HYDROLOGY AND HYDRAULICS

A hydrologic and hydraulic analysis was performed for Onion Creek and Williamson Creek. The U.S. Army Corps of Engineers Fort Worth District (USACE) Hydrology and Hydraulics Section, Halff Associates, Inc. (Fort Worth) and HDR, Inc. (Austin) each contributed significant technical efforts as part of the overall investigation. The analysis consisted of the development of an Existing Conditions hydrologic and hydraulic model for Onion Creek and Williamson Creek and the development of structural and non-structural flood protection alternatives for selected flood damage reaches along Onion Creek and Williamson Creek.

ONION CREEK-EXISTING CONDITIONS

DESCRIPTION OF CREEK

Onion Creek is located within the Colorado River basin. Onion Creek originates in eastern Blanco County and flows easterly through Hays County and Travis County to the Colorado River. The Onion Creek drainage area is 343 square miles, of which 172 square miles lie upstream from the Travis/Hays County line. The headwater area of Onion Creek, constituting approximately 50 percent of the watershed, lies within the Edwards Plateau region above the Balcones Escarpment and is hilly and rocky. Below the Balcones Escarpment the hilly characteristics gradually blend into the rolling plains of the Blackland Prairie. The Onion Creek channel varies from an earthen channel to limestone banks and bottom. The average channel slope of Onion Creek from Hays County to the Colorado River is approximately 11.5 feet-per-mile (approximately 750 feet elevation difference). Figure A-1 is a typical view of the Onion Creek channel.

Figure A-1 Onion Creek channel

HYDRAULIC MODEL

The Onion Creek hydraulic model developed for this analysis is based on the Onion Creek backwater models developed for the 1997 Travis County Flood Insurance Study (FIS). The Onion Creek 1997 FIS models were based on the Onion Creek backwater models developed by the U.S. Army Corps of Engineers Galveston District for the 1972 Onion Creek Flood Plain Information Report and updated using current information.

The Onion Creek 1997 FIS backwater models were developed using the HEC-2 Water Surface Profiles, September 1982 version computer program. Seven distinct backwater models, each representing a reach of Onion Creek from the Colorado River through Hays County, were developed. These backwater models were combined and converted to HEC-RAS River Analysis System, version 3.0.1. HEC-RAS is software that computes one-dimensional steady and unsteady flow hydraulics calculations. The HEC-RAS software was developed at the Hydrologic Engineering Center (HEC) in Davis, California, which is a division of the Institute for Water Resources of the U.S. Army Corps of Engineers. The most recent version of HEC-RAS (version 3.1.3) was used to compute the final water surface profiles.

The Onion Creek hydraulic model incorporated input data developed from the following sources: TXDOT bridge plans, USGS 7.5-minute quadrangle topographic maps, June 1972 field surveyed cross-sections, February - March 1986 field surveyed cross-sections, City of Austin 2-foot topography, City of Austin 1-foot topography, City of Austin bridge plans, Travis County bridge plans, 1988 field surveyed cross-sections, and digitized cross-sections from the Hays County FIS. The orientation of the cross-section data is downstream left-to-right. Total number of cross-section in the Onion Creek hydraulic model is 886.

Manning coefficients of roughness (n values) were incorporated in the Onion Creek hydraulic model to represent the Onion Creek channel and overbanks roughness. The n values were determined from aerial photography and site field reconnaissance. The ranges of n values are as follows: channel: 0.035 – 0.085, overbanks: 0.040 – 0.090.

The Onion Creek hydraulic model limits extend from the Onion Creek/Colorado River confluence in Travis County at the downstream limit to creek station 349330 (66.16 miles) in Hays County. The Travis County/Hays County line is located at creek station 144930. The identified damage reaches along Onion Creek are located within Travis County.

GAGE ANALYSIS

There are two USGS stream gages along Onion Creek. Specifics are as follows:

Onion Creek at U.S. 183

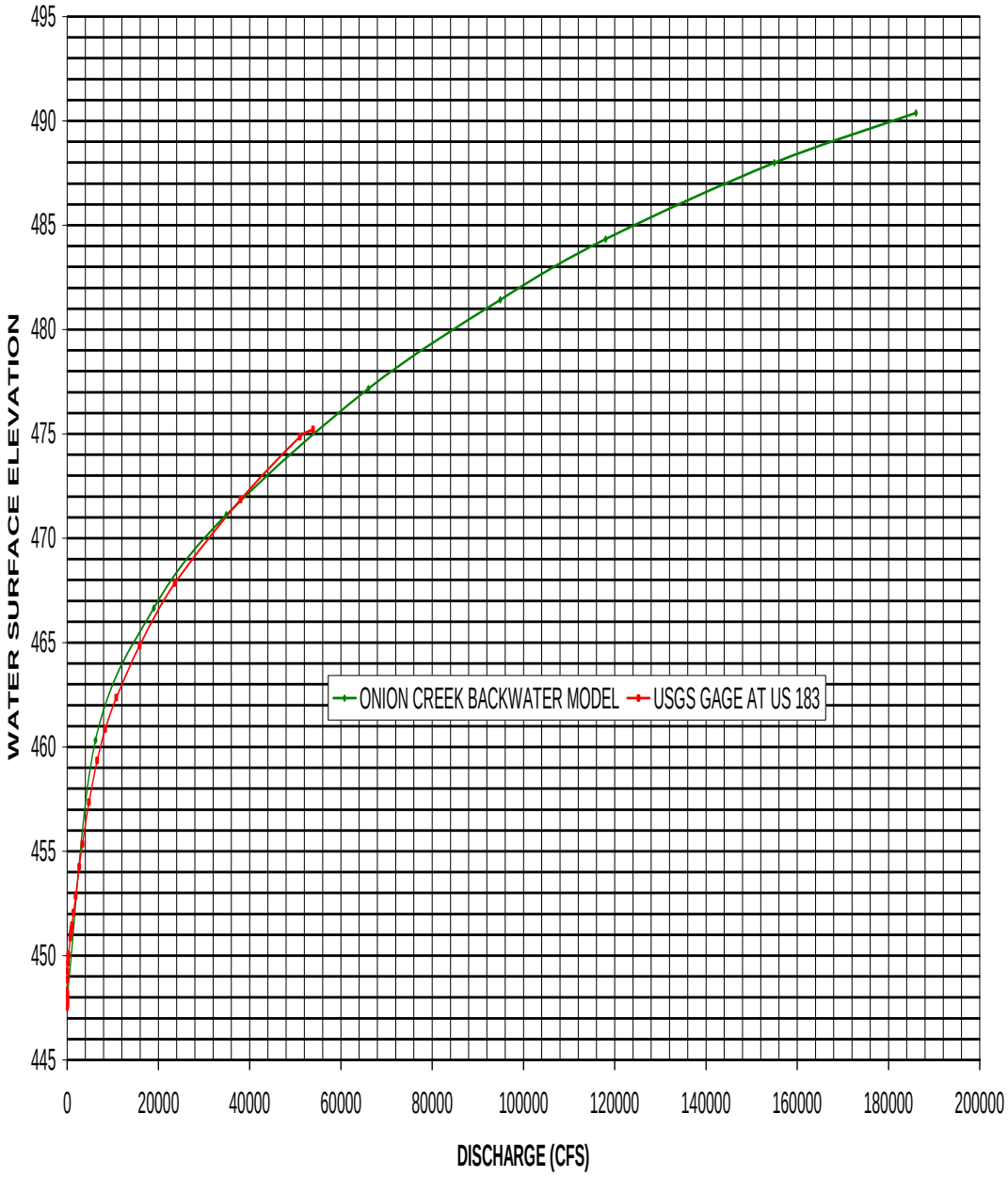
- station number 08159000
- drainage area 321 square miles
- located on right bank at downstream side of bridge – Travis County
- datum 442.85 feet above sea level

Onion Creek near Driftwood

- station number 08158700
- drainage area 124 square miles
- located on left bank 160 feet left of the upstream side of bridge at low water crossing on FM 150 – Hays County
- datum 878.13 feet above sea level

Figure A-2 indicates the comparison of the Onion Creek backwater model with the USGS Gage at U.S. Highway 183.

Figure A-2
ONION CREEK AT US HIGHWAY 183



STRUCTURES

Table A-1 indicates the structures crossing Onion Creek.

Table A-1

Structure	**Creek Station**
low water crossing	23502.5
FM 973	35265
New Burleson Road	44345
Old Burleson Road	45335
US 183	55590
Doyle Crossing	56830
McKinney Falls Parkway	65655
William Cannon Drive	83882.5
Bluff Springs Road	100375
Slaughter Road	102550
River Plantation Drive	111865
IH 35	125345
Old San Antonio Road	129722.5
Twin Creek Road	134560
channel dam	136022.5
Missouri-Pacific Railroad	157840
FM 967	162870
FM 150	243200
FM 1826	271225
FM 150	293460
FM 12	317010

SPLIT FLOW ANALYSIS

There are three split flow areas along Onion Creek. These are as follows:

1. Overflow in left overbank downstream of cross-section 14240. Flows at this location are diverted into the Colorado River. The split flow analysis incorporates a rating curve at cross-section 14240 to represent flow conditions.

2. Overflow over New Burleson Road. Weir flow begins over New Burleson Road at the intersection with Old Burleson Road. The new roadway is raised 8-10 feet above natural ground and is parallel to the Onion Creek natural flow path creating a split flow in the left overbank. Split flow is defined between creek stations 46020 – 50750. Split flow returns to Onion Creek at creek station 44260. The split flow analysis incorporates the top of roadway elevations from the New Burleson Road plans and a weir coefficient.

3. Overflow to Williamson Creek. Split flow occurs along two areas adjacent to Williamson Creek near William Cannon Drive at the site of the existing golf course on the site of the former sewage treatment plant. The split flow occurs from creek stations 70820 – 71260 and returns to Onion Creek at creek station 67620, and occurs at creek stations 81220 – 83445 and returns to Onion Creek at creek station 67620. The split flow analysis incorporates the natural ground points along the split flow reaches and a corresponding Manning coefficient of roughness value.

This split flow analysis is part of the 1997 Onion Creek FIS HEC-2 model. However application of the split flow analysis in the HEC-RAS yielded different results. Evaluation of this occurrence which included technical support from the Hydrologic Engineering Center and resulted in performing the split flow analysis using the HEC-2 model (with flood event discharges from the HEC-HMS model). The resulting split flow discharges were incorporated in the HEC-RAS Onion Creek hydraulic model.

HYDROLOGIC ANALYSIS

Halff Associates, Inc. performed an extensive Onion Creek basin hydrologic analysis, under contract with the USACE. The results of their analysis were documented in "Interim Report Onion Creek HEC-GeoHMS Hydrologic Analysis December 2002" report. Halff Associates, Inc. coordinated with the City of Austin, LCRA, Travis County, and USACE during the development of their work. Several pages of that report are excerpted here.

PURPOSE OF STUDY

The purpose of the Onion Creek hydrologic analysis was to develop and calibrate a hydrologic model of the Onion Creek watershed basin located in south Central Texas utilizing the Corps of Engineers hydrologic computer program HEC-HMS Version

The hydrologic model was developed, in part, by utilizing the newly released program HEC-GeoHMS Version 1.0. The HEC-HMS model was calibrated to the October 1998 and November 2001 flood events and simulated to USGS statistical flood frequencies at locations where streamflow gage data was available. The ultimate goal of this study is to supply Onion Creek frequency discharge data to be utilized for the Fort Worth District Corps of Engineer's hydraulic and economic analysis.

DESCRIPTION OF BASIN

Onion Creek lies in the Colorado River basin and is located in Blanco, Hays, and Travis Counties. The City of Austin, Texas lies within the lower watershed. The headwaters are located west of Austin in Blanco County. Onion Creek generally flows easterly through Hays County to the confluence with the Colorado River in Travis County. The Onion Creek watershed encompasses approximately 344 square miles. The majority of the watershed is undeveloped. The City of Austin and the town of Buda are the only major urbanized areas. The basin includes 13 stream gaging stations and 14 rainfall gaging stations (10 recording).

GAGE-ADJUSTED RADAR-RAINFALL AND HYPOTHETICAL RAINFALL

NEXRAIN Corporation developed gage-adjusted radar-rainfall for the Onion Creek watershed basin. A detailed report of procedures and results for the development of gage-adjusted radar-rainfall can be found in Appendix B**.**

A series of 15-minute rainfall estimates were developed for each sub-basin of the Onion Creek watershed basin for the October 1998 and November 2001 flood events. This rainfall series was developed from a database of available selected rainfall gages located in the vicinity of the Onion Creek basin and available radar data. Essentially, a radar image is used as an areal template for the spatial distribution of rainfall. The rain gage data are used to scale the areal template. The net result is a gage-adjusted radar rainfall data set that combines the spatial distribution characteristics of the radar image with the scaling information from the gages. NEXRAIN then averaged the rainfall data over each of the sub-basins of the Onion Creek watershed basin. The resulting 15-minute precipitation was stored in HEC-DSS database.

Hypothetical rainfall was determined for the flood frequency events. A series of point rainfall depths was provided by the USGS. USGS rainfall data was compiled from Depth-Duration Frequency of Precipitation for Texas, Water Resources Investigations Report 98-4044. The USGS Depth-Duration Frequency for Austin and Travis County report can be found in Appendix C. The rainfall was adjusted utilizing the TP-40 "Depth-Area-Duration Curves" for each storm area. A triangular precipitation distribution was constructed from the adjusted depth/duration rainfall values. In addition, the SCS Type III rainfall distribution was also utilized, in accordance with the City of Austin Design Criteria Manual. The USGS depth/duration rainfall can be found in Table 3-1.

HYDROLOGIC MODELING

Watershed Delineation

The Onion Creek drainage basin encompasses approximately 344 square miles. The City of Austin provided the initial basin delineation compiled using HEC-GeoHMS. Sub-basins were generally delineated based on the location of selected stream gages and pertinent locations to the City of Austin. The delineation consists of approximately 472 sub-basins ranging in size from 0.03 square miles to 8.67 square miles. In order to simplify the hydrologic analysis, the basin was divided into multiple hydrologic models grouped as nine (9) major basins including:

- Bear and Little Bear Creek
- Slaughter Creek
- Williamson Creek
- South Boggy Creek
- Rinard Creek
- Marble Creek
- Cottonmouth Creek
- Upper Onion Creek
- Lower Onion Creek

The Onion Creek watershed delineation is illustrated on Figure 1. A User's Guide detailing the structure of the Onion Creek HEC-HMS models is provided in Appendix E.

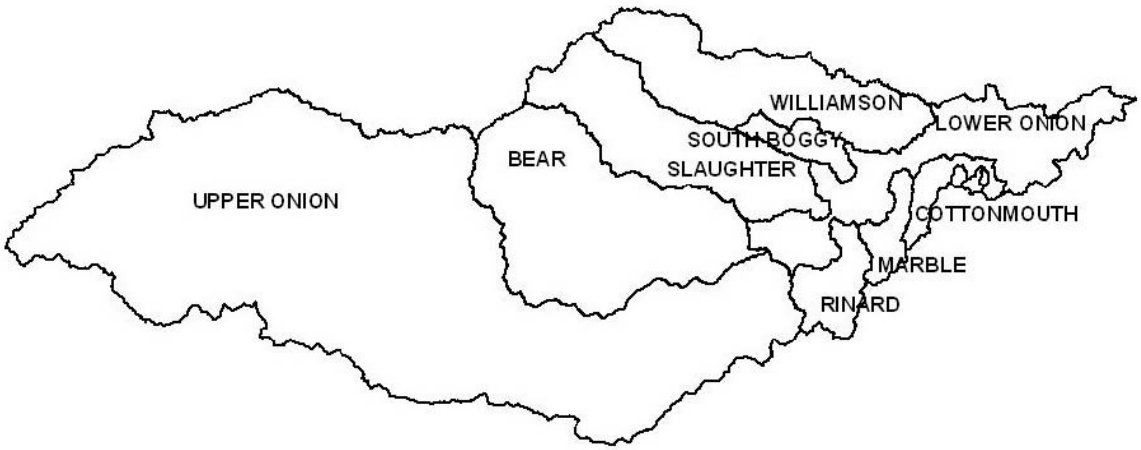


Figure 1 - The Onion Creek Watershed

HYDROLOGIC PARAMETERS

Snyder's Unit Hydrograph

The Snyder Unit Hydrograph method is the primary method utilized by the Corps of Engineers Fort Worth District for the majority of hydrologic studies in the region; therefore, under the direction of the Corps, the Snyder Unit Hydrograph method was utilized for this study. The Snyder method requires two parameters, the Snyder standard lag (Tp) and the Snyder peaking coefficient (Cp).

Snyder's Tp is defined as the time from the center of mass of the excess rainfall to the peak discharge. Initial estimates of Snyder's Tp values were determined utilizing the Corps of Engineers Fort Worth District Urbanization Curves. The length of longest flow, corresponding slope, and length of centroid flow were calculated utilizing HEC-GeoHMS for computation of Tp values. Initial values of Tp were then calculated utilizing the Corps Utility Program and the Corps Urbanization Curves. Time of concentration (Tp x 1.66) values were calculated by several methods including TR55, Kirpich, and SCS lag equations to establish a range of Tp used for calibration. Generally, for the larger sub-basins, calibrated lag times corresponded to the Corps Urbanization Curves. Calibrated lag times were generally about double the value of the Corps Urbanization Curves for the smaller sub-basins less than about 5 square miles. Table 4-1 indicates the range of Tp utilized for this analysis.

Table 4-1

Creek	
Rinard Creek	0.24-0.75
Marble Creek	0.27-0.72
Cottonmouth Creek	0.26-0.89
Upper Onion Creek	0.32-2.76
Lower Onion Creek	0.17-1.48

SCS Curve Number

At the request of the Corps of Engineers and the City of Austin, the SCS Curve Number (CN) loss rate method was utilized for this study. The SCS Curve Number method utilizes a curve number, percent impervious, and initial abstraction. Composite CN's were calculated for each sub-basin utilizing a raw curve number based on soil type only. Table 4-2 depicts the Curve Number corresponding to particular cover type and hydrologic condition. Soil Survey Geographic (SSURGO) data was utilized where available (Travis County), and State Soil Geographic (STATSGO) database was utilized for the remaining sub-basins (Hays and Blanco Counties) as shown on Figure 2. Hydrologic soil groups corresponding to the STATSSO and SSURGO soil types are specified in Tables 4-3 and 4-4, respectively. HEC-GeoHMS and the Corps Utility Program were utilized to compute composite CN's based on soil type for each sub-basin.

The percent impervious coverage assumed for each sub-basin was determined by land use data and corresponding percent impervious values provided by the City of Austin. An illustration of the Onion Creek land use map is shown on Figure 3. HEC-GeoHMS and the Corps Utility Program were utilized to calculate composite percent impervious values for each sub-basin. The Initial Abstraction was estimated by the SCS Curve Number equation [0.2(1000-10*CN)/CN] initially and adjusted for calibration purposes.

