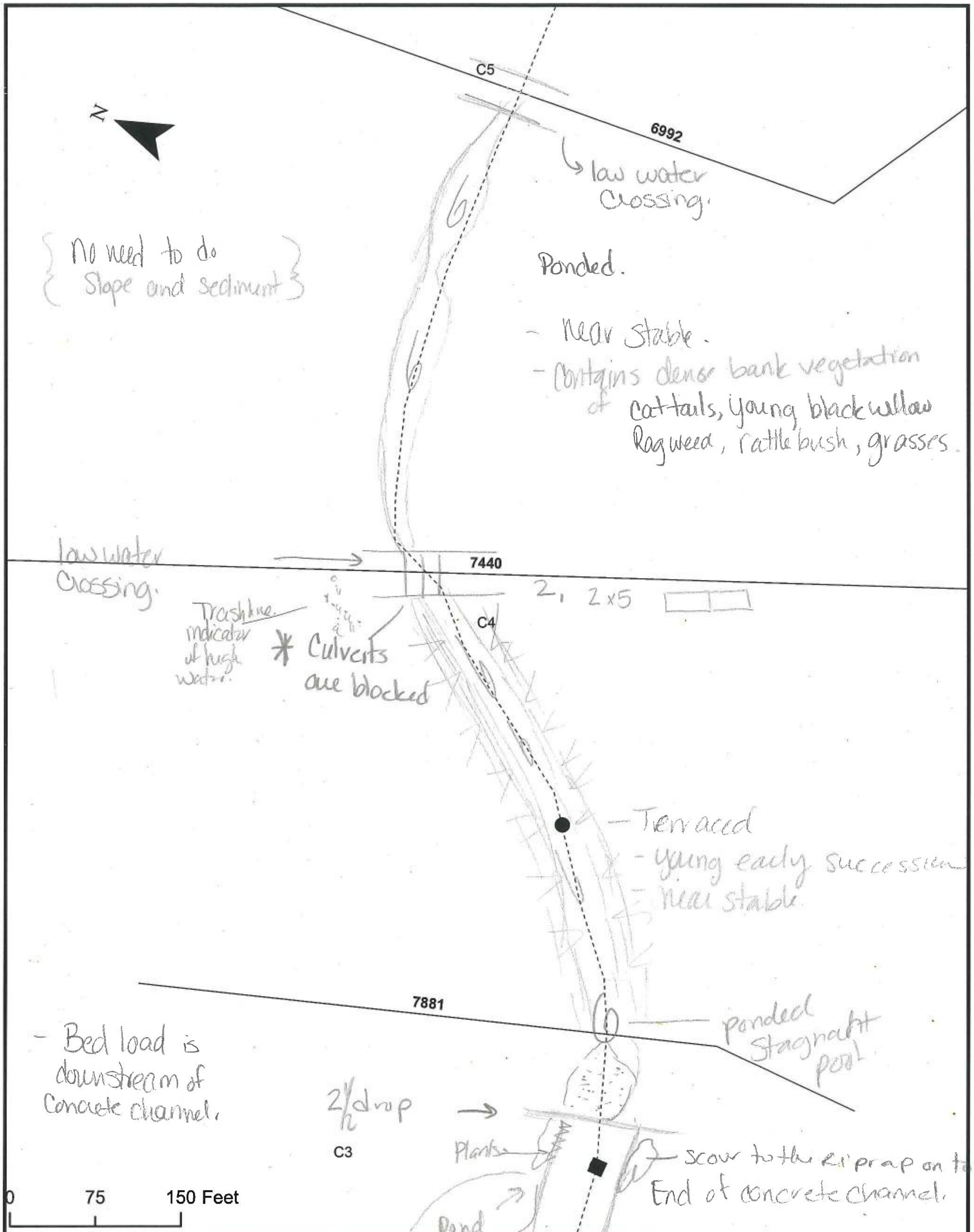
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C3
DATE 7-28-11	
STREAM N Fork Cottonwood	FIGURE
TEAM SLE DKC	

Hard Point @ 6992

Hard point @ 7440



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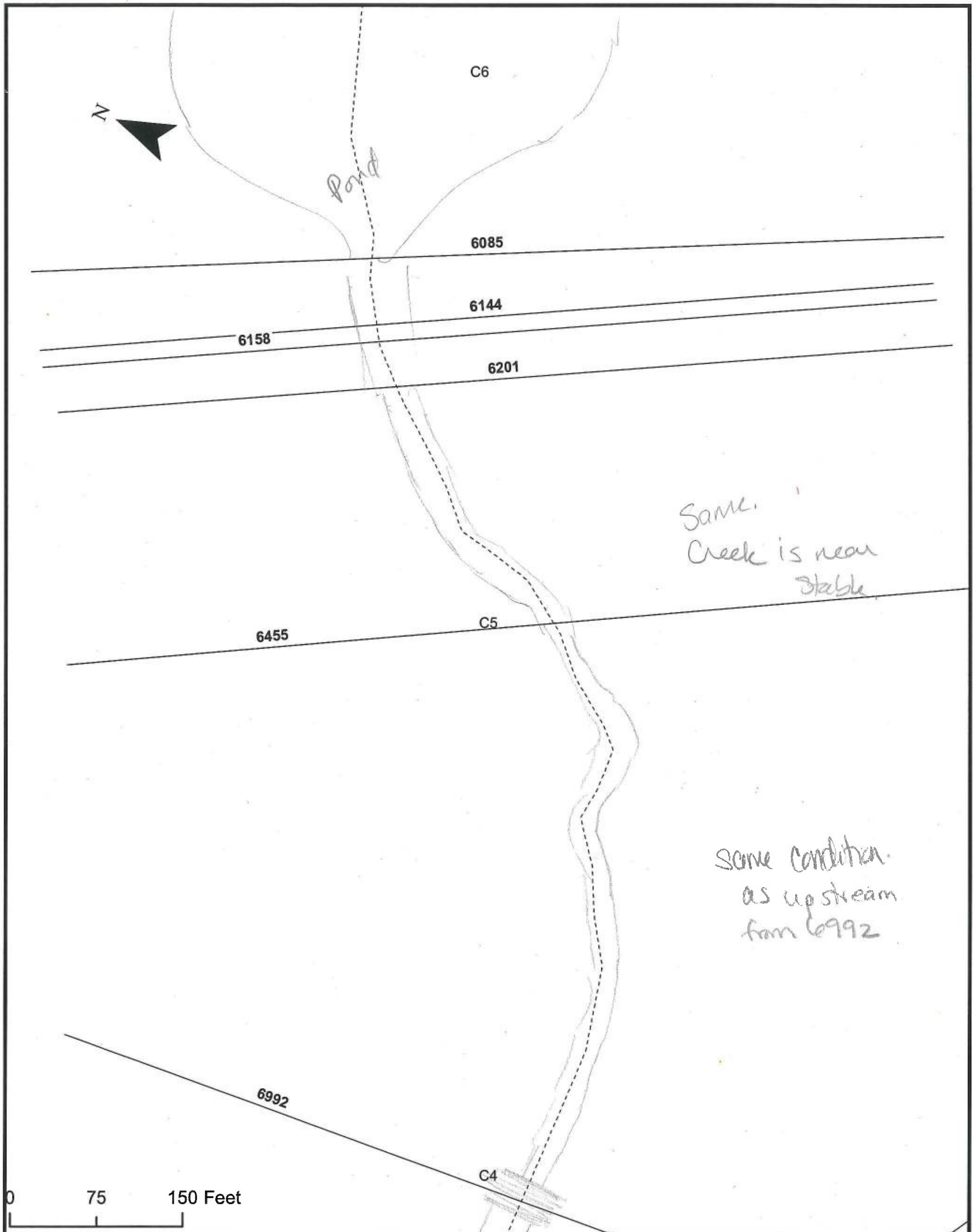
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C4
DATE 7/28/11	
STREAM N. Fork of Mc	FIGURE
TEAM SVC, DXC	



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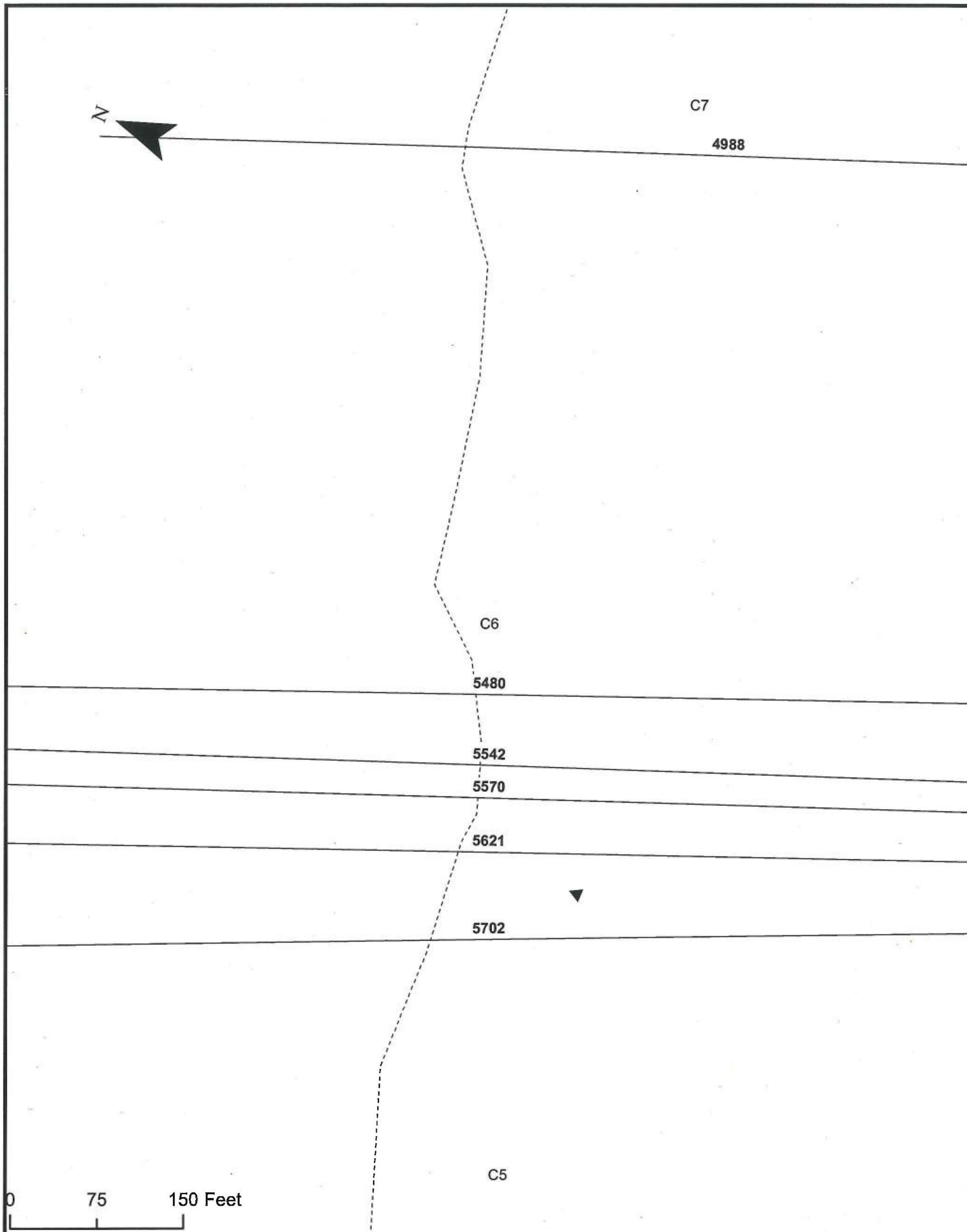
▲ Outfall ● WW
■ Pipeline ____ XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-28-11
STREAM	N. Fork CW
TEAM	SVC, DK

C5

FIGURE



Outfall
WW
Pipeline
XS
Water
Creek

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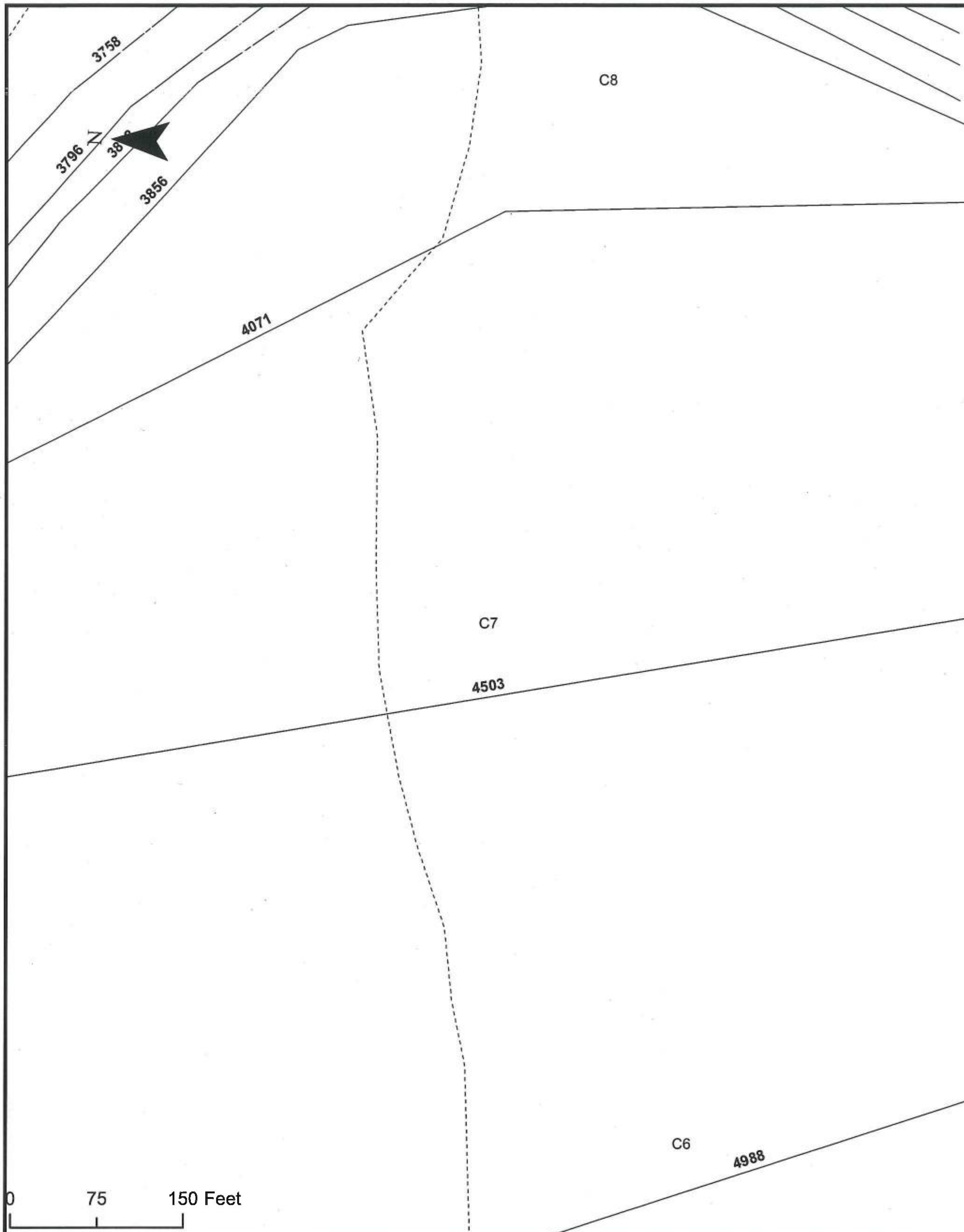
Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7-28-11
STREAM	
TEAM	

C6

FIGURE



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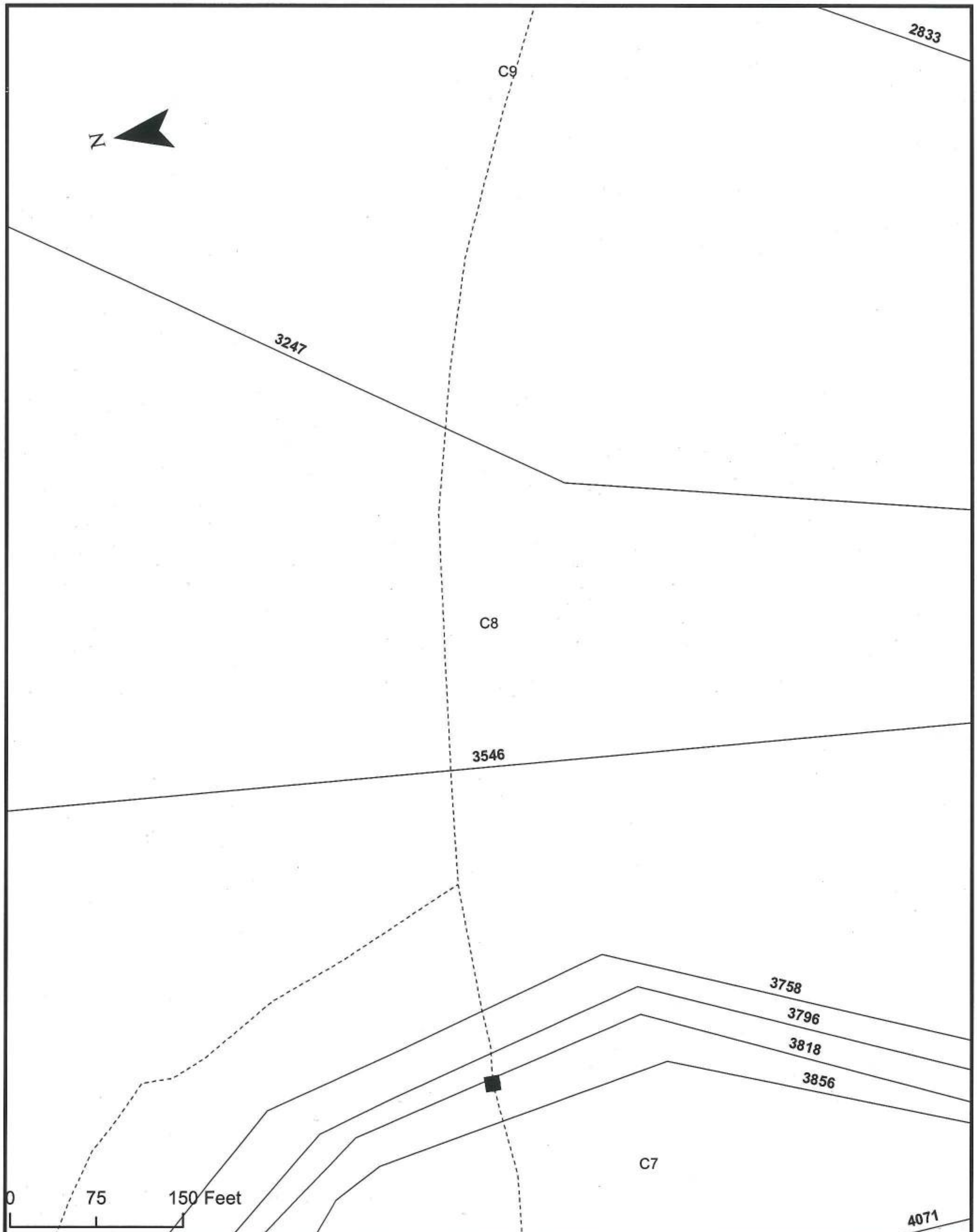
- Outfall
- WW
- Pipeline
- XS
- Water
- Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP.11227
DATE	7-28-11
STREAM	N. Fork
TEAM	SK, MCC

C7

FIGURE



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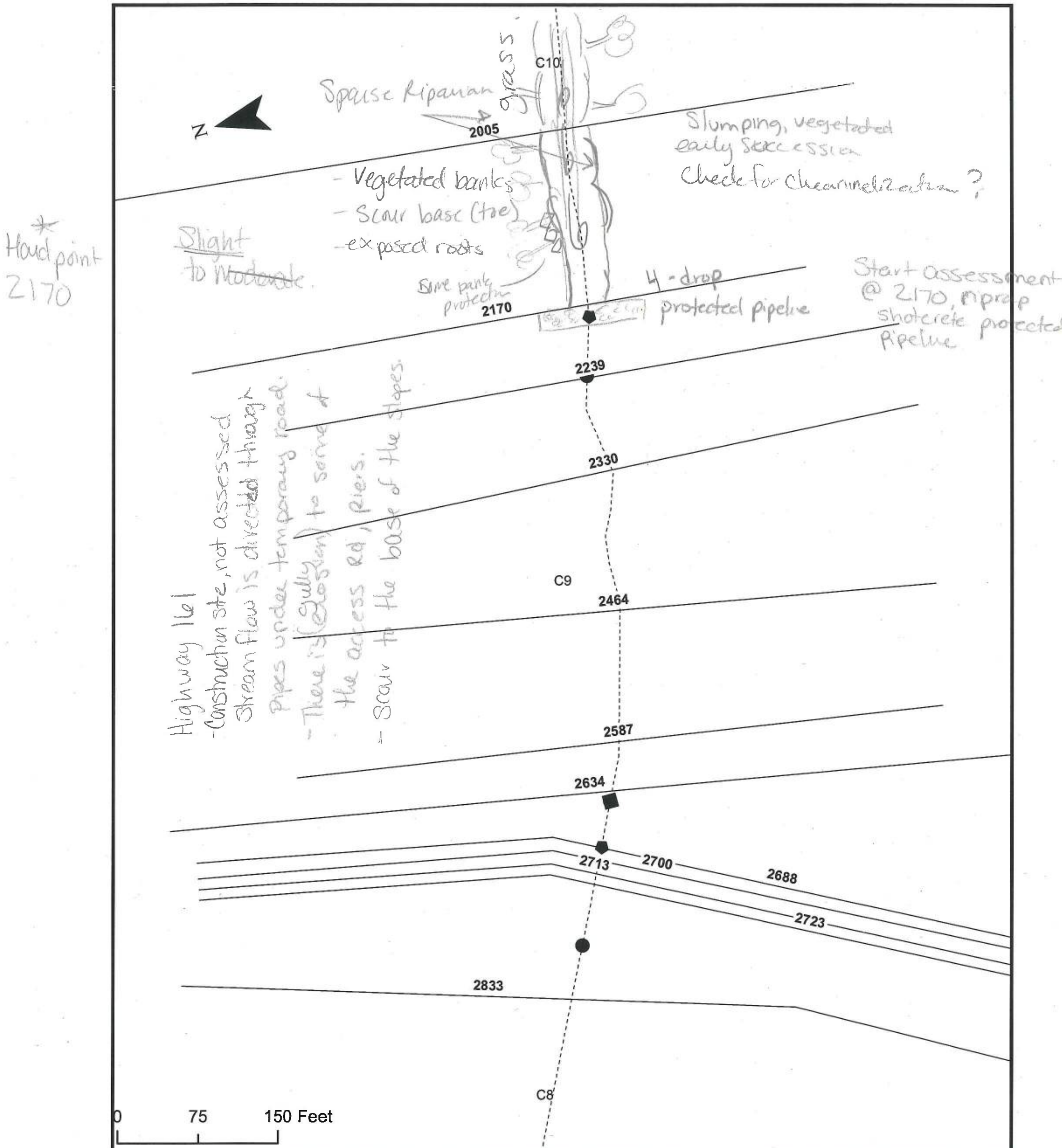
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C8
DATE 7-28-11	
STREAM N.Fork	FIGURE
TEAM SVC, DKC	



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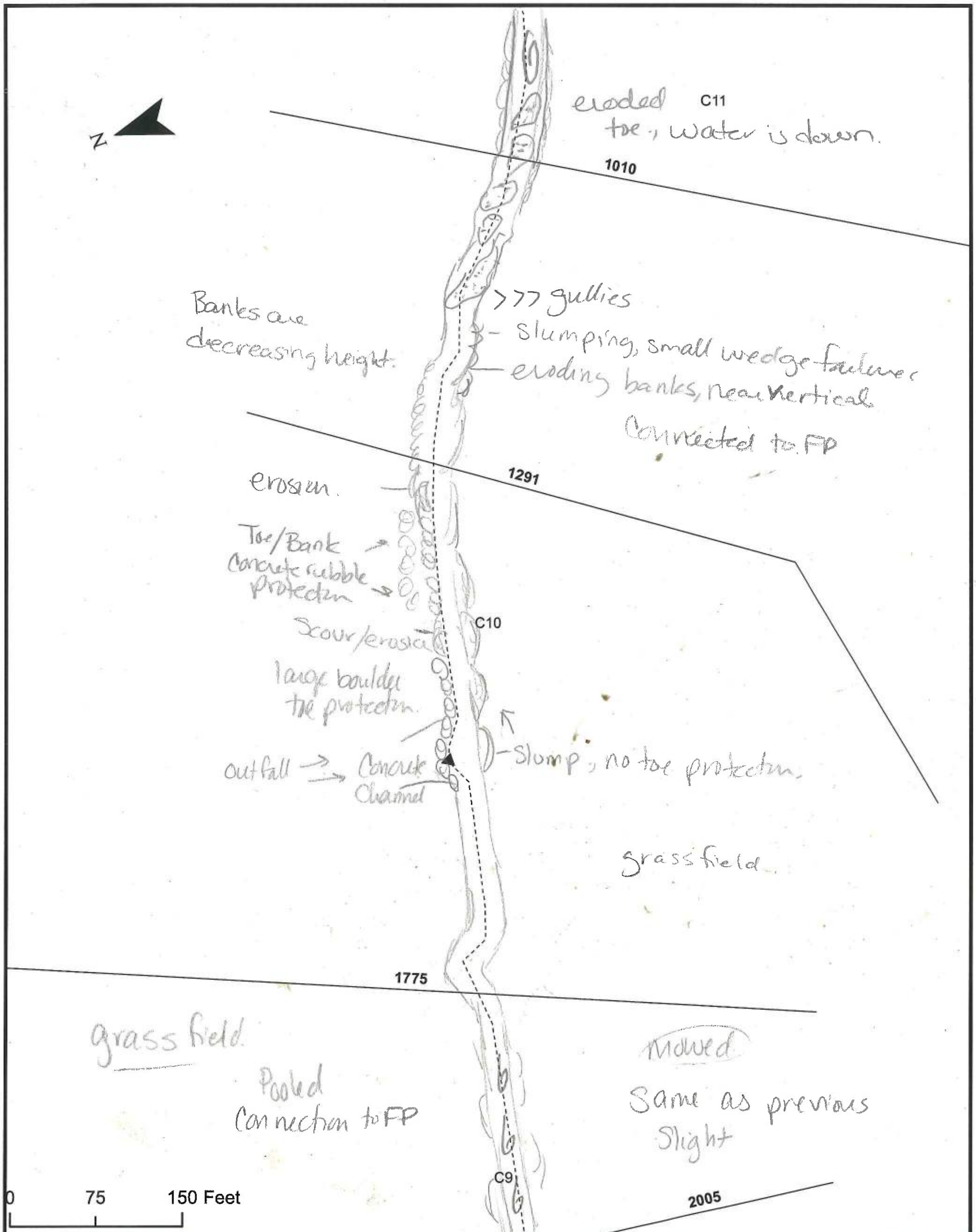
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water - - - - - Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C9
DATE 7/28/11	FIGURE
STREAM N Fork CW	
TEAM SVC, DKC	



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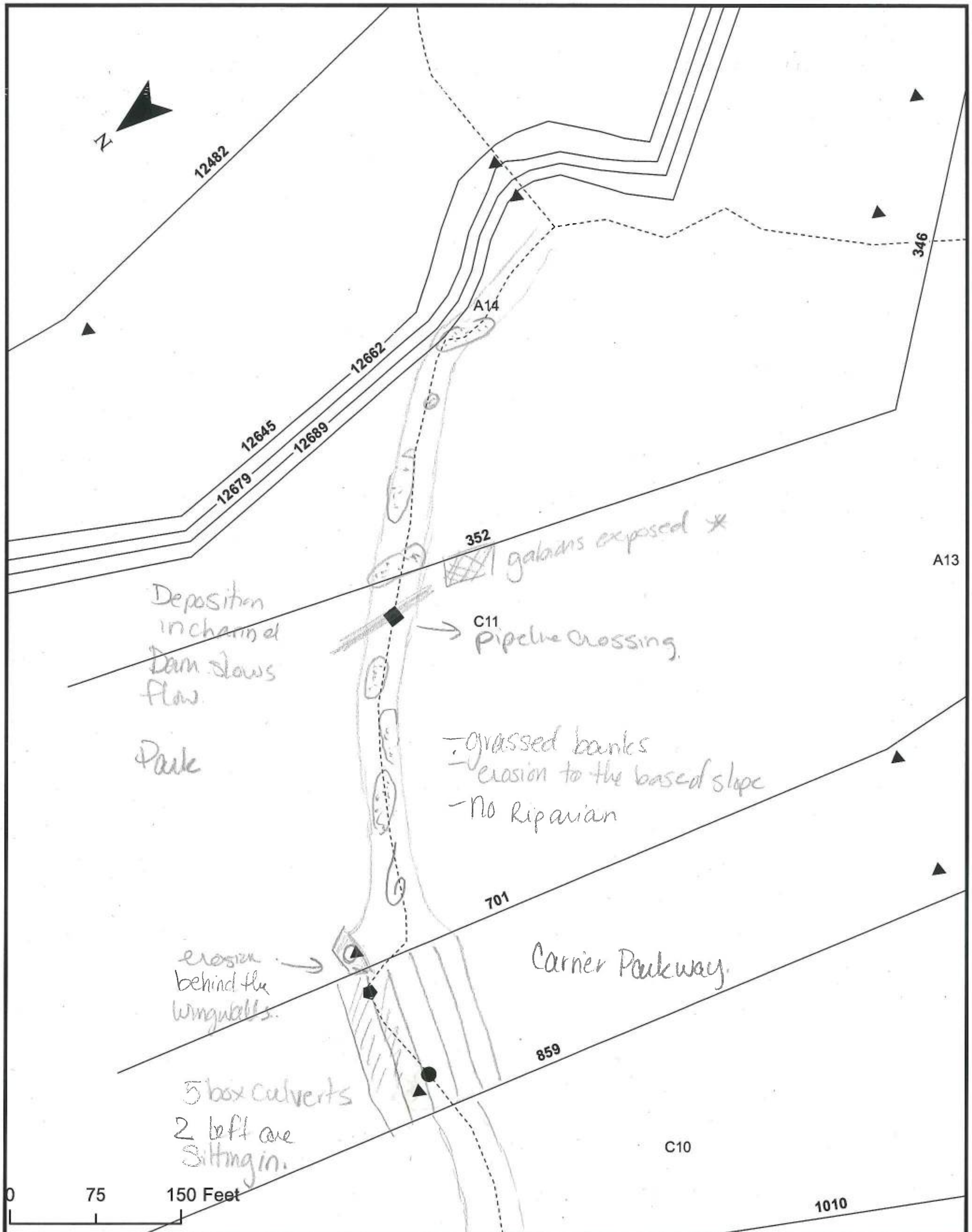
▲ Outfall	● WW
■ Pipeline	——— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/29/11
STREAM	N Fork CW
TEAM	JJC DKC

