

2023 REGIONAL FLOOD PLAN REGION 6 SAN JACINTO

July 2023

PREPARED FOR THE SAN JACINTO
REGIONAL FLOOD PLANNING GROUP

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ATTACHMENT 1

**PROJECT APPLICATION
SUMMARY FORM**

BRAYS BAYOU WATERSHED
MITIGATION PROJECT

Standard Form for CDBG-MIT Applications

Harris County Flood Control District

General Information

CDBG-MIT Program: Hurricane Harvey Hurricane Harvey State Mitigation Competition --- HUD MID

Individual or Shared (Harvey Only): Shared

Applicant (Primary): Harris County Flood Control District

SubApplicant (Secondary): City of Houston

FY End Date: 2/28/2021

Council of Governments: Houston-Galveston Area Council (HGAC)

Contact: Alan Black, P.E. (HCFCD)

Authorized Representative: Paresh Lad (COH)

Grant Administrator: Chris Fenner, P.E. (Stuart Consulting Group)

Project Information

Project Name: Brays Bayou Watershed Mitigation Project

Project Type: Mitigation

Risk Mitigated: Riverine Flooding

Street Address (nearest to project): _____

Street Limits on Street – From Street: D-133 from Beechnut – To Street S. Braeswood Blvd.

Zip Code: 77074

City: Houston

County: Harris

State: TX

Latitude (Decimal Degrees – 5 decimal places): 29.68413

Longitude (Decimal Degrees – 5 decimal places): -95.50739

Project Summary Narrative:

The Brays Bayou Mitigation Project is a joint effort between HCFCD and the City of Houston. The project is composed of various drainage and flood control improvements including improved channel conveyance and stormwater detention basins. Collectively the components of this project are referred to as improvements to Bintliff Ditch (HCFCD Channel D133-00-00) and the

Sharpstown Area. The project is generally located west of IH-610 between Brays Bayou to the South, Harwin to the north, and east of Fondren Road. The area is a mix of single family residential, institutional, commercial and multi-family parcels.

The existing drainage system in the area is primarily curb and gutter with some open ditch streets. Bintliff Ditch drains from north to south and outfall to Brays Bayou. There is significant ponding throughout the study boundary and flood losses closer to Brays Bayou and along Bintliff Ditch. Approximately 65 miles of streets experience ponding greater than 6-inches affecting mobility and 4,100 parcels have greater than 3-inches of water encroaching its lots.

Analysis of the storm drainage shows that it was built in 1955 and does not adequately serve the 2-year and Atlas 14 rainfall events. The effects of Bayou Brays also add to the ponding and structural losses in the drainage areas.

Describe how the risk listed above is currently affecting the project area:

This project area is plagued by drainage challenges. During rain and flood events roads become impassable & homes are flooded.

How will the Project mitigate against the risk listed above?

This project will reduce ponding and thus allow for easier access to the area not only for residences, but also for emergency vehicles. Likewise, the number of structures that have previously flooded will be reduced.

Does the project enhance any other mitigation efforts already underway?

This project will complement the ongoing *Project Brays* with overall Water Surface Elevation reductions along the tributary channel. Project Brays is a joint effort program led by HCFCD and the US Army Corps of Engineers along with several local stakeholders. The program consists of over 75 projects throughout 31 miles of Brays Bayou to reduce flood risk and increase greenspace and amenities for the community. More can be found on this ongoing program at the following website: <https://www.projectbrays.org/>.

Have you procured construction services for the proposed project? No

What is the construction completion method to be used? Competitive Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required? Yes

If yes: Provide the Estimated Number of Parcels: Three (3)

What is the status of the acquisition? Still needed.

Provide a brief narrative describing the acquisition activities required: 466 ac-ft of detention is needed for the Project.

A vacant piece of property in the neighborhood and a general commercial vacant piece of property have already been acquired for the project.

Three (3) additional parcels still need to be acquired.

Congressional Representative District #: 7

State Representative District #: 146

State Senator District #: 13 & 17

Eligibility Check

- Meets HUD’s definition of mitigation activities
 - Long-term Vulnerability Reduction, Community Resilience

Figure 2-14: The Aspects of Mitigation



- Meets GLO Application project definition
 - Reducing risk of natural hazards through infrastructure improvements
- Addresses identified current and future risks; (NOTE: identified risks change per program)
 - This project will reduce the current and future risk of flooding due to heavy rainfall
- Meets the definition of a CDBG-eligible activity under Title I of HCDA or otherwise pursuant to a waiver or alternative requirement
 - Construction of public works
- Meets a CDBG National Objective; as amended for MIT funds
 - LMI National Objective
- Includes a plan for the long-term funding and management of the operations and maintenance of the project
 - This project along with all HCFC DDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFC D. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFC D are included in this budget.
- Cost verification controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction
 - All construction contracts will be advertised and bid publicly through Competitive Sealed Bid/Contract, in accordance with Texas State Law and Local laws and policies.

Locally Adopted Plan

Name of Local Adopted Plan: Harris County Flood Control District 2018 Bond Program for Flood Risk Reduction and Resilience: Brays Bayou

Is a copy of the plan attached? Yes
Year plan was adopted: 2018 (Updated May 2020)
project page number in plan: Page 12 of 67 (Bond ID C-13)

Added Resiliency Measures

The proposed drainage improvements will provide the resilience of the Brays Bayou Watershed against the risk of flooding in future storms and tropical weather events. By improving conveyance and adding stormwater detention, ponding will be significantly reduced, protecting homes, businesses and vital transportation thoroughfares. Additionally, the use of stormwater detention basins with vegetated side slopes and bottoms provides for increased infiltration of stormwater as the basins slowly empty.

Covered Projects (Harvey Only)

Is this a Covered Project? Yes

Brief Project Description:

The proposed project includes various drainage improvements in the Brays Bayou Watershed to reduce flood risks and provide resilience for this flood-prone community against future storms. The project includes various storm sewer upgrades to provide additional conveyance for stormwater and multiple detention basins to mitigate the additional conveyance flow and provide temporary storage for peak runoff. With the improved drainage system, the WSE is reduced throughout the drainage area, thus reducing ponding on 10 miles of streets and removing many structures from potential flood damage. Reduction in right-of-way ponding also provides benefit to Sewer Lift Station #31 along Bintliff Ditch. This lift station sustained flood damage during Hurricane Harvey. This is a joint project between the Harris County Flood Control District and the City of Houston.

See "Eligibility Check" section for justification for amendment to State Action Plan.

Benefit Cost Analysis (Harvey Only)

Project Benefits: \$13,569,459.00

Project Cost: \$107,060,788.62

Calculated BCR: 0.13

Description of benefit cost analysis methodology: A modified version of the FEMA Tool Kit --- See attached BCA Calculations & Description.

Citizen Participation Plan

Date Project was first posted for public comment? October 3, 2020

Date Project was last posted for public comment? TBD

Were any comments received from the public? TBD

Were responses provided to all public comments within 15 days of receipt? Yes

Citizen Participation Plan will be included with the application once the public comment period is complete.

Grant Management Plan

Is a Grant Management Plan attached? This document is being finalized and will be included with the final grant submission.

Beneficiary Data

Total number of project beneficiaries: 774,180

Cost per beneficiary: (\$107,060,788.62) / (774,180) = \$138.29

Total Population: 4,602,523

% Beneficiaries per Population: 16.82%

Does the Project benefit >51% LMI population? Yes (57.5%)

Environmental Clearance

Is this an Aggregate Project (multiple activities)? YES

Type of Aggregation (if applicable): Geographic Aggregation

What is the current status of the project? Not Yet Begun

Brief Project Narrative:

This project will improve the D-133 Bintliff Channel with a triple box system from Beechnut to Brays Bayou along with additional drainage system under Fondren Rd from Tanager Street to Brays Bayou outfall. Later improvements will also be done on Tanager Street and Sandpiper.

Along D-133 channel there will be 13,947 linear feet of 3-10'x12' RCB (reinforced concrete box) between Beechnut and Brays Bayou outfall.

Along Fondren Rd, there will be 13,888 linear feet of 3-10'x12' RCB between D-133 and Brays Bayou.

At various locations, there will be place over 3,171 linear feet of lateral RCP (reinforced concrete pipe) lines.

Four (4) new detention basins will be constructed.

The benefits resulting from this project include reduction in ponding depth and duration: reduction in structural flooding --- 169 structures will be removed from the floodplain and 10 miles of surface streets will have improved access & mobility as a result ponding reduction.

These improvements will also benefit Lift Station #31 located on Carvel Lane which was flooded and damaged during Hurricane Harvey.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No

If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A

Is the proposed project site likely to require a historical resources/archaeological assessment? No

If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A

Is the proposed project site listed on the National Register of Historic Places? No

If yes, provide a brief narrative explaining how the historic site will be impacted: N/A

Is the proposed project site in a designated flood hazard area or a designated wetland? YES

Is the applicant participating in the National Flood Insurance Program? Yes

Is the project in a designated Regulatory Floodway? No

Is the proposed project site located in a known critical habitat for endangered species? No

Is the proposed project site a known hazardous site? No

Is the proposed project site located on federal lands or at a federal installation? No

If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

What level of environmental review is likely needed for the proposed project site? Categorical Exclusion

Provide a brief narrative to include any additional detail or information relevant to Environmental Review: Areas that will be disturbed by this project have previously been disturbed by earlier activities.

Affirmatively Furthering Fair Housing

Harris County and Harris County Flood Control District comply with CDBG and GLO regulations for affirmatively furthering fair housing. See attached documentation for more information

Scoring Criteria

Anticipated Score

Composite Disaster Index: 5 (Top 10%) 10 points

Social Vulnerability Index: 3 - Medium 5 points

Per Capita Market Value: $\$529,092,108,213/4,602,523=\$114,957$ 2 points

LMI National Objective: Yes 20 points

In a Local Adopted Plan? Yes 5 points

Applicant Management Capacity: Proc policy, single audit, recent grants 15 points

Amount per Beneficiary: \$138.29 12 points

% of Beneficiaries per Population: 0.168 1.68 points

% Non-CDBG Funds	<u>6.6% Local</u>	<u>5 points</u>
Resiliency Measures:	<u>Yes</u>	<u>5 points</u>
TOTAL		<u>80.68 points</u>
Poverty Rate:	<u>16.2%</u>	

List of Attachments

1. Application Summary
2. Project Area Map
3. Project Beneficiary Map
4. Beneficiary Data and Demographics
5. Site Photos
6. Local Adopted Plan (with Commissioners Court Adoption)
7. Project Cost Estimate
8. Project Schedule
9. Citizen Participation Plan Documents **Final will be provided with final application after public comment period is complete**
10. Grant Management Plan **This document will be finalized and included with the grant application**
11. Memorandum of Understanding (MOU) between HCFCD and City of Houston
12. Harris County Procurement Policy
13. Fair Housing Activity Information
14. Harris County Comprehensive Annual Financial Report for FY Ending 2/29/20 (To meet the *Local Financial Management Policies and Procedures* and the *Single Audit or Annual Financial Statement* requirements)
15. Social Vulnerability Index Data
16. Per Capita Market Value Data
17. Composite Disaster Index Data
18. GLO Local Certifications Form **To be signed by Judge Hidalgo**
19. SF 424 Form **To be signed by Judge Hidalgo**
20. Benefit Cost Analysis

ATTACHMENT 20

BENEFIT COST ANALYSIS

BENEFIT-COST ANALYSIS

BRAYS BAYOU WATERSHED MITIGATION PROJECT

Prepared for:

Harris County Flood Control District

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
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APPENDICES

Appendix A: Building Replacement Values

EXECUTIVE SUMMARY

The benefit-cost analysis performed for Brays Bayou Watershed Mitigation Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	\$ 9,112	\$ 125,748
Displacement, Residential	\$ 74	\$ 1,028
Displacement, Non-residential	\$ -	\$ -
Social (Mental Health & Productivity)	\$ 100,792	\$ 1,391,005
Environmental (Ecosystem services of converted land)	\$ 873,171	\$ 12,050,409
Total Expected Benefits (all categories)	\$ 983,149	\$ 13,568,190

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the Brays Bayou Watershed Mitigation Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	151	\$ 2,443	\$ 368,893
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	117	\$ 8,736	\$ 1,022,112
Total Social Benefit			\$ 1,391,005

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The Brays Bayou Watershed Mitigation Project requires some acquisition and conversion of developed land to undeveloped floodplain or detention space. The benefit value for Green Open Space has been applied to these areas. Environmental benefits of the Brays Bayou Watershed Mitigation Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	105.1	\$ 8,308	\$ 873,171	\$ 12,050,409
Riparian	0	\$ 39,545	\$-	\$-
Wetlands	0	\$ 6,010	\$-	\$-
Forests	0	\$ 554	\$-	\$-
Marine / Estuary	0	\$ 1,799	\$-	\$-
Total Environmental Benefit			\$ 873,171	\$ 12,050,409

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the Brays Bayou Watershed Mitigation Project represents a holistic benefit to its service area, the Brays Bayou Watershed, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event (estimated losses to structural damage are reduced)	47
Number of structures removed from 10% AEP (10-year) floodplain	1
Number of structures removed from 1% AEP (100-year) floodplain	25
Number of acres removed from 10% AEP (10-year) floodplain	0
Number of acres removed from 1% AEP (100-year) floodplain	0
Number of structures removed from risk* in 10% AEP (10-year) event	0
Number of structures removed from risk* in 1% AEP (100-year) event	1

*Structures “at risk” refer to those for which the modeled water surface elevation is at or above finished floor elevation.

The Present Value Benefits, as shown in *Table ES-1* and *Table ES-3*, were developed from Annual Benefits using a 7% discount rate as required by the Office of Management and Budget (OMB) Circular No. A-94¹. (Social benefit unit values are provided as standard Present Value amounts and are discounted using a 7% rate to estimate Annual Benefits.) This discount rate assumes present benefits have much more value than future benefits, which is not necessarily true for flood risk mitigation projects with a 50-year and greater life cycle. A lower discount rate assumes present benefits are only slightly more valuable than future benefits – a more realistic assumption when considering extended life cycle projects that provide the same level of risk reduction from year to year. U.S. Department of Housing and Urban Development (HUD) Notice CPD-16-06, which was created to provide guidance on benefit-cost analyses for Community Development Block Grant Disaster Recovery (CDBG-DR) projects, notes “grantees may additionally calculate benefits and costs using alternate discount rates (no lower than 3%) provided it also includes justification acceptable to HUD based on the nature of the project.” For comparison purposes, Present Value Benefits were also determined using a 3% discount rate.

Project costs as estimated for the Community Development Block Grant Mitigation (CDBG-MIT) grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expected Benefits to Total Project Cost. *Table ES-5* presents the project cost, along with the estimated benefits and benefit-cost ratio resulting from use of both the 7% and 3% discount rates. It is important to note that the Brays Bayou Watershed Mitigation Project will

¹ *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

	7% Discount Rate	3% Discount Rate
Present Value Total Benefits	\$ 13,568,190	\$ 24,093,841
Present Value Total Cost	\$ 107,060,789	\$ 107,060,789
Benefit-Cost Ratio	0.13	0.23

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,² this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
 - a. Calculations should be prepared in accordance with OMB Circular A-94³.
 - b. BCA methodology should follow FEMA standardized methodologies unless
 - 1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
 - 2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
 - 3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
 - a. A BCA is still completed following the methodologies described above.
 - b. The project “serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster.”
 - c. A qualitative description is provided for “benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters.”

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

² Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

³ *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0⁴ (hereafter “FEMA Toolkit”) and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
 - Assess thousands of potentially impacted structures.
 - Utilize spatially variable modeled water surface elevation data.
 - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1*.

⁴ *Benefit Cost Toolkit Version 6.0*. FEMA. October 2019. Available at <https://www.fema.gov/media-library/assets/documents/179903>.

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description
Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	City of Houston	parcels and impacted structures to be bought out as part of project
Capital Costs	City of Houston	project capital costs
Existing and Proposed Water Surface Elevations	City of Houston	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data ⁵	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

The Harris County Flood Control District maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year⁵ data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

⁵ U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services (\$/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values (\$/sq. ft.)	Hazus Technical Manual ⁶
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District ⁷
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District ⁷
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District ⁷

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This

⁶ Hazus-MH MR3 Technical Manual. FEMA.

⁷ *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSV) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study.* U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

method is described in a FEMA guidance document for flood risk assessments⁸. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$\begin{aligned}
 \text{Expected Annual Loss} = & \left(\frac{1}{500} * \text{Loss}_{500\text{yr}} \right) \\
 & + \left(\frac{1}{100} - \frac{1}{500} \right) (\text{Loss}_{100\text{yr}} + \text{Loss}_{500\text{yr}}) \\
 & + \left(\frac{1}{50} - \frac{1}{100} \right) (\text{Loss}_{50\text{yr}} + \text{Loss}_{100\text{yr}}) \\
 & + \left(\frac{1}{25} - \frac{1}{50} \right) (\text{Loss}_{25\text{yr}} + \text{Loss}_{50\text{yr}}) \\
 & + \left(\frac{1}{10} - \frac{1}{25} \right) (\text{Loss}_{10\text{yr}} + \text{Loss}_{25\text{yr}})
 \end{aligned}
 \tag{Equation 1}$$

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions (*Equation 2*).

$$\text{Expected Annual Benefit} = (\text{Expected Annual Loss})_{\text{Existing}} - (\text{Expected Annual Loss})_{\text{Post-mitigation}}
 \tag{Equation 2}$$

1.5 PRESENT VALUE ANALYSIS

Benefits in all categories except Social Benefits were determined on an annualized basis as described in the previous section or using standard annual benefit values. (Social benefit unit values are provided as standard Present Value amounts and are not discounted.) The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Alternate factors were also determined using a lower discount rate of 3%. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$\text{Capital Recovery Factor } \left(\frac{A}{P} \right) = \frac{\text{Annual Value}}{\text{Present Value}} = \frac{i(1+i)^n}{(1+i)^n - 1}
 \tag{Equation 3}$$

$$\text{Uniform Series Present Worth Factor } \left(\frac{P}{A} \right) = \frac{\text{Present Value}}{\text{Annual Value}} = \frac{(1+i)^n - 1}{i(1+i)^n}
 \tag{Equation 4}$$

⁸ "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

$$BCR = \frac{(Expected\ Annual\ Benefits * Uniform\ Series\ Present\ Worth\ Factor) + Present\ Worth\ Social\ Benefits}{Project\ Capital\ Cost} \quad \text{Equation 5}$$

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single equivalence factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory⁹.

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of \$100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual¹⁰. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology¹¹, a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of

⁹ Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.

¹⁰ Hazus-MH MR3 Technical Manual. FEMA.

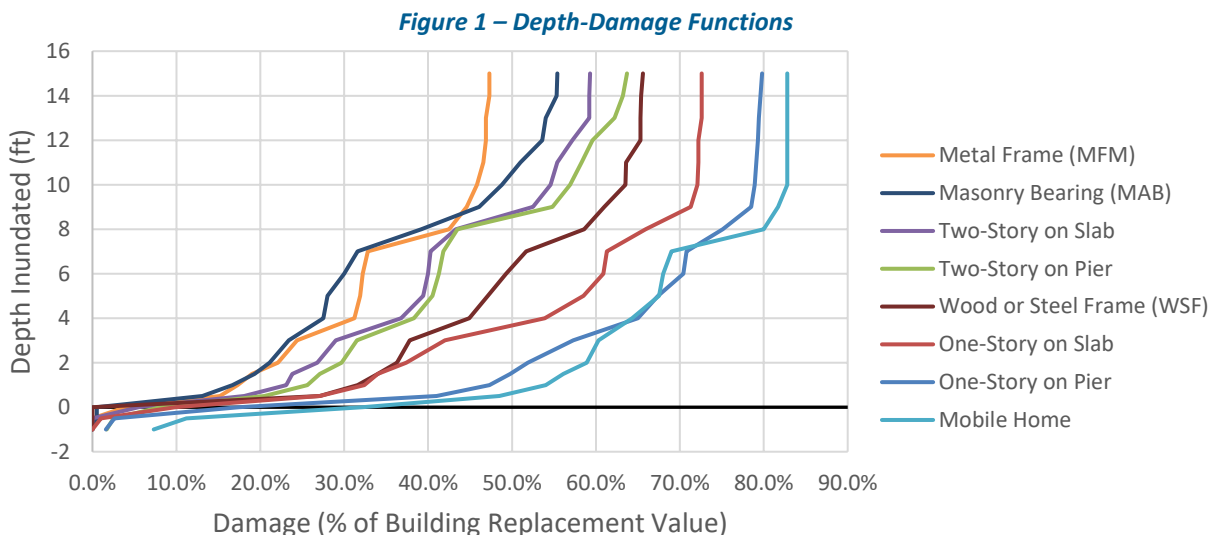
¹¹ Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size (*Equation 6*). This approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf) \tag{Equation\ 6}$$

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*¹² and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District¹³ and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.



¹² R.S. Means, 2005.

¹³ Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios developed by the USACE New Orleans District¹³, which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
\$55	\$7	\$94	\$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment
- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as \$/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (Table 2-2). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor (\$/sf)	Rental Cost Factor (\$/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity (*Table 2-3*). These values are based on studied prevalence, severity, and course of mental effects following a disaster¹⁴. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

¹⁴ *Final Sustainability Benefits Methodology Report*. FEMA. Task order HSFEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	\$2,443	Resident of home benefitted by project
Lost productivity	\$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year ¹⁵				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
\$8,308	\$39,545	\$6,010	\$554	\$1,799

¹⁵ Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,¹⁶ as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to “low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster,” including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 57.5% of the beneficiaries of Brays Bayou Watershed Mitigation Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 38.7% of the households in the project service area are considered to be housing cost-burdened, and 18.8% are severely housing cost-burdened¹⁷. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 24.7% of the households in the project service area have no computer and/or no internet subscription¹⁸. Lack of reliable internet access may reduce residents’ ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values generally slowed from 2014 to 2018 in the Brays Bayou Watershed (*Figure 2*). This trend could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in

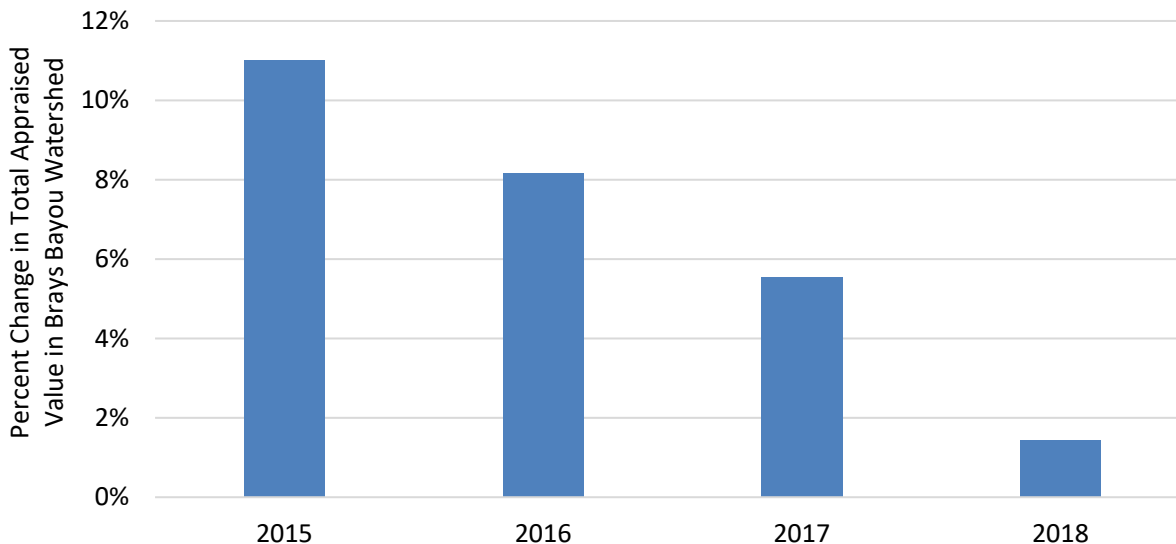
¹⁶ Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

¹⁷ Estimates derived from data in tables B25070 (Gross Rent as a Percentage of Household Income in the Past 12 Months) and B25091 (Mortgage Status by Selected Monthly Owner Costs as a Percentage of Household Income in the Past 12 Months). U.S. Census Bureau. American Community Survey, 2014-2018.

¹⁸ Estimate derived from data in table B28003 (Presence of a Computer and Type of Internet Subscription in Household). U.S. Census Bureau. American Community Survey, 2014-2018.

Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters.

Figure 2 – Year-to-Year Percent Change in Total Appraised Value of Property in Brays Bayou Watershed



4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the Brays Bayou Watershed Covered Project. However, as discussed in **Section 2.1.1**, the use of structural damages in a benefit-cost ratio, while valid, means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1

Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

Income Ratio (r) Number of Stories	$r < 0.5$	$0.5 < r < 0.85$	$0.85 \leq r < 1.25$	$1.25 \leq r < 2.0$	$r > 2.0$
1	\$97.28	\$107.21	\$145.17	\$169.60	\$206.28
2	\$103.51	\$110.89	\$141.45	\$166.65	\$196.43
3	\$103.51	\$112.50	\$147.76	\$172.67	\$202.32
split	\$95.14	\$102.70	\$132.88	\$155.34	\$184.21

Table A-2

Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value (\$/sf)
2	\$117.00
3-4	\$128.00
5-9	\$228.00
10-19	\$203.00
20-49	\$200.00
50+	\$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub Class	Unit Building Replacement Value (\$/sf)
Manufactured Housing	Manufactured Housing	\$52.76
Retail Trade	Dept Store, 1 st	\$121.96
Wholesale Trade	Warehouse, medium	\$112.10
Personal and Repair Services	Garage, Repair	\$151.05
Prof./ Tech./Business Services	Office, medium	\$196.93
Banks	Bank	\$282.68
Hospital	Hospital, medium	\$331.04
Medical Office/Clinic	Med. Office, medium	\$242.32
Entertainment & Recreation	Restaurant	\$251.66
Theaters	Movie Theatre	\$180.14
Parking	Parking garage	\$64.53
Heavy	Factory, small	\$130.29
Light	Warehouse, medium	\$112.10
Food/Drugs/Chemicals	College Laboratory	\$214.11
Metals/Minerals Processing	College Laboratory	\$214.11
High Technology	College Laboratory	\$214.11
Construction	Warehouse, medium	\$112.10
Agriculture	Warehouse, medium	\$112.10
Church	Church	\$204.52
General Services	Town Hall, small	\$158.34
Emergency Response	Police Station	\$245.87
Schools/Libraries	High School	\$170.19
Colleges/Universities	College Classroom	\$213.61

ATTACHMENT 7

PROJECT COST ESTIMATE



CDBG-MIT: Budget Justification of Retail Costs (Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:							Harris County Flood Control District						
Site/Activity Title:							Right-of-Way, Design and Construction of Conveyance Improvements along Blintliff Ditch D133-						
Eligible Activity:							Flood Control and Drainage Improvements						
Materials/Facilities/Services		\$/Unit	Unit	Quantity	Construction	Acquisition	Total						
Paving Items													
Removing Existing Pavement		\$ 9.01	SY	37,547	\$ 338,260.62	\$ -	\$ 338,260.62						
Removing existing driveways		\$ 7.51	SY	2,633	\$ 19,769.75	\$ -	\$ 19,769.75						
10" concrete		\$ 97.60	SY	26747	\$ 2,610,437.03	\$ -	\$ 2,610,437.03						
Lime Stabilized Subgrade, 6" thick		\$ 4.50	SY	37547	\$ 169,130.31	\$ -	\$ 169,130.31						
Lime (6%, 7% by weight)		\$ 240.24	EA	465	\$ 111,626.00	\$ -	\$ 111,626.00						
6" Concrete Curb		\$ 6.01	LF	25717	\$ 154,457.09	\$ -	\$ 154,457.09						
6" concrete for driveways		\$ 12.01	SY	23700	\$ 284,684.40	\$ -	\$ 284,684.40						
4 1/2" concrete for sidewalks		\$ 10.51	SY	82293	\$ 864,940.58	\$ -	\$ 864,940.58						
TRAFFIC SIGNAL/INTERSECTION		\$ 390,000.00	Ea	1	\$ 390,000.00		\$ 390,000.00						
Storm Items													
Remove Storm Sewer		\$ 31.46	LF	3167	\$ 99,629.43	\$ -	\$ 99,629.43						
Remove inlets		\$ 582.01	EA	24	\$ 13,968.24	\$ -	\$ 13,968.24						
Remove Manholes		\$ 613.47	EA	15	\$ 9,202.05	\$ -	\$ 9,202.05						
Cub Inlets		\$ 4,372.94	EA	24	\$ 104,950.56	\$ -	\$ 104,950.56						
MANHOLES (FOR 42" DIA. PIPE OR SMALLER) (ALL TYPES)		\$ 5,458.31	EA	13	\$ 70,958.03	\$ -	\$ 70,958.03						
MANHOLES (FOR 48" TO 72" DIA. PIPE) (ALL TYPES)		\$ 9,438.00	EA	2	\$ 18,876.00	\$ -	\$ 18,876.00						
MANHOLES (FOR 78" DIA. PIPE AND LARGER) (ALL TYPES)		\$ 17,303.00	EA	58	\$ 1,003,574.00	\$ -	\$ 1,003,574.00						
24-INCH RCP		\$ 149.44	LF	800	\$ 119,538.08	\$ -	\$ 119,538.08						
36-INCH RCP		\$ 251.68	LF	699	\$ 175,914.58	\$ -	\$ 175,914.58						
48-INCH RCP		\$ 330.33	LF	149	\$ 49,073.81	\$ -	\$ 49,073.81						
54-INCH RCP		\$ 424.71	LF	683	\$ 290,201.52	\$ -	\$ 290,201.52						
72-INCH RCP		\$ 637.07	LF	50	\$ 31,853.25	\$ -	\$ 31,853.25						
12x10 RCB		\$ 1,735.50	LF	27835	\$ 48,307,642.50	\$ -	\$ 48,307,642.50						
Dry detention pond		\$ 26,000.00	EA	466	\$ 12,116,000.00	\$ -	\$ 12,116,000.00						
DEWATERING (FOR BOX CULVERTS WITH 50 SF OR GREATER)		\$ 39.33	LF	27835	\$ 1,094,611.38	\$ -	\$ 1,094,611.38						
TRENCH SAFETY SYSTEM		\$ 3.15	LF	27835	\$ 87,568.91	\$ -	\$ 87,568.91						
General Items													
Traffic Signals		\$ 250,000.00	EA	1	\$ 250,000.00		\$ 250,000.00						
Traffic Control and regulation		\$300,000.00	EA	1	\$ 300,000.00		\$ 300,000.00						
Flagmen		\$100,000.00	EA	1	\$ 100,000.00		\$ 100,000.00						
Tree Protection		\$600,000.00	EA	1	\$ 600,000.00		\$ 600,000.00						
Mobilization (5%)		\$ 3,489,343.41		1	\$ 3,489,343.41		\$ 3,489,343.41						
							Subtotal		\$ 73,276,211.51				
Engineering Fee (Design, Bidding, Survey, Geotechnical, Construction Phase Services) (15%)			EA				\$ 10,991,431.73						
Environmental Investigation and Permitting (6%)							\$ 4,396,572.69						
Administrative Costs (Delivery) (6%)							\$ 4,396,572.69						
Acquisition (Detention Sites)													
Site #1		\$ 2,000,000.00	EA	1			\$ 2,000,000.00						
Site #2		\$ 5,500,000.00	EA	1			\$ 5,500,000.00						
Site #3		\$ 6,500,000.00	EA	1			\$ 6,500,000.00						
TOTAL							\$ 107,060,788.62						

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFC and City of Houston. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFC and City of Houston are included in this budget

2. Identify and explain any special engineering activities.



Seal

Date:	9/29/2020
Phone Number:	713 462 3242

Signature of Registered Engineer/Architect Responsible
For Budget Justification:

ATTACHMENT 4

PROJECT BENEFICIARY DATA AND DEMOGRAPHICS

TxCDBG RACE AND ETHNICITY / GENDER CALCULATOR

INSTRUCTIONS AND DATA SOURCE

Data Source: Most Recent ACS 5-year Est. - Table DP05

City Applicants: Enter city-wide data as reflected on Table DP05

County Applicants: Enter census tract data as reflected on Table DP05

APPLICANT: Harris County

Sex and Age	ENTER DP05 DATA HERE
--------------------	-----------------------------

Male:	385872
-------	--------

Female:	388308
---------	--------

One Race

White:	381881
--------	--------

Black or African American:	187933
----------------------------	--------

American Indian and Alaska Native:	2246
------------------------------------	------

Asian:	99734
--------	-------

Native Hawaiian and Other Pacific Islander:	416
---	-----

Some Other Race:	87770
------------------	-------

Two or more races:	14200
--------------------	-------

-White and Black or African American:	2605
---------------------------------------	------

-White and American Indian and Alaska Native:	1384
---	------

-White and Asian:	5411
-------------------	------

-Black or African American and American Indian and Alaska Native:	402
---	-----

Hispanic or Latino and Race

Hispanic or Latino (of any race):	312851
-----------------------------------	--------

Not Hispanic or Latino:	461329
-------------------------	--------

-White alone:	164643
---------------	--------

-Black or African American alone:	183425
-----------------------------------	--------

-American Indian and Alaska Native alone:	1087
---	------

-Asian alone:	99158
---------------	-------

-Native Hawaiian and Other Pacific Islander alone:	302
--	-----

-Some other race alone:	2142
-------------------------	------

-Two or more races:	10573
---------------------	-------

Enter Number of Project Beneficiaries:	774180
---	---------------

Gender of Project Beneficiaries

Male	385872
------	--------

Female	388308
--------	--------

Race and Ethnicity of Project Beneficiaries

	Hispanic	Non-Hispanic
--	----------	--------------

White	217238	164643
-------	--------	--------

Black/African American	4508	183425
------------------------	------	--------

American Indian/Alaska Native	1159	1087
-------------------------------	------	------

Asian	576	99158
-------	-----	-------

Native Hawaiian/Other Pacific Islander	114	302
--	-----	-----

Some Other Race	85628	2142
-----------------	-------	------

White and Black/African American	665	1940
----------------------------------	-----	------

White and American Indian/Alaska Native	354	1030
---	-----	------

White and Asian	1382	4029
-----------------	------	------

Black/African American and American Indian/Alaska Native	103	299
--	-----	-----

Other multi racial	1123	3275
--------------------	------	------

Total:	774180	
---------------	---------------	--

Project Information

Project Name	Brays Bayou Watershed Mitigation Project
Project Service Area Description	portion of Brays watershed occurring within Harris County

Beneficiary Data

Beneficiary Population and Project Impact

Total number of project beneficiaries	774,180
Total population within a jurisdiction (Harris County)	4,602,523
Percentage of total project beneficiaries out of the total population within a jurisdiction(s)	16.82%

Total number of project beneficiaries:

Number of residents living in structures located inside the watershed boundary and within Harris County. This is not a sum of block group populations; instead, the number of residents were estimated at the individual structure level.