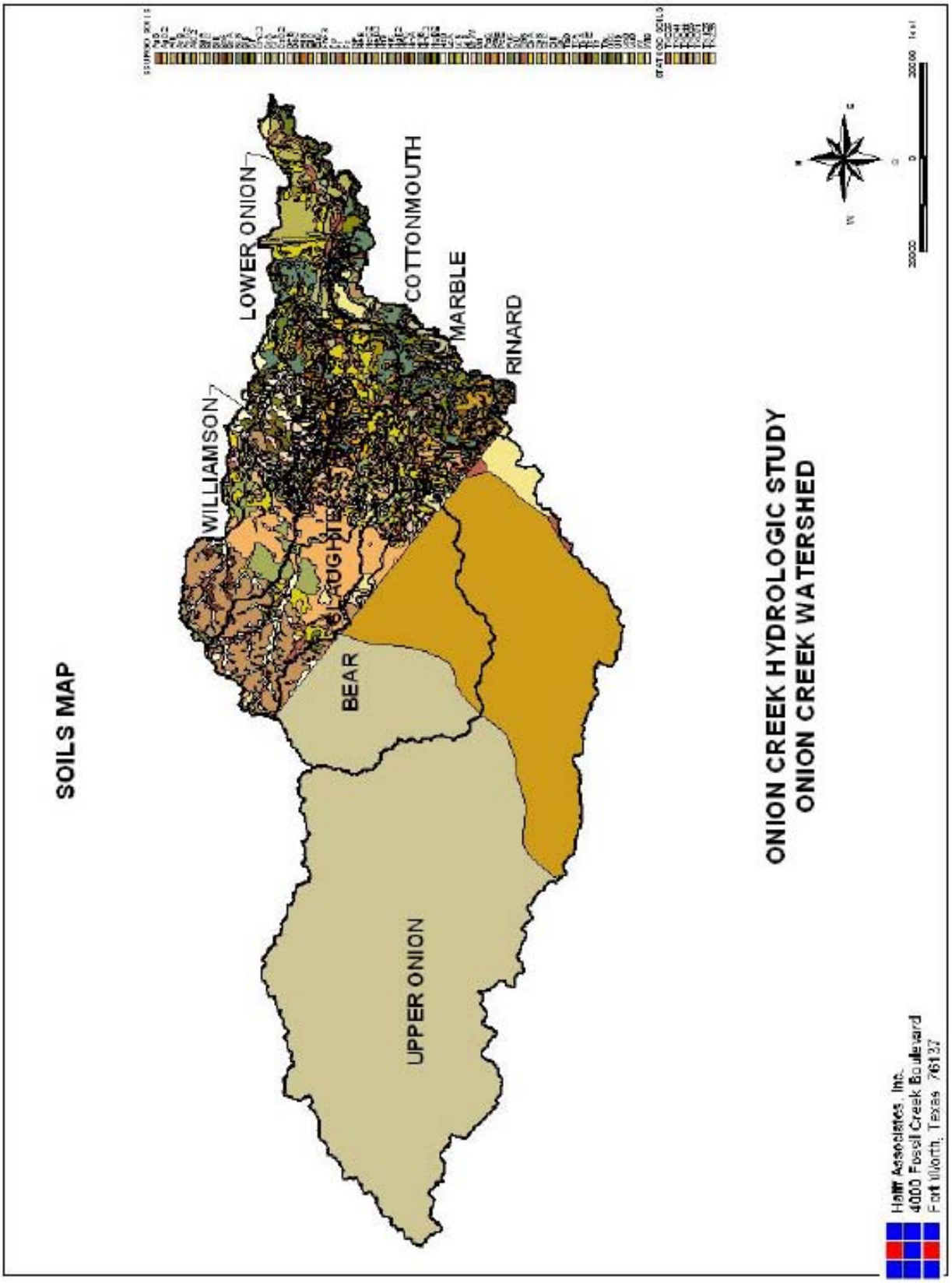

SOILS MAP
WILLIAMSON
LOWER ONION
COTTONMOUTH
MARBLE
RINARD
BEAR
UPPER ONION
ONION CREEK HYDROLOGIC STUDY
ONION CREEK WATERSHED
Halff Associates, Inc.
4000 Fossil Creek Boulevard
Fort Worth, Texas 76137

TABLE 4-2 **SCS CURVE NUMBERS** **COVER TYPE AND HYDROLOGIC CONTION**	**HYDROLOGIC SOIL GROUP**			
OPEN SPACE:	**A**	**B**	**C**	**D**
POOR CONDTION	68	79	86	89
FAIR CONDITION	49	69	79	84
GOOD CONDITION	39	61	74	80

Table 4-3 Statsgo Hydrologic Soil Classifications

SOIL	**HYDROLOGIC SOIL GROUP**			
TYPE	**PERCENT A**	**PERCENT B**	**PERCENT C**	**PERCENT D**
TX035	0	5	55	40
TX041	18	33	22	27
TX044	0	80	0	20
TX066	1	91	3	5
TX071	0	3	54	43
TX105	0	0	28	72
TX235	0	0	16	84

TABLE 4-4 SSURGO HYDROLOGIC SOIL CLASSIFICATION SOIL TYPE	**HYDROLOGIC GROUP**	**SOIL TYPE**	**HYDROLOGIC GROUP**
AgB	C	HhC	C
AgC2	C	HnA	D
AlD	C	HnB	D
AsB	C	HnC2	D
AsC2	C	HoD2	D
AtC2	C	HsD	D
BgA	B	LcA	B
BkC	C	LcB	B
BlD	C	LeB	B
BoF	C	M-W	W
BsA	D	Md	A
BsB	D	PaC	B
BtB	D	PaE	B
CF	D	PcE	B
ChC2	C	PuC	D
CrA	D	QU	D
CrB	D	SaB	D
CsC2	D	SbA	D
DeB	D	SpB	D
DeC	D	SsC	D
EdB	C	StB	C
EdC	C	StC	C
EuC	C	TaD	D
FhF3	D	TcA	D
Fo	B	TeA	D
Fr	B	TeE	D
Fs	B	Tv	D
GP	D	Tw	D
HeB	D	UsC	C
HeC2	D	UtD	C
HeD2	D	VoD	C
HfB	D	VuD	C
HfC	D	W	W
HgF2	D	WlB	D

TABLE 4-5 PERCENT IMPERVIOUS PER LAND USE LAND USE	ASSUMED PERCENT IMPERVIOUS*
Large Lot Single Family	25%
Single Family	45%
Multi-Family	60%
Commercial	65%
Office	65%
Industrial	65%
Civic	45%
Park/Open Space	0%
Transportation	100%
Undeveloped	0%
Water	100%
* Provided by City of Austin	

Flood Routing

The Modified Puls routing method was chosen for this study because of the availability of detail channel and flood plain hydraulic data. The Corps of Engineers Fort Worth District executed existing HEC-2 models and provided routing data where available. The Corps also developed HEC-GeoRAS models where GIS data was available in order to provide routing data. For routing reaches with no detail data available, the Muskingum Cunge routing method was utilized.

Streamflow Data

Observed 15-minute streamflow data was provided by USGS Water Resources for the Onion Creek watershed for the October 1998 and November 2001 historical events. Selected stream gaging stations for the October 1998 and November 2001 flood events include the following:

- Onion Creek near Driftwood, TX (Upper Onion)
- Bear Creek below Farm Road 1826 near Driftwood, TX
- Slaughter Creek at Farm Road 1826 near Austin, TX
- Williamson Creek at Brush Country Blvd, Oak Hill, TX (Oct. 1998 Event)
- Williamson Creek at Manchaca Road at Austin, TX (Nov. 2001 Event)
- Onion Creek at Highway 183 at Austin, TX (Lower Onion).

The Corps provided an analysis of statistical flood frequencies prepared by the USGS for seven (7) gages in the Onion Creek watershed basin. Peak discharges were provided for the 2-, 5-, 10-, 25-, 50-, 100-, and 500- year flood frequencies. Peak-stream flow frequency analyses in Central Texas are difficult to verify because of the nature of

large storms and associated large floods in the area. Because of the random occurrence of large floods, relatively short periods of stream flow data (less than about 25 years) could produce peak-stream flow frequency estimates that could be substantially different from those that would result from a longer database. Selected stream gaging stations for the flood frequency analysis include the following gages:

- Upper Onion Creek near Driftwood, TX (21 years of record)
- Bear Creek below Farm Road 1826 near Driftwood, TX (22 years of record)
- Slaughter Creek at Farm Road 1826 near Austin, TX (23 years of record)
- Williamson Creek at Brush Country Blvd, Oak Hill, TX (7 years of record)
- Williamson Creek at Manchaca Road at Austin, TX (10 years of record)
- Williamson Creek at Jimmy Clay Road at Austin, TX (12 years of record)
- Lower Onion Creek at Highway 183 at Austin, TX (31 years of record)

A detailed report of procedures and results for the USGS flood frequency analysis can be found in Appendix D**.**

Hydrologic Calibration/Simulation

Calibration to October 1998 Historical Event

Hydrologic calibrations were generally conducted to simulate peak flows and hydrograph trends. Volumes were also considered but were difficult to compare depending on the length and shape of the hydrograph. Calibrations were conducted for the October 1998 and November 2001 flood events utilizing the aforementioned range of hydrological parameters (Tp, initial loss rates, percent impervious cover, and routing). Initial calibrations were prepared for the October 1998 flood event and then verified and redefined with the November 2001 flood event. The results of the historical event calibrations indicated that the calibrated lag times (Tp) generally corresponded well with the Corps Urbanization Curves for large sub-basins; however, the Urbanization Curves tend to underestimate Tp for smaller basins. Initial loss rates were calibrated to individual flood events and sub-watersheds. Summary tables of the historical event calibrations are presented in Table 5-1 and Table 5-2. Hydrograph plots of the historical calibration are available in Appendix A. Assumed hydrologic parameters can be found in the HEC-HMS model presented in Appendix F and the Onion Creek User's Guide presented in Appendix E.

Summaries of the historical event calibrations at each gage are as follows:

- Onion Creek near Driftwood, TX – Computed peak flows at Driftwood were within -2% and -10% of the observed peaks for the October 1998 and November 2001 events. Computed volumes were somewhat higher than observed for the October 1998 event; however, the calibration generally matched the trend of the observed hydrographs. For these events, the assumed initial abstraction was 1.5 inches.

- Bear Creek below FM 1826 near Driftwood, TX – Computed peak flows for Bear Creek at Driftwood were within –13% and +61% of the observed peaks for the October 1998 and November 2001 events. The observed peak for the 2001 events was less than 1000 cfs (flows were confined to the natural channel), therefore, it was difficult to calibrate peaks. Initial abstraction values of 0.2" and 2.0" were utilized for this basin for the October 1998 and November 2001 events, respectively.

• Slaughter Creek at FM 1826 near Austin, TX – Computed peak flows for Slaughter Creek were within -1% and +689% of the observed peaks for the October 1998 and November 2001 events. The observed peak for the 2001 events was less than 200 cfs (flows were confined to the natural channel), therefore, it was difficult to calibrate peaks. Initial abstraction values of 0.2" and 2.0" were utilized for this basin for the October 1998 and November 2001 events, respectively.

• Williamson Creek at Brush Country Blvd, Oak Hill, TX– Computed peak flows at Brush Country Blvd were within +7% of the observed peaks for the October 1998 event. An initial abstraction value of 0.2" was utilized for this basin.

• Williamson Creek at Manchaca Road at Austin, TX– Computed peak flows at Manchaca Road were within +87% of the observed peaks for the November 2001 event. An initial abstraction value of 2.0" was utilized for this basin.

• Onion Creek at Hwy 183 at Austin, TX– Computed peak flows at Hwy 183 were within +9% and -7% of the observed peaks for the October 1998 and November 2001 events. For these events, the assumed initial abstraction was 1.0 inches.[1]

[1] "Interim Report Onion Creek HEC-GeoHMS Hydrologic Analysis December 2002" report. Halff Associates, Inc.

STORAGE ANALYSIS

The Onion Creek hydraulic model and tributary backwater models were used to develop hydrologic routing (discharge-elevation-volume) data for use in the Onion Creek Watershed hydrology model HEC-HMS Hydrologic Modeling System. Table A-2 includes a comprehensive listing of the creeks analyzed for the storage analysis.

Table A-2

Creek Name	**Model Type**	**Source**
Onion Creek	HEC-RAS	Travis County FIS 1997
South Gatlin Creek	HEC-RAS	USACE*
South Onion Creek	HEC-RAS	USACE*
Cottonmouth Creek	HEC-2	Travis County FIS 1988
Cottonmouth Creek Trib-1	HEC-RAS	USACE*
Marble Creek	HEC-RAS	City of Austin
Marble Creek Trib-1	HEC-RAS	USACE*
Marble Creek Trib-2	HEC-RAS	USACE*
Williamson Creek	HEC-RAS	City of Austin
St. Elmo Creek	HEC-RAS	City of Austin
Pleasant Hill Creek	HEC-RAS	City of Austin
Sunset Valley Creek	HEC-RAS	City of Austin
Kincheon Creek	HEC-RAS	City of Austin
Wheeler Creek	HEC-RAS	City of Austin
Motorola Creek	HEC-RAS	City of Austin
Scenic Brook Creek	HEC-RAS	City of Austin
South Boggy Creek	HEC-2	Austin LMMP 1995
Slaughter Creek	HEC-RAS	USACE*
Slaughter Creek Trib-1	HEC-RAS	USACE*
Slaughter Creek Trib-1a	HEC-RAS	USACE*
Slaughter Creek Trib-2	HEC-RAS	USACE*
Slaughter Creek Trib-2a	HEC-RAS	USACE*
Slaughter Creek Trib-3	HEC-RAS	USACE*
Table A-2 continued		
Creek Name	**Model Type**	**Source**
Slaughter Creek Trib-4	HEC-RAS	USACE*
Slaughter Creek Trib-4a	HEC-RAS	USACE*
Slaughter Creek Trib-5	HEC-RAS	USACE*

Slaughter Creek Trib-6	HEC-RAS	USACE*
Slaughter Creek Trib-7	HEC-RAS	USACE*
Slaughter Creek Trib-8	HEC-RAS	USACE*
Slaughter Creek Trib-8a	HEC-RAS	USACE*
Slaughter Creek Trib-9	HEC-RAS	USACE*
Rinard Creek	HEC-RAS	USACE*
Rinard Creek Trib-1	HEC-RAS	USACE*
Bear Creek	HEC-2	Travis County LMMP 1997
Bear Creek Trib-1	HEC-RAS	USACE*
Little Bear Creek	HEC-2	Hays County FIS 1995

* Backwater models were developed by the USACE by use of HEC-GeoRAS. HEC-GeoRAS is ArcView GIS extension specifically designed to process geo-spatial data for use with HEC-RAS. HEC-GeoRAS allows users to create a HEC-RAS import file containing geometric attribute data from an existing Digital Terrain Model (DTM) and complimentary data sets. HEC-GeoRAS creates an import file that includes data such as river-reach-station identifiers, cross-sectional surface lines, cross-sectional bank stations, and downstream reach lengths. The City of Austin created a 5-meter grid file for the study area, which was modified by the USACE to create a Triangulated Irregular Network (TIN) file. This TIN file was utilized by HEC-GeoRAS to a HEC-RAS import file.

A range of appropriate discharges was incorporated in each of the backwater models listed in Table A-2. Routing reaches were determined from the delineation of the Onion Creek watershed sub-area boundaries. Discharge-elevation-volume routing data was computed for each routing reach. Discharge-elevation-volume routing data was computed for New Burleson Road and Williamson Creek split flow areas described in the Split Flow Analysis above. The data was added to the appropriate Onion Creek main stem data routing reach.

USACE HYDROLOGIC ANALYSIS

The USACE modified the Onion Creek HEC-HMS model developed by Halff Associates, Inc. to develop flood event peak discharges using the rainfall areal reduction procedure in HEC-1. The resulting discharges (Table A-3) were incorporated in the Onion Creek HEC-2 model and the split flow routine performed. The resulting discharges were rounded and incorporated into the HEC-RAS model. Table A-4 is a copy of the flow file used in the HEC-RAS final existing conditions hydraulic model indicating the rounding of the computed discharges.

Table A-3
Existing Conditions Flood Event Peak Discharges

Location	Drainage Area (sq.mi.)	Peak Discharge (Cfs) For Given Recurrence Interval							
		2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	250-Yr	500-Yr
Above Rbt Near County Line	171.127	2623.2	10470	20354	38093	56720	76728	100381	120552
Below Rbt Near County Line	173.172	2641.2	10539	20472	38272	56929	76966	100637	120817
Above Garlic Creek	174.348	2632.4	10552	20486	38344	56969	76983	100646	120798
Below Garlic Creek	180.044	2694.0	10763	20806	38803	57505	77616	101394	121646
Below Lbt	180.480	2697.7	10779	20832	38844	57554	77675	101458	121713
Above Bear Creek	181.052	2696.9	10787	20845	38878	57584	77681	101485	121714
Below Bear Creek	231.078	3367.5	12814	24677	49423	72200	95119	123747	149491
At IH-35	233.796	3374.4	12872	24786	49546	72423	95388	123928	149645
Above Rinard Creek	236.593	3356.9	12909	24846	49532	72460	95344	123767	149302
Below Rinard Creek	244.510	3430.1	13238	25546	51152	74987	98320	127015	152860
Above Slaughter Creek	244.963	3417.8	13234	25529	51097	74916	98260	126967	152744
Below Slaughter Creek	275.671	4539.0	16199	31378	51480	86824	113640	147160	178293
Above South Boggy Creek	277.674	4546.1	16236	31382	51536	86886	113772	147345	178450
Below South Boggy Creek	282.468	4655.9	16451	31687	52039	87503	114509	148250	179514
Above Marble Creek	286.567	4684.9	16568	31688	51537	87034	113771	147426	178007
Below Marble Creek	290.976	4748.3	16752	31956	51929	87541	114378	148184	178914
Above Williamson Creek	291.929	4750.0	16777	31990	51941	87500	112808	147361	177087
Below Williamson Creek	322.350	6196.6	18968	34899	57324	94914	118336	155381	186115
At U.S. Highway 183	323.728	6192.3	18997	34892	57360	94960	118389	155436	186147
Above Cottonmouth Creek	327.637	6265.3	19149	35087	57649	95313	118861	155939	186645
Below Cottonmouth Creek	333.048	6407.3	19408	35472	58145	95914	119556	156769	187573
Above Diversion To Colorado River	343.047	6458.3	19648	35895	58516	96264	119957	157354	187941
Below Diversion To Colorado River	343.047	6458.3	19648	35895	58277	83030	93101	106506	116869
At Confluence With Colorado River	344.370	6460.6	19667	35951	58120	83022	93087	106474	116807

Table A-4

Steady Flow Data - Onion Creek - Existing Conditions

File Options Help

Enter/Edit Number of Profiles (2000 max): 8 | Reach Boundary Conditions | Apply Data

Locations of Flow Data Changes

River: onion

Reach: oc-1 | River Sta.: 349330 | Add A Flow Change Location

Flow Change Location				Profile Names and Flow Rates							
	River	Reach	RS	2-YEAR	5-YEAR	10-YEAR	25-YEAR	50-YEAR	100-YEAR	250-YEAR	500-YEAR
1	onion	oc-1	349330	2630	10600	20500	38300	57000	77000	101000	121000
2	onion	oc-1	144630	2630	10600	20500	38300	57000	77000	101000	121000
3	onion	oc-1	138100	2690	10800	20800	38800	57500	77600	101000	122000
4	onion	oc-1	136110	2700	10800	20800	38900	57600	77700	101000	122000
5	onion	oc-1	134630	3370	12800	24700	49400	72200	95100	124000	149000
6	onion	oc-1	126450	3360	12900	24800	49500	72500	95300	124000	149000
7	onion	oc-1	109460	3430	13200	25500	51200	75000	98300	127000	153000
8	onion	oc-1	107350	3420	13200	25500	51100	74900	98300	127000	153000
9	onion	oc-1	105300	4540	16200	31400	59850	86800	114000	147000	178000
10	onion	oc-1	100440	4550	16200	31400	59900	86900	114000	147000	178000
11	onion	oc-1	95670	4660	16500	31700	60400	87500	115000	148000	180000
12	onion	oc-1	83970	4680	16600	31700	60300	87000	114000	147000	178000
13	onion	oc-1	82230	4680	16600	31700	60300	87000	113682	144411	172344
14	onion	oc-1	81220	4680	16600	31700	60300	86999	113644	144113	171060
15	onion	oc-1	76690	4750	16800	32000	60700	87499	113644	145113	172060
16	onion	oc-1	71940	4750	16800	32000	60700	87499	113644	144827	170450
17	onion	oc-1	71260	4750	16800	32000	60700	87499	113438	142384	164795
18	onion	oc-1	70820	4750	16800	32000	60700	87412	111468	136850	153851
19	onion	oc-1	67620	6200	19000	34900	66000	94900	118000	155000	186000
20	onion	oc-1	52940	6200	19000	34900	66000	94900	118000	154461	179026
21	onion	oc-1	52035	6270	19100	35100	66300	95300	119000	155461	180026
22	onion	oc-1	51185	6410	19400	35500	66800	95900	120000	157000	188000
23	onion	oc-1	50240	6410	19400	35500	66800	95900	119919	153496	180852
24	onion	oc-1	49960	6410	19400	35500	66800	95900	119632	151186	176672
25	onion	oc-1	49660	6410	19400	35500	66800	95900	118614	147639	171107
26	onion	oc-1	49440	6410	19400	35500	66800	95900	117251	143988	165738
27	onion	oc-1	49190	6410	19400	35500	66800	95900	115188	138026	156802
28	onion	oc-1	48340	6410	19400	35500	66800	95900	114626	133924	148797
29	onion	oc-1	47560	6410	19400	35500	66800	95900	114626	133921	147986
30	onion	oc-1	46980	6410	19400	35500	66800	95900	114626	133276	145716
31	onion	oc-1	46020	6410	19400	35500	66800	95900	114526	127381	133523
32	onion	oc-1	45400	6410	19400	35500	66800	95900	112962	118000	118344
33	onion	oc-1	44260	6410	19400	35500	66800	95900	120000	157000	188000
34	onion	oc-1	36330	6460	19600	35900	67000	96300	120000	157000	188000
35	onion	oc-1	9860	6460	19600	35900	65800	83000	93100	107000	117000
36	onion	oc-1	6060	6460	19700	36000	65700	83000	93100	106000	117000

Edit Steady flow data for the profiles (cfs)

Halff Associates, Inc. also developed Onion Creek 2060 peak discharges, under contract by the USACE. Table A-5 shows flood peak discharges at three selected points.

