Flood Study on Rock Creek for Lot 16AA Block 218, Lot 4 Block 235, and Lot 1 Block 236 on Arbala Road

City of Sulphur Springs
Hopkins County, Texas

O'Brien Engineering, Inc.
2340 E. Trinity Mills Road
Suite 220
Carrollton, Texas 75006
Ph: 972-233-2288
Fax: 972-233-2818

Texas Firm No. 3758

September 5, 2018
Revised: October 9, 2018
Revised: July 15, 2019
Revised: November 18, 2019

OEI Project No: 492.002

Jim O'Brien

STATE OF TEXAS
JIM O'BRIEN
55861
REGISTERED
PROFESSIONAL ENGINEER

November 19, 2019

O'BrienEngineering, Inc.

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Appendices

I. Introduction

O'Brien Engineering, Inc. (OEI) has been asked by Wayne Cooper to provide civil engineering services for an approximately 2.7-acre parcel of land straddling Rock Creek, which flows from west to east, and is considered part of Lot 16AA Block 218 in Sulphur Springs, Hopkins County, Texas. Mr. Cooper plans to build an office building on the 1.0-acre portion on the north side of Rock Creek and would like to reclaim as much area as feasible from the floodplain. He would also like to reclaim as much land as possible from the floodplain on the south side of Rock Creek for possible future development. The parcel is located on the east side of Arbala Road (FM 2297) approximately 750 feet north of Wildcat Way (State Highway 11). A grading concept was developed for this study to assess potential floodplain reclamation. A site and grading plan provided by Mr. Cooper will be necessary to fully evaluate the floodplain impacts.

The effective Flood Insurance Rate Map (FIRM) for the area, map panel 48223C0330E for Hopkins County, (dated March 17, 2011) indicates that the property is partially encumbered by a FEMA flood hazard Zone 'A'. **Exhibit 1** shows the project site superimposed on the FIRM panel.

The City of Sulphur Springs (City) is requiring the submittal of a flood study with a floodplain development application but is not requiring a submittal to FEMA. Mr. Cooper has opted not to apply for a Letter of Map Revision (LOMR), Conditional LOMR (CLOMR), or other submittal to FEMA at this time. Therefore, this flood study addresses compliance with City ordinances only and the property will remain in the FEMA regulatory floodplain.

II. Objectives

The primary objectives of this study are to evaluate the existing floodplain conditions on site and develop a floodplain reclamation grading concept. As part of this process, the grading concept was evaluated for potential impacts to the hydraulics of Rock Creek and to provide a flood study for evaluation of the project by the City for compliance with City ordinances. Compliance with FEMA regulations is not one of the objectives of this study.

III. Hydrologic Modeling

A hydrologic analysis was not performed to determine peak flows on Rock Creek. The 100-year peak flows for this study were obtained from two sources: the USACE hydraulic model discussed below, and design plans obtained from the Texas Department of Transportation (TxDOT) contained in the hydraulic model discussed below. The USACE model contains the flows established in the Flood Insurance Study (FIS) for Rock Creek, with the most upstream 100-year peak flows being 2,490 cfs. Peak flows upstream of the extents of the USACE model and near the project site are 1,500 cfs for the 100-year flood and were obtained from TxDOT design plans (dated November 12, 2007) for a culvert extension project on Rock Creek at Arbala Road. The TxDOT analysis was performed using a currently accepted regression equation. The design plans obtained from TxDOT are found in Appendix B.

IV. Hydraulic Modeling

A hydraulic analysis was performed to determine the potential impacts to the floodplain hydraulics from the proposed development. The hydraulic analysis was conducted using the USACE's computer program, HEC-RAS version 5.0.5.

A. Methodology

The topography for the subject area was obtained from a combination of 2017 LiDAR data and on-the-ground field-survey data from Chaney Engineering, dated March 2018, mapped to two-foot contour intervals. Cross sections for the model were placed along Rock Creek throughout the subject property to best analyze the proposed project. Channel and overbank reach lengths were digitally measured using ESRI's ArcMap software. Manning's roughness coefficients were verified through field reconnaissance and aerial photography with reference to "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains Water-Supply Paper 2339," by the United States Geological Survey, 1989 and "Open-Channel Hydraulics" by Ven Te Chow, 1959.

B. Duplicate Effective Model

A data request was made to the FEMA Engineering Library, but FEMA could not provide hydrologic or hydraulic models for Rock Creek. A hydraulic model for Rock Creek was obtained by OEI from the Unites States Army Corps of Engineers (USACE) in HEC-2 format. The USACE model and accompanying workmaps are contained in Appendix D. This model does not include the project site since the most upstream cross section is located approximately 1,800 feet downstream of the project site. The workmap accompanying the model obtained from USACE is provided in Appendix D. The HEC-2 model was converted to HEC-RAS format. A summary output of the Duplicate Effective HEC-RAS model is provided in **Table 1** of Appendix C.

C. Corrected Effective Model

The Duplicate Effective model is used as a platform for establishing the Corrected Effective model through the project area. The model was updated to represent the existing conditions, against which the proposed project improvements can be evaluated. The model was extended from approximately 1,800 feet downstream of the project site (cross section 96420) to approximately 1,000 feet upstream of the project site (cross section 97581) by adding 12 cross sections based on the topographic data referenced above. The culvert at Arbala Road was added to the model using design drawings requested from TxDOT. Manning's 'n' values were assigned based on existing conditions throughout the subject property. Standard contraction and expansion coefficients were used, 0.1 and 0.3 for normal hydraulics and 0.3 and 0.5 near constrictions such as culverts. The locations of the model cross sections are shown on **Exhibit 2**, Appendix A. A summary output of the Corrected Effective model is shown in **Table 2**, Appendix C.

D. Pre-Project Model

The purpose of the Pre-Project model is to simulate any manmade modifications that have occurred within the floodplain since the date of the Effective model. The only manmade modification added to the extended effective model is the culvert crossing

at Arbala Road, which was added to the Corrected Effective model. Therefore, the Corrected Effective model is considered the Pre-Project model. The Pre-Project floodplain delineation is show on **Exhibit 2**. A summary output of the Pre-Project/Corrected Effective model is shown in **Table 2**, Appendix C.

E. Post-Project Model

The Pre-Project model is used as a platform to develop the Post-Project model. The Post-Project model represents proposed improvements, which would include changes in grading throughout the site. The extent of proposed grading is shown on **Exhibit 3** and **Exhibit 4**. The grading shown is preliminary in nature and should be verified with a grading plan. The proposed changes include placing fill on the north side of Rock Creek and both excavating and placing fill on portions of the tract on the south side of Rock Creek. The areas of cut and fill would tie into existing grades at a 4H:1V slope. It is proposed that trees be cleared in the areas of excavation and fill. The Manning's 'n' value is lowered to from 0.1 to 0.05 in Post-Project model in the areas to be cleared of trees.

The fill placed on both sides of the creek could disconnect portions of the floodplain fringe depending on how close the fill could be placed to the Arbala Road right-of-way for road frontage and a driveway. It is assumed for modeling purposes that fill would be placed as close to the road as cross section 96590. To allow for drainage along the right-of-way and to re-connect those portions of the floodplain, a culvert would need to be installed under the driveway and any other fill that could hinder drainage near the right-of-way, as shown on **Exhibit 5**. The Post-Project model floodplain delineations for the 100-year design storm is shown on **Exhibit 3** and **Exhibit 4**. A summary output of the Post-Project hydraulic model for the 100-year design storm is provided in **Table 3**.