Total Population Within a Jurisdiction:

Population of Harris County, based on ACS 2014-2018 5-year estimate

Percentage of total project beneficiaries out of the total population within a jurisdiction(s):

Equal to (total number of project beneficiaries) / (total population of Harris County)

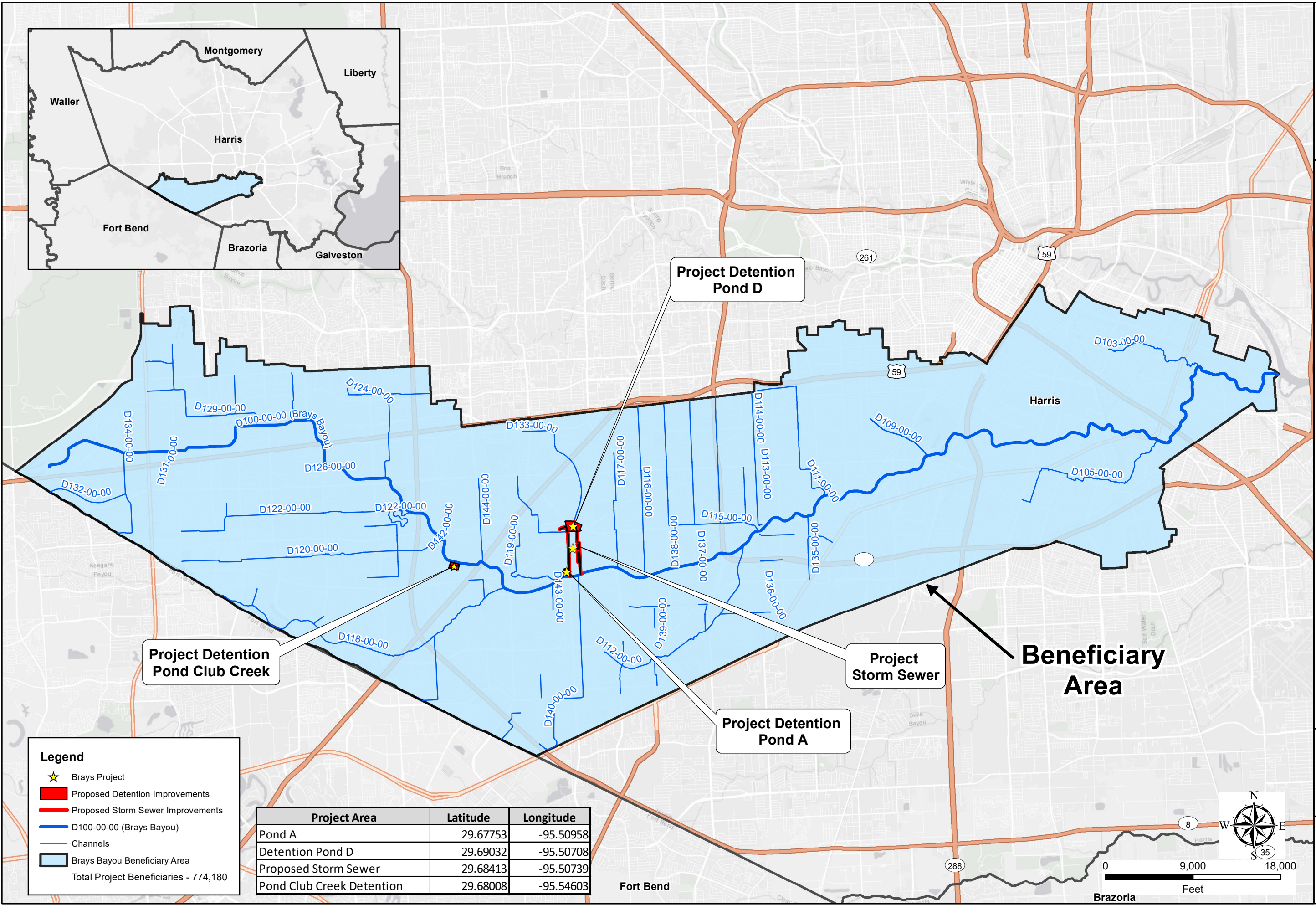
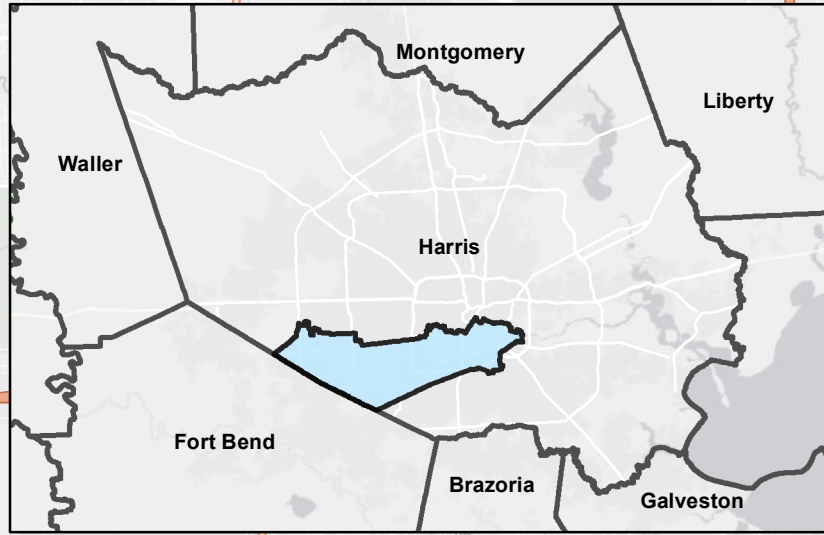
LMI Evaluation

Number of LMI Persons (<i>numerator for LMI %</i>)	413,675
Persons with the potential for being deemed Low-, Moderate- and Middle-income (<i>denominator for LMI %</i>)	719,100
Percent LMI in project beneficiary area	57.5%

HUD guidance indicates that Percent LMI is to be determined with the variable “Persons with the potential for being deemed Low-, Moderate- and Middle-income” as the denominator (**not** total population). Subsequently, this variable was used, rather than the Total Number of Project Beneficiaries, as the denominator in the determination of Percent LMI. Furthermore, all population estimates for this project were estimated from ACS 5-year 2014-2018 data (the most recent ACS data available), but the LMI Spatial Dataset (LMISD) generated by HUD for use in FY 2020 is based on 5-year 2011-2015 ACS data. More information is available at <https://www.hudexchange.info/news/updates-to-low-moderate-income-summary-data-now-available/>. These variables and the process for calculating them is described in further detail in the **LMI Evaluation Attachment**.

ATTACHMENT 2

PROJECT AREA MAP



Project Detention Pond Club Creek

Project Detention Pond D

Project Storm Sewer

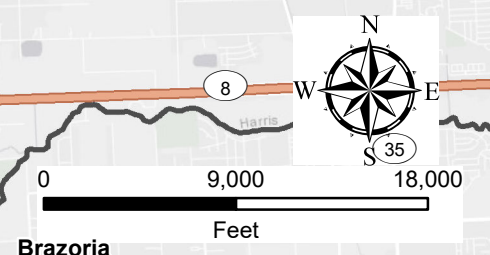
Project Detention Pond A

Beneficiary Area

Legend

- ★ Brays Project
- Proposed Detention Improvements
- Proposed Storm Sewer Improvements
- D100-00-00 (Brays Bayou)
- Channels
- Brays Bayou Beneficiary Area
Total Project Beneficiaries - 774,180

Project Area	Latitude	Longitude
Pond A	29.67753	-95.50958
Detention Pond D	29.69032	-95.50708
Proposed Storm Sewer	29.68413	-95.50739
Pond Club Creek Detention	29.68008	-95.54603



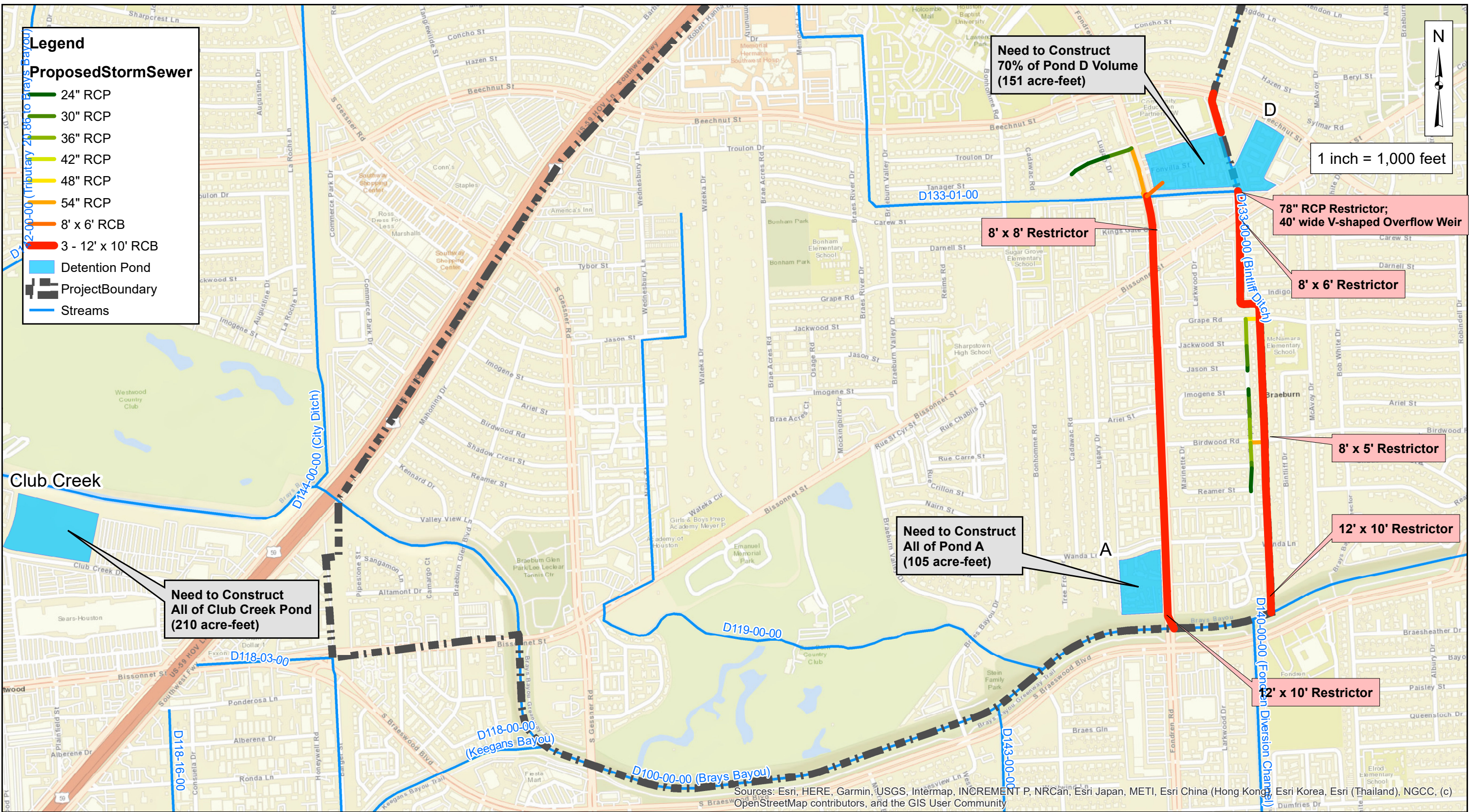
FN PROJECT NO: SCC17257
 DATE CREATED: 9/28/2020
 DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
 FILE NAME: Brays_Project_Area_Map
 PREPARED BY: ANJ

STUART CONSULTING GROUP
 CDBG-MIT

Brays Bayou Watershed - Project Area Map

FRESE NICHOLS
 STUART CONSULTING GROUP

EXHIBIT
 1



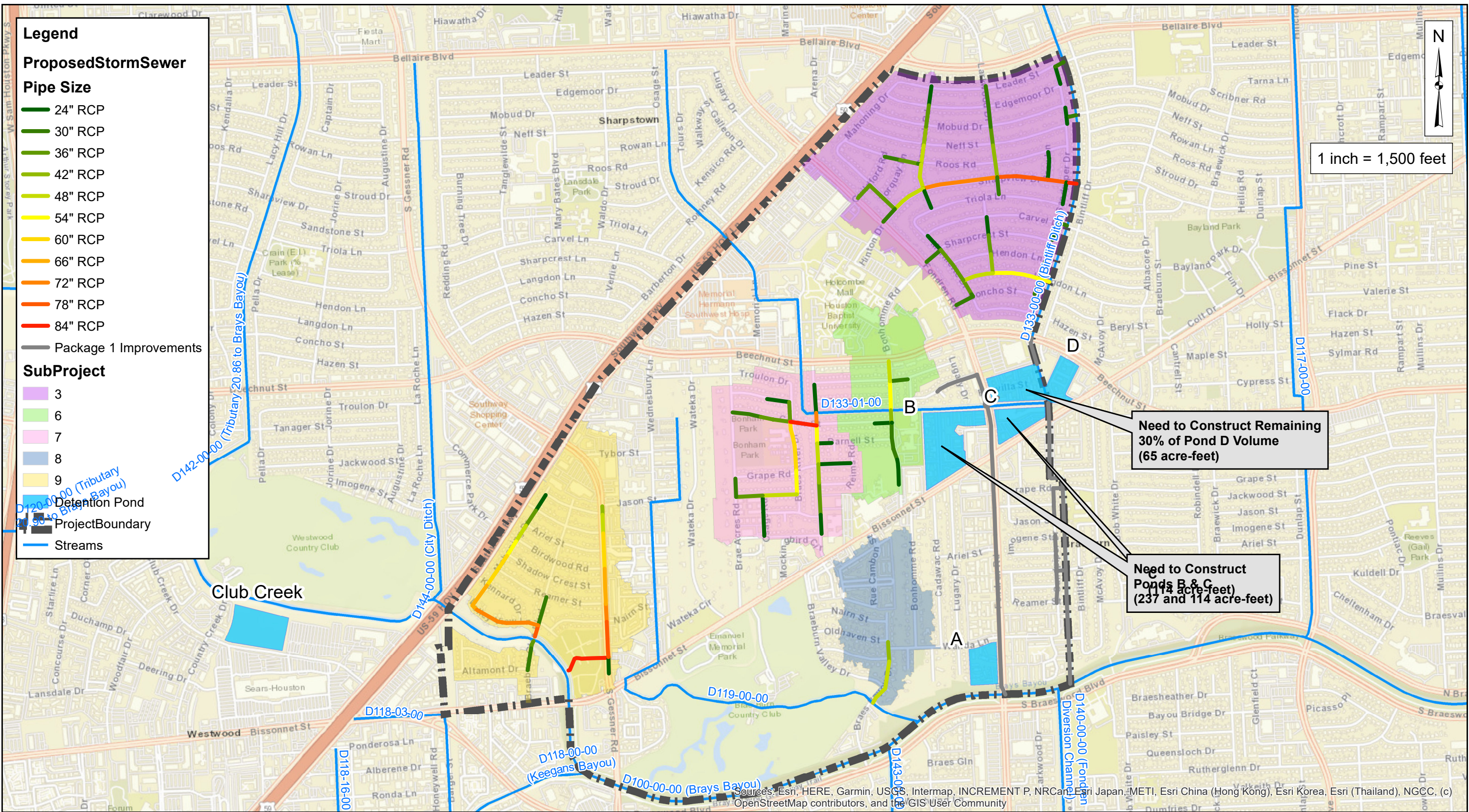
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

CobbFendley
 Texas Registration No. 274
 13430 Northwest Freeway, Suite 1100
 Houston, Texas 77040
 713.462.3242 | fax 713.462.3262
 www.cobbfendley.com

**Sharpstown Drainage Masterplan
 Package 1 Proposed Improvements**

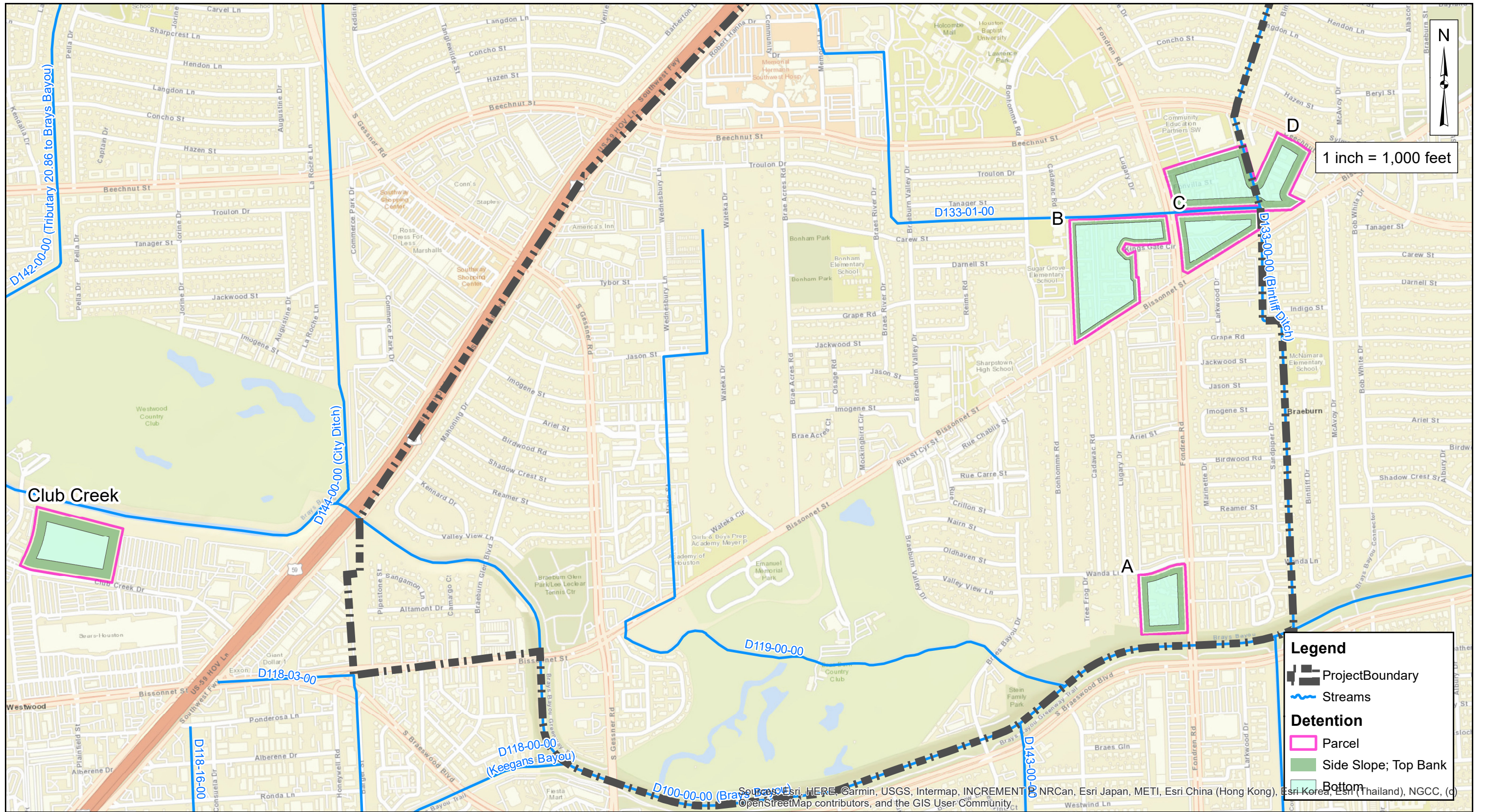
Date: July 2020

EXHIBIT 1



**Sharpstown Drainage Masterplan
 Additional Sub-Project Proposed Improvements**

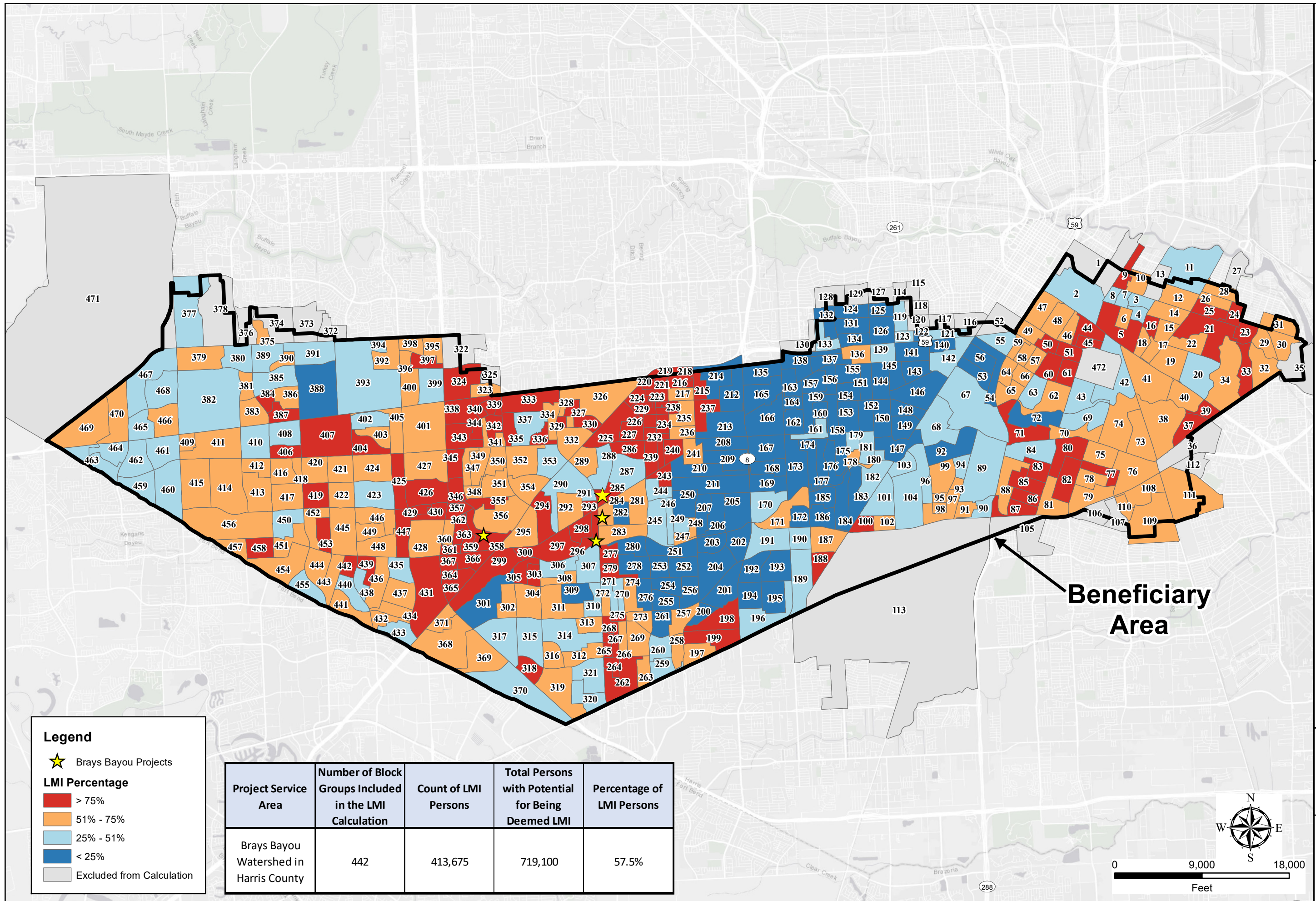
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCA, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Source: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

ATTACHMENT 3

PROJECT BENEFICIARY MAP



Legend

- ★ Brays Bayou Projects

LMI Percentage

- > 75%
- 51% - 75%
- 25% - 51%
- < 25%
- Excluded from Calculation

Project Service Area	Number of Block Groups Included in the LMI Calculation	Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Brays Bayou Watershed in Harris County	442	413,675	719,100	57.5%

STUART CONSULTING GROUP
CDBG-MIT

Brays Bayou Watershed Beneficiary Area Map

PROJECT NO. SCC17257

DATE CREATED 9/28/2020

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILE NAME Brays_Protect_Area_Map_LMI_1

PREPARED BY ANJ

EXHIBIT
2
(1 of 2)

Block Group ID	Block Group	# Residents in Block Group in Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage	Block Group ID	Block Group	# Residents in Block Group in Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage	Block Group ID	Block Group	# Residents in Block Group in Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage	Block Group ID	Block Group	# Residents in Block Group in Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482013101002	937	2,283	41%	No	39.6%	61	482013128002	1,015	1,015	100%	Yes	84.3%	121	482014109001	970	1,171	83%	Yes	47.1%	181	482014132022	3,068	3,068	100%	Yes	33.9%
2	482013102001	1,692	1,830	92%	Yes	28.2%	62	482013129001	2,655	2,655	100%	Yes	66.5%	122	482014109002	1,082	1,082	100%	Yes	16.5%	182	482014133001	1,901	1,901	100%	Yes	35.0%
3	482013103001	671	671	100%	Yes	48.4%	63	482013129002	1,367	1,367	100%	Yes	47.0%	123	482014109003	616	616	100%	Yes	32.6%	183	482014133002	2,835	2,835	100%	Yes	24.3%
4	482013103002	678	678	100%	Yes	41.5%	64	482013130001	801	801	100%	Yes	63.2%	124	482014110001	1,427	1,596	89%	Yes	20.7%	184	482014133003	1,526	1,528	100%	Yes	7.9%
5	482013103003	1,190	1,190	100%	Yes	81.1%	65	482013130002	1,016	1,016	100%	Yes	56.1%	125	482014110002	2,232	2,332	96%	Yes	17.0%	185	482014133004	836	836	100%	Yes	17.5%
6	482013103004	890	890	100%	Yes	56.7%	66	482013130003	786	786	100%	Yes	66.7%	126	482014110003	1,470	1,470	100%	Yes	23.5%	186	482014133005	679	679	100%	Yes	0.0%
7	482013103005	632	632	100%	Yes	30.9%	67	482013131001	2,887	2,887	100%	Yes	28.7%	127	482014110003	718	1,218	59%	No	20.8%	187	482014201001	1,855	1,855	100%	Yes	55.5%
8	482013103006	798	798	100%	Yes	36.1%	68	482013131002	674	674	100%	Yes	35.6%	128	482014110002	197	853	23%	No	0.0%	188	482014201002	1,079	1,079	100%	Yes	81.8%
9	482013104002	547	862	63%	Yes	81.2%	69	482013132001	1,032	1,034	100%	Yes	43.9%	129	482014114003	357	624	57%	No	1.3%	189	482014202001	1,104	1,106	100%	Yes	41.9%
10	482013104003	802	826	97%	Yes	72.0%	70	482013132002	648	648	100%	Yes	60.6%	130	482014115001	725	2,532	29%	No	26.0%	190	482014202002	1,630	1,630	100%	Yes	44.3%
11	482013105001	727	895	82%	Yes	49.4%	71	482013132003	1,641	1,643	100%	Yes	83.9%	131	482014115002	991	991	100%	Yes	7.7%	191	482014203001	1,605	1,605	100%	Yes	35.8%
12	482013105002	1,850	1,850	100%	Yes	74.4%	72	482013132004	677	677	100%	Yes	15.7%	132	482014115002	722	760	95%	Yes	12.3%	192	482014203002	832	832	100%	Yes	9.9%
13	482013105003	479	1,772	27%	No	69.7%	73	482013133001	898	898	100%	Yes	65.1%	133	482014115003	393	621	63%	Yes	36.3%	193	482014203003	1,357	1,357	100%	Yes	9.0%
14	482013106001	1,065	1,068	100%	Yes	56.3%	74	482013133002	1,544	1,546	100%	Yes	54.2%	134	482014115004	1,639	1,639	100%	Yes	17.5%	194	482014204001	1,097	1,097	100%	Yes	22.9%
15	482013106002	2,034	2,037	100%	Yes	65.4%	75	482013134001	875	875	100%	Yes	54.7%	135	482014117002	2,104	2,104	100%	Yes	23.5%	195	482014204002	1,588	1,588	100%	Yes	24.7%
16	482013106003	671	671	100%	Yes	77.4%	76	482013134002	2,277	2,277	100%	Yes	69.4%	136	482014117001	1,078	1,078	100%	Yes	67.7%	196	482014204003	962	962	100%	Yes	42.6%
17	482013106004	595	595	100%	Yes	61.3%	77	482013135001	872	872	100%	Yes	83.3%	137	482014118002	1,499	1,499	100%	Yes	12.4%	197	482014205001	1,183	1,183	100%	Yes	70.9%
18	482013106005	1,503	1,503	100%	Yes	69.4%	78	482013135002	1,021	1,021	100%	Yes	74.9%	138	482014118003	1,556	1,556	100%	Yes	18.6%	198	482014205002	1,114	1,114	100%	Yes	100.0%
19	482013107001	2,050	2,053	100%	Yes	67.8%	79	482013135003	969	969	100%	Yes	73.1%	139	482014118004	956	956	100%	Yes	25.0%	199	482014205003	1,628	1,628	100%	Yes	99.6%
20	482013108002	2,249	2,249	100%	Yes	45.4%	80	482013136001	1,081	1,081	100%	Yes	76.0%	140	482014119001	984	984	100%	Yes	20.9%	200	482014206001	791	791	100%	Yes	23.3%
21	482013108003	1,186	1,186	100%	Yes	87.5%	81	482013136002	1,587	1,587	100%	Yes	64.0%	141	482014119002	967	967	100%	Yes	7.7%	201	482014206002	1,582	1,582	100%	Yes	22.4%
22	482013108002	1,418	1,418	100%	Yes	71.3%	82	482013136003	1,943	1,952	100%	Yes	83.8%	142	482014119003	1,302	1,302	100%	Yes	36.0%	202	482014207001	626	626	100%	Yes	6.9%
23	482013109002	1,139	1,139	100%	Yes	79.8%	83	482013137001	876	876	100%	Yes	80.6%	143	482014120001	1,520	1,520	100%	Yes	22.2%	203	482014207002	481	481	100%	Yes	2.7%
24	482013109003	1,234	1,237	100%	Yes	90.8%	84	482013137002	1,389	1,389	100%	Yes	45.6%	144	482014120002	1,436	1,436	100%	Yes	10.8%	204	482014207003	1,891	1,891	100%	Yes	10.5%
25	482013109004	484	484	100%	Yes	91.2%	85	482013138001	1,040	1,040	100%	Yes	85.5%	145	482014120003	1,102	1,102	100%	Yes	3.7%	205	482014208001	599	599	100%	Yes	12.0%
26	482013109005	1,558	1,558	100%	Yes	68.6%	86	482013138002	725	725	100%	Yes	93.0%	146	482014121001	2,768	2,768	100%	Yes	0.0%	206	482014208002	1,042	1,042	100%	Yes	6.9%
27	482013110002	5	925	1%	No	94.7%	87	482013138003	715	715	100%	Yes	91.2%	147	482014122001	688	688	100%	Yes	15.4%	207	482014208003	707	707	100%	Yes	11.0%
28	482013110005	1,437	1,656	87%	Yes	68.7%	88	482013138004	2,283	2,283	100%	Yes	73.2%	148	482014122002	916	916	100%	Yes	3.5%	208	482014209001	1,071	1,071	100%	Yes	9.4%
29	482013111002	1,179	1,179	100%	Yes	73.2%	89	482013139001	2,617	2,617	100%	Yes	46.1%	149	482014122003	2,016	2,016	100%	Yes	13.3%	209	482014209002	2,046	2,046	100%	Yes	10.0%
30	482013111003	1,620	1,626	100%	Yes	69.9%	90	482013139002	1,136	1,136	100%	Yes	33.8%	150	482014122004	2,294	2,294	100%	Yes	20.2%	210	482014209003	2,098	2,098	100%	Yes	3.0%
31	482013111004	1,250	1,250	100%	Yes	75%	91	482013139003	802	802	100%	Yes	67.8%	151	482014123001	1,453	1,453	100%	Yes	9.1%	211	482014209004	2,626	2,626	100%	Yes	79.1%
32	482013112001	1,790	1,790	100%	Yes	65.1%	92	482013140011	83	83	100%	Yes	0.0%	152	482014123002	1,520	1,520	100%	Yes	5.7%	212	482014210001	1,101	1,101	100%	Yes	9.1%
33	482013112002	1,909	1,909	100%	Yes	81.3%	93	482013140012	614	614	100%	Yes	72.1%	153	482014123003	1,215	1,217	100%	Yes	14.6%	213	482014210002	1,821	1,824	100%	Yes	13.2%
34	482013112003	1,176	1,176	100%	Yes	73.4%	94	482013140013	2,108	2,108	100%	Yes	37.6%	154	482014123004	1,665	1,665	100%	Yes	0.0%	214	482014211011	831	831	100%	Yes	21.8%
35	482013114001	725	1,541	47%	No	55.8%	95	482013140021	1,537	1,537	100%	Yes	72.9%	155	482014123005	1,166	1,166	100%	Yes	4.3%	215	482014211012	2,397	2,397	100%	Yes	80.6%
36	482013117002	0	2,425	0%	No	68.6%	96	482013140022	839	839	100%	Yes	40.7%	156	482014124001	700	700	100%	Yes	6.6%	216	482014211021	3,427	3,427	100%	Yes	88.6%
37	482013118001	1,473	1,473	100%	Yes	77.3%	97	482013140023	1,096	1,096	100%	Yes	51.5%	157	482014124002	1,485	1,485	100%	Yes	1.9%	217	482014211022	1,500	1,500	100%	Yes	70.7%
38	482013118002	1,651	1,651	100%	Yes	57.8%	98	482013140024	981	981	100%	Yes	58.3%	158	482014124003	891	891	100%	Yes	9.8%	218	482014211023	821	821	100%	Yes	90.5%
39	482013118003	1,341	1,341	100%	Yes	93.7%	99	482013140025	2,164	2,164	100%	Yes	50.3%	159	482014124004	1,661	1,661	100%	Yes	3.8%	219	482014212011	2,202	2,202	100%	Yes	76.3%
40	482013119001	1,228	1,228	100%	Yes	72.7%	100	482013143001	769	769	100%	Yes	96.3%	160	482014125001	916	916	100%	Yes	2.2%	220	482014212012	2,542	2,542	100%	Yes	81.4%
41	482013119002	1,372	1,372	100%	Yes	67.8%	101	482013143002	984	984	100%	Yes	47.8%	161	482014125002	680	680	100%	Yes	40.2%	221	482014212013	1,802	1,802	100%	Yes	79.1%
42	482013120001	1,037	1,040	100%	Yes	45.1%	102	482013143003	2,510	2,510	100%	Yes	59.8%	162	482014126001	1,551	1,551	100%	Yes	9.4%	222	482014212021	2,524	2,524	100%	Yes	98.8%
43	482013120002	2,556	2,556	100%	Yes	49.8%	103	482013144001	1,004	1,004	100%	Yes	48.4%	163	482014126002	1,621	1,621	100%	Yes	8.4%	223	482014212022	2,266	2,266	100%	Yes	97.8%
44	482013122001	582	588	99%	Yes	93.3%	104	482013144002	2,258	2,258	100%	Yes	39.2%	164	482014126003	769	769	100%	Yes	10.7%	224	482014212023	221	221	100%	Yes	76.7%
45	482013122002	933	933	100%	Yes	91.5%	105	482013144003	0	1,538	0%	No	75.6%	165	482014127001	1,233	1,233	100%	Yes	18.1%	225	482014213001	2,687	2,687	100%	Yes	63.3%

SHARPSTOWN MASTER DRAINAGE PLAN TECHNICAL MEMORANDUM

CITY OF HOUSTON, TEXAS

WBS No. M-000100-0015-3 Work Order No. 20
CobbFendley Project No. 1311-013-20



August 2020

Submitted By:
 **CobbFendley**
Texas Registration No. 274

Civil Engineering ♦ Construction Management ♦ GIS/CADD ♦ Land Development ♦ Land Surveying
Municipal ♦ Right-of-Way ♦ Site Development ♦ Subsurface Utility Engineering
Hydraulics/Hydrology ♦ Telecommunications ♦ Transportation ♦ Utility Coordination

13430 Northwest Freeway, Suite 1100 | Houston, Texas 77040 | Voice 713.462.3242 | Fax 713.462.3262 | www.cobbfendley.com

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1. Study Area Location and Description

The City of Houston (City) contracted with Cobb Fendley & Associates, Inc (CobbFendley) to develop a Drainage Masterplan for the drainage problems associated with the Sharpstown and Braeburn Super Neighborhoods. The study area is bound by Bellaire Boulevard on the north, Brays Bayou on the south, US-59 on the west, and Bintliff Ditch (HCFCD Unit No. D133-00-00) on the east. The Sharpstown study area is located in the western portion of the City, in City Council District J, and can be found on Key Map grids 530G through 530V. For an overview of the project location, see Exhibit 1 – Project Location Map.