C10

FIGURE



Hand point Between 701 & 859

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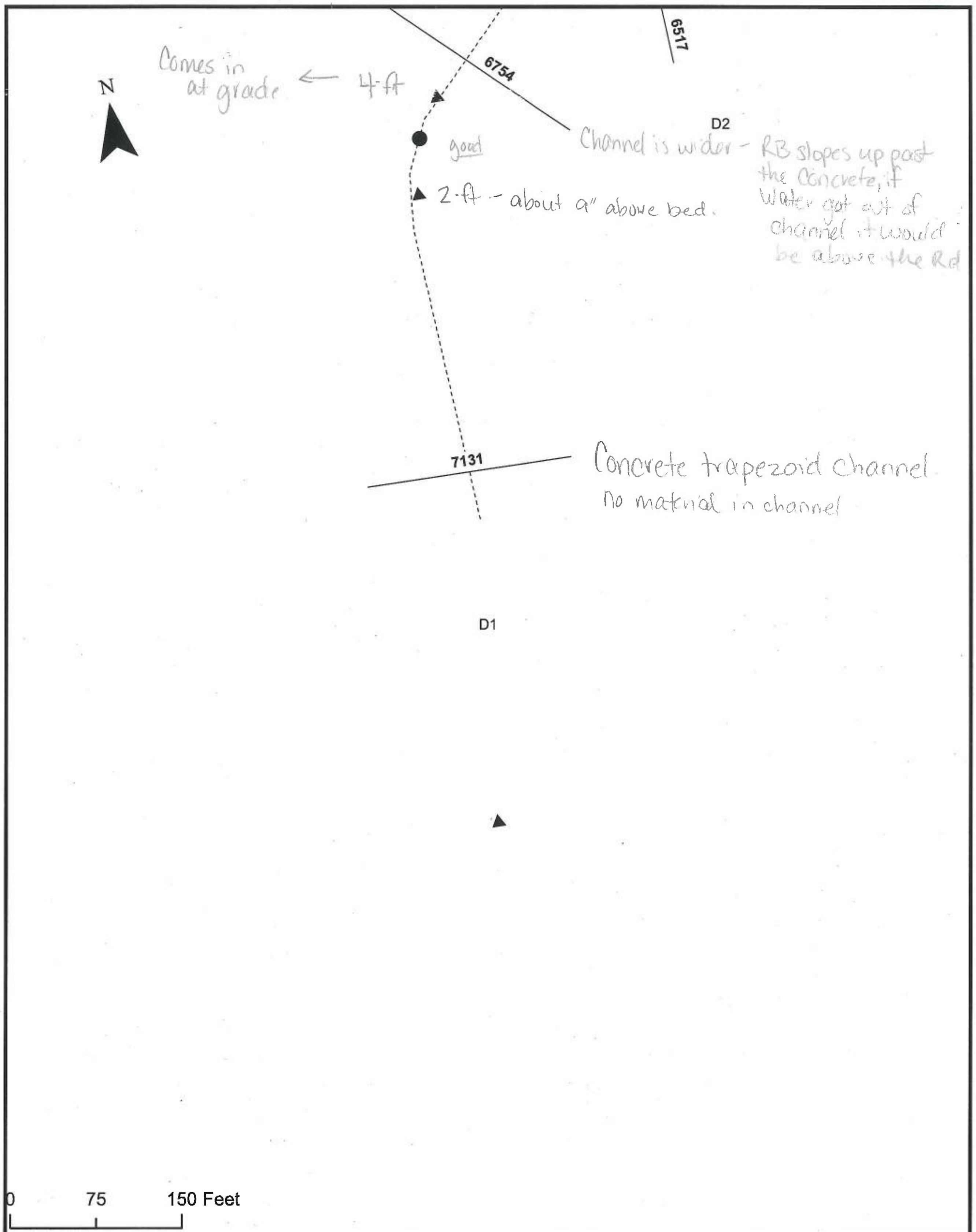
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	C11
DATE 7-28-11	
STREAM N. Fork of CW	FIGURE
TEAM JVC, DKC	



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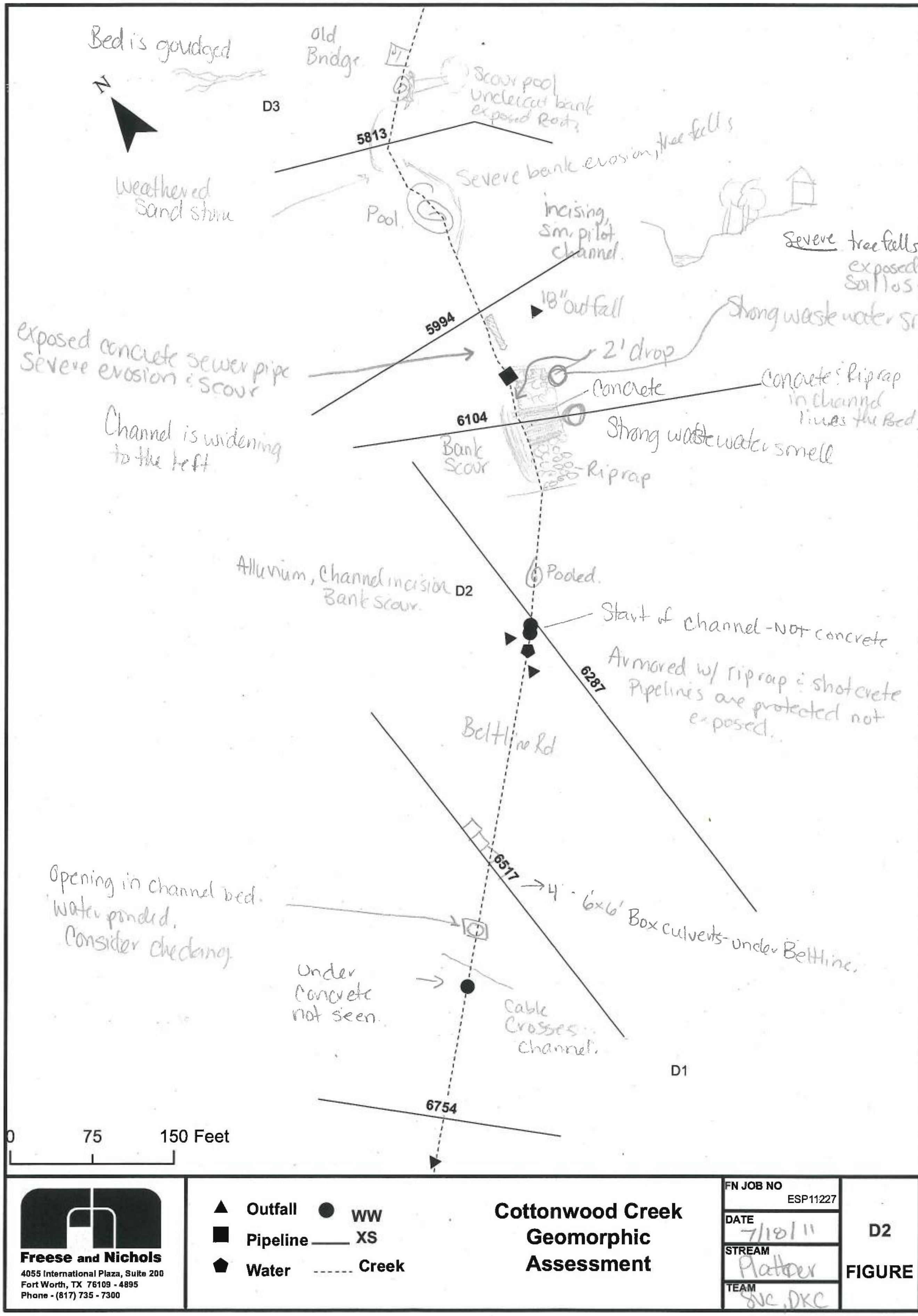
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water - - - - - - Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	D1
DATE 7/18/11	
STREAM Plattner	FIGURE
TEAM SVC, DKC	


Bed is goudged
Old Bridge
Scour pool undercut bank exposed Roots
N
D3
5813
Severe bank erosion, tree falls
Weathered Sand stone
Pool
Incising sm. pilot channel
Severe tree falls exposed roots soil loss
5994
18" outfall
Strong waste water smell
Houd point 6104
exposed concrete sewer pipe Severe erosion & scour
2' drop
Concrete
Concrete & Riprap in channel lines the Bed
6104
Channel is widening to the left
Bank Scour
Strong waste water smell
Riprap
Alluvium, Channel incision Bank scour
D2
Pooled
Start of channel - Not concrete
Armored w/ riprap & shotcrete Pipelines are protected not exposed
6287
Beltline Rd
6517
4 - 6'x6' Box culverts - under Beltline
Opening in channel bed water ponded. Consider checking
Under concrete not seen
Cable crosses channel
D1
6754
0
75
150 Feet
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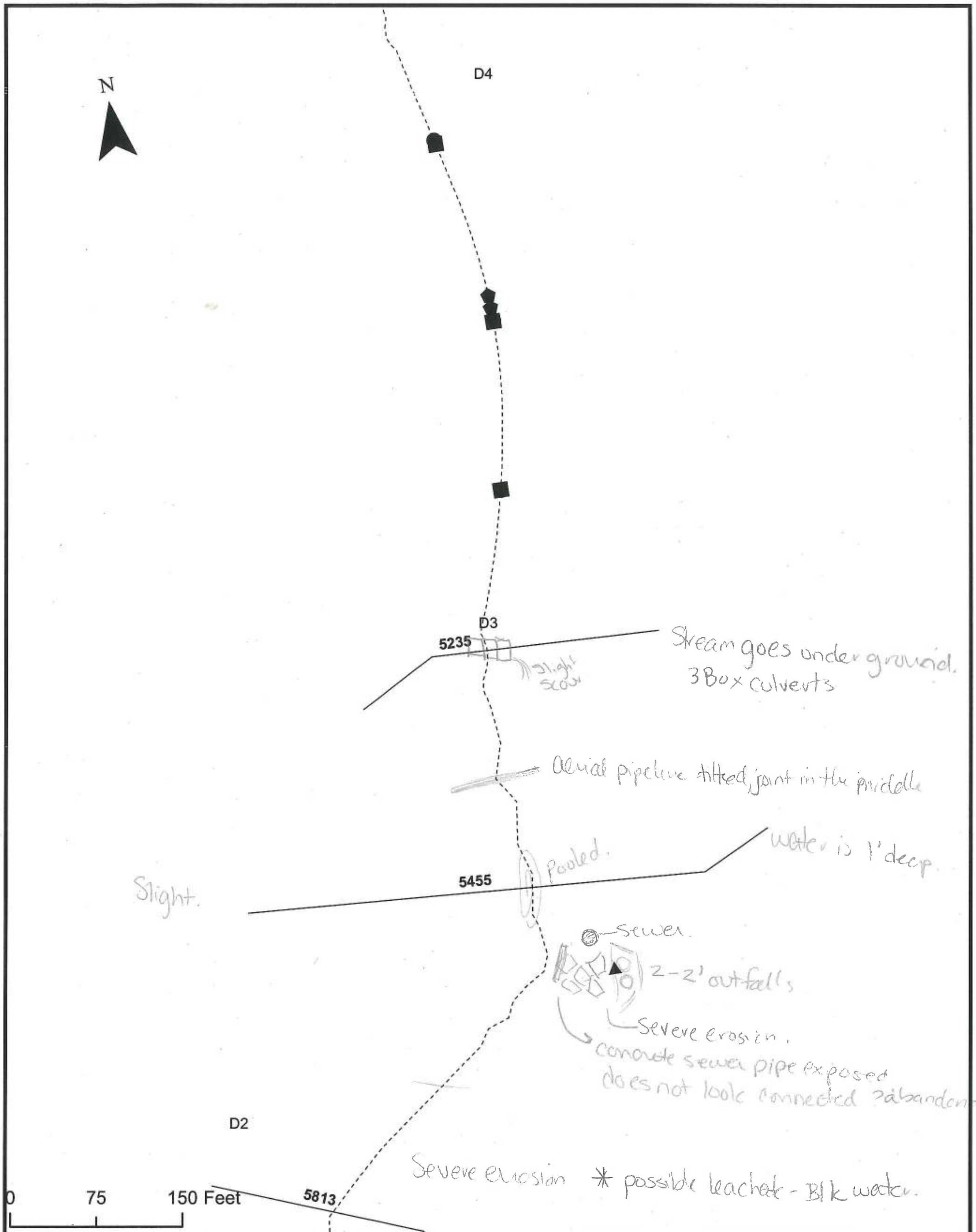
Outfall
WW
Pipeline
XS
Water
Creek
Cottonwood Creek Geomorphic Assessment
FN JOB NO
ESP11227
DATE
7/18/11
STREAM
Platner
TEAM
SVC, DKC
D2
FIGURE



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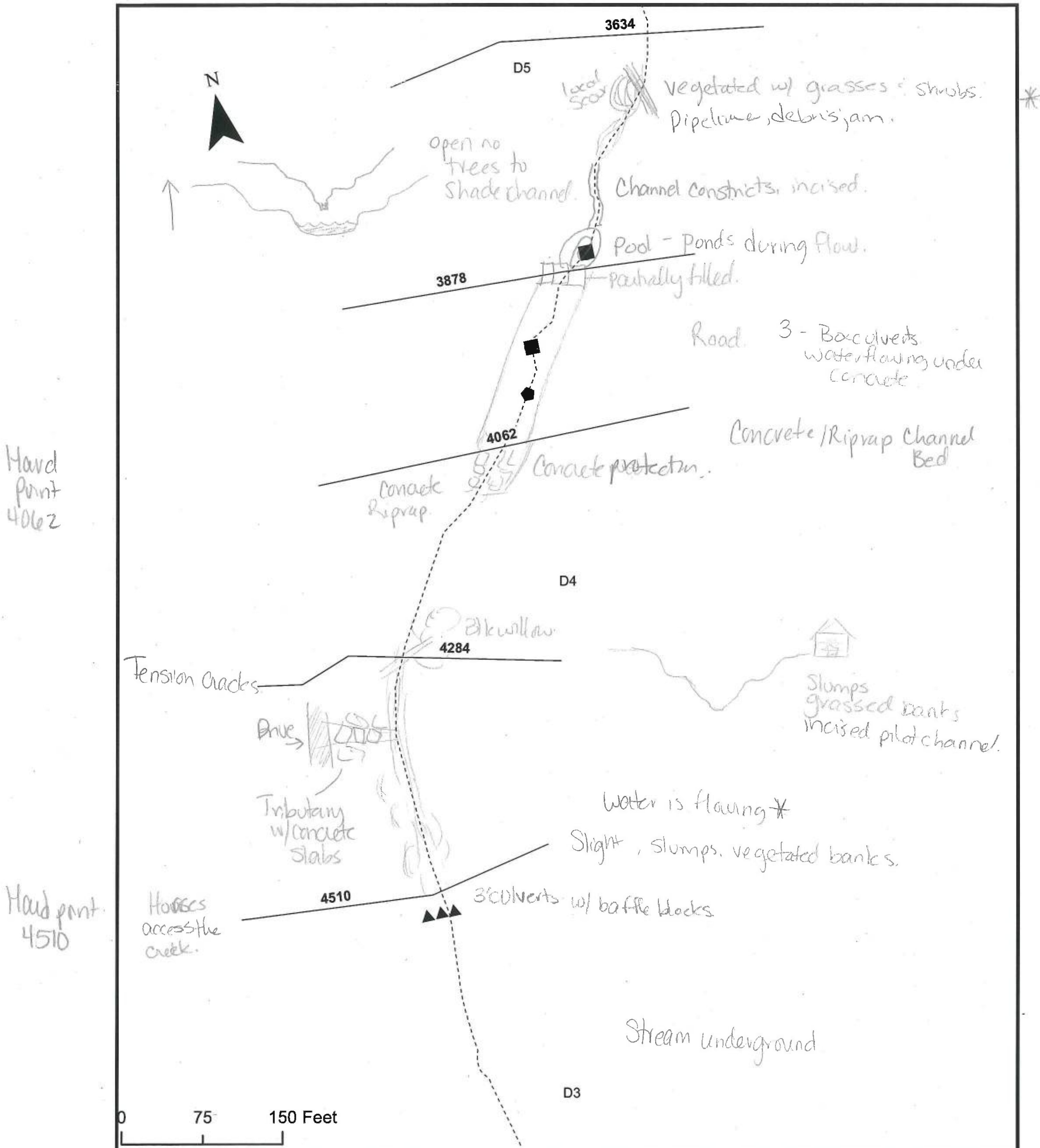
▲ Outfall	● WW
■ Pipeline	—— XS
⬟ Water	------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/18/11
STREAM	Plattner
TEAM	SVC, DKC

D3

FIGURE



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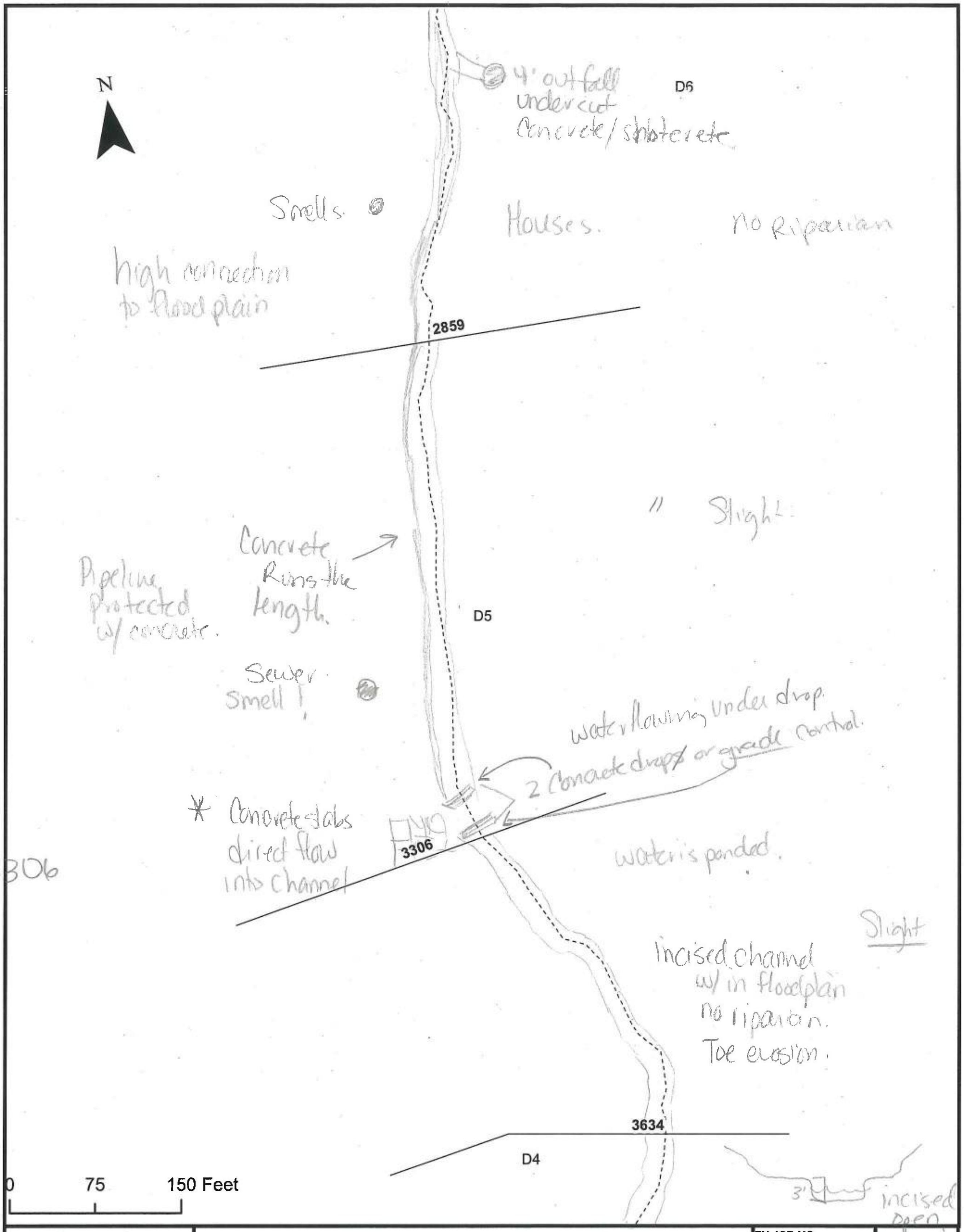
▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/18/11
STREAM	Mather
TEAM	SVC, DKC

D4

FIGURE



* Hard point 3306

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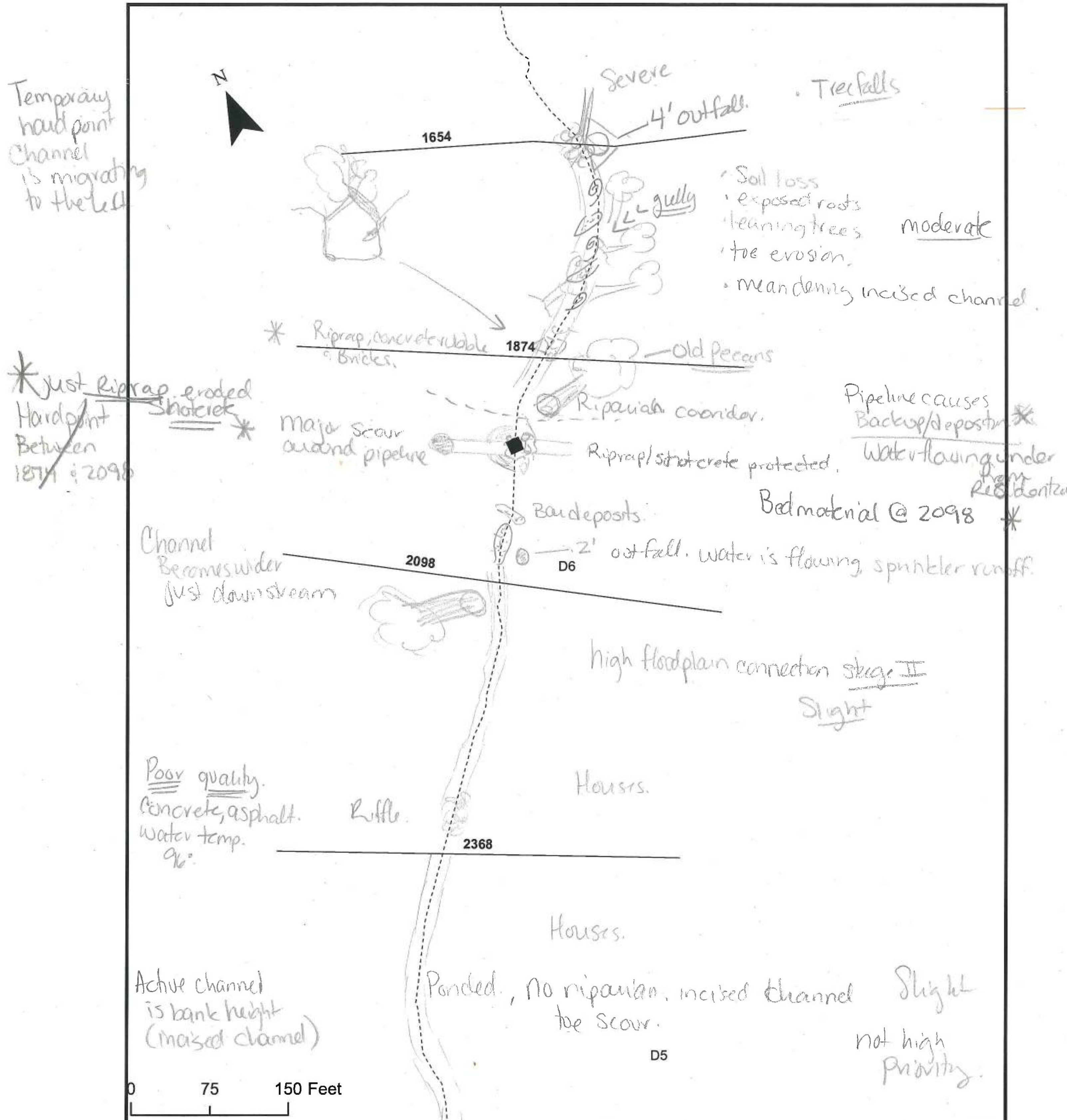
▲ Outfall ● WW
■ Pipeline ——— XS
⬟ Water ------ Creek

Cottonwood Creek Geomorphic Assessment

FN JOB NO ESP11227	D5
DATE 7/18/11	
STREAM Plattner	FIGURE
TEAM SVC, OKC	



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▲ Outfall ● WW
■ Pipeline —— XS
⬟ Water ------ Creek

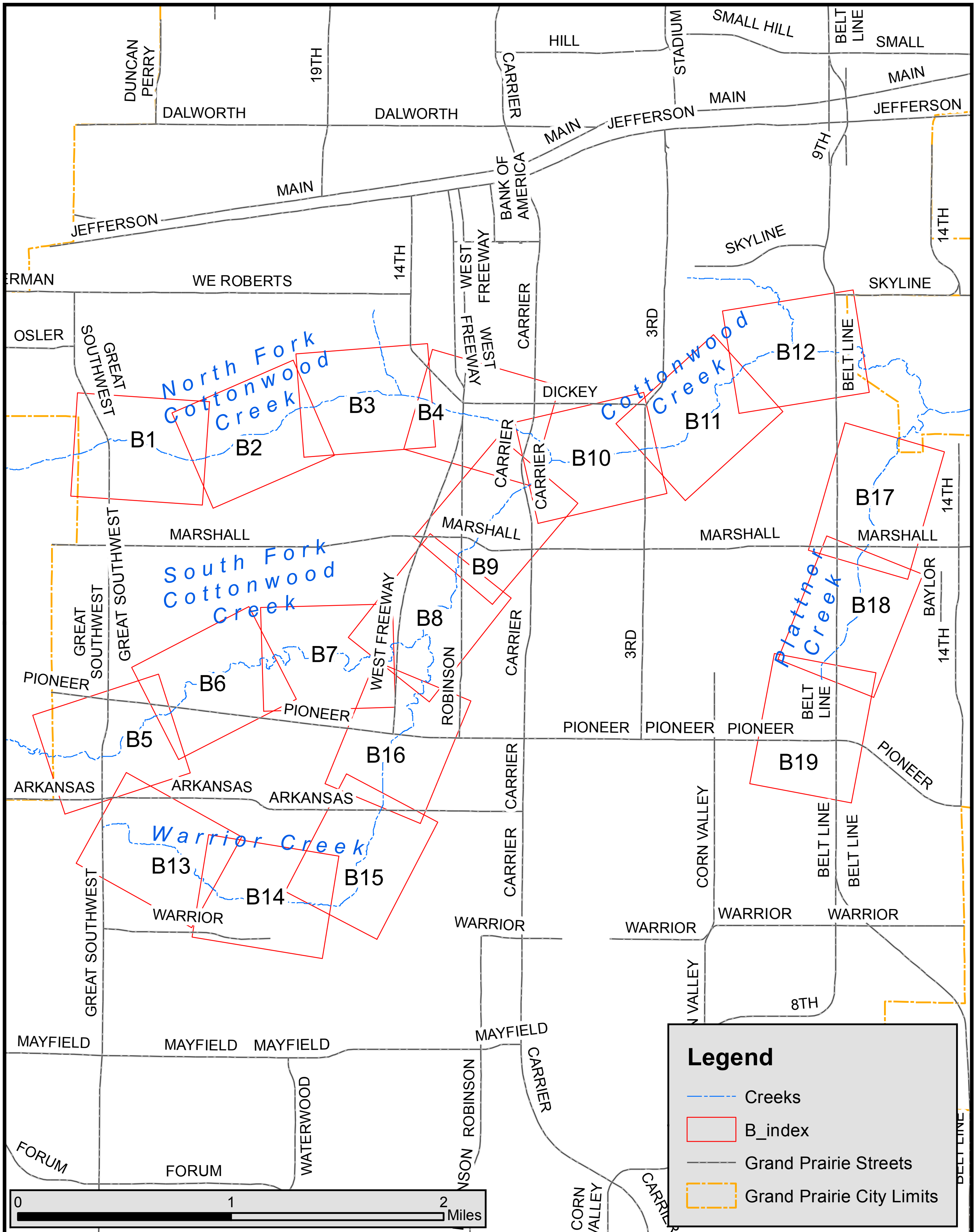
Cottonwood Creek Geomorphic Assessment

FN JOB NO	ESP11227
DATE	7/18/11
STREAM	Plattner
TEAM	SUC, DKC

D6

FIGURE

Appendix B



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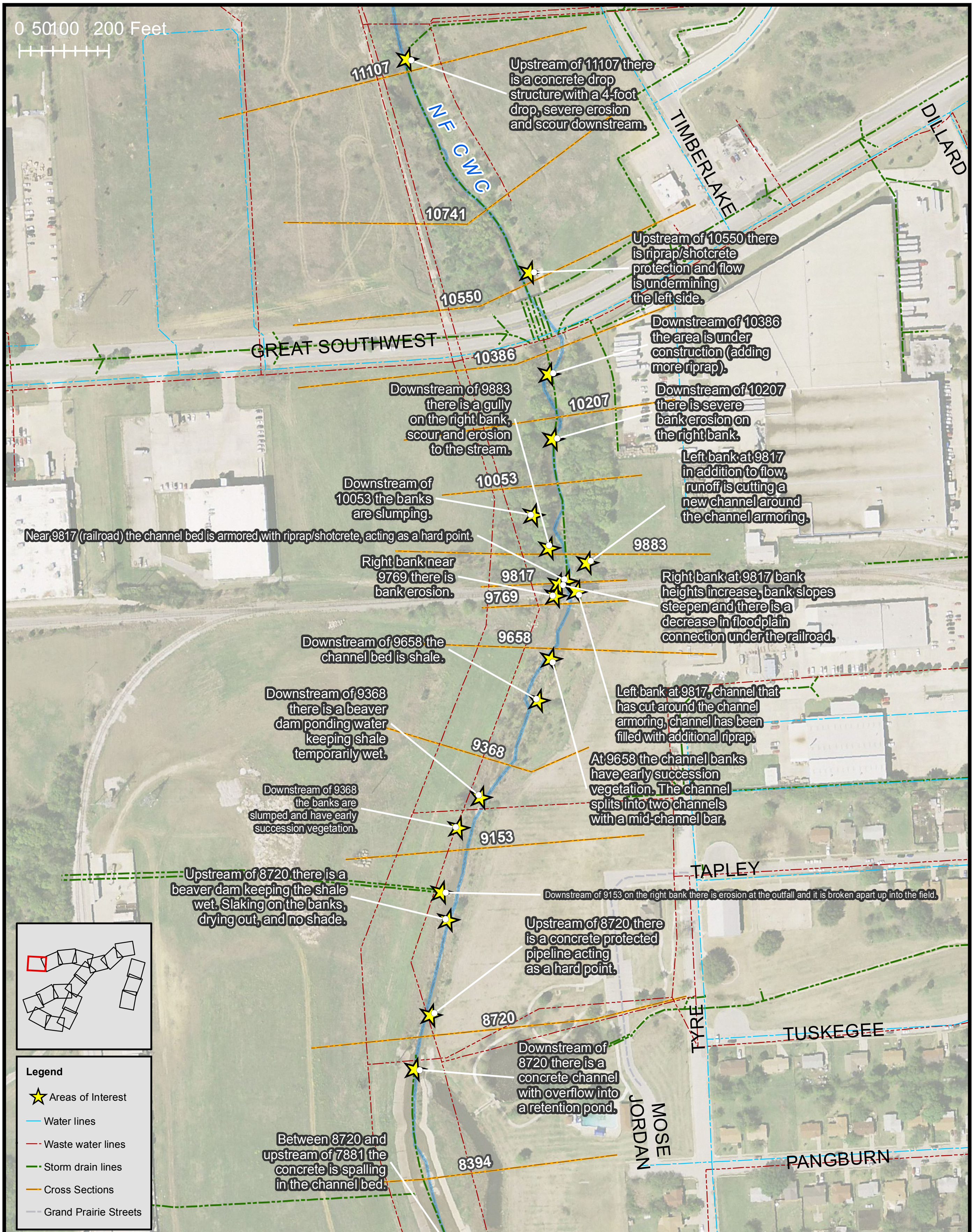
N
W E
S

Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest
Page Index

FN JOB NO	ESP11227
FILE	APP_B_AOI_index.mxd
DATE	June 21 2012
SCALE	1:40,000
DESIGNED	SVC
DRAFTED	DKC

B
FIGURE



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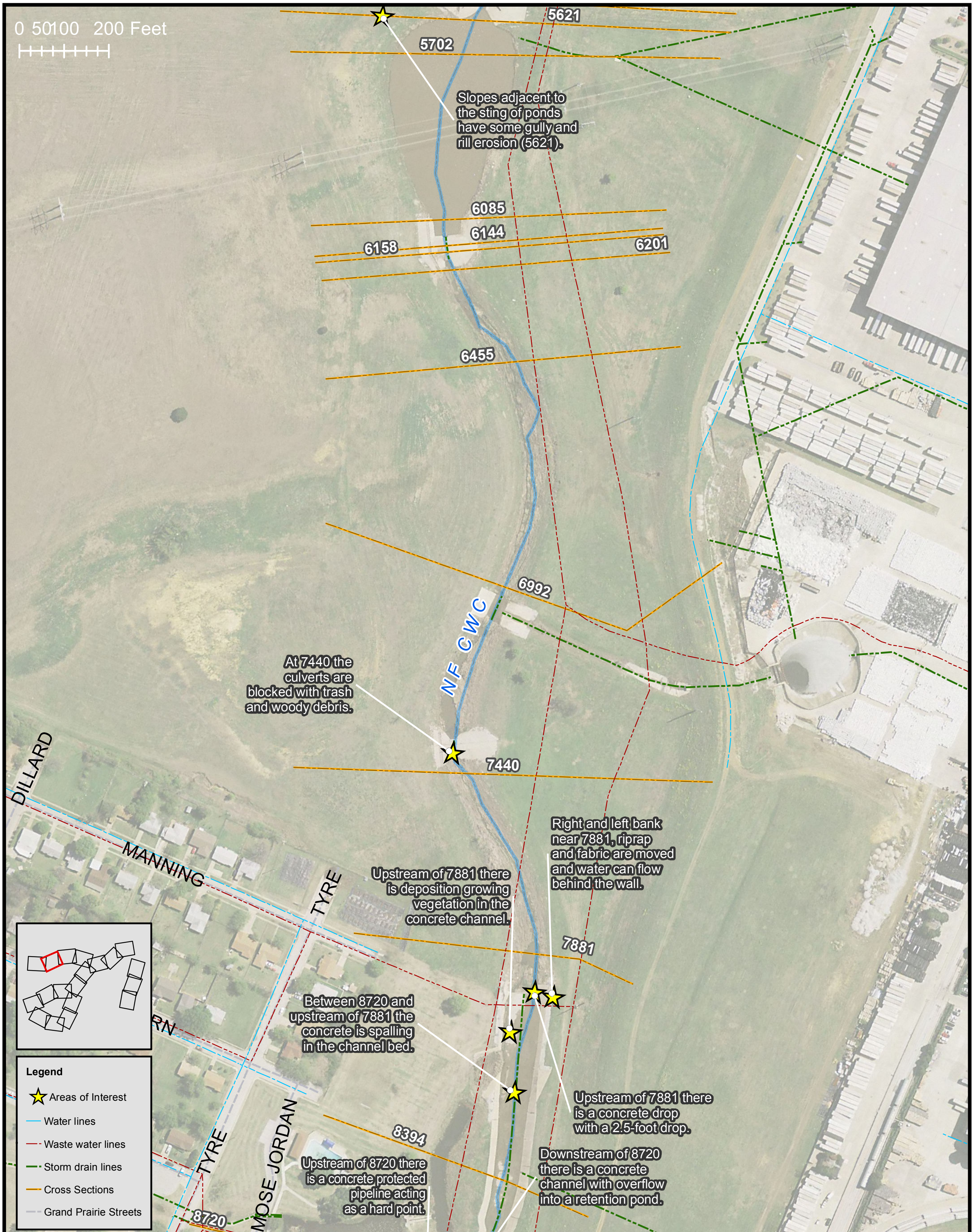
Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest

FN JOB NO	ESP11227
FILE	APP_B_AOI.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

B1

FIGURE



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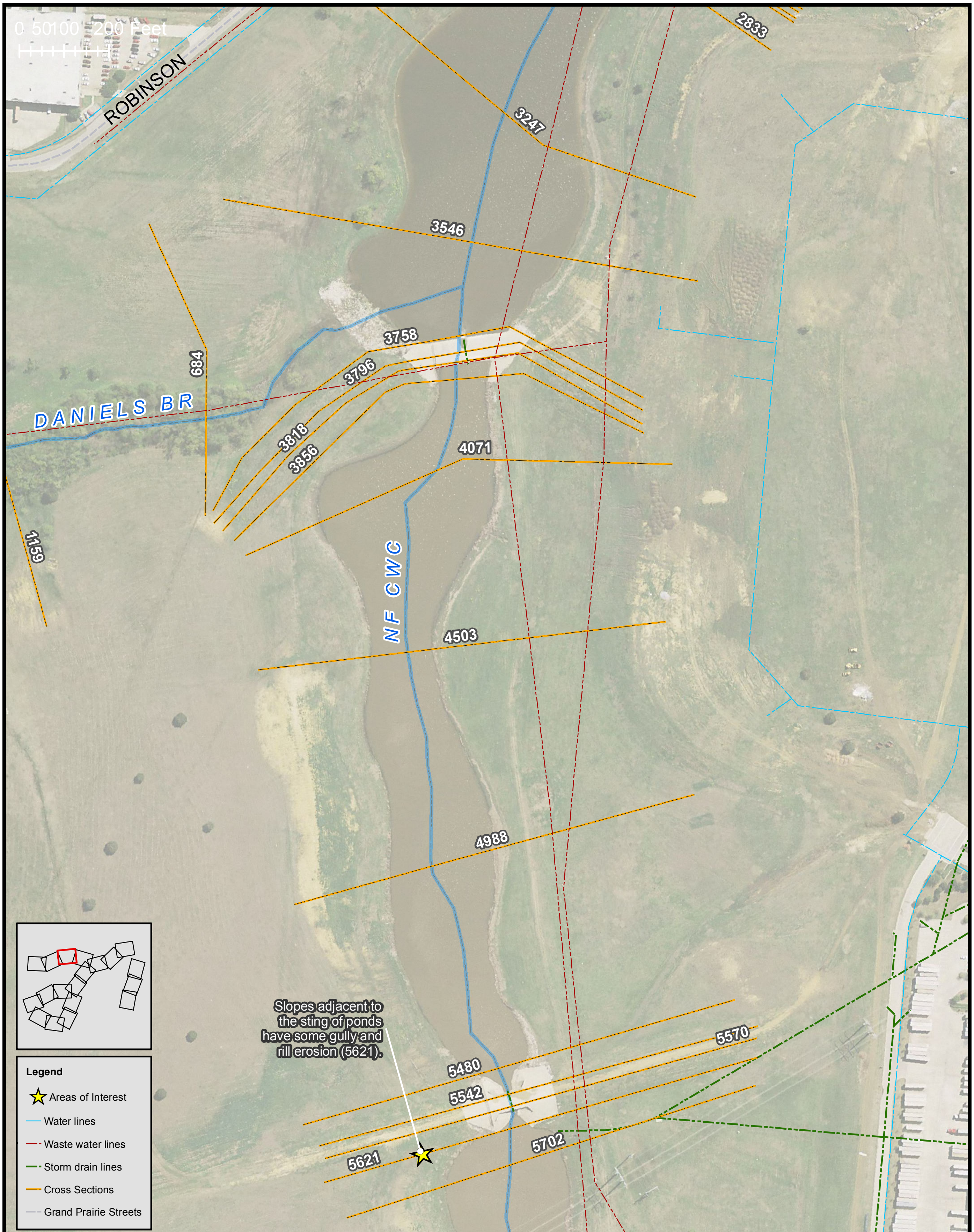
Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest

FN JOB NO	ESP11227
FILE	APP_B_AOI.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

B2
FIGURE



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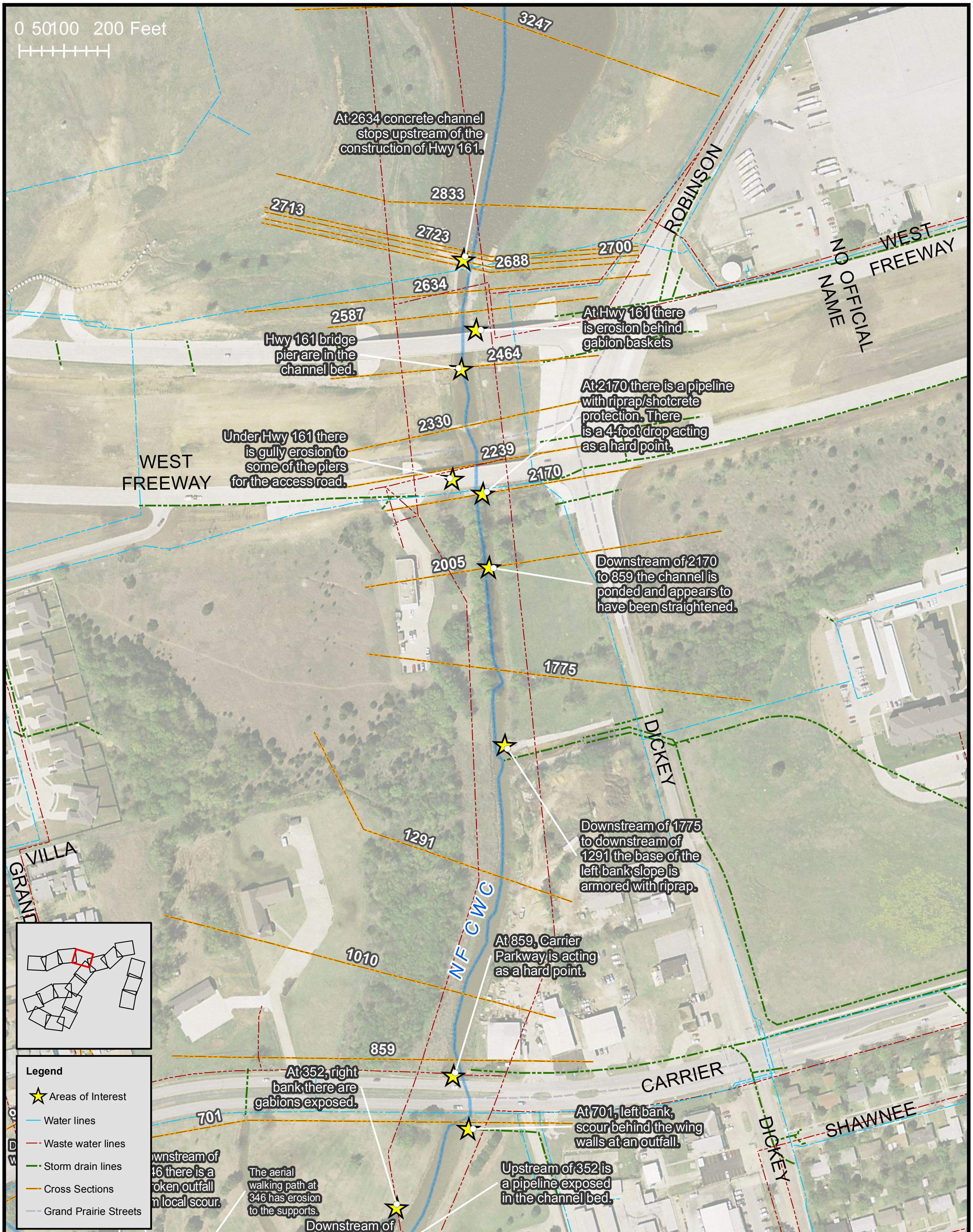
Cottonwood Creek Geomorphic Stream Assessment

Areas of Interest

FN JOB NO	ESP11227
FILE	APP_B_AOI.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

B3

FIGURE



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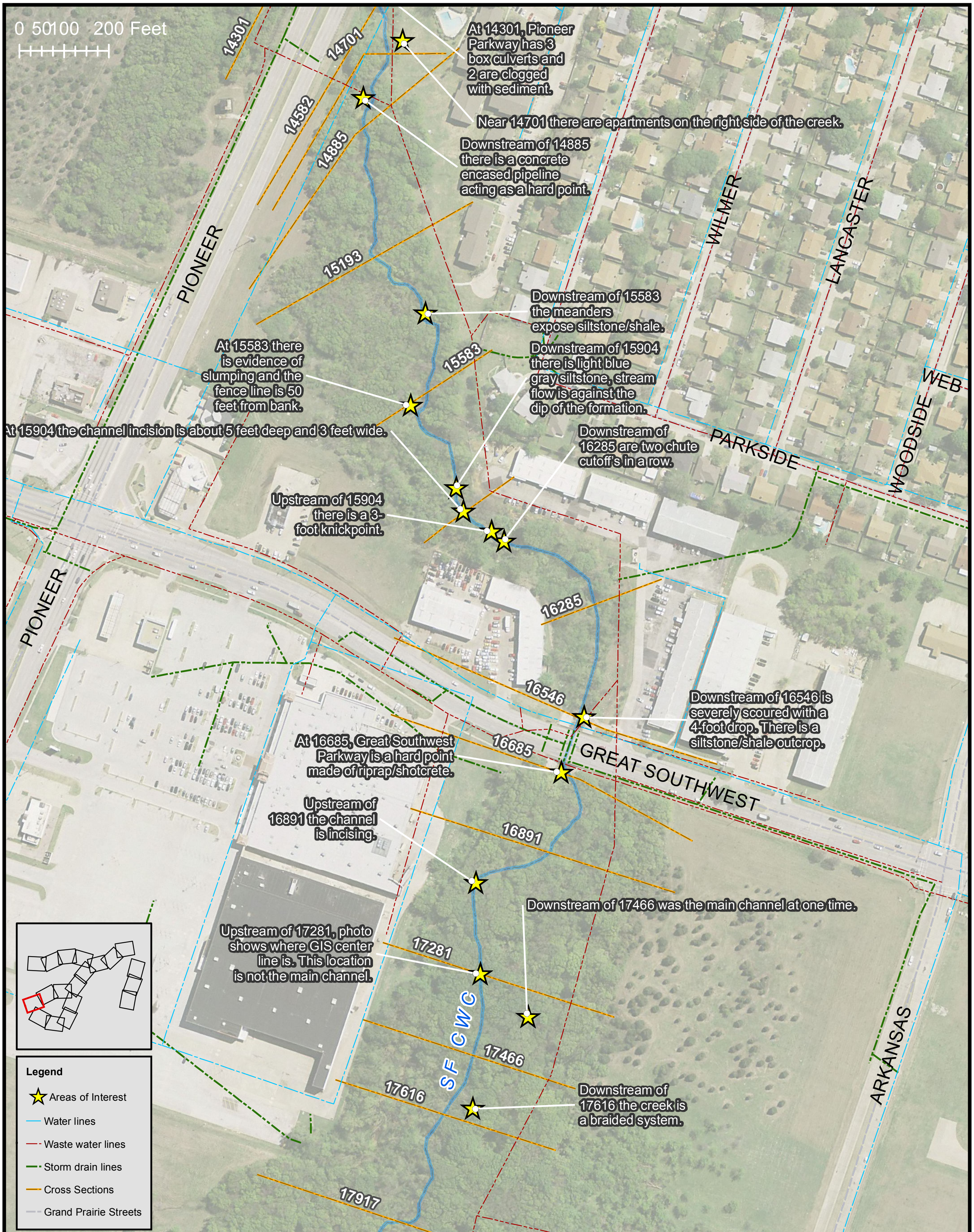
Cottonwood Creek Geomorphic Stream Assessment

Areas of Interest

FN JOB NO	ESP11227
FILE	APP_B_AOI.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

B4
FIGURE



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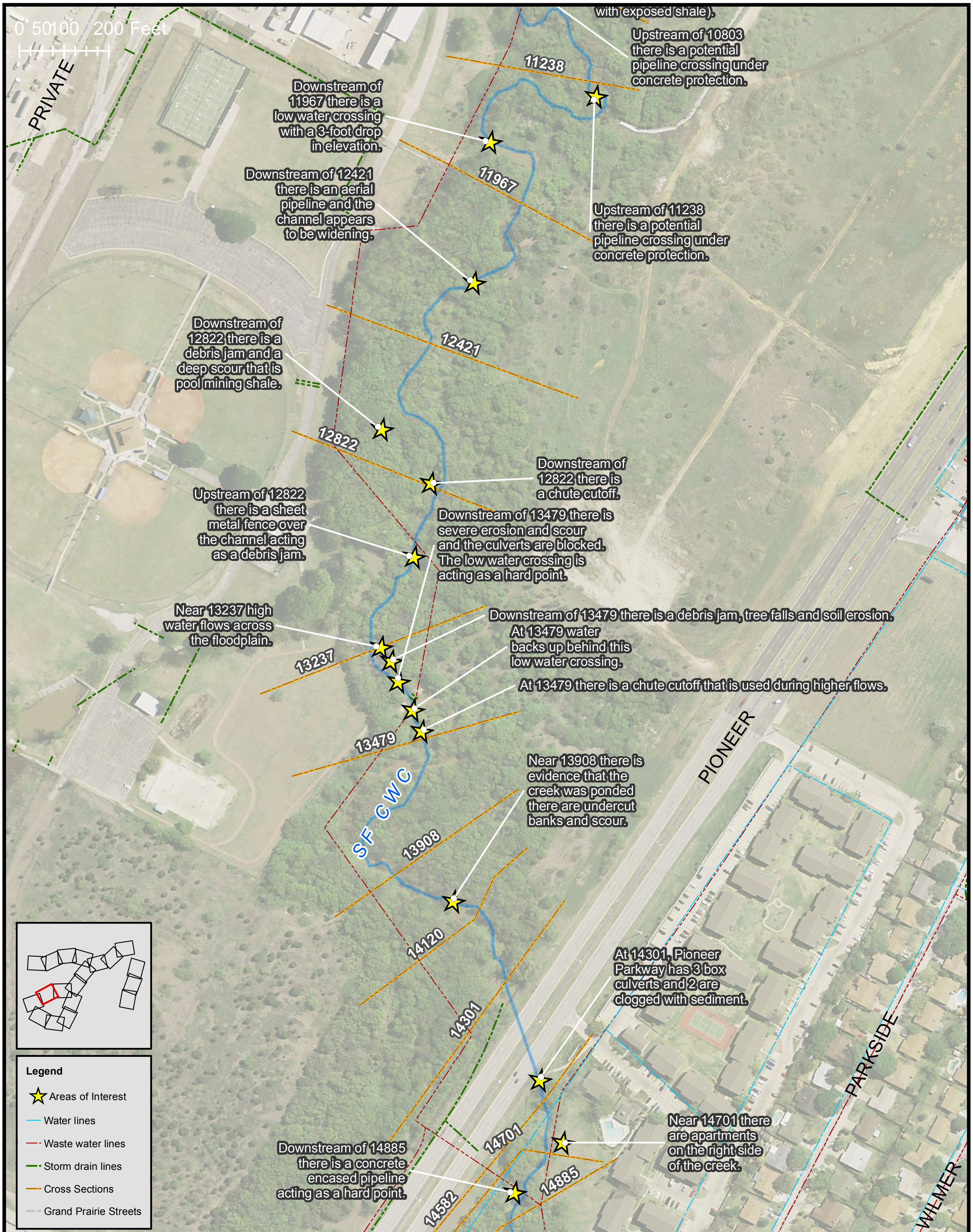
Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest

FN JOB NO	ESP11227
FILE	APP_B_AOI.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

B5

FIGURE



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Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest

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B6
FIGURE

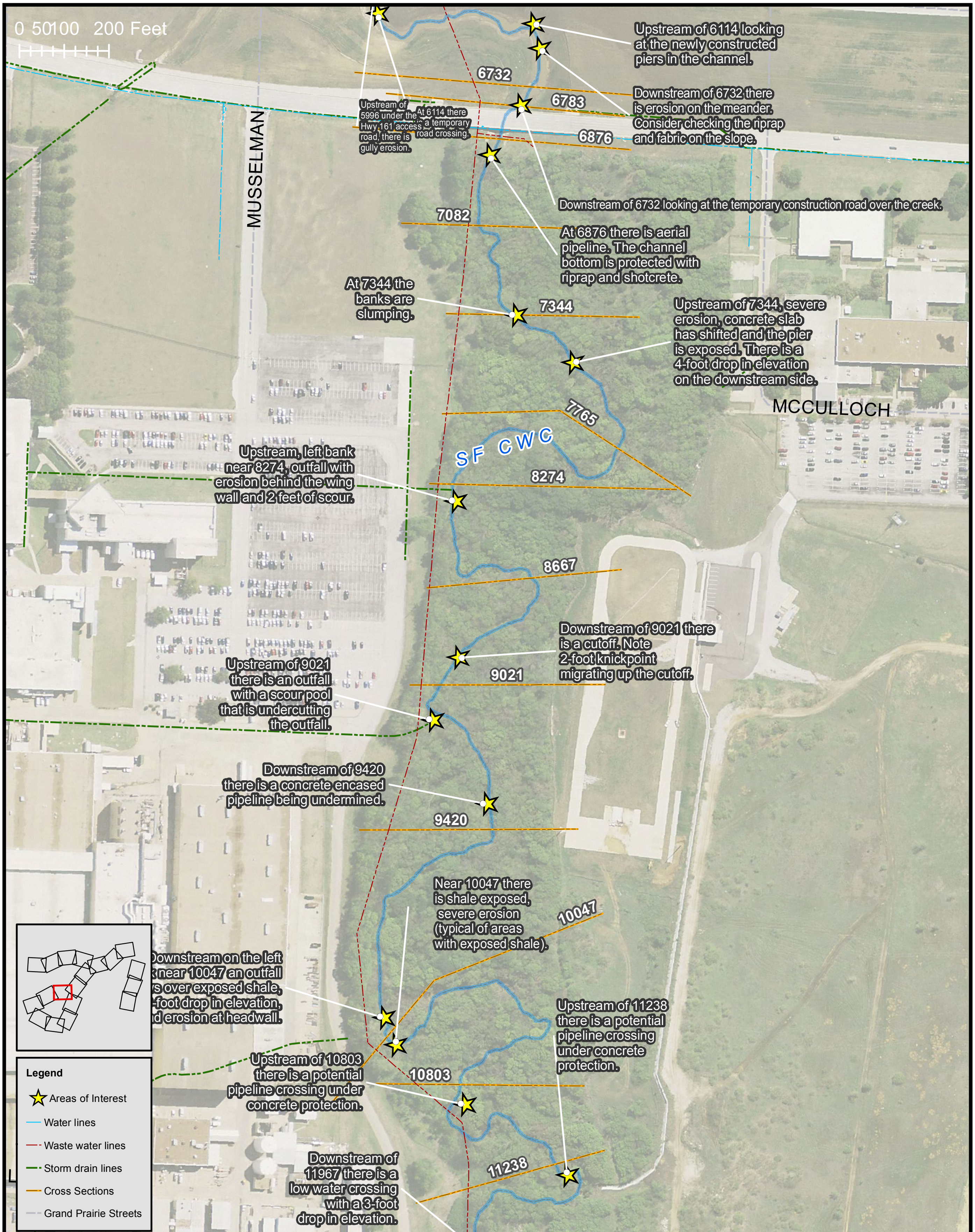

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FIGURE

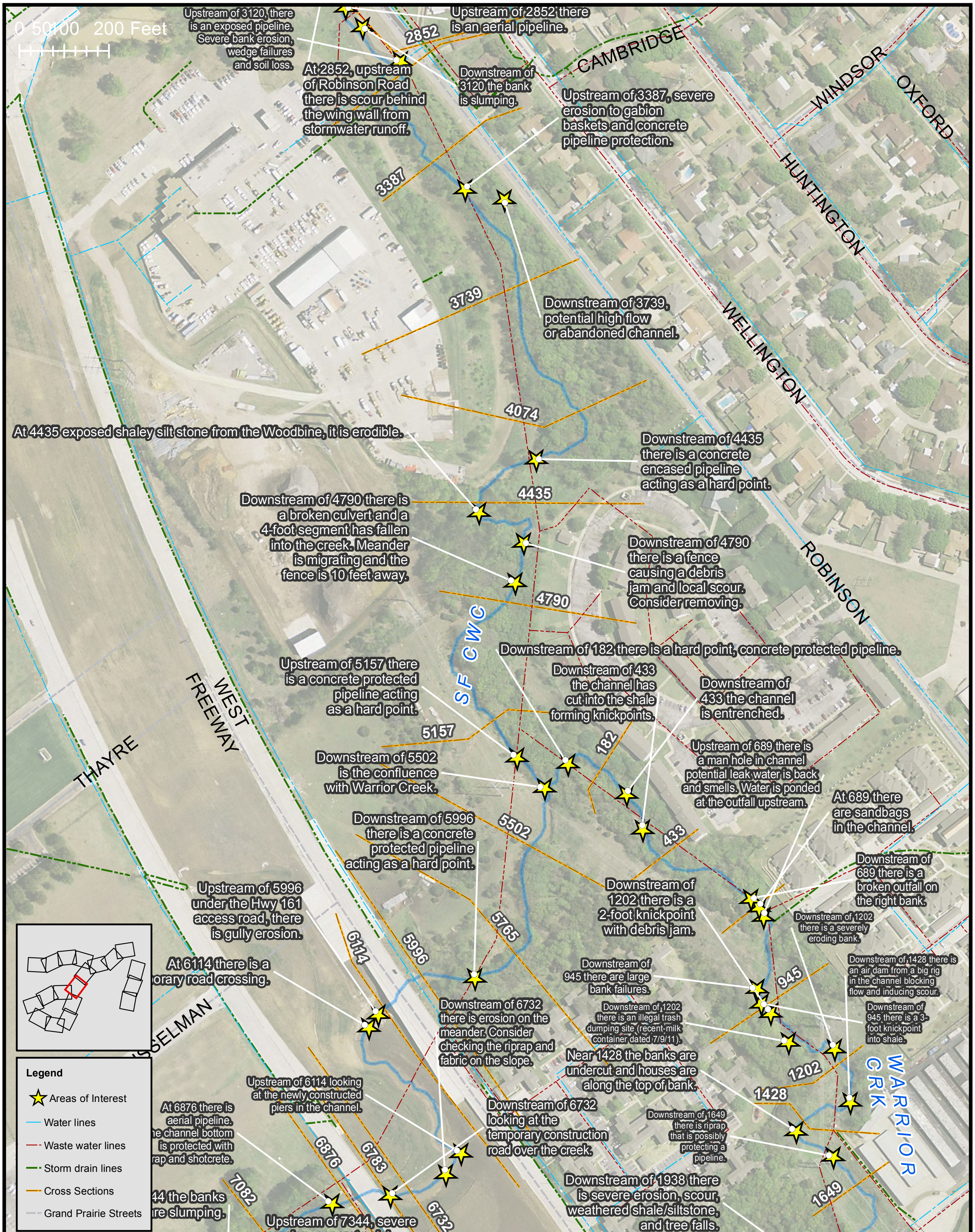

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FIGURE

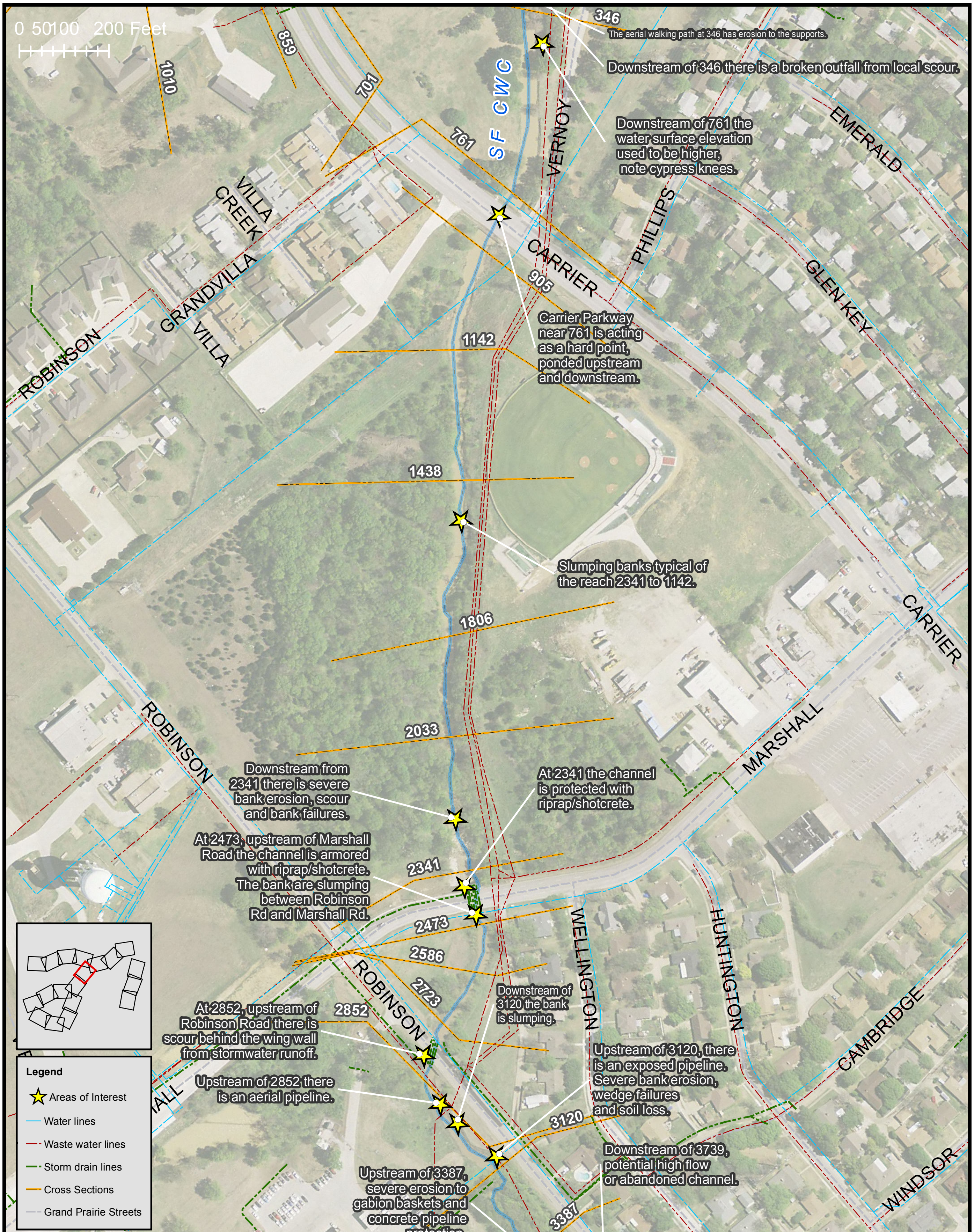

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FIGURE

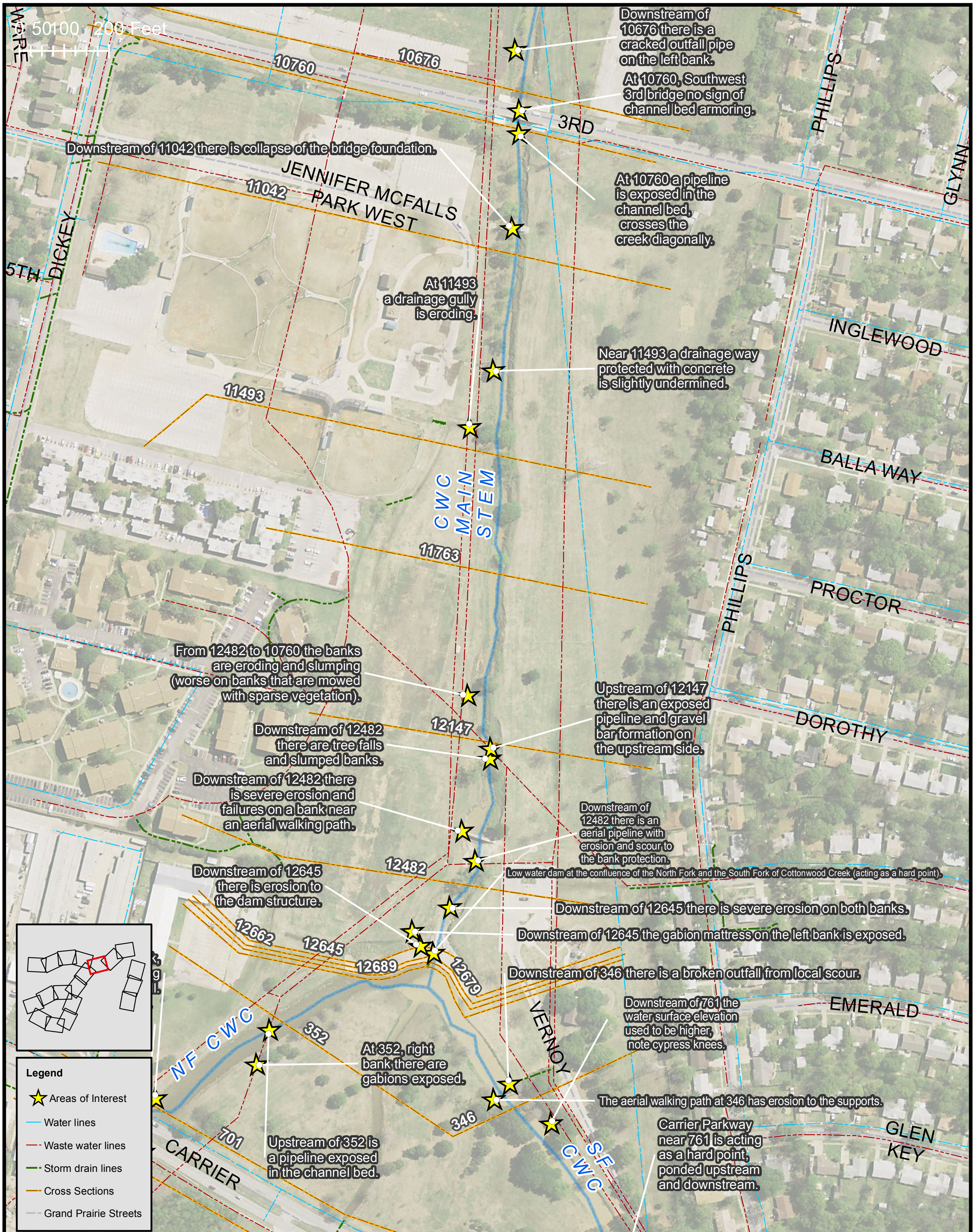

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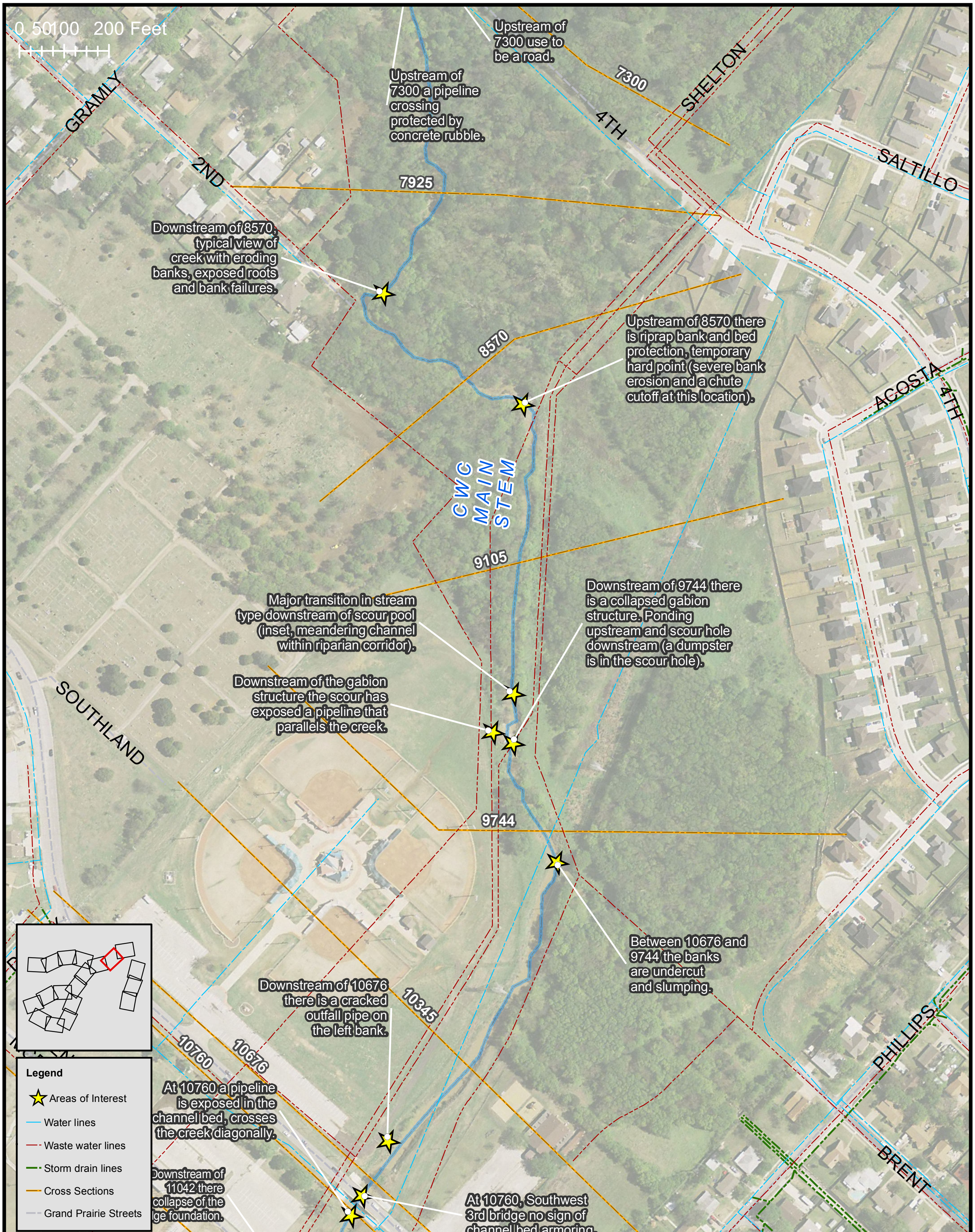
FIGURE