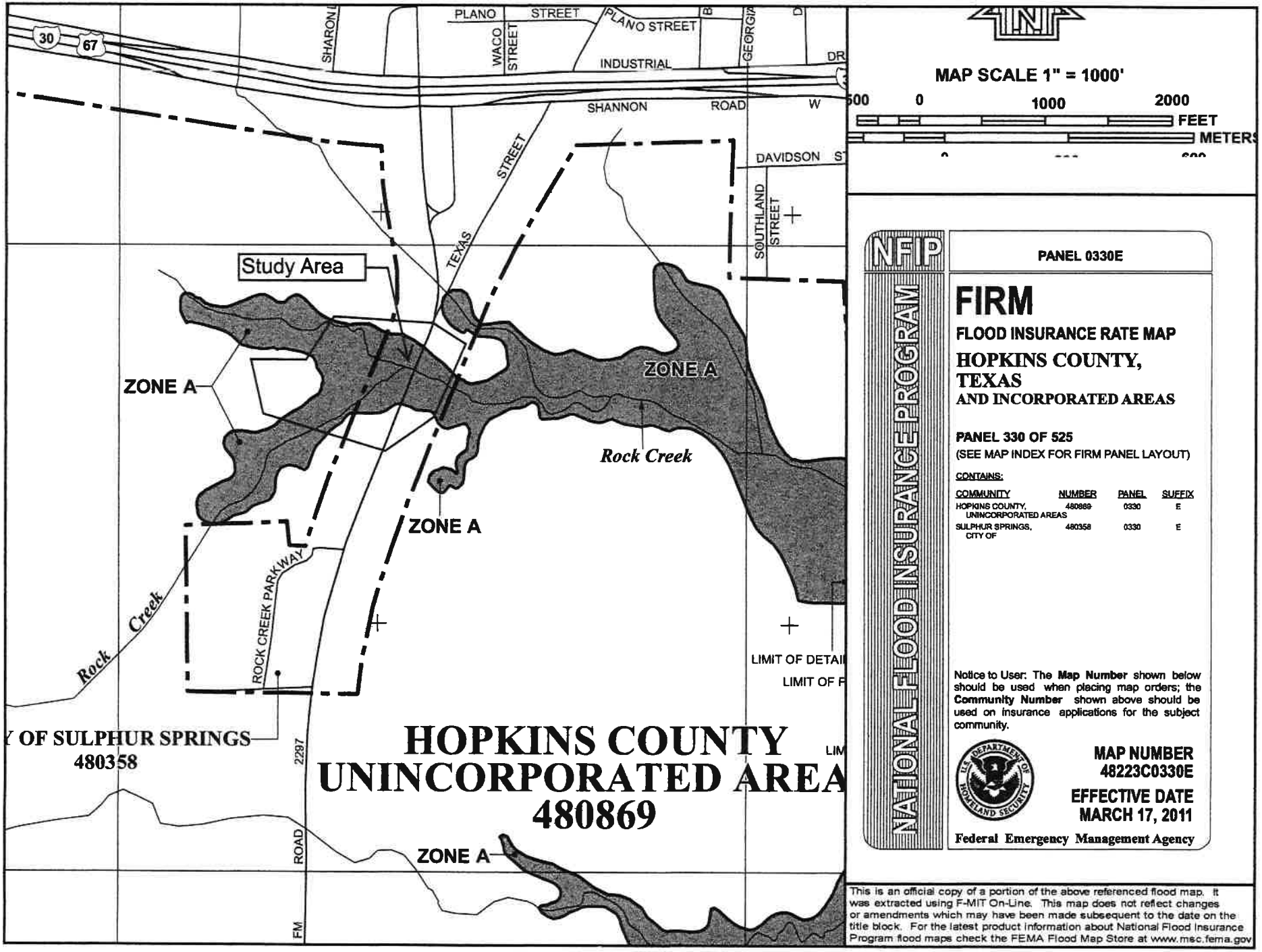
V. Results & Conclusions

The results indicate that the attached grading concept would result in no increase of the 100-year floodplain of Rock Creek with several cross sections that show decreases in the

100-year (1% AC) water surface elevation. No erosive velocities (above 6 feet per second) would be caused or increased upstream or downstream of the subject property.

A summary tabulation of the water surface elevations and velocities for various conditions are found in **Table 4** of Appendix C. Digital copies of the hydraulic models are contained in Appendix D. The results indicate that there is a minimum of two feet of freeboard between the Rock Creek 100-year Post-Project water surface elevation and the proposed top of fill elevation when compared on the grading concept, as indicated by the reclaimed area shown on **Exhibit 5**, Appendix A. As discussed in the introduction, site and grading plans matching the preliminary proposed grading concept are necessary to confirm the results of this study.

Appendix A
Exhibits



MAP SCALE 1" = 1000'

500 0 1000 2000

FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0330E

FIRM

FLOOD INSURANCE RATE MAP

HOPKINS COUNTY, TEXAS AND INCORPORATED AREAS

PANEL 330 OF 525

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

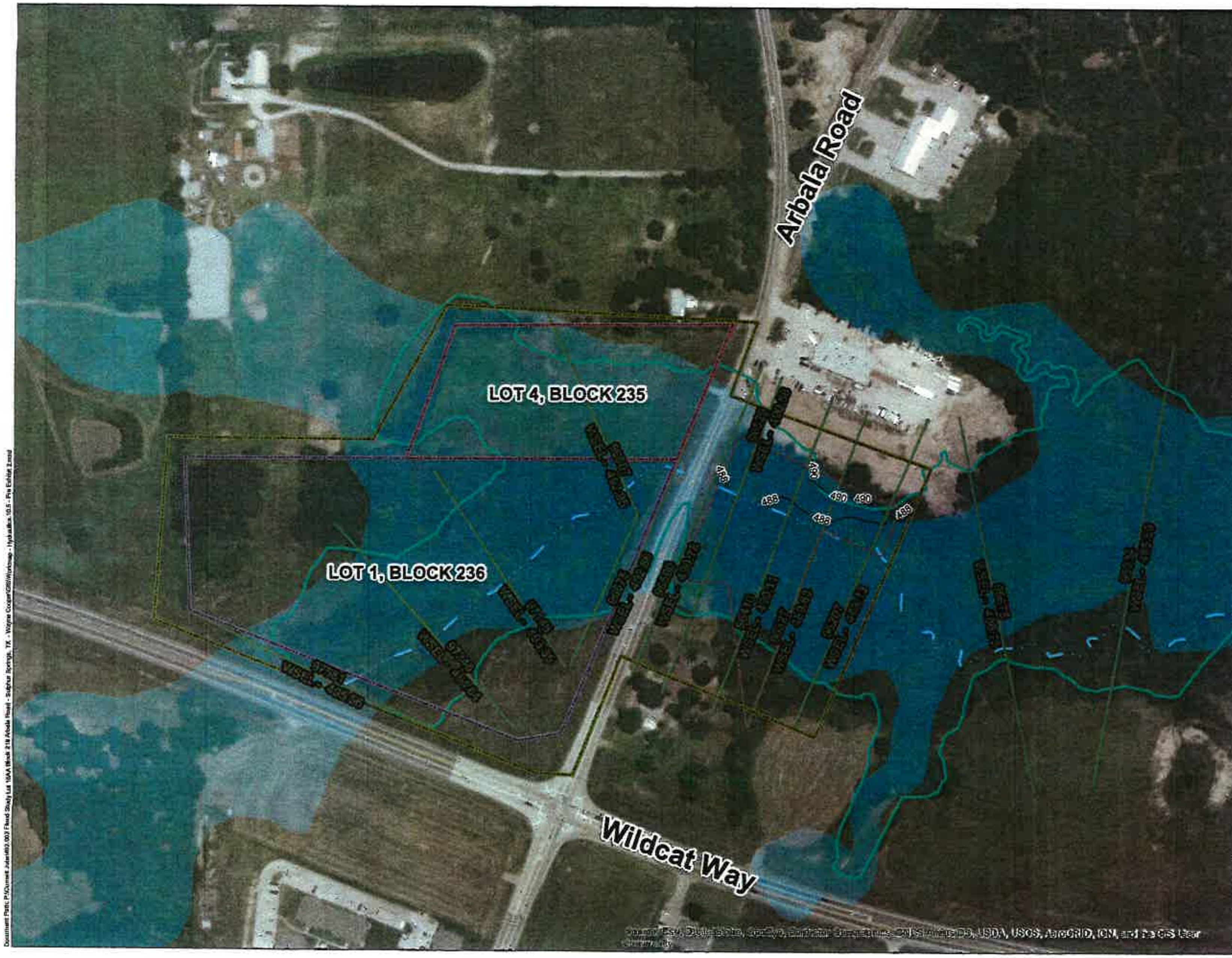
COMMUNITY	NUMBER	PANEL	SUFFIX
HOPKINS COUNTY, UNINCORPORATED AREAS	480869	0330	E
SULPHUR SPRINGS, CITY OF	480358	0330	E

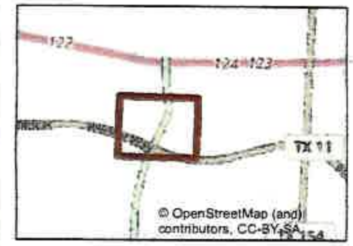
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
48223C0330E

EFFECTIVE DATE
MARCH 17, 2011

Federal Emergency Management Agency





VICINITY MAP
NO SCALE

Legend

- Study
- LOT 1, BLOCK 236 Boundary
- LOT 4, BLOCK 235 Boundary
- Wayne Cooper Lot Boundary
- Cross Sections
- Survey 2 FT Contours
- Pre-Project 100-yr Floodplain using TXDOT Flows
- Stream Centerline - OEI
- 100-Year Floodplain
- 500-Year Floodplain
- Floodway

0 100 200 400 Feet

N

NOTES:
Lot 1, Block 235 and Lot 4, Block 236 boundaries approximated using County Parcel data obtained from the City of Sulphur Springs website and aerial photography.

Contours from 2017 TNRIS LIDAR data and on-site survey by Chaney Engineering dated March 2018. On-the-ground survey data only available for Wayne Cooper property. Topographic data for all other portions of study from TNRIS.

100-yr Pre-Project water surface elevations (WSEL) shown at each cross section.

EXHIBIT 2

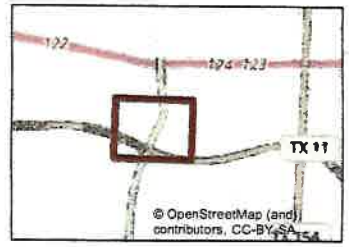
O'BrienEngineering, Inc.
2340 E. Trinity Mills Rd. Ste 220, Carrollton, Texas, 75006
p: 972.233.2284 f: 972.233.2816 www.OBrienEng.com
Texas Registered Engineering Firm F-3758

WAYNE COOPER

PRE-PROJECT FLOODPLAIN
MAP AT ARBALA ROAD LOT

SULPHUR SPRINGS, HOPKINS COUNTY, TX

Date: 11/17/2019 OEI JOB #: 492.002



VICINITY MAP
NO SCALE

Legend

- Cross Sections
- Approximate Lot Boundaries
- Proposed 100-Year Floodplain

ELEVATION

- Proposed 2 FT Contours
- Survey 2 FT Contours
- Stream Centerline - OEI

LIDAR Contours

- Intermediate 1 ft
- Index 5 ft
- 100-Year Floodplain
- 500-Year Floodplain
- Floodway

0 100 200 400 Feet

N

NOTES:
Contours from 2017 LIDAR data and on-site survey by Chaney Engineering dated March 2018.