Under the Capital Improvement Projects program, several areas of concern were identified as drainage concerns or as needing street repairs performed. As such, the City determined these were “Need Areas” and assigned individual project numbers to each. Drainage studies were performed for each of these Need Areas (M-2013-016, M-2016-008, and M-2016-J01), but an overall solution was not feasible on an individual project basis. As such, this project combines those areas into what is now referred to as the Sharpstown Drainage Masterplan.

The large study area has diverse land uses including residential neighborhoods, apartment complexes, commercial properties, as well as some industrial areas. The study area encompasses Houston Baptist University, Sharpstown High School, Bonham Elementary School, the PlazAmericas Shopping Centre, and the Brae Burn Country Club. Most of the drainage systems in the study area are comprised of concrete curb and gutter streets with underground storm sewer systems, but there are a few areas with asphalt streets and roadside ditches. Brays Bayou (HCFCD Unit# D100-00-00) serves as the receiving stream with several different outfall locations within the study area. This study area also includes D133-00-00 from US-59 to Brays Bayou, D133-01-00 from Bellaire Blvd to its connection with D133-00-00, and D118-00-00 from Bissonnet St to its connection with Brays Bayou.

A portion of the project area is located within the effective floodplain of Brays Bayou and D133-00-00, see Exhibit 2. The effective floodplain for Brays Bayou does not take in to account the improvements that have been constructed as part of Project Brays. Project Brays has completed numerous projects along Brays Bayou with the intent of lowering the water surface elevations and is scheduled to be complete in 2021, see Exhibit 3.

2. Scope of Work

The purpose of this study is to build upon the previous existing condition analysis in order to review and analyze candidate projects to alleviate flooding within the study area. Specific tasks include:

- Develop selected conceptual alternatives
- Analyze impacts of the proposed improvements
- Determine necessary mitigation to eliminate impacts
- Assess project viability

- Determine whether the project is maintenance/rehabilitation or a capital project

It should be noted that findings within this report are preliminary and were intended to find possible solutions to address the identified deficiencies. Any proposed improvements will be verified through a more detailed proposed condition analysis.

3. Methodology

3.1. Hydrology

The July 2019 City of Houston Infrastructure Design Manual was followed for the hydrologic analysis. The total study area is comprised of approximately 3,645 acres. Newly obtained LiDAR data for this project location was utilized to study the overland terrain allowing for identification of sheetflow patterns in order to determine drainage area boundaries. To perform hydrologic calculations, the rational method was used to calculate peak flow rates for the 2-, and 100-year (Atlas-14) rainfall along with the 500-year (TP-40) rainfall event using City of Houston Time of Concentration calculation. The calculated rational method drainage area peak flows were used to calibrate the flows for each rainfall event which were generated within runoff mode of the XP-SWMM model. The drainage area map is provided in Exhibit 4 and existing condition Hydrologic calculations are provided in Exhibit 5.

3.2. Hydraulics

3.2.1. XP-SWMM

XP-SWMM (v2019) models were created for the 2-, and 100-year (Atlas-14) rainfall events along with the 500-year (TP-40) rainfall event to simulate conveyance through interconnected drainage systems within the Sharpstown area. The XP-SWMM models are comprehensive models which allow interconnection of all drainage systems (roadside ditches, culverts, storm sewer trunks, open channels) with Brays Bayou as the outfall location. The drainage system network was created by utilizing collected survey data, City of Houston GIMS data, and as-built plan sets. The topographic survey was collected through the use of a new LiDAR data set with detailed high definition points to identify overland terrain as well as cross sectional roadside ditch details. Storm sewer manholes were identified from the LiDAR data and top of rim elevations were determined. Storm sewer sizing and flowline elevation were manually obtained via on-site measurements and observations, see Exhibit 6 for an Existing Storm Sewer map.

The outfall boundary condition for the XP-SWMM model utilized rating curves to establish the backwater effect on the drainage system at each outfall location. The rating curves utilize established water surface elevations for the various rainfall events with respect to expected flows for each event. For instance, the 2-year (Atlas-14) rainfall event utilizes a normal depth outfall condition, the 100-year (Atlas-14) and 500-year (TP-40) models utilize the 10-year (TP-40) water surface elevations and flows from the Project Brays HEC-RAS preliminary models, as construction on Project Brays is slated to be completed by 2021, see Exhibits 7, 8 and 9 for 2-year (Atlas-14), 100-year (Atlas-

14) and 500-year (TP-40) ponding maps respectively. The 100-year tailwater was not used to analyze the effects of this project as it inundates a large portion of the study area.

3.2.2. HEC-RAS

In addition to the XP-SWMM Analysis, a hydraulic impact analysis was performed using HEC-RAS (v5.0.7) to ensure that there were no adverse effects to Brays Bayou due to increased flow rates from the project improvements. The Brays Bayou HEC-RAS and HEC-HMS models used as part of this analysis utilize TP-40 rainfall. Due to HCFCD's interim criteria related to the Atlas 14 rainfall update, the 500-year (TP-40) storm event was analyzed instead of the 100-year (TP-40). This section presents the HEC-RAS modeling approach, results and the detention volumes needed to mitigate the flow impacts.

The FEMA effective HEC-RAS model was converted from a steady-flow to an unsteady-flow dynamic model. This allowed for a more detailed analysis to better represent the effects of the project on Brays Bayou throughout the entire storm event, rather than just analyzing the peak flow. The unsteady-flow model also allowed for the modeling of detention along Brays Bayou within the HEC-RAS model.

Since the proposed improvements are isolated to a small portion of Brays Bayou, only a portion of the HEC-RAS model was converted. A downstream limit of Hillcroft St (river station 89871) and an upstream limit of Beltway 8 (river station 116858) were chosen as the limits of the model conversion. This range extends approximately 2 miles upstream of the project and approximately $\frac{3}{4}$ mile downstream of the project.

3.2.2.1. Duplicate Effective Model

For the initial model conversion (duplicate effective model), hydrographs were obtained from the effective HEC-HMS model. Only the 500-year (TP-40) storm was analyzed to determine mitigation needs for the proposed project. Instead of a normal depth tailwater downstream of Hillcroft St, a stage/flow rating curve was utilized to better mimic the effective HEC-RAS model by allowing the FEMA effective analysis downstream to affect the truncated model. The stage/flow rating curve was created using data from the effective model from the same cross section (station 89871) as the truncated model. Stage and flow data from the FEMA effective 10-, 50-, 100-, and 500-year (TP-40) storm events were augmented with additional steady-flow model runs with various flow rates to create a smoother stage-flow curve for the unsteady tailwater condition.

Time steps and baseflows were iterated until a stable unsteady-flow model was created. Baseflows were kept below 5% of the 100-year (TP-40) peak flows, as required by HCFCD. The resulting peak water surface elevations were within +/- 0.46 ft of the FEMA effective model, so the unsteady-flow model was considered to

be an accurate conversion of the steady-flow FEMA effective model, see Exhibit 10 for a comparison of the Effective and Duplicate Effective Profiles.

3.2.2.2. Revised Existing Model

A Revised Existing Condition model was created by replacing the hydrographs obtained from the HEC-HMS model with those generated in the XP-SWMM model. Hydrographs from Brays Bayou Subbasins D100H, D100I and D133A were replaced with hydrographs generated in the XP-SWMM model

Project Brays is scheduled to be completed in 2021 and so should be completed before the construction of this project. Project Brays will primarily improve Brays Bayou downstream of this project but will lower water surface elevations in the project area. Therefore, Project Brays flow/stage data for the 10-, 50, 100- and 500-year (TP-40) events were obtained and incorporated into the tailwater rating curve downstream of Hillcroft St. The replacement of the hydrographs had little effect on the model results, but the lowered Project Brays tailwater did reduce the 500-year (TP-40) water surface elevations by up to 0.52 ft in the project area, see Exhibit 11 for a comparison of Revised Existing and Duplicate Effective Profiles.

4. Alternative Analysis

4.1. Existing Condition Summary

According to the Effective FEMA 100- and 500-year floodplain data (FEMA Floodplain Map Number 48201C0835L Effective 6/18/2007 and 48201C0845M Effective 5/2/2019), much of the project area is located within the 100- and 500-year floodplains associate with Brays Bayou and Bintliff Ditch (D133-00-00) as shown in Exhibit 2 – Effective FEMA Floodplain map. However, HCFCD has a project within the Brays Bayou watershed known as Project Brays. This project is currently being constructed, is slated to be completed in 2021, and will reduce the floodplain of Brays Bayou. While all of the project has not yet been constructed, the resulting floodplain from the plan provided to the City is shown in Exhibit 3 – Proposed Brays Floodplain Map.

Within the study area, the existing storm sewer system ranges in size from 18” reinforced concrete pipes (RCPs) to 10’ x 10’ reinforced concrete boxes (RCBs). There are several open channel sections also located within the project area.

Analysis of the existing storm sewer systems and roadside ditches (where applicable) indicated the majority of the existing drainage infrastructure within the project area is undersized and does not have adequate capacity to convey the 2-year (Atlas-14) rainfall event to the outfall locations, resulting in significant street ponding in areas, see Exhibit 6 – Existing Condition Storm Sewer Layout and Exhibit 7 – Existing Condition 2-year (Atlas-14) Ponding Map. Compounded with the undersized drainage system, overland sheetflow is unable to be conveyed directly to the channel in some locations as well. As shown in Exhibit 8 – Existing Condition 100-year (Atlas-14) Ponding Map and Exhibit 9 – Existing Condition 500-year (TP-40) Ponding Map, there is significant ponding in several locations within the project area. Coincidentally, these ponding areas identified on the overland ponding map coincide with the majority of the repetitive loss claims.

4.2. Proposed System Analysis

In order to measure the effects of the proposed project on Brays Bayou, the outfall hydrographs from the XP-SWMM analysis were input into an unsteady HEC-RAS model. This use of both XP-SWMM for the storm sewer improvements and HEC-RAS for Brays Bayou provided a more comprehensive view of how the storm sewer improvements and Brays Bayou would interact.

4.2.1. XP-SWMM Analysis

The XP-SWMM models previously created to analyze the Existing Condition were copied and modified to use time-stage outfall conditions reflecting the improvements realized as a result of the Project Brays Ultimate Condition. These time-stage relationships were determined by correlating the Effective Brays 10-year hydrographs from HEC-HMS and the proposed 10-year WSEs from the Project Brays Preliminary

HEC-RAS model. The resulting Project Brays Ultimate Condition tailwater peaks at approximately 4' less than the Effective 10-year tailwater.

The proposed storm sewer and channel improvements previously determined in the original pre-engineering studies (M-2013-016, M-2016-008, and M-2016-J01), were then incorporated in the model. The improvements proposed in the original studies used TP-40 rainfall and were analyzed as independent projects without backwater effects; therefore, some pipes sizes were increased from the original proposed sizes in order to achieve 2-year (Atlas-14) capacity in the combined systems model. Proposed pipes sized to convey the 2-year (Atlas-14) event were also incorporated in isolated storm sewer systems outside of the original pre-engineering study need areas where the existing condition analysis revealed inadequacies.

In general, the proposed storm sewers closely reflected those determined in the original pre-engineering studies. The proposed improvements were divided into sub-projects which could be constructed independently, as shown in Exhibit 12 – Proposed Sub-Project Map. It is important to note that Sub-Projects 1 and 2 must be completed before improvements can be made to the storm sewer systems outfalling into the D133-00-00 and D133-01-00 channels. Sub-Projects 8 and 9 are independent of the others; however, these projects rely on detention volume provided as part of the Sub-Project 1 and 2 improvements for mitigation to offset impacts to Brays Bayou. See Exhibits 13, and 14 for the 2-year (Atlas-14), and 100-year (Atlas-14) Ultimate Condition Ponding Maps, respectively.

4.2.1.1. Sub-Project 1

Sub-Project 1 includes disconnecting D133-01-00 from D133-00-00 and re-routing flow down Fondren Road in triple 10' x 12' RCBs. This provides relief to D133-00-00 by reducing flows from Bissonnet Street to the confluence with Brays Bayou. The proposed storm sewer will also collect flows along Fondren Road, replacing the existing parallel storm sewer system.

4.2.1.2. Sub-Project 2

Sub-Project 2 includes converting the existing open-channel portion of D133-00-00 from Bellaire Boulevard to the confluence with Brays Bayou to an enclosed triple 12' x 10' RCB system with a swale on top for local drainage. The existing channel is concrete-lined with a 40-foot top width in a 60-foot Right-of-Way. D133-00-00 is bordered by residential lots on either side of the channel, which will make construction of the RCB system difficult.

4.2.1.3. Sub-Project 3

Sub-Project 3 replaces the existing storm sewer in the residential area West of D133-00-00 between Bellaire Boulevard and Beechnut Street (original need area M-2013-0016). The existing storm sewer within this neighborhood is largely

undersized for the 2-year (Atlas-14) event, resulting in significant street flooding. The area is presently served by 6 separate storm sewer systems which outfall to D133-00-00. In the proposed condition, the northern drainage areas previously contributing to the Bellaire Blvd system are to be re-routed south along Cannock Rd and Larkwood Dr to tie into the Sharpview Dr trunkline. The proposed pipes range in size from 24" to 84" RCP. This provides some relief to the Bellaire Blvd system and limits the proposed improvements to local neighborhood streets, leaving the major collectors undisturbed.

4.2.1.4. Sub-Project 4

Sub-Project 4 replaces the existing storm sewer systems along Sandpiper Dr, which serve the residential neighborhood West of D133-00-00 between Grape St and Reamer St in order to provide 2-year (Atlas-14) capacity. The existing storm sewer is served by two outfalls into D133-00-00. The proposed system maintains the same configuration as existing but increases sizes to range from 24" to 54" RCP.

4.2.1.5. Sub-Project 5

Sub-Project 5 replaces the storm sewer system along Tanager St and Fondren Rd just north of D133-01-00 to provide 2-year (Atlas-14) conveyance capacity. The proposed system ranges in size from 24" to 36" RCP.

4.2.1.6. Sub-Project 6

Sub-Project 6 replaces the storm sewer systems along Bonhomme Rd which outfall to D133-01-00 to provide 2-year (Atlas-14) conveyance capacity. The proposed system ranges in size from 24" to 36" RCP.

4.2.1.7. Sub-Project 7

Sub-Project 7 replaces the storm sewer systems serving the area between Beechnut St and Bissonnet St from Brae Acres Rd to Braeburn Valley Drive. In addition to serving residential homes, this area includes Bonham Elementary School, Bonham Park, Sharpstown High School, and Sugar Grove Academy Middle School. In the existing condition, this area is served by 3 storm sewer systems, two outfalling into D133-01-00 at Braeburn Valley Dr (north and south) and one outfalling between lots near Tanager Street. The proposed improvements include combining the two southern systems into one, eliminating the outfall between lots. Proposed pipes range in size from 24" to 84" RCP and 8' x 6' RCB.

4.2.1.8. Sub-Project 8

Sub-Project 8 involves construction of a new trunkline along Braes Bayou Dr to consolidate the two existing systems serving the residential area. The existing

systems pass between lots and are largely undersized for the 2-year (Atlas-14) event. The proposed system abandons the lines passing through lots, collecting flow along Braes Bayou Dr, outfalling to D119-00-00, and this system ranges in size from 24" to 48" RCP.

4.2.1.9. Sub-Project 9

Sub-Project 9 addresses the Braeburn Glen neighborhood previously studied as Pre-engineering project M-2016-J01, but it also includes improvements to the system serving Gessner Rd which was not included in the original study. The area is bound by US-59 on the West, Gessner Rd on the East, and Altamont Dr on the South. This area has nine outfalls into Brays Bayou between US-59 and Bissonnet St. Many of the existing outfalls run between lots. The proposed improvements consolidate the trunklines along Mahoning Dr, Valley View Ln, and Braeburn Glen Blvd to have a single outfall into Brays Bayou at Braeburn Glen Blvd. The proposed storm sewers range in size from 24" to 84" RCP.

4.2.2. HEC-RAS Hydraulic Impact Analysis

To analyze the effects of the proposed improvements, the revised existing condition model was modified to incorporate the proposed flow hydrographs from the XP-Storm modeling. The increased flow rates from the proposed improvements raised water surface elevations on Brays Bayou by up to 0.23' and increased peak flow downstream of Hillcroft St by 312 cfs (1% increase) for the 500-year (TP-40) storm event, see Exhibit 15.

4.3. Proposed Mitigation

Providing detention along the D133 and Fondren systems results in a delayed peak, which ultimately causes greater impacts to Brays Bayou when considering both the storm sewers and Brays Bayou in a combined manner. Concentrating all the detention in the Fondren area proved to be inefficient at mitigating impacts to Brays Bayou in extreme events; thus, a comprehensive detention plan including a combination of ponds along Brays Bayou and ponds directly connected to the proposed storm sewer was required to provide mitigation for both the local 2-year (Atlas-14) event and for the extreme event.

4.3.1 Local 2-Year Mitigation

Mitigation for the increased flows in the proposed condition 2-year (Atlas-14) event is provided in a single pond (shown as Pond D in Exhibit 16 – Proposed Local Mitigation) near the existing confluence of D133-00-00 and D133-01-00. The proposed design routes D133-00-00 directly into Pond D, restricting outflow to a 72" RCP with a concrete-lined 40-foot wide v-shaped overflow weir. Pond D is shown encompassing the southeast quadrant of the Beechnut St and Fondren Rd intersection and provides 216 acre-feet of storage. This land is currently occupied by an apartment complex and a

vacant commercial building. Should other land be acquired more easily, this pond could be replaced with equivalent detention volumes adjacent to the D133-00-00 and D133-01-00 systems. Additional restrictors are required along D133-00-00 south of the detention pond in order to reduce flow and step-up the HGL between Brays and Bissonnet to more closely match the existing condition. Additionally, 2-year (Atlas-14) mitigation was provided for Sub-Project 1 by connecting D133-01-00 to Pond D via an 8' x 6' RCB and placing restrictors on the Fondren Rd box system to reduce flows downstream.

4.3.2 Extreme Event Mitigation

The proposed condition HEC-RAS model was modified to include detention storage volume to mitigate the peak flow impacts to Brays Bayou. Detention was gradually added and the outfall structures and spillways were modified until a solution was reached. A total of 666 ac-ft of detention volume was needed to mitigate the 500-year storm event. This volume is in addition to the 216 detention required to mitigate the 2-year (Atlas-14) storm events as determined from the XP-Storm modeling, for a combined total of 882 ac-ft.

The City has purchased a 7.8 acre apartment property on Fondren at Brays Bayou which may provide 105 ac-ft of detention volume when excavated (See Pond A in Exhibit 16). To gain more detention volume, two properties at Fondren and Bissonnet St totaling 28.3 acres were modeled as detention ponds for an additional 351 ac-ft of detention volume (ponds B and C). Ponds B and C are adjacent to the D133-00-00 channel which allows them to drain to D133, but they will be filled by Brays Bayou which inundates the area in the 500-year event. Ponds B and C can be replaced with equivalent detention volumes nearby as long as they're sufficiently connected to the Brays floodplain.

More detention in the Fondren area was tested but proved to be less efficient in mitigating the remaining impacts. The remaining detention should ideally be located along Brays Bayou between Bissonnet St and Sam Houston Parkway. Detention on Keegans Bayou just downstream of Bissonnet St may be adequate but was not tested in the modeling. The detention location used to complete the mitigation model is located on an undeveloped tract near Country Creek St and Club Creek Dr. The 13.7 acre area can provide 210 ac-ft of detention volume (County Creek Pond), which will fully mitigate impacts to Brays Bayou in combination with ponds A, B, and C.

The hydraulic modeling showed no increases in peak flow rates of Brays Bayou downstream of the project area, with a 6 cfs reduction at Hillcroft in the 500-year storm event, as well as no adverse impacts to water surface elevations of Brays Bayou for the 500-year storm event, see Exhibit 17.

4.3.3 Detention Details

The hydraulic modeling in HEC-RAS determined that 666 ac-ft of detention is required to mitigate the increased peak flow rates leaving the project. This volume was achieved in

the model with ponds A, B, C, and Country Creek Pond (See Exhibit 16). Pond A and Country Creek Pond are adjacent to Brays Bayou and will connect to Brays Bayou with the outlet structure and weir. Pond B and Pond C are located on the channel D133-00-00 and D133-01-00 and will outfall to those channels, but the weir won't be topped until Brays Bayou inundates the area. The details of the ponds are shown in the table below.

The top of bank elevations were originally set at the approximate existing ground elevations. However, the Brays Bayou 500-year water surface elevation is several feet above the existing ground and the ponds filled up too early in the simulation and were not effectively detaining peak flows. The banks and weirs had to be raised to make the ponds more effective, sometimes pushing the top of bank several feet above existing ground. Constructing this may require retaining walls or steeper side slopes. Alternatively, pond locations may be selected at higher existing ground elevations, or more detention volume may be needed.

Table 8 – Detention Pond Summary

Description	Pond A	Pond B	Pond C	Pond D	Country Creek Pond
Berm Width	30 feet	30 feet	30 feet	30 feet	30 feet
Side Slope	3:1	3:1	3:1	3:1	4:1
Approximate Existing Ground Elevation	59'	61.5'	61.5'	61.00	65.5'
Top of Bank Elevation	62.50'	63.00'	62.00'	61.00	67.20'
Bottom Elevation	37.82'	46.39'	40.92'	41.63	46.18'
Pond Depth	24.68 feet	16.61 feet	21.08 feet	19.67 feet	21.02 feet
Outfall Pipe	24" RCP w/ flap gate	24" RCP w/ flap gate	24" RCP w/ flap gate		24" RCP
Weir	30 ft wide @ elevation 60.50'	100 ft wide @ elevation 61.00'	100 ft wide @ elevation 61.00'		100 ft wide @ elevation 65.20'

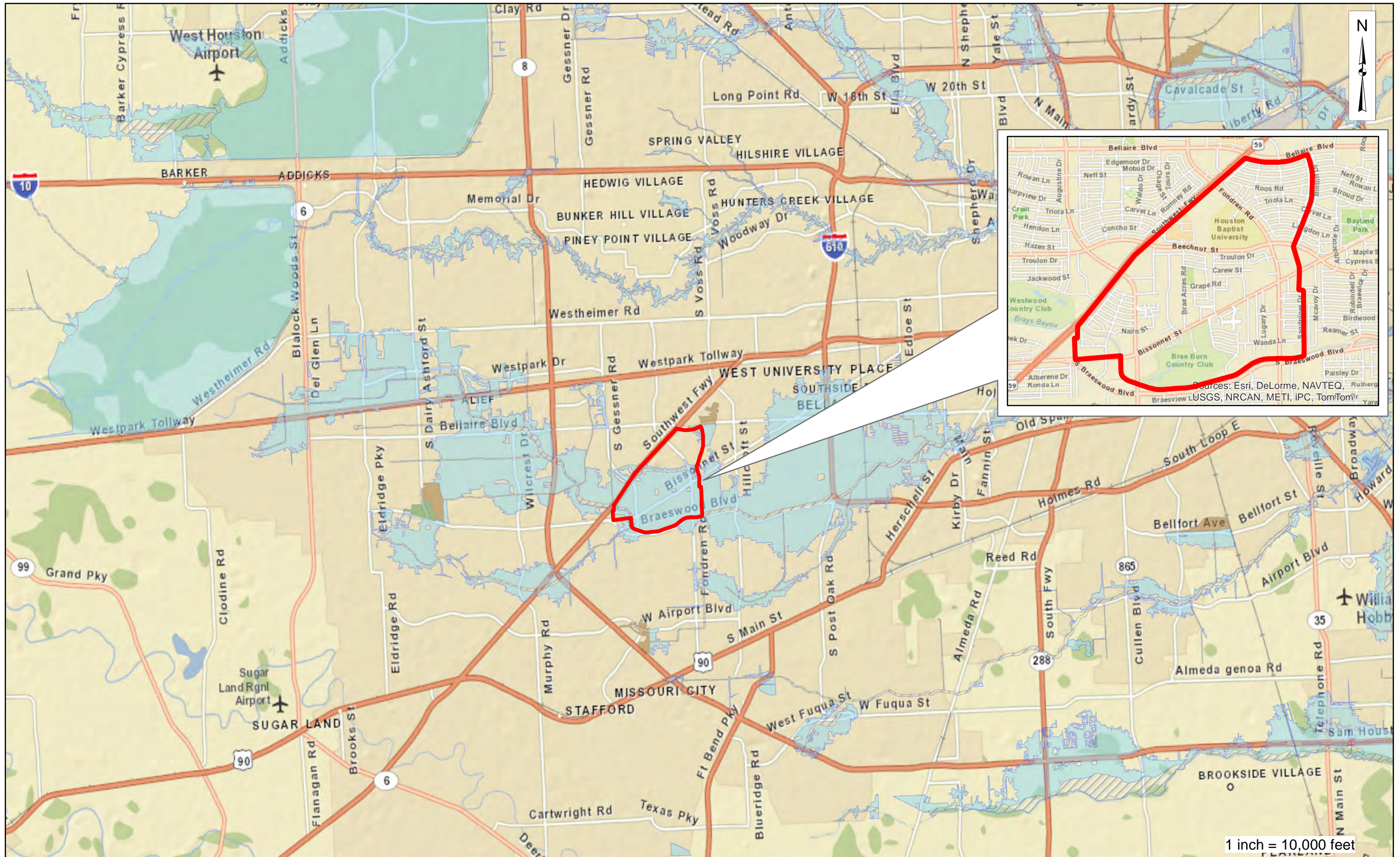
500-Year Pond WSE	62.98'	63.02'	62.64'	60.47'	67.66'
Detention Volume (does not include volume above existing ground elevation)	105 ac-ft	237 ac-ft	114 ac-ft	216 ac-ft	210 ac-ft

4.4. Benefitted Population

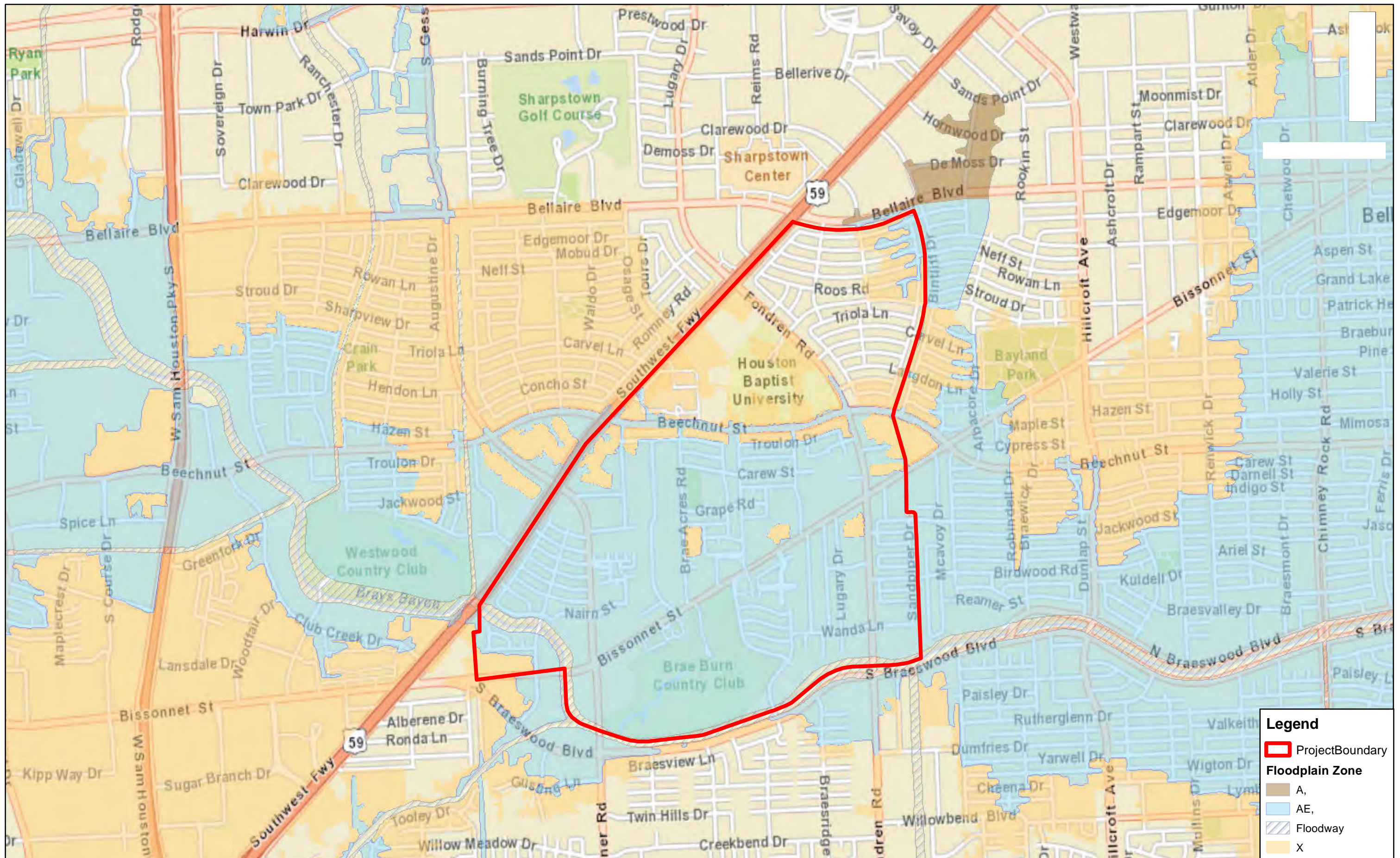
When all of these sub-projects are combined, there is a reduction in both risk of flooding to structures in the area and length of impassible streets, see Exhibit 18 for an Overall Benefitted Population Map.

5. Selected Alternative

Once the alternative analysis was completed, a preferred alternative was selected to provide the most cost-effective solution for the area. The selected sub-projects, referred to as Phase 1, includes construction of sub-projects 1, 2 (south of Beechnut St), 4 and 5, see Exhibit 10. When looking at the most cost-effective combination of sub-project, it was determined that constructing sub-project 2 north of Beechnut St provided minimal benefit to the adjoining neighborhoods, and so it is recommended to only construct sub-project 2 south of Beechnut St. This combination of sub-projects provided the greatest benefit to the area, see Exhibits 20, 21, and 22 for the 2-year (Atlas-14), 100-year (Atlas-14) and 500-year (TP-40) Ponding Maps, respectively. This alternative greatly increased street passibility in rain events and decreases risk of flooding for many areas.