Table A-5

			Year 2060 Peak Discharges (cfs)						
Description	Hydrologic Element	Area (sm)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Onion Creek Main Stem at F.M. 973	JLOCR279	338.989	12,440	31,190	49,180	80,320	107,550	130,340	196,760
Onion Creek Main Stem at William Cannon Drive	JLOCR790	286.264	11,120	27,840	44,830	73,730	99,180	125,240	189,740
Onion Creek Main Stem just U.S. of Bear Creek	Outlet	181.052	9,250	21,330	32,770	50,780	66,990	84,320	127,570

RESULTS OF BACKWATER ANALYSIS

Existing Conditions water surface profiles were computed for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 250-year, and 500-year flood events. Peak discharges for these flood events developed in the Onion Creek hydrologic analysis were incorporated in the Onion Creek HEC-RAS hydraulic model.

Table A-6 indicates the Onion Creek 25-year and 100-year water surface elevations at locations within Travis County.

Table A-6

Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
1720	25-yr	65700	408.94	100-yr	93100	414.66
3610	25-yr	65700	413.6	100-yr	93100	419.16
4835	25-yr	65700	418.31	100-yr	93100	422.82
6060	25-yr	65700	421.18	100-yr	93100	425.25
7285	25-yr	65800	423.26	100-yr	93100	427.02
8500	25-yr	65800	424.78	100-yr	93100	428.28
9860	25-yr	65800	426.07	100-yr	93100	429.4
14240	25-yr	67000	428.46	100-yr	120000	431.91
15990	25-yr	67000	429.03	100-yr	120000	432.71
19210	25-yr	67000	431.78	100-yr	120000	435.84
19680	25-yr	67000	432.07	100-yr	120000	436.22
22300	25-yr	67000	435.7	100-yr	120000	439.76
22400	25-yr	67000	435.81	100-yr	120000	439.84
22490	25-yr	67000	435.94	100-yr	120000	439.91
22560	25-yr	67000	436.23	100-yr	120000	440.52
22580	25-yr	67000	436.9	100-yr	120000	441.75
22630	25-yr	67000	436.98	100-yr	120000	441.91
22700	25-yr	67000	437.38	100-yr	120000	443.01
23000	25-yr	67000	437.7	100-yr	120000	443.2
23440	25-yr	67000	437.87	100-yr	120000	443.35
23490	25-yr	67000	437.98	100-yr	120000	443.43
23502.5			low water crossing			
23515	25-yr	67000	438.01	100-yr	120000	443.45
23565	25-yr	67000	438.03	100-yr	120000	443.47
24220	25-yr	67000	438.2	100-yr	120000	443.62
25960	25-yr	67000	438.9	100-yr	120000	444.24
26890	25-yr	67000	439.77	100-yr	120000	444.9
30230	25-yr	67000	443.5	100-yr	120000	447.74
33290	25-yr	67000	447.29	100-yr	120000	451.23
35200	25-yr	67000	449.4	100-yr	120000	453.32
35240	25-yr	67000	449.34	100-yr	120000	453.35
35265			FM 973			
35290	25-yr	67000	449.47	100-yr	120000	453.58
35300	25-yr	67000	449.75	100-yr	120000	453.65
35750	25-yr	67000	450.01	100-yr	120000	453.94

36330	25-yr	67000	450.11	100-yr	120000	454.07
Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
38390	25-yr	66800	451.1	100-yr	120000	455.06
40710	25-yr	66800	455	100-yr	120000	459.53
41040	25-yr	66800	455.7	100-yr	120000	460.4
41900	25-yr	66800	457.2	100-yr	120000	462.15
42230	25-yr	66800	457.7	100-yr	120000	462.56
42870	25-yr	66800	458.93	100-yr	120000	464.13
43540	25-yr	66800	459.59	100-yr	120000	464.88
44260	25-yr	66800	460.28	100-yr	120000	465.61
44310	25-yr	66800	460.32	100-yr	112962	465.56
44345			New Burleson Road			
44380	25-yr	66800	460.44	100-yr	112962	465.97
44430	25-yr	66800	460.38	100-yr	112962	465.95
45265	25-yr	66800	461.33	100-yr	112962	466.7
45310	25-yr	66800	462.02	100-yr	112962	467.56
45335			Old Burleson Road			
45360	25-yr	66800	462.14	100-yr	112962	468.34
45400	25-yr	66800	462.19	100-yr	112962	468.58
46020	25-yr	66800	463.42	100-yr	114526	469.68
46980	25-yr	66800	465.36	100-yr	114626	471.55
47560	25-yr	66800	465.86	100-yr	114626	472.03
48340	25-yr	66800	466.09	100-yr	114626	472.24
49190	25-yr	66800	466.6	100-yr	115188	472.65
49440	25-yr	66800	466.73	100-yr	117251	472.7
49660	25-yr	66800	467	100-yr	118614	472.93
49960	25-yr	66800	467.5	100-yr	119632	473.53
50240	25-yr	66800	468.05	100-yr	119919	474.12
50750	25-yr	66800	469.08	100-yr	120000	475.49
51185	25-yr	66800	470.29	100-yr	120000	477.65
51540	25-yr	66300	471.18	100-yr	119000	478.25
52035	25-yr	66300	472.77	100-yr	119000	479.91
52490	25-yr	66000	473.64	100-yr	118000	480.87
52940	25-yr	66000	474.19	100-yr	118000	481.37
53980	25-yr	66000	475.02	100-yr	118000	482.17
54350	25-yr	66000	475.38	100-yr	118000	482.46
54650	25-yr	66000	475.84	100-yr	118000	482.94
54920	25-yr	66000	476.3	100-yr	118000	483.45
55460	25-yr	66000	477.09	100-yr	118000	484.26
55510	25-yr	66000	477.16	100-yr	118000	484.34
55590			US 183			
55670	25-yr	66000	477.79	100-yr	118000	486.61
55720	25-yr	66000	478.17	100-yr	118000	487.04
56150	25-yr	66000	478.69	100-yr	118000	487.51
56515	25-yr	66000	479.14	100-yr	118000	487.97
56770	25-yr	66000	479.75	100-yr	118000	488.6

56820	25-yr	66000	479.85	100-yr	118000	488.69
56830			Doyle Crossing			
56840	25-yr	66000	480.06	100-yr	118000	488.89

Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
56900	25-yr	66000	480.1	100-yr	118000	488.88
57070	25-yr	66000	480.27	100-yr	118000	489.02
57220	25-yr	66000	480.5	100-yr	118000	489.19
57490	25-yr	66000	481.09	100-yr	118000	489.71
57780	25-yr	66000	481.92	100-yr	118000	490.41
57900	25-yr	66000	482.1	100-yr	118000	490.52
58020	25-yr	66000	482.43	100-yr	118000	490.68
58200	25-yr	66000	483.4	100-yr	118000	492.14
58380	25-yr	66000	484.01	100-yr	118000	493.01
58475	25-yr	66000	484.22	100-yr	118000	493.15
58570	25-yr	66000	484.65	100-yr	118000	493.38
58660	25-yr	66000	485.21	100-yr	118000	493.72
58920	25-yr	66000	487.01	100-yr	118000	494.61
59180	25-yr	66000	489.85	100-yr	118000	496.62
59355	25-yr	66000	491.64	100-yr	118000	500.55
59530	25-yr	66000	492.92	100-yr	118000	502.44
59705	25-yr	66000	493.88	100-yr	118000	503.62
59910	25-yr	66000	495.4	100-yr	118000	506.19
60080	25-yr	66000	495.62	100-yr	118000	506.44
60255	25-yr	66000	495.94	100-yr	118000	506.81
60440	25-yr	66000	496.21	100-yr	118000	507.14
60630	25-yr	66000	496.78	100-yr	118000	507.8
60895	25-yr	66000	497.67	100-yr	118000	509.62
60960	25-yr	66000	497.74	100-yr	118000	509.54
61025	25-yr	66000	497.93	100-yr	118000	509.57
61150	25-yr	66000	498.39	100-yr	118000	510.24
61420	25-yr	66000	498.77	100-yr	118000	510.59
61650	25-yr	66000	498.92	100-yr	118000	510.75
62060	25-yr	66000	499.24	100-yr	118000	511.08
62450	25-yr	66000	500.3	100-yr	118000	512.15
62785	25-yr	66000	500.76	100-yr	118000	512.63
63080	25-yr	66000	501.56	100-yr	118000	513.61
63180	25-yr	66000	501.75	100-yr	118000	513.82
63280	25-yr	66000	501.93	100-yr	118000	514.03
63520	25-yr	66000	502.6	100-yr	118000	515.33
63740	25-yr	66000	503.29	100-yr	118000	516.23
63985	25-yr	66000	503.81	100-yr	118000	516.76
64305	25-yr	66000	504.62	100-yr	118000	517.75
64540	25-yr	66000	504.68	100-yr	118000	517.77
64790	25-yr	66000	504.69	100-yr	118000	517.77
65170	25-yr	66000	505.82	100-yr	118000	518.94

65580	25-yr	66000	506.01	100-yr	118000	519.11
65620	25-yr	66000	506.01	100-yr	118000	519.1
65655			McKinney Falls Parkway			
65690	25-yr	66000	506.07	100-yr	118000	519.17
65740	25-yr	66000	506.06	100-yr	118000	519.15
Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
66435	25-yr	66000	506.42	100-yr	118000	519.53
67620	25-yr	66000	508.4	100-yr	118000	521.55
68780	25-yr	60700	509.01	100-yr	111468	522.03
69800	25-yr	60700	511.34	100-yr	111468	522.77
70820	25-yr	60700	512.94	100-yr	111468	523.7
71260	25-yr	60700	514.57	100-yr	113438	525.27
71940	25-yr	60700	516.75	100-yr	113644	526.15
72525	25-yr	60700	518.61	100-yr	113644	527.48
73340	25-yr	60700	520.5	100-yr	113644	529.05
73980	25-yr	60700	522.48	100-yr	113644	530.93
74660	25-yr	60700	525.13	100-yr	113644	534.23
75670	25-yr	60700	527	100-yr	113644	536.15
76350	25-yr	60700	528.43	100-yr	113644	537.63
76690	25-yr	60700	529.66	100-yr	113644	539.18
77210	25-yr	60300	530.39	100-yr	113644	540.08
78650	25-yr	60300	531.69	100-yr	113644	541.1
81220	25-yr	60300	534.2	100-yr	113644	541.95
82230	25-yr	60300	534.5	100-yr	113682	542.07
83445	25-yr	60300	534.93	100-yr	114000	542.25
83810	25-yr	60300	535.17	100-yr	114000	542.37
83870	25-yr	60300	535.73	100-yr	114000	542.48
83882.5			William Cannon Drive			
83895	25-yr	60300	535.86	100-yr	114000	542.5
83970	25-yr	60300	535.78	100-yr	114000	542.49
87000	25-yr	60400	539.62	100-yr	115000	543.94
87780	25-yr	60400	540.15	100-yr	115000	544.33
88370	25-yr	60400	540.91	100-yr	115000	545.01
90620	25-yr	60400	543.19	100-yr	115000	547.26
91070	25-yr	60400	543.64	100-yr	115000	547.79
91330	25-yr	60400	543.77	100-yr	115000	547.82
91990	25-yr	60400	545.07	100-yr	115000	549.57
92570	25-yr	60400	546.26	100-yr	115000	551.08
93190	25-yr	60400	547.36	100-yr	115000	552.84
94170	25-yr	60400	549.39	100-yr	115000	554.95
95670	25-yr	60400	551.71	100-yr	115000	556.92
97140	25-yr	59900	553.15	100-yr	114000	558.36
98240	25-yr	59900	554.72	100-yr	114000	560.08
99400	25-yr	59900	556.67	100-yr	114000	561.68
100220	25-yr	59900	557.85	100-yr	114000	562.85
100300	25-yr	59900	557.93	100-yr	114000	562.94

100350	25-yr	59900	557.89	100-yr	114000	562.94
100375			Bluff Springs Road			
100400	25-yr	59900	558.15	100-yr	114000	563.14
100440	25-yr	59900	558.79	100-yr	114000	563.47
101580	25-yr	59850	559.92	100-yr	114000	564.82
102450	25-yr	59850	560.74	100-yr	114000	565.79
102500	25-yr	59850	560.82	100-yr	114000	566.01
Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
102550			Slaughter Road			
102600	25-yr	59850	560.96	100-yr	114000	566.26
102650	25-yr	59850	561.01	100-yr	114000	566.32
103300	25-yr	59850	561.54	100-yr	114000	567.23
103675	25-yr	59850	562.75	100-yr	114000	569.07
104050	25-yr	59850	563.31	100-yr	114000	569.82
104420	25-yr	59850	563.61	100-yr	114000	570.24
105300	25-yr	59850	563.94	100-yr	114000	570.71
107350	25-yr	51100	565	100-yr	98300	572.14
109460	25-yr	51200	567.55	100-yr	98300	574.71
111415	25-yr	49500	570.31	100-yr	95300	576.76
111590	25-yr	49500	571.26	100-yr	95300	577.01
111700	25-yr	49500	571.41	100-yr	95300	577.24
111780	25-yr	49500	571.39	100-yr	95300	577.19
111836	25-yr	49500	571.42	100-yr	95300	577.12
111865			River Plantation Road			
111894	25-yr	49500	571.56	100-yr	95300	577.36
111950	25-yr	49500	572.21	100-yr	95300	578.8
112170	25-yr	49500	572.94	100-yr	95300	580.15
112410	25-yr	49500	573.63	100-yr	95300	580.8
112690	25-yr	49500	574.01	100-yr	95300	581.28
113090	25-yr	49500	574.76	100-yr	95300	581.91
113690	25-yr	49500	575.36	100-yr	95300	582.36
114110	25-yr	49500	575.92	100-yr	95300	582.71
114590	25-yr	49500	576.58	100-yr	95300	583.08
115300	25-yr	49500	577.2	100-yr	95300	583.52
115800	25-yr	49500	577.42	100-yr	95300	583.73
116090	25-yr	49500	577.3	100-yr	95300	583.68
116380	25-yr	49500	577.77	100-yr	95300	583.95
116670	25-yr	49500	579.69	100-yr	95300	585.52
117070	25-yr	49500	580.31	100-yr	95300	586.4
117830	25-yr	49500	582.2	100-yr	95300	588.69
119470	25-yr	49500	584.94	100-yr	95300	591.89
119980	25-yr	49500	586.04	100-yr	95300	592.85
121965	25-yr	49500	588.35	100-yr	95300	594.96
123190	25-yr	49500	590.99	100-yr	95300	597.68
124050	25-yr	49500	592.49	100-yr	95300	599.11
124705	25-yr	49500	593.64	100-yr	95300	600.26

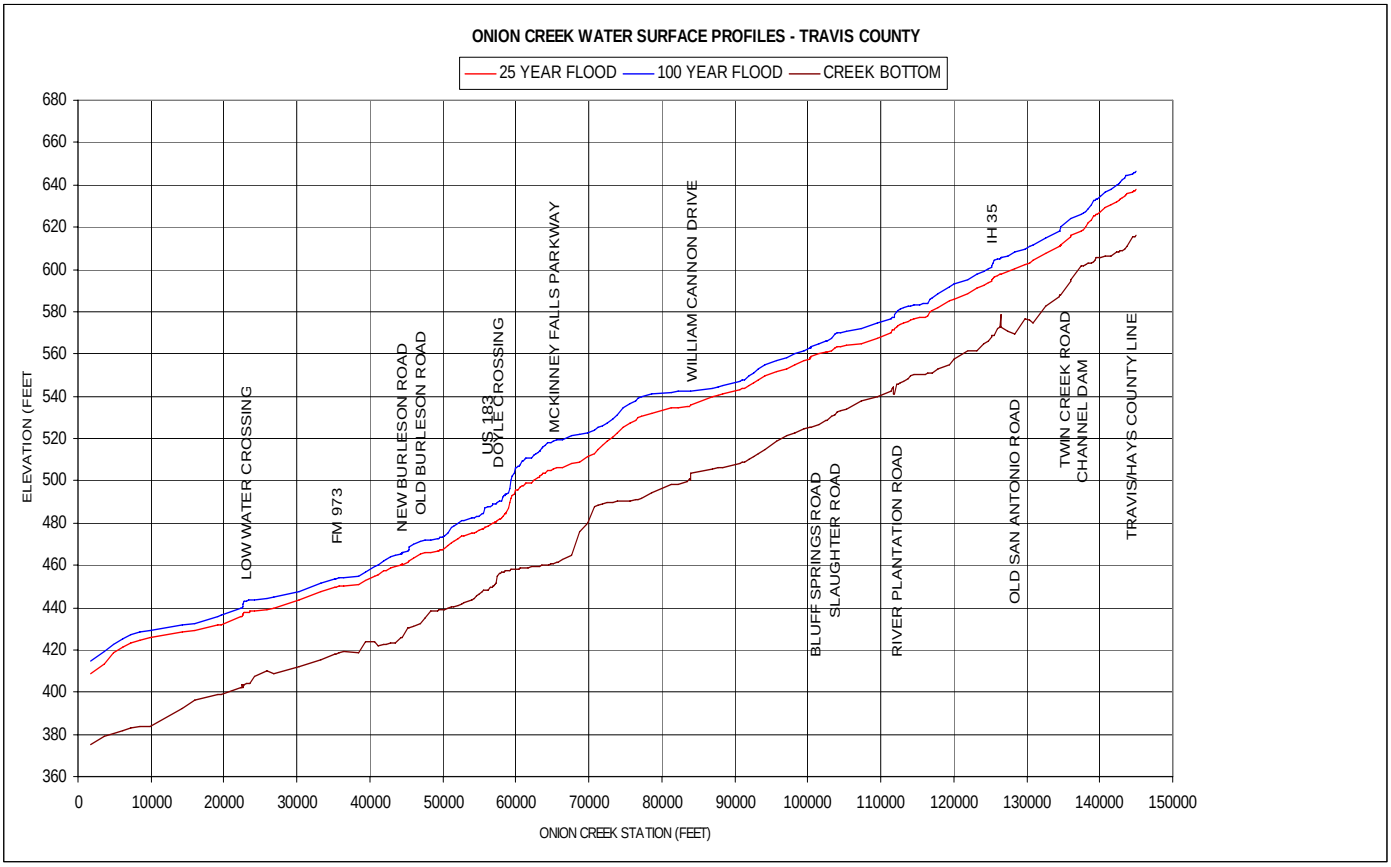
125190	25-yr	49500	594.49	100-yr	95300	601.18
125270	25-yr	49500	595.23	100-yr	95300	601.5
125345			IH 35			
125420	25-yr	49500	595.95	100-yr	95300	603.14
125485	25-yr	49500	596.43	100-yr	95300	603.96
125940	25-yr	49500	597.11	100-yr	95300	604.78
126280	25-yr	49500	597.51	100-yr	95300	605.18
126400	25-yr	49500	597.6	100-yr	95300	605.28
126450	25-yr	49500	597.85	100-yr	95300	605.41
Creek Station	Flood Event	Q Total (cfs)	WSEL (ft)	Profile	Q Total (cfs)	WSEL (ft)
127415	25-yr	49400	598.88	100-yr	95100	606.28
128390	25-yr	49400	600.24	100-yr	95100	607.91
129700	25-yr	49400	602.06	100-yr	95100	609.5
129710	25-yr	49400	602.08	100-yr	95100	609.53
129722.5			Old San Antonio Road			
129735	25-yr	49400	602.33	100-yr	95100	609.81
129745	25-yr	49400	602.35	100-yr	95100	609.82
130350	25-yr	49400	603.24	100-yr	95100	610.77
130830	25-yr	49400	604.25	100-yr	95100	611.76
132510	25-yr	49400	607.26	100-yr	95100	614.89
134490	25-yr	49400	610.65	100-yr	95100	618.1
134540	25-yr	49400	610.84	100-yr	95100	618.33
134560			Twin Creek Road			
134580	25-yr	49400	611.44	100-yr	95100	619.6
134630	25-yr	49400	611.81	100-yr	95100	619.78
135985	25-yr	38900	615.67	100-yr	77700	623.74
136022.5			channel dam			
136060	25-yr	38900	616	100-yr	77700	624.08
136110	25-yr	38900	616.04	100-yr	77700	624.11
137500	25-yr	38800	618.36	100-yr	77600	626.11
137800	25-yr	38800	619.04	100-yr	77600	626.62
138100	25-yr	38800	620.21	100-yr	77600	627.53
138400	25-yr	38300	621.75	100-yr	77000	628.85
138815	25-yr	38300	623.35	100-yr	77000	630.41
139210	25-yr	38300	625.23	100-yr	77000	632.36
139340	25-yr	38300	625.44	100-yr	77000	632.7
139470	25-yr	38300	625.9	100-yr	77000	633.26
139525	25-yr	38300	625.91	100-yr	77000	633.24
139580	25-yr	38300	625.95	100-yr	77000	633.21
140120	25-yr	38300	627.52	100-yr	77000	634.67
140745	25-yr	38300	628.98	100-yr	77000	636.26
141490	25-yr	38300	630.44	100-yr	77000	637.95
142290	25-yr	38300	631.98	100-yr	77000	639.86
142565	25-yr	38300	632.45	100-yr	77000	640.47
142840	25-yr	38300	633.03	100-yr	77000	641.21

143110	25-yr	38300	633.76	100-yr	77000	642.31
143335	25-yr	38300	634.79	100-yr	77000	643.41
143560	25-yr	38300	635.45	100-yr	77000	644.12
143775	25-yr	38300	635.9	100-yr	77000	644.6
144480	25-yr	38300	636.81	100-yr	77000	645.43
144630	25-yr	38300	636.95	100-yr	77000	645.53
144780	25-yr	38300	637.26	100-yr	77000	645.75
144920	25-yr	38300	637.79	100-yr	77000	646.11
144930			Travis/Hays County Line			

The finish floor elevations of the structures in the floodplain were surveyed using NAVD 88. The original Onion Creek topography and cross-sections were developed using NGVD 29, which is 0.27 feet lower. Therefore, 0.27 feet was added to the HEC-RAS output water surface elevations for use in the economic analysis.