On-the-ground survey data only available for Wayne Cooper property. Topographic data for all other portions of study from TNRIS.

100-yr Proposed-Project water surface elevations (WSEL) shown at each cross section.

EXHIBIT 3

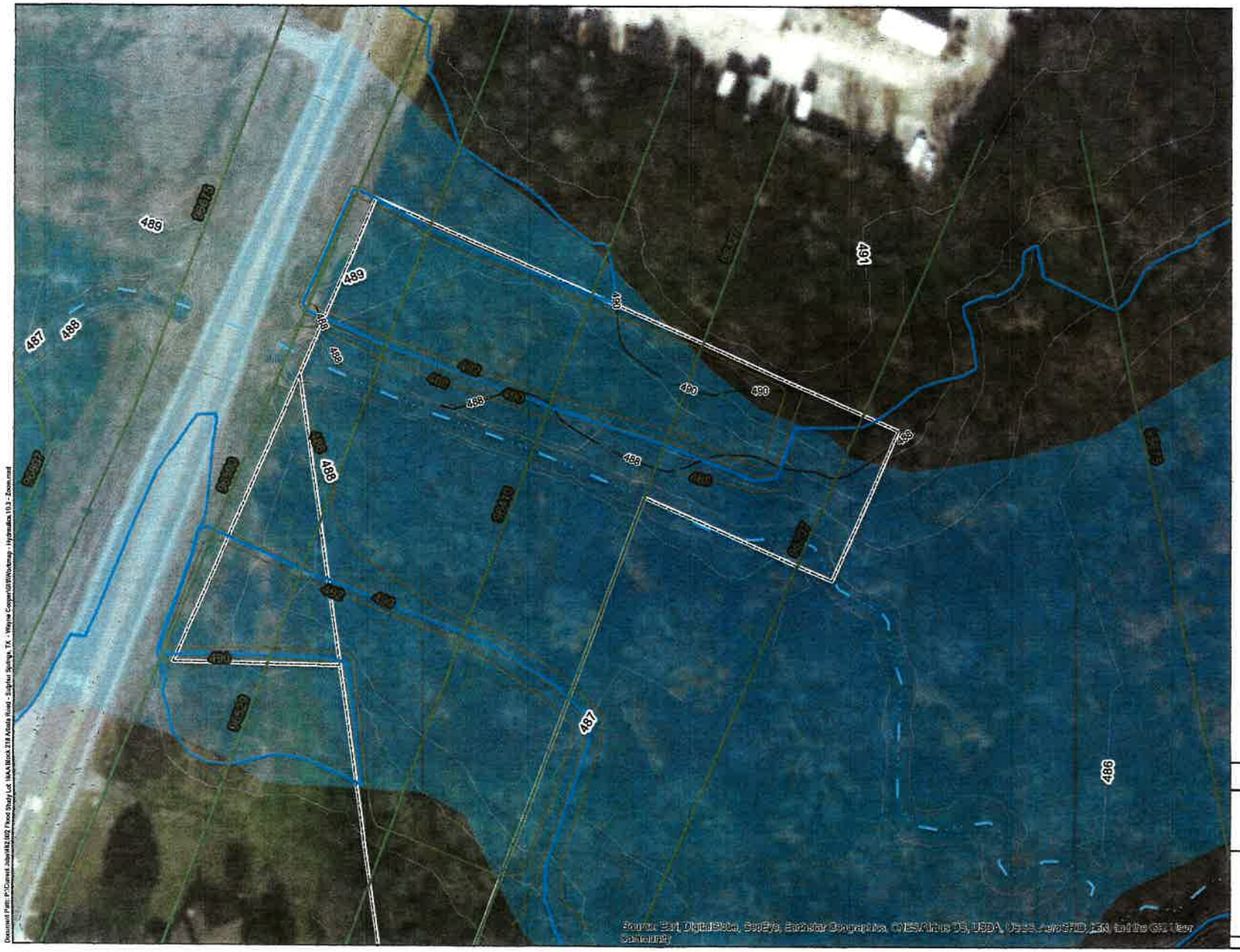
O'BrienEngineering, Inc.
2340 E. Trinity Mills Rd, Ste 220, Carrollton, Texas, 75006
p: 972.233.2266 f: 972.233.2618 www.OBrienEng.com
Texas Registered Engineering Firm F-3758

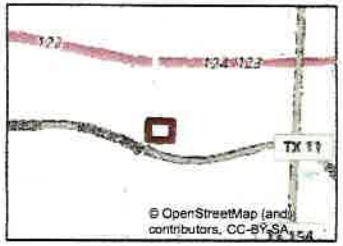
WAYNE COOPER

POST-PROJECT FLOODPLAIN MAP AT ARBALA ROAD LOT

SULPHUR SPRINGS, HOPKINS COUNTY, TX

Date: 11/18/2019 OEI JOB #: 492.002





VICINITY MAP
NO SCALE

Legend

- Cross Sections
- Proposed_100YR_Floodplain
- Arbala Road Lot Boundary

ELEVATION

- Proposed 2 FT Contours
- Survey 2 FT Contours
- Stream Centerline - OEI

LIDAR Contours

- Index 5 ft
- Intermediate 1 ft
- Intermediate_1 ft
- 100-Year Floodplain
- 500-Year Floodplain
- Floodway

0 25 50 100 Feet

N

NOTES:
Contours from 2017 LIDAR data and on-site survey by Chaney Engineering dated March 2018.

EXHIBIT 4

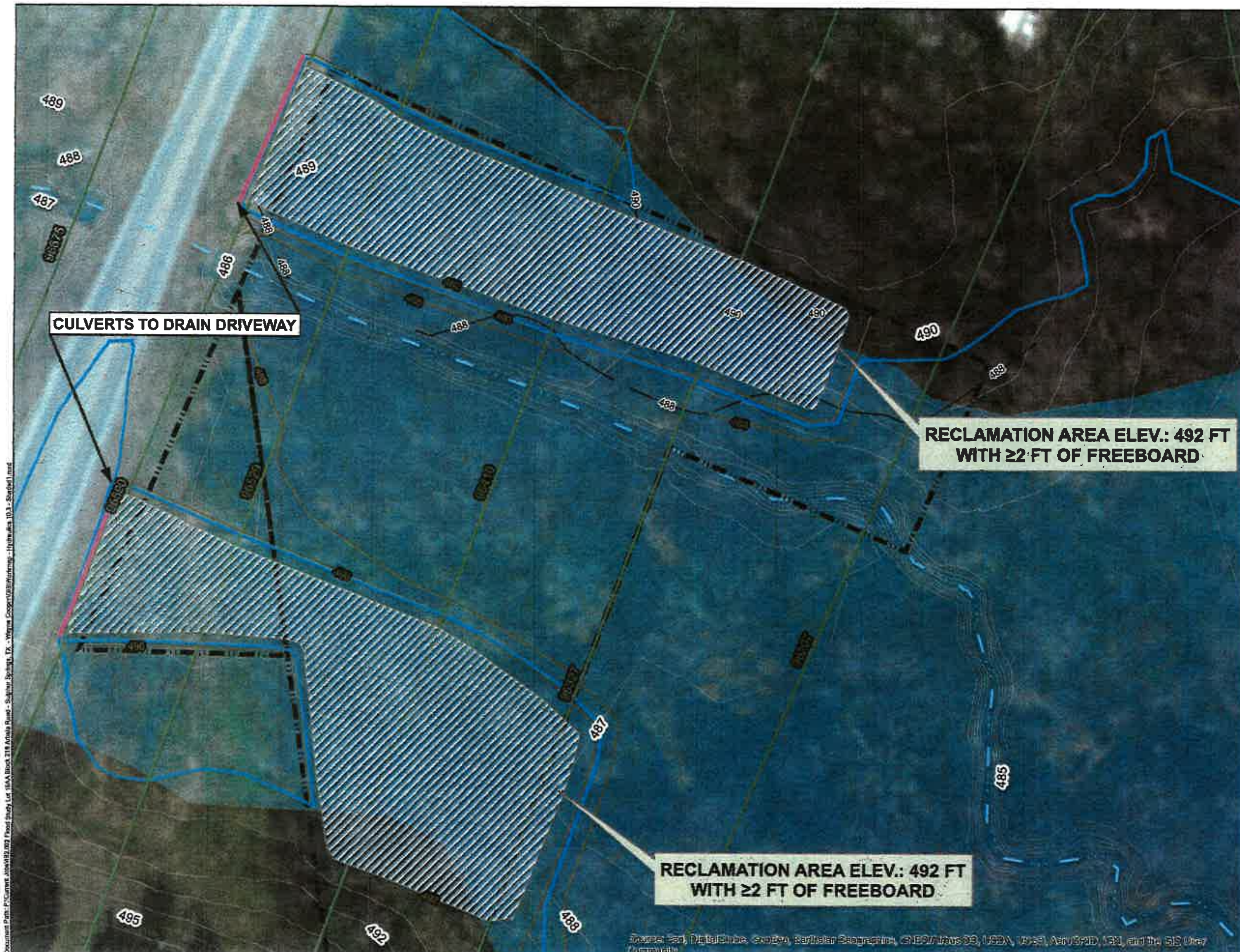
O'BrienEngineering, Inc.
2340 E. Trinity Mills Rd. Ste 200, Carrollton, Texas, 75006
p: 972.233.2264 f: 972.233.2815 www.OBrienEng.com
Texas Registered Engineering Firm F-3768