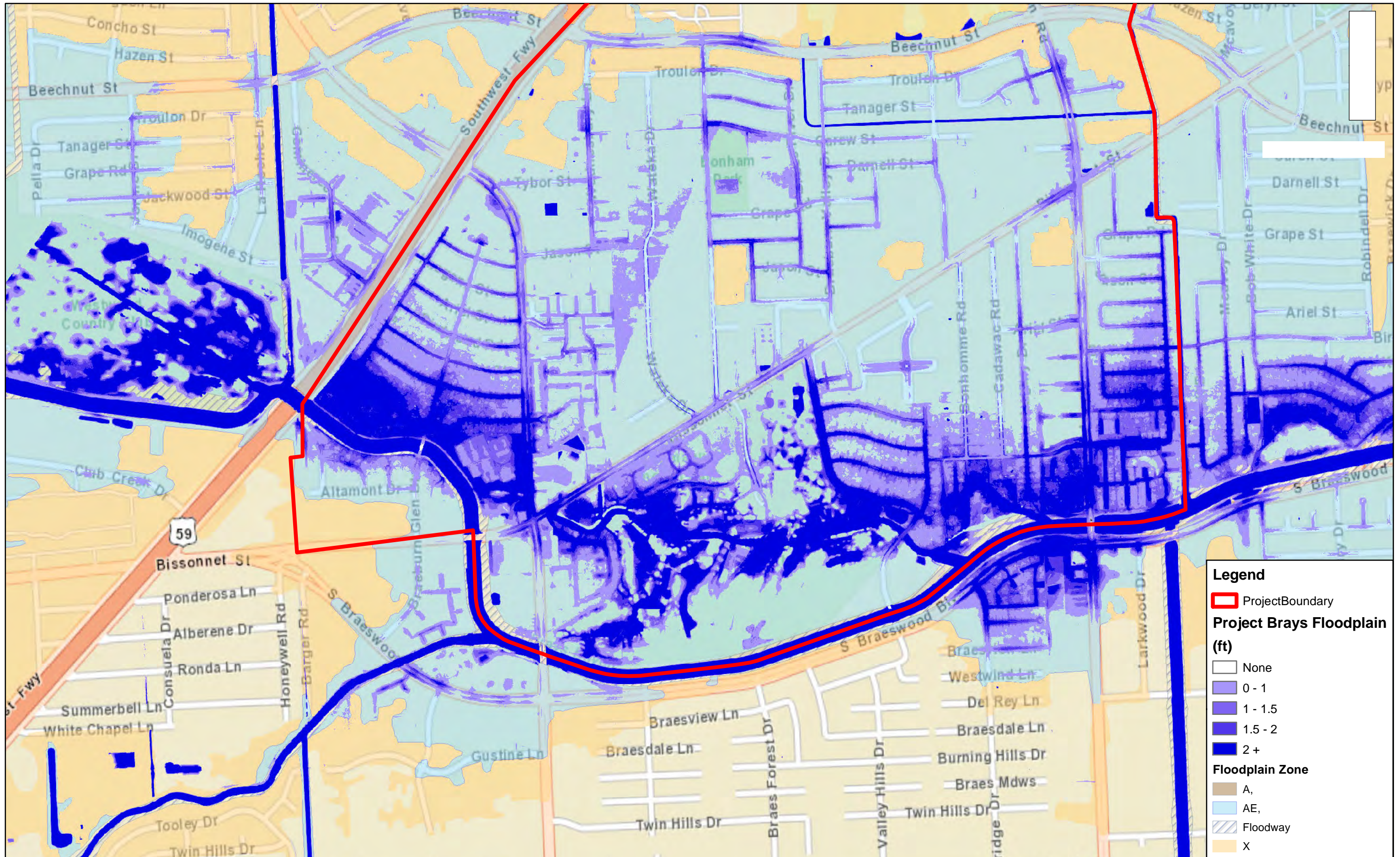


1 inch = 10,000 feet



Legend

- Project Boundary
- Floodplain Zone**
- A,
- AE,
- Floodway
- X



Legend

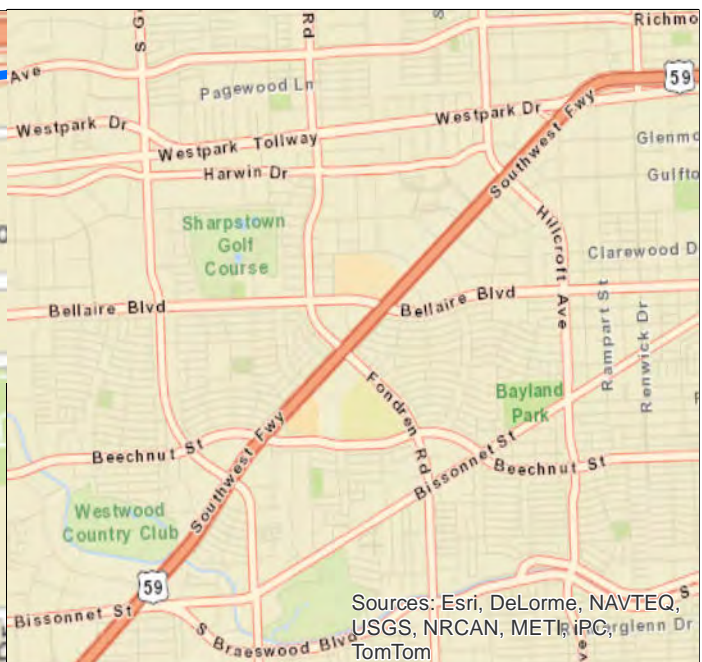
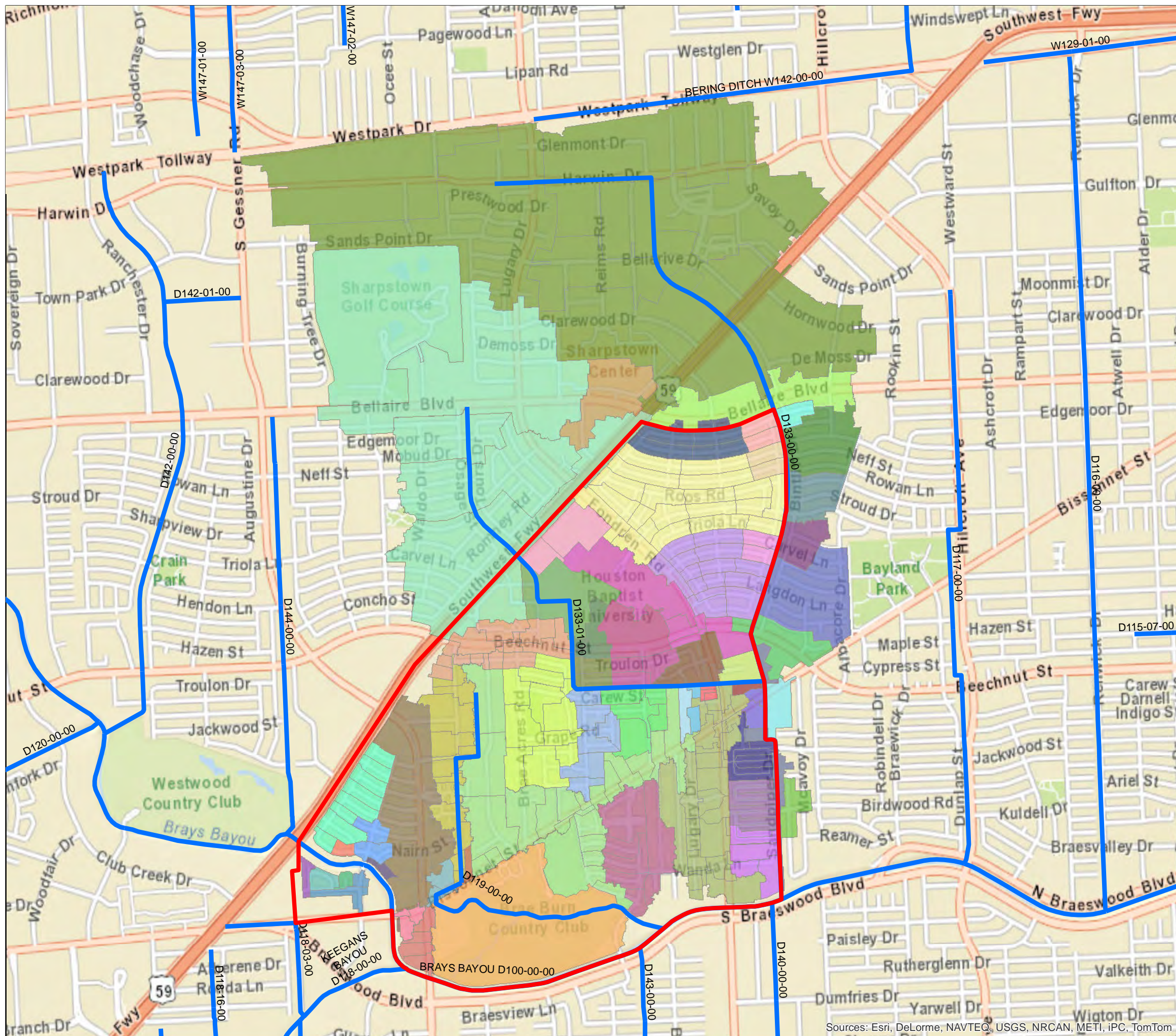
- Project Boundary

Project Brays Floodplain (ft)

- None
- 0 - 1
- 1 - 1.5
- 1.5 - 2
- 2 +

Floodplain Zone

- A,
- AE,
- Floodway
- X



Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, IPC, glenn, TomTom

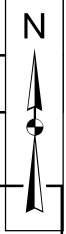
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**Sharpstown Master Drainage Plan
 Drainage Area Map**

Date: August 2020

EXHIBIT 4 -

1 inch = 2,000 feet



Legend

DA_Grid3	01057-00-OUT	05001-00-OUT
ProjectBoundary	01058-00-OUT	05026-00-OUT
Streams	01060-00-OUT	05287-00-OUT
00405-00-OUT	01591-00-OUT	05364-00-OUT
00406-00-OUT	01592-00-OUT	05380-00-OUT
00407-00-OUT	01593-00-OUT	05381-00-OUT
00538-00-OUT	01594-00-OUT	05385-00-OUT
00539-00-OUT	01595-00-OUT	05386-00-OUT
00545-00-OUT	01596-00-OUT	05419-00-OUT
00546-00-OUT	01597-00-OUT	05450-00-OUT
00547-00-OUT	01599-00-OUT	06691-00-OUT
00567-00-OUT	01601-00-OUT	06692-00-OUT
00755-00-OUT	02451-00-OUT	06693-00-OUT
00756-00-OUT	02458-00-OUT	06694-00-OUT
01051-00-OUT	04926-00-OUT	11900-00-GLF
01052-00-OUT	04980-00-OUT	13300-00-OUT
01053-00-OUT	04981-00-OUT	13300-00-STR
01054-00-OUT	04993-00-OUT	13301-00-OUT
01055-00-OUT	04994-00-OUT	13301-00-STR
01056-00-OUT	05000-00-OUT	

Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, IPC, TomTom

EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
00407-00-OUT_01	5.72	28.6	0.75	91.70	3.49	14.98	4.37	18.77	5.14	22.04	6.22	26.71	7.10	30.47	7.99	34.27
13300-00-OUT_04	151.57	39.2	0.78	96.32	2.92	343.74	3.67	432.41	4.32	509.42	5.26	619.82	6.02	709.63	6.80	801.22
01595-00-OUT_01	2.31	26.6	0.55	58.33	3.63	4.61	4.55	5.78	5.34	6.78	6.46	8.21	7.37	9.36	8.28	10.52
01596-00-OUT_03	2.83	27.0	0.55	58.33	3.60	5.60	4.51	7.02	5.29	8.24	6.41	9.98	7.31	11.38	8.22	12.79
01598-00-OUT_01	35.86	33.8	0.70	83.75	3.18	80.07	3.99	100.53	4.69	118.24	5.70	143.56	6.51	164.08	7.34	184.88
01599-00-OUT_16	24.79	32.6	0.46	42.86	3.24	36.76	4.07	46.13	4.79	54.24	5.81	65.82	6.64	75.20	7.47	84.70
01601-00-OUT_03	4.42	28.0	0.77	94.29	3.53	11.95	4.42	14.98	5.20	17.58	6.29	21.30	7.18	24.30	8.07	27.32
02458-00-OUT_06	19.14	31.8	0.55	58.53	3.29	34.69	4.13	43.53	4.85	51.16	5.88	62.07	6.72	70.89	7.57	79.83
13301-00-OUT_02	186.21	40.1	0.67	78.83	2.88	360.50	3.62	453.65	4.27	534.58	5.19	650.66	5.95	745.14	6.72	841.60
04926-00-OUT_11	4.38	28.0	0.79	97.61	3.53	12.15	4.43	15.23	5.20	17.88	6.30	21.67	7.18	24.71	8.08	27.79
04993-00-OUT_16	6.34	28.8	0.55	58.33	3.47	12.11	4.35	15.18	5.11	17.83	6.20	21.61	7.07	24.65	7.95	27.73
13300-00-OUT_01	146.19	39.1	0.80	100.00	2.92	341.73	3.68	429.86	4.33	506.39	5.27	616.10	6.03	705.34	6.81	796.33
05348-00-OUT_01	20.01	31.9	0.75	91.09	3.28	49.01	4.12	61.49	4.84	72.28	5.87	87.70	6.71	100.17	7.55	112.80
05364-00-OUT_01	2.94	27.1	0.69	82.18	3.59	7.32	4.50	9.18	5.29	10.77	6.40	13.04	7.30	14.87	8.21	16.72
05419-00-OUT_29	18.75	31.8	0.56	60.69	3.29	34.82	4.13	43.69	4.85	51.35	5.89	62.30	6.73	71.15	7.57	80.12
06694-00-OUT_01	42.56	34.4	0.80	100.00	3.15	107.17	3.95	134.59	4.65	158.32	5.65	192.27	6.46	219.79	7.28	247.72
13301-00-OUT_05	170.87	39.7	0.66	76.79	2.89	326.61	3.64	410.95	4.29	484.21	5.22	589.26	5.98	674.75	6.75	761.99
13301-00-OUT_04	99.61	37.5	0.58	63.82	2.99	173.79	3.76	218.50	4.43	257.27	5.39	312.82	6.16	357.95	6.96	403.90
01054-00-OUT_10	60.77	35.6	0.55	58.33	3.08	103.06	3.87	129.49	4.56	152.38	5.54	185.14	6.33	211.72	7.14	238.74
01056-00-OUT_02	5.07	28.3	0.55	58.33	3.51	9.78	4.40	12.26	5.16	14.40	6.26	17.45	7.14	19.90	8.03	22.38
01056-00-OUT_01	4.76	28.2	0.55	58.33	3.52	9.21	4.41	11.55	5.18	13.56	6.27	16.42	7.16	18.74	8.05	21.07
01053-00-OUT_10	4.95	28.3	0.55	58.33	3.51	9.56	4.40	11.99	5.17	14.07	6.26	17.05	7.14	19.45	8.03	21.87
01053-00-OUT_11	2.87	27.0	0.55	58.33	3.60	5.68	4.51	7.12	5.29	8.35	6.41	10.11	7.31	11.53	8.21	12.96
01053-00-OUT_12	4.64	28.1	0.55	58.33	3.52	8.99	4.42	11.27	5.18	13.23	6.28	16.03	7.16	18.28	8.06	20.56
01053-00-OUT_13	9.3	29.8	0.55	58.33	3.41	17.44	4.28	21.87	5.02	25.70	6.09	31.15	6.95	35.55	7.82	40.00
01053-00-OUT_14	5.97	28.7	0.55	58.33	3.48	11.44	4.37	14.33	5.13	16.83	6.21	20.40	7.09	23.27	7.97	26.18
01053-00-OUT_03	4.91	28.2	0.55	58.33	3.51	9.49	4.40	11.89	5.17	13.97	6.27	16.92	7.15	19.30	8.04	21.71
01053-00-OUT_02	6.75	29.0	0.64	74.14	3.46	15.07	4.34	18.89	5.10	22.19	6.18	26.89	7.05	30.69	7.93	34.52
01053-00-OUT_06	2.58	26.8	0.55	58.33	3.61	5.13	4.53	6.42	5.31	7.54	6.43	9.13	7.34	10.41	8.25	11.70
01053-00-OUT_05	2.31	26.6	0.55	58.33	3.63	4.61	4.55	5.78	5.34	6.78	6.46	8.21	7.37	9.36	8.28	10.52
01053-00-OUT_07	2.27	26.6	0.55	58.33	3.63	4.54	4.55	5.68	5.34	6.67	6.47	8.07	7.37	9.21	8.29	10.35
01053-00-OUT_08	6.85	29.0	0.55	58.33	3.46	13.04	4.34	16.34	5.09	19.20	6.17	23.26	7.05	26.54	7.93	29.86
01053-00-OUT_09	6.61	28.9	0.55	58.33	3.47	12.60	4.35	15.80	5.10	18.55	6.18	22.48	7.06	25.65	7.94	28.86
01053-00-OUT_04	3.86	27.7	0.55	58.33	3.55	7.54	4.45	9.45	5.23	11.09	6.33	13.44	7.22	15.33	8.12	17.23
01053-00-OUT_01	6.64	29.0	0.55	58.33	3.47	12.66	4.34	15.87	5.10	18.63	6.18	22.58	7.06	25.77	7.94	28.98
01055-00-OUT_01	17.24	31.5	0.55	58.33	3.31	31.35	4.15	39.33	4.88	46.23	5.91	56.08	6.75	64.04	7.60	72.10
01057-00-OUT_01	22.67	32.3	0.55	58.33	3.26	40.63	4.09	50.99	4.81	59.95	5.83	72.74	6.66	83.10	7.51	93.59
01058-00-OUT_01	39.36	34.1	0.55	58.33	3.16	68.44	3.97	85.95	4.67	101.09	5.67	122.76	6.48	140.31	7.30	158.13
02451-00-OUT_02	6.65	29.0	0.55	58.33	3.47	12.67	4.34	15.89	5.10	18.66	6.18	22.61	7.05	25.80	7.94	29.02
13301-00-OUT_03	46.36	34.7	0.55	58.33	3.13	79.87	3.93	100.31	4.63	118.01	5.62	143.33	6.43	163.86	7.24	184.70
04981-00-OUT_11	6.59	28.9	0.55	58.33	3.47	12.57	4.35	15.75	5.10	18.50	6.19	22.42	7.06	25.58	7.94	28.77
04981-00-OUT_10	6.26	28.8	0.55	58.33	3.48	11.96	4.36	15.00	5.12	17.61	6.20	21.34	7.07	24.35	7.96	27.39

EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
04981-00-OUT_12	8.12	29.5	0.55	58.33	3.43	15.33	4.30	19.22	5.06	22.58	6.13	27.37	6.99	31.23	7.87	35.14
04981-00-OUT_16	6.29	28.8	0.55	58.33	3.47	12.02	4.36	15.07	5.11	17.69	6.20	21.44	7.07	24.47	7.95	27.52
04981-00-OUT_18	5.18	28.4	0.55	58.33	3.51	9.99	4.39	12.52	5.16	14.70	6.25	17.81	7.13	20.32	8.02	22.85
04981-00-OUT_19	5.15	28.3	0.55	58.33	3.51	9.93	4.39	12.45	5.16	14.62	6.25	17.71	7.13	20.20	8.02	22.72
04981-00-OUT_20	7.28	29.2	0.55	58.33	3.45	13.82	4.33	17.32	5.08	20.34	6.16	24.66	7.03	28.14	7.90	31.65
04981-00-OUT_17	6.12	28.8	0.55	58.33	3.48	11.71	4.36	14.68	5.12	17.24	6.21	20.89	7.08	23.83	7.96	26.81
04981-00-OUT_15	6.87	29.0	0.55	58.33	3.46	13.07	4.34	16.39	5.09	19.25	6.17	23.33	7.04	26.62	7.92	29.94
04981-00-OUT_13	9.5	29.9	0.55	58.33	3.41	17.80	4.27	22.32	5.02	26.22	6.08	31.79	6.94	36.28	7.81	40.83
04981-00-OUT_14	10.45	30.1	0.55	58.33	3.39	19.49	4.25	24.44	5.00	28.71	6.06	34.81	6.91	39.74	7.78	44.72
04981-00-OUT_07	10.38	30.1	0.55	58.33	3.39	19.37	4.25	24.29	5.00	28.53	6.06	34.59	6.92	39.48	7.78	44.43
04981-00-OUT_04	8.36	29.5	0.71	85.15	3.43	20.37	4.30	25.54	5.05	30.00	6.12	36.37	6.98	41.51	7.86	46.70
04981-00-OUT_01	10.44	30.1	0.68	80.56	3.39	24.19	4.25	30.34	5.00	35.64	6.06	43.22	6.91	49.33	7.78	55.51
04981-00-OUT_03	3.68	27.6	0.55	58.33	3.56	7.20	4.46	9.03	5.24	10.60	6.34	12.84	7.23	14.64	8.13	16.46
04981-00-OUT_05	2.77	27.0	0.55	58.33	3.60	5.49	4.51	6.88	5.30	8.07	6.42	9.78	7.32	11.15	8.22	12.53
04981-00-OUT_02	7.65	29.3	0.55	58.33	3.44	14.48	4.32	18.16	5.07	21.33	6.14	25.85	7.01	29.50	7.89	33.19
04981-00-OUT_08	8.34	29.5	0.55	58.33	3.43	15.73	4.30	19.72	5.05	23.16	6.12	28.07	6.98	32.04	7.86	36.05
04981-00-OUT_06	9.13	29.8	0.55	58.33	3.41	17.14	4.28	21.49	5.03	25.25	6.09	30.61	6.96	34.93	7.83	39.30
04981-00-OUT_09	7.55	29.3	0.55	58.33	3.44	14.30	4.32	17.93	5.07	21.06	6.15	25.53	7.02	29.13	7.89	32.77
04980-00-OUT_01	5.55	28.5	0.55	58.33	3.49	10.67	4.38	13.37	5.14	15.70	6.23	19.02	7.11	21.70	8.00	24.41
04980-00-OUT_02	5.13	28.3	0.55	58.33	3.51	9.90	4.40	12.40	5.16	14.56	6.25	17.64	7.13	20.13	8.02	22.64
00567-00-OUT_02	5.34	28.4	0.55	58.33	3.50	10.28	4.39	12.89	5.15	15.13	6.24	18.33	7.12	20.92	8.01	23.52
00567-00-OUT_01	5.32	28.4	0.55	58.33	3.50	10.24	4.39	12.84	5.15	15.08	6.24	18.27	7.12	20.84	8.01	23.44
05026-00-OUT_02	7.76	29.3	0.55	58.33	3.44	14.68	4.31	18.41	5.07	21.62	6.14	26.21	7.01	29.91	7.88	33.65
05026-00-OUT_03	8.86	29.7	0.55	58.33	3.42	16.66	4.29	20.89	5.03	24.54	6.10	29.74	6.97	33.94	7.84	38.19
05026-00-OUT_05	8.14	29.5	0.55	58.33	3.43	15.37	4.30	19.27	5.05	22.63	6.13	27.43	6.99	31.30	7.87	35.22
05026-00-OUT_07	1.59	25.9	0.55	58.33	3.69	3.22	4.62	4.04	5.42	4.74	6.56	5.73	7.47	6.54	8.40	7.34
05026-00-OUT_08	1.56	25.8	0.55	58.33	3.69	3.17	4.62	3.96	5.42	4.65	6.56	5.63	7.48	6.42	8.40	7.21
05026-00-OUT_09	0.67	24.3	0.55	58.33	3.81	1.40	4.77	1.76	5.59	2.06	6.76	2.49	7.71	2.84	8.65	3.19
05026-00-OUT_04	6.72	29.0	0.55	58.33	3.46	12.80	4.34	16.05	5.10	18.85	6.18	22.84	7.05	26.06	7.93	29.32
00406-00-OUT_01	41.88	34.3	0.80	100.00	3.15	105.56	3.96	132.56	4.65	155.93	5.65	189.36	6.46	216.46	7.28	243.96
13300-00-OUT_07	134.36	38.7	0.80	100.00	2.94	315.76	3.69	397.14	4.35	467.79	5.29	569.06	6.06	651.41	6.84	735.36
00405-00-OUT_01	57.93	35.4	0.71	85.34	3.09	127.55	3.88	160.24	4.57	188.56	5.55	229.09	6.35	261.97	7.16	295.37
06691-00-OUT_01	20.5	32.0	0.80	100.00	3.28	53.73	4.11	67.43	4.83	79.26	5.86	96.17	6.70	109.84	7.54	123.69
06691-00-OUT_02	7.45	29.2	0.80	100.00	3.45	20.54	4.32	25.76	5.08	30.25	6.15	36.66	7.02	41.84	7.90	47.07
13300-00-OUT_06	126.18	38.4	0.79	98.92	2.95	295.30	3.71	371.38	4.37	437.42	5.31	532.05	6.08	609.00	6.87	687.41
13300-00-OUT_05	103.05	37.6	0.73	88.91	2.99	225.75	3.76	283.83	4.42	334.21	5.38	406.38	6.15	465.04	6.94	524.76
06692-00-OUT_10	6.34	28.8	0.80	100.00	3.47	17.62	4.35	22.08	5.11	25.93	6.20	31.43	7.07	35.86	7.95	40.33
06692-00-OUT_11	1.83	26.1	0.80	100.00	3.67	5.37	4.59	6.72	5.39	7.89	6.52	9.55	7.43	10.88	8.35	12.23
06692-00-OUT_12	0.36	23.4	0.80	100.00	3.89	1.12	4.87	1.40	5.71	1.64	6.90	1.99	7.86	2.26	8.83	2.54
06692-00-OUT_13	8.39	29.5	0.80	100.00	3.43	23.00	4.30	28.84	5.05	33.88	6.12	41.07	6.98	46.87	7.86	52.73
06692-00-OUT_14	7.72	29.3	0.80	100.00	3.44	21.25	4.31	26.64	5.07	31.29	6.14	37.93	7.01	43.29	7.88	48.70
06692-00-OUT_15	1.69	26.0	0.80	99.50	3.68	4.95	4.61	6.20	5.40	7.28	6.54	8.81	7.46	10.04	8.38	11.29

EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
06692-00-OUT_16	0.99	25.0	0.80	100.00	3.75	2.97	4.70	3.72	5.51	4.37	6.67	5.28	7.60	6.02	8.54	6.76
06692-00-OUT_17	5.58	28.5	0.80	99.25	3.49	15.51	4.38	19.44	5.14	22.83	6.23	27.66	7.11	31.55	7.99	35.49
06692-00-OUT_18	3.88	27.7	0.80	100.00	3.55	11.02	4.45	13.81	5.22	16.22	6.33	19.64	7.22	22.40	8.12	25.19
04926-00-OUT_01	3.79	27.6	0.63	72.45	3.55	8.55	4.45	10.72	5.23	12.58	6.33	15.24	7.22	17.38	8.12	19.54
04926-00-OUT_02	5.5	28.5	0.69	81.55	3.50	13.25	4.38	16.61	5.15	19.51	6.23	23.64	7.11	26.96	8.00	30.33
06692-00-OUT_03	2.75	26.9	0.80	100.00	3.60	7.93	4.52	9.93	5.30	11.66	6.42	14.12	7.32	16.10	8.23	18.10
06692-00-OUT_04	1.63	25.9	0.80	100.00	3.68	4.80	4.61	6.01	5.41	7.06	6.55	8.54	7.47	9.74	8.39	10.94
06692-00-OUT_05	4.85	28.2	0.57	62.01	3.52	9.76	4.41	12.23	5.17	14.36	6.27	17.39	7.15	19.84	8.04	22.31
06692-00-OUT_06	2.43	26.7	0.62	70.71	3.62	5.50	4.54	6.89	5.33	8.08	6.45	9.79	7.35	11.16	8.27	12.54
06692-00-OUT_07	1.63	25.9	0.71	84.61	3.68	4.25	4.61	5.32	5.41	6.24	6.55	7.56	7.47	8.61	8.39	9.68
06692-00-OUT_08	0.89	24.8	0.59	64.61	3.77	1.97	4.72	2.47	5.54	2.90	6.70	3.50	7.63	3.99	8.57	4.48
06692-00-OUT_09	1.32	25.5	0.70	82.77	3.71	3.41	4.65	4.28	5.46	5.02	6.60	6.07	7.53	6.92	8.45	7.77
01590-00-OUT_10	8.4	29.5	0.55	58.33	3.43	15.83	4.30	19.85	5.05	23.32	6.12	28.27	6.98	32.26	7.86	36.29
01590-00-OUT_11	5.68	28.6	0.55	58.70	3.49	10.95	4.38	13.72	5.14	16.12	6.23	19.53	7.10	22.28	7.99	25.06
01590-00-OUT_01	4.44	28.0	0.55	58.33	3.53	8.62	4.42	10.80	5.19	12.68	6.29	15.37	7.18	17.53	8.07	19.71
01590-00-OUT_02	4.62	28.1	0.55	58.33	3.52	8.95	4.42	11.22	5.19	13.18	6.28	15.96	7.17	18.21	8.06	20.47
01590-00-OUT_03	13.8	30.9	0.67	78.56	3.34	30.98	4.19	38.87	4.93	45.67	5.98	55.39	6.83	63.24	7.68	71.19
01590-00-OUT_04	8.56	29.6	0.49	48.10	3.42	14.32	4.29	17.96	5.04	21.09	6.11	25.57	6.98	29.18	7.85	32.83
01590-00-OUT_05	9.49	29.9	0.55	58.33	3.41	17.78	4.27	22.30	5.02	26.20	6.08	31.76	6.94	36.25	7.81	40.79
01590-00-OUT_06	13.24	30.8	0.50	50.34	3.35	22.28	4.20	27.94	4.94	32.83	5.99	39.82	6.84	45.46	7.70	51.17
01590-00-OUT_07	6.37	28.9	0.55	58.33	3.47	12.17	4.35	15.25	5.11	17.91	6.19	21.70	7.07	24.76	7.95	27.85
01590-00-OUT_08	1.33	25.5	0.55	58.33	3.71	2.72	4.65	3.40	5.45	3.99	6.60	4.83	7.52	5.50	8.45	6.18
01590-00-OUT_09	7.88	29.4	0.48	47.10	3.44	13.07	4.31	16.39	5.06	19.25	6.14	23.33	7.00	26.63	7.88	29.96
00539-00-OUT_01	4.58	28.1	0.71	85.78	3.53	11.54	4.42	14.46	5.19	16.98	6.28	20.57	7.17	23.46	8.06	26.38
00539-00-OUT_02	8.53	29.6	0.68	80.07	3.42	19.88	4.29	24.92	5.04	29.27	6.11	35.49	6.98	40.50	7.85	45.57
00539-00-OUT_03	5.49	28.5	0.55	58.33	3.50	10.56	4.38	13.23	5.15	15.54	6.24	18.83	7.11	21.48	8.00	24.16
00539-00-OUT_05	6.69	29.0	0.55	58.33	3.46	12.75	4.34	15.98	5.10	18.77	6.18	22.74	7.05	25.95	7.93	29.19
00539-00-OUT_04	6.33	28.8	0.55	58.46	3.47	12.11	4.35	15.18	5.11	17.83	6.20	21.60	7.07	24.65	7.95	27.73
00539-00-OUT_06	4.37	28.0	0.55	58.33	3.53	8.49	4.43	10.64	5.20	12.49	6.30	15.13	7.18	17.26	8.08	19.41
00547-00-OUT_01	10.43	30.1	0.61	67.96	3.39	21.50	4.25	26.96	5.00	31.67	6.06	38.40	6.91	43.83	7.78	49.33
00547-00-OUT_02	3.65	27.6	0.80	100.00	3.56	10.40	4.46	13.03	5.24	15.29	6.34	18.53	7.24	21.13	8.14	23.75
00547-00-OUT_03	7.51	29.3	0.63	71.59	3.45	16.29	4.32	20.42	5.07	23.99	6.15	29.07	7.02	33.18	7.89	37.32
00547-00-OUT_04	3.01	27.1	0.80	100.00	3.59	8.65	4.50	10.83	5.28	12.72	6.39	15.40	7.29	17.56	8.20	19.74
00547-00-OUT_05	5.83	28.6	0.55	58.33	3.49	11.18	4.37	14.01	5.13	16.46	6.22	19.94	7.10	22.75	7.98	25.59
00538-00-OUT_01	5.23	28.4	0.55	58.33	3.50	10.08	4.39	12.63	5.16	14.83	6.25	17.97	7.13	20.50	8.02	23.06
00538-00-OUT_02	5.45	28.5	0.55	58.33	3.50	10.48	4.38	13.14	5.15	15.43	6.24	18.70	7.12	21.33	8.00	23.99
01591-00-OUT_01	6.72	29.0	0.55	58.33	3.46	12.80	4.34	16.05	5.10	18.85	6.18	22.84	7.05	26.06	7.93	29.32
01591-00-OUT_02	5.44	28.5	0.55	58.33	3.50	10.47	4.38	13.12	5.15	15.40	6.24	18.66	7.12	21.29	8.00	23.95
01591-00-OUT_03	4.45	28.0	0.55	58.33	3.53	8.64	4.42	10.83	5.19	12.71	6.29	15.40	7.18	17.56	8.07	19.75
01591-00-OUT_04	28.19	33.0	0.76	92.65	3.22	68.63	4.04	86.15	4.75	101.30	5.77	122.96	6.59	140.49	7.43	158.26
06693-00-OUT_01	11.12	30.3	0.74	89.96	3.38	27.81	4.24	34.88	4.98	40.97	6.04	49.68	6.89	56.71	7.76	63.83
06693-00-OUT_02	1.67	25.9	0.80	100.00	3.68	4.92	4.61	6.16	5.41	7.22	6.55	8.74	7.46	9.97	8.38	11.20