The Onion Creek water surface profiles for 25-year flood and 100-year flood events within Travis County are shown in Figure A-3.

Figure A-3
Water Surface Profiles



Onion Creek - Alternative Analysis

Five damage reaches were initially analyzed for development of potential structural flood control projects. These reaches consisted of Timber Creek, Forrest/Yarrabee Bend, Bluff Springs Road/Perkins Valley, Onion Creek Subdivision, and Bear Creek/Onion. Of these, potential for specific structural flood damage reduction solutions were investigated further at Yarrabee Bend and Bear Creek/Onion. Also, detailed consideration was given for a major upstream detention facility capable of reducing peak flood discharges at each of the individual damage centers.

UPSTREAM DENTENTION-BUDA SITE

A detailed analysis was undertaken to ascertain the feasibility of implementing a major floodwater detention project slightly upstream from the Bear Creek/Onion economic damage center. A tentative site for the potential dam axis was placed at creek station 139,200, about 5700 feet downstream from the Travis/Hays County Line and about 5300 feet upstream from the confluence of Bear Creek.

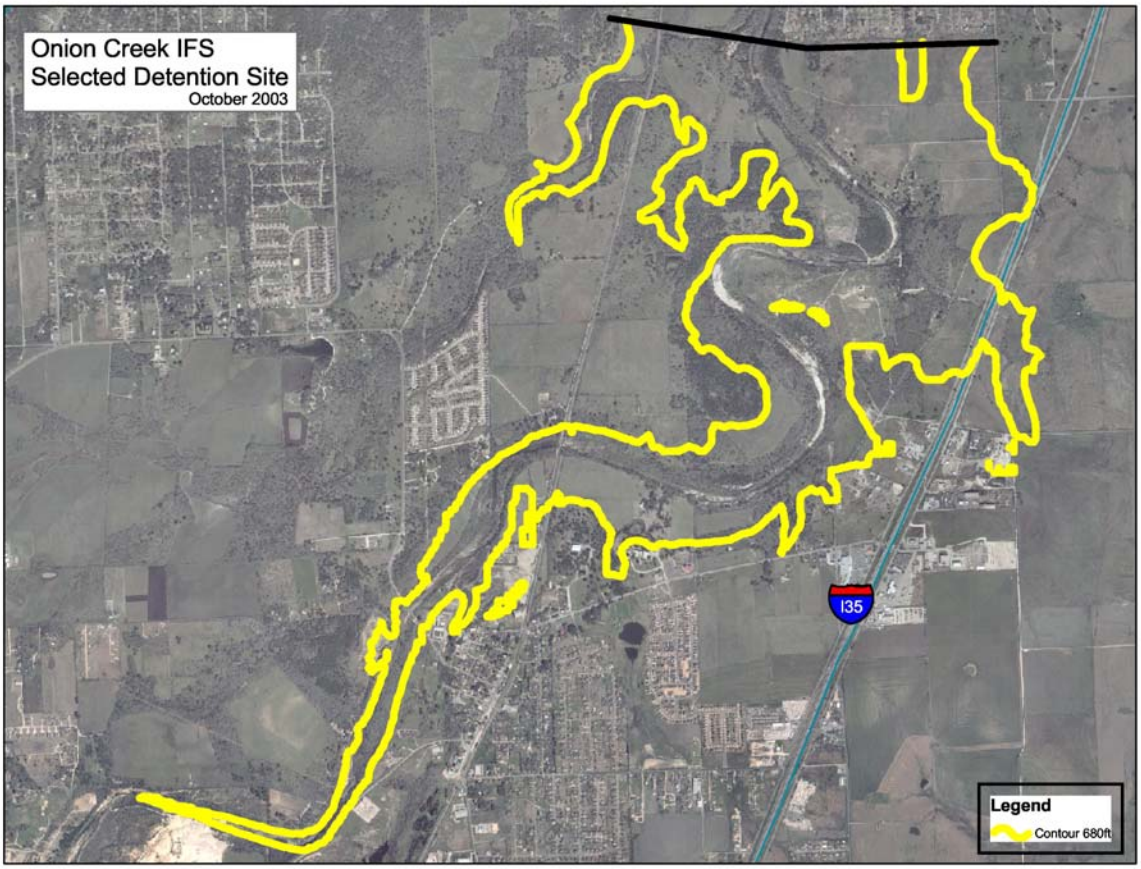
Standard U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle maps were used to develop area and capacity relationships for the pool area that would be formed upstream from the potential embankment. The range in pool elevations considered extended from 603 feet National Geodetic Vertical Datum (NGVD), which represents the channel invert at the axis of the dam, to 700 feet NGVD, at which the pool area would inundate more than 2700 acres, forming a flood control pool volume of almost 66,000 acre-feet.

Care was taken to ensure that potential pool elevations upstream from the project would not negatively impact developed properties in and around Buda, in Hays County, Texas.

A series of low flow conduit capacities was considered by applying a range of from one to five, 20-foot diameter round concrete pipes. Hydrologic routing functions were developed for each of the five low flow conduit configurations. The USACE HEC-1 program was utilized to assess the downstream impacts of each tested alternative. Prior to applying the HEC-1 program, it was tested using the without-project conditions runoff modeling input parameters to ensure that its computed hydrograph peaks reasonably matched those via the HEC-HMS program, which was used for the official without-project analyses. HEC-1 was found to replicate the HEC-HMS results at each of the key downstream nodes by about 0.8 percent on average, which was considered an adequate match for plan formulation purposes.

To support economic evaluation of this alternative, the resulting with-project discharge frequency functions were sequentially applied within the HEC-FDA program at each economic damage center along Onion Creek. However, estimated expected annual flood damage reduction benefits were subsequently found to be insufficient to justify the implementation of a major floodwater detention project in this vicinity. Analysis results indicated that the uncontrolled contributing drainage areas downstream of the potential dam site (beginning with the Bear Creek watershed) were too great for this alternative to have an impact on peak discharges at the identified damage centers further downstream along Onion Creek.

Figure A-4 Onion Creek Detention Site



YARRABEE BEND REACH

Detailed evaluations of an array of potential structural solutions were undertaken for this particular reach of Onion Creek. Based upon recommendations by the Project Manager, these analyses were initially focused evaluation of a relief channel (referred to as the Lower Swale) intended to provide enhanced conveyance across the natural oxbow straddling William Cannon Drive. A series of five trapezoidal, grass-lined channels with bottom widths ranging from 100 to 570 feet were investigated. These relief channels were aligned such that they would intersect the Onion Creek channel at Stream Stations 78,600 and 86,100 and each had a flow path length of about 1,500 feet. As such, they essentially reduced the overland travel length of a portion of the floodwaters by 80 percent.

The trapezoidal template for these trial relief channel plans was configured to have a level base, set at elevation 510 feet NGVD, throughout their entire length. This particular elevation was chosen such that all normal flows within Onion Creek (less than 5 feet in depth) would be passed entirely within the existing channel. Excavated sides slopes were set based upon a 3 horizontal to 1 vertical ratio.

Each of these relief channel configurations would require a bridge structure for William Cannon Drive. It was assumed that the bridge associated with each configuration would span the excavated trapezoidal section at that point. Roadway profile elevations were assumed to match the current conditions and the low chord elevation was determined based on a total bridge deck thickness of 4 feet.

Economic evaluations of these alternatives indicated that the net flood damage reduction benefits would be maximized by implementing the narrower solutions. Based upon recommendations by the Project Manager, the 200-foot bottom width relief channel alternative was selected as the "first added" component of all of the subsequent project feature evaluations.

The next series of potential alternatives involved the addition of overbank levees along the intensively developed reach upstream from William Cannon Drive. Initially, the left and right overbank levees were tested independently, but it was subsequently deemed unacceptable to consider levee protection for properties situated on only one side. The right overbank levee was aligned along a pronounced ridge adjacent to the Onion Creek channel and the left overbank levee was aligned so as to not encroach upon an imaginary line positioned approximately 30 feet behind the long row of residential properties in that area. In each case, the levees were configured to wrap around the existing development and tie back to higher ground. Interior drainage facilities (sumps) were sized in a very general fashion, to handle runoff volumes from the contributing drainage area that would be trapped by the proposed levees.

A subsequent series of tests involved the concept of levee setback, as a means of reducing the impacts upon both environmental resources and upstream water surface elevations (i.e. in the reaches upstream from the Yarrabee Bend economic damage center). A total of five setback positions for the left overbank levee were evaluated. In each set of runs, it was assumed that the right overbank levee would remain in a fixed position, since the overwhelming majority of conveyance area gained via any setback applied to the left overbank area.

Lastly, the concept of retaining the initial left overbank levee alignment, while implementing benching of the strip of land between that levee and the left bank of Onion Creek, was considered. For this alternative, the elevation grading of the benched left overbank was chosen such that all normal flows within Onion Creek (less than 5 feet in depth) would be passed entirely within the existing channel. Excavated sides slopes adjacent to the right toe of the left overbank levee were set based upon a 7 horizontal to 2 vertical ratio.

Subsequent economic analyses failed to identify sufficient flood damage reduction benefits to justify the anticipated project implementation costs. Analyses for potential structural solutions for the Yarrabee Bend damage center were thus terminated.

These analyses demonstrated that the effectiveness of structural alternatives in this particular damage reach was significantly limited primarily due to excessive tailwater elevations. Encroachments into the floodplain downstream of Yarrabee Bend substantially increased water surface profile elevations in the vicinity of William Cannon Drive. Increased tailwater elevations and reduced downstream conveyance are the result of an abandoned wastewater treatment facility that encroaches on the channel between creek stations 72,400 and 77,700. Though this was a known hydraulic limitation, authorization was not given to extend structural alternatives analysis downstream of William Cannon Drive.

- feature: levees
- length: 11100 feet
- material: compacted soil
- average height: 10 feet
- side slopes: 3H/1V

BEAR CREEK/ONION

The Bear Creek/Onion reach is located between Onion Creek stations 134490 – 137500. The structural project consists of a levee located along the left bank. The levee parameters are:

- length: 1600 feet
- material: compacted soil
- average height: 7 feet
- side slopes: 3H/1V

This project also includes a diversion channel located behind the area protected by the levee along Onion Doble Road. The diversion channel conveys overland flow from the residential area west of the protected area northeast towards Onion Creek. Figure A-5 shows the profile of the centerline of the floodwall crest.

Figure A-5

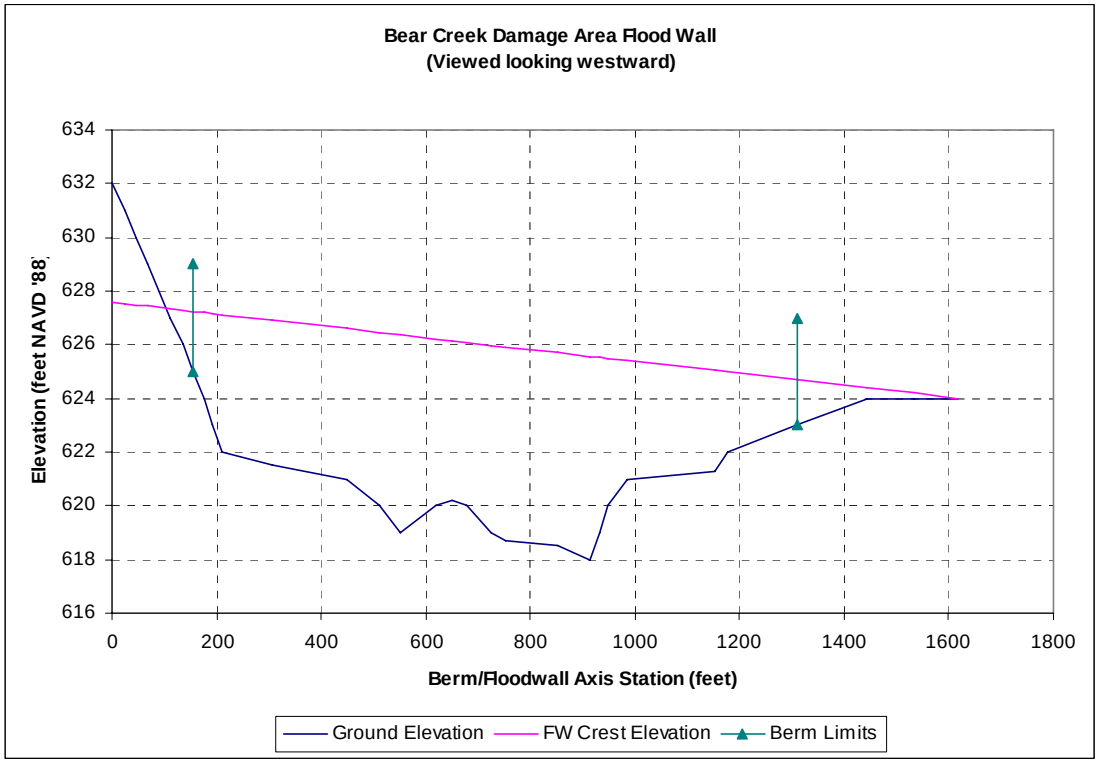
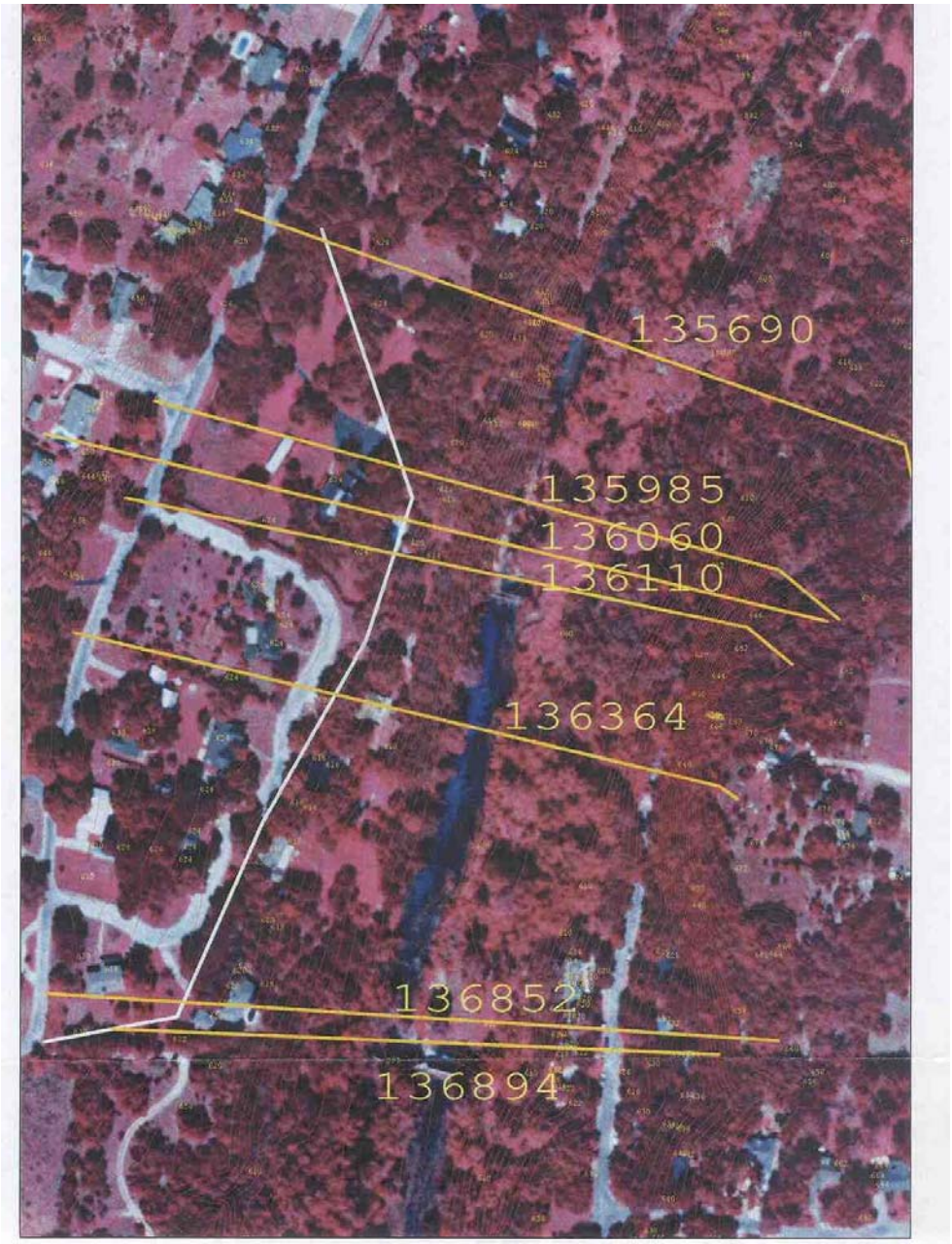

Bear Creek Damage Area Flood Wall
(Viewed looking westward)
Elevation (feet NAVD '88)
634
632
630
628
626
624
622
620
618
616
0
200
400
600
800
1000
1200
1400
1600
1800
Berm/Floodwall Axis Station (feet)
Ground Elevation
FW Crest Elevation
Berm Limits

Figure A-6 is the plan view of the Bear Creek/Onion proposed floodwall and the cross-sections along Onion Creek.

Figure A-6


135690
135985
136060
136110
136364
136852
136894

WILLIAMSON CREEK-EXISTING CONDITIONS

DESCRIPTION OF CREEK

Williamson Creek is a major tributary of Onion Creek. Williamson Creek rises in the vicinity of the Balcones Escarpment. The average creek slope is approximately 25 feet-per-mile. Williamson Creek is characterized by a narrow, deep channel in the downstream reach to a limestone bed channel in the upstream reaches. Figure A-7 and Figure A-8 indicate typical channel reaches. The Williamson Creek watershed is approximately 31 square miles and is located entirely within Travis County. The creek originates near the Balcones Escarpment and flows easterly to its confluence with Onion Creek at McKinney State Falls Park.