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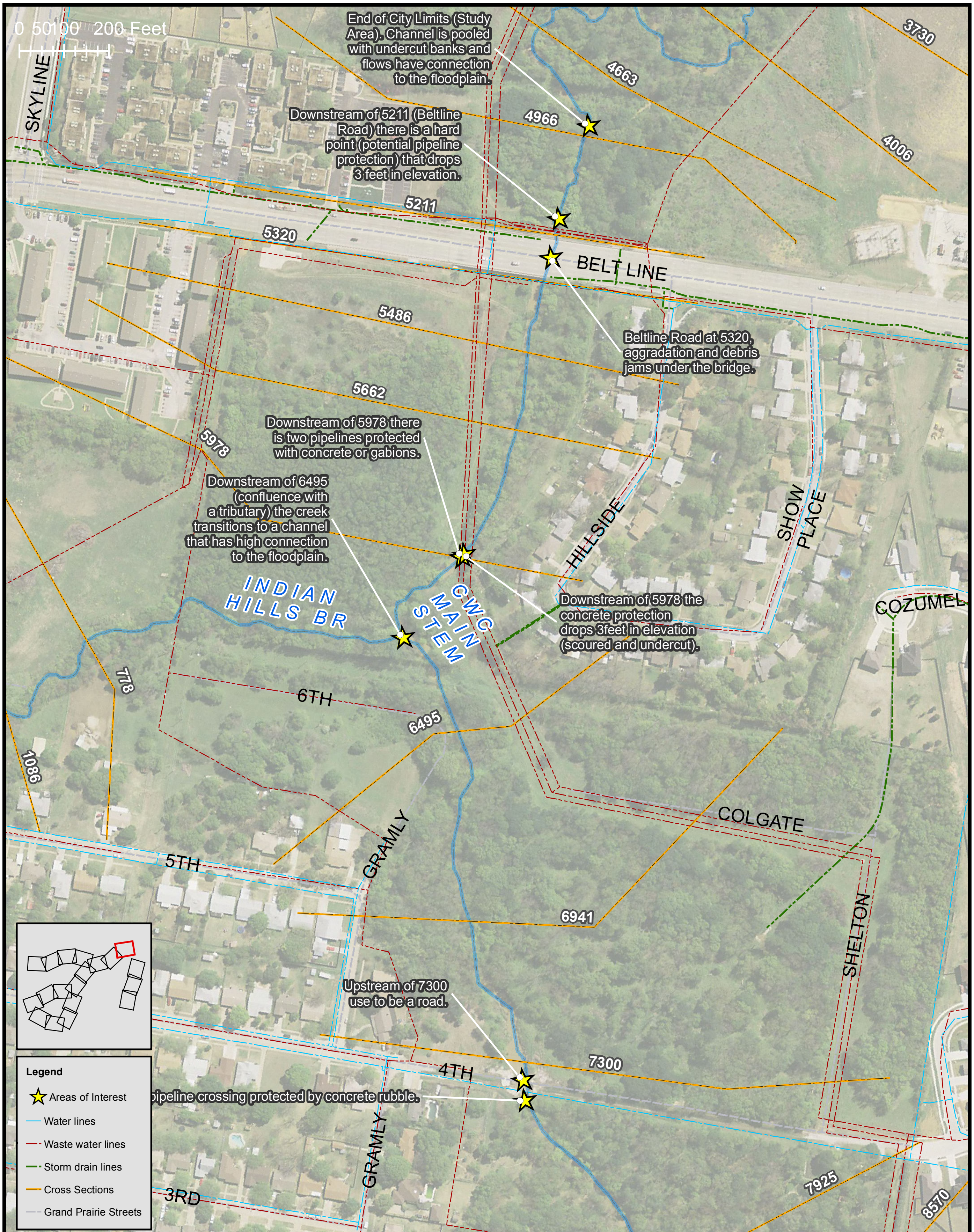

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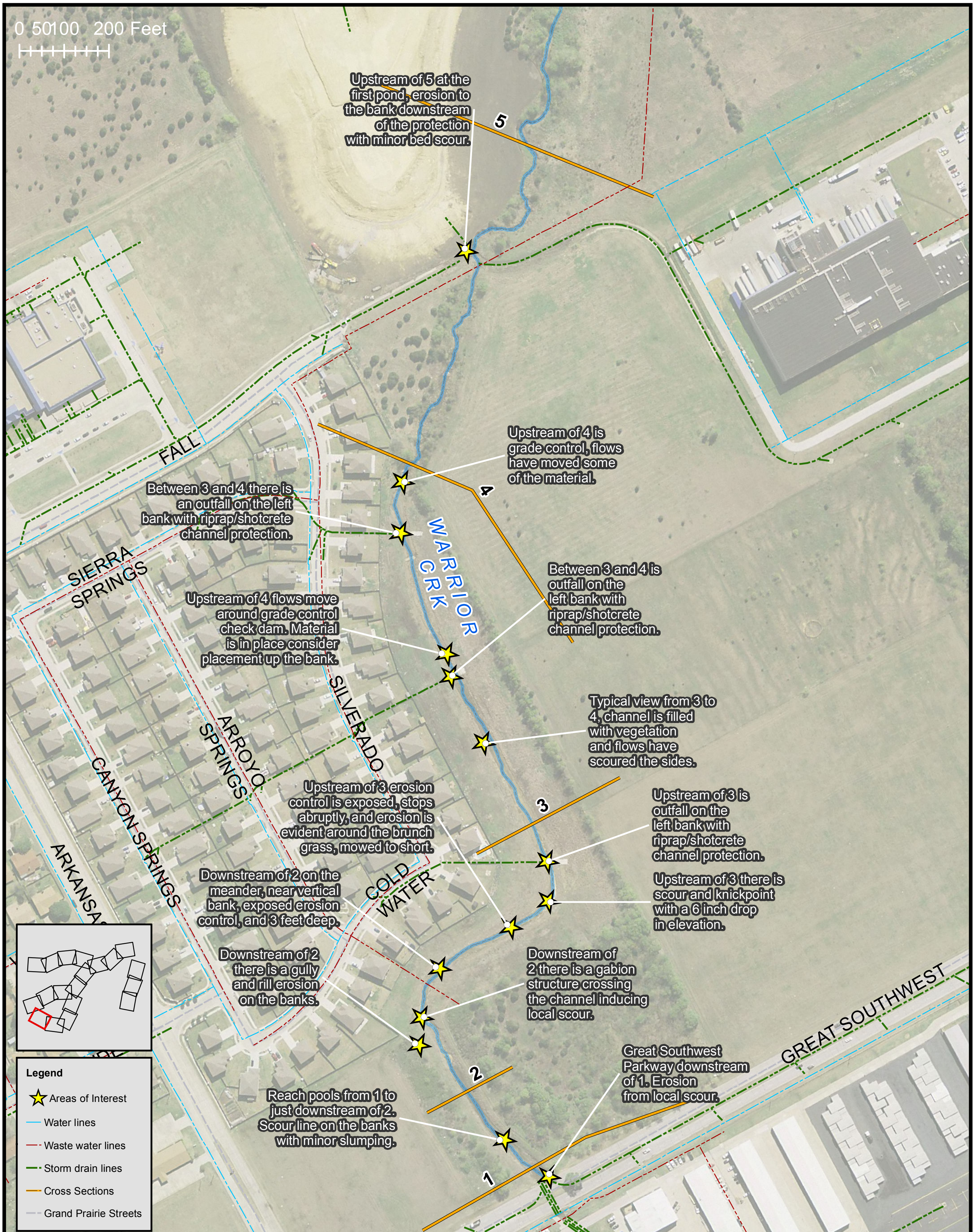
FIGURE



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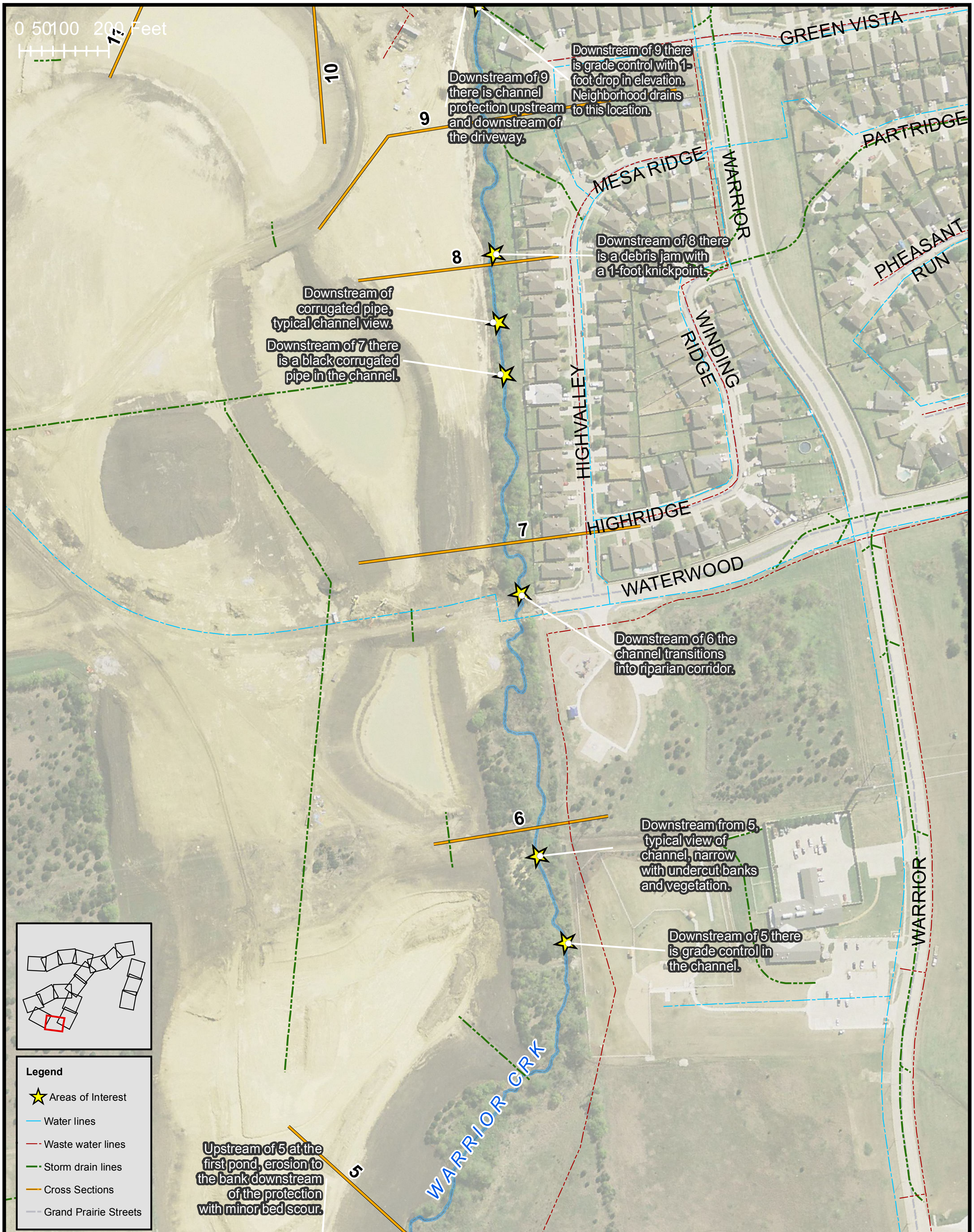

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FIGURE

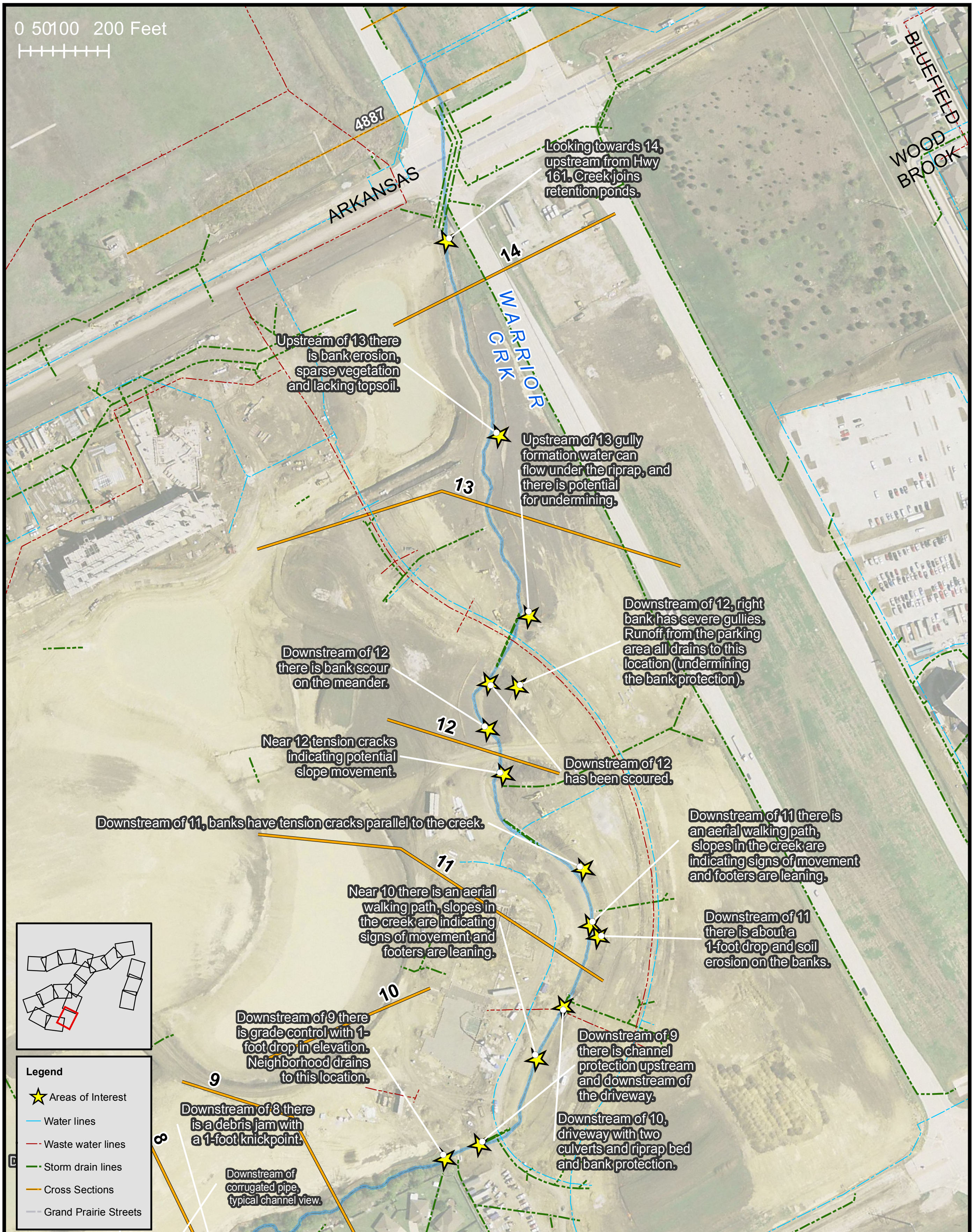

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FIGURE

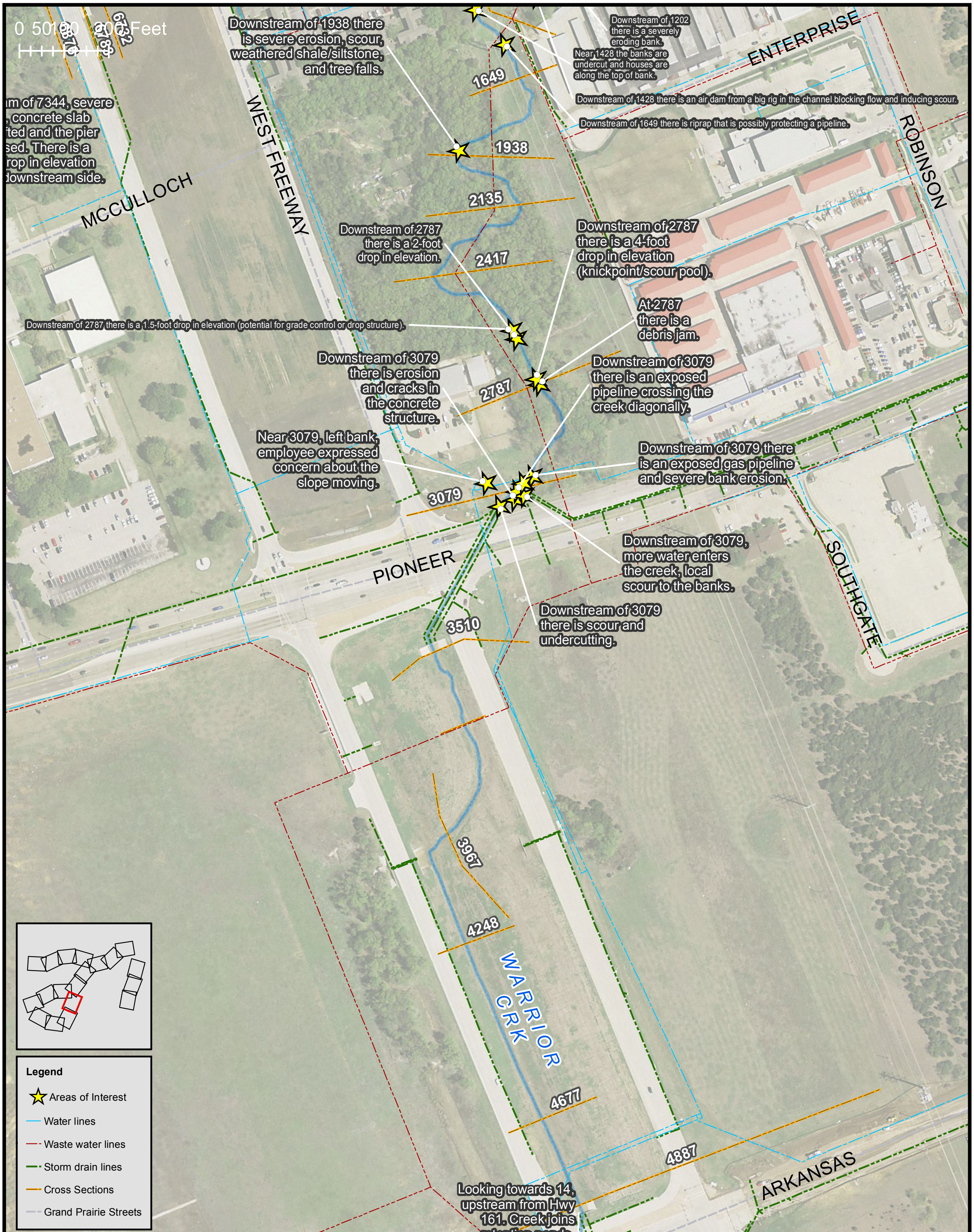

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FIGURE

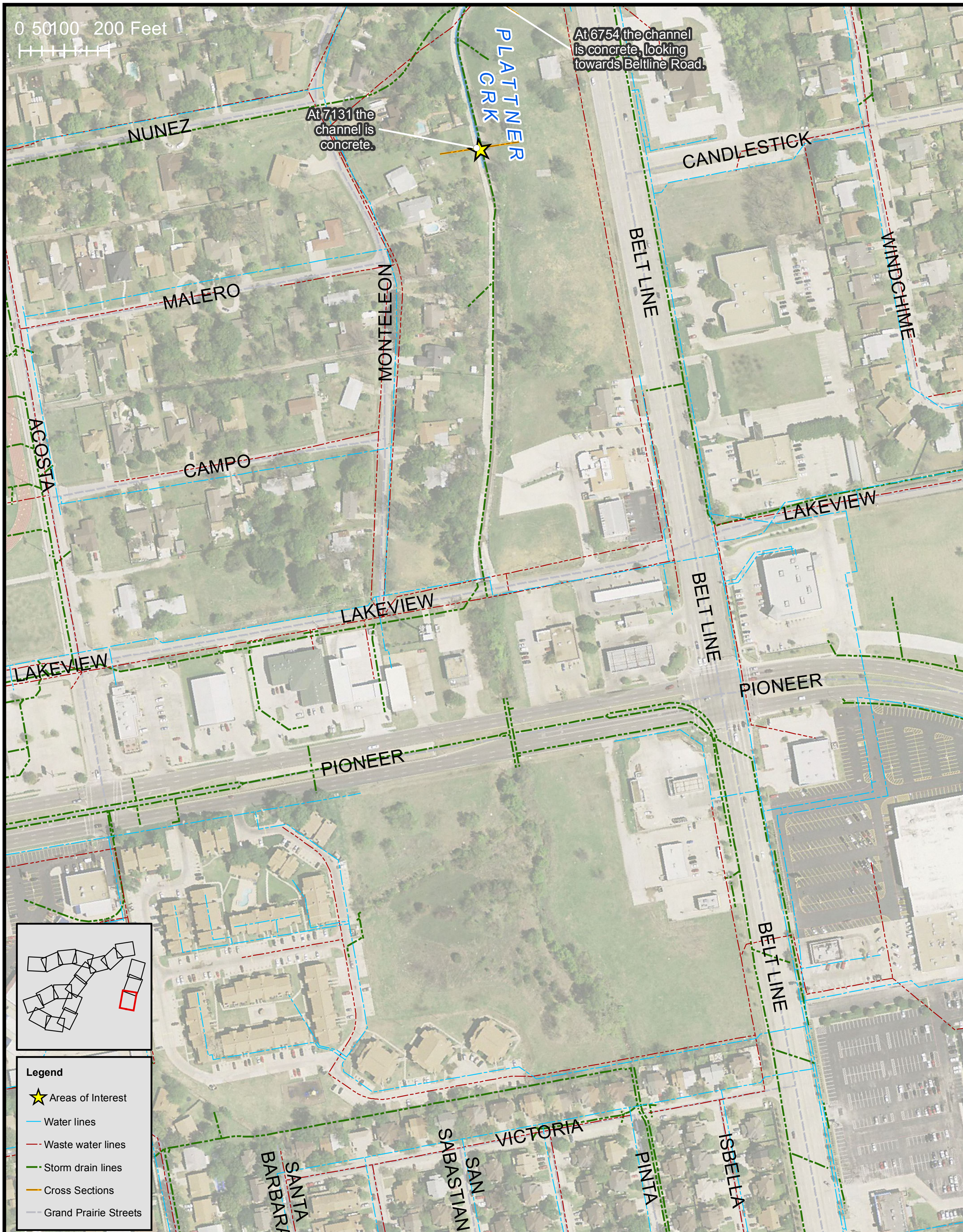

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FIGURE

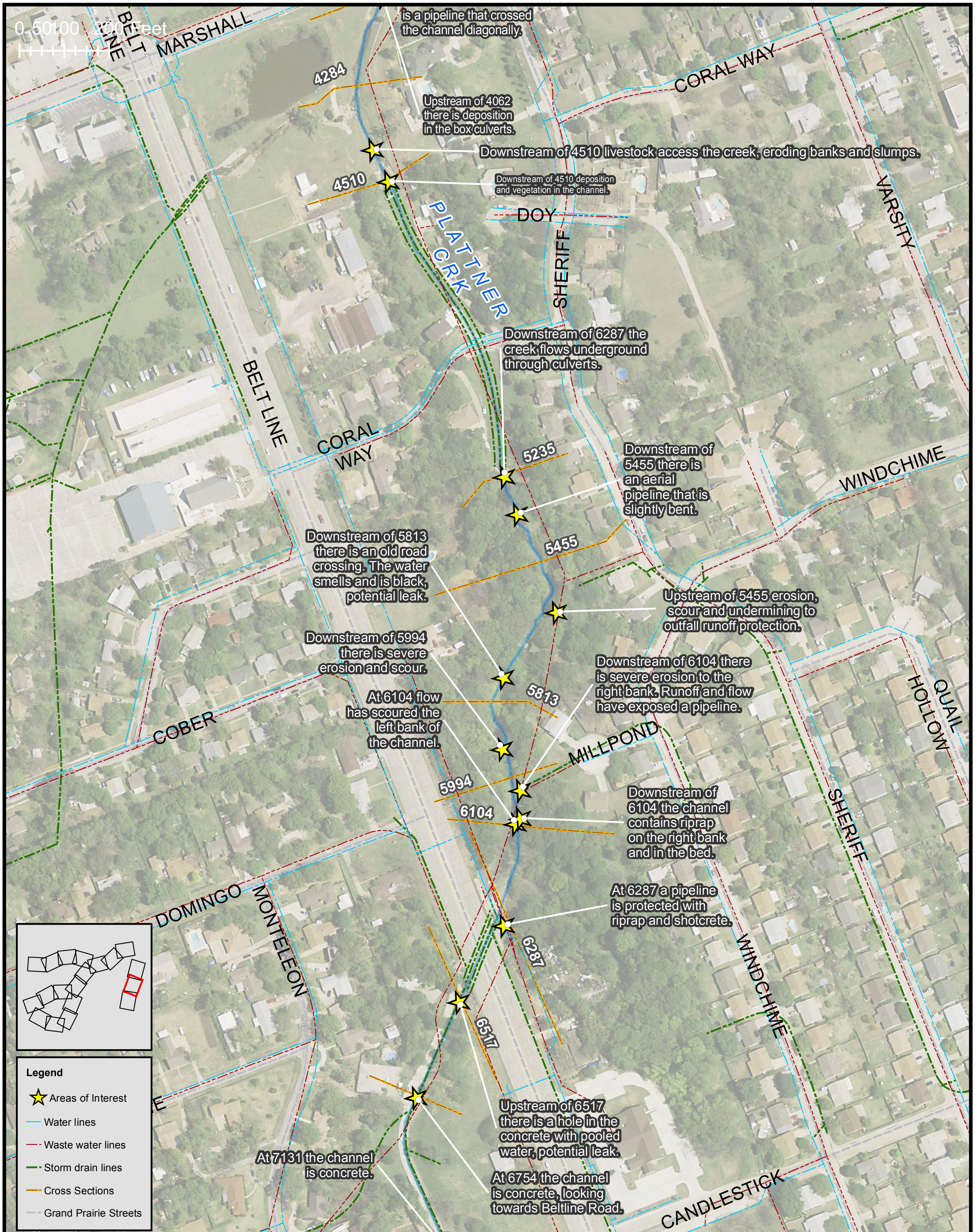

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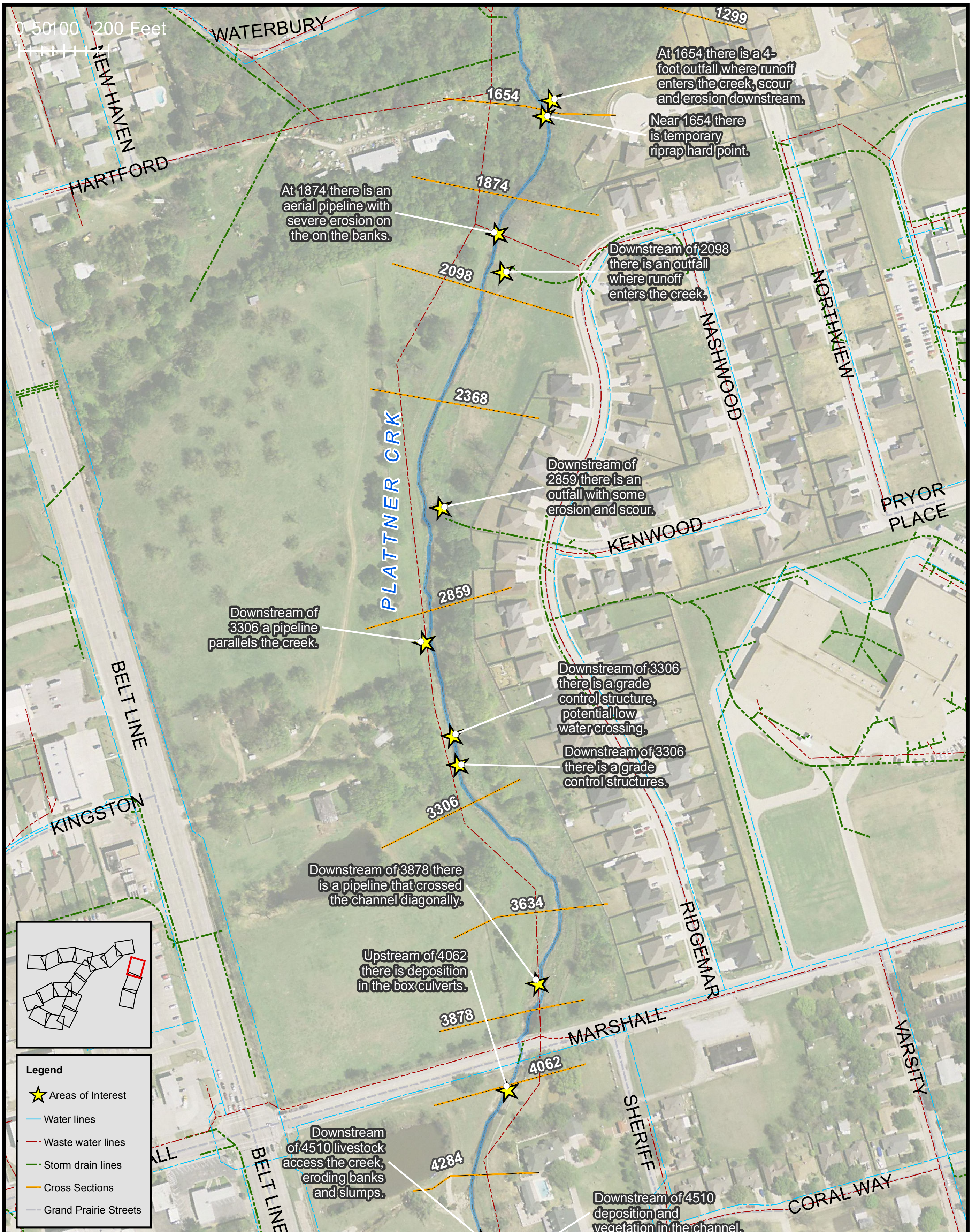
FIGURE



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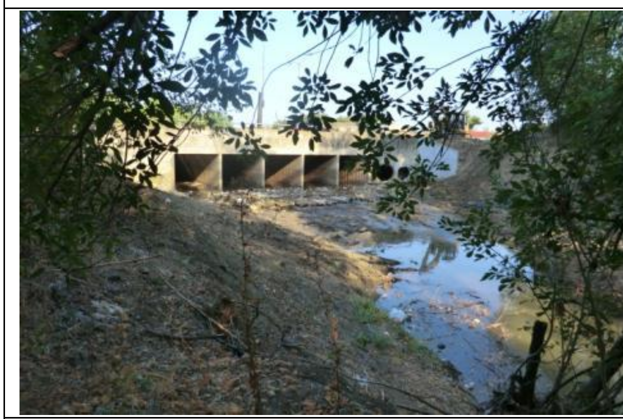
B19

FIGURE

Upstream of 11107 there is a concrete drop structure with a 4-foot drop, severe erosion and scour downstream.