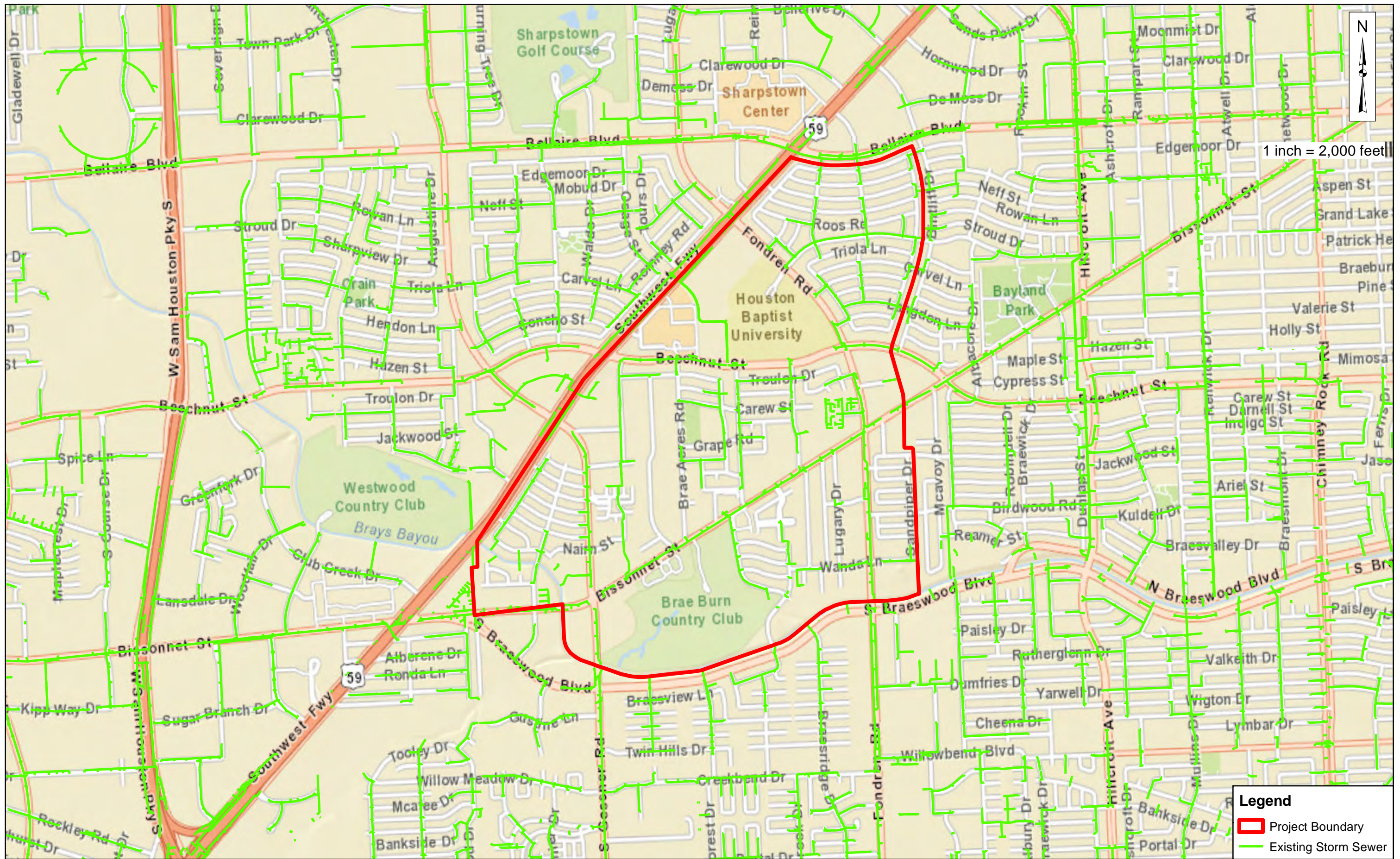
EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
01052-00-OUT_01	11.1	30.3	0.74	90.08	3.38	27.79	4.24	34.85	4.98	40.94	6.04	49.65	6.90	56.67	7.76	63.78
01052-00-OUT_02	2.57	26.8	0.63	71.79	3.61	5.86	4.53	7.34	5.31	8.62	6.44	10.43	7.34	11.89	8.25	13.37
01052-00-OUT_04	1.43	25.7	0.62	70.28	3.70	3.29	4.64	4.12	5.44	4.84	6.58	5.85	7.50	6.67	8.43	7.49
01052-00-OUT_03	46.22	34.6	0.80	99.70	3.13	115.58	3.93	145.17	4.63	170.78	5.62	207.42	6.43	237.13	7.24	267.29
01052-00-OUT_05	5.35	28.4	0.80	99.92	3.50	14.97	4.39	18.77	5.15	22.04	6.24	26.70	7.12	30.46	8.01	34.26
01060-00-OUT_01	9.79	29.9	0.80	100.00	3.40	26.64	4.27	33.41	5.01	39.25	6.08	47.58	6.93	54.31	7.80	61.11
05380-00-OUT_01	0.81	24.6	0.80	100.00	3.78	2.45	4.74	3.07	5.55	3.60	6.72	4.35	7.66	4.96	8.60	5.57
05380-00-OUT_02	0.59	24.1	0.80	100.00	3.83	1.81	4.79	2.26	5.62	2.65	6.79	3.21	7.74	3.65	8.69	4.10
05380-00-OUT_03	7.3	29.2	0.78	96.69	3.45	19.65	4.33	24.63	5.08	28.93	6.16	35.06	7.03	40.01	7.90	45.01
05380-00-OUT_04	9.16	29.8	0.55	58.33	3.41	17.19	4.28	21.56	5.03	25.33	6.09	30.70	6.96	35.04	7.83	39.43
05380-00-OUT_05	3.96	27.7	0.55	58.33	3.55	7.73	4.45	9.68	5.22	11.37	6.32	13.77	7.21	15.71	8.11	17.66
05001-00-OUT_01	5.19	28.4	0.80	100.00	3.51	14.55	4.39	18.24	5.16	21.42	6.25	25.95	7.13	29.61	8.02	33.29
05000-00-OUT_01	1.09	25.2	0.80	100.00	3.74	3.26	4.68	4.08	5.49	4.79	6.65	5.80	7.58	6.61	8.51	7.42
05289-00-OUT_01	0.88	24.8	0.80	100.00	3.77	2.65	4.72	3.32	5.54	3.90	6.70	4.72	7.63	5.37	8.58	6.04
05289-00-OUT_02	0.5	23.9	0.80	100.00	3.85	1.54	4.82	1.93	5.65	2.26	6.83	2.73	7.78	3.11	8.74	3.49
05289-00-OUT_03	0.81	24.6	0.80	100.00	3.78	2.45	4.74	3.07	5.55	3.60	6.72	4.35	7.66	4.96	8.60	5.57
05419-00-OUT_10	0.92	24.9	0.80	100.00	3.76	2.77	4.71	3.47	5.53	4.07	6.69	4.92	7.62	5.61	8.56	6.30
05419-00-OUT_11	1.29	25.5	0.80	100.00	3.72	3.84	4.65	4.80	5.46	5.64	6.61	6.82	7.53	7.77	8.46	8.73
05419-00-OUT_12	5.12	28.3	0.80	100.00	3.51	14.37	4.40	18.01	5.16	21.14	6.25	25.62	7.13	29.22	8.02	32.86
05419-00-OUT_13	1.97	26.3	0.80	100.00	3.65	5.76	4.58	7.21	5.37	8.47	6.50	10.25	7.41	11.68	8.33	13.13
05419-00-OUT_14	2.26	26.5	0.80	100.00	3.63	6.57	4.55	8.23	5.34	9.66	6.47	11.70	7.37	13.33	8.29	14.99
05419-00-OUT_01	3.02	27.1	0.74	89.65	3.59	8.00	4.50	10.02	5.28	11.77	6.39	14.25	7.29	16.25	8.20	18.27
05419-00-OUT_02	3.83	27.7	0.78	97.16	3.55	10.66	4.45	13.35	5.23	15.68	6.33	18.99	7.22	21.66	8.12	24.35
05419-00-OUT_03	1.42	25.6	0.79	98.24	3.70	4.15	4.64	5.20	5.44	6.10	6.59	7.38	7.51	8.41	8.43	9.45
05419-00-OUT_04	0.44	23.7	0.80	100.00	3.86	1.36	4.84	1.70	5.67	2.00	6.86	2.41	7.81	2.75	8.77	3.09
05419-00-OUT_05	0.55	24.0	0.80	100.00	3.83	1.69	4.80	2.11	5.63	2.48	6.81	3.00	7.76	3.41	8.71	3.83
05419-00-OUT_06	1.66	25.9	0.80	100.00	3.68	4.89	4.61	6.12	5.41	7.18	6.55	8.69	7.46	9.91	8.38	11.14
05419-00-OUT_07	2.62	26.8	0.80	100.00	3.61	7.57	4.52	9.48	5.31	11.13	6.43	13.48	7.33	15.37	8.24	17.28
05419-00-OUT_08	2.38	26.6	0.80	100.00	3.63	6.90	4.54	8.65	5.33	10.15	6.46	12.29	7.36	14.01	8.27	15.75
05419-00-OUT_09	1.1	25.2	0.80	100.00	3.74	3.29	4.68	4.12	5.49	4.83	6.65	5.85	7.57	6.67	8.51	7.49
05450-00-OUT_01	2.26	26.5	0.80	100.00	3.63	6.57	4.55	8.23	5.34	9.66	6.47	11.70	7.37	13.33	8.29	14.99
05450-00-OUT_02	4.5	28.0	0.80	100.00	3.53	12.70	4.42	15.92	5.19	18.69	6.29	22.64	7.17	25.82	8.07	29.04
05287-00-OUT_01	12.05	30.5	0.79	98.93	3.37	32.20	4.22	40.38	4.96	47.45	6.02	57.54	6.87	65.68	7.73	73.93
05381-00-OUT_01	3.81	27.7	0.55	58.33	3.55	7.45	4.45	9.33	5.23	10.96	6.33	13.27	7.22	15.14	8.12	17.02
05381-00-OUT_02	2.24	26.5	0.55	58.33	3.64	4.48	4.55	5.61	5.34	6.58	6.47	7.97	7.38	9.09	8.29	10.22
05381-00-OUT_03	2.49	26.7	0.55	58.33	3.62	4.96	4.53	6.21	5.32	7.29	6.44	8.83	7.35	10.06	8.26	11.31
05381-00-OUT_04	2.01	26.3	0.55	58.33	3.65	4.04	4.57	5.06	5.37	5.93	6.50	7.18	7.41	8.19	8.33	9.20
05381-00-OUT_05	2.52	26.8	0.55	58.33	3.62	5.01	4.53	6.28	5.32	7.37	6.44	8.93	7.34	10.18	8.25	11.44
05381-00-OUT_06	3.47	27.4	0.66	76.95	3.57	8.19	4.47	10.27	5.25	12.05	6.36	14.60	7.25	16.65	8.15	18.72
05381-00-OUT_07	1.84	26.1	0.55	59.01	3.66	3.74	4.59	4.68	5.39	5.49	6.52	6.65	7.43	7.58	8.35	8.52
05386-00-OUT_01	2.89	27.1	0.55	58.33	3.60	5.72	4.51	7.16	5.29	8.41	6.41	10.18	7.30	11.61	8.21	13.05
05386-00-OUT_02	2.65	26.9	0.55	58.33	3.61	5.26	4.52	6.59	5.31	7.74	6.43	9.37	7.33	10.68	8.24	12.01

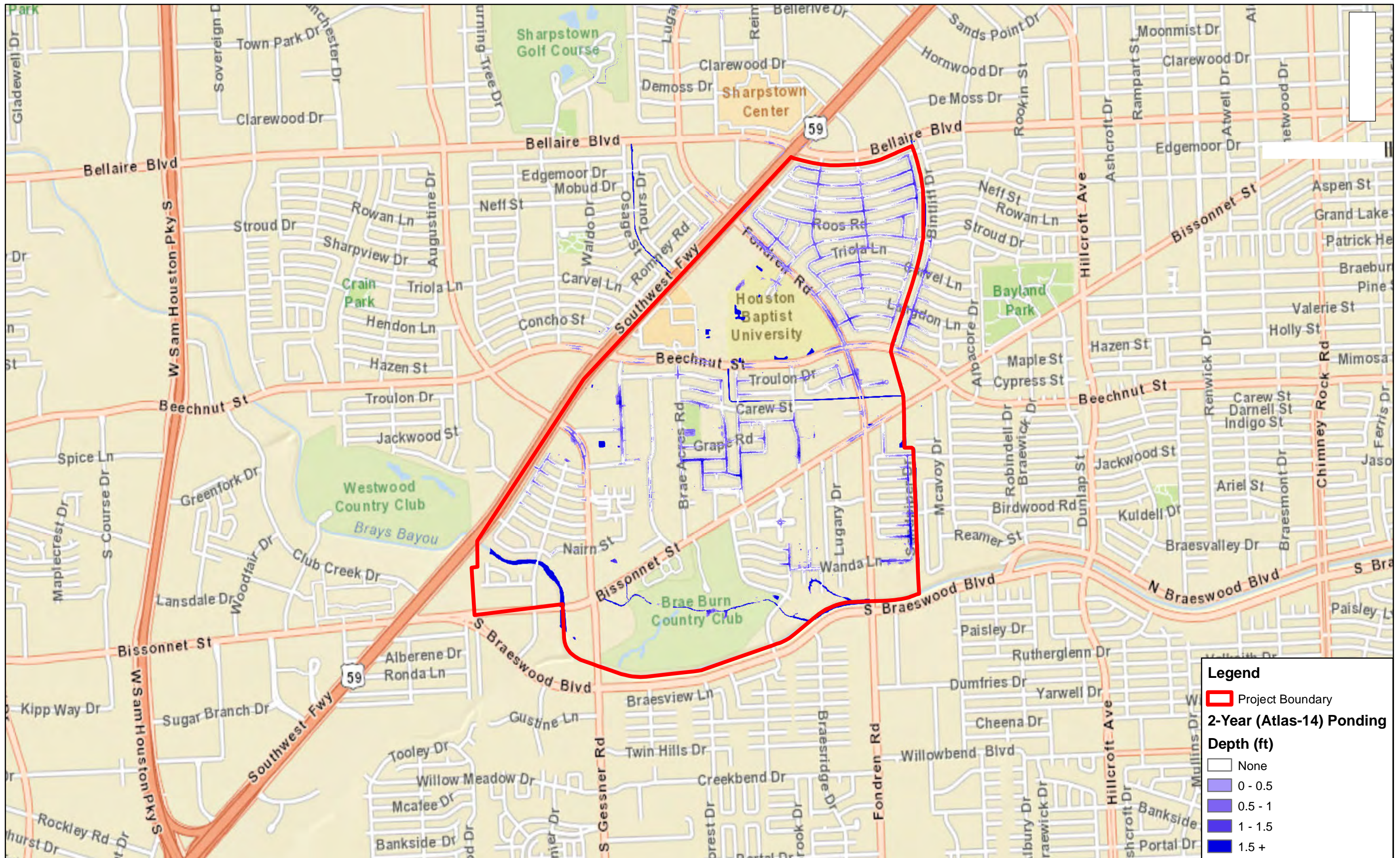
EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
05386-00-OUT_03	2.13	26.4	0.55	58.33	3.64	4.27	4.56	5.35	5.36	6.27	6.48	7.60	7.39	8.66	8.31	9.73
05386-00-OUT_04	3.56	27.5	0.55	58.33	3.56	6.98	4.47	8.75	5.24	10.27	6.35	12.44	7.24	14.18	8.14	15.94
05386-00-OUT_05	2.82	27.0	0.55	58.33	3.60	5.58	4.51	7.00	5.29	8.21	6.41	9.94	7.31	11.34	8.22	12.75
05386-00-OUT_06	2.34	26.6	0.55	58.33	3.63	4.67	4.55	5.85	5.34	6.87	6.46	8.31	7.36	9.48	8.28	10.65
05386-00-OUT_07	3.48	27.5	0.55	58.33	3.57	6.83	4.47	8.56	5.25	10.05	6.36	12.17	7.25	13.88	8.15	15.60
05386-00-OUT_08	2.4	26.7	0.55	58.33	3.63	4.79	4.54	5.99	5.33	7.04	6.45	8.52	7.36	9.71	8.27	10.92
05386-00-OUT_09	#N/A	#N/A	0.55	58.33	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
05385-00-OUT_01	11.12	30.3	0.55	58.33	3.38	20.68	4.24	25.93	4.98	30.46	6.04	36.94	6.89	42.17	7.76	47.45
04994-00-OUT_01	2.25	26.5	0.55	58.33	3.63	4.50	4.55	5.63	5.34	6.61	6.47	8.01	7.38	9.13	8.29	10.26
04994-00-OUT_02	4.33	27.9	0.56	59.49	3.53	8.52	4.43	10.68	5.20	12.54	6.30	15.19	7.18	17.33	8.08	19.48
04994-00-OUT_03	7.4	29.2	0.80	99.94	3.45	20.40	4.32	25.58	5.08	30.04	6.15	36.41	7.02	41.55	7.90	46.74
04994-00-OUT_04	3.8	27.7	0.80	100.00	3.55	10.81	4.45	13.54	5.23	15.90	6.33	19.25	7.22	21.96	8.12	24.69
04994-00-OUT_05	6.96	29.1	0.80	100.00	3.46	19.25	4.34	24.14	5.09	28.35	6.17	34.36	7.04	39.20	7.92	44.10
01051-00-OUT_01	27.54	32.9	0.65	74.36	3.22	57.39	4.05	72.03	4.76	84.70	5.78	102.80	6.60	117.46	7.44	132.31
01592-00-OUT_06	2.87	27.0	0.55	58.33	3.60	5.68	4.51	7.12	5.29	8.35	6.41	10.11	7.31	11.53	8.21	12.96
01592-00-OUT_05	5.92	28.7	0.55	58.33	3.48	11.34	4.37	14.22	5.13	16.70	6.21	20.23	7.09	23.09	7.97	25.97
01592-00-OUT_04	5.66	28.6	0.55	58.33	3.49	10.87	4.38	13.62	5.14	16.00	6.23	19.38	7.10	22.12	7.99	24.87
01592-00-OUT_03	5.42	28.5	0.55	58.33	3.50	10.43	4.38	13.07	5.15	15.35	6.24	18.60	7.12	21.22	8.00	23.86
01592-00-OUT_02	4.55	28.1	0.55	58.33	3.53	8.82	4.42	11.06	5.19	12.98	6.29	15.73	7.17	17.94	8.06	20.18
01592-00-OUT_01	4.22	27.9	0.55	58.33	3.54	8.21	4.43	10.29	5.21	12.08	6.31	14.64	7.19	16.69	8.09	18.77
01592-00-OUT_07	8.73	29.6	0.55	58.33	3.42	16.43	4.29	20.59	5.04	24.19	6.11	29.33	6.97	33.47	7.84	37.66
01592-00-OUT_08	3.39	27.4	0.55	58.33	3.57	6.66	4.48	8.35	5.25	9.80	6.36	11.87	7.26	13.53	8.16	15.21
00545-00-OUT_01	2.74	26.9	0.55	58.33	3.60	5.43	4.52	6.81	5.30	7.99	6.42	9.67	7.32	11.03	8.23	12.40
00546-00-OUT_01	5.57	28.5	0.55	58.33	3.49	10.70	4.38	13.42	5.14	15.75	6.23	19.09	7.11	21.78	8.00	24.49
00546-00-OUT_02	6.28	28.8	0.55	58.33	3.47	12.00	4.36	15.04	5.12	17.67	6.20	21.41	7.07	24.43	7.96	27.48
04993-00-OUT_01	16.98	31.5	0.80	99.29	3.31	44.71	4.15	56.09	4.88	65.92	5.92	79.97	6.76	91.32	7.61	102.82
04993-00-OUT_03	2.31	26.6	0.79	97.66	3.63	6.59	4.55	8.26	5.34	9.69	6.46	11.73	7.37	13.38	8.28	15.04
04993-00-OUT_02	5.22	28.4	0.80	100.00	3.50	14.63	4.39	18.34	5.16	21.54	6.25	26.09	7.13	29.77	8.02	33.48
04993-00-OUT_04	1.15	25.2	0.80	100.00	3.73	3.43	4.67	4.30	5.48	5.05	6.64	6.11	7.56	6.96	8.50	7.82
04993-00-OUT_05	3.58	27.5	0.55	58.33	3.56	7.02	4.47	8.79	5.24	10.32	6.35	12.50	7.24	14.26	8.14	16.03
04993-00-OUT_07	7.46	29.2	0.55	58.33	3.45	14.14	4.32	17.73	5.08	20.82	6.15	25.24	7.02	28.80	7.90	32.40
04993-00-OUT_09	5.43	28.5	0.55	58.33	3.50	10.45	4.38	13.09	5.15	15.38	6.24	18.63	7.12	21.25	8.00	23.90
04993-00-OUT_06	8.06	29.4	0.66	76.74	3.43	18.28	4.31	22.92	5.06	26.92	6.13	32.63	7.00	37.24	7.87	41.89
04993-00-OUT_08	7.52	29.3	0.62	70.30	3.45	16.11	4.32	20.20	5.07	23.72	6.15	28.75	7.02	32.81	7.89	36.91
04993-00-OUT_10	4.23	27.9	0.55	58.33	3.54	8.23	4.43	10.31	5.20	12.11	6.31	14.67	7.19	16.73	8.09	18.81
04993-00-OUT_11	15.04	31.1	0.73	88.72	3.33	36.67	4.18	46.01	4.91	54.06	5.95	65.57	6.80	74.88	7.65	84.29
04993-00-OUT_13	2.84	27.0	0.77	95.60	3.60	7.91	4.51	9.91	5.29	11.63	6.41	14.08	7.31	16.06	8.22	18.05
04993-00-OUT_14	3.59	27.5	0.64	73.65	3.56	8.21	4.46	10.29	5.24	12.08	6.35	14.63	7.24	16.69	8.14	18.76
04993-00-OUT_15	2.45	26.7	0.55	58.33	3.62	4.88	4.54	6.11	5.33	7.18	6.45	8.69	7.35	9.91	8.26	11.13
04993-00-OUT_12	4.46	28.0	0.55	58.33	3.53	8.66	4.42	10.85	5.19	12.74	6.29	15.43	7.18	17.60	8.07	19.79
01594-00-OUT_01	5.72	28.6	0.58	62.89	3.49	11.52	4.37	14.44	5.14	16.96	6.22	20.55	7.10	23.45	7.99	26.37
01594-00-OUT_02	1.99	26.3	0.55	58.33	3.65	4.00	4.58	5.01	5.37	5.88	6.50	7.12	7.41	8.11	8.33	9.12

EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
00755-00-OUT_01	2.18	26.5	0.55	58.33	3.64	4.36	4.56	5.47	5.35	6.42	6.48	7.77	7.39	8.85	8.30	9.95
00756-00-OUT_01	5.15	28.3	0.55	58.33	3.51	9.93	4.39	12.45	5.16	14.62	6.25	17.71	7.13	20.20	8.02	22.72
01593-00-OUT_01	3.09	27.2	0.55	58.44	3.59	6.10	4.49	7.65	5.27	8.97	6.39	10.87	7.28	12.39	8.19	13.93
01596-00-OUT_01	2.1	26.4	0.55	58.73	3.65	4.23	4.57	5.30	5.36	6.22	6.49	7.53	7.40	8.58	8.31	9.64
01596-00-OUT_02	0.93	24.9	0.55	58.33	3.76	1.92	4.71	2.41	5.53	2.83	6.69	3.42	7.62	3.90	8.56	4.38
01597-00-OUT_01	0.39	23.5	0.55	58.33	3.88	0.83	4.86	1.04	5.69	1.22	6.89	1.48	7.84	1.68	8.81	1.89
01601-00-OUT_01	3.43	27.4	0.69	82.26	3.57	8.49	4.47	10.64	5.25	12.49	6.36	15.13	7.25	17.26	8.16	19.40
01601-00-OUT_02	2.27	26.6	0.60	66.96	3.63	4.96	4.55	6.22	5.34	7.30	6.47	8.83	7.37	10.07	8.29	11.32
01601-00-OUT_04	4	27.8	0.65	75.46	3.55	9.26	4.44	11.60	5.22	13.62	6.32	16.50	7.21	18.82	8.11	21.16
01599-00-OUT_01	2.04	26.3	0.80	100.00	3.65	5.96	4.57	7.46	5.36	8.75	6.49	10.60	7.40	12.08	8.32	13.58
01599-00-OUT_02	12.95	30.7	0.75	90.99	3.35	32.41	4.21	40.65	4.94	47.76	6.00	57.92	6.85	66.13	7.71	74.44
01599-00-OUT_03	5.57	28.5	0.79	98.13	3.49	15.35	4.38	19.24	5.14	22.59	6.23	27.38	7.11	31.23	8.00	35.13
01599-00-OUT_04	5.22	28.4	0.80	99.92	3.50	14.63	4.39	18.33	5.16	21.52	6.25	26.08	7.13	29.75	8.02	33.46
01599-00-OUT_05	6.33	28.8	0.80	99.83	3.47	17.57	4.35	22.02	5.11	25.86	6.20	31.34	7.07	35.76	7.95	40.22
01599-00-OUT_06	4.65	28.1	0.80	100.00	3.52	13.10	4.41	16.42	5.18	19.28	6.28	23.36	7.16	26.65	8.06	29.97
01599-00-OUT_07	3.19	27.3	0.80	100.00	3.58	9.14	4.49	11.45	5.27	13.44	6.38	16.28	7.28	18.57	8.18	20.87
01599-00-OUT_08	1.47	25.7	0.80	100.00	3.70	4.35	4.63	5.45	5.43	6.39	6.58	7.73	7.50	8.82	8.42	9.90
01599-00-OUT_10	5.57	28.5	0.80	99.63	3.49	15.53	4.38	19.46	5.14	22.85	6.23	27.69	7.11	31.59	8.00	35.53
01599-00-OUT_09	0.93	24.9	0.80	100.00	3.76	2.80	4.71	3.51	5.53	4.11	6.69	4.98	7.62	5.67	8.56	6.37
01599-00-OUT_22	26.82	32.8	0.22	3.88	3.23	19.34	4.05	24.28	4.77	28.54	5.78	34.64	6.61	39.58	7.45	44.59
01599-00-OUT_11	1.75	26.0	0.35	24.42	3.67	2.23	4.60	2.79	5.40	3.27	6.53	3.96	7.45	4.52	8.37	5.07
01599-00-OUT_12	7.89	29.4	0.62	69.17	3.44	16.68	4.31	20.91	5.06	24.56	6.14	29.77	7.00	33.98	7.88	38.22
01599-00-OUT_13	16.68	31.4	0.48	46.68	3.31	26.52	4.16	33.27	4.88	39.10	5.92	47.43	6.76	54.17	7.62	60.99
01599-00-OUT_14	20.54	32.0	0.46	42.77	3.28	30.73	4.11	38.56	4.83	45.32	5.86	54.99	6.70	62.82	7.54	70.74
01599-00-OUT_15	23.75	32.5	0.49	48.72	3.25	38.01	4.08	47.70	4.80	56.08	5.82	68.05	6.65	77.75	7.49	87.56
01599-00-OUT_17	2.15	26.4	0.39	31.88	3.64	3.06	4.56	3.84	5.35	4.50	6.48	5.45	7.39	6.22	8.30	6.99
01599-00-OUT_18	2.97	27.1	0.39	32.39	3.59	4.21	4.50	5.27	5.28	6.19	6.40	7.49	7.30	8.55	8.20	9.61
00407-00-OUT_02	2	26.3	0.75	91.17	3.65	5.46	4.57	6.84	5.37	8.02	6.50	9.71	7.41	11.07	8.33	12.44
04926-00-OUT_03	15.75	31.2	0.80	100.00	3.32	41.85	4.17	52.51	4.90	61.71	5.94	74.85	6.78	85.47	7.64	96.22
04926-00-OUT_04	8.6	29.6	0.80	100.00	3.42	23.55	4.29	29.53	5.04	34.69	6.11	42.05	6.98	47.99	7.85	53.99
04926-00-OUT_05	1.65	25.9	0.77	95.05	3.68	4.68	4.61	5.86	5.41	6.88	6.55	8.32	7.46	9.49	8.39	10.66
04926-00-OUT_06	1.39	25.6	0.77	94.96	3.71	3.97	4.64	4.97	5.45	5.83	6.59	7.05	7.51	8.04	8.44	9.03
04926-00-OUT_07	4.7	28.1	0.80	99.75	3.52	13.21	4.41	16.56	5.18	19.45	6.28	23.56	7.16	26.87	8.05	30.22
04926-00-OUT_08	2.25	26.5	0.80	100.00	3.63	6.54	4.55	8.20	5.34	9.62	6.47	11.65	7.38	13.28	8.29	14.92
04926-00-OUT_09	3.76	27.6	0.80	100.00	3.56	10.70	4.46	13.40	5.23	15.74	6.34	19.06	7.23	21.74	8.13	24.44
04926-00-OUT_10	7.16	29.1	0.80	100.00	3.45	19.78	4.33	24.80	5.08	29.13	6.16	35.30	7.03	40.28	7.91	45.31
04926-00-OUT_12	2.14	26.4	0.80	100.00	3.64	6.24	4.56	7.81	5.35	9.17	6.48	11.10	7.39	12.65	8.31	14.22
04926-00-OUT_13	1.26	25.4	0.80	100.00	3.72	3.75	4.66	4.70	5.47	5.51	6.61	6.67	7.54	7.60	8.47	8.54
01599-00-OUT_19	5.88	28.7	0.74	89.17	3.49	15.06	4.37	18.88	5.13	22.17	6.22	26.87	7.09	30.65	7.98	34.48
01599-00-OUT_20	3.99	27.8	0.53	55.77	3.55	7.57	4.44	9.48	5.22	11.13	6.32	13.48	7.21	15.38	8.11	17.29
01599-00-OUT_21	2.92	27.1	0.54	56.01	3.60	5.63	4.50	7.05	5.29	8.28	6.40	10.02	7.30	11.43	8.21	12.85
01599-00-OUT_23	4.35	28.0	0.40	32.82	3.53	6.10	4.43	7.64	5.20	8.98	6.30	10.87	7.18	12.40	8.08	13.95

EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	C	%IMP	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
05419-00-OUT_15	0.35	23.3	0.62	69.91	3.89	0.84	4.87	1.06	5.71	1.24	6.91	1.50	7.87	1.71	8.84	1.92
05419-00-OUT_16	0.63	24.2	0.72	86.11	3.82	1.72	4.78	2.16	5.60	2.53	6.78	3.06	7.72	3.49	8.67	3.92
05419-00-OUT_17	6.99	29.1	0.76	93.20	3.46	18.35	4.33	23.00	5.09	27.01	6.17	32.74	7.04	37.36	7.92	42.02
05419-00-OUT_18	8.45	29.6	0.56	60.75	3.43	16.34	4.30	20.49	5.05	24.07	6.12	29.18	6.98	33.30	7.85	37.46
05419-00-OUT_19	4.7	28.1	0.79	98.14	3.52	13.05	4.41	16.36	5.18	19.21	6.28	23.27	7.16	26.55	8.05	29.85
05419-00-OUT_20	4.07	27.8	0.76	93.02	3.54	10.93	4.44	13.70	5.21	16.09	6.32	19.49	7.20	22.23	8.10	24.99
05419-00-OUT_21	0.66	24.3	0.57	61.49	3.81	1.43	4.77	1.79	5.59	2.10	6.77	2.54	7.71	2.90	8.66	3.25
05419-00-OUT_22	9.52	29.9	0.79	97.99	3.41	25.55	4.27	32.04	5.02	37.64	6.08	45.63	6.94	52.08	7.81	58.60
05419-00-OUT_23	2.09	26.4	0.55	58.33	3.65	4.19	4.57	5.25	5.36	6.16	6.49	7.46	7.40	8.50	8.31	9.56
05419-00-OUT_24	2.01	26.3	0.55	58.33	3.65	4.04	4.57	5.06	5.37	5.93	6.50	7.18	7.41	8.19	8.33	9.20
05419-00-OUT_25	3.39	27.4	0.60	67.06	3.57	7.29	4.48	9.14	5.25	10.73	6.36	13.00	7.26	14.82	8.16	16.66
05419-00-OUT_26	1.15	25.2	0.70	83.92	3.73	3.02	4.67	3.78	5.48	4.44	6.64	5.37	7.56	6.12	8.50	6.87
05419-00-OUT_27	2.04	26.3	0.56	59.76	3.65	4.16	4.57	5.21	5.36	6.11	6.49	7.40	7.40	8.44	8.32	9.48
05419-00-OUT_28	1.21	25.3	0.57	61.09	3.73	2.55	4.67	3.20	5.47	3.75	6.62	4.54	7.55	5.17	8.48	5.81
05419-00-OUT_30	3.76	27.6	0.80	100.00	3.56	10.70	4.46	13.40	5.23	15.74	6.34	19.06	7.23	21.74	8.13	24.44
05419-00-OUT_31	0.38	23.4	0.80	100.00	3.88	1.18	4.86	1.48	5.70	1.73	6.89	2.10	7.85	2.39	8.81	2.68
05419-00-OUT_32	1.31	25.5	0.80	100.00	3.71	3.89	4.65	4.87	5.46	5.72	6.61	6.92	7.53	7.89	8.46	8.86
05419-00-OUT_33	12.53	30.6	0.78	97.14	3.36	32.96	4.21	41.35	4.95	48.58	6.01	58.91	6.86	67.26	7.72	75.70
02458-00-OUT_01	18.67	31.7	0.66	77.21	3.29	40.77	4.13	51.16	4.86	60.13	5.89	72.95	6.73	83.32	7.58	93.81
02458-00-OUT_02	5.77	28.6	0.55	59.03	3.49	11.15	4.37	13.98	5.13	16.42	6.22	19.89	7.10	22.70	7.98	25.53
02458-00-OUT_03	8.73	29.6	0.56	59.17	3.42	16.58	4.29	20.78	5.04	24.41	6.11	29.59	6.97	33.78	7.84	38.00
02458-00-OUT_04	5.71	28.6	0.55	58.33	3.49	10.96	4.37	13.74	5.14	16.13	6.22	19.55	7.10	22.30	7.99	25.08
02458-00-OUT_05	4.44	28.0	0.51	52.36	3.53	8.06	4.42	10.10	5.19	11.86	6.29	14.36	7.18	16.39	8.07	18.42
02458-00-OUT_07	3.69	27.6	0.55	58.33	3.56	7.22	4.46	9.05	5.24	10.63	6.34	12.87	7.23	14.68	8.13	16.50
13301-00-STR_01	1.24	25.4	0.55	58.33	3.72	2.54	4.66	3.18	5.47	3.73	6.62	4.51	7.54	5.14	8.47	5.78
13301-00-STR_02	1.65	25.9	0.55	58.33	3.68	3.34	4.61	4.18	5.41	4.91	6.55	5.94	7.46	6.77	8.39	7.61
13301-00-STR_03	2.05	26.3	0.70	82.72	3.65	5.21	4.57	6.52	5.36	7.66	6.49	9.27	7.40	10.57	8.32	11.88
13301-00-STR_04	3.44	27.4	0.80	100.00	3.57	9.82	4.47	12.31	5.25	14.45	6.36	17.50	7.25	19.96	8.15	22.44
13300-00-STR_01	0.36	23.4	0.55	58.33	3.89	0.77	4.87	0.96	5.71	1.13	6.90	1.37	7.86	1.56	8.83	1.75
13300-00-STR_02	1.12	25.2	0.55	58.33	3.74	2.30	4.68	2.88	5.49	3.38	6.64	4.09	7.57	4.66	8.50	5.24
13300-00-STR_03	1.55	25.8	0.55	58.33	3.69	3.15	4.62	3.94	5.42	4.62	6.56	5.60	7.48	6.38	8.41	7.17
13300-00-STR_04	0.92	24.9	0.55	58.33	3.76	1.90	4.71	2.38	5.53	2.80	6.69	3.39	7.62	3.86	8.56	4.33
13300-00-STR_05	1.22	25.4	0.55	58.33	3.72	2.50	4.66	3.13	5.47	3.67	6.62	4.44	7.55	5.06	8.48	5.69
13300-00-STR_06	1.19	25.3	0.55	58.33	3.73	2.44	4.67	3.06	5.48	3.58	6.63	4.34	7.55	4.94	8.49	5.55
13300-00-STR_07	4.29	27.9	0.80	100.00	3.54	12.13	4.43	15.21	5.20	17.85	6.30	21.63	7.19	24.67	8.08	27.74
13300-00-STR_08	0.83	24.7	0.80	100.00	3.78	2.51	4.73	3.14	5.55	3.68	6.71	4.46	7.65	5.08	8.59	5.71
13300-00-STR_09	4.13	27.8	0.80	99.39	3.54	11.65	4.44	14.60	5.21	17.14	6.31	20.76	7.20	23.68	8.09	26.62
13300-00-STR_10	6.62	28.9	0.55	58.46	3.47	12.64	4.35	15.84	5.10	18.61	6.18	22.55	7.06	25.73	7.94	28.94
13300-00-STR_11	1.51	25.8	0.63	71.30	3.69	3.50	4.63	4.39	5.43	5.15	6.57	6.23	7.49	7.10	8.41	7.98
13300-00-STR_12	1.1	25.2	0.66	76.08	3.74	2.70	4.68	3.38	5.49	3.97	6.65	4.80	7.57	5.47	8.51	6.15
11900-00-GLF_01	177.31	39.9	0.26	10.04	2.89	133.15	3.63	167.54	4.28	197.42	5.21	240.26	5.96	275.14	6.73	310.73
13300-00-OUT_03	159.56	39.4	0.79	97.96	2.91	365.21	3.66	459.46	4.31	541.32	5.24	658.69	6.00	754.18	6.78	851.60