Development of Hydraulic Model

Figure A-7 Williamson Creek Channel

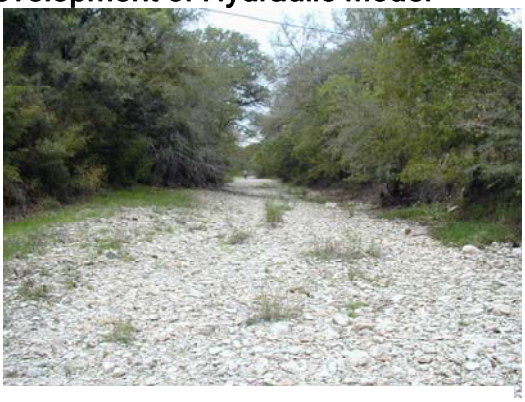


Figure A-8 Williamson Creek channel

The Williamson Creek model developed for this analysis is originally based on backwater model developed in for the Williamson Creek Expanded Flood Plain Information Study (XFPI) May 1980. The XFPI model was modified to develop the 1997 Flood Insurance Study model. The XFPI and FIS models were developed using HEC-2 Water Surface Profiles, September 1982 version, computer program. The existing conditions in the HEC-RAS model for this project include discharges from the HEC-HMS model developed by Halff Associates, Inc. and the geometry from the HEC-RAS model developed by Camp Dresser and McKee (CDM). This updated existing conditions model results in different existing water surface elevation profiles than were used in the preliminary Williamson Creek project. The increased discharges and the updated existing geometry produced net reduction in water surface in the Heartwood and Radam reaches, and minimal change in water surfaces in the Broken Bow and Bayton Loop reaches. The existing hydraulic model was modified by HDR to include 2003 LIDAR (Light Detection and Ranging) data to update the cross-section geometry in most areas of Williamson Creek and Sunset Valley Creek between Congress Avenue and Brodie Lane. The cross-section geometries adjacent to bridges and culverts were not modified, as there is no new data relevant to these sections.

When the cross sections on Sunset Valley Creek were modified to include 2003 LIDAR data a consistent discrepancy was noticed at the culvert locations. As in the Williamson Creek model, the cross sections bounding the culverts, as well as the specific culvert configurations were not changed. However, with respect to the updated cross section geometry and channel lengths, the culverts appeared to be located too low (based on the average channel invert profile). Lacking any new information about the culverts themselves, the culvert configuration was not changed. However, the culvert crossings have been modified to raise the roadway (i.e. bridge deck) to the elevations shown in the 2003 LIDAR. The intent of this modification is to make the overtopping weir section consistent with the adjacent cross sections and the 2003

LIDAR data. This comparison was not possible for Williamson Creek since the LIDAR TIN was trimmed in the region of the channel itself, making it impossible to determine roadway elevations.

Existing Conditions water surface profiles were computed for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 250-year, and 500-year flood events. Peak discharges for these flood events were developed in the Onion Creek hydrologic analysis and incorporated in the Williamson Creek HEC-RAS hydraulic model.

The Williamson Creek Model incorporated input data developed from the following sources; TXDOT bridge plans, USGS quadrangle topographic maps, City of Austin 2-foot topography, City of Austin bridge plans, Travis County bridge plans, LIDAR, and field surveyed cross-sections. The orientation of the cross-section data is viewed downstream left-to-right. Total number of cross-sections in the Williamson Creek hydraulic model is 472.

The Manning coefficients of roughness (n values) were incorporated in the Williamson Creek Model to represent the Williamson Creek channel and overbanks roughness. The n values were determined from aerial photography and site field reconnaissance. The ranges of n values are as follows: channel: 0.035 – 0.080 and overbanks: 0.050 – 0.120.

The Williamson Creek hydraulic model limits extend from the Williamson Creek/Onion Creek confluence at the downstream limit (Onion Creek station 68250) to creek station 92570 (17.53 miles).

STREAM GAGES

The two existing stream gages on Williamson Creek are as follows:

Williamson Creek at Brush Country Boulevard

- station number 08158922
- drainage area 6.79 square miles
- located on downstream side of bridge
- datum 740.25 feet above sea level

Williamson Creek at Manchaca Road

- station number 08158930
- drainage area 19.0 square miles
- located on downstream side of bridge
- datum 618.39 feet above sea level

STRUCTURES

Table A-7 indicates the structures crossing Williamson Creek.

Table A-7

Structure	**Creek Station**
Jimmy Clay Drive	7255
Nuckols Crossing Road	15750
Stassney Lane	24000
I.H. 35	26600
Wasson Road	32470
Table A-7 continued	
Structure	**Creek Station**
South Congress Avenue	32705
South First Street	36995
South First Street	38475
South First Street	39845
Emerald Forest Drive	42575
Missouri Pacific Railroad	43850
Manchaca Road	46220
Jones Road	50340
West Gate Boulevard	52775
Brodie Lane	60136
Brush Country Road	67275
Joe Tanner Lane	73915
U.S. 290	74815
William Cannon Drive	76550
U.S. 71	84805
Silvermine Drive	86325
channel weir	87300
Oak Hill Dam	90300

WILLIAMSON CREEK-HYDROLOGIC ANALYSIS

Halff Associates, Inc. performed an updated Williamson Creek basin hydrologic analysis, under contract with the USACE. The results of their analysis were documented in "Onion Creek Interim Feasibility Study Urbanization Discharges Williamson Creek Discharge Comparison" May 2006 report. Several pages of that report are excerpted here. Note that the "No Broken Bow" alternative referred to in the report was a variation of the Recommended Plan that consisted of the removal of the Broken Bow reach channel modification from the Recommended Plan. This option was evaluated for information purposes only.

INTRODUCTION

The Williamson Creek HEC-HMS model was updated to reflect the geometry of the latest version of the USACE Williamson Creek HEC-RAS model. The study area is located on the main stem of Williamson Creek from below the Kitcheon Branch confluence to Congress Avenue. The Williamson Creek drainage area map is shown in Figures 1 and 2. The June 2004 Williamson Creek HEC-HMS model, updated with a new rating curve for Oak Hill pond provided by the City of Austin, was used as the current hydrologic model. Storage routing in the hydrologic model was updated using the Williamson Creek HEC-RAS model for revised existing conditions and USACE proposed projects ("With Project" and "No Broken Bow" conditions).

PROCEDURE

The HEC-RAS model provided by the USACE was edited to stabilize the storage routing values for the study area. Crossing profiles were eliminated in the hydraulics model by deleting the ineffective flow limits for cross sections 50250 to 53160. Additionally, the bridge modeling approach for cross section 52775 was changed for high flows to energy only for the revised existing model, the "With Project" model, and the "No Broken Bow" model. For reaches WCR160 and WCR1100 discharges were eliminated between 20000 cfs and 27500 cfs. The model was very sensitive in this range and would require additional effort to eliminate the crossing profiles. The updated models still have some crossing profiles, but the profiles are relatively smooth for storage volume purposes.

The revised existing HEC-RAS (Version 3.1.3) plan was used to update the existing storage routing conditions in the HEC-HMS (Version 2.2.2) model. Five routing reaches were changed including reaches WCR160, WCR1100, WCR120, WCR1000, and WCR240.

Areal reduction of point rainfall was estimated for selected storm areas using the method outlined in TP-40, which is incorporated in the HEC-HMS model. Areal reductions were used only for basins with a drainage area greater than 10 square miles. The HEC-HMS model was ran at storm areas of 0, 15, 20, and 25 square miles. The resulting peak flow rates were tabulated. The revised existing 100-year tabulated areal reduction results are shown in Table 1.

Peak discharges for each design point was interpolated based on the drainage area of the point of interest using the equation:

Area Reduction Interpolation = ((HA-LA)(UD-LD)/(UA-LA))+LD
Where: HA = Hydrologic Element Area
UA = Upper Limit Storm Area
LA = Lower Limit Storm Area
UD = Upper Limit Peak Discharge
LD = Lower Limit Peak Discharge

Table 1. Revised Existing 100-yr Areal Reduction Tabulated Results

Hydrologic Element	Hydrologic Element Area	Peak Discharge (cfs)			
		0 mi^2 Storm Area	15 mi^2 Storm Area	20 mi^2 Storm Area	25 mi^2 Storm Area
WCR160W160	0.18	790.28	716.21	694.73	674.82
WCR1100W1170	0.416	1277.7	1174.9	1144.5	1116.3
WCR1000W1060	0.43	1090.7	1007.1	982.34	959.43
WCR120W113	0.52	1326.5	1228.9	1199.8	1172.8
WCR240W1040	0.87	1998.9	1860.1	1817.6	1778.2
JWCR160	15.587	22226	21098	20765	20463
J130W	15.767	22114	20997	20649	20312
JWCR130	17.91	24422	23182	22783	22362
JWCR120	18.364	24858	23595	23184	22747
WCR1100	18.364	24697	23371	22938	22516
JWCR1170	18.78	24804	23477	23041	22619
WCR120	18.78	24678	23347	22917	22521
J1000a	19.3	24842	23507	23077	22677
JWCR1000	20.734	25504	24134	23695	23276
WCR1000	20.734	25268	23932	23515	23128
J103a	21.164	25350	24016	23600	23211
JWCR103	21.498	25407	24074	23659	23271
WCR240	21.498	25313	23988	23580	23204
J360a	22.368	25499	24173	23767	23390

As an example, the peak discharge for JWCR160 was calculated using the areal reduction interpolation equation. The hydrologic element has a drainage area of 15.587 square miles. The lower limit storm area used was 15 square miles and the upper limit storm area was 20 square miles. The upper limit discharge used for the calculation was 20765 cfs, the value calculated when the hydrologic model was ran with a 20 square mile areal reduction. The lower limit discharge value was calculated in a similar manner using a 15 square mile areal reduction. The resulting areal reduction interpolation equation for JWCR160 is shown below.

JWCR160=((15.587sm-15sm)(20765cfs-21098cfs)/(20sm-15sm))+21098cfs = 21060cfs

RESULTS

The 100-year peak flow rates for the five scenarios are compared below in Table 7. The "with project" condition produced an average of approximately 1-percent increase in flows when compared with the revised existing conditions model. At Congress Avenue the peak flow rates for the "with project" run are approximately 3-percent higher than the revised existing conditions. The "No Broken Bow" conditions produced an average of approximately 1-percent increase in flows when compared with the revised existing conditions model. At Manchaca Road the peak flows for the "No Broken Bow" run are approximately 1-percent higher than the revised conditions model. Computed peak discharges for the 2060 flows were approximately 3-percent greater than the 2010 peak discharges. At Congress Avenue the peak flow rates for the "2060 With Project" are approximately 2-percent higher than the 2060 revised existing conditions.

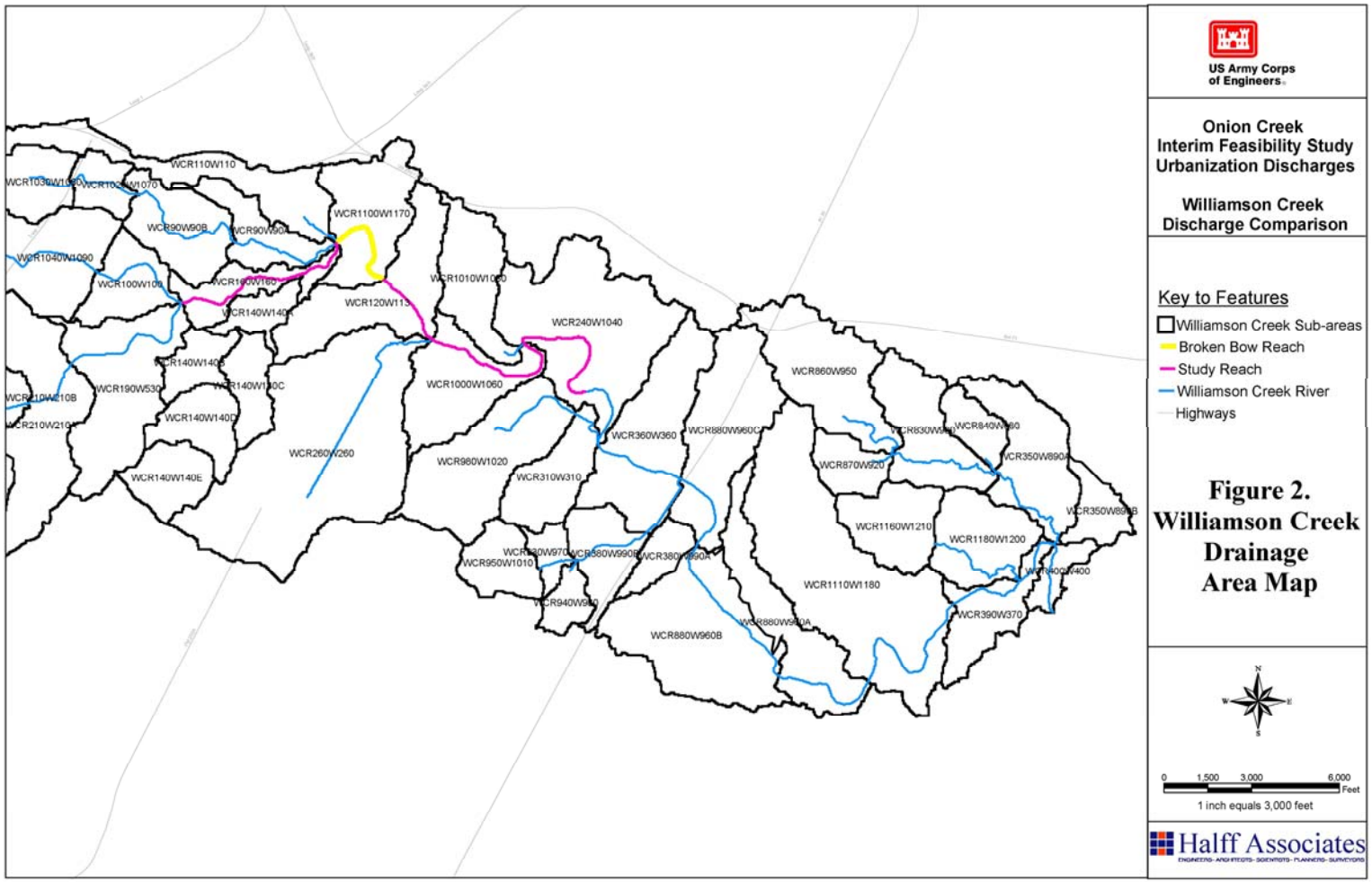
CONCLUSIONS

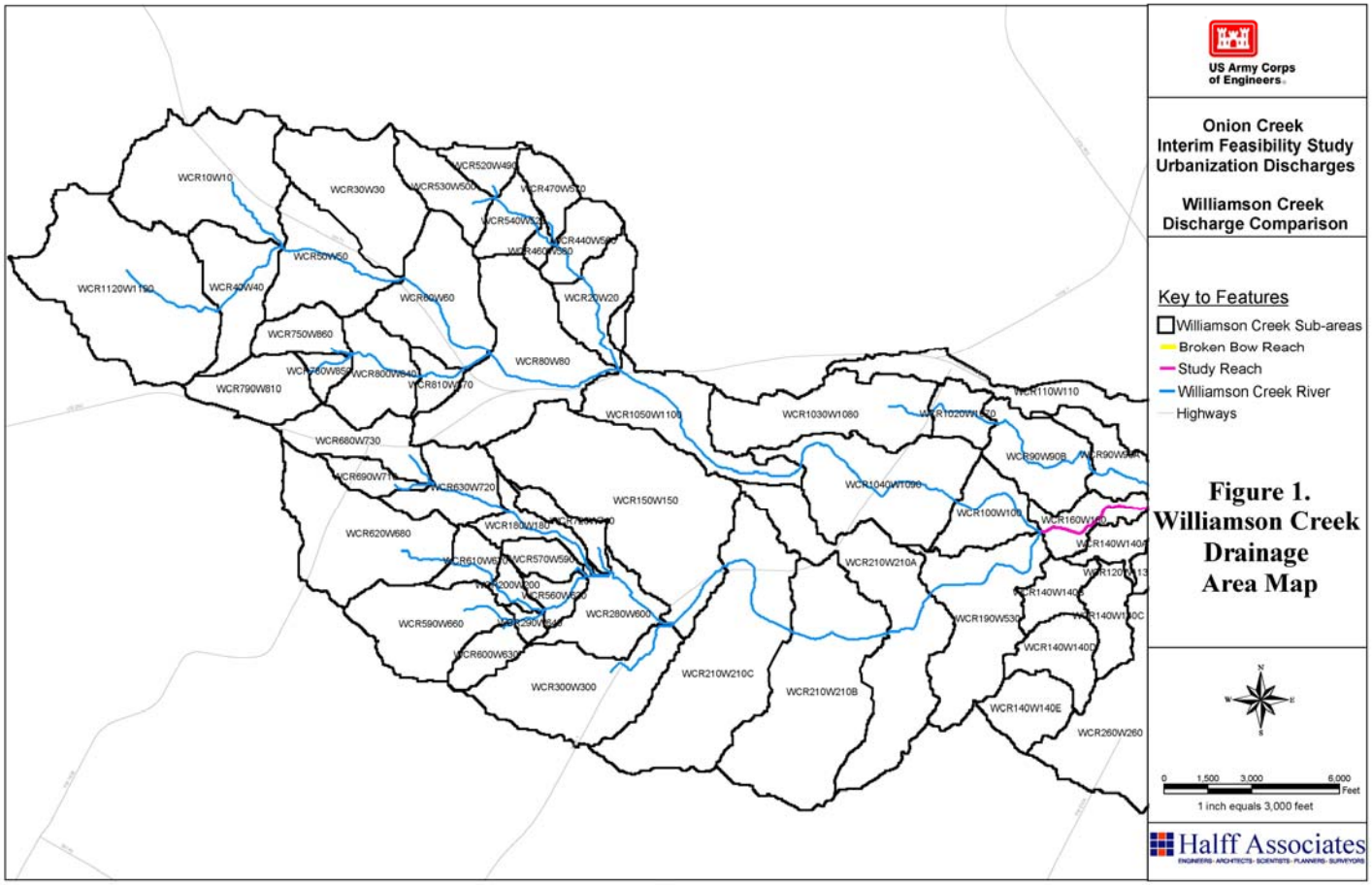
The peak discharges from the hydrologic model were similar for the five different scenarios. The storage volumes for the revised existing conditions and with project conditions were not substantially different.

At Junction JWCR120, the 100-year storm event results are different than expected. The "No Broken Bow" 100-year discharge is higher than the "With Project" results and the "2060 With Project" 100-year is lower than the 2060 revised existing 100-year discharge. A curve showing the storage routing data for reach WCR160 is shown below in Figure 1. Even though the curves appear smooth and the amount of storage decreases with the proposed projects, the routing is attenuating the hydrographs more for the "With Project" model than the "No Broken Bow" model and the "2060 With Project" more than the 2060 revised existing conditions model. Even though all conditions are modeled with the same routing step, the routing steps appear to be contributing to the unusual results of the routing reach. The timing then compounds the difference as the hydrograph moves downstream.

Table 7. Williamson Creek Discharge Comparison

			100yr Peak Flow (cfs)				
			2010			2060	
Description	Junction	Area (sm)	Revised Existing	With Project	Project with no Broken Bow	2060 Revised Existing	2060 With Project
At the confluence with Kincheon Branch	JWCR160	15.58	21060	21060	21060	21870	21870
Approximately 600 feet downstream of Jones Road	JWCR120	18.36	23320	23320	23380	24060	23990
At Manchaca Road	JWCR1170	18.78	23150	23360	23320	23930	23980
Approximately 900 feet upstream of Emerald Forest Drive	JWCR1000	20.73	23630	24120	23920	24380	24610
Approximately 500 feet downstream of 1st Street	JWCR103	21.49	23540	24090	23840	24230	24570
Approximately 3000 feet downstream of Congress Avenue	J360a	22.36	23590	24180	23910	24250	24660
Below confluence with Williamson Creek Tributary 4	JWCR360	23.24	23660	24280	24000	24320	24750
At I-35	J880W	23.76	23670	24310	24010	24320	24770
Approximately 1100 ft US confluence with Williamson Creek Tributary 3	JWCR370	26.37	23820	24480	24170	24430	24930
At Jimmy Clay Road	JWCR3900	27.59	23990	24660	24340	24540	25090
Below confluence with Williamson Creek Tributary 2	J400W	28.49	24000	24660	24340	24520	25060
Below confluence with Williamson Creek Tributary 1	JWCR400	30.32	24170	24840	24510	24670	25260
Above confluence with Onion Creek	Outlet	30.42	24160	24820	24490	24640	25170


US Army Corps of Engineers
Onion Creek
Interim Feasibility Study
Urbanization Discharges
Williamson Creek
Discharge Comparison
Key to Features
Williamson Creek Sub-areas
Broken Bow Reach
Study Reach
Williamson Creek River
Highways
Figure 2.
Williamson Creek
Drainage
Area Map
0 1,500 3,000 6,000 Feet
1 inch equals 3,000 feet
Halff Associates
WCR110W110
WCR1100W1170
WCR1040W1090
WCR100W100
WCR140W140
WCR1010W1060
WCR120W115
WCR240W1040
WCR860W950
WCR190W530
WCR1000W1060
WCR140W140D
WCR260W260
WCR980W1020
WCR310W310
WCR360W360
WCR880W960C
WCR870W920
WCR350W890
WCR140W140E
WCR1160W1210
WCR1180W1200
WCR950W1010
WCR1110W1180
WCR390W370
WCR880W960B


US Army Corps of Engineers
Onion Creek
Interim Feasibility Study
Urbanization Discharges
Williamson Creek
Discharge Comparison
Key to Features
Williamson Creek Sub-areas
Broken Bow Reach
Study Reach
Williamson Creek River
Highways
Figure 1.
Williamson Creek
Drainage
Area Map
0 1,500 3,000 6,000 Feet
1 inch equals 3,000 feet
Halff Associates
WCR10W10
WCR30W30
WCR520W490
WCR530W500
WCR470W510
WCR540W530
WCR440W520
WCR460W550
WCR50W50
WCR1120W1190
WCR40W40
WCR60W60
WCR20W20
WCR750W860
WCR80W80
WCR790W810
WCR810W870
WCR1050W1100
WCR1030W1080
WCR110W110
WCR680W730
WCR90W90B
WCR690W710
WCR630W720
WCR1040W1090
WCR150W150
WCR100W100
WCR620W680
WCR180W180
WCR210W210A
WCR610W630
WCR570W590
WCR140W140A
WCR140W140
WCR560W580
WCR280W600
WCR190W530
WCR140W140C
WCR590W660
WCR140W140D
WCR600W630
WCR210W210C
WCR300W300
WCR210W210B
WCR140W140E
WCR260W260

The tables of flood event peak discharges developed by Halff Associates, Inc. were edited by the USACE by removing points of similar discharges from the upstream end of the project damage reaches to Onion Creek. The discharges tables used in the HEC-RAS hydraulic model are listed in Tables A-8 and A-9.