Upstream of 10550 there is riprap/shotcrete protection and flow is undermining the left side.



Downstream of 10386 the area is under construction (adding more riprap).

Downstream of 10207 there is severe bank erosion on the right bank.

Downstream of 10053 the banks are slumping.

Downstream of 9883 there is a gully on the right bank, scour and erosion to the stream.

North Fork of Cottonwood Creek (11107-9883) upstream and downstream of Great Southwest Hwy

Left and right bank views assume downstream direction

	
Near 9817 (railroad) the channel bed is armored with riprap/shotcrete, acting as a hard point.	Right bank at 9817 bank heights increase, bank slopes steepen and there is a decrease in floodplain connection under the railroad.
	
Left bank at 9817 in addition to flow, runoff is cutting a new channel around the channel armoring.	Left bank at 9817, channel that has cut around the channel armoring, channel has been filled with additional riprap.
	
Right bank near 9769 there is bank erosion.	At 9658 the channel banks have early succession vegetation. The channel splits into two channels with a mid-channel bar.

North Fork of Cottonwood Creek (9817-9658) downstream of Great Southwest Hwy

Left and right bank views assume downstream direction

	
Downstream of 9658 the channel bed is shale.	Downstream of 9368 there is a beaver dam ponding water keeping shale temporarily wet.
	
Downstream of 9368 the banks are slumped and have early succession vegetation.	Downstream of 9153 on the right bank there is erosion at the outfall and it is broken apart up into the field.
	
Upstream of 8720 there is a beaver dam keeping the shale wet. Slaking on the banks, drying out, and no shade.	Upstream of 8720 there is a concrete protected pipeline acting as a hard point.

North Fork of Cottonwood Creek (9658-8720) downstream of Great Southwest Hwy

Left and right bank views assume downstream direction

	
Downstream of 8720 there is a concrete channel with overflow into a retention pond.	Between 8720 and upstream of 7881 the concrete is spalling in the channel bed.
	
Upstream of 7881 there is deposition growing vegetation in the concrete channel.	Upstream of 7881 there is a concrete drop with a 2.5-foot drop.
	
Right and left bank near 7881, riprap and fabric are moved and water can flow behind the wall.	At 7440 the culverts are blocked with trash and woody debris.

North Fork of Cottonwood Creek (8720-7440) downstream of Great Southwest Hwy, upstream of detention ponds.

	
Slopes adjacent to the sting of ponds have some gully and rill erosion (5621)	At 2634 concrete channel stops upstream of the construction of Hwy 161.
	
At Hwy 161there is erosion behind gabion baskets.	Hwy 161 bridge pier are in the channel bed.
	
Under Hwy 161 there is gully erosion to some of the piers for the access road.	At 2170 there is a pipeline with riprap/shotcrete protection. There is a 4-foot drop acting as a hard point.

North Fork of Cottonwood Creek (5621-2170) upstream of Hwy 161 and downstream of detention ponds.

Left and right bank views assume downstream direction

Downstream of 2170 to 859 the channel is ponded and appears to have been straightened.

Downstream of 1775 to downstream of 1291 the base of the left bank slope is armored with riprap.

At 859, Carrier Parkway is acting as a hard point.

At 701, left bank, scour behind the wing walls at an outfall.

Upstream of 352 is a pipeline exposed in the channel bed.

At 352, right bank there are gabions exposed.

North Fork of Cottonwood Creek (2170-352) upstream and downstream of Carrier Parkways.

Left and right bank views assume downstream direction

	
Downstream of 17616 the creek is a braided system.	Downstream of 17466 was the main channel at one time.
	
Upstream of 17281, photo shows where GIS center line is. This location is not the main channel.	Upstream of 16891 the channel is incising.
	
At 16685, Great Southwest Parkway is a hard point made of riprap/shotcrete.	Downstream of 16546 is severely scoured with a 4-foot drop. There is a siltstone/shale outcrop.

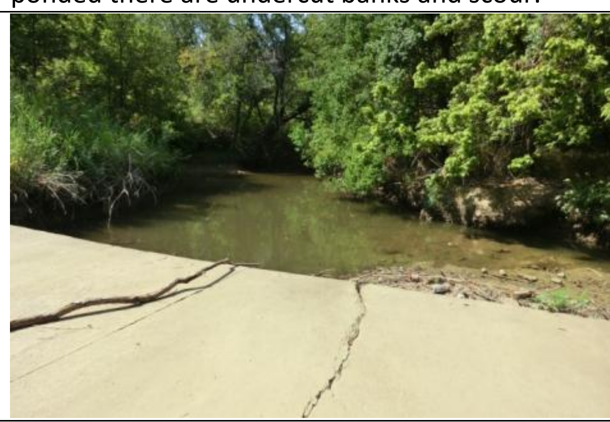
South Fork of Cottonwood Creek (17616-16546) upstream and downstream of Great Southwest Hwy

Left and right bank views assume downstream direction

	
Downstream of 16285 are two chute cutoff's in a row.	Upstream of 15904 there is a 3-foot knickpoint.
	
At 15904 the channel incision is about 5 feet deep and 3 feet wide.	Downstream of 15904 there is light blue gray siltstone, stream flow is against the dip of the formation (Bledsoe
	
At 15583 there is evidence of slumping and the fence line is 50 feet from bank.	Downstream of 15583 the meanders expose siltstone/shale.

South Fork of Cottonwood Creek (16285-15583) downstream of Great Southwest Hwy and upstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 14885 there is a concrete encased pipeline acting as a hard point.	Near 14701 there are apartments on the right side of the creek.
	
At 14301, Pioneer Parkway has 3 box culverts and 2 are clogged with sediment.	Near 13908 there is evidence that the creek was ponded there are undercut banks and scour.
	
At 13479 there is a chute cutoff that is used during higher flows.	At 13479 water backs up behind this low water crossing.

South Fork of Cottonwood Creek (14885-13479) upstream and downstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 13479 there is severe erosion and scour and the culverts are blocked. The low water crossing is acting as a hard point.	Downstream of 13479 there is a debris jam, tree falls and soil erosion.
	
Near 13237 high water flows across the floodplain.	Upstream of 12822 there is a sheet metal fence over the channel acting as a debris jam.
	
Downstream of 12822 there is a chute cutoff.	Downstream of 12822 there is a debris jam and a deep scour that is pool mining shale.

South Fork of Cottonwood Creek (13479-12822) downstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 12421 there is an aerial pipeline and the channel appears to be widening.	Downstream of 11967 there is a low water crossing with a 3-foot drop in elevation.
	
Upstream of 11238 there is a potential pipeline crossing under concrete protection.	Upstream of 10803 there is a potential pipeline crossing under concrete protection.
	
Near 10047 there is shale exposed, severe erosion (typical of areas with exposed shale).	Downstream on the left bank near 10047 an outfall flows over exposed shale, 9-foot drop in elevation, and erosion at headwall.

South Fork of Cottonwood Creek (12421-10047) downstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 9420 there is a concrete encased pipeline being undermined.	Upstream of 9021 there is an outfall with a scour pool that is undercutting the outfall.
	
Downstream of 9021 there is a cutoff. Note 2-foot knickpoint migrating up the cutoff.	Upstream, left bank near 8274, outfall with erosion behind the wing wall and 2 feet of scour.
	
Upstream of 7344, severe erosion, concrete slab has shifted and the pier is exposed. There is a 4-foot drop in elevation on the downstream side.	Near 7344 slumping of the banks.

South Fork of Cottonwood Creek (9420-7344) downstream of Pioneer

Left and right bank views assume downstream direction

	
At 6876 there is aerial pipeline. The channel bottom is protected with riprap and shotcrete.	Downstream of 6732 looking at the temporary construction road over the creek.
	
Downstream of 6732 there is erosion on the meander. Consider checking the riprap and fabric on the slope.	Upstream of 6114 looking at the newly constructed piers in the channel.
	
At 6114 there is a temporary road crossing.	Upstream of 5996 under the Hwy 161 access road, there is gully erosion.

South Fork of Cottonwood Creek (6876-5996) under Hwy 161

	
Downstream of 5996 there is a concrete protected pipeline acting as a hard point.	Downstream of 5502 is the confluence with Warrior Creek.
	
Upstream of 5157 there is a concrete protected pipeline acting as a hard point.	Downstream of 4790 there is a broken culvert and a 4-foot segment has fallen into the creek. Meander is migrating and the fence is 10 feet away
	
Downstream of 4790 there is a fence causing a debris jam and local scour. Consider removing.	At 4435 exposed shaley silt stone from the Woodbine, it is erodible.

South Fork of Cottonwood Creek (5996-4435) downstream of Hwy 161

Left and right bank views assume downstream direction

	
Downstream of 4435 there is a concrete encased pipeline acting as a hard point.	Downstream of 3739, potential high flow or abandoned channel.
	
Upstream of 3387, severe erosion to gabion baskets and concrete pipeline protection.	Upstream of 3120, there is an exposed pipeline. Severe bank erosion, wedge failures and soil loss.
	
Downstream of 3120 the bank is slumping.	Upstream of 2852 there is an aerial pipeline.

South Fork of Cottonwood Creek (4435-2852) upstream of Robinson Road

Left and right bank views assume downstream direction

	
At 2852, upstream of Robinson Road there is scour behind the wing wall from stormwater runoff.	At 2473, upstream of Marshall Road the channel is armored with riprap/shotcrete. The bank are slumping between Robinson Rd and Marshall Rd.
	
At 2341 the channel is protected with riprap/shotcrete.	Downstream from 2341 there is severe bank erosion, scour and bank failures.
	
Slumping banks typical of the reach 2341 to 1142.	Carrier Parkway near 761 is acting as a hard point, ponded upstream and downstream.

South Fork of Cottonwood Creek (2852-761) upstream and downstream of Robinson Road and upstream of Carrier Parkway

	
Downstream of 761 the water surface elevation used to be higher, note cypress knees.	The aerial walking path at 346 has erosion to the supports.
	
Downstream of 346 there is a broken outfall from local scour.	Low water dam at the confluence of the North Fork and the South Fork of Cottonwood Creek (acting as a hard point).

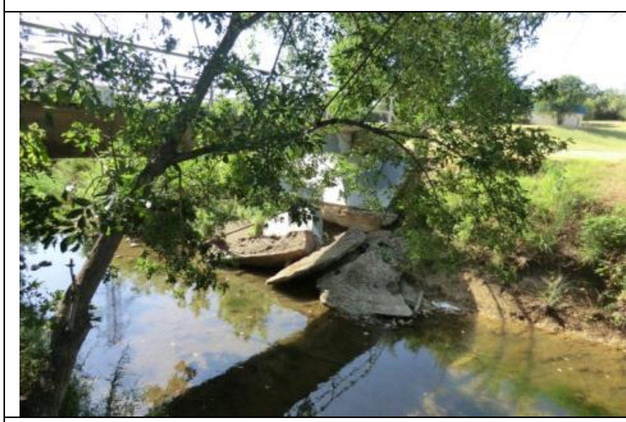
South Fork of Cottonwood Creek (761-346) downstream of Carrier Parkway

Left and right bank views assume downstream direction

	
Downstream of 12645 there is erosion to the dam structure.	Downstream of 12645 there is severe erosion on both banks.
	
Downstream of 12645 the gabion mattress on the left bank is exposed.	Downstream of 12482 there is an aerial pipeline with erosion and scour to the bank protection.
	
Downstream of 12482 there is severe erosion and failures on a bank near an aerial walking path.	Downstream of 12482 there are tree falls and slumped banks.

Cottonwood Creek (12645-12482) upstream of SW 3rd bridge crossing

Left and right bank views assume downstream direction

	
Upstream of 12147 there is an exposed pipeline and gravel bar formation on the upstream side.	From 12482 to 10760 the banks are eroding and slumping (worse on banks that are mowed with sparse vegetation).
	
At 11493 a drainage gully is eroding.	Near 11493 a drainage way protected with concrete is slightly undermined.
	
Downstream of 11042 there is collapse of the bridge foundation.	At 10760 a pipeline is exposed in the channel bed, crosses the creek diagonally.

Cottonwood Creek (12147-10760) upstream of SW 3rd bridge crossing

Left and right bank views assume downstream direction

	
At 10760, Southwest 3rd bridge no sign of channel bed armoring.	Downstream of 10676 there is a cracked outfall pipe on the left bank.
	
Between 10676 and 9744 the banks are undercut and slumping.	Downstream of 9744 there is a collapsed gabion structure. Ponding upstream and scour hole downstream (a dumpster is in the scour hole).
	
Downstream of 9744 the gabion structure the scour has exposed a pipeline that parallels the creek.	Downstream of 9744 major transition in stream type downstream of scour pool (inset, meandering channel within riparian corridor).

Cottonwood Creek (10760-9744) downstream of SW 3rd bridge crossing

Left and right bank views assume downstream direction

	
Upstream of 8570 there is riprap bank and bed protection, temporary hard point (severe bank erosion and a chute cutoff at this location).	Downstream of 8570, typical view of creek with eroding banks, exposed roots and bank failures.
	
Upstream of 7300 a pipeline crossing protected by concrete rubble.	Upstream of 7300 use to be a road.
	
Downstream of 6495 (confluence with a tributary) the creek transitions to a channel that has high connection to the floodplain.	Downstream of 5978 there is two pipelines protected with concrete or gabions.

Cottonwood Creek (8570-5978) downstream of SW 3rd bridge crossing and upstream of Beltline

Left and right bank views assume downstream direction

	
Downstream of 5978 the concrete protection drops 3feet in elevation (scoured and undercut).	Beltline Road at 5320, aggradation and debris jams under the bridge.
	
Downstream of 5211 (Beltline Road) there is a hard point (potential pipeline protection) that drops 3 feet in elevation.	End of City Limits (Study Area) 3730. Channel is pooled with undercut banks and flows have connection to the floodplain.

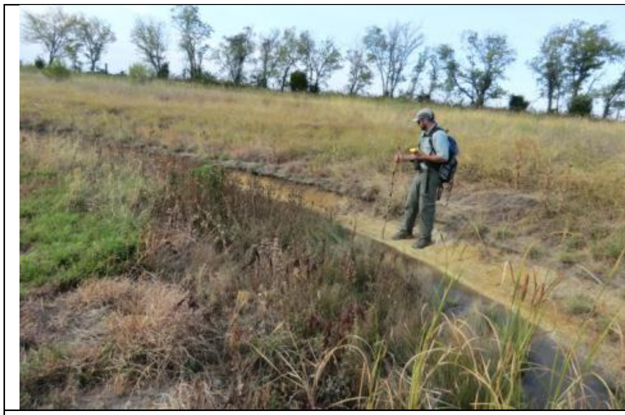
Cottonwood Creek (5978-City Limits) downstream of Beltline

Left and right bank views assume downstream direction

	
Great Southwest Parkway downstream of 1. Erosion from local scour.	Reach pools from 1 to just downstream of 2. Scour line on the banks with minor slumping.
	
Downstream of 2 there is a gully and rill erosion on the banks.	Downstream of 2 there is a gabion structure crossing the channel inducing local scour.
	
Downstream of 2 on the meander, near vertical bank, exposed erosion control, and 3 feet deep.	Upstream of 3 erosion control is exposed, stops abruptly, and erosion is evident around the brunch grass, mowed to short.

Warrior Creek (1-3) downstream of Great Southwest

Left and right bank views assume downstream direction

	
Upstream of 3 there is scour and knickpoint with a 6 inch drop in elevation.	Upstream of 3 is outfall on the left bank with riprap/shotcrete channel protection.
	
Typical view from 3 to 4, channel is filled with vegetation and flows have scoured the sides.	Between 3 and 4 is outfall on the left bank with riprap/shotcrete channel protection.
	
Upstream of 4 flows move around grade control check dam. Material is in place consider placement up the bank.	Between 3 and 4 there is an outfall on the left bank with riprap/shotcrete channel protection.

Warrior Creek (3-4) downstream of Great Southwest

Left and right bank views assume downstream direction

	
Upstream of 4 is grade control, flows have moved some of the material.	Upstream of 5 at the first pond, erosion to the bank downstream of the protection with minor bed scour.
	
Downstream of 5 there is grade control in the channel.	Downstream from 5, typical view of channel, narrow with undercut banks and vegetation.
	
Downstream of 6 the channel transitions into riparian corridor.	Downstream of 7 there is a black corrugated pipe in the channel.

Warrior Creek (4-7) downstream of Great Southwest

Left and right bank views assume downstream direction

	
Downstream of 7, corrugated pipe, typical channel view.	Downstream of 8 there is a debris jam with a 1-foot knickpoint.
	
Downstream of 9 there is grade control with 1-foot drop in elevation. Neighborhood drains to this location.	Downstream of 9 there is channel protection upstream and downstream of the driveway.
	
Near 10 there is an aerial walking path, slopes in the creek are indicating signs of movement and footers are leaning.	Downstream of 10, driveway with two culverts and riprap bed and bank protection.

Warrior Creek (7-10) downstream of Great Southwest and upstream of driveway

Left and right bank views assume downstream direction

	
Downstream of 11 there is an aerial walking path, slopes in the creek are indicating signs of movement and footers are leaning.	Downstream of 11 there is about a 1-foot drop and soil erosion on the banks.
	
Downstream of 11, banks have tension cracks parallel to the creek.	Near 12 tension cracks indicating potential slope movement.
	
Downstream of 12 there is bank scour on the meander.	Downstream of 12 has been scoured.

Warrior Creek (11-12) upstream of West Freeway

Left and right bank views assume downstream direction

	
Downstream of 12, right bank has severe gullies. Runoff from the parking area all drains to this location (undermining the bank protection).	Upstream of 13 gully formation water can flow under the riprap, and there is potential for undermining.
	
Upstream of 13 there is bank erosion, sparse vegetation and lacking topsoil. .	Looking towards 14, upstream from Hwy 161. Creek joins retention ponds.

Warrior Creek (12-14) upstream of Hwy 161

Left and right bank views assume downstream direction

	
Near 3079, left bank, employee expressed concern about the slope moving.	Downstream of 3079 there is scour and undercutting.
	
Downstream of 3079 there is erosion and cracks in the concrete structure.	Downstream of 3079 there is an exposed pipeline crossing the creek diagonally.
	
Downstream of 3079, more water enters the creek, local scour to the banks.	Downstream of 3079 there is an exposed gas pipeline and severe bank erosion.

Warrior Creek (3079) downstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 3079 there is a drop in channel bed elevation.	At 2787 there is a debris jam.
	
Downstream of 2787 there is a 4-foot drop in elevation (knickpoint/scour pool).	Downstream of 2787 there is a 2-foot drop in elevation
	
Downstream of 2787 there is a 1.5-foot drop in elevation (potential for grade control or drop structure).	Downstream of 1938 there is severe erosion, scour, weathered shale/siltstone, and tree falls.

Warrior Creek (3079-1938) downstream of Pioneer

Left and right bank views assume downstream direction


Downstream of 1649 there is riprap that is possibly protecting a pipeline.


Near 1428 the banks are undercut and houses are along the top of bank.


Downstream of 1428 there is an air dam from a big rig in the channel blocking flow and inducing scour.


Downstream of 1202 there is a severely eroding bank.


Downstream of 1202 there is an illegal trash dumping site (recent-milk container dated 7/9/11).


Downstream of 1202 there is a 2-foot knickpoint with debris jam.

Warrior Creek (1649-1202) downstream of Pioneer

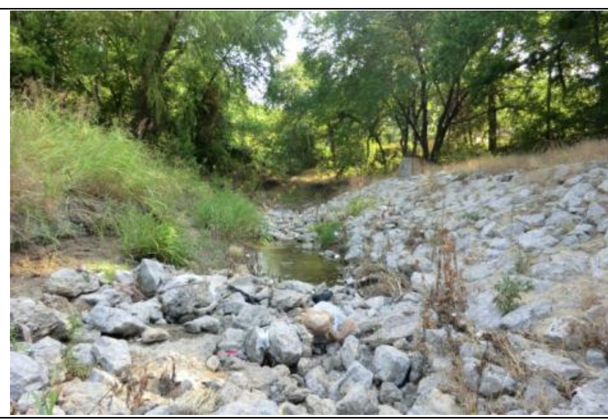
Left and right bank views assume downstream direction

	
Downstream of 945 there is a 3-foot knickpoint into shale.	Downstream of 945 there are large bank failures.
	
Upstream of 689 there is a man hole in channel potential leak water is back and smells. Water is ponded at the outfall upstream.	At 689 there are sandbags in the channel.
	
Downstream of 689 there is a broken outfall on the right bank.	Downstream of 433 the channel has cut into the shale forming knickpoints.

Warrior Creek (945-433) downstream of Pioneer and upstream of the confluence with Cottonwood Creek

	
Downstream of 433 the channel is entrenched.	Downstream of 182 there is a hard point, concrete protected pipeline.

Warrior Creek (433-182) downstream of Pioneer and upstream of the confluence with Cottonwood Creek

	
At 7131 the channel is concrete.	Upstream of 6517 there is a hole in the concrete with pooled water, potential leak.
	
At 6754 the channel is concrete, looking towards Beltline Road.	At 6287 a pipeline is protected with riprap and shotcrete.
	
At 6104 flow has scoured the left bank of the channel.	Downstream of 6104 the channel contains riprap on the right bank and in the bed.

Plattner Creek (7131-6104) Concrete channel downstream of Pioneer

Left and right bank views assume downstream direction

	
Downstream of 6104 there is severe erosion to the right bank. Runoff and flow have exposed a pipeline.	Downstream of 5994 there is severe erosion and scour.
	
Downstream of 5813 there is an old road crossing. The water smells and is black, potential leak.	Upstream of 5455 erosion, scour and undermining to outfall runoff protection.
	
Downstream of 5455 there is an aerial pipeline that is slightly bent.	Downstream of 6287 the creek flows underground through culverts.

Plattner Creek (6104-6287) downstream of Beltline

	
Downstream of 4510 deposition and vegetation in the channel.	Downstream of 4510 livestock access the creek, eroding banks and slumps
	
Upstream of 4062 there is deposition in the box culverts.	Downstream of 3878 there is a pipeline that crossed the channel diagonally.
	
Downstream of 3306 there is a grade control structures.	Downstream of 3306 there is a grade control structure, potential low water crossing.

Plattner Creek (4510-3306) upstream and downstream of E. Marshall Dr

	
Downstream of 3306 a pipeline parallels the creek.	Downstream of 2859 there is an outfall with some erosion and scour.
	
Downstream of 2098 there is an outfall where runoff enters the creek.	At 1874 there is an aerial pipeline with severe erosion on the on the banks.
	
Near 1654 there is temporary riprap hard point	At 1654 there is a 4-foot outfall where runoff enters the creek, scour and erosion downstream.

Plattner Creek (3306-1654) downstream of E. Marshall Dr

Left and right bank views assume downstream direction

Appendix C

Results of bed material grain size analysis for the study reaches

	Cross-section	D_{50} (mm)	D_{90} (mm)
North Fork CWC	7881	5.3	19.5
North Fork CWC	701	3.6	13.0
South Fork CWC	346	2.1	7.9
Warrior Creek	8841	4.1	12.0
Warrior Creek	2417	5.3	19.0
Plattner Creek	2098	3.4	15.0

Figure C1 Bed material gradation from sieve analysis – North Fork Cottonwood Creek Cross-section 7881

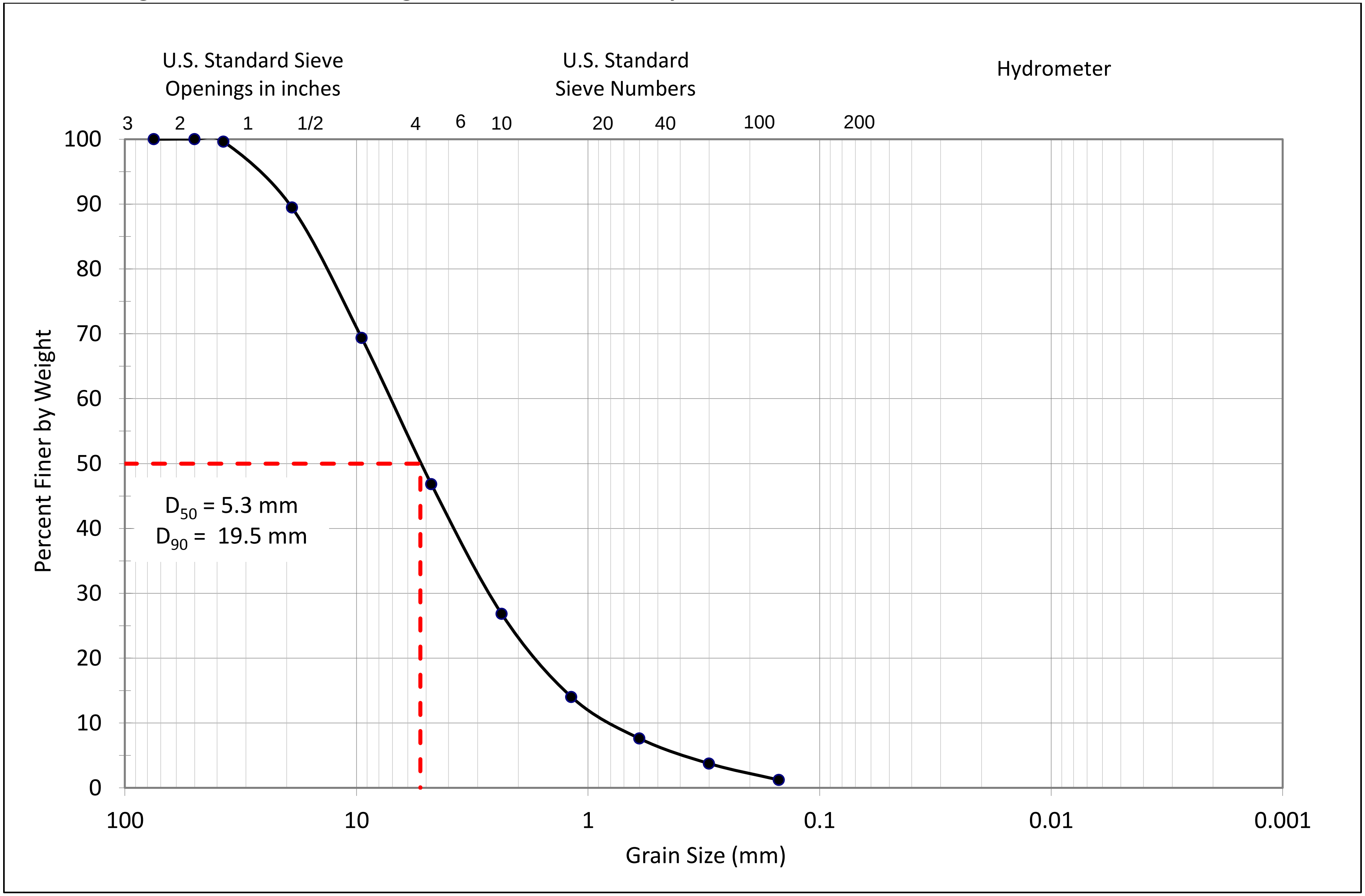


Figure C2 Bed material gradation from sieve analysis – North Fork Cottonwood Creek Cross-section 701

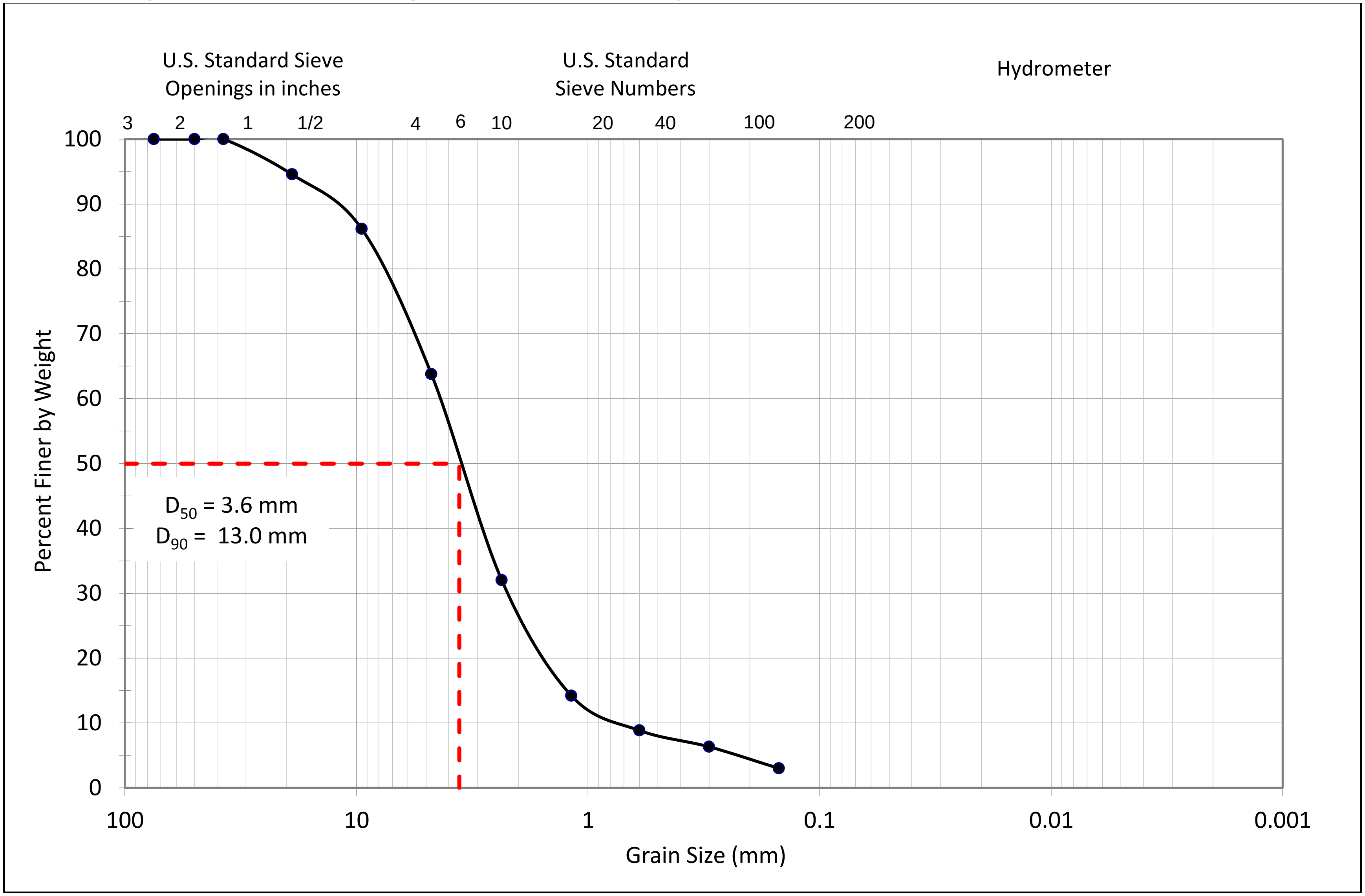


Figure C3 Bed material gradation from sieve analysis – South Fork Cottonwood Creek Cross-section 346