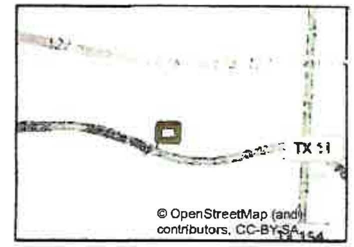
WAYNE COOPER

SITE PLAN
ARBALA ROAD LOT

SULPHUR SPRINGS, HOPKINS COUNTY, TX

Date: 9/6/2018 OEI JOB #: 468.001





VICINITY MAP
NO SCALE

Legend

- Proposed Culverts
- Reclamation Area
- Cross Sections
- Proposed 100YR Floodplain
- Arbala Road Lot Boundary

ELEVATION

- Proposed 2 FT Contours
- Survey 2 FT Contours
- Stream Centerline - OEI

LIDAR Contours

- Index 5 ft
- Intermediate 1 ft
- Intermediate_1 ft
- 100-Year Floodplain
- 500-Year Floodplain
- Floodway

0 25 50 100 Feet

N

NOTES:
Contours provided by USGS from National Elevation Dataset (NED) and the National Hydrography Dataset (NHD).

EXHIBIT 5

O'BrienEngineering, Inc.
2340 E. Trinity Mills Rd, Ste 220, Carrollton, Texas, 75006
p: 972.233.3288 f: 972.233.2818 www.OBrienEng.com
Texas Registered Engineering Firm F-3758

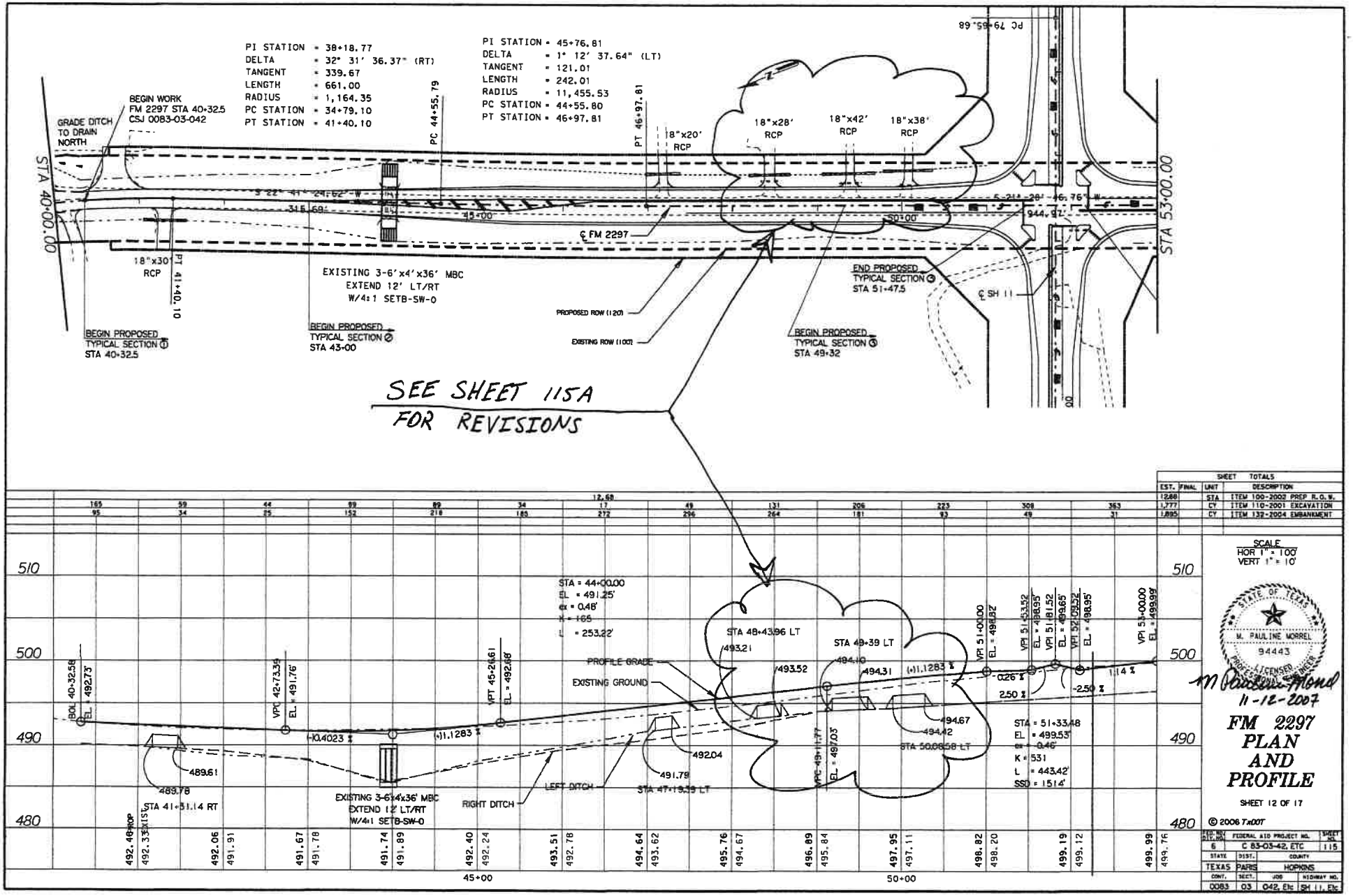
WAYNE COOPER

RECLAMATION MAP
ARBALA ROAD LOT

SULPHUR SPRINGS, HOPKINS COUNTY, TX

Date: 9/6/2018 OEI JOB #: 492.002

Appendix B
TxDOT Design Plans



SHEET TOTALS			
EST.	FINAL	UNIT	DESCRIPTION
1268		STA	ITEM 100-2002 PREP R.O.W.
1,777		CY	ITEM 110-2001 EXCAVATION
1,895		CY	ITEM 132-2004 EMBANKMENT

SCALE
HOR 1" = 100'
VERT 1" = 10'