Table A-8

2010 Revised Existing HEC-HMS Results

Location	Creek Station	Hydrologic Element	Area (mi2)	Peak Flow (cfs)							
				2 yr	5 yr	10 yr	25yr	50yr	100yr	250yr	500yr
d/s Kincheon	55560	JWCR160	15.587	3580	6960	9710	14230	17700	21060	26580	31350
d/s Sunset Valley	49550	JWCR130	17.91	3860	7540	10510	15050	18970	22950	28460	33150
d/s left bank trib	49430	JWCR120	18.364	3930	7670	10660	15250	19260	23320	28840	33530
at MP Railroad	43800	J1000a	19.3	3920	7740	10770	15350	19330	23140	28780	33600
d/s MP Railroad trib	43460	JWCR1000	20.734	4020	7970	11050	15710	19810	23630	29410	34340
u/s 1st Street trib	30340	J360a	22.368	4010	8050	11190	15860	19920	23590	29420	34420
near Nuckols Crossing	13745	JWCR370	26.376	4050	8180	11300	16080	20110	23820	29560	34460

2010 With Project HEC-HMS Results

Location	Creek Station	Hydrologic Element	Area (mi2)	Peak Flow (cfs)							
				2 yr	5 yr	10 yr	25yr	50yr	100yr	250yr	500yr
d/s Kincheon	55560	JWCR160	15.587	3580	6960	9760	14230	17700	21060	26580	31350
d/s Sunset Valley	49550	JWCR130	17.91	3880	7600	10680	15340	19030	22940	28440	33130
d/s left bank trib	49430	JWCR120	18.364	3940	7740	10880	15600	19300	23320	28840	33530
at MP Railroad	43800	J1000a	19.3	3950	7830	11010	15740	19390	23470	29000	33690
d/s MP Railroad trib	43460	JWCR1000	20.734	4050	8090	11390	16210	19890	24120	29750	34530
u/s 1st Street trib	30340	J360a	22.368	4040	8170	11530	16400	20080	24180	29810	34590
near Nuckols Crossing	13745	JWCR370	26.376	4080	8300	11730	16640	20380	24480	29970	34600

Table A-9

2060 Revised Existing HEC-HMS Results

Location	Creek Station	Hydrologic Element	Area (mi2)	Peak Flow (cfs) 2 yr	5 yr	10 yr	25yr	50yr	100yr	250yr	500yr
d/s Kincheon	55560	JWCR160	15.587	3900	7440	10300	14890	18400	21870	27900	33160
d/s Sunset Valley	49550	JWCR130	17.91	4180	7960	10950	15650	19570	23690	29660	34790
d/s left bank trib	49430	JWCR120	18.364	4240	8080	11110	15850	19840	24060	30040	35170
at MP Railroad	43800	J1000a	19.3	4250	8150	11200	15930	19910	23900	29960	35170
d/s MP Railroad trib	43460	JWCR1000	20.734	4340	8350	11480	16260	20350	24380	30510	35780
u/s 1st Street trib	30340	J360a	22.368	4320	8410	11580	16360	20400	24250	30400	35690
near Nuckols Crossing	13745	JWCR370	26.376	4350	8530	11750	16530	20630	24430	30450	35610

2060 With Project HEC-HMS Results

Location	Creek Station	Hydrologic Element	Area (mi2)	Peak Flow (cfs) 2 yr	5 yr	10 yr	25yr	50yr	100yr	250yr	500yr
d/s Kincheon	55560	JWCR160	15.587	4430	7440	10300	14890	18400	21870	27900	33160
d/s Sunset Valley	49550	JWCR130	17.91	4750	8020	11100	15960	19990	23640	29580	34680
d/s left bank trib	49430	JWCR120	18.364	4820	8150	11290	16210	20290	23990	29950	35050
at MP Railroad	43800	J1000a	19.3	4830	8240	11440	16350	20220	24050	30000	35090
d/s MP Railroad trib	43460	JWCR1000	20.734	4930	8460	11780	16770	20680	24610	30600	35710
u/s 1st Street trib	30340	J360a	22.368	4900	8530	11920	16920	20590	24660	30650	35760
near Nuckols Crossing	13745	JWCR370	26.376	4930	8660	12100	17100	20850	24930	30780	35740

Results of Analysis

Existing Conditions water surface profiles were computed for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 250-year, and 500-year flood events, with emphasis from the upstream damage reach to Onion Creek. The hydrology represented the Williamson Creek 2010 Revised Existing Conditions and 2010 With-Project Conditions, and 2060 Revised Conditions and 2060 With-Project Conditions. Tables A-10 and A-11 show the 2010 25-year and 100-year water surface elevations within the project reaches.

Table A-10
2010 Conditions 25-year Flood

Revised Existing			With-Project		
River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
33530	15710	594.47	33530	16210	594.69
33630	15710	594.71	33630	16210	594.93
			33845	16210	594.97
34112	15710	594.41	34112	16210	595.92
34226	15710	595.94	34226	16210	596.32
34794	15710	598.59	34794	16210	597.39
			35010	16210	598.07
35600	15710	602.07	35600	16210	600.71
36350	15710	602.47	36350	16210	601.34
36710	15710	603.31	36710	16210	602.7
36900	15710	604.01	36900	16210	603.8
36960	15710	605.27	36960	16210	605.23
		South First Street			
37030	15710	605.52	37030	16210	605.51
37300	15710	605.58	37300	16210	605.57
37430	15710	605.61	37430	16210	605.61
37680	15710	607.61	37680	16210	607.75
38110	15710	608.47	38110	16210	608.62
38325	15710	608.25	38325	16210	608.39
38450	15710	608.56	38450	16210	608.71
		South First Street			
38500	15710	609.94	38500	16210	610
38560	15710	609.81	38560	16210	609.86
38710	15710	610.12	38710	16210	610.19
38760	15710	610.14	38760	16210	610.21
39130	15710	611.37	39130	16210	611.5
39470	15710	611.93	39470	16210	612.08
39820	15710	613.66	39820	16210	613.85
		South First Street			
39870	15710	613.97	39870	16210	614.18
40050	15710	614.18	40050	16210	614.39
40375	15710	615.83	40375	16210	616.05

40940	15710	617.41	40940	16210	617.64
41040	15710	617.75	41040	16210	617.98

Table A-10 continued

River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
41200	15710	618.33	41200	16210	618.54
41390	15710	618.86	41390	16210	619.07
41470	15710	619.15	41470	16210	619.36
41550	15710	619.33	41550	16210	619.54
			41650	16210	619.77
41950	15710	620.45	41950	16210	620.58
42220	15710	621.19	42220	16210	620.78
42550	15710	622.22	42550	16210	621.54
		Emerald Forest Drive			
42600	15710	623.01	42600	16210	622.47
42710	15710	623	42710	16210	622.99
			42916	16210	622.58
43101	15710	624.93	43101	16210	624.34
43460	15710	626.67	43460	16210	626.45
43750	15350	627	43750	15740	626.79
43800	15350	627.19	43800	15740	627.01
43825	15250	626.79	43825	15600	626.61
		Missouri Pacific Railroad			
43875	15250	628.22	43875	15600	628.28
44050	15250	630.23	44050	15600	630.36
44230	15250	630.36	44230	15600	630.45
44450	15250	630.84	44450	15600	631.02
44580	15250	631.16	44580	15600	631.34
44750	15250	632.17	44750	15600	632.35
44850	15250	631.86	44850	15600	632.04
45050	15250	632.42	45050	15600	632.59
45200	15250	632.83	45200	15600	633
45680	15250	635.15	45680	15600	635.32
46090	15250	636.49	46090	15600	636.64
46190	15250	637.89	46190	15600	637.95
		Manchaca Road			
46250	15250	638.68	46250	15600	638.69
46390	15250	638.79	46390	15600	638.68
			46660	15600	639.26
46900	15250	640.2	46900	15600	639.94
47050	15250	640.4	47050	15600	640.11
47300	15250	640.85	47300	15600	640.47
47550	15250	641.39	47550	15600	640.66
47800	15250	641.97	47800	15600	641.27
47930	15250	642.51	47930	15600	641.44
48330	15250	644.8	48330	15600	642.31
48505	15250	645.79	48505	15600	643.81

48706	15250	646.24	48706	15600	644.24
48915	15250	646.74	48915	15600	644.82
49100	15250	647.01	49100	15600	645.18
49253	15250	647.74	49253	15600	645.82

Table A-10 continued

River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
49430	15250	648.22	49430	15600	646.27
49550	15050	648.7	49550	15340	646.68
50069	14230	650.87	50069	14230	649.31
50250	14230	650.63	50250	14230	649.4
50310	14230	651.13	50310	14230	650.01
		Jones Road			
50370	14230	652.75	50370	14230	652.75
50460	14230	653.04	50460	14230	653.04
51050	14230	654.35	51050	14230	654.34
51170	14230	654.42	51170	14230	654.41
51380	14230	654.83	51380	14230	654.61
51580	14230	655.41	51580	14230	655
51950	14230	656.25	51950	14230	654.81
52150	14230	658.01	52150	14230	654.85
52320	14230	659.33	52320	14230	656.82
52490	14230	659.9	52490	14230	657.71
52600	14230	660.28	52600	14230	657.67
52740	14230	661.06	52740	14230	658.22
		West Gate Boulevard			
52810	14230	661.81	52810	14230	661.29
52860	14230	662.61	52860	14230	662.42
53160	14230	663.37	53160	14230	662.25
53450	14230	664.66	53450	14230	663.29
53810	14230	665.62	53810	14230	663.31

Table A-11
2010 Conditions 100-year Flood

Revised Existing			With-Project		
River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
33530	23630	597.85	33530	24120	598.05
33630	23630	598.11	33630	24120	598.31
			33845	24120	598.36
34112	23630	597.52	34112	24120	598.84
34226	23630	598.94	34226	24120	599.3
34794	23630	601.8	34794	24120	600.39
			35010	24120	601.09
35600	23630	605.51	35600	24120	603.94
36350	23630	605.9	36350	24120	604.55
36710	23630	606.58	36710	24120	605.64
36900	23630	606.93	36900	24120	606.25
36960	23630	608.6	36960	24120	608.29
		South First Street			
37030	23630	609.11	37030	24120	608.74
37300	23630	609.22	37300	24120	608.87
37430	23630	609.23	37430	24120	608.87
37680	23630	611.1	37680	24120	611.01
38110	23630	611.78	38110	24120	611.73
38325	23630	611.37	38325	24120	611.3
38450	23630	611.61	38450	24120	611.56
		South First Street			
38500	23630	613.59	38500	24120	613.6
38560	23630	613.21	38560	24120	613.2
38710	23630	613.6	38710	24120	613.61
38760	23630	613.44	38760	24120	613.45
39130	23630	615.5	39130	24120	615.58
39470	23630	615.79	39470	24120	615.85
39820	23630	617.8	39820	24120	618.01
		South First Street			
39870	23630	618.54	39870	24120	618.77
40050	23630	618.68	40050	24120	618.9
40375	23630	619.99	40375	24120	620.17
40940	23630	621.42	40940	24120	621.62
41040	23630	621.66	41040	24120	621.86
41200	23630	622.08	41200	24120	622.27
41390	23630	622.44	41390	24120	622.61
41470	23630	622.8	41470	24120	623.01
41550	23630	623.05	41550	24120	623.26
			41650	24120	623.43
41950	23630	623.94	41950	24120	624.2
42220	23630	624.47	42220	24120	624.31

42550	23630	625.2	42550	24120	624.78

Table A-11 continued

River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
		Emerald Forest Drive			
42600	23630	628.27	42600	24120	628.12
42710	23630	628	42710	24120	628.44
			42916	24120	628.37
43101	23630	629.69	43101	24120	628.76
43460	23630	630.59	43460	24120	630.09
43750	23140	630.77	43750	23470	630.27
43800	23140	630.85	43800	23470	630.37
43825	23320	629.85	43825	23320	629.35
		Missouri Pacific Railroad			
43875	23320	631.97	43875	23320	631.45
44050	23320	634.69	44050	23320	634.36
44230	23320	634.79	44230	23320	634.47
44450	23320	635.02	44450	23320	634.74
44580	23320	635.24	44580	23320	634.98
44750	23320	636.24	44750	23320	636.03
44850	23320	635.9	44850	23320	635.67
45050	23320	636.42	45050	23320	636.21
45200	23320	636.72	45200	23320	636.53
45680	23320	638.87	45680	23320	638.76
46090	23320	640.13	46090	23320	640.06
46190	23320	641.58	46190	23320	641.43
		Manchaca Road			
46250	23320	642.01	46250	23320	641.73
46390	23320	642	46390	23320	641.58
			46660	23320	642.55
46900	23320	643.67	46900	23320	643.31
47050	23320	643.83	47050	23320	643.46
47300	23320	644.16	47300	23320	643.71
47550	23320	644.51	47550	23320	643.67
47800	23320	644.93	47800	23320	644.37
47930	23320	645.28	47930	23320	644.43
48330	23320	647.7	48330	23320	645.21
48505	23320	648.55	48505	23320	646.65
48706	23320	648.92	48706	23320	647.1
48915	23320	649.25	48915	23320	647.47
49100	23320	649.5	49100	23320	647.57
49253	23320	649.93	49253	23320	648.22
49430	23320	650.5	49430	23320	648.65
49550	22950	650.99	49550	22940	648.98
50069	21060	652.86	50069	21060	651.84
50250	21060	652.46	50250	21060	651.14
50310	21060	653.56	50310	21060	653.49

		Jones Road			
50370	21060	655.07	50370	21060	655.04
50460	21060	655.12	50460	21060	655.09

Table A-11 continued

River Sta	Q Total (cfs)	WSEL (ft)	River Sta	Q Total (cfs)	WSEL (ft)
51050	21060	655.41	51050	21060	655.39
51170	21060	655.51	51170	21060	655.5
51380	21060	656.15	51380	21060	655.79
51580	21060	657.08	51580	21060	656.48
51950	21060	658.11	51950	21060	656.13
52150	21060	660.89	52150	21060	656.51
52320	21060	660.96	52320	21060	659.37
52490	21060	661.5	52490	21060	659.81
52600	21060	662.01	52600	21060	659.72
52740	21060	662.81	52740	21060	659.92
		West Gate Boulevard			
52810	21060	662.99	52810	21060	660.24
52860	21060	663.85	52860	21060	663.61
53160	21060	665.02	53160	21060	663.25
53450	21060	666.95	53450	21060	665.13
53810	21060	667.59	53810	21060	665.08

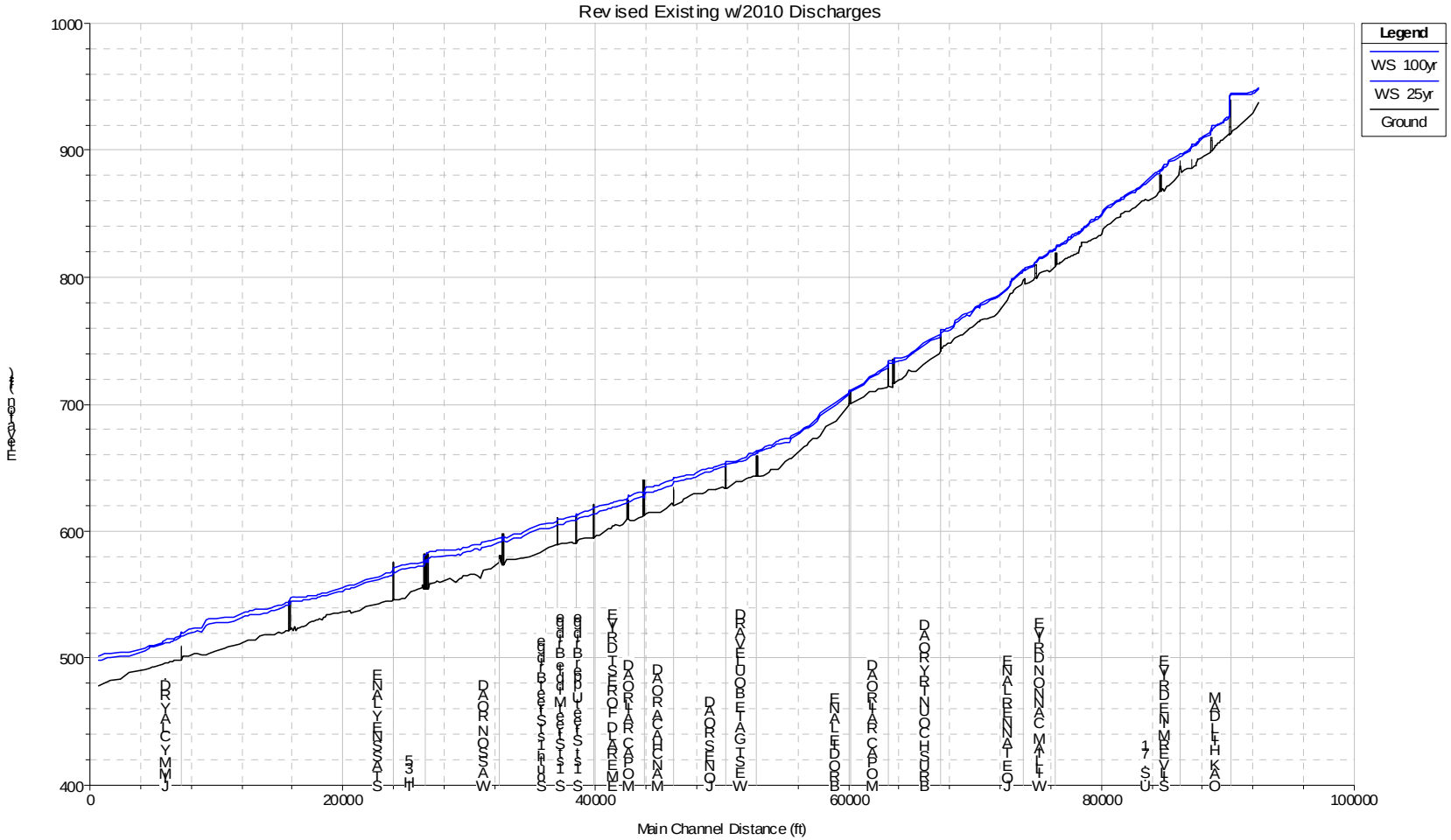
The Recommended Plan causes a 0.2 foot rise on average in the 100-year water surface profile downstream of the Heartwood Reach to Onion Creek, due to the increase peak discharges. This inducement will be investigated in the PED.