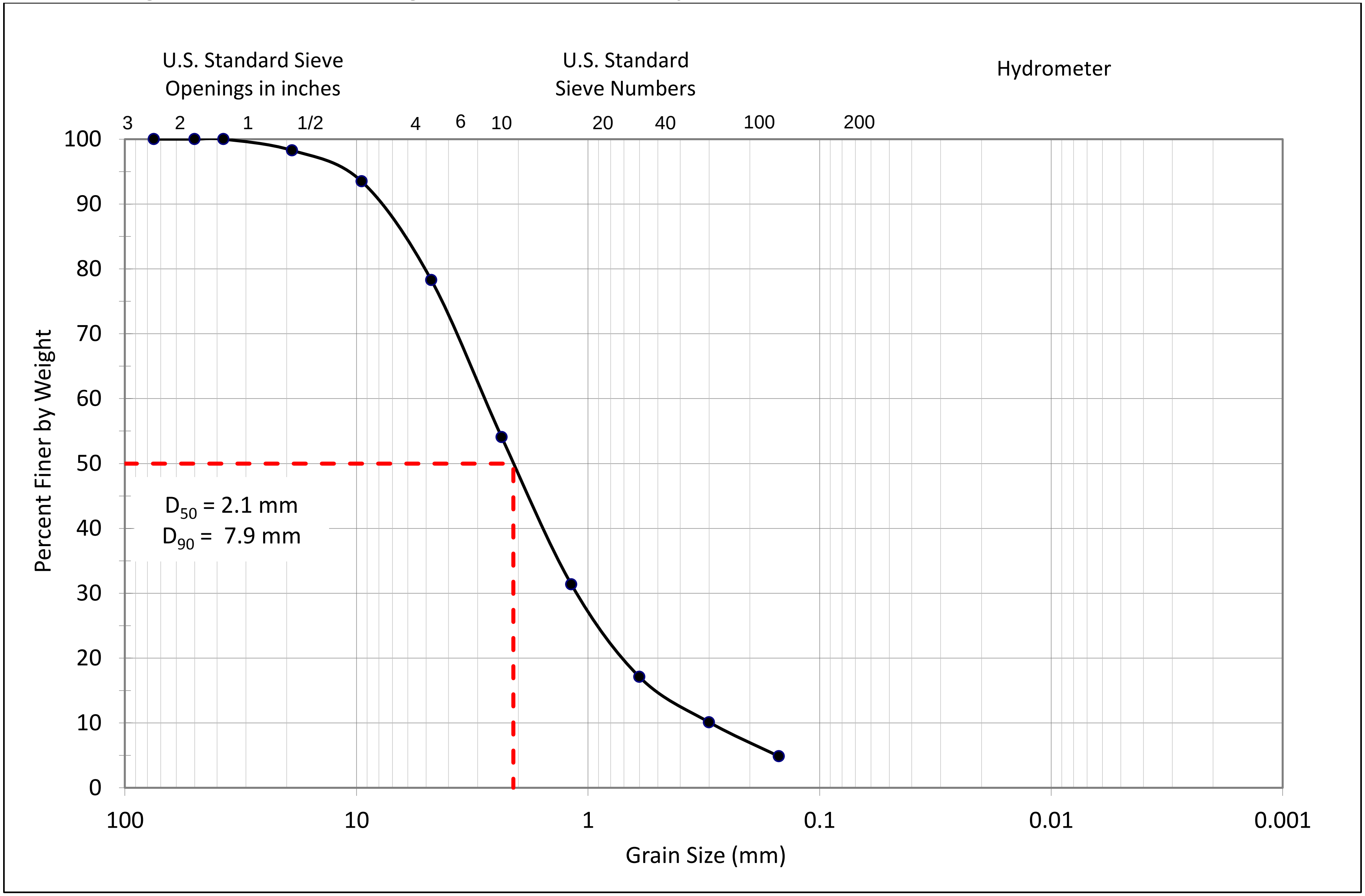


Figure C4 Bed material gradation from sieve analysis – Warrior Creek Cross-section 8841

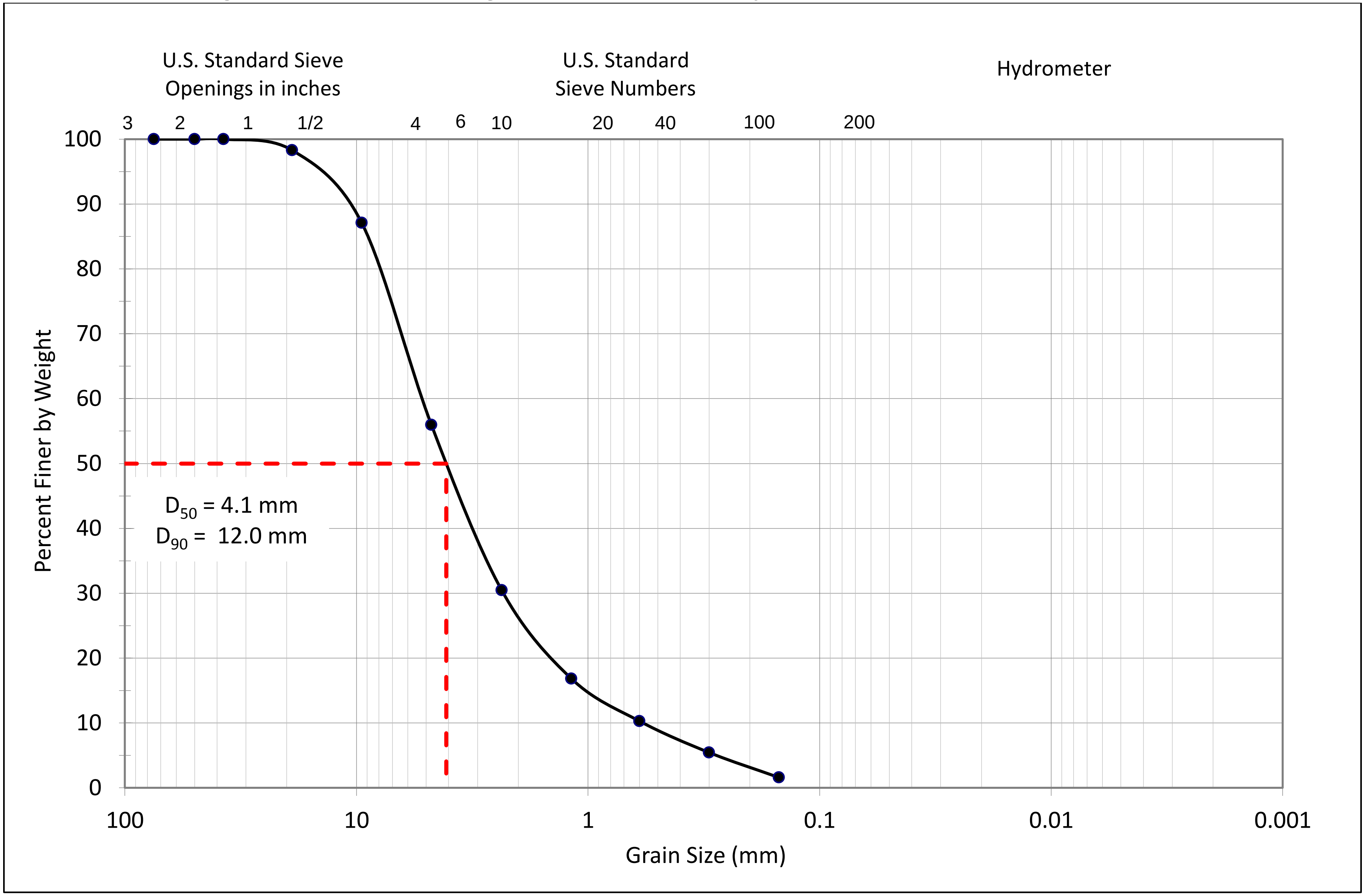


Figure C5 Bed material gradation from sieve analysis – Warrior Creek Cross-section 2417

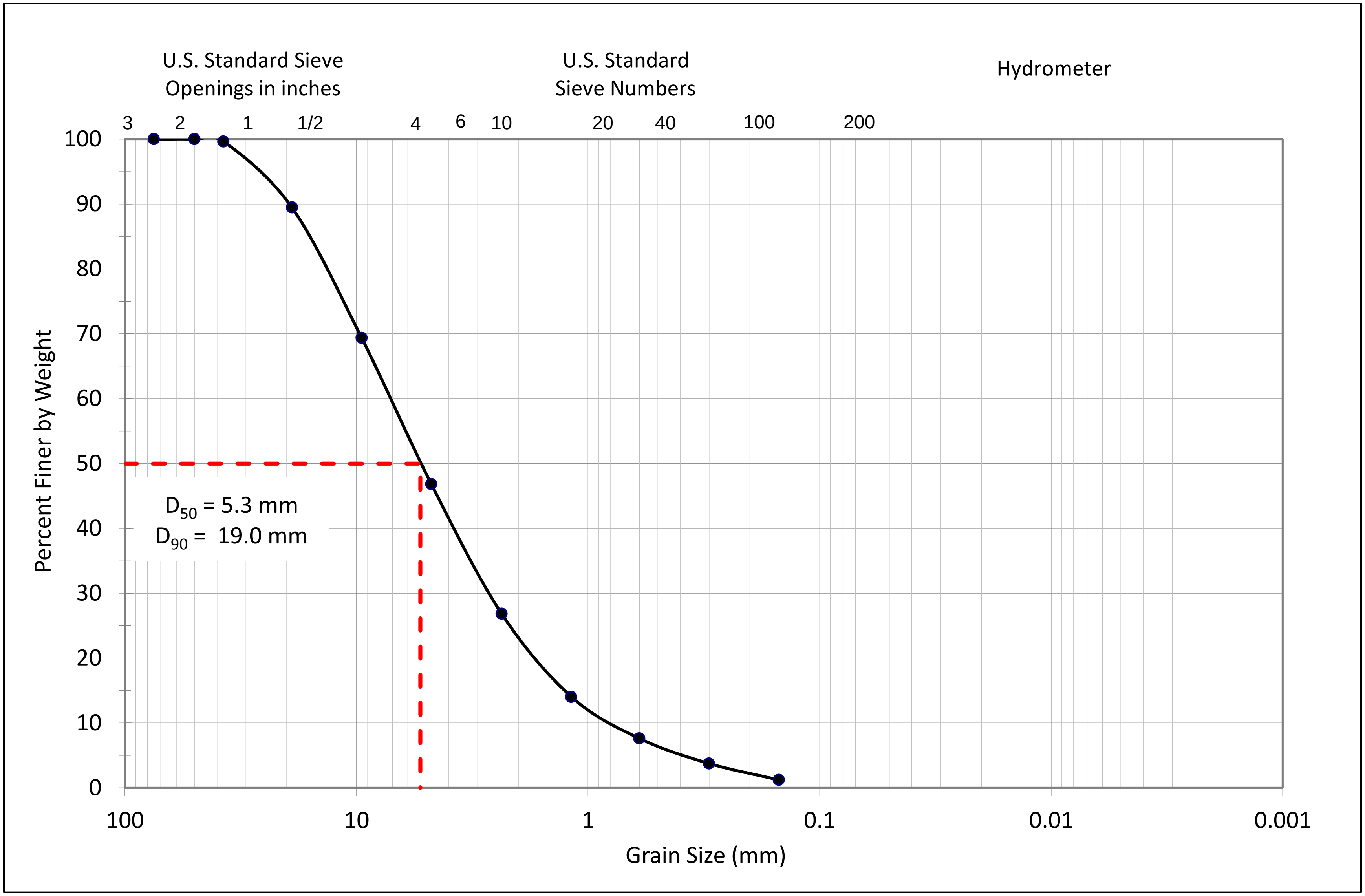
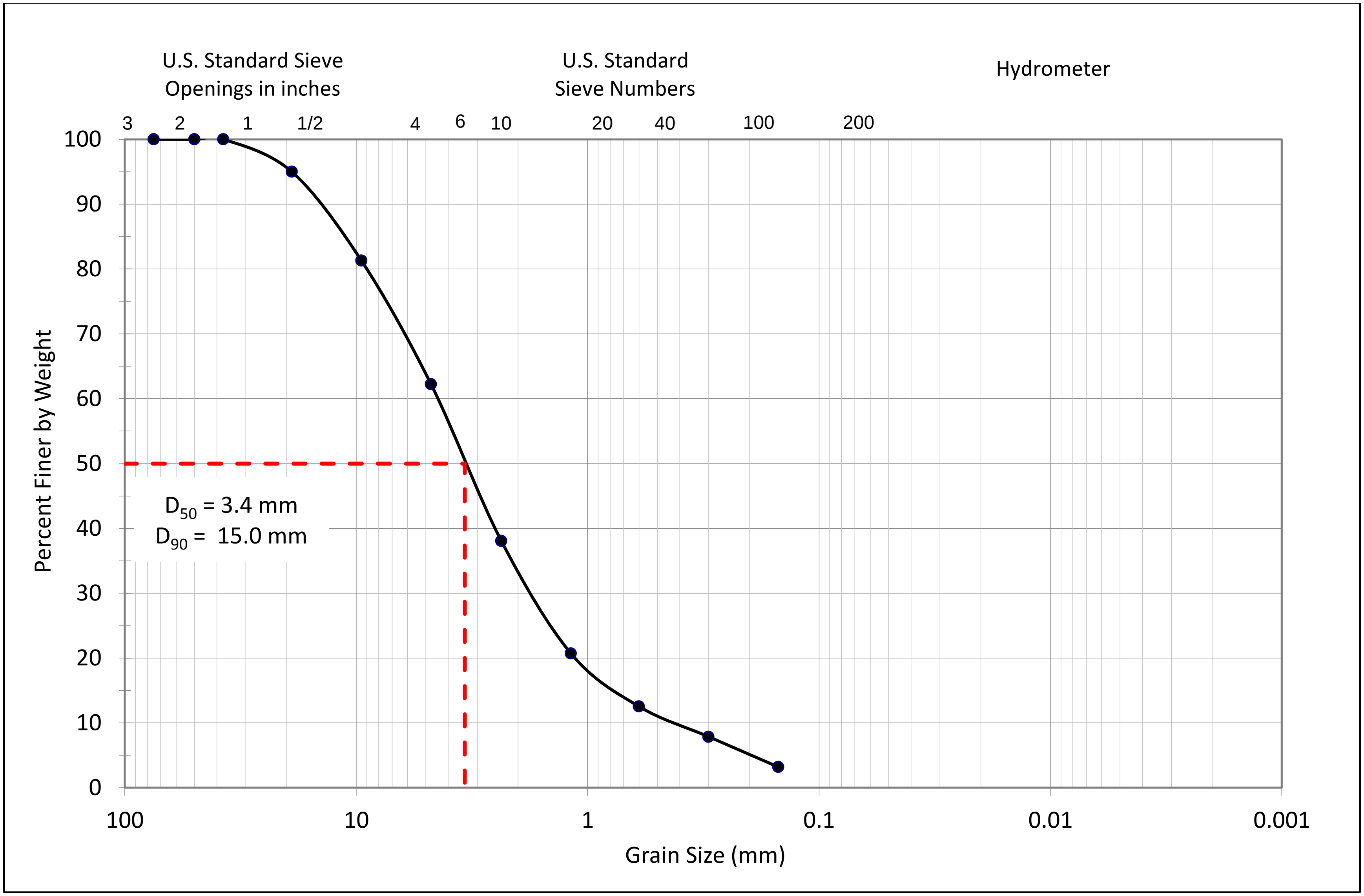
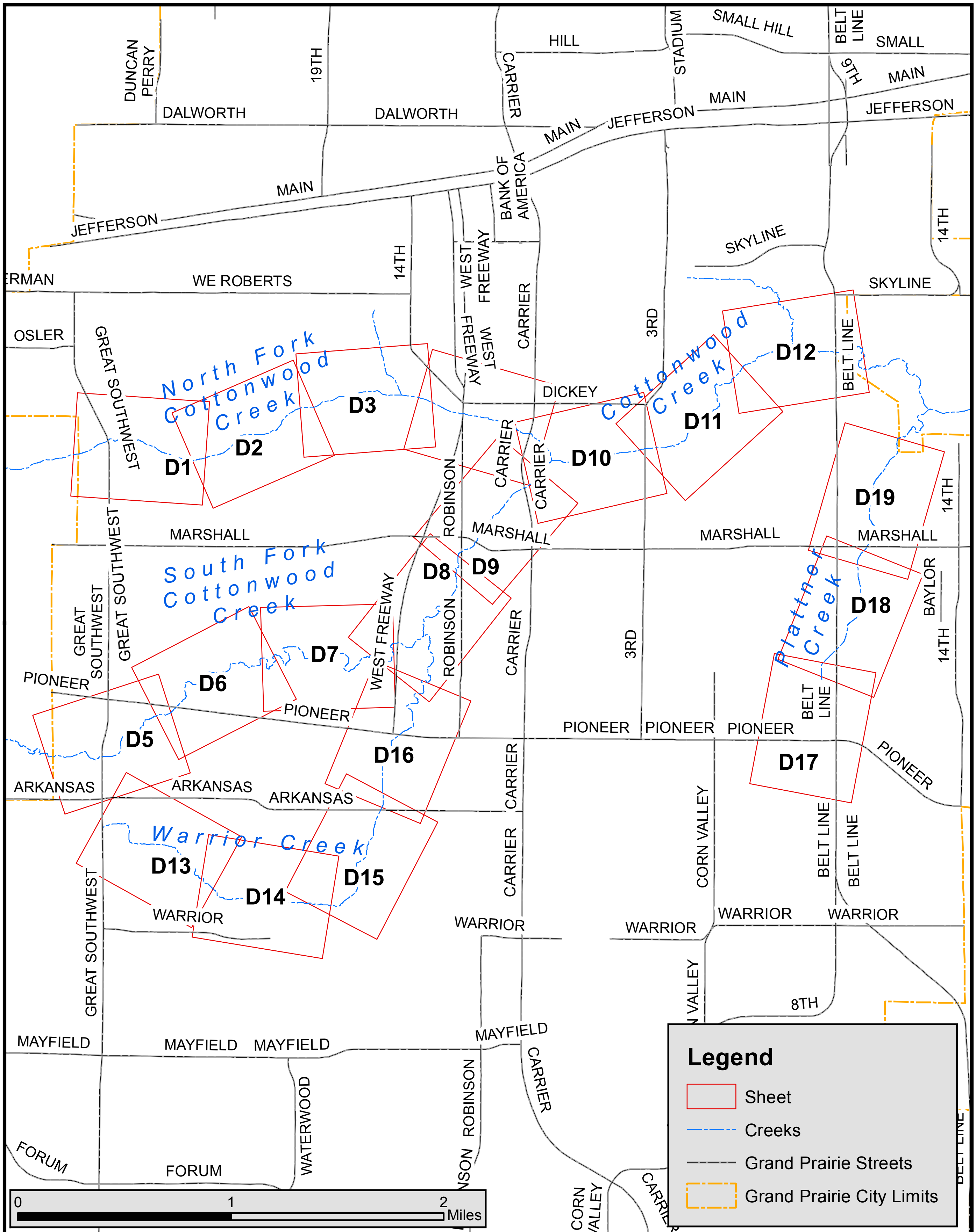


Figure C6 Bed material gradation from sieve analysis – Plattner Creek Cross-section 2098



Appendix D



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Cottonwood Creek
Geomorphic Stream Assessment

Areas of Interest
Page Index

FN JOB NO	ESP11227
FILE	APP_D_erosion_index.mxd
DATE	June 21 2012
SCALE	1:40,000
DESIGNED	SVC
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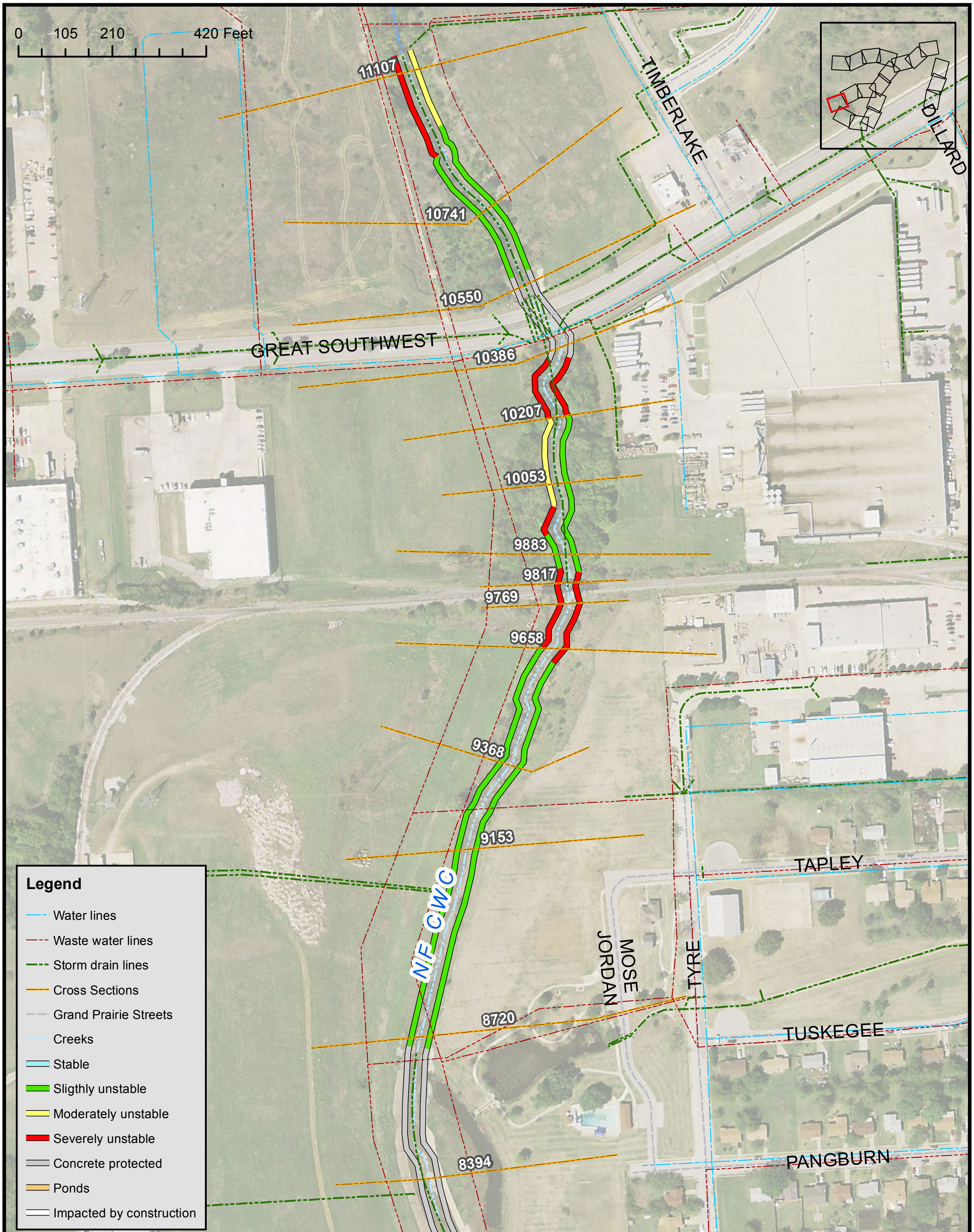

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Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

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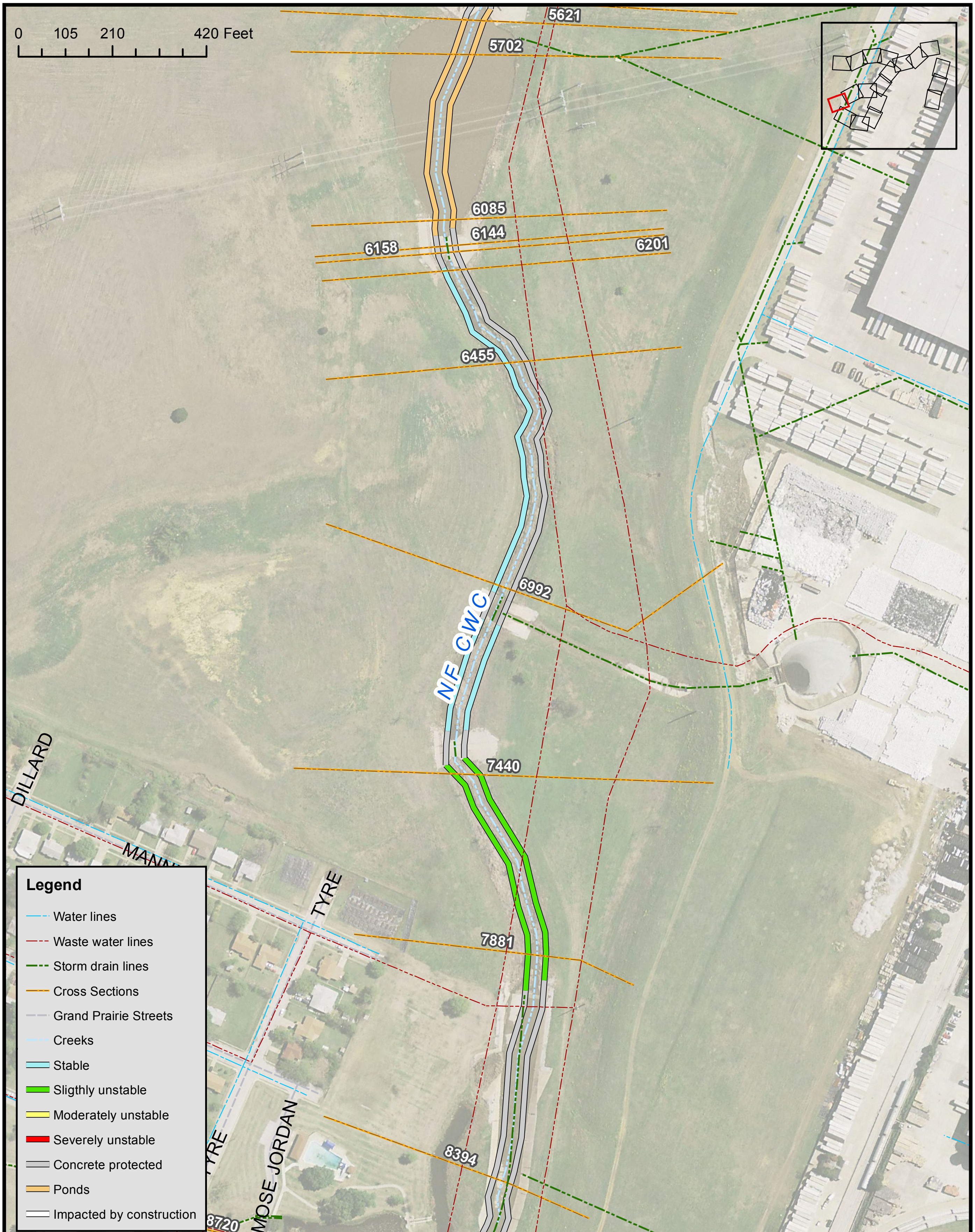

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Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

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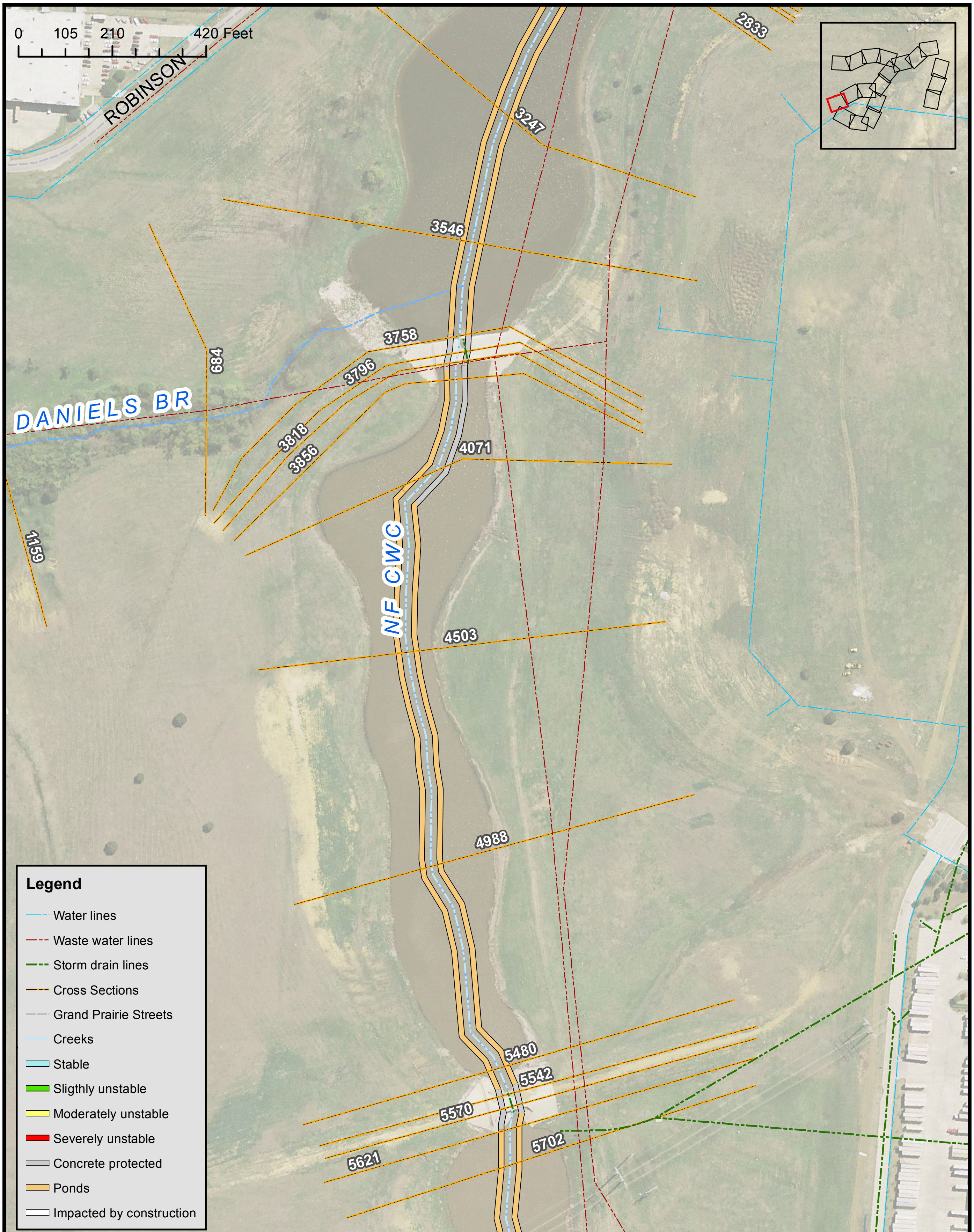