STATE OF TEXAS
M. PAULINE MORREL
94443
LICENSED PROFESSIONAL ENGINEER

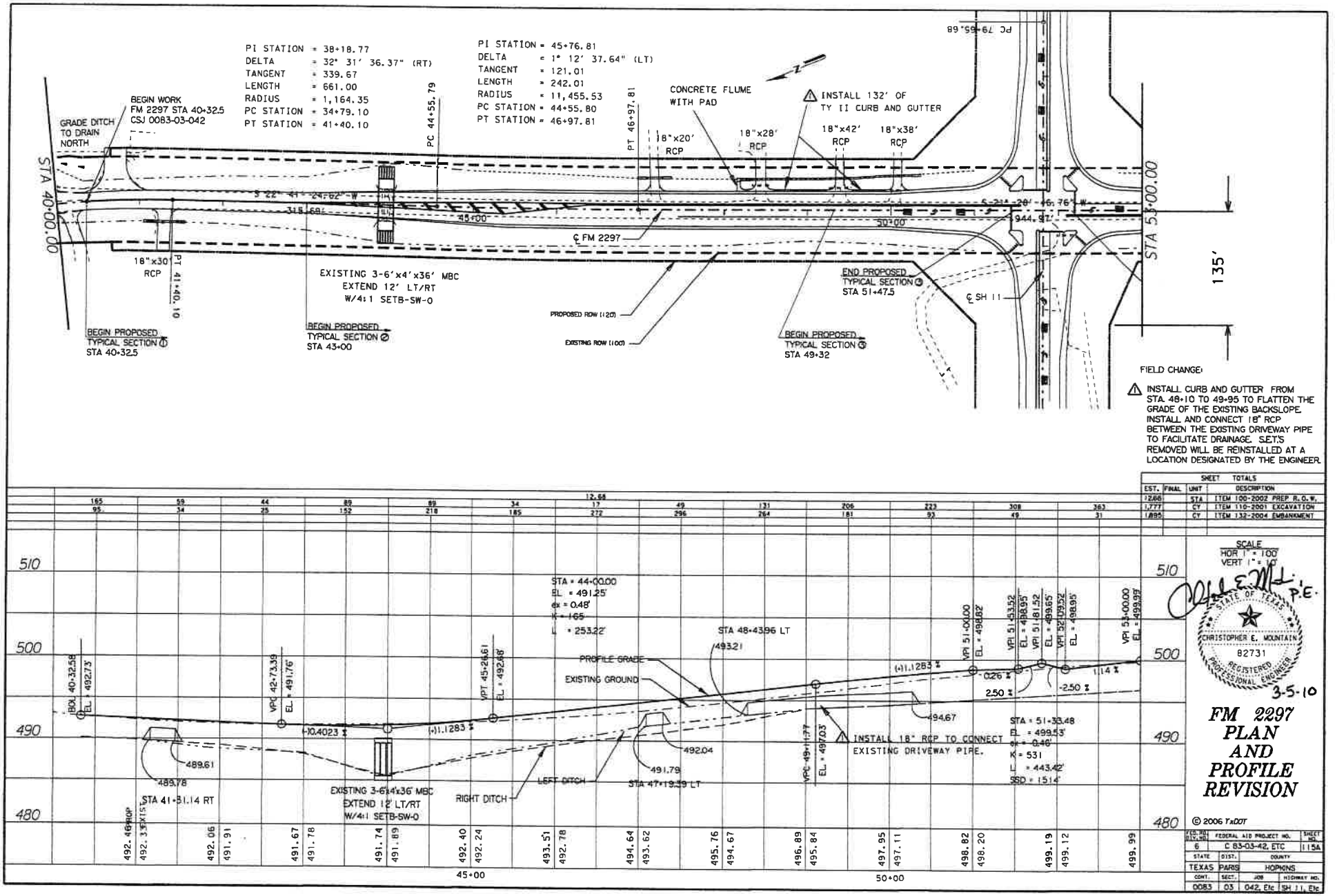
11-12-2007

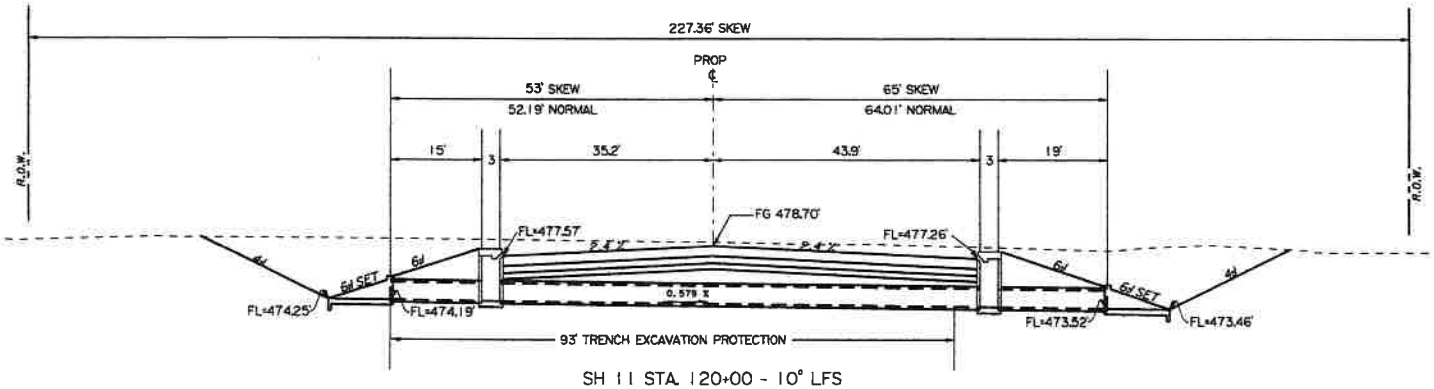
FM 2297 PLAN AND PROFILE

SHEET 12 OF 17

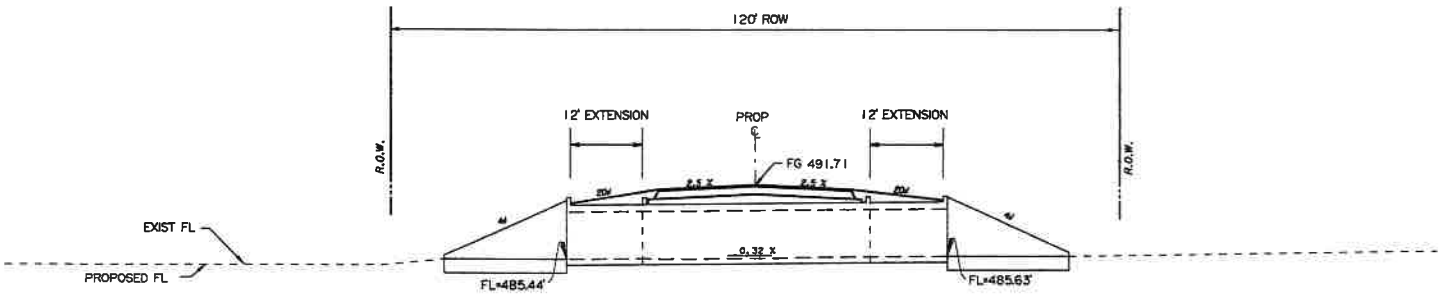
DIST. NO. / DIV. NO.	FEDERAL AID PROJECT NO.	SHEET NO.
6	C 83-03-42, ETC	115
STATE	DIST.	COUNTY
TEXAS	PARIS	HOPKINS
CONT.	SECT.	JOB	HIGHWAY NO.
0083	03	042, Etc	SH 11, Etc

2297 FINALPP3.DGN


PI STATION = 38+18.77
DELTA = 32° 31' 36.37" (RT)
TANGENT = 339.67
LENGTH = 661.00
RADIUS = 1,164.35
PC STATION = 34+79.10
PT STATION = 41+40.10
PI STATION = 45+76.81
DELTA = 1° 12' 37.64" (LT)
TANGENT = 121.01
LENGTH = 242.01
RADIUS = 11,455.53
PC STATION = 44+55.80
PT STATION = 46+97.81
BEGIN WORK
FM 2297 STA 40+32.5
CSJ 0083-03-042
GRADE DITCH TO DRAIN NORTH
PC 44+55.79
PT 46+97.81
PC 79+65.68
CONCRETE FLUME WITH PAD
INSTALL 132' OF TY II CURB AND GUTTER
18"x20' RCP
18"x28' RCP
18"x42' RCP
18"x38' RCP
STA 40+00.00
STA 53+00.00
S 22° 41' 24.62" W
315.68'
45+00
50+00
S 21° 20' 46.76" W
944.91'
℄ FM 2297
18"x30' RCP
PT 41+40.10
EXISTING 3-6'x4'x36' MBC
EXTEND 12' LT/RT
W/4:1 SETB-SW-0
PROPOSED ROW (120')
EXISTING ROW (100')
END PROPOSED TYPICAL SECTION ②
STA 51+47.5
℄ SH 11
135'
BEGIN PROPOSED TYPICAL SECTION ①
STA 40+32.5
BEGIN PROPOSED TYPICAL SECTION ②
STA 43+00
BEGIN PROPOSED TYPICAL SECTION ③
STA 49+32
FIELD CHANGE:
⚠ INSTALL CURB AND GUTTER FROM STA. 48+10 TO 49+95 TO FLATTEN THE GRADE OF THE EXISTING BACKSLOPE. INSTALL AND CONNECT 18" RCP BETWEEN THE EXISTING DRIVEWAY PIPE TO FACILITATE DRAINAGE. S.E.T.S REMOVED WILL BE REINSTALLED AT A LOCATION DESIGNATED BY THE ENGINEER.
SHEET TOTALS
EST. FINAL UNIT DESCRIPTION
12.66 STA ITEM 100-2002 PREP R.O.W.
1,777 CY ITEM 110-2001 EXCAVATION
1,895 CY ITEM 132-2004 EMBANKMENT
SCALE
HOR 1" = 100'
VERT 1" = 10'
510
500
490
480
BOL 40+32.58
EL = 492.73'
VPC 42+73.39
EL = 491.76'
VPT 45+24.61
EL = 492.48'
-0.4023 %
+1.1283 %
489.61
489.78
STA 41+31.14 RT
EXISTING 3-6'x4'x36' MBC
EXTEND 12' LT/RT
W/4:1 SETB-SW-0
RIGHT DITCH
LEFT DITCH
STA = 44+00.00
EL = 491.25'
ex = 0.48'
K = 165
L = 253.22'
PROFILE GRADE
EXISTING GROUND
STA 48+43.96 LT
493.21
492.04
491.79
STA 47+19.39 LT
VPC 49+11.77
EL = 497.03'
INSTALL 18" RCP TO CONNECT EXISTING DRIVEWAY PIPE.
494.67
VPI 51+00.00
EL = 498.82'
VPI 51+53.52
EL = 498.95'
VPI 51+81.52
EL = 499.65'
VPI 52+09.52
EL = 498.95'
VPI 53+00.00
EL = 499.99'
+1.1283 %
0.26 %
2.50 %
-2.50 %
1.14 %
STA = 51+33.48
EL = 499.53'
ex = 0.46'
K = 531
L = 443.42'
SSD = 1514'
45+00
50+00
165 95. 59 34 44 25 89 152 89 218 34 185 12.66 17 272 49 296 131 264 206 181 223 93 308 49 363 31
492.46 492.35 492.06 491.91 491.67 491.78 491.74 491.89 492.40 492.24 493.51 492.78 494.64 493.62 495.76 494.67 496.89 495.84 497.95 497.11 498.82 498.20 499.19 499.12 499.99
STATE OF TEXAS
CHRISTOPHER E. MOUNTAIN
82731
REGISTERED PROFESSIONAL ENGINEER
P.E.
3-5-10
FM 2297
PLAN
AND
PROFILE
REVISION
© 2006 TxDOT
FED.RD. DIV.NO. 6
FEDERAL AID PROJECT NO. C 83-03-42, ETC
SHEET NO. 115A
STATE TEXAS
DIST. PARIS
COUNTY HOPKINS
CONT. 0083
SECT. 03
JOB 042, Etc
HIGHWAY NO. SH 11, Etc
2297 FINALPP3.DGN



SH 11 STA. 120+00 - 10° LFS
INSTALL 2 - 18" X 114' RCP
INSTALL 6:1 SET LT & RT



FM 2297 STA. 43+95
EXTEND EXISTING 3-6' X 4' X 36'
MULTIPLE BOX CULVERT 12' LT & RT
INSTALL 4:1 SET LT & RT

CULVERT LAYOUT

STATE OF TEXAS
M. PAULINE MORREL
94443
LICENSED PROFESSIONAL ENGINEER

M Pauline Morrel
11-12-2007

SCALE
HORIZONTAL 1" = 20'
VERTICAL 1" = 10'