HYDRAULIC MODELING DURING PED

Further analysis of the hydraulic design of the Recommended Plan will be performed during the PED phase of the project. The analysis will consist of a new baseline existing conditions HEC-RAS model currently being developed by an Austin engineering firm. This model will serve as the base model for the Recommended Plan. The Recommended Plan hydraulic details will be refined, in particular the channel modification geometry and slope. Additional analysis will be performed at the transitions of the modified reaches to improve the flow characteristics at these points. Erosion protection measures will be investigated.

Figure A-9 is the Williamson Creek Revised Existing Conditions water surface profiles for the 25-year flood and 100-year flood.

Figure A-9



WILLIAMSON CREEK ALTERNATIVE ANALYSIS

Several structural flood control alternatives were investigated for the four damage reaches. Table A-12 lists the alternatives.

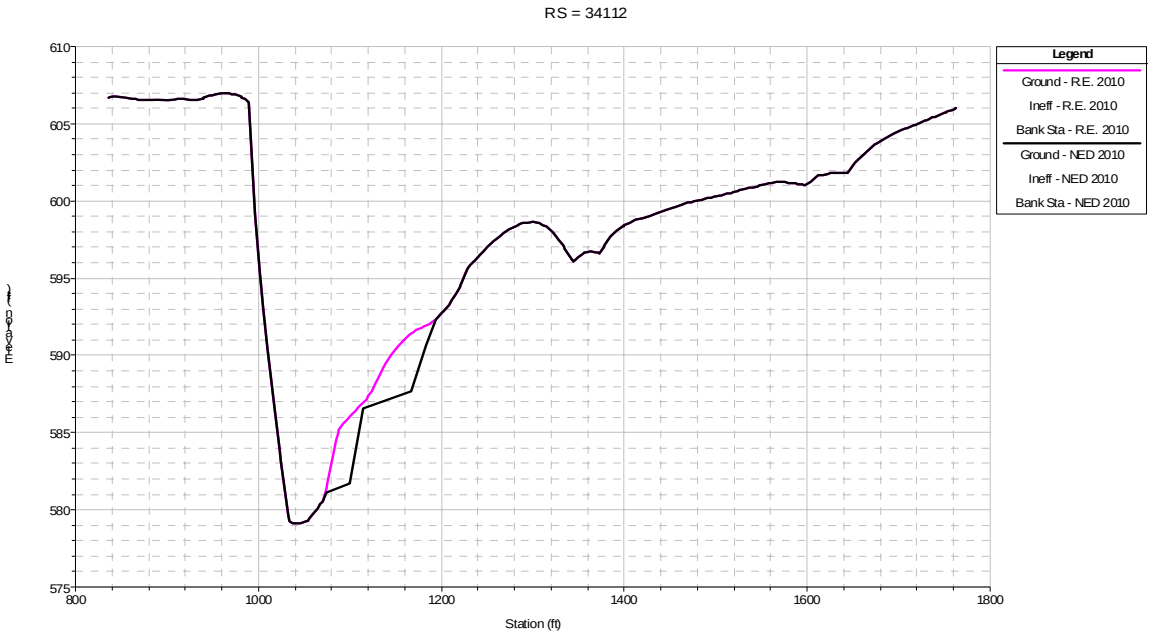
Table A-12

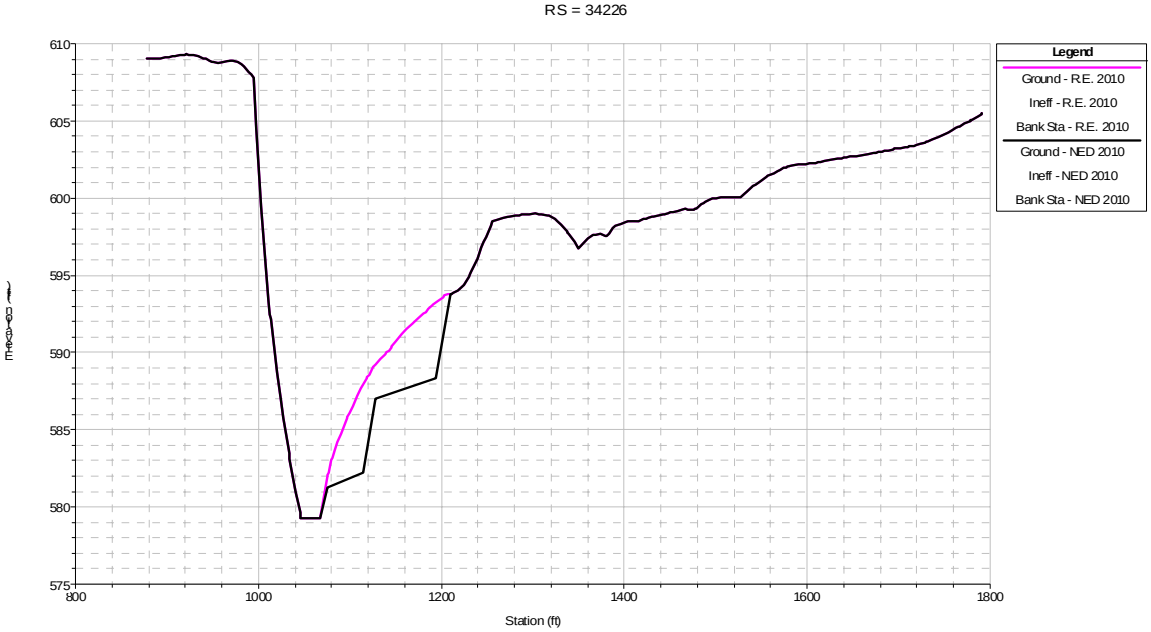
REACH	10-YR	25-YR	100-YR
Heartwood	no modification	34112 – 34794	33530 - 35600
Radam	41950 – 42710	41950 – 42710	41950 – 42710* new Emerald Forest bridge
Broken Bow	47800 – 49550	47800 – 49550	46900 - 49550
Bayton Loop	51380 – 53810	51050 – 53810* new West Gate bridge	51050 – 53810* new West Gate bridge

The Recommended Plan consists of a compilation of the reaches identified below. Additional cross-sections were added at the downstream and upstream ends of each reach to develop smoother flow profiles of the modified channel as it transitions to the natural channel.

Heartwood Reach (25-year)

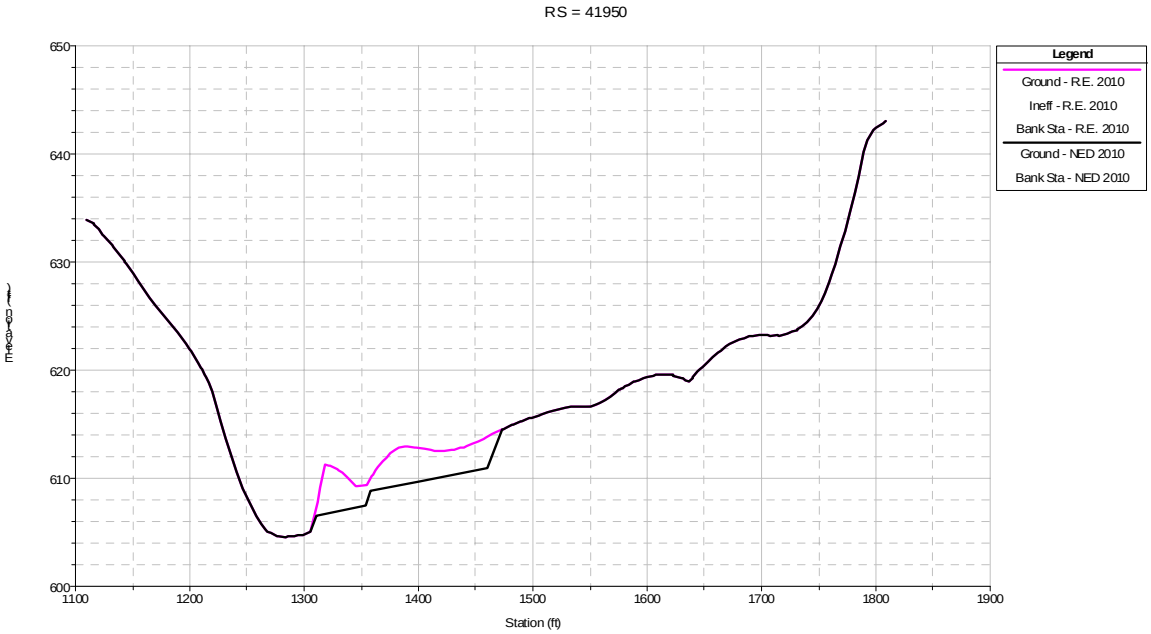
Preserves a 2-ft pilot channel and widens along right bank with a vegetated bench (2% slope, width varies), and a 3:1 slope from edge of bank until daylight to existing. Approximately 1165 feet of channel improvements. Typical cross-section views within the reach, indicating the existing channel and modified geometry, follows.

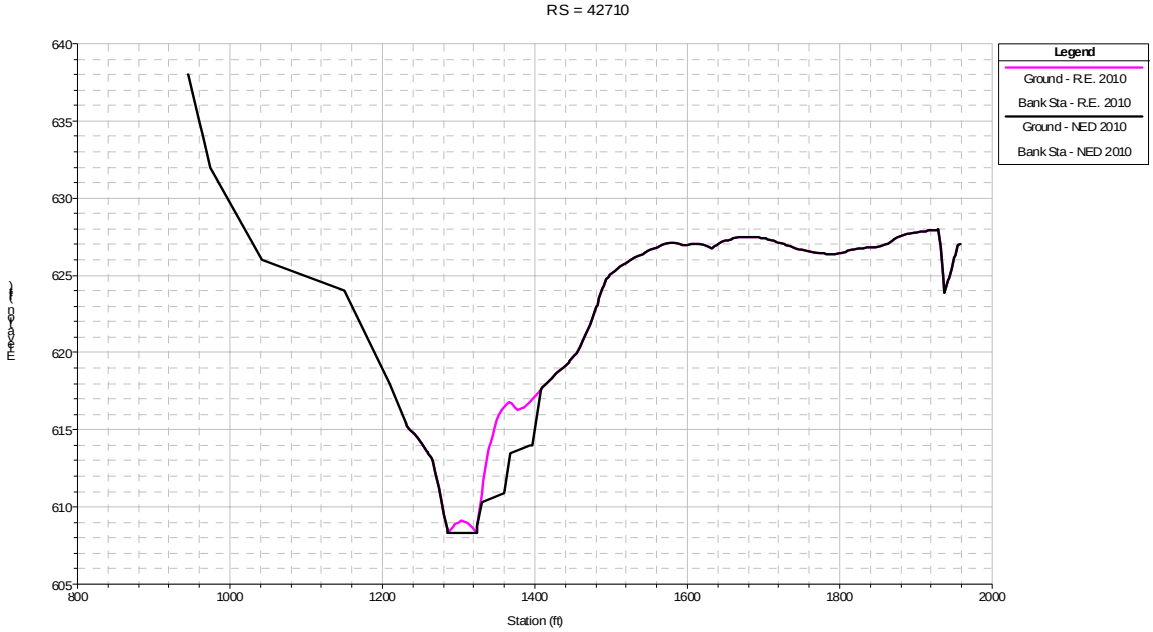




Radam Reach (10-year)

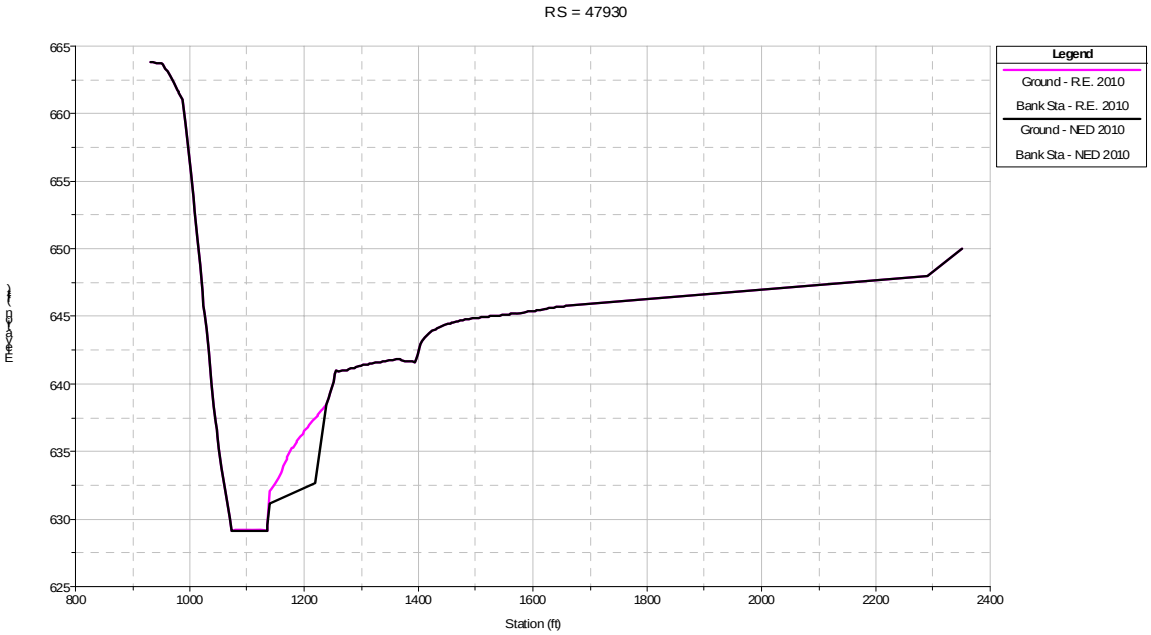
Preserves a 2-ft pilot channel and widens along right bank w/vegetated bench (2% slope, width varies), and a 3:1 slope from edge of bank until daylight to existing. Approximately 1270 feet of channel improvements. Typical cross-section views within the reach, indicating the existing channel and modified geometry, follows.

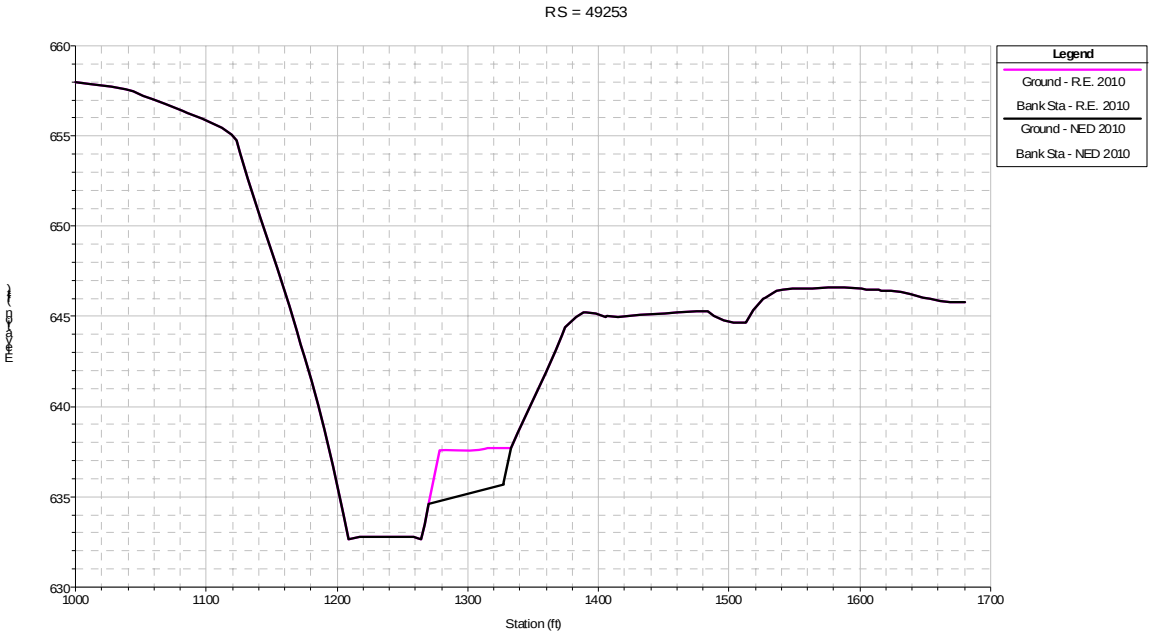


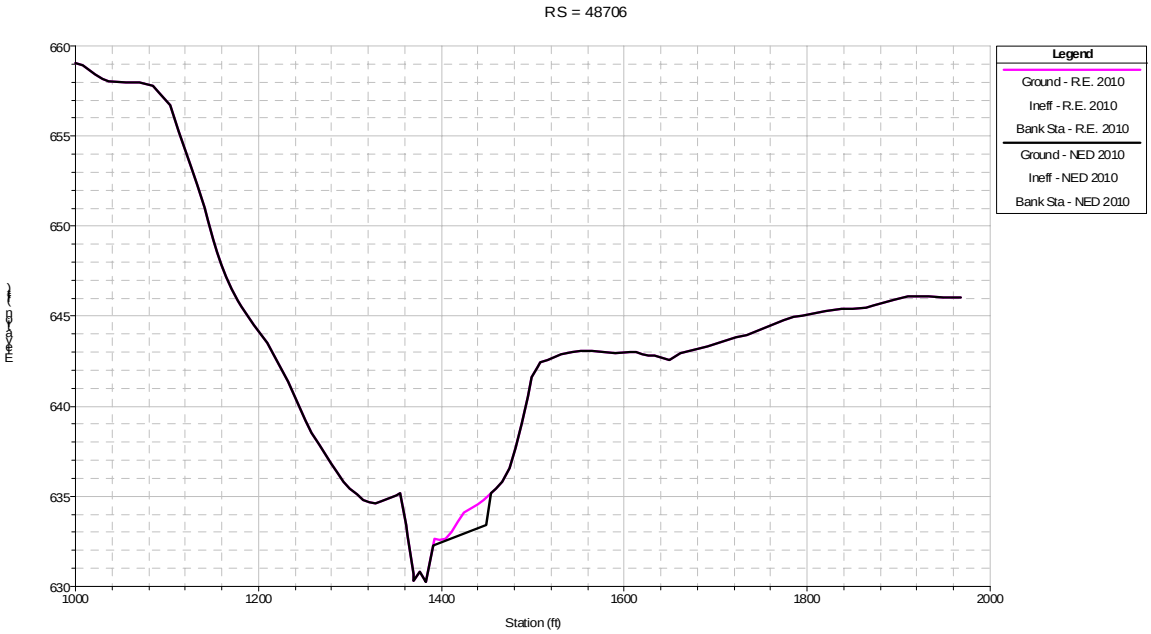


Broken Bow Reach (100-year)

Preserves a 2-ft pilot channel and widens along right bank w/vegetated bench (2% slope, width varies), and a 3:1 slope from edge of bank until daylight to existing. Approximately 2900 feet of channel improvements. Typical cross-section views within the reach, indicating the existing channel and modified geometry, follows.