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Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

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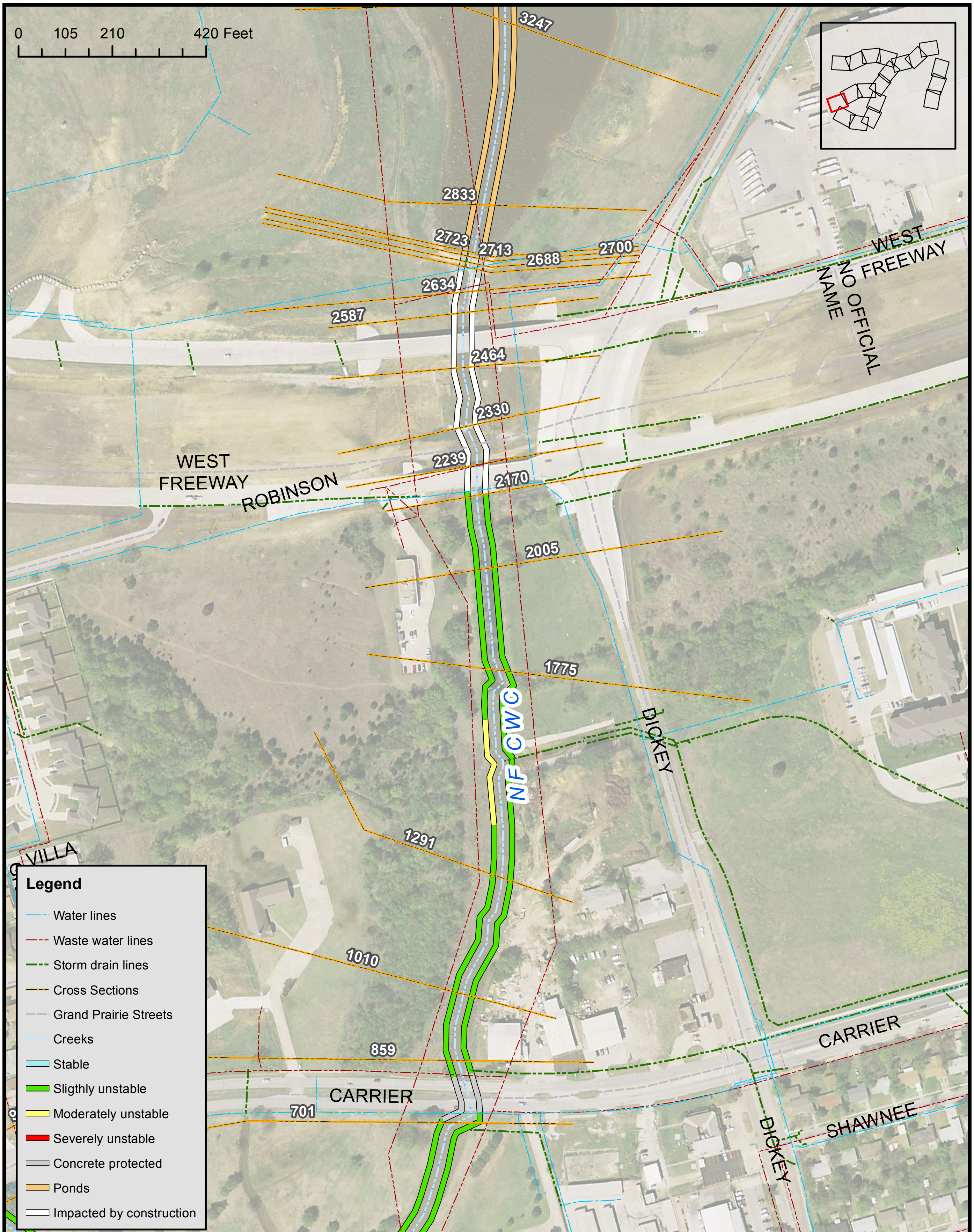

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

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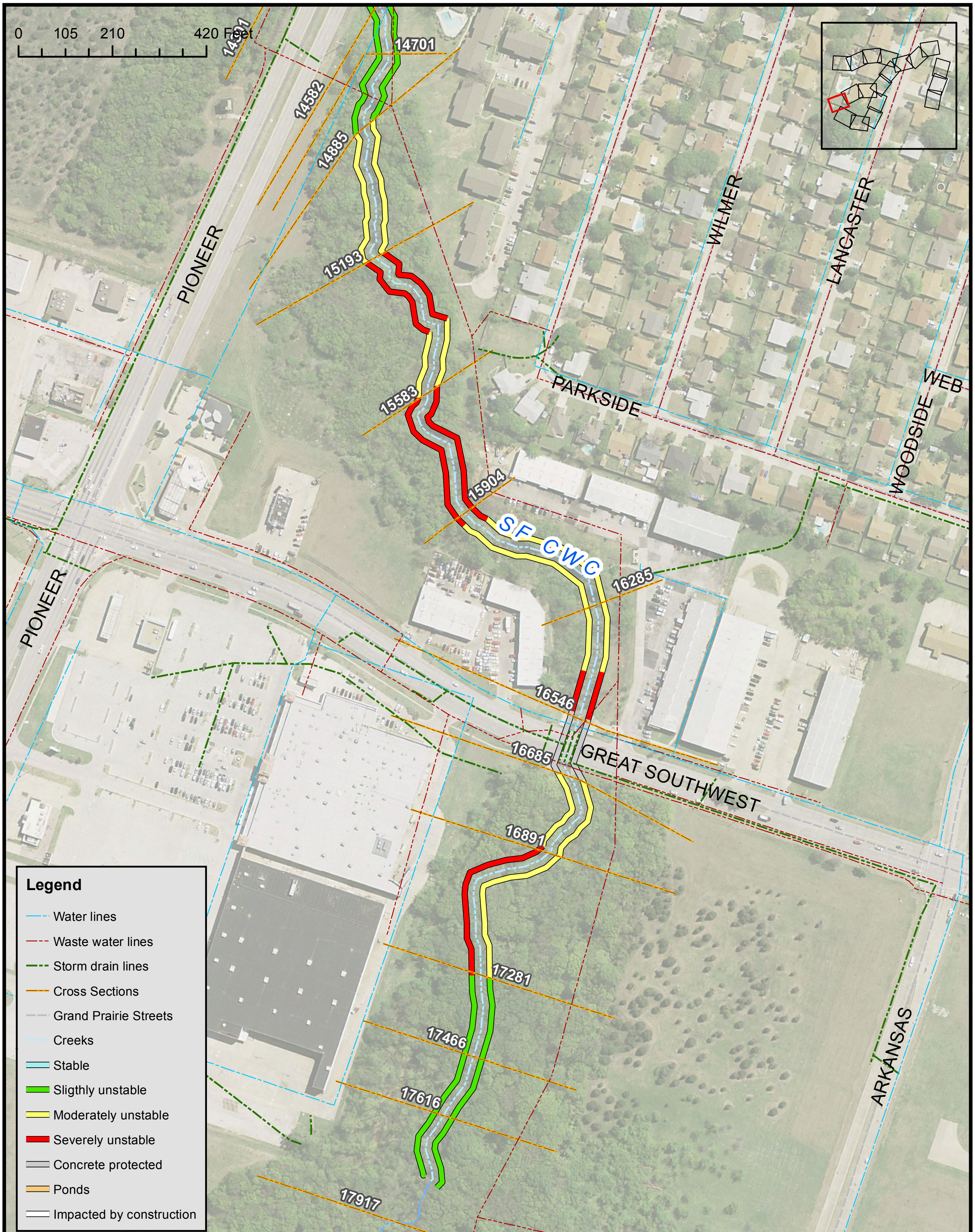

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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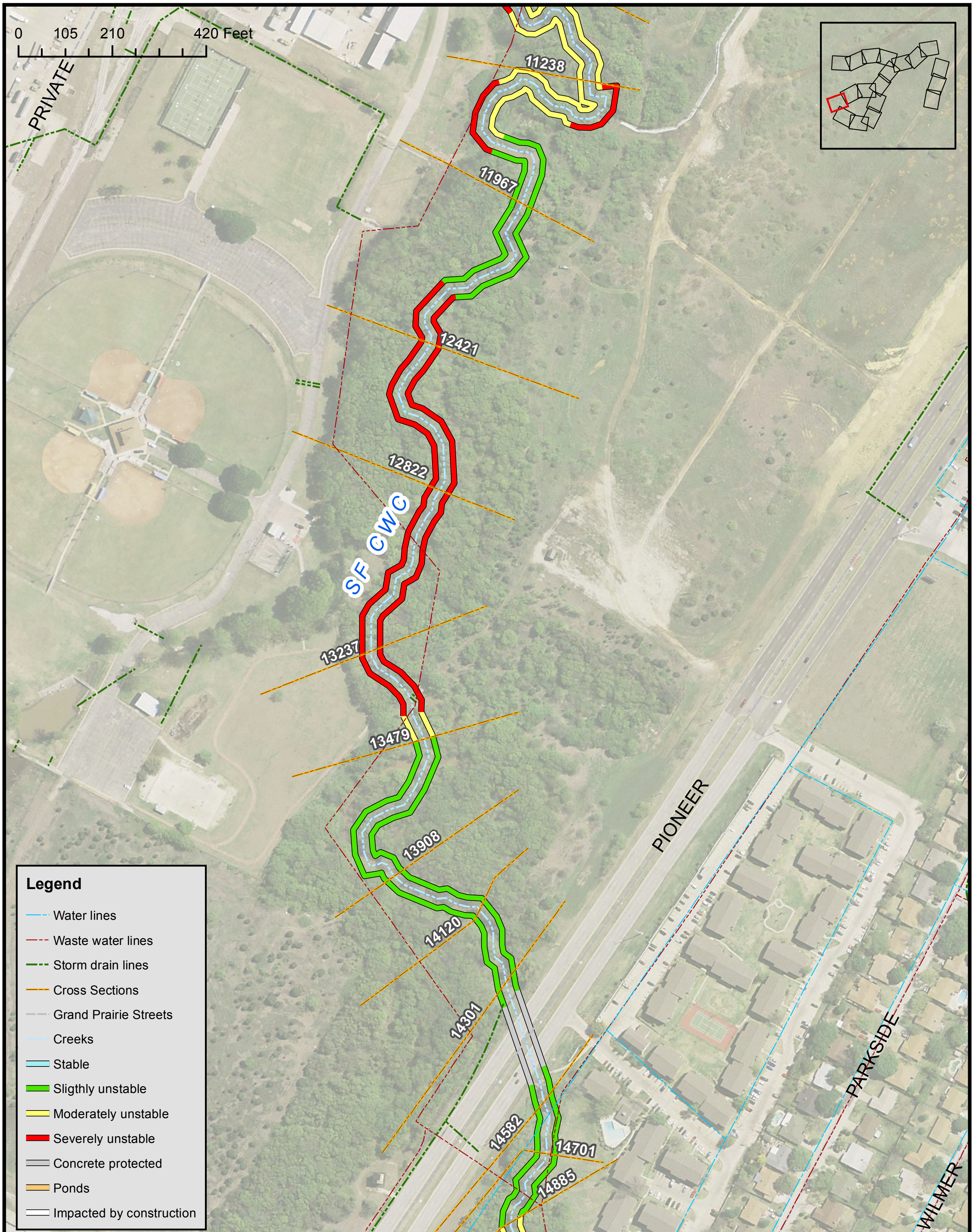

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

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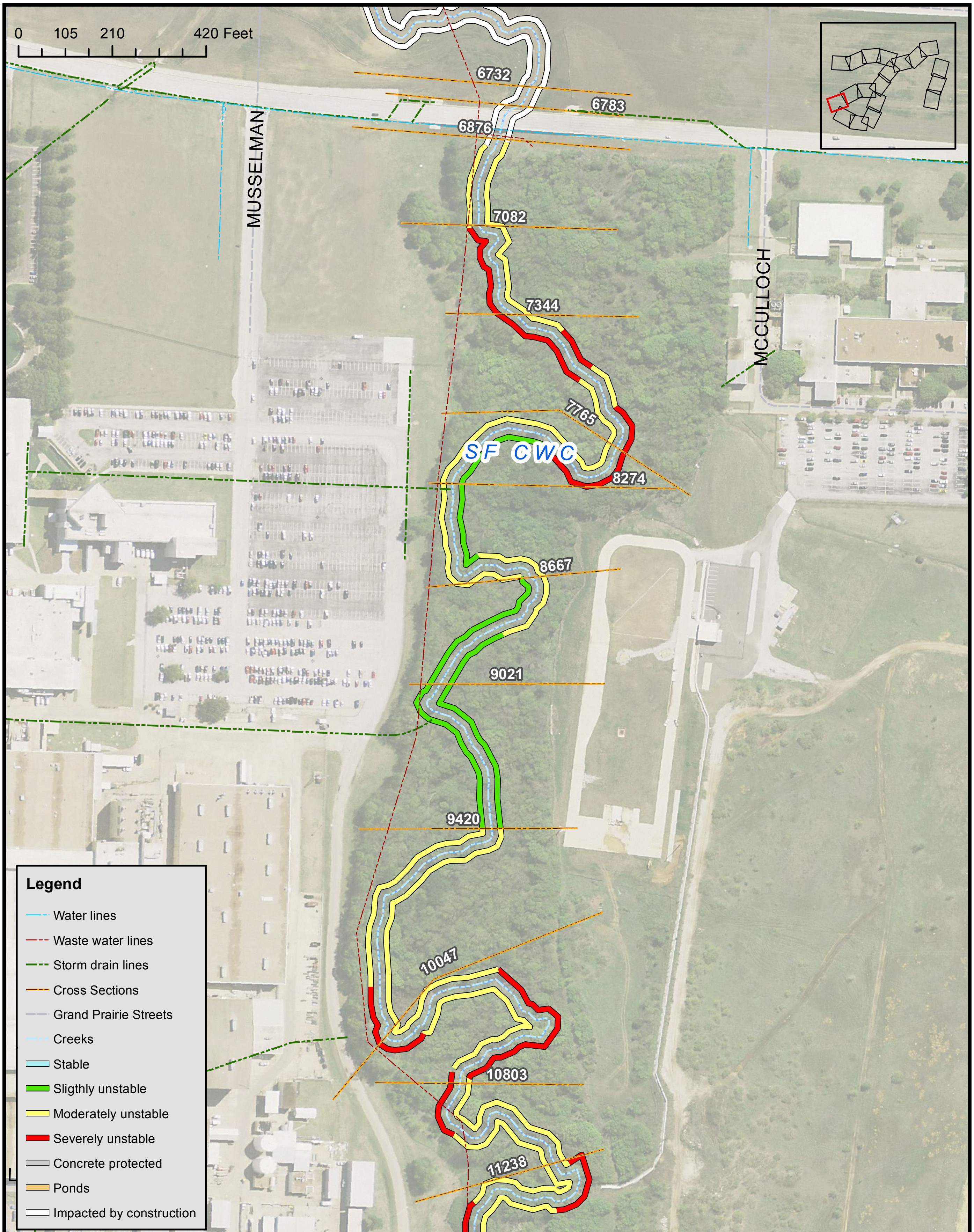

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Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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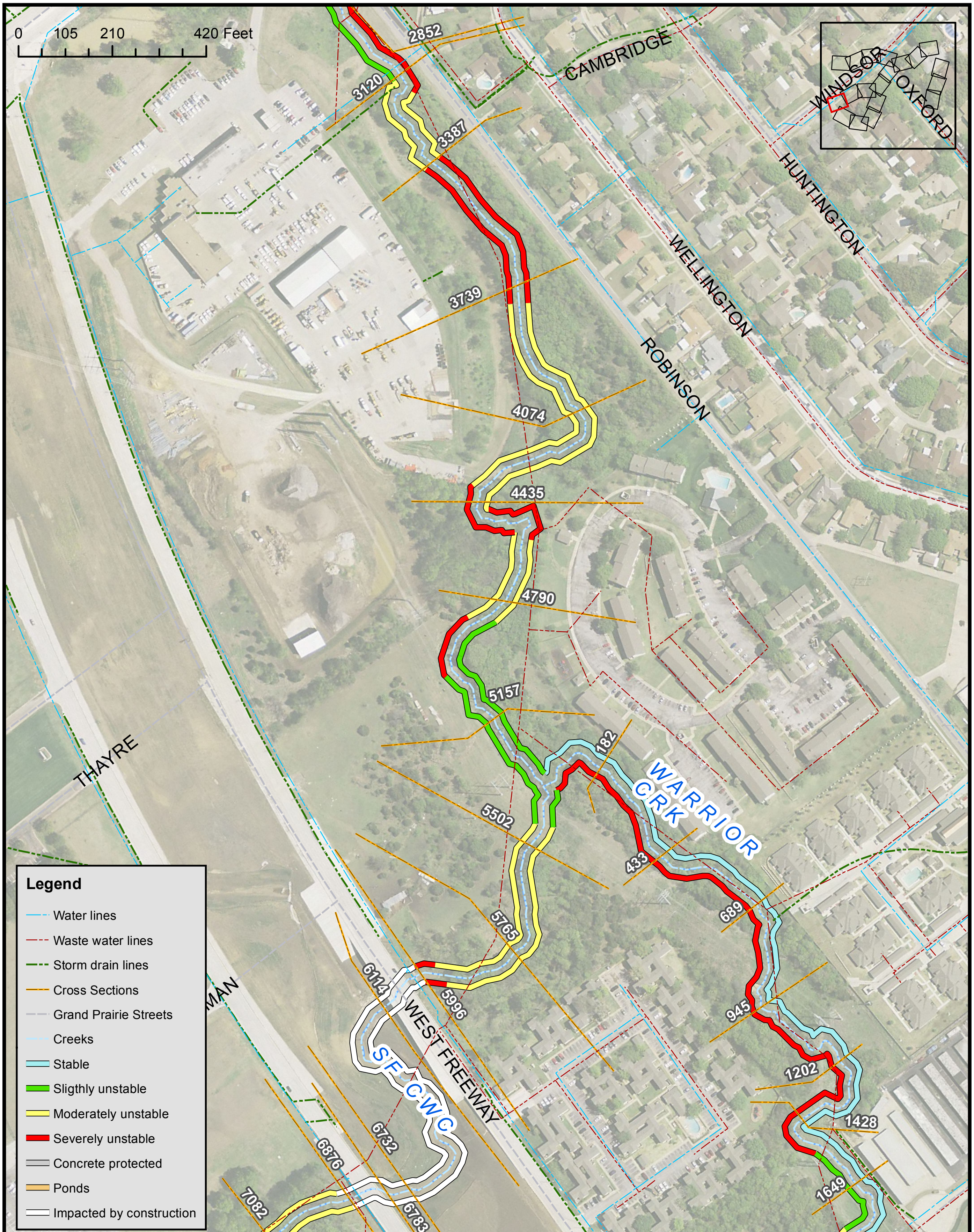

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Channel Erosion and Instability

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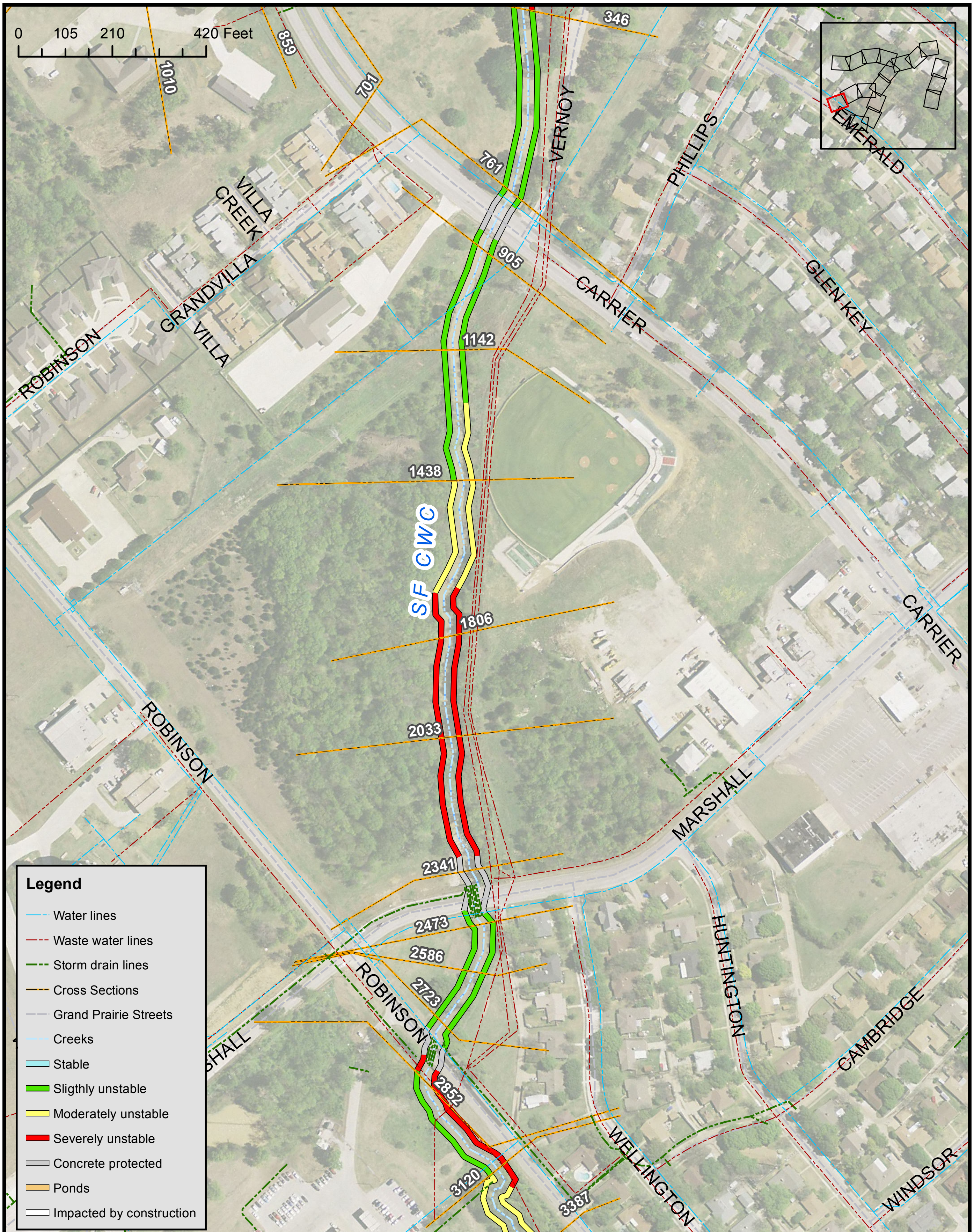

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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DATE	June 21 2012
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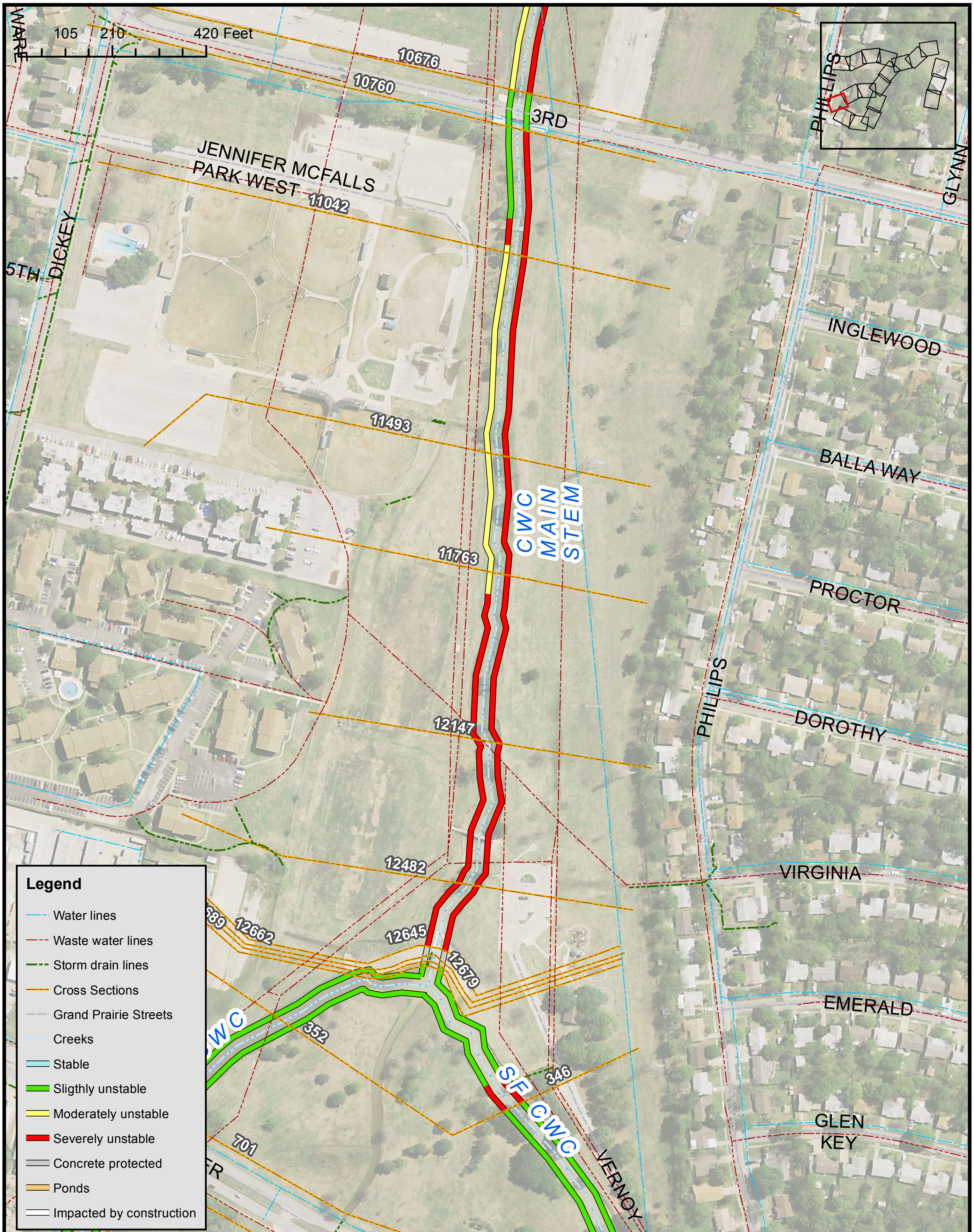

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

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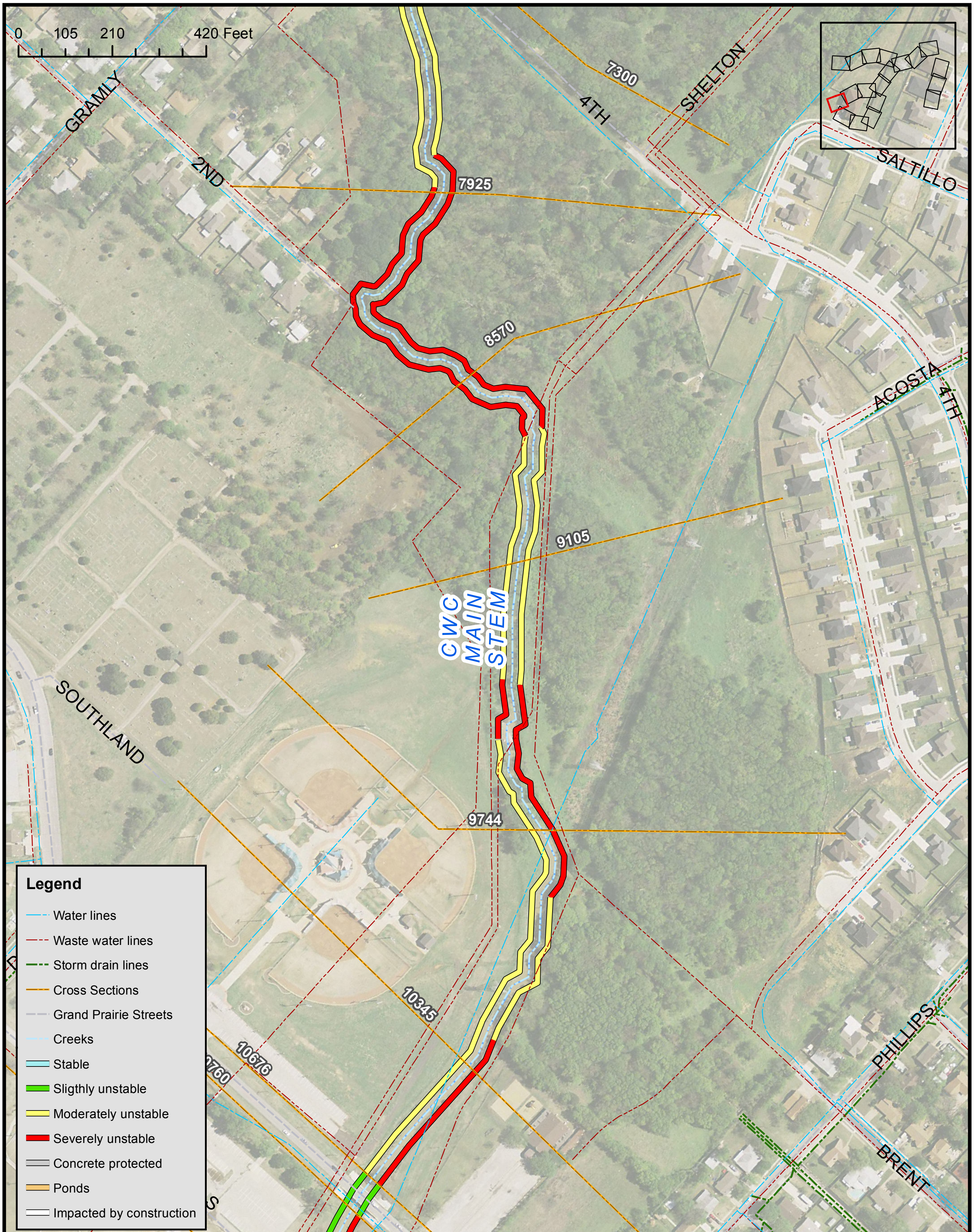

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Channel Erosion and Instability

FN JOB NO	ESP11227
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DRAFTED	DKC

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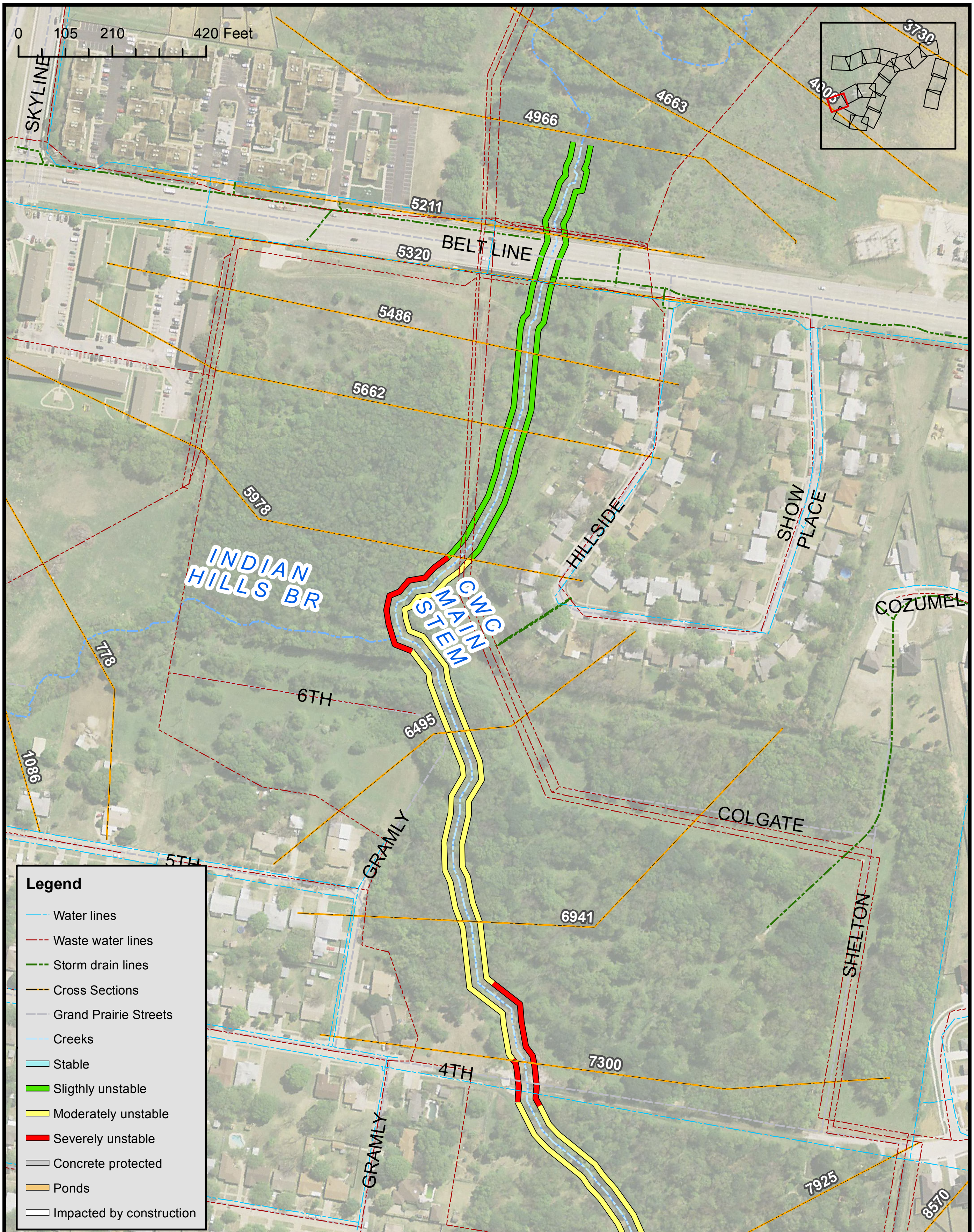