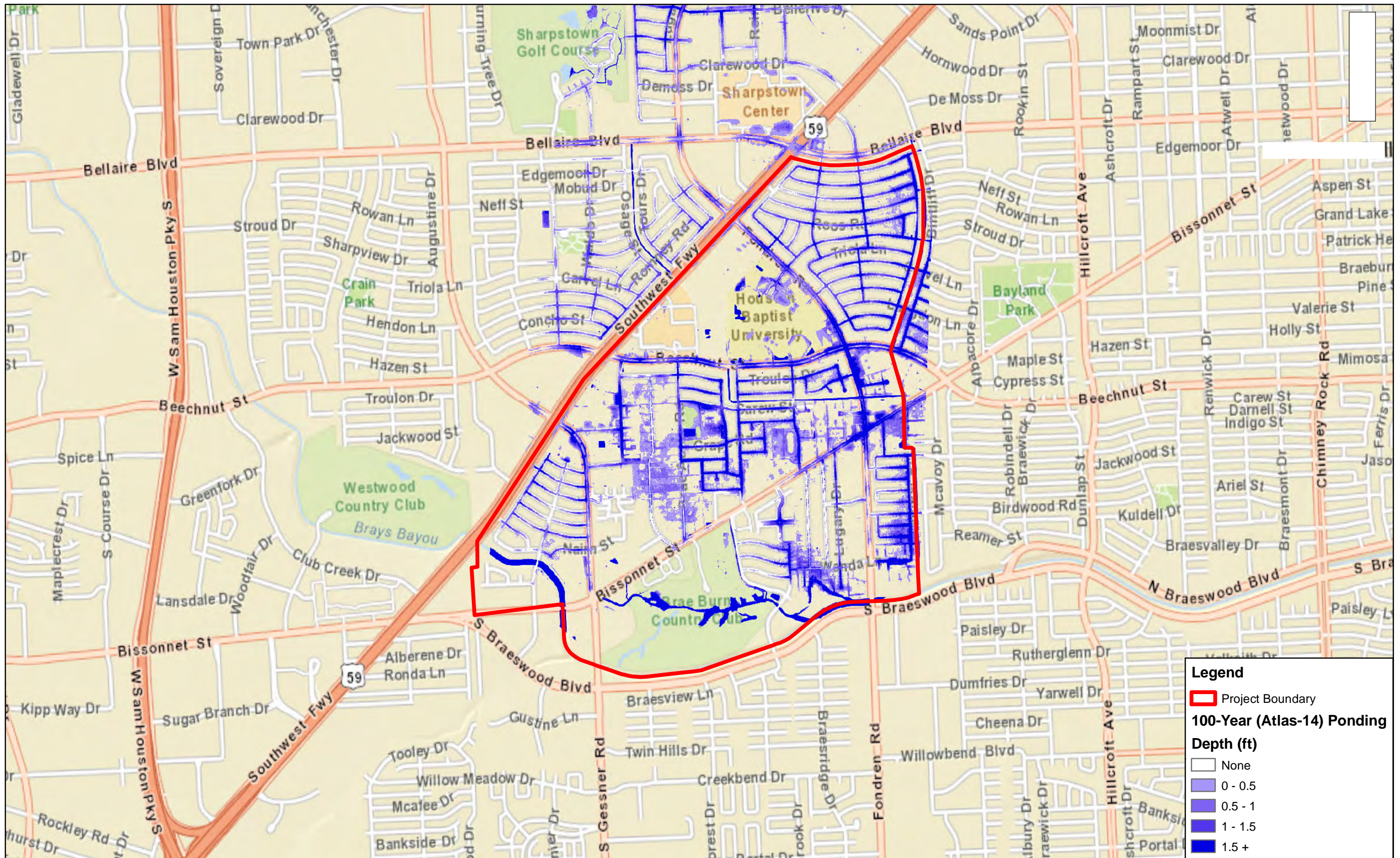
EXHIBIT 5 - Existing Condition Hydrologic Calculations																
Drainage Area	Area (acre)	Tc (min)	<u>C</u>	<u>%IMP</u>	2 year		5 year		10 year		25 year		50 year		100 year	
					Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)	Intensity I (in/hr)	Flow Q (cfs)
13300-00-OUT_02	187.7	40.1	0.68	80.41	2.88	368.30	3.62	463.46	4.26	546.15	5.19	664.75	5.94	761.29	6.71	859.85
13301-00-OUT_01	182.71	40.0	0.30	16.47	2.88	157.26	3.62	197.89	4.27	233.19	5.20	283.82	5.95	325.02	6.72	367.08





Legend

- Project Boundary
- 2-Year (Atlas-14) Ponding Depth (ft)**
- None
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 +



Legend

- Project Boundary
- 100-Year (Atlas-14) Ponding Depth (ft)**
- None
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 +

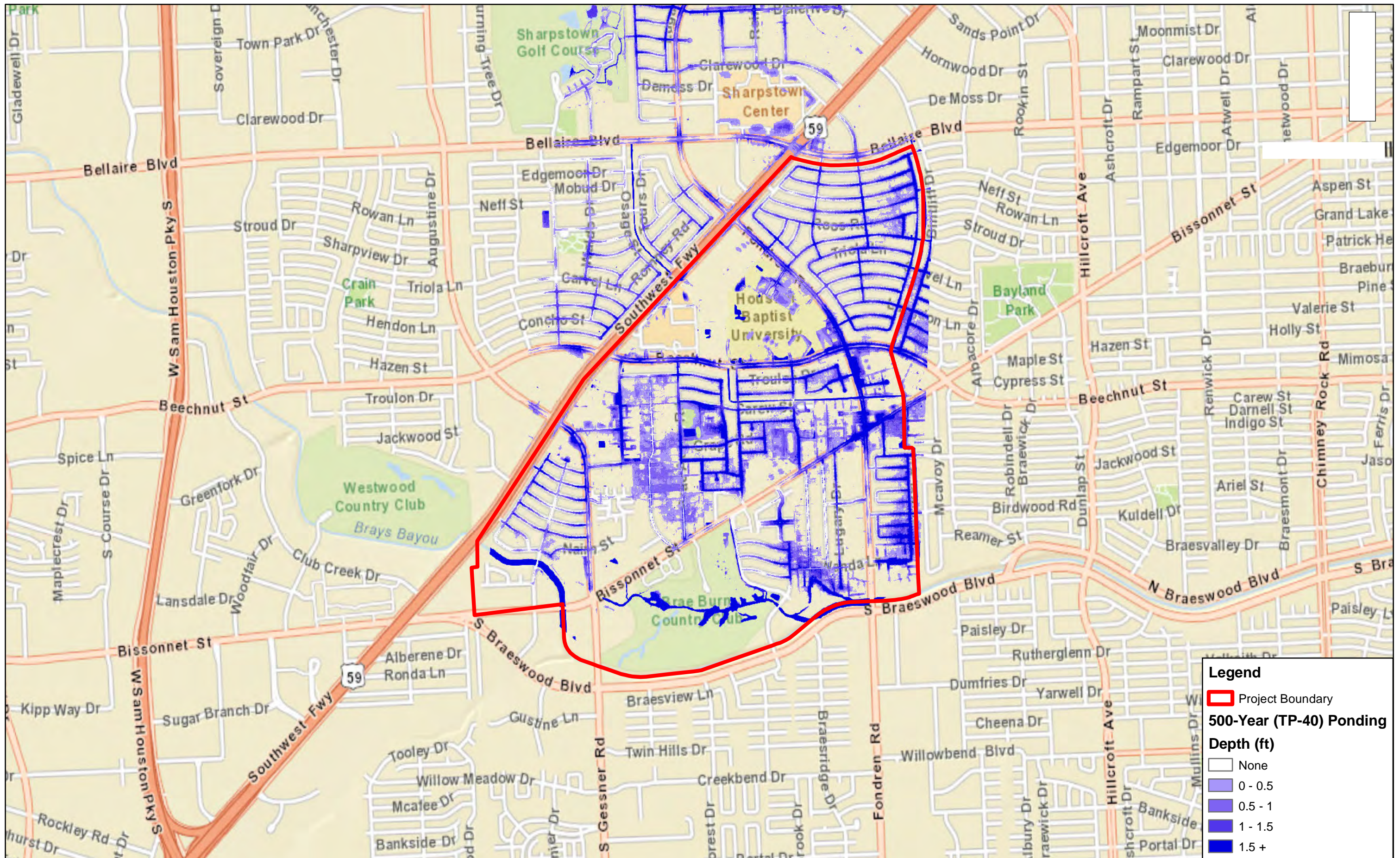


Exhibit 10

Effective vs Duplicate Effective HEC-RAS Profile

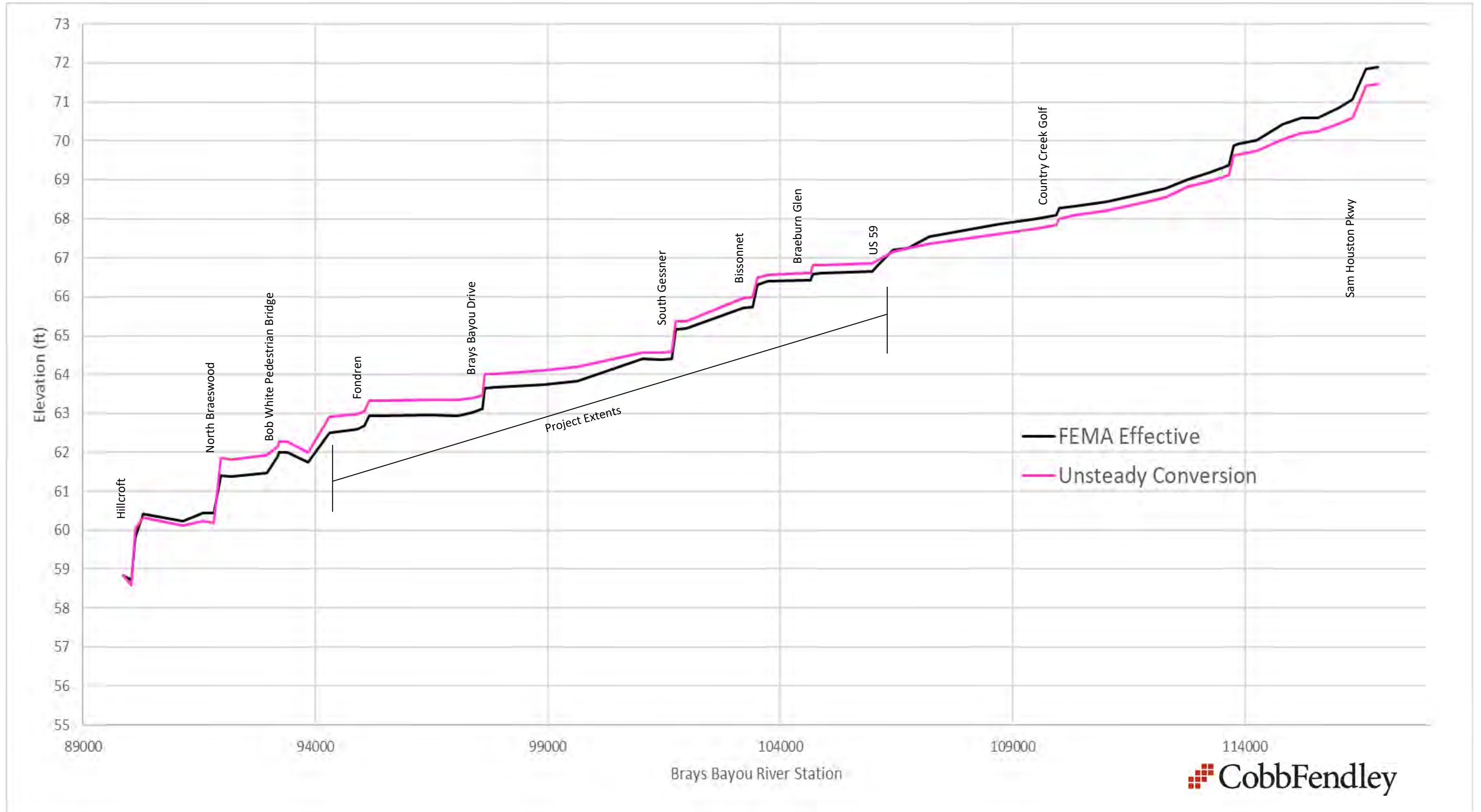
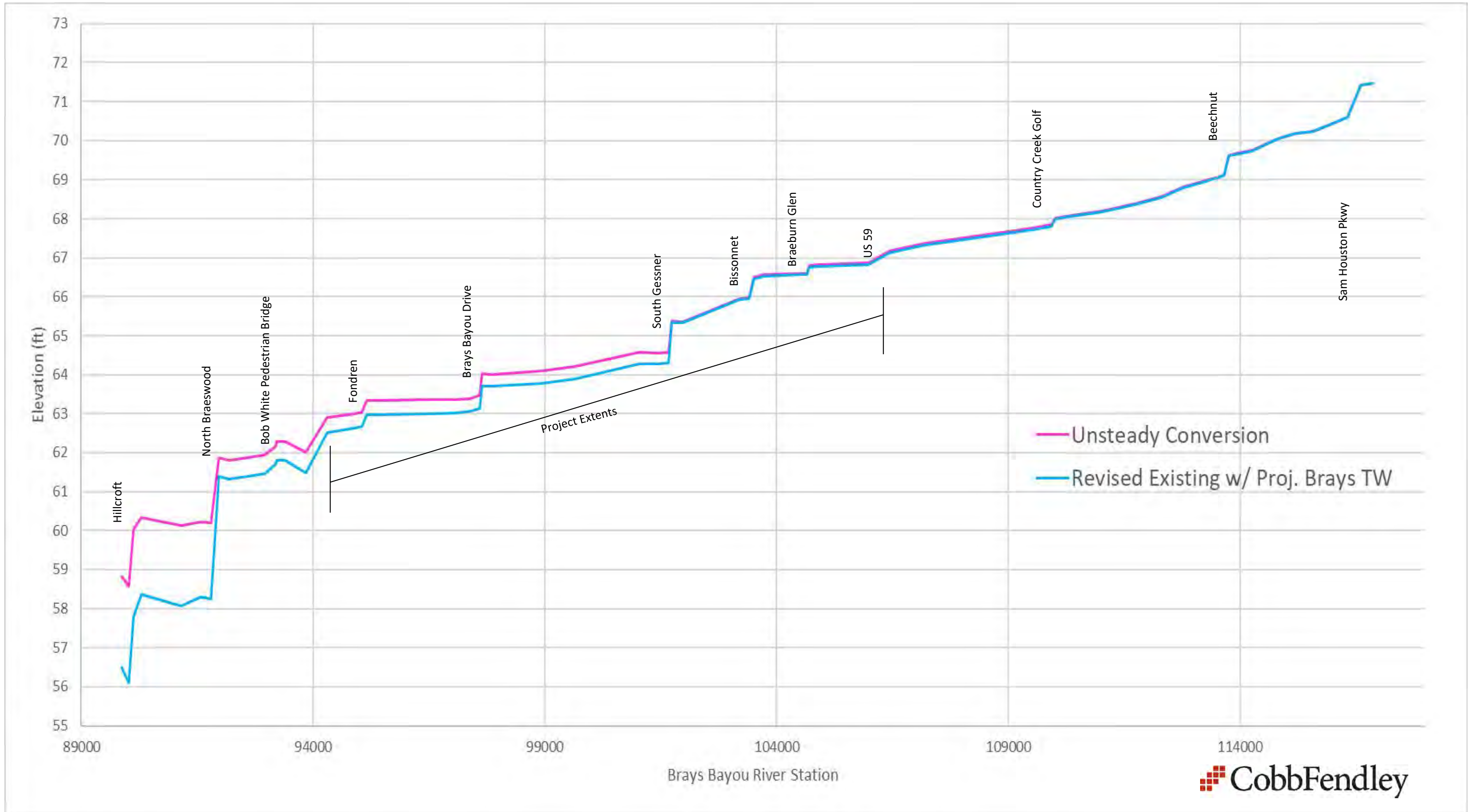
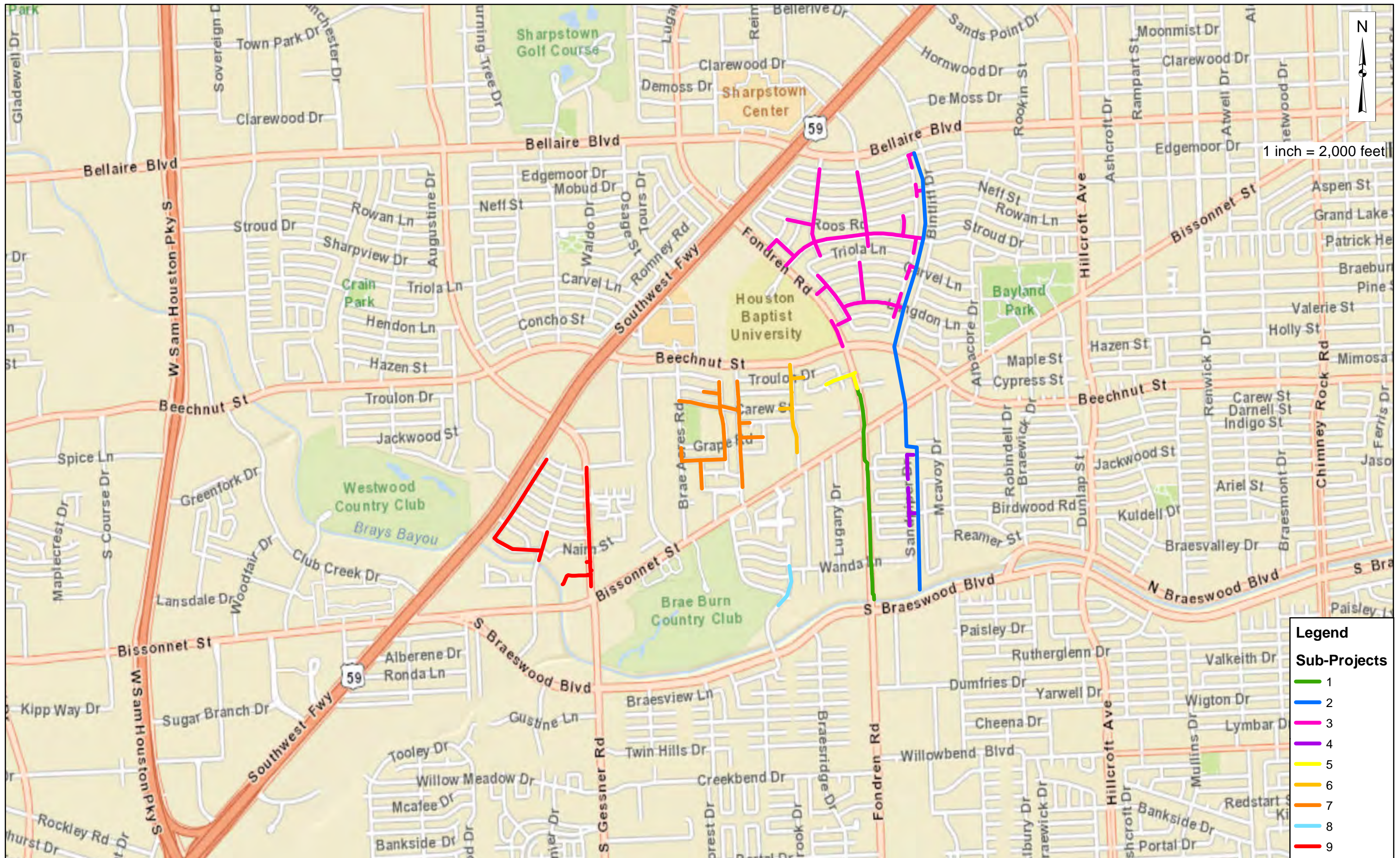
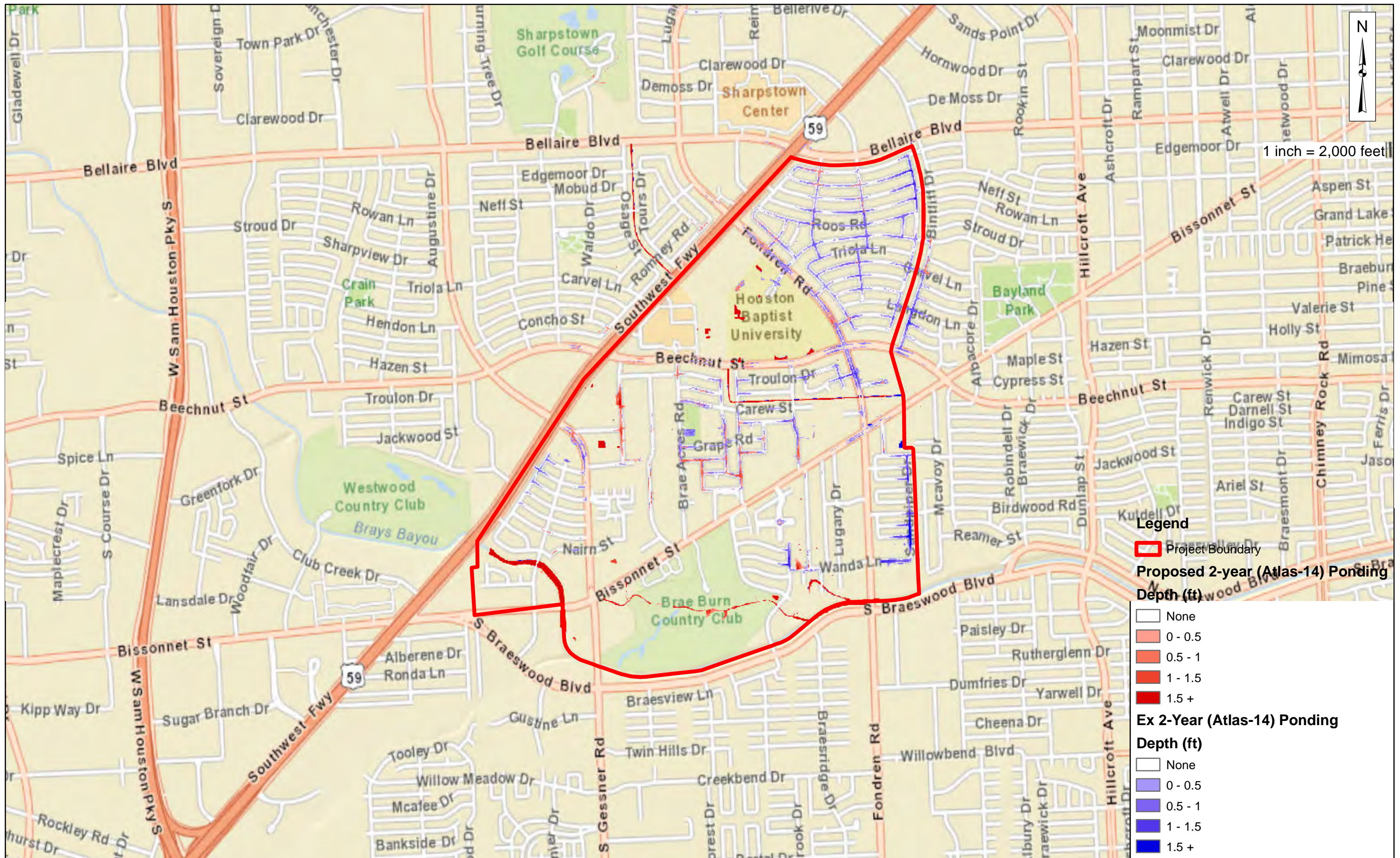


Exhibit 11

Duplicate Effective vs Revised Existing HEC-RAS Profile







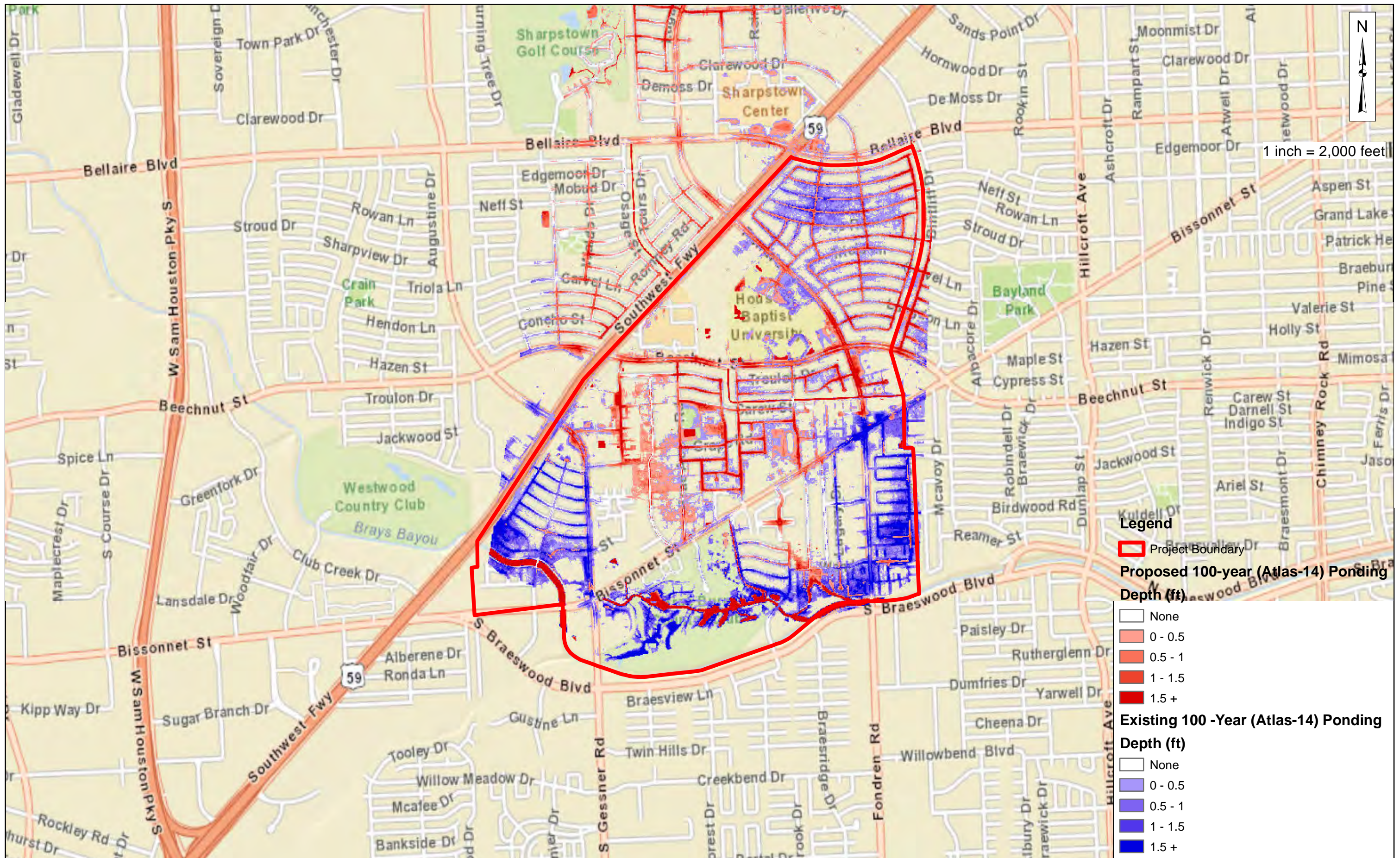
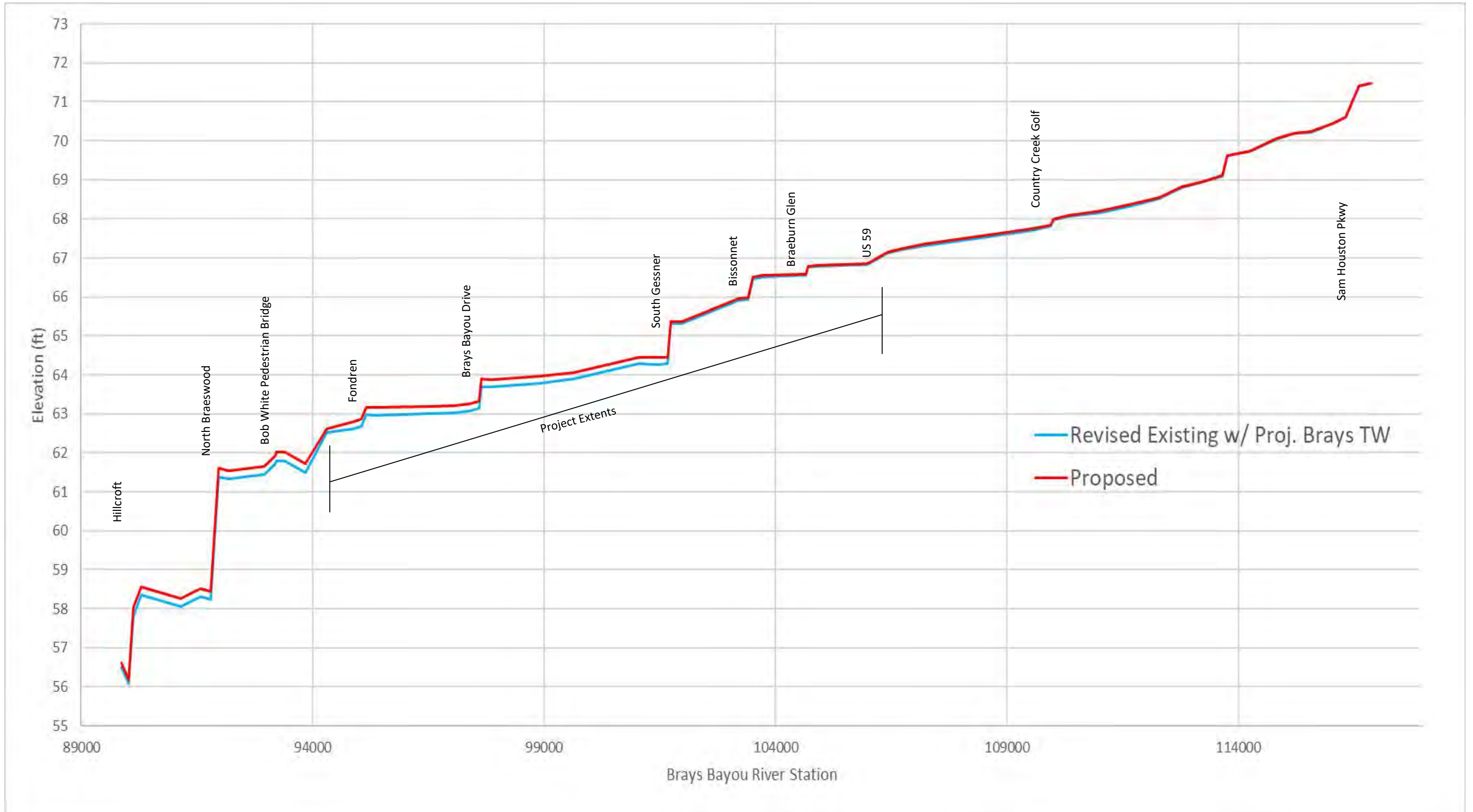
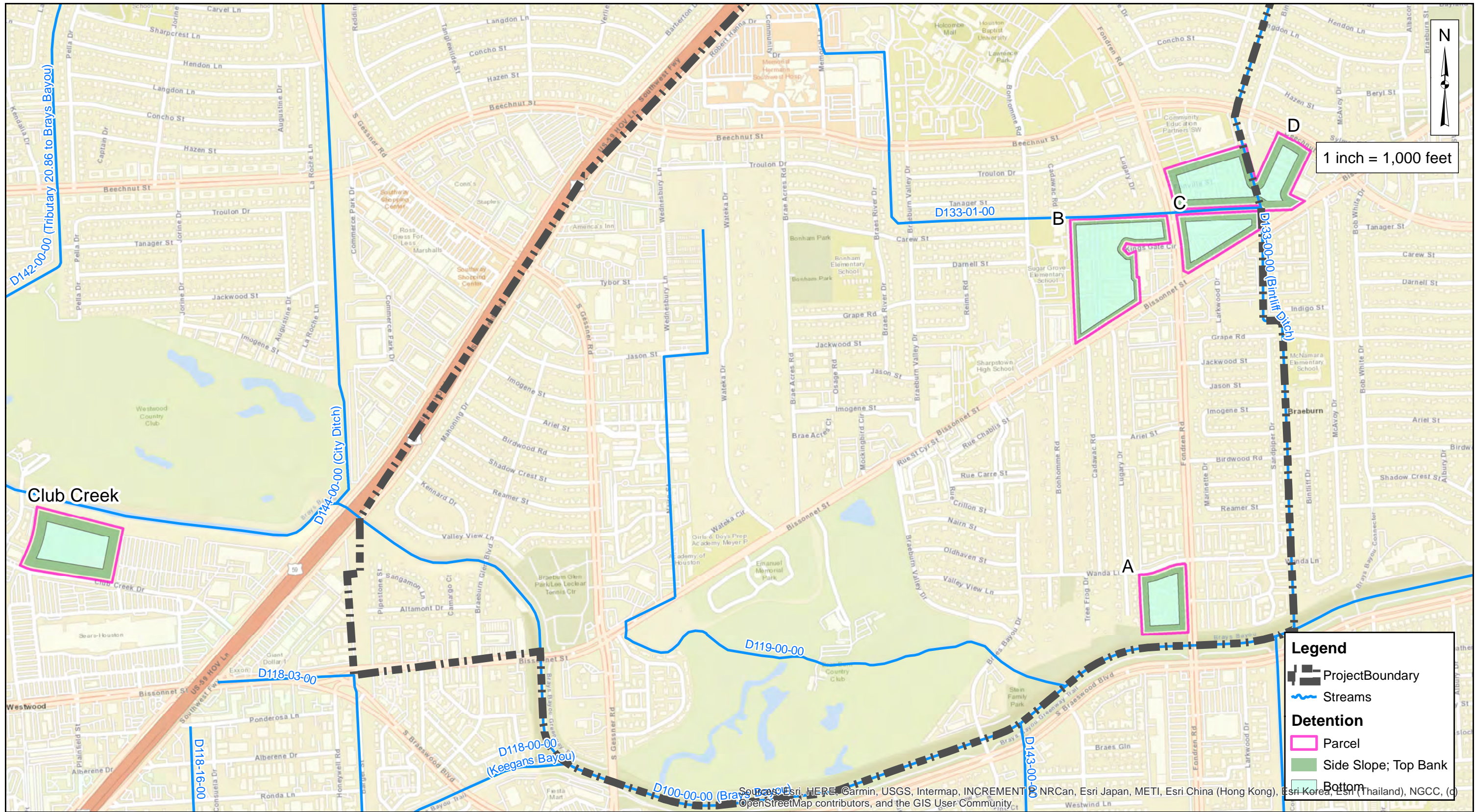