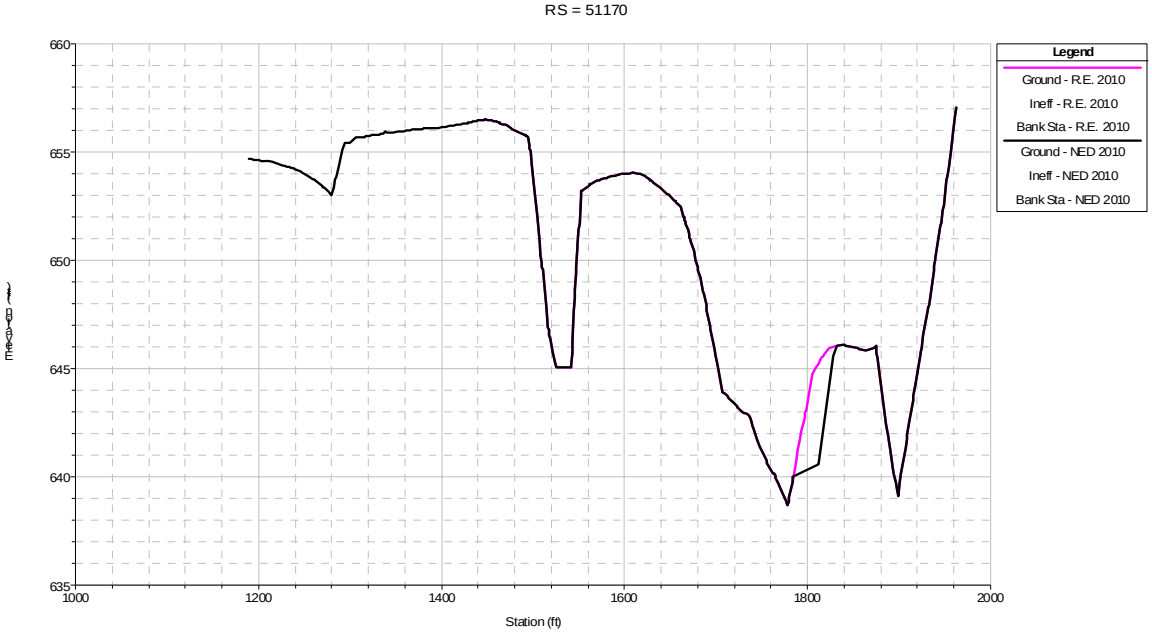


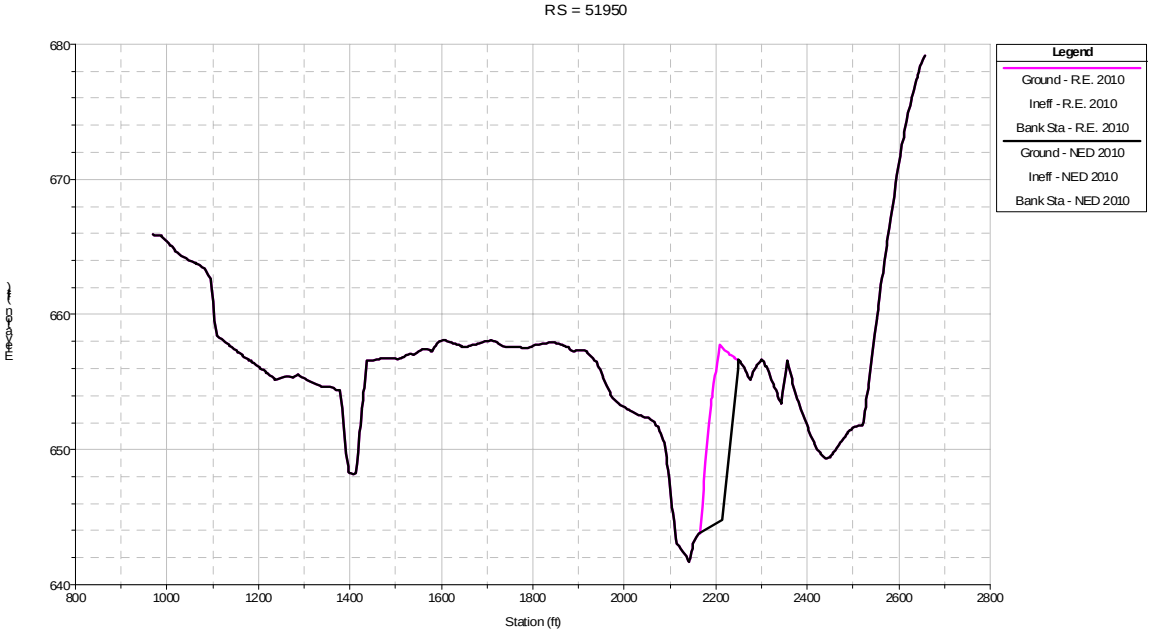


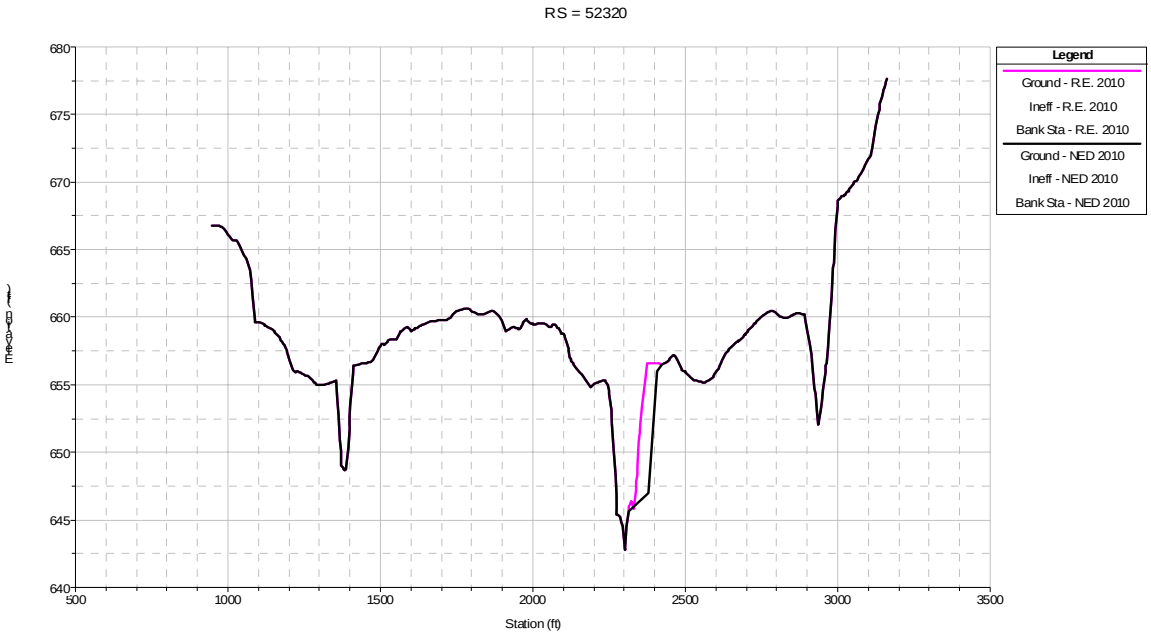


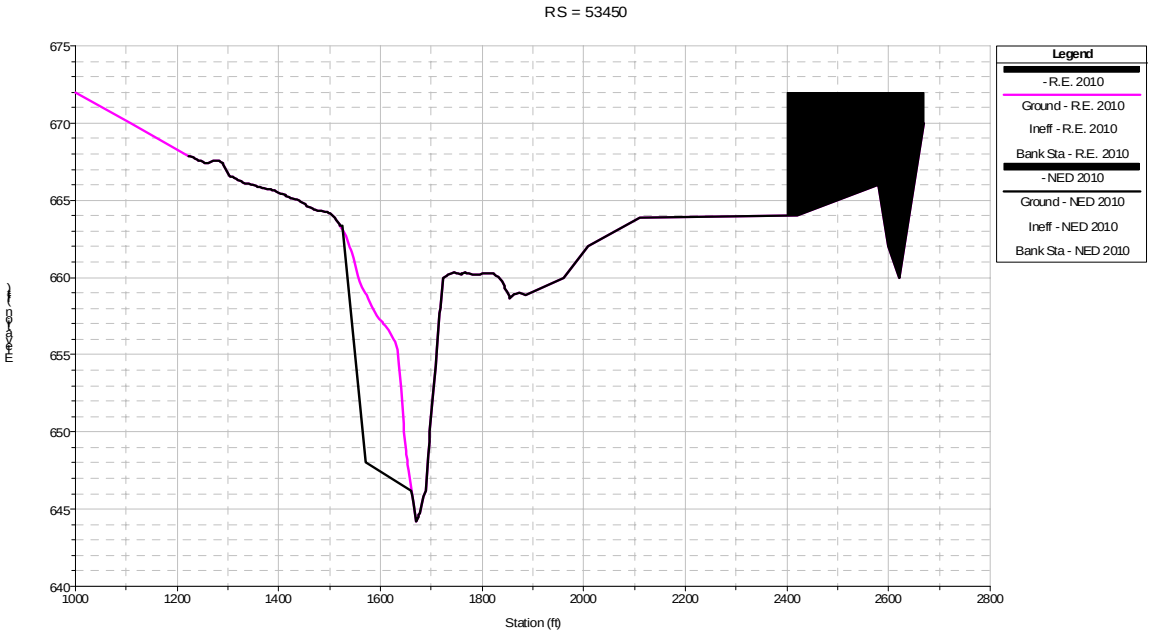
Bayton Loop Reach (10-year)

Preserves a 2-ft pilot channel and widens along left bank upstream of West Gate Boulevard and right bank downstream, and a 3:1 slope from edge of bank until daylight to existing. Approximately 2900 feet of channel improvements. Typical cross-section views within the reach, indicating the existing channel and modified geometry, follows.


RS = 51170
Legend
Ground - R.E. 2010
Ineff - R.E. 2010
Bank Sta - R.E. 2010
Ground - NED 2010
Ineff - NED 2010
Bank Sta - NED 2010
660
655
650
645
640
635
1000
1200
1400
1600
1800
2000
Station (ft)


RS = 51950
Legend
Ground - R.E. 2010
Ineff - R.E. 2010
Bank Sta - R.E. 2010
Ground - NED 2010
Ineff - NED 2010
Bank Sta - NED 2010
680
670
660
650
640
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
Station (ft)





Sunset Valley Tributary

No specific channel work is proposed on the Sunset Valley tributary. The proposed improvements on main stem of Williamson Creek reduce backwater and provide some relief to structures on this tributary, but would be limited to areas downstream of Westgate Boulevard.

Channel velocity

The existing conditions channel velocity and the Recommended Plans channel velocities in the damage reaches are shown in Table A-13. In most cases, the channel velocity is reduced by the channel modifications. The instances where the channel velocity is increased is due to more flow within the confines of the enlarged channel. As the channel design is refined in the PED, the velocity profiles within the channel reaches will be evaluated with respect to possible erosion protection measures and minor alteration of the channel geometry.

Table A-13
Williamson Creek Velocity Table

Revised Existing 2010				With-Project 2010			
River Sta	Profile	Q Total (cfs)	Vel Chnl (ft/s)	River Sta	Profile	Q Total (cfs)	Vel Chnl (ft/s)
Downstream end of Heartwood Reach							
				33845	10yr	11390	8.71
				33845	25yr	16210	8.67
				33845	50yr	19890	8.61
				33845	100yr	24120	8.40
34112	10yr	11050	12.19	34112	10yr	11390	7.54
34112	25yr	15710	13.78	34112	25yr	16210	8.77
34112	50yr	19810	14.65	34112	50yr	19890	9.55
34112	100yr	23630	15.27	34112	100yr	24120	10.19
34226	10yr	11050	10.78	34226	10yr	11390	7.09
34226	25yr	15710	12.04	34226	25yr	16210	8.19
34226	50yr	19810	12.85	34226	50yr	19890	8.87
34226	100yr	23630	13.80	34226	100yr	24120	9.49
34794	10yr	11050	11.62	34794	10yr	11390	9.27
34794	25yr	15710	13.52	34794	25yr	16210	10.81
34794	50yr	19810	14.64	34794	50yr	19890	11.85
34794	100yr	23630	15.01	34794	100yr	24120	12.42
				35010	10yr	11390	9.59
				35010	25yr	16210	10.97
				35010	50yr	19890	11.66
				35010	100yr	24120	12.38
Upstream end of Heartwood Reach							
Downstream end of Radam Reach							
				41650	10yr	11390	7.51
				41650	25yr	16210	8.13
				41650	50yr	19890	8.52
				41650	100yr	24120	8.82

41950	10yr	11050	7.33	41950	10yr	11390	5.30
41950	25yr	15710	7.93	41950	25yr	16210	5.93
41950	50yr	19810	8.10	41950	50yr	19890	6.27
41950	100yr	23630	8.14	41950	100yr	24120	6.39
42220	10yr	11050	8.45	42220	10yr	11390	7.06
42220	25yr	15710	9.00	42220	25yr	16210	7.53
42220	50yr	19810	9.70	42220	50yr	19890	7.92
42220	100yr	23630	9.67	42220	100yr	24120	8.12
42550	10yr	11050	7.09	42550	10yr	11390	8.06
42550	25yr	15710	8.30	42550	25yr	16210	9.15
42550	50yr	19810	9.18	42550	50yr	19890	9.84
42550	100yr	23630	9.70	42550	100yr	24120	10.25
42575		Bridge		42575		Bridge	
42600	10yr	11050	6.70	42600	10yr	11390	7.37
42600	25yr	15710	7.72	42600	25yr	16210	8.37
42600	50yr	19810	7.90	42600	50yr	19890	8.56
42600	100yr	23630	7.25	42600	100yr	24120	7.53
42710	10yr	11050	10.33	42710	10yr	11390	7.29
42710	25yr	15710	11.13	42710	25yr	16210	7.88
42710	50yr	19810	10.93	42710	50yr	19890	7.86
42710	100yr	23630	11.32	42710	100yr	24120	7.16
				42916	10yr	11390	12.00
				42916	25yr	16210	12.82
				42916	50yr	19890	12.52
				42916	100yr	24120	9.93
Upstream end of Radam Reach							
Downstream end of Broken Bow Reach							
				46660	10yr	10880	9.05
				46660	25yr	15600	9.56
				46660	50yr	19300	10.15
				46660	100yr	23320	10.69
46900	10yr	10660	5.93	46900	10yr	10880	5.32
46900	25yr	15250	6.12	46900	25yr	15600	5.69
46900	50yr	19260	6.27	46900	50yr	19300	5.93
46900	100yr	23320	6.33	46900	100yr	23320	6.06
47050	10yr	10660	5.19	47050	10yr	10880	5.26
47050	25yr	15250	5.67	47050	25yr	15600	5.78
47050	50yr	19260	5.80	47050	50yr	19300	5.90
47050	100yr	23320	5.80	47050	100yr	23320	5.88

47300	10yr	10660	6.18	47300	10yr	10880	5.24
47300	25yr	15250	7.47	47300	25yr	15600	6.25
47300	50yr	19260	7.38	47300	50yr	19300	6.33
47300	100yr	23320	7.69	47300	100yr	23320	6.63
47550	10yr	10660	6.48	47550	10yr	10880	8.37
47550	25yr	15250	7.59	47550	25yr	15600	9.23
47550	50yr	19260	8.19	47550	50yr	19300	9.93
47550	100yr	23320	8.21	47550	100yr	23320	10.44
47800	10yr	10660	9.19	47800	10yr	10880	8.61
47800	25yr	15250	10.40	47800	25yr	15600	9.48
47800	50yr	19260	11.54	47800	50yr	19300	10.04
47800	100yr	23320	11.17	47800	100yr	23320	10.20
47930	10yr	10660	9.74	47930	10yr	10880	9.31
47930	25yr	15250	11.22	47930	25yr	15600	10.55
47930	50yr	19260	11.37	47930	50yr	19300	11.20
47930	100yr	23320	12.59	47930	100yr	23320	11.55
48330	10yr	10660	10.30	48330	10yr	10880	11.12
48330	25yr	15250	10.33	48330	25yr	15600	12.55
48330	50yr	19260	11.17	48330	50yr	19300	13.15
48330	100yr	23320	10.68	48330	100yr	23320	13.35
48505	10yr	10660	6.68	48505	10yr	10880	8.12
48505	25yr	15250	6.99	48505	25yr	15600	9.25
48505	50yr	19260	7.05	48505	50yr	19300	9.63
48505	100yr	23320	7.07	48505	100yr	23320	9.84
48706	10yr	10660	7.41	48706	10yr	10880	10.73
48706	25yr	15250	7.75	48706	25yr	15600	11.55
48706	50yr	19260	7.55	48706	50yr	19300	11.80
48706	100yr	23320	7.53	48706	100yr	23320	11.58
48915	10yr	10660	7.75	48915	10yr	10880	10.43
48915	25yr	15250	7.98	48915	25yr	15600	11.05
48915	50yr	19260	8.01	48915	50yr	19300	11.43
48915	100yr	23320	8.15	48915	100yr	23320	11.38
49100	10yr	10660	8.64	49100	10yr	10880	9.91
49100	25yr	15250	9.72	49100	25yr	15600	11.39
49100	50yr	19260	10.83	49100	50yr	19300	12.11
49100	100yr	23320	9.71	49100	100yr	23320	12.76
49253	10yr	10660	7.98	49253	10yr	10880	8.94
49253	25yr	15250	8.74	49253	25yr	15600	10.49
49253	50yr	19260	8.90	49253	50yr	19300	11.42

49253	100yr	23320	9.69	49253	100yr	23320	11.85
49430	10yr	10660	8.83	49430	10yr	10880	9.63
49430	25yr	15250	9.95	49430	25yr	15600	11.33
49430	50yr	19260	10.24	49430	50yr	19300	12.23
49430	100yr	23320	10.56	49430	100yr	23320	12.90
49550	10yr	10510	8.18	49550	10yr	10680	9.62
49550	25yr	15050	9.56	49550	25yr	15340	11.01
49550	50yr	18970	9.40	49550	50yr	19030	12.20
49550	100yr	22950	9.83	49550	100yr	22940	12.93
Upstream end of Broken Bow Reach							
Downstream end of Bayton Loop Reach							
51170	10yr	9710	5.18	51170	10yr	9760	4.98
51170	25yr	14230	6.11	51170	25yr	14230	5.66
51170	50yr	17700	7.00	51170	50yr	17700	6.51
51170	100yr	21060	8.10	51170	100yr	21060	7.55
51380	10yr	9710	5.74	51380	10yr	9760	5.47
51380	25yr	14230	6.77	51380	25yr	14230	6.42
51380	50yr	17700	7.73	51380	50yr	17700	7.44
51380	100yr	21060	8.84	51380	100yr	21060	8.60
51580	10yr	9710	7.13	51580	10yr	9760	4.27
51580	25yr	14230	7.72	51580	25yr	14230	4.80
51580	50yr	17700	8.55	51580	50yr	17700	5.45
51580	100yr	21060	9.52	51580	100yr	21060	6.21
51950	10yr	9710	9.80	51950	10yr	9760	8.43
51950	25yr	14230	10.91	51950	25yr	14230	9.23
51950	50yr	17700	11.80	51950	50yr	17700	10.31
51950	100yr	21060	12.95	51950	100yr	21060	11.66
52150	10yr	9710	9.72	52150	10yr	9760	11.33
52150	25yr	14230	9.99	52150	25yr	14230	12.79
52150	50yr	17700	10.77	52150	50yr	17700	14.09
52150	100yr	21060	6.60	52150	100yr	21060	15.04
52320	10yr	9710	8.20	52320	10yr	9760	8.74
52320	25yr	14230	8.31	52320	25yr	14230	9.74
52320	50yr	17700	8.20	52320	50yr	17700	9.82
52320	100yr	21060	9.32	52320	100yr	21060	10.08
52490	10yr	9710	7.74	52490	10yr	9760	7.35
52490	25yr	14230	8.67	52490	25yr	14230	8.38
52490	50yr	17700	8.96	52490	50yr	17700	9.12
52490	100yr	21060	10.10	52490	100yr	21060	9.75

52600	10yr	9710	8.06	52600	10yr	9760	9.29
52600	25yr	14230	9.42	52600	25yr	14230	10.41
52600	50yr	17700	9.60	52600	50yr	17700	11.06
52600	100yr	21060	10.60	52600	100yr	21060	11.62
52740	10yr	9710	7.07	52740	10yr	9760	10.29
52740	25yr	14230	9.05	52740	25yr	14230	11.73
52740	50yr	17700	9.97	52740	50yr	17700	13.29
52740	100yr	21060	10.76	52740	100yr	21060	14.76
52775		Bridge		52775		Bridge	
52810	10yr	9710	6.39	52810	10yr	9760	8.76
52810	25yr	14230	8.44	52810	25yr	14230	8.87
52810	50yr	17700	9.79	52810	50yr	17700	11.04
52810	100yr	21060	10.32	52810	100yr	21060	14.35
52860	10yr	9710	5.68	52860	10yr	9760	5.28
52860	25yr	14230	6.71	52860	25yr	14230	5.21
52860	50yr	17700	7.82	52860	50yr	17700	6.11
52860	100yr	21060	8.84	52860	100yr	21060	6.94
53160	10yr	9710	6.85	53160	10yr	9760	8.62
53160	25yr	14230	8.16	53160	25yr	14230	8.45
53160	50yr	17700	9.18	53160	50yr	17700	9.90
53160	100yr	21060	10.16	53160	100yr	21060	11.38
53450	10yr	9710	6.84	53450	10yr	9760	4.98
53450	25yr	14230	7.65	53450	25yr	14230	5.07
53450	50yr	17700	7.54	53450	50yr	17700	5.81
53450	100yr	21060	7.44	53450	100yr	21060	6.28
53810	10yr	9710	5.70	53810	10yr	9760	7.41
53810	25yr	14230	6.79	53810	25yr	14230	7.38
53810	50yr	17700	7.31	53810	50yr	17700	8.33
53810	100yr	21060	8.09	53810	100yr	21060	9.23
53930	10yr	9710	5.85	53930	10yr	9760	8.57
53930	25yr	14230	6.53	53930	25yr	14230	6.58
53930	50yr	17700	7.60	53930	50yr	17700	6.99
53930	100yr	21060	8.27	53930	100yr	21060	7.40
Upstream end of Bayton Loop Reach							