FED. RD. DIV. NO.	PROJECT NO.		SHEET NO.
6	C 83-03-42, ETC		163
STATE	DIST.	COUNTY	
TEXAS	PARIS	HOPKINS	
CONT.	SECT.	JOB	HIGHWAY NO.
0083	03	042, ETC	SH 11, ETC

LOCATION	PROPOSED STRUCTURE								EXISTING CHANNEL						
	STA	25 YEAR FREQ			100 YEAR FREQ				STA	25 YEAR FREQ			100 YEAR FREQ		
		Q (cfs)	CHANN VEL (ft/s)	WSEL (ft)	Q (cfs)	CHANN VEL (ft/s)	WSEL (ft)	LOW CHORD ELEV		Q (cfs)	CHANN VEL (ft/s)	WSEL (ft)	Q (cfs)	CHANN VEL (ft/s)	WSEL (ft)
SECTION 1 (END OF EXPANSION)	12+95	866	2.05	474.66	1500	2.43	475.01		12+95	866	2.05	474.66	1500	2.45	475.01
SECTION 2 (d.s. OF BRIDGE)	11+00	866	4.36	475.33	1500	6.26	475.67		11+00	866	2.36	475.30	1500	2.97	475.64
BRIDGE FACE (DS)	10+83	866	5.04	475.36	1500	7.41	475.66	477.55	10+50	866	1.91	475.45	1500	2.51	475.83
ROAD	10+00	866	-	-	1500	-	-		10+00	866	2.08	475.52	1500	2.71	475.92
BRIDGE FACE (US)	9+33	866	3.1	475.96	1500	4.18	476.78	477.55	9+50	866	2.50	475.59	1500	3.34	476.00
SECTION 3 (u.s OF BRIDGE)	9+00	866	2.81	476.04	1500	3.54	476.92		9+00	866	2.25	475.68	1500	2.90	476.15
SECTION 4 (BEGIN CONTRACTION)	7+05	866	1.60	476.45	1500	1.62	477.33		7+05	866	1.91	476.23	1500	2.28	476.73

NOTE:
HEC-RAS USED FOR HYDRAULIC ANALYSIS AND DESIGN.

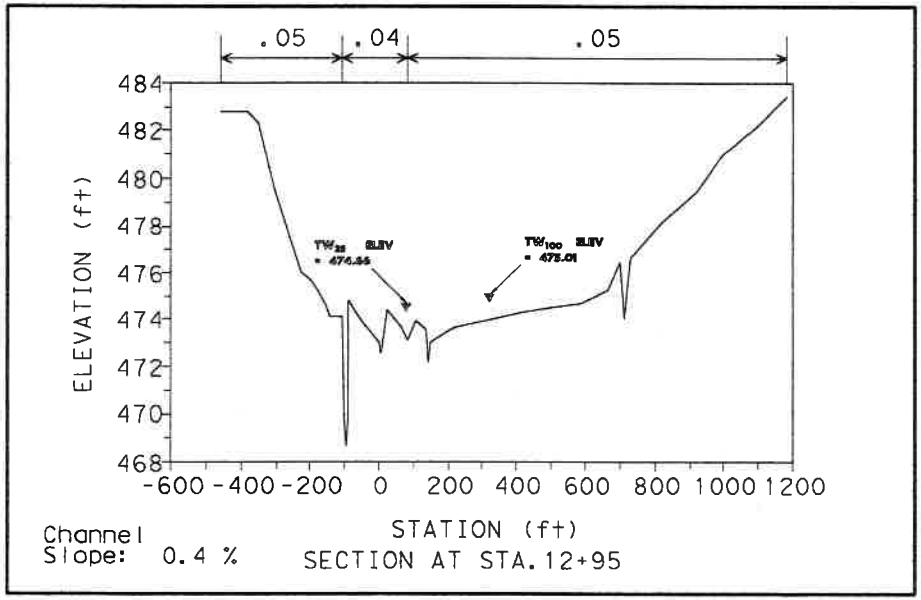
PROPOSED ANALYSIS WAS PERFORMED ON A 140' (80'-60') TY C PRESTRESSED CONCRETE BEAM STRUCTURE

NRCS RUNOFF CURVE NUMBER METHOD

FREQUENCY YEAR	25	100
AREA (sq mi)	1.858	1.858
INITIAL ABSTRACTION (in)	1.967	1.967
ACCUMULATED RAINFALL (in)	7.95	10.22
ACCUMULATED DIRECT RUNOFF (in)	2.286	3.791
TIME OF CONCENTRATION (hr)	1.22	1.22
UNIT PEAK DISCHARGE (cfs/sq mi/in)	234.47	245.00
COEFFICIENT 0	2.4155	2.4348
COEFFICIENT 1	-0.5136	-0.5153
COEFFICIENT 2	-0.1421	-0.1517
PONDING ADJUSTMENT FACTOR	0.87	0.87

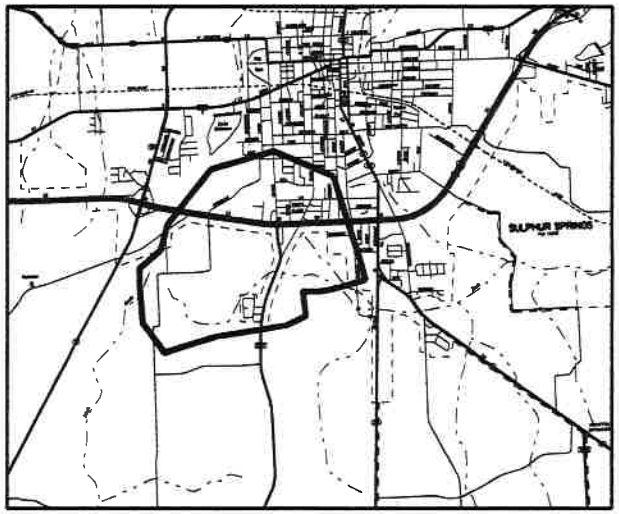
WHERE: $q_u = 10^{C_0+C_1 \log T_c + C_2 (\log T_c)^2}$

$Q = q_u (\text{area}) (R) (F)$



HYDRAULIC DATA

SH 11 - ROCK CREEK BRIDGE



DRAINAGE AREA MAP

0 0.5 1.0
MILES

N

STATE OF TEXAS
M. PAULINE MORREL
94443
LICENSED PROFESSIONAL ENGINEER

11-12-2007

FED. RD. DIV. NO.	FEDERAL PROJECT NO.		SHEET NO.
6	C 83-03-42, ETC		183
STATE	DIST.	COUNTY	
TEXAS	PAR	HOPKINS	
CONT.	SECT.	JOB	HIGHWAY NO.
0083	03	042, ETC.	SH 11, ETC.

ROCK CREEK BRIDGE HYDRAULIC DETAILS

ROCKCREEK HYDRAULIC.DGN

Appendix C
Tables

Table 1: Duplicate Effective Model Summary											
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)	
94620	PF 1	2490	477.00	483.67		483.77	0.004392	3.83	1088.85	548.06	0.30
94330	PF 1	2490	477.00	482.28		482.38	0.005986	3.76	1134.75	715.63	0.34
94160	PF 1	2490	476.00	481.74		481.80	0.003048	3.14	1441.68	779.49	0.25
93920	PF 1	2490	475.00	480.98		481.06	0.003148	3.10	1142.70	474.03	0.25
93550	PF 1	2490	473.50	479.51		479.62	0.005174	3.47	996.21	492.98	0.31
93070	PF 1	2490	471.00	477.83		477.89	0.002759	2.79	1362.90	695.96	0.23
92600	PF 1	2490	471.00	476.81		476.85	0.001795	2.39	1911.89	917.76	0.19
92340	PF 1	2490	470.10	476.61		476.62	0.000484	1.36	3148.69	1149.68	0.10
92200	PF 1	2490	469.70	476.57		476.57	0.00024	1.01	3838.06	1085.27	0.07
92020	PF 1	2490	469.00	476.54		476.55	0.000111	0.70	4656.46	1014.15	0.05
91740	PF 1	2490	464.50	476.53		476.53	0.000025	0.50	7558.56	1108.30	0.03
91707	PF 1	2490	464.50	476.51	475.15	476.53	0.000516	2.20	2542.17	1221.48	0.12
91700		Bridge									
91693	PF 1	2490	464.50	473.84	473.84	475.90	0.024021	12.68	236.41	51.00	0.80
91680	PF 1	2490	464.50	473.48		473.48	0.00014	0.90	4632.91	1249.60	0.06
90930	PF 1	5710	464.00	473.29		473.33	0.000931	2.46	3666.81	855.70	0.16
90320	PF 1	5710	464.00	473.13		473.14	0.000144	1.04	7880.64	1379.44	0.06
90140	PF 1	6560	464.40	473.03		473.09	0.000792	2.51	3922.82	786.07	0.15
90086	PF 1	6560	464.00	473.01	469.49	473.04	0.000505	2.06	4610.26	803.18	0.12
90070		Bridge									
90054	PF 1	6560	464.00	470.45	469.00	470.56	0.002233	3.48	2723.96	680.79	0.24
89980	PF 1	6560	464.00	470.26		470.38	0.002561	3.65	2595.58	672.92	0.26
89490	PF 1	6560	461.00	469.38		469.47	0.0016	3.56	3029.65	823.69	0.23
88760	PF 1	6560	460.90	468.96		468.98	0.000342	1.67	5803.81	1218.36	0.10
88080	PF 1	6560	460.60	468.86		468.87	0.000096	0.91	10392.03	2154.16	0.06
88012	PF 1	6560	460.60	468.86	467.55	468.86	0.000096	0.92	10377.96	2152.24	0.06
87990		Bridge									
87968	PF 1	6560	457.90	465.68	465.00	465.72	0.000945	2.61	4899.30	1864.04	0.17
87900	PF 1	6560	457.90	465.61		465.65	0.001017	2.69	4770.50	1847.97	0.18