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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DATE	June 21 2012
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DESIGNED	SVC
DRAFTED	DKC

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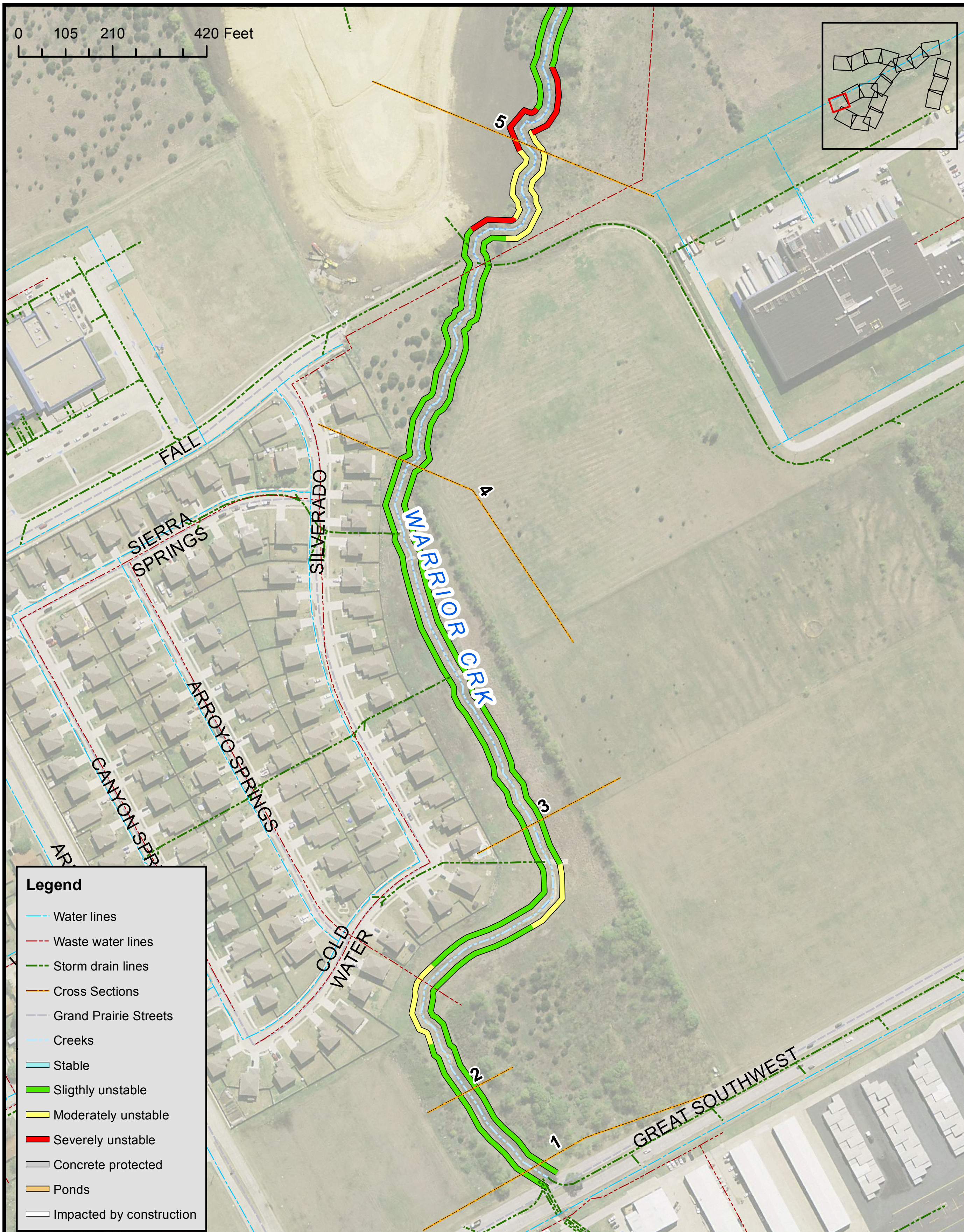

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Geomorphic Stream Assessment

Channel Erosion and Instability

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DATE	June 21 2012
SCALE	1:3,600
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DRAFTED	DKC

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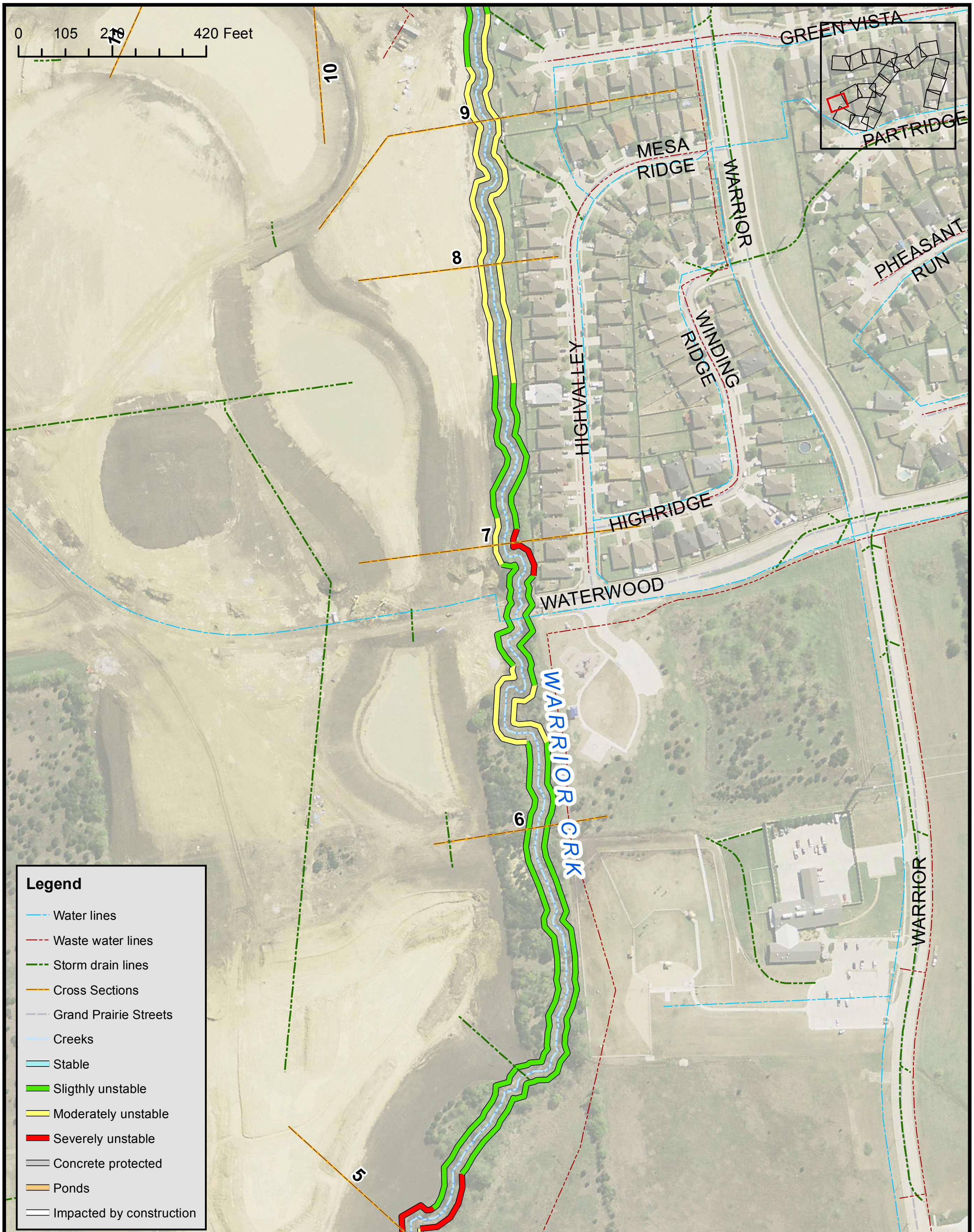

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Channel Erosion and Instability

FN JOB NO	ESP11227
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DATE	June 21 2012
SCALE	1:3,600
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DRAFTED	DKC

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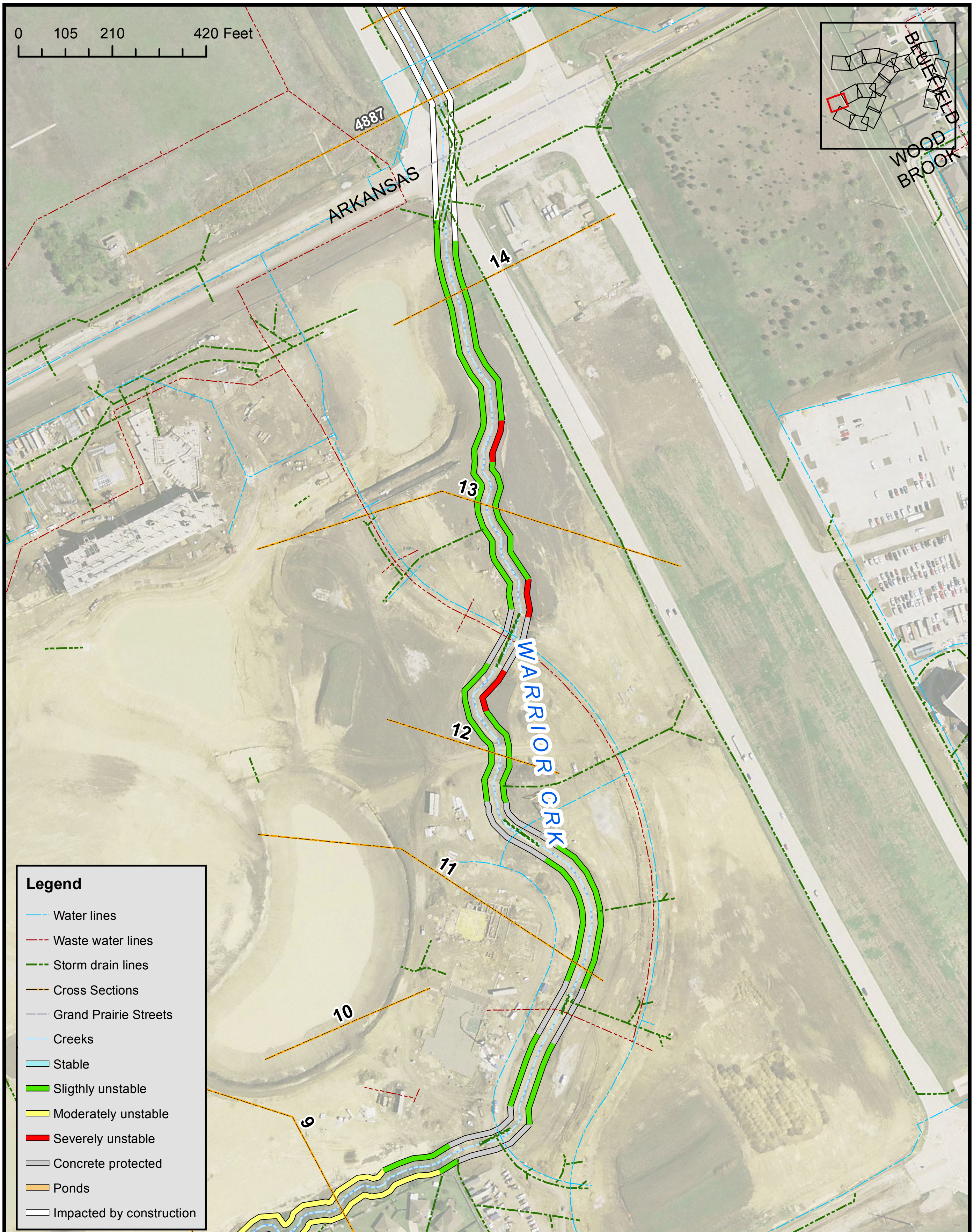

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

D15

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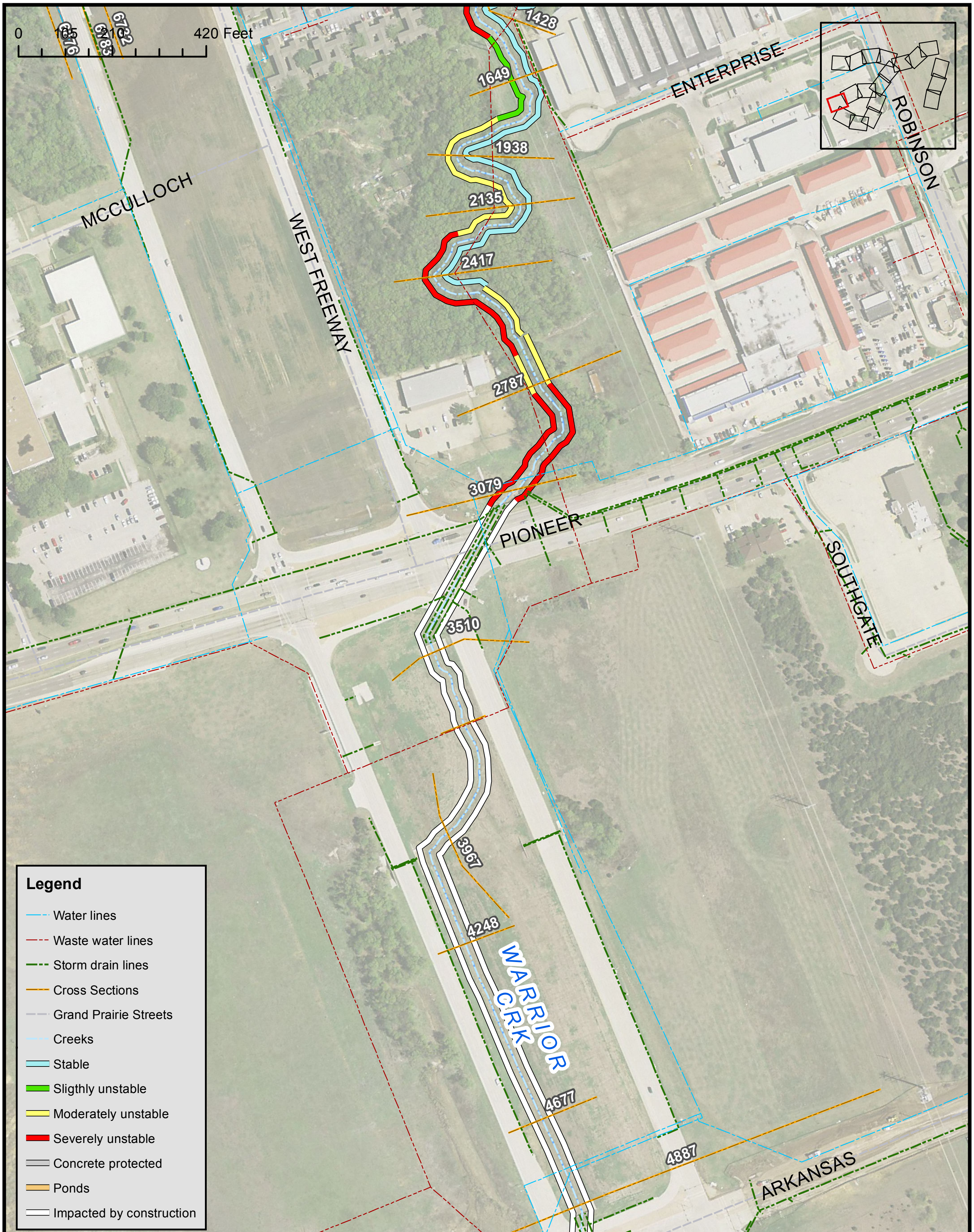

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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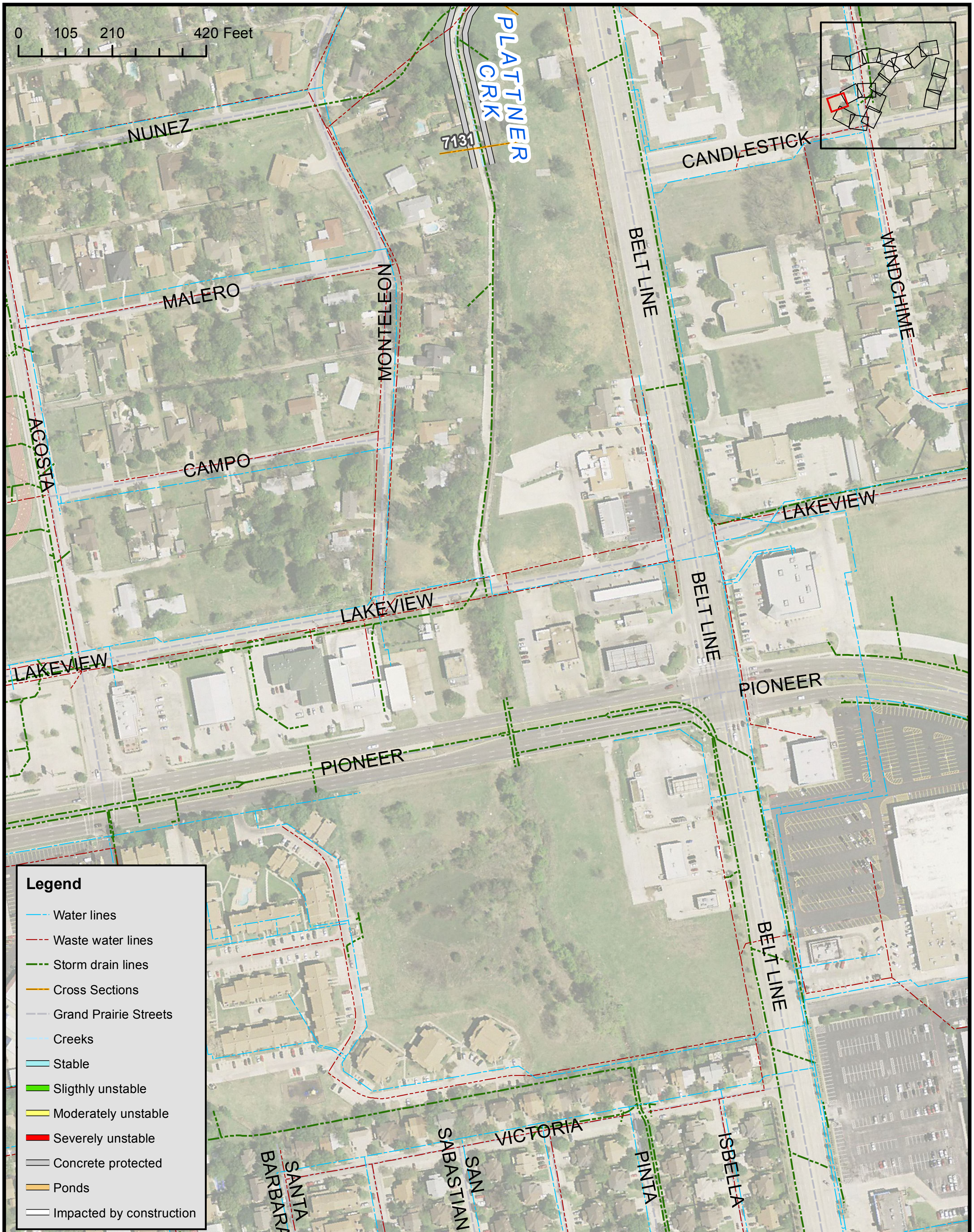

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
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DRAFTED	DKC

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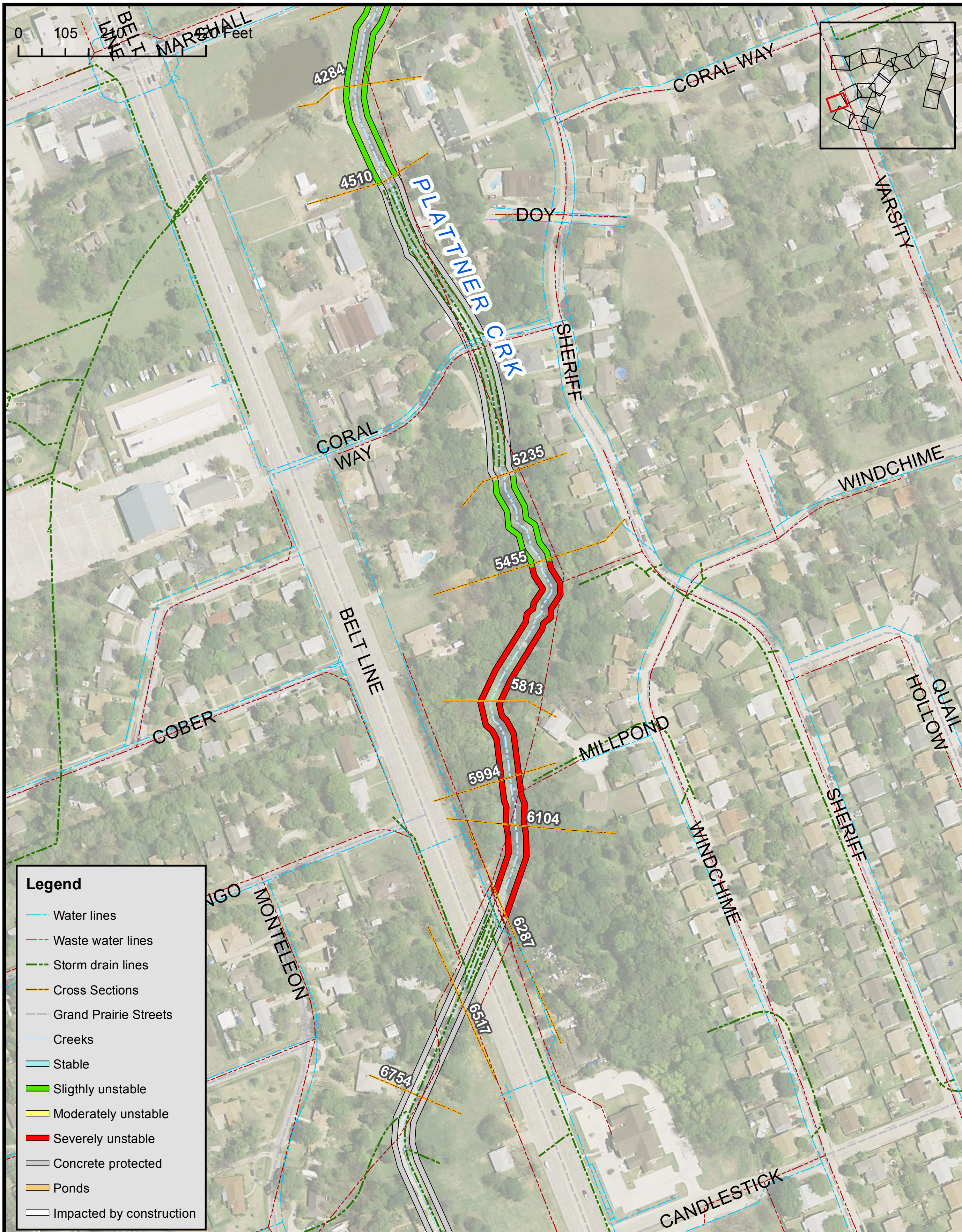

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Cottonwood Creek
Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
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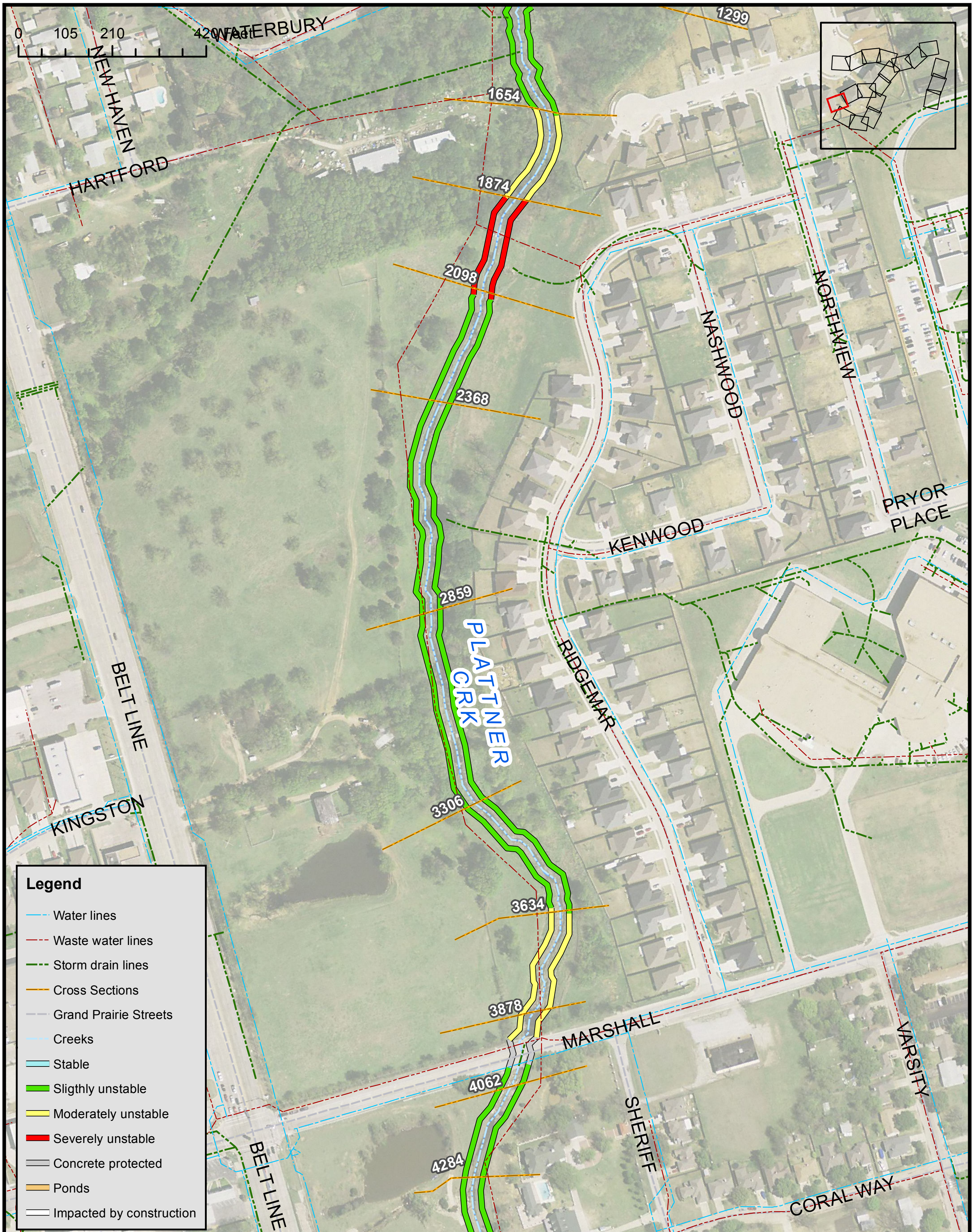

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Geomorphic Stream Assessment

Channel Erosion and Instability

FN JOB NO	ESP11227
FILE	APP_D_erosion.mxd
DATE	June 21 2012
SCALE	1:3,600
DESIGNED	SVC
DRAFTED	DKC

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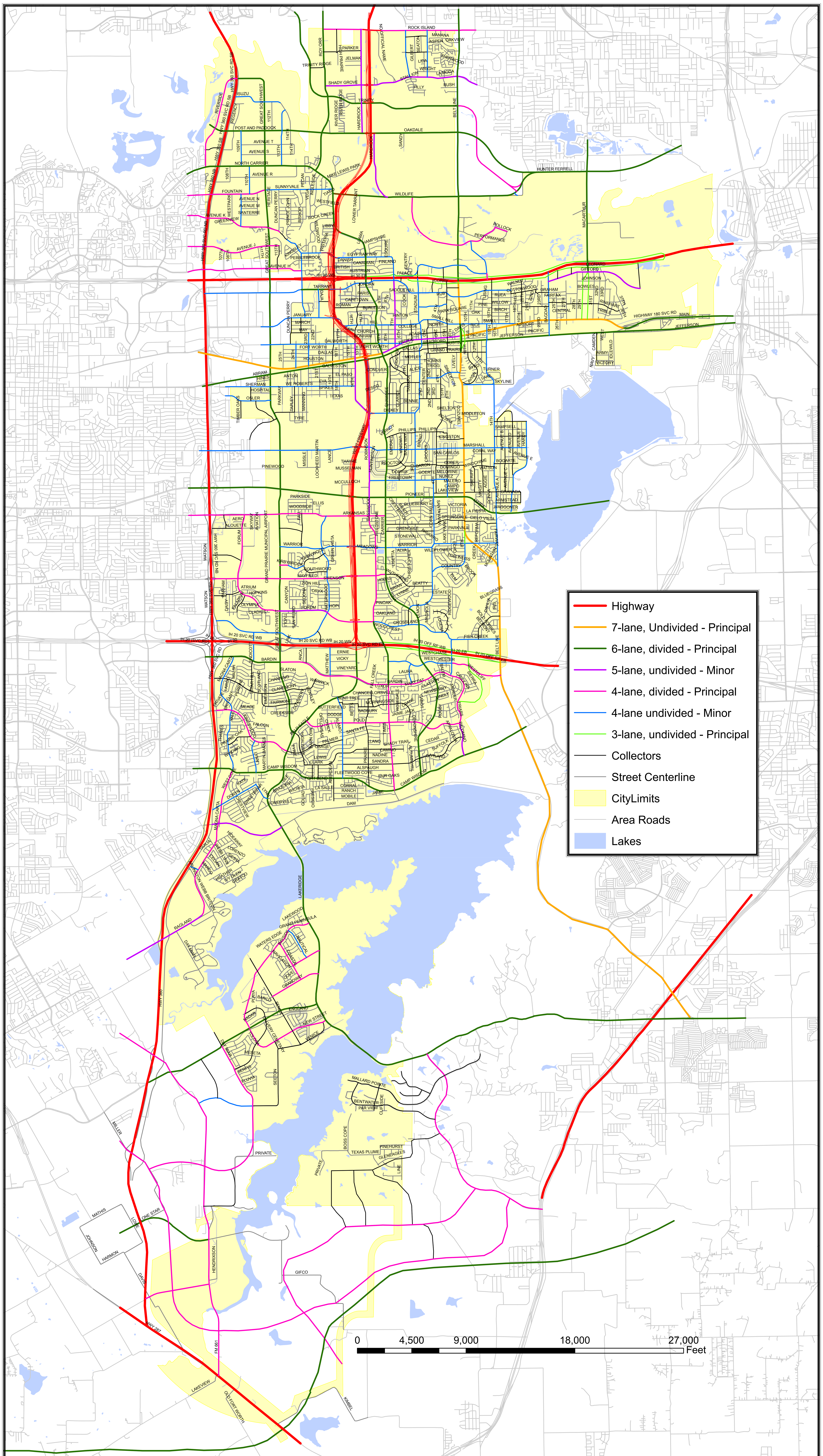
Attachment 1

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