Exhibit 15

Proposed vs Revised Existing HEC-RAS Profiles



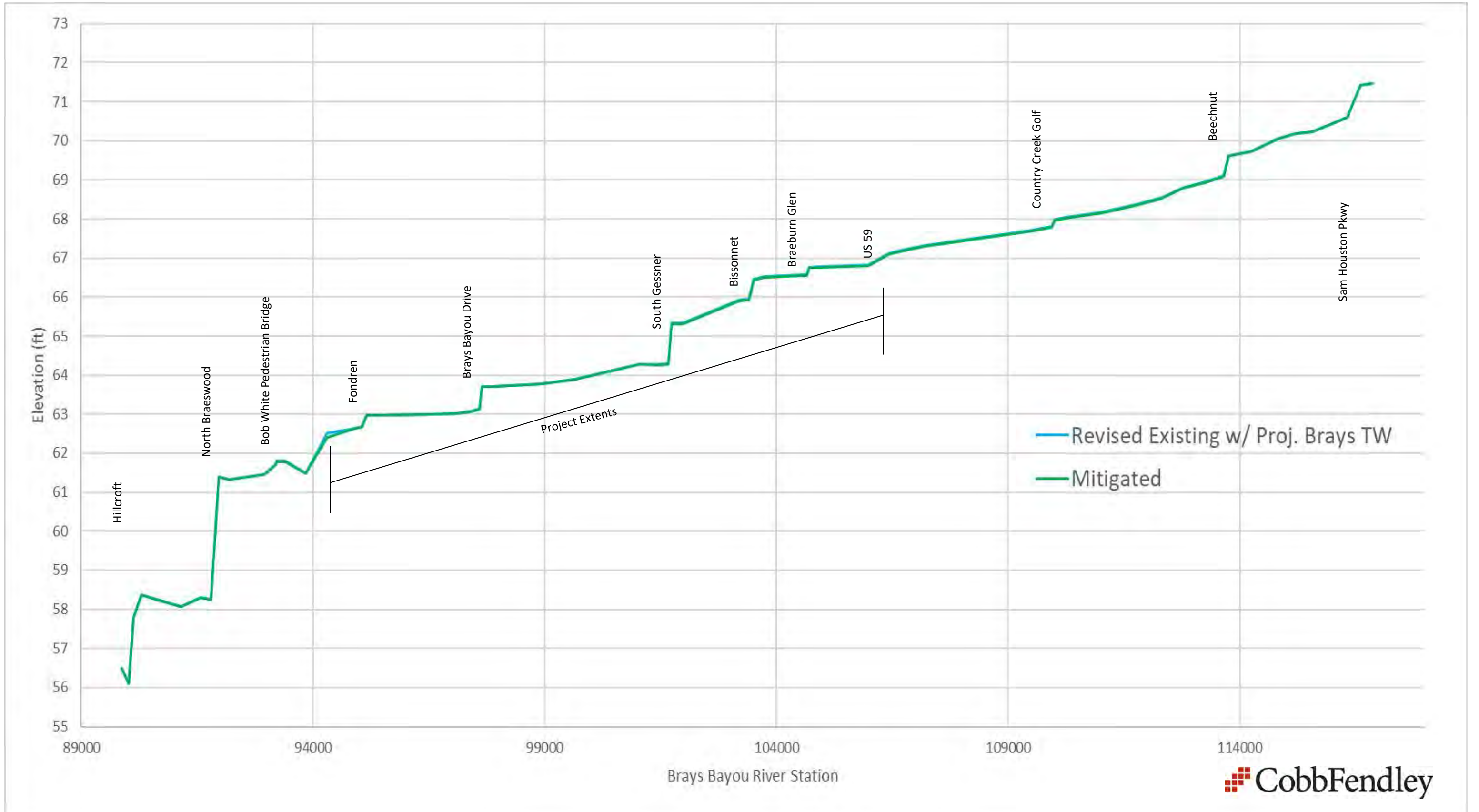


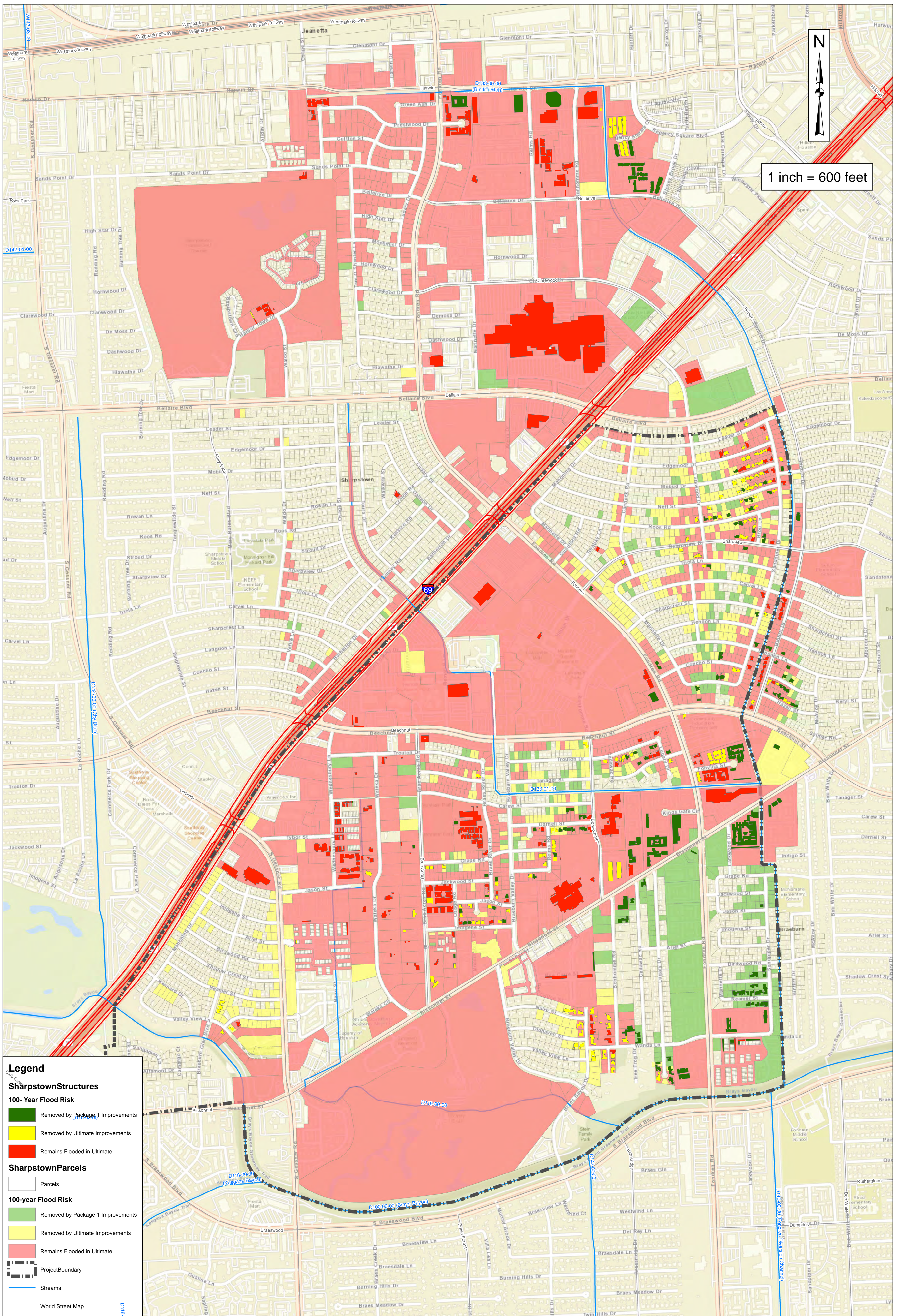
**Sharpstown Drainage Masterplan
Proposed Detention Facilities**

Source: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community.

Exhibit 17

Mitigated vs Revised Existing HEC-RAS Profile





Legend

SharpstownStructures

- Removed by Package 1 Improvements
- Removed by Ultimate Improvements
- Remains Flooded in Ultimate

SharpstownParcels

- Parcels
- 100-year Flood Risk
 - Removed by Package 1 Improvements
 - Removed by Ultimate Improvements
 - Remains Flooded in Ultimate
- ProjectBoundary
- Streams
- World Street Map

Sharpstown

Exhibit 18 Benefitted Parcels and Structures

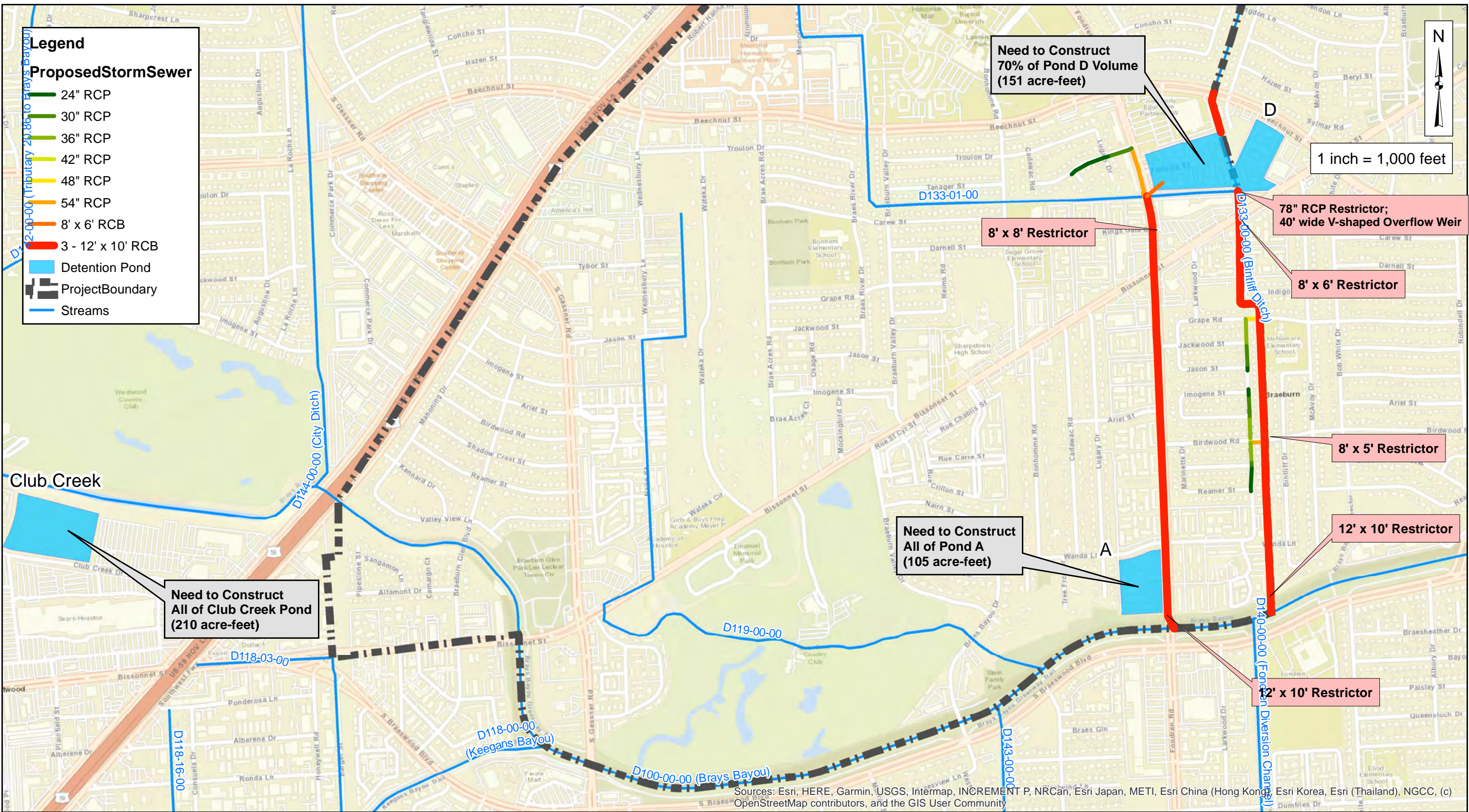
Identified features have at least 3" of ponding touching the parcel or structure boundary during the stated conditions



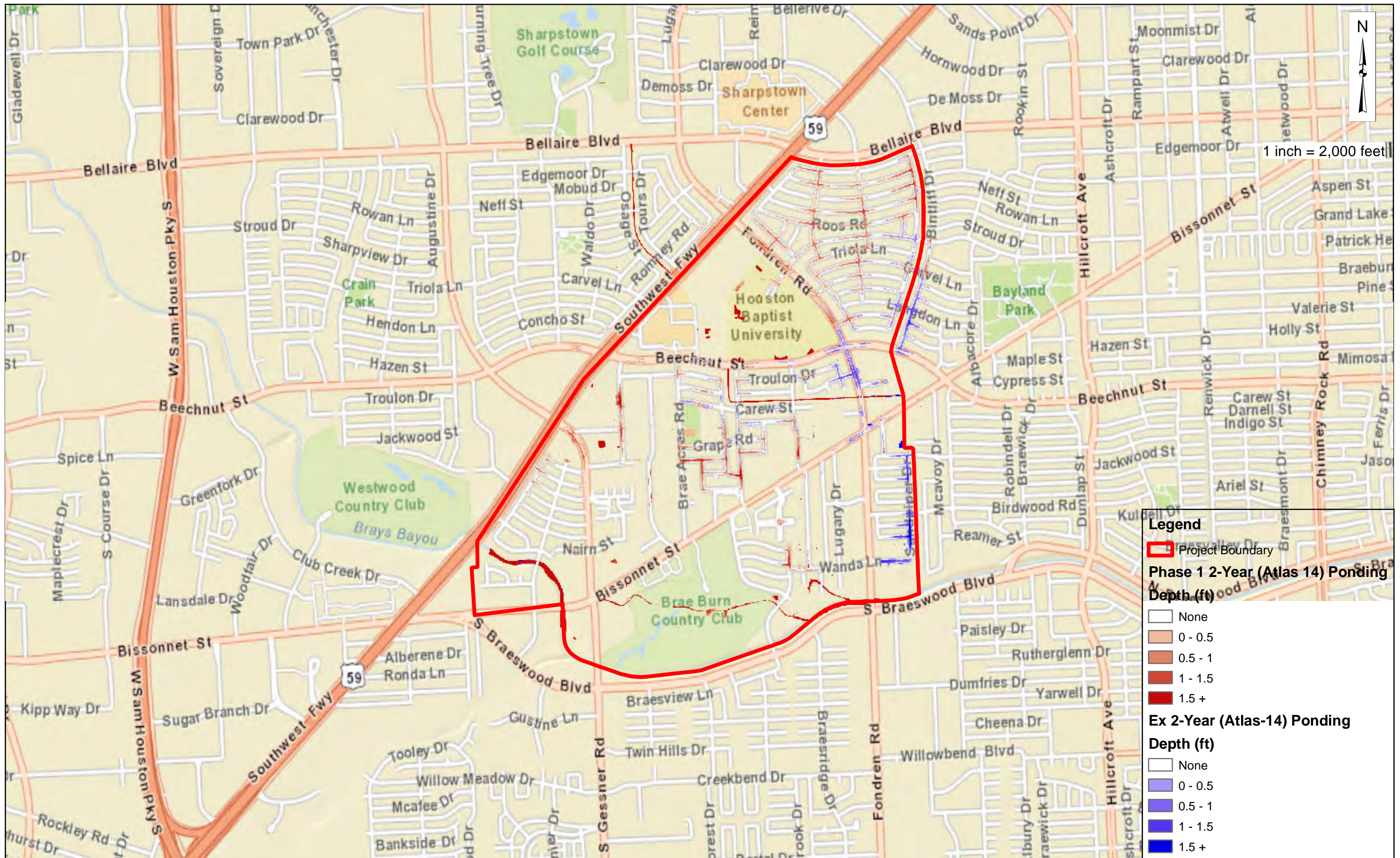
Willow Meadow

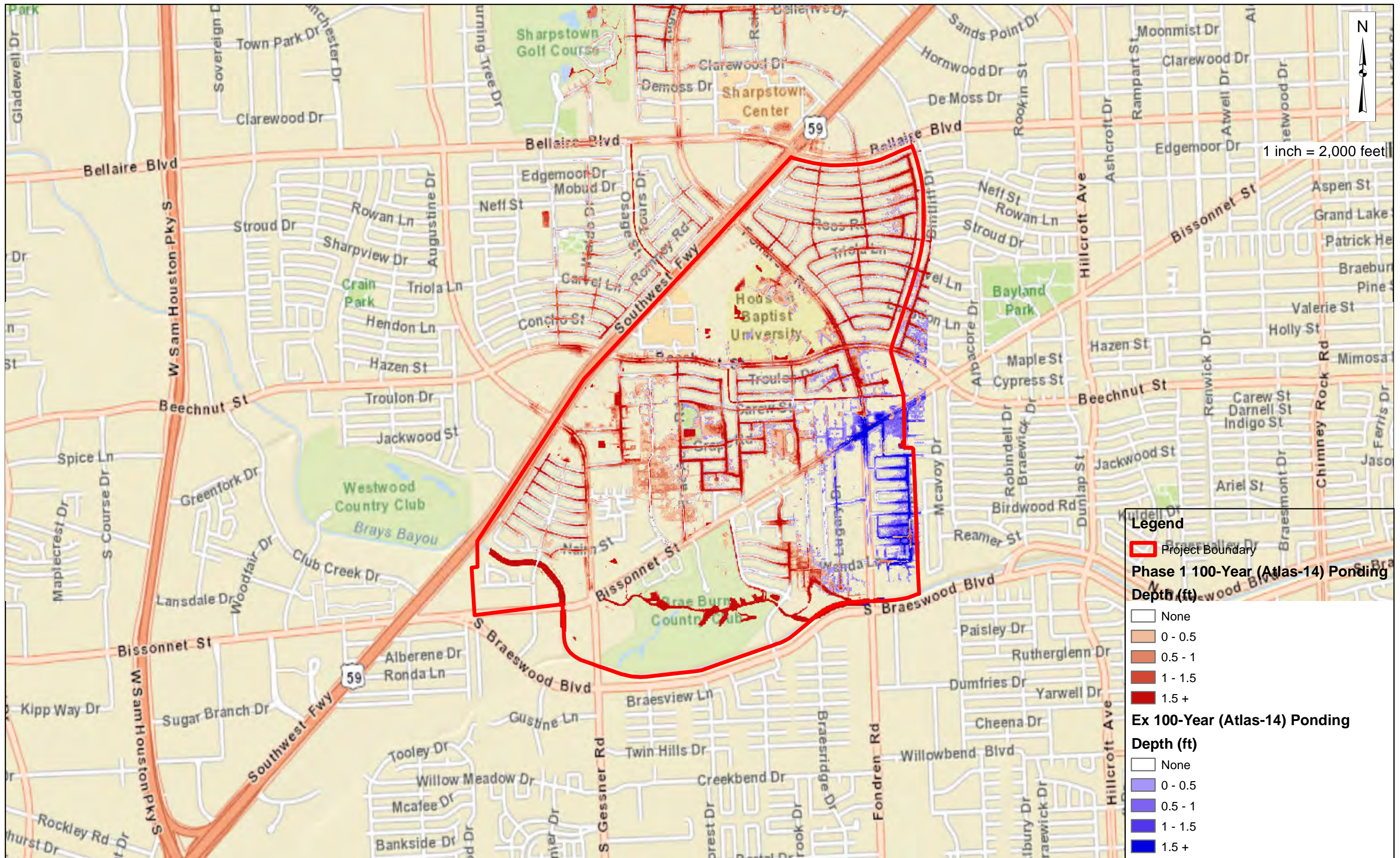
Willow Bend

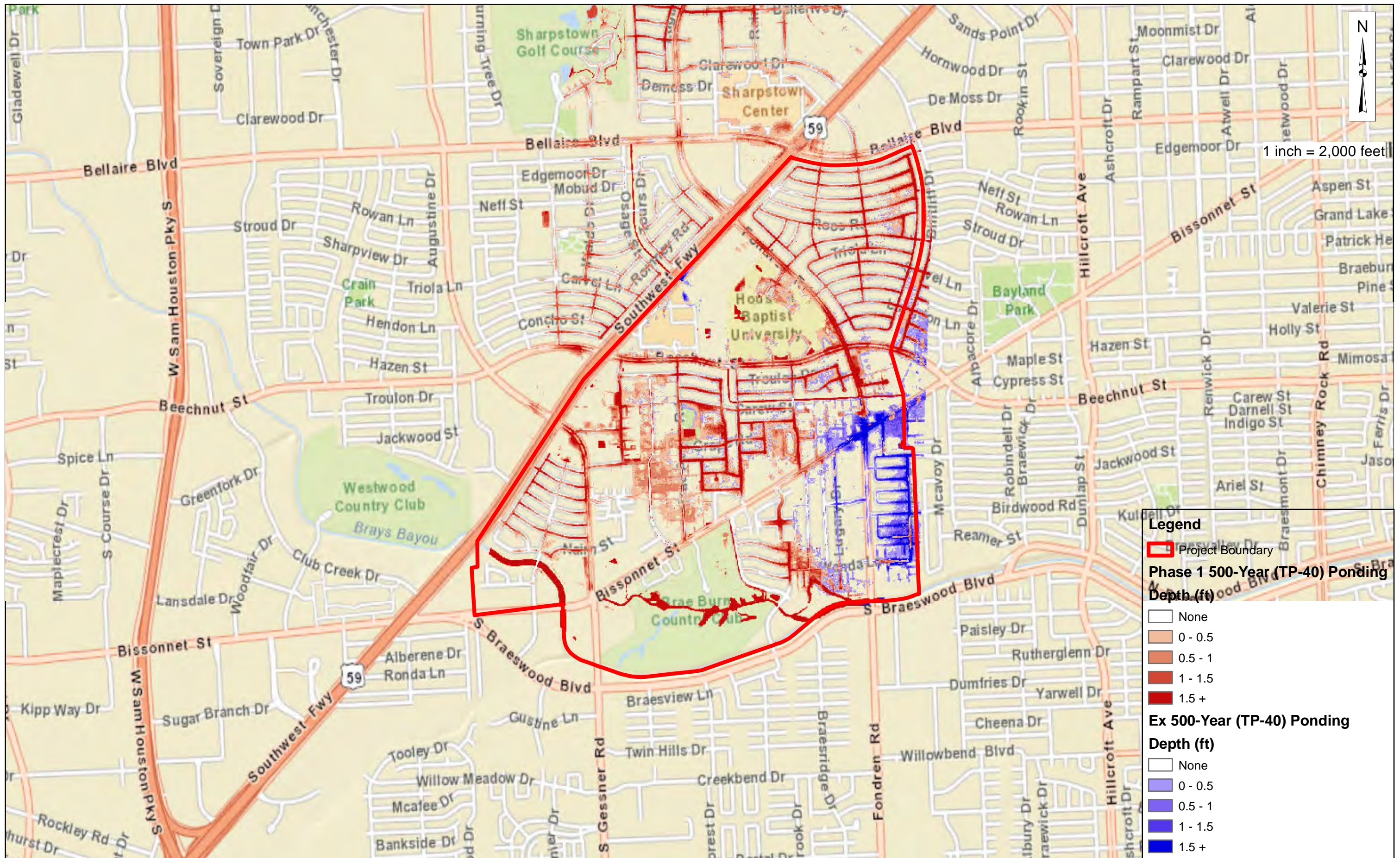
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community







1 inch = 2,000 feet

Legend

Project Boundary

Phase 1 500-Year (TP-40) Ponding Depth (ft)

- None
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 +

Ex 500-Year (TP-40) Ponding Depth (ft)

- None
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 +

**Appendix 5-4AK:
Sims Bayou CDBG-MIT Application Projects**

ATTACHMENT 1C

**PROJECT APPLICATION
SUMMARY FORM**

MITIGATION ACTIVITY:
STORMWATER DETENTION BASIN AND
CHANNEL CONVEYANCE
IMPROVEMENTS ALONG SALT WATER
DITCH

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT

Standard Form for CDBG-MIT Applications

Harris County Flood Control District

General Information

This is an individual Mitigation Activity included in the Sims Bayou Watershed Mitigation Project

Project Information (Individual Mitigation Activities)

Project Name: Stormwater Detention Basin and Channel Conveyance Improvements Along Saltwater Ditch

Project Type: Flood Risk Reduction

Risk Mitigated: Riverine Flooding

Street Address (nearest to project): 7545 Martin Luther King Jr. Blvd.

Street Limits on Street – From Street Airport Blvd – To Street I-610

Zip Code: 77033

City: Houston

County: Harris

State: TX

Latitude (Decimal Degrees – 5 decimal places): 29.67246

Longitude (Decimal Degrees – 5 decimal places): -95.33358

Project Summary Narrative:

The objective of this project is to maximize the stormwater conveyance capacity of Salt Water Ditch (HCFCD Unit # C118-00-00) by converting the existing drainage ditch to a storm sewer enclosure consisting of multiple barrels of Steel Reinforced Polyethylene (SRPE) pipe; and, therefore providing flood reduction benefits. The finished project will achieve a 10-year level of service vs. the current 2-year level of service or less, which frequently causes flooding in the neighborhoods along Salt Water Ditch. A detention pond will also be constructed to mitigate impacts from the project to Sims Bayou due to increased discharge from the improved Salt Water Ditch. The project provides benefits in the 10-year storm event to approximately 2,000 structures and 9 roadways across the Salt Water Ditch watershed.

Historically, structural flooding has been an issue along Sims Bayou and its tributaries. The Salt Water Ditch (HCFCD Unit # C108-00-00) - a sub-watershed of Sims Bayou - has a documented history of street and structural flooding due to an inadequate level of service because of insufficient stormwater conveyance capacity in Salt Water Ditch. This project has been in the study phase for several years by several engineering consultants and agencies, and is ready to

move forward with the design and construction to provide flood risk reduction for the area of Salt Water Ditch.

- In February 1989, HCFCF retained Dodson and Associates to prepare a Preliminary Design Report of Channel Improvements for Salt Water Ditch. This report analyzed the existing conditions of Salt Water Ditch and proposed two alternatives to improve the capacity of the channel. The two alternatives consisted of channel improvements from the confluence with Sims Bayou (HCFCF Unit # C100-00-00) to the upstream limits of the ditch at Calhoun Road. The majority of channel improvements proposed for both alternatives included a concrete channel section.

- In June 2010, HCFCF prepared a HCFCF Internal Reconstruction Report for Salt Water Ditch. This report presented the existing flooding issues along Salt Water Ditch and offered two alternatives with either a 10-year or 25-year level of service. For the two alternatives, channel improvements were proposed from Martin Luther King Jr. Blvd to either Vasser Road or the confluence of Sims Bayou.

- In February 2016, the City of Houston and HCFCF retained CivilTech to perform a study of potential flood mitigation strategies for Salt Water Ditch which CivilTech recommended two improvement options as follows.

- 1) Widen the existing channel to a proposed trapezoidal channel with a minimum of 6-foot bottom width and 4H:1H side slopes throughout the entire length of Salt Water Ditch to achieve a 100-year level of service.

- 2) Install closed conduit drainage system in lieu of channel improvements for the portion of Salt Water Ditch upstream of Martin Luther King Jr. Blvd. The size of the closed conduit ranges from 3-12'x8' RCB's to 3-12'x10' RCB's; downstream of Martin Luther King Jr. Blvd the closed conduit system would transition to the proposed improved channel. This option was proposed to reduce the ROW acquisition.

- In April 2018, the City of Houston again retained CivilTech to perform an addendum to the previous study for Salt Water Ditch which CivilTech recommended two additional improvement options to further reduce the ROW acquisition.

- 1) Install a closed storm sewer system consisting of 2-6'x6' RCB's, 2-8'x6' RCB's, 2-8'x8' RCB's, 2-10'x8' RCB's with a ditch above to provide a 5-year level of service.

- 2) Install a closed storm sewer system consisting of 2-6'x6' RCB's, 2-8'x6' RCB's, 2-8'x8' RCB's, 2-10'x8' RCB's, 2-10'x10' RCB's with a ditch above to provide a 10-year level of service.

Recently, Harris County Engineering Department retained WSB dba NAK with the assistance of GAUGE to perform the final drainage study for Salt Water Ditch with the newest adopted ATLAS-14 drainage requirements. The team recommends a new piping technology known as Steel Reinforced Polyethylene (SRPE) Pipe consisting of 2-84", 2-108", 3-108", 3-120" pipes which are less expensive than the concrete storm sewer products. In addition, the construction will be faster as SRPE pipes can be fabricated in longer sections and they are lighter in weight. This new drainage system will convey stormwater more efficiently and provide a 10-year level of service from Calhoun Road to Van Fleet Street, a 25-year level of service from Van Fleet Street to Bellfort Avenue; 100-year level of service from Bellfort Avenue to Vasser Road, and 500-year level of service from Vasser Road to Sims Bayou.

Describe how the risk listed above is currently affecting the project area:

Without any improvements to Salt Water Ditch, many properties along the Salt Water Ditch and those neighborhoods that have storm sewer outfalls connected to Salt Water Ditch will continue to experience frequent flooding at a significantly low-level storm events (2-year event or less). This level of flooding inhibits community development.

How will the Project mitigate against the risk listed above?

By installing the new underground storm sewer enclosure along Salt Water Ditch and constructing a new detention pond south of Sim Bayou east of Salt Water Ditch, it will reduce the flood risks within the Salt Water Ditch watershed while not causing adverse impacts to Sims Bayou.

Does the project enhance any other mitigation efforts already underway?

This project could help to provide storage to mitigate some of the City of Houston's plans to improve the neighborhood drainage systems in the area. Currently, the City of Houston is conducting a drainage study in the same project area, where several storm sewer outfalls to Salt Water Ditch could be upsized or combined in order to effectively convey stormwater into the new storm sewer enclosure. Together with the other mitigation activities included in the Sims Bay Watershed Mitigation Project, this activity will bring significant flood risk reduction benefits to the residents of the Sims Bayou watershed.

Have you procured construction services for the proposed project? No

What is the construction completion method to be used? Competitive Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required? Yes

If yes: Provide the Estimated Number of Parcels: 1

What is the status of the acquisition? Continue coordination with the City of Houston

Provide a brief narrative describing the acquisition activities required: It is anticipated that a parcel will be acquired to provide for the required stormwater detention volume to mitigate the project.

Congressional Representative District #: 9

State Representative District #: 147

State Senator District #: 13

Eligibility Check

- Meets HUD's definition of mitigation activities
 - **Long-term Vulnerability Reduction, Community Resilience**

Figure 2-14: The Aspects of Mitigation



- Meets GLO Application project definition
 - Reducing risk of natural hazards through infrastructure improvements
- Addresses identified current and future risks; (NOTE: identified risks change per program)
 - This project will reduce the current and future risk of flooding due to heavy rainfall
- Meets the definition of a CDBG-eligible activity under Title I of HCDA or otherwise pursuant to a waiver or alternative requirement
 - Construction of public works
- Meets a CDBG National Objective; as amended for MIT funds
 - LMI National Objective
- Includes a plan for the long-term funding and management of the operations and maintenance of the project
 - HCFCFCD operates, inspects, and maintains a vast network of nearly 2,500 miles of stormwater conveyance channels and detention basins across Harris County. The proposed basin and feeder lines will be owned, inspected and maintained by HCFCFCD as part of their ongoing process.
- Cost verification controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction
 - All construction contracts will be advertised and bid publicly through Competitive Sealed Bid/Contract, in accordance with Texas State Law and Local laws and policies.