Table 1, Page 2 of 3

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)	
86370	PF 1	6560	453.70	465.18		465.19	0.00016	1.23	8339.73	2055.46	0.07
83980	PF 1	9900	452.10	463.74		463.85	0.004158	4.83	4652.86	1758.47	0.32
82790	PF 1	9900	450.80	460.89		460.94	0.001674	2.88	6247.25	2178.32	0.20
81790	PF 1	9900	449.80	458.76		458.83	0.002777	4.17	5182.65	1668.43	0.27
81700	PF 1	9900	449.50	458.67		458.70	0.00075	2.15	8044.47	1842.26	0.14
79250	PF 1	11660	442.20	455.48		455.62	0.00226	3.86	3971.88	783.17	0.21
76600	PF 1	9940	437.10	448.87		449.02	0.002921	4.11	3557.54	1054.99	0.26
75250	PF 1	9940	435.50	446.84		446.89	0.001013	3.30	5952.26	2032.14	0.19
71880	PF 1	14920	434.00	446.19		446.21	0.000158	1.49	14611.49	2365.48	0.08
71830	PF 1	14920	433.80	446.09	440.51	446.18	0.002387	2.46	6216.09	2477.28	0.25
71820		Bridge									
71810	PF 1	14920	433.80	445.55		445.68	0.003457	2.94	5120.67	1758.68	0.29
71780	PF 1	14920	434.00	445.54		445.57	0.000492	1.79	13100.62	2289.75	0.10
70230	PF 1	14920	429.80	444.60		444.67	0.001506	3.38	7135.42	1066.55	0.17
67950	PF 1	13860	427.00	441.69		441.75	0.001223	3.01	8102.98	1577.22	0.16
65330	PF 1	13860	426.00	440.77		440.79	0.000256	1.68	11989.16	1457.23	0.08
64080	PF 1	13860	425.70	440.02		440.17	0.001675	3.96	5814.49	1080.75	0.19
64010	PF 1	13860	425.60	439.92	433.24	440.07	0.00135	3.78	5820.40	1080.97	0.18
63995		Bridge									
63980	PF 1	13860	425.50	439.23	433.15	439.40	0.001696	4.11	5201.79	986.84	0.20
63900	PF 1	13860	425.80	438.26		438.89	0.00681	7.70	2919.04	748.61	0.40
63730	PF 1	13860	424.80	436.98		437.61	0.008229	8.05	3171.53	1167.32	0.44
63550	PF 1	13860	423.70	435.62		436.04	0.007387	7.18	3716.64	1311.70	0.41
63370	PF 1	13860	422.60	434.76		434.92	0.00371	4.93	5143.99	1469.41	0.29
62760	PF 1	15410	419.40	432.27		432.40	0.004606	5.06	6631.76	2728.91	0.31
62480	PF 1	15410	418.30	431.70		431.75	0.001806	3.15	9097.57	2761.94	0.19
62030	PF 1	15410	417.60	431.06		431.09	0.001164	2.73	11699.18	3678.67	0.15
60190	PF 1	15410	414.60	430.34		430.35	0.000204	1.03	20794.61	4165.94	0.06
58130	PF 1	15410	411.80	430.05		430.06	0.000122	1.47	17322.20	3034.20	0.08

Table 1, Page 3 of 3

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)	
57390	PF 1	15410	414.00	429.99		430.00	0.000053	1.10	24552.55	3893.16	0.05
56480	PF 1	15410	413.20	429.94		429.95	0.000054	1.07	17906.74	1750.00	0.05
56420	PF 1	15410	413.20	429.85	422.91	429.93	0.003998	2.48	6808.61	3066.64	0.10
56240	PF 1	15410	413.20	428.13	422.91	428.57	0.01173	5.33	2889.82		0.24
56180	PF 1	15410	413.00	427.35	421.16	427.63	0.015686	4.35	3774.02	1977.11	0.20
56140	PF 1	15410	413.00	425.50	421.16	426.46	0.023656	7.84	1965.87		0.39
56090	PF 1	15410	413.00	425.60		425.64	0.000602	2.31	10185.83	1478.96	0.12
52100	PF 1	15410	409.70	420.70		421.12	0.00778	7.55	3800.97	1015.00	0.42
52030	PF 1	15410	409.10	420.60	414.45	420.86	0.001565	4.16	3761.46	422.85	0.25
52020		Bridge									
52010	PF 1	15410	409.1	420.57		420.83	0.001584	4.18	3747.1	422.74	0.25
51910	PF 1	15410	408.00	420.57		420.62	0.000733	3.00	9434.77	1330.00	0.15
48000	PF 1	15410	403.50	418.35		418.44	0.001168	3.80	7624.65	1203.22	0.19
45970	PF 1	15410	397.90	417.43	412.07	417.45	0.000267	1.96	16020.90	2330.00	0.09

Table 2: Corrected Effective/Pre-Project Model Summary											
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)	
97581	1500-TXDOT	1500	490.00	495.56		495.69	0.003928	3.25	632.14	398.50	0.29
97348	1500-TXDOT	1500	488.00	494.64		494.76	0.004045	4.37	836.80	422.33	0.31
97145	1500-TXDOT	1500	488.00	493.35		493.54	0.009527	5.70	593.82	320.02	0.45
96807	1500-TXDOT	1500	486.00	492.95		492.97	0.000588	1.68	1689.69	620.23	0.12
96675	1500-TXDOT	1500	485.00	492.86	489.96	492.88	0.000594	1.87	1612.80	586.45	0.12
96640		Culvert									
96590	1500-TXDOT	1500	485.00	490.78	490.65	491.14	0.010847	6.16	559.15	470.58	0.48
96529	1500-TXDOT	1500	484.00	490.58	489.74	490.66	0.003414	3.52	942.70	465.92	0.27
96410	1500-TXDOT	1500	484.00	490.11	488.83	490.19	0.003673	3.88	895.28	429.91	0.29
96327	1500-TXDOT	1500	483.99	489.63	488.52	489.79	0.006177	4.84	602.30	356.29	0.38
96207	1500-TXDOT	1500	482.00	489.13		489.21	0.003596	3.75	882.54	416.68	0.28
95675	1500-TXDOT	1500	480.00	486.75		486.93	0.007348	5.15	689.04	424.90	0.40
95334	1500-TXDOT	1500	480.00	485.59		485.62	0.002449	2.55	1249.48	660.11	0.22
94620	1500-TXDOT	2490	477.00	483.67		483.77	0.004392	3.83	1088.85	548.06	0.30
94330	1500-TXDOT	2490	477.00	482.28		482.38	0.005986	3.76	1134.75	715.63	0.34
94160	1500-TXDOT	2490	476.00	481.74		481.80	0.003048	3.14	1441.68	779.49	0.25
93920	1500-TXDOT	2490	475.00	480.98		481.06	0.003148	3.10	1142.70	474.03	0.25
93550	1500-TXDOT	2490	473.50	479.51		479.62	0.005174	3.47	996.21	492.98	0.31
93070	1500-TXDOT	2490	471.00	477.83		477.89	0.002759	2.79	1362.90	695.96	0.23
92600	1500-TXDOT	2490	471.00	476.81		476.85	0.001795	2.39	1911.89	917.76	0.19
92340	1500-TXDOT	2490	470.10	476.61		476.62	0.000484	1.36	3148.69	1149.68	0.10
92200	1500-TXDOT	2490	469.70	476.57		476.57	0.00024	1.01	3838.06	1085.27	0.07
92020	1500-TXDOT	2490	469.00	476.54		476.55	0.000111	0.70	4656.46	1014.15	0.05
91740	1500-TXDOT	2490	464.50	476.53		476.53	0.000025	0.50	7558.56	1108.30	0.03
91707	1500-TXDOT	2490	464.50	476.51	475.15	476.53	0.000516	2.20	2542.17	1221.48	0.12
91700		Bridge									
91693	1500-TXDOT	2490	464.50	473.84	473.84	475.90	0.024021	12.68	236.41	51.00	0.80
91680	1500-TXDOT	2490	464.50	473.48		473.48	0.00014	0.90	4632.91	1249.60	0.06
90930	1500-TXDOT	5710	464.00	473.29		473.33	0.000931	2.46	3666.81	855.70	0.16

Table 2, Page 2 of 3

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)	
90320	1500-TXDOT	5710	464.00	473.13		473.14	0.000144	1.04	7880.64	1379.44	0.06
90140	1500-TXDOT	6560	464.40	473.03		473.09	0.000792	2.51	3922.82	786.07	0.15
90086	1500-TXDOT	6560	464.00	473.01	469.49	473.04	0.000505	2.06	4610.26	803.18	0.12
90070		Bridge									
90054	1500-TXDOT	6560	464.00	470.45	469.00	470.56	0.002233	3.48	2723.96	680.79	0.24
89980	1500-TXDOT	6560	464.00	470.26		470.38	0.002561	3.65	2595.58	672.92	0.26
89490	1500-TXDOT	6560	461.00	469.38		469.47	0.0016	3.56	3029.65	823.69	0.23
88760	1500-TXDOT	6560	460.90	468.96		468.98	0.000342	1.67	5803.81	1218.36	0.10
88080	1500-TXDOT	6560	460.60	468.86		468.87	0.000096	0.91	10392.03	2154.16	0.06
88012	1500-TXDOT	6560	460.60	468.86	467.55	468.86	0.000096	0.92	10377.96	2152.24	0.06
87990		Bridge									
87968	1500-TXDOT	6560	457.90	465.68	465.00	465.72	0.000945	2.61	4899.30	1864.04	0.17
87900	1500-TXDOT	6560	457.90	465.61		465.65	0.001017	2.69	4770.50	1847.97	0.18
86370	1500-TXDOT	6560	453.70	465.18		465.19	0.00016	1.23	8339.73	2055.46	0.07
83980	1500-TXDOT	9900	452.10	463.74		463.85	0.004158	4.83	4652.86	1758.47	0.32
82790	1500-TXDOT	9900	450.80	460.89		460.94	0.001674	2.88	6247.25	2178.32	0.20
81790	1500-TXDOT	9900	449.80	458.76		458.83	0.002777	4.17	5182.65	1668.43	0.27
81700	1500-TXDOT	9900	449.50	458.67		458.70	0.00075	2.15	8044.47	1842.26	0.14
79250	1500-TXDOT	11660	442.20	455.48		455.62	0.00226	3.86	3971.88	783.17	0.21
76600	1500-TXDOT	9940	437.10	448.87		449.02	0.002921	4.11	3557.54	1054.99	0.26
75250	1500-TXDOT	9940	435.50	446.84		446.89	0.001013	3.30	5952.26	2032.14	0.19
71880	1500-TXDOT	14920	434.00	446.19		446.21	0.000158	1.49	14611.49	2365.48	0.08
71830	1500-TXDOT	14920	433.80	446.09	440.51	446.18	0.002387	2.46	6216.09	2477.28	0.25
71820		Bridge									
71810	1500-TXDOT	14920	433.80	445.55		445.68	0.003457	2.94	5120.67	1758.68	0.29
71780	1500-TXDOT	14920	434.00	445.54		445.57	0.000492	1.79	13100.62	2289.75	0.10
70230	1500-TXDOT	14920	429.80	444.60		444.67	0.001506	3.38	7135.42	1066.55	0.17
67950	1500-TXDOT	13860	427.00	441.69		441.75	0.001223	3.01	8102.98	1577.22	0.16
65330	1500-TXDOT	13860	426.00	440.77		440.79	0.000256	1.68	11989.16	1457.23	0.08

Table 2, Page 3 of 3

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)	
64080	1500-TXDOT	13860	425.7	440.02		440.17	0.001675	3.96	5814.49	1080.75	0.19
64010	1500-TXDOT	13860	425.6	439.92	433.24	440.07	0.00135	3.78	5820.4	1080.97	0.18
63995		Bridge									
63980	1500-TXDOT	13860	425.5	439.23	433.15	439.4	0.001696	4.11	5201.79	986.84	0.2
63900	1500-TXDOT	13860	425.8	438.26		438.89	0.00681	7.7	2919.04	748.61	0.4
63730	1500-TXDOT	13860	424.8	436.98		437.61	0.008229	8.05	3171.53	1167.32	0.44
63550	1500-TXDOT	13860	423.7	435.62		436.04	0.007387	7.18	3716.64	1311.7	0.41
63370	1500-TXDOT	13860	422.6	434.76		434.92	0.00371	4.93	5144.03	1469.41	0.29
62760	1500-TXDOT	15410	419.4	432.26		432.4	0.004607	5.06	6631.09	2728.9	0.31
62480	1500-TXDOT	15410	418.3	431.7		431.75	0.001807	3.15	9096.31	2761.9	0.19
62030	1500-TXDOT	15410	417.6	431.06		431.09	0.001165	2.73	11695.7	3678.62	0.15
60190	1500-TXDOT	15410	414.6	430.34		430.35	0.000205	1.03	20787.74	4165.81	0.06
58130	1500-TXDOT	15410	411.8	430.05		430.06	0.000122	1.48	17316.27	3033.91	0.08
57390	1500-TXDOT	15410	414	429.99		430	0.000053	1.1	24544.59	3892.61	0.05
56480	1500-TXDOT	15410	413.2	429.94		429.95	0.000054	1.07	17903.11	1750	0.05
56420	1500-TXDOT	15410	413.2	429.85	422.91	429.93	0.00401	2.49	6801.69	3066.1	0.1
56240	1500-TXDOT	15410	413.2	428.13	422.91	428.57	0.01173	5.33	2889.82		0.24
56180	1500-TXDOT	15410	413	427.34	421.16	427.62	0.015978	4.38	3750.8	1975.05	0.2
56140	1500-TXDOT	15410	413	425.49	421.16	426.44	0.023656	7.84	1965.87		0.39
56090	1500-TXDOT	15410	413	425.58		425.62	0.000606	2.32	10164.43	1478.74	0.12
52100	1500-TXDOT	15410	409.7	420.98		421.34	0.006277	6.91	4093.1	1015	0.38
52030	1500-TXDOT	15410	409.1	420.87	414.45	421.12	0.001423	4.04	3876.56	423.74	0.23
52020		Bridge									
52010	1500-TXDOT	15410	409.1	420.84		421.09	0.001438	4.05	3863.59	423.64	0.24
51910	1500-TXDOT	15410	408	420.85		420.9	0.000646	2.86	9808.15	1330	0.14
48000	1500-TXDOT	15410	403.5	419.05		419.12	0.000883	3.43	8484.36	1283.07	0.17
45970	1500-TXDOT	15410	397.9	418.43	411.92	418.44	0.000172	1.64	18350.9	2330	0.07

Table 3: Post-Project Model Summary											
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)	
97581	1500-TXDOT	1500	490	495.56		495.69	0.00	3.25	632.10	398.49	0.29
97348	1500-TXDOT	1500	488	494.64		494.76	0.00	4.37	836.58	422.30	0.31
97145	1500-TXDOT	1500	488	493.33		493.52	0.01	5.77	586.96	318.96	0.45
96807	1500-TXDOT	1500	486	492.91		492.93	0.00	1.71	1666.23	617.66	0.12
96675	1500-TXDOT	1500	485	492.81	489.97	492.84	0.00	1.91	1588.23	584.43	0.12
96640		Culvert									
96590	1500-TXDOT	1500	485	490.71	489.66	490.92	0.00	4.19	416.56	286.97	0.32
96529	1500-TXDOT	1500	484	490.36	489.43	490.59	0.01	4.43	392.66	296.87	0.35
96410	1500-TXDOT	1500	484	489.85	488.51	490.03	0.00	3.59	443.99	186.27	0.29
96327	1500-TXDOT	1500	484	489.53	488.42	489.70	0.00	3.81	462.28	187.83	0.30
96207	1500-TXDOT	1500	482	489.13	487.86	489.22	0.00	3.75	846.15	416.82	0.28
95675	1500-TXDOT	1500	480	486.75		486.93	0.01	5.15	689.04	424.90	0.40
95334	1500-TXDOT	1500	480	485.59		485.62	0.00	2.55	1249.48	660.11	0.22
94620	1500-TXDOT	2490	477	483.67		483.77	0.00	3.83	1088.85	548.06	0.30
94330	1500-TXDOT	2490	477	482.28		482.38	0.01	3.76	1134.75	715.63	0.34
94160	1500-TXDOT	2490	476	481.74		481.80	0.00	3.14	1441.68	779.49	0.25
93920	1500-TXDOT	2490	475	480.98		481.06	0.00	3.1	1142.70	474.03	0.25
93550	1500-TXDOT	2490	473.5	479.51		479.62	0.01	3.47	996.21	492.98	0.31
93070	1500-TXDOT	2490	471	477.83		477.89	0.00	2.79	1362.90	695.96	0.23
92600	1500-TXDOT	2490	471	476.81		476.85	0.00	2.39	1911.89	917.76	0.19
92340	1500-TXDOT	2490	470.1	476.61		476.62	0.00	1.36	3148.69	1149.68	0.10
92200	1500-TXDOT	2490	469.7	476.57		476.57	0.00	1.01	3838.06	1085.27	0.07
92020	1500-TXDOT	2490	469	476.54		476.55	0.00	0.7	4656.46	1014.15	0.05
91740	1500-TXDOT	2490	464.5	476.53		476.53	0.00	0.5	7558.56	1108.30	0.03
91707	1500-TXDOT	2490	464.5	476.51	475.15	476.53	0.00	2.2	2542.17	1221.48	0.12
91700		Bridge									
91693	1500-TXDOT	2490	464.5	473.84	473.84	475.90	0.02	12.68	236.41	51.00	0.80
91680	1500-TXDOT	2490	464.5	473.48		473.48	0.00	0.9	4632.91	1249.60	0.06
90930	1500-TXDOT	5710	464	473.29		473.33	0.00	2.46	3666.81	855.70	0.16