Locally Adopted Plan

Name of Local Adopted Plan: Harris County Flood Control District 2018 Bond Program for Flood Risk Reduction and Resilience

Is a copy of the plan attached? YES

Year plan was adopted: 2018 (Updated May 2020)

project page number in plan: 19 of 67 (Bond ID C-08)

Added Resiliency Measures

This project following construction will provide resiliency to flooding for the benefit area. This project will be designed and constructed in manner to provide resiliency of the improvements and provide for improved access for maintenance.

Historically, structural flooding has been an issue along Sims Bayou and its tributaries. The Salt Water Ditch (HCFCU Unit # C108-00-00) - a sub-watershed of Sims Bayou - has a documented history of street and structural flooding due to an inadequate level of service because of insufficient stormwater conveyance capacity in Salt Water Ditch. This project has been in the study phase for several years by several engineering consultants and agencies, and is ready to move forward with the design and construction to provide flood risk reduction for the area of Salt Water Ditch.

Covered Projects (Harvey Only)

Is this a Covered Project? yes

Brief Project Description: See watershed project level summary

See "Eligibility Check" section for justification for amendment to State Action Plan.

Benefit Cost Analysis (Harvey Only)

Project Benefits: See watershed project level summary

Project Cost: See watershed project level summary

Calculated BCR: See watershed project level summary

Description of benefit cost analysis methodology: See watershed project level summary

Citizen Participation Plan

Date Project was first posted for public comment? October 3, 2020

Date Project was last posted for public comment? TBD

Were any comments received from the public? TBD

Were responses provided to all public comments within 15 days of receipt? YES

The final plan will be included with the application once the public comment period is complete.

Grant Management Plan

See watershed project level summary

Beneficiary Data

See watershed project level summary

Environmental Clearance

Is this an Aggregate Project (multiple activities)? YES

Type of Aggregation (if applicable): Geographic Aggregation

What is the current status of the project? Completed.

Brief Project Narrative: The objective of this project is to maximize the stormwater conveyance capacity of Salt Water Ditch (HCFCD Unit # C118-00-00) by converting the existing drainage ditch to a storm sewer enclosure consisting of multiple barrels of Steel Reinforced Polyethylene (SRPE) pipe; and, therefore providing flood reduction benefits. The finished project will achieve a 10-year level of service vs. the current 2-year level of service or less, which frequently causes flooding in the neighborhoods along Salt Water Ditch. A detention pond will also be constructed to mitigate impacts from the project to Sims Bayou due to increased discharge from the improved Salt Water Ditch. The project provides benefits in the 10-year storm event to approximately 2,000 structures and 9 roadways across the Salt Water Ditch watershed.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No

If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A

Is the proposed project site likely to require a historical resources/archaeological assessment? N/A

If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: The area associated with the potential historical resource and archaeological issue has been identified. A preliminary design study regarding the construction of the proposed improvements has been investigated to avoid disturbance to this area. It's not anticipated that additional archaeological assessment will be required.

Is the proposed project site listed on the National Register of Historic Places? No

If yes, provide a brief narrative explaining how the historic site will be impacted: N/A

Is the proposed project site in a designated flood hazard area or a designated wetland? Yes

Is the applicant participating in the National Flood Insurance Program? Yes

Is the project in a designated Regulatory Floodway? Yes

Is the proposed project site located in a known critical habitat for endangered species? No

Is the proposed project site a known hazardous site? No

Is the proposed project site located on federal lands or at a federal installation? No

If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

What level of environmental review is likely needed for the proposed project site? Environmental Assessment

Provide a brief narrative to include any additional detail or information relevant to Environmental Review: A Cultural Resource Desktop Assessment, a Threatened and Endangered Species Assessment, a Wetlands Delineation and Jurisdictional Determination, and Phase 1 and Phase 2 ESA reports are completed for this project as part of the due diligence for environmental assessments. Only one site at 7535 Martin Luther King Jr. Blvd was identified with recognized environmental conditions (REC). It was recommended that a Soil and Groundwater Management Plan (S&GMP) be prepared prior to initiation of construction activities near this site. Another environmentally sensitive area is the F.M. Law Park on the east side of Salt Water Ditch between Vasser Road and Sims Bayou. Based on the Cultural Resource Desktop Assessment reviews, F.M. Law Park and its golf course was a historic Prison Farm where remnants of structures, intact archeological deposits or materials may have been associated with the Prison Farm system. The proposed improvements of Salt Water Ditch between Vasser Road and Sims Bayou will remain within the existing 60-foot drainage easement with some minor regrading to the ground adjacent to F.M. Law Park. No deep excavation will be performed on F.M. Law Park; therefore, it should not create any environmental or archaeological impacts to this area. No wetland and critical habitat were found within the project limits.

Affirmatively Furthering Fair Housing

See watershed project level summary

Scoring Criteria

See watershed project level summary

List of Attachments

See watershed project level summary

ATTACHMENT 1

PROJECT APPLICATION SUMMARY FORM

**SIMS BAYOU WATERSHED
MITIGATION PROJECT**

Standard Form for CDBG-MIT Applications

Harris County Flood Control District

General Information

CDBG-MIT Program: Hurricane Harvey State Mitigation Competition – HUD MID

Individual or Shared (Harvey Only): Individual

Applicant (Primary): Harris County Flood Control District

SubApplicant (Secondary): _____

FY End Date: 2/28/2020

Council of Governments: Houston-Galveston Area Council (HGAC)

Contact: Alan Black, PE (HCFCD)

Authorized Representative: Alan Black, PE

Grant Administrator: Chris Fenner (Stuart Consulting)

Project Information

Project Name: Sims Bayou Watershed Mitigation Project

Project Type: Mitigation

Risk Mitigated: Riverine Flooding

Street Address (nearest to project): See individual mitigation activity summary documents attached

Street Limits on Street – From Street See Indiv. Activities – To Street See Indiv. Activities

Zip Code: See Individual Activities

City: See Individual Activities

County: Harris

State: TX

Latitude (Decimal Degrees – 5 decimal places): See Individual Activities

Longitude (Decimal Degrees – 5 decimal places): See Individual Activities

Project Summary Narrative:

Summary

Subdivisions and businesses throughout the Sims Bayou Watershed in Harris County Experience localized and regionalized flooding conditions during hurricanes, tropical storms, and even

intense rainfall events that overwhelm the existing drainage and flood control systems, resulting in riverine, or out-of-bank, flooding of the local bayous, tributaries, and drainage channels. The risk of flooding is a daily threat to the residents that live in areas with aging and inadequate drainage systems. The individual mitigation activity sites identified throughout this application are part of an organized county-wide effort to analyze infrastructure shortfalls, build community resilience, and mitigate future hazards through flood risk reduction projects and strict floodplain management practices. The project sites described in this application benefit many residents in some of the most vulnerable and at-risk areas of the County.

Residents within the aforementioned watershed most recently experienced structural flooding damage during Tropical Storm Imelda in 2019. The most notable, though, was Hurricane Harvey in 2017 where estimates indicate that flooding damages exceeded \$125 billion. Harris County's housing flood insurance claims exceeded \$2.9 billion (over 47,000 homes), and FEMA individual assistance claims was estimated at \$4.6 billion (177,600 claims). The estimated residential losses within Harris County include 154,170 flooded homes and 36 flood related deaths. Additionally, more than 300,000 vehicles were flooded across Harris County, many of which were at homes, parking garages and dealership lots.

While Hurricane Harvey is viewed as the most disastrous flood on record in Harris County, other similar type flooding occurred in the area over the past five years. The Memorial Day Flood (May 25-27, 2015) flooded over 6,000 structures and the Tax Day Flood (April 17-18, 2016) flooded 9,820 structures. More recently, Tropical Storm Imelda (September 17-19, 2019) brought more than 30 inches of rain to the area, resulting in a death and several hundred high-water rescues. A portion of the losses are located within the FEMA designated floodplain, which is anticipated during rainfall events of this magnitude, but a large portion of the flooded population are located outside of those typical flood prone areas.

The prevalence of residential losses outside the regulated floodplain spurred local investment into drainage studies to identify drainage infrastructure problems, propose solutions to mitigate future flooding, and estimate project costs. The studies determined that while the existing flood control measures were built according to the standards and regulations at the time, continued development in Harris County has increased the stormwater runoff and over-burdened the existing system. Several projects have been identified throughout the County and this Watershed to increase channel conveyance and to provide increased stormwater detention to help protect the communities within the watershed from future flood risk.

The massive and long-term financial commitment is recognized locally, and the mitigation activities included in this application were approved for funding in the 2018 Harris County Flood Control District Bond Program. While some funding was earmarked for these subdivision drainage sites and is currently being used to fund the engineering study and design, the bond funding is not adequate to construct the required improvements. As a result, Harris County and Harris County Flood Control District are in dire need of additional funding to help address these urgent concerns. Income and need were factors when selecting projects for inclusion in the Bond program and the improvements were designed to assist low- and moderate-income persons/communities.

The Sims Bayou Watershed Mitigation Project is comprised of 3 individual mitigation activities:

South Post Oak SWDB and Channel Improvements

South Shaver Detention Basin C506-01-00-E0003

Stormwater Detention Basin and Channel Conveyance Improvements Along Saltwater Ditch

Project Area

The activity sites included in this application were selected because the proposed improvements will result in increased resilience and reduction of the long-term risk for loss of homes and contents, injury or loss of life. The sites were also chosen as they are located in a designated most impacted and distressed area (MID). Additionally, these sites qualify for a CDBG eligible activity, Flood and Drainage Facilities, and meet the low to moderate income national objective.

Included with this package are summaries of each mitigation activity site, the unique challenges each area faces, and the creative solutions to bring reduced flood risks to the watershed.

Describe how the risk listed above is currently affecting the project area: See indiv. activity narratives

How will the Project mitigate against the risk listed above? See individual activity narratives.

Does the project enhance any other mitigation efforts already underway? See indiv. activity narratives.

Have you procured construction services for the proposed project? No _____

What is the construction completion method to be used? Competitive Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required? See individual site narratives

If yes: Provide the Estimated Number of Parcels: _____ See individual activity narratives

What is the status of the acquisition? See individual activity narratives

Provide a brief narrative describing the acquisition activities required: See individual activity narratives

Congressional Representative District #: 9 & 29

State Representative District #: 131, 145, & 147

State Senator District #: 6 & 13

Eligibility Check

- Meets HUD's definition of mitigation activities
 - **Long-term Vulnerability Reduction, Community Resilience**

Figure 2-14: The Aspects of Mitigation



- Meets GLO Application project definition
 - Reducing risk of natural hazards through infrastructure improvements
- Addresses identified current and future risks; (NOTE: identified risks change per program)
 - This project will reduce the current and future risk of flooding due to heavy rainfall
- Meets the definition of a CDBG-eligible activity under Title I of HCDA or otherwise pursuant to a waiver or alternative requirement
 - Construction of public works
- Meets a CDBG National Objective; as amended for MIT funds
 - LMI National Objective
- Includes a plan for the long-term funding and management of the operations and maintenance of the project
 - HCFCD operates, inspects, and maintains a vast network of nearly 2,500 miles of stormwater conveyance channels and detention basins across Harris County. The proposed basin and feeder lines will be owned, inspected and maintained by HCFCD as part of their ongoing process.
- Cost verification controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction
 - All construction contracts will be advertised and bid publicly through Competitive Sealed Bid/Contract, in accordance with Texas State Law and Local laws and policies.

Locally Adopted Plan

Name of Local Adopted Plan: Harris County Flood Control District 2018 Bond Program for Flood Risk Reduction and Resilience

Is a copy of the plan attached? YES

Year plan was adopted: 2018 (Updated May 2020)

project page number in plan: See individual activity summaries

Added Resiliency Measures

The combined result of the proposed mitigation activities in the Sims Bayou Watershed will greatly increase the resiliency of the communities in this watershed against negative impacts from flooding in future heavy rainfall events. The proposed improvements will greatly reduce the water surface elevation in flood events and protect homes, business, and vital transportation routes in the Sims Bayou Watershed. Additionally, the proposed detention basins will behave as dry basins that allow a maximum of 48-hour detention period after the design storm and remain completely dry between storms, promoting additional infiltration of stored water.

Covered Projects (Harvey Only)

Is this a Covered Project? Yes _____

Brief Project Description:

Subdivisions and businesses throughout the Sims Bayou Watershed in Harris County Experience localized and regionalized flooding conditions during hurricanes, tropical storms, and even intense rainfall events that overwhelm the existing drainage and flood control systems, resulting in riverine, or out-of-bank, flooding of the local bayous, tributaries, and drainage channels. The Sims Bayou Watershed Mitigation Project is comprised of 3 individual mitigation activities:

South Post Oak SWDB and Channel Improvements

South Shaver Detention Basin C506-01-00-E0003

Stormwater Detention Basin and Channel Conveyance Improvements Along Saltwater Ditch

These mitigation activities will result in increased resilience and reduction of the long-term risk for loss of homes and contents, injury or loss of life. The sites are also located in a designated most impacted and distressed area (MID) and the activities bring significant benefits to the low to moderate income residents that make up the service area.

See "Eligibility Check" section for justification for amendment to State Action Plan.

Benefit Cost Analysis (Harvey Only)

Project Benefits: \$192,024,910.00

Project Cost: \$106,810,450.00

Calculated BCR: 1.80

Description of benefit cost analysis methodology: The benefit-cost analysis performed for Sims Bayou Watershed Mitigation Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)

- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. This Project requires some acquisition and conversion of developed land to undeveloped floodplain or detention space. The benefit value for Green Open Space has been applied to these areas.

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, this project represents a holistic benefit to its watershed service area by removing structures and land area from the floodplain.

Project costs as estimated for the CDBG-MIT grant application include the estimated costs outlined on the *CDBG MIT: Budget Justification of Retail Costs* for each of the proposed mitigation activities. The benefit-cost ratio was determined as the ratio of the present value of Total Expect Benefits to Total Project Cost. It is important to note that this Project will provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on Qualitative Benefits in the attached BCA document.

Citizen Participation Plan

See individual activity narratives for details.

Citizen Participation Plan will be included with the application once the public comment period is complete.

Grant Management Plan

Is a Grant Management Plan attached? Harris County Community Services Department has a Grant Management Plan on file with GLO. A list of the stakeholders and their roles is attached to this application.

Beneficiary Data

Total number of project beneficiaries: 309,645

Cost per beneficiary: \$344.94

Total Population: 4,602,523 (2018 5-year Census estimate)

% Beneficiaries per Population: 0.067

Does the Project benefit >51% LMI population? Yes

Environmental Clearance

See individual activity narratives

Affirmatively Furthering Fair Housing

Harris County and Harris County Flood Control District comply with CDBG and GLO regulations for affirmatively furthering fair housing. See attached documentation for more information.

Scoring Criteria –

Composite Disaster Index: <u>5 (Top 10%)</u>	<u>10 points</u>
Social Vulnerability Index: <u>3 - Medium</u>	<u>5 points</u>
Per Capita Market Value: <u>\$529,092,108,213/4,602,523=\$114,957</u>	<u>2 points</u>
LMI National Objective: <u>Yes</u>	<u>20 points</u>
In a Local Adopted Plan? <u>Yes</u>	<u>5 points</u>
Applicant Management Capacity: Proc policy, single audit, recent grants	<u>15 points</u>
Amount per Beneficiary: <u>\$344.94</u>	<u>12 points</u>
% of Beneficiaries per Population: <u>0.067</u>	<u>0.67 points</u>
% Non-CDBG Funds: <u>6.4% from HCFC</u>	<u>5 points</u>
Resiliency Measures: <u>yes</u>	<u>N/A</u>
TOTAL	<u>74.67 points</u>
Poverty Rate: <u>16.8%</u>	

List of Attachments

1. Application Summary (Sims Bayou Watershed Mitigation Project)
 - a. Application Summary (South Post Oak SWDB and Channel Improvements)
 - b. Application Summary (South Shaver Detention Basin C506-01-00-E0003)
 - c. Application Summary (SWDB and Channel Conveyance Improvements Along Saltwater Ditch)
2. Project Area Map (Sims Bayou Watershed Mitigation Project)
 - a. Project Area Map (South Post Oak SWDB and Channel Improvements)
 - b. Project Area Map (South Shaver Detention Basin C506-01-00-E0003)
 - c. Project Area Map (SWDB and Channel Conveyance Improvements Along Saltwater Ditch)
3. Project Beneficiary Map (Sims Bayou Watershed Mitigation Project)
4. Beneficiary Data and Demographics (Sims Bayou Watershed Mitigation Project)
5. Site Photos

- a. Site Photos (South Post Oak SWDB and Channel Improvements)
- b. Site Photos (South Shaver Detention Basin C506-01-00-E0003)
- c. Site Photos (SWDB and Channel Conveyance Improvements Along Saltwater Ditch)
6. Local Adopted Plan (with Commissioners Court Adoption)
7. Project Cost Estimate
 - a. Project Cost Estimate (South Post Oak SWDB and Channel Improvements)
 - b. Project Cost Estimate (South Shaver Detention Basin C506-01-00-E0003)
 - c. Project Cost Estimate (SWDB and Channel Conveyance Improvements Along Saltwater Ditch)
8. Project Schedule
 - a. Project Schedule (South Post Oak SWDB and Channel Improvements)
 - b. Project Schedule (South Shaver Detention Basin C506-01-00-E0003)
 - c. Project Schedule (SWDB and Channel Conveyance Improvements Along Saltwater Ditch)
9. Citizen Participation Plan Documents **Final will be provided with final application after public comment period is complete**
10. Grant Management Plan **This document will be finalized and included with the grant application**
11. Benefit Cost Analysis (Sims Bayou Watershed Mitigation Project)
12. Harris County Procurement Policy
13. Fair Housing Activity Information
14. Harris County Comprehensive Annual Financial Report for FY Ending 2/29/20 (To meet the *Local Financial Management Policies and Procedures* and the *Single Audit or Annual Financial Statement* requirements)
15. Social Vulnerability Index Data
16. Per Capita Market Value Data
17. Composite Disaster Index Data
18. GLO Local Certifications Form **To be signed by Judge Hidalgo**
19. SF 424 Form **To be signed by Judge Hidalgo**

ATTACHMENT 1B

PROJECT APPLICATION SUMMARY FORM

MITIGATION ACTIVITY:
SOUTH SHAVER STORMWATER
DETENTION BASIN (C506-01-00-E003)

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT

Standard Form for CDBG-MIT Applications

Harris County Flood Control District

General Information

This is an individual Mitigation Activity included in the Sims Bayou Watershed Mitigation Project

Project Information

Project Name: South Shaver Stormwater Detention Basin (C506-01-00-E003)

Project Type: Mitigation

Risk Mitigated: Riverine Flooding

Street Address (nearest to project): 8300 Galveston Road

Street Limits on Street – From Street Shaver Street – To Street Witt Road

Zip Code: 77034

City: Houston

County: Harris

State: TX

Latitude (Decimal Degrees – 5 decimal places): 29.63708

Longitude (Decimal Degrees – 5 decimal places): -95.21676

Project Summary Narrative:

The objective of this project is to maximize the detention volume within property owned by Harris County Flood Control District (HCFCD) and to provide flood reduction benefits. HCFCD owns four parcels totaling 96 acres where a detention basin can be constructed. The finished project will remove approximately 45 acres of land from the floodplain and remove 355 structures from the 100-year floodplain.

Describe how the risk listed above is currently affecting the project area:

The neighborhoods downstream of this detention basin are prone to frequent flooding from heavy rain events and tropical weather. The flooding causes property damage to homes, businesses and vehicles and restricts transportation access for emergency vehicles.

How will the Project mitigate against the risk listed above?

Stormwater detention basins provide temporary storage for stormwater in heavy rain events. Surplus runoff is diverted into the basins and stored. Control structures at the discharge of the basin limit the flow leaving the basin to help attenuate the peak flow in the flood control channels. The basin will empty slowly over 48 hours to as the peak flow in the channel recedes. This helps to reduce ponding in the floodplain and limits risks of flooding for the community.

Does the project enhance any other mitigation efforts already underway?

This project could help mitigate some of the City of Houston's plans to enlarge existing storm sewer pipes in the project benefit area. Together with the other mitigation activities included in the Sims Bay Watershed Mitigation Project, this activity will bring significant flood risk reduction benefits to the residents of the Sims Bayou watershed.

Have you procured construction services for the proposed project? No

What is the construction completion method to be used? Competitive Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required? No

If yes: Provide the Estimated Number of Parcels: N/A

What is the status of the acquisition? Completed

Provide a brief narrative describing the acquisition activities required: N/A

Congressional Representative District #: 29

State Representative District #: 145

State Senator District #: 6

Eligibility Check

- Meets HUD's definition of mitigation activities
 - **Long-term Vulnerability Reduction, Community Resilience**

Figure 2-14: The Aspects of Mitigation



- Meets GLO Application project definition

- **Reducing risk of natural hazards through infrastructure improvements**
- Addresses identified current and future risks; (NOTE: identified risks change per program)
 - **This project will reduce the current and future risk of flooding due to heavy rainfall**
- Meets the definition of a CDBG-eligible activity under Title I of HCDA or otherwise pursuant to a waiver or alternative requirement
 - **Construction of public works**
- Meets a CDBG National Objective; as amended for MIT funds
 - **LMI National Objective**
- Includes a plan for the long-term funding and management of the operations and maintenance of the project
 - **HCFCFCD operates, inspects, and maintains a vast network of nearly 2,500 miles of stormwater conveyance channels and detention basins across Harris County. The proposed basin and feeder lines will be owned, inspected and maintained by HCFCFCD as part of their ongoing process.**
- Cost verification controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction
 - **All construction contracts will be advertised and bid publicly through Competitive Sealed Bid/Contract, in accordance with Texas State Law and Local laws and policies.**

Locally Adopted Plan

Name of Local Adopted Plan: Harris County Flood Control District 2018 Bond Program for Flood Risk Reduction and Resilience

Is a copy of the plan attached? YES

Year plan was adopted: 2018 (Updated May 2020)

project page number in plan: 20 of 67 (Bond ID C-10)

Added Resiliency Measures

This project following construction will provide resiliency to flooding for the benefit area. This project will be designed and constructed in manner to provide resiliency of the improvements and provide for improved access for maintenance.

Prior to Hurricane Harvey, this project was in the Conceptual Design Reporting (CDR) Stage (see attached). The Harris County Flood Control District purchased property in the early 2000's with the foresight of building detention along this reach of Berry Bayou. The CDR efforts were paused during Hurricane Harvey and re-started shortly thereafter. This project area was identified during the August 2018 bond approval by voters as an ideal spot for mitigation. The CDR showed major benefits to many structures directly downstream of the project area. Many if not all of these structures had flood damage during Hurricane Harvey. The HCFCFCD placed projects like this one on the bond table since it was property the HCFCFCD already owned and would allow HCFCFCD to quickly put projects on the ground that would benefit the adjacent areas.

Covered Projects (Harvey Only)

Is this a Covered Project? yes

Brief Project Description: See watershed project level summary

See "Eligibility Check" section for justification for amendment to State Action Plan.

Benefit Cost Analysis (Harvey Only)

Project Benefits: See watershed project level summary

Project Cost: See watershed project level summary

Calculated BCR: See watershed project level summary

Description of benefit cost analysis methodology: See watershed project level summary

Citizen Participation Plan

Date Project was first posted for public comment? October 3, 2020

Date Project was last posted for public comment? TBD

Were any comments received from the public? TBD

Were responses provided to all public comments within 15 days of receipt? YES

The final plan will be included with the application once the public comment period is complete.

Grant Management Plan

See watershed project level summary

Beneficiary Data

See watershed project level summary

Environmental Clearance

Is this an Aggregate Project (multiple activities)? YES

Type of Aggregation (if applicable): Geographic Aggregation

What is the current status of the project? In Progress

Brief Project Narrative: The objective of this project is to maximize the detention volume within property owned by Harris County Flood Control District (HCFCD) and to provide flood reduction benefits. HCFCD owns four parcels totaling 96 acres where a detention basin can be constructed. The finished project will remove approximately 45 acres of land from the floodplain and remove 355 structures from the 100-year floodplain.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No

If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A

Is the proposed project site likely to require a historical resources/archaeological assessment? No

If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A

Is the proposed project site listed on the National Register of Historic Places? No

If yes, provide a brief narrative explaining how the historic site will be impacted: N/A

Is the proposed project site in a designated flood hazard area or a designated wetland? There are four wetlands on this project site that will be protected during and post construction.

Is the applicant participating in the National Flood Insurance Program? Yes

Is the project in a designated Regulatory Floodway? No

Is the proposed project site located in a known critical habitat for endangered species? No

Is the proposed project site a known hazardous site? No

Is the proposed project site located on federal lands or at a federal installation? No

If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

What level of environmental review is likely needed for the proposed project site? Environmental Assessment

Provide a brief narrative to include any additional detail or information relevant to Environmental Review: A Cultural Desktop Study, a Threatened and Endangered Species Assessment, a Wetlands Delineation and Jurisdictional Determination, and an ESA Phase 1 report are in progress for this project site as part of the due diligence for environmental assessments.

There are four existing wetlands on the project site that will be protected during/post construction. The preliminary jurisdictional determination was sent by the USACE in May of 2019. The USACE determined that all waters and wetlands that would be affected in any way on the site are considered jurisdictional waters of the United States. Therefore, the project will protect any waters on site.

Affirmatively Furthering Fair Housing

See watershed project level summary

Scoring Criteria

See watershed project level summary

List of Attachments

See watershed project level summary

ATTACHMENT 1A

PROJECT APPLICATION SUMMARY FORM

**MITIGATION ACTIVITY:
SOUTH POST OAK STORMWATER
DETENTION BASIN AND CHANNEL
IMPROVEMENTS (C147-00-00/C547-00-00)**

**PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT**

Standard Form for CDBG-MIT Applications

Harris County Flood Control District

General Information

This is an individual Mitigation Activity included in the Sims Bayou Watershed Mitigation Project

Project Information (Individual Mitigation Activities)

Project Name: South Post Oak Stormwater Detention Basin and Channel Improvements (C147-00-00/C547-00-00)

Project Type: Mitigation

Risk Mitigated: Riverine Flooding

Street Address (nearest to project): 14925 S. Post Oak Rd.

Street Limits on Street – From Sam Houston Tollway 8 – To Trafalgar Dr.

Zip Code: 77053

City: Houston

County: Harris

State: TX

Latitude (Decimal Degrees – 5 decimal places): 29.61093

Longitude (Decimal Degrees – 5 decimal places): -95.46317

Project Summary Narrative: The project consists of channel widening 7,000-feet of channel C147-00-00 from Sims Bayou to diversion channel C147-02-00. The typical right-of-way width is 215-feet along the entire project reach. The bridge crossings at Tiffany Rd, Fuqua Gardens View Rd, and South Post Oak Rd will be replaced. The recommended alternative preserves the West Fuqua Rd bridge crossing. Basin C547 is proposed to be expanded to 1,020 acre-feet to mitigate the loss of floodplain storage and impacts to Sims Bayou. Project will be developed in multiple phases.

Describe how the risk listed above is currently affecting the project area:

Historically, structural flooding has been an issue along Sims Bayou and its tributaries. The lower C147 watershed has a documented history of street and structural flooding primarily due to an inadequate level of service from Sims Bayou and C147-00-00. Secondary flooding issues are related to inadequate conveyance of storm water runoff in the areas adjacent to C147-00-00.

Approximately sixty-seven (67) structures are estimated to be impacted at 0- to 1-feet of flood depth, an additional one-hundred twenty-five (125) structures are estimate to be impacted at 1- to 2-feet of flood depth, and an additional forty-one (41) structures are estimated to be impacted at flood depths greater than 2-feet. A total of two-hundred twenty-eight (228)

structures are estimated to be impacted in the 500-year event. The project aim is to reduce the number of structures affected during the 500-year event.

How will the Project mitigate against the risk listed above?

The project will utilize basin C547 to mitigate loss of floodplain storage in the lower C147 watershed and hydraulic impact to Sims Bayou resulting from the project. The channel and basin improvements provide significant flood risk reduction to the community by containing the WSEL resulting from the current effective 0.2% annual chance event (500-year) within the banks of C147-00-00.

Does the project enhance any other mitigation efforts already underway?

The Sims Bayou Federal Flood Damage Reduction Project, which was completed in 2015, greatly improved flood risk conditions in the lower C147 watershed by reducing areas subject to flooding by the current effective 1% annual chance event (100-year Zone AE).

The Sims Bayou Federal Flood Risk Management Project was a 25-year long partnership between the HCFCD and the U.S. Army Corps of Engineers (USACE) which included widening and deepening of Sims Bayou from the Houston Ship Channel to just west of South Post Oak Rd. The Civil Works project was completed in late 2015 and created additional depth and capacity within Sims Bayou, allowing HCFCD to assess tributaries for potential drainage improvements. The C147 watershed, a tributary drainage area to Sims Bayou, was identified by HCFCD as presenting an opportunity for flood risk reduction improvements.

In November 2017, IDS was contracted to perform a Flood Risk Reduction Study (FRRS) for the C147 watershed in Harris County and upstream into Fort Bend County to determine the feasibility of improving the level of service of C147-00-00 and C147-02-00. Following the completion of the FRRS, IDS submitted a Preliminary Alternatives Assessment to HCFCD on August 21, 2018 which identified three alternatives for potential improvements in the lower C147 watershed in Harris County.

The FRRS found the average depth of street and structural flooding in the project limit to be 1- to 2-feet. The preliminary alternatives assessment documented potential improvements to C147-00-00, C147-02-00, and basin C547 with the goal of greatly reducing or eliminating the relatively shallow depth of flooding within the project limit without adverse impact to Sims Bayou. Based on the results of the FRRS and preliminary alternatives assessment, HCFCD decided to advance the project to preliminary engineering phase.

- On March 30, 2017, HCFCD completed a preliminary stream condition assessment in the lower C147 watershed.
- On April 6, 2018, IDS submitted findings to HCFCD from the previously mentioned FRRS that included the lower C147 watershed. The study analyzed approximately 10,000-feet of the existing channel from confluence at Sims Bayou upstream to approximately 1,500-feet south of the SHT into Fort Bend County to the lateral structure that first transfers flow from C147-02-00 to C147-00-00.
- On June 27, 2018, IDS submitted a preliminary water availability assessment to HCFCD. The purpose of this conceptual analysis was to determine the seasonal viability of converting C547-01-00 from dry bottom to wet bottom in order to maximize available storage volumes.

- On August 21, 2018, IDS submitted a preliminary alternatives assessment to HCFCF. The report documented three (3) potential projects to improve the C147-00-00, C147-02-00, and C547-01-00 level of service and significantly reduce or eliminate street and structural flooding within the project limit.
- On April 28, 2020 IDS submitted the final preliminary engineering report to HCFCF. This report summarized alternative analysis, right of way requirements, all environmental studies/analysis/reports, geotechnical report, project cost and defined a potential phasing plan for construction.

The Boulevard Oaks tract west of South Post Oak Rd is currently undergoing new commercial and light industrial development with subsequent increase in impervious land cover, placement of fill to remove areas from the regulatory floodplain, and mitigation on-site by detention basin. Development of Boulevard Oaks also includes an agreement with HCFCF to acquire mitigating floodplain storage volume in basin C547. Together with the other mitigation activities included in the Sims Bay Watershed Mitigation Project, this activity will bring significant flood risk reduction benefits to the residents of the Sims Bayou watershed.

Have you procured construction services for the proposed project? No

What is the construction completion method to be used? Competitive Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required? Yes

If yes: Provide the Estimated Number of Parcels: 19

What is the status of the acquisition? Still needed

Provide a brief narrative describing the acquisition activities required: The proposed right-of-way for C147-00-00 within the project limit varies is 215-feet wide. This is an increase of 145-feet from the existing 70-foot right-of-way width. Land use on the parcels includes single-family residential, auto salvage, auto service, church, and trucking.

Congressional Representative District #: 9

State Representative District #: 131

State Senator District #: 13

Eligibility Check

- Meets HUD's definition of mitigation activities
 - **Long-term Vulnerability Reduction, Community Resilience**

Figure 2-14: The Aspects of Mitigation



- Meets GLO Application project definition
 - Reducing risk of natural hazards through infrastructure improvements
- Addresses identified current and future risks; (NOTE: identified risks change per program)
 - This project will reduce the current and future risk of flooding due to heavy rainfall
- Meets the definition of a CDBG-eligible activity under Title I of HCDA or otherwise pursuant to a waiver or alternative requirement
 - Construction of public works
- Meets a CDBG National Objective; as amended for MIT funds
 - LMI National Objective
- Includes a plan for the long-term funding and management of the operations and maintenance of the project
 - HCFCF operates, inspects, and maintains a vast network of nearly 2,500 miles of stormwater conveyance channels and detention basins across Harris County. The proposed basin and feeder lines will be owned, inspected and maintained by HCFCF as part of their ongoing process.
- Cost verification controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction
 - All construction contracts will be advertised and bid publicly through Competitive Sealed Bid/Contract, in accordance with Texas State Law and Local laws and policies.

Locally Adopted Plan

Name of Local Adopted Plan: Harris County Flood Control District 2018 Bond Program for Flood Risk Reduction and Resilience

Is a copy of the plan attached? YES

Year plan was adopted: 2018 (Updated May 2020)

Project page number in plan: 20 of 67 (Bond ID C-09)

Added Resiliency Measures

This project following construction will provide resiliency to flooding for the benefit area. This project will be designed and constructed in manner to provide resiliency of the improvements and provide for improved access for maintenance.

Historically, structural flooding has been an issue along Sims Bayou and its tributaries. The lower C147 watershed has a documented history of street and structural flooding primarily due to an inadequate level of service from Sims Bayou and C147-00-00. Secondary flooding issues are related to inadequate conveyance of storm water runoff in the areas adjacent to C147-00-00. This project will help to reduce these chronic flooding issues and increase the resilience of this watershed against future flooding risks.

Covered Projects (Harvey Only)

Is this a Covered Project? yes

Brief Project Description: See watershed project level summary

See "Eligibility Check" section for justification for amendment to State Action Plan.

Benefit Cost Analysis (Harvey Only)

Project Benefits: See watershed project level summary

Project Cost: See watershed project level summary

Calculated BCR: See watershed project level summary

Description of benefit cost analysis methodology: See watershed project level summary

Citizen Participation Plan

Date Project was first posted for public comment? October 3, 2020

Date Project was last posted for public comment? TBD

Were any comments received from the public? TBD

Were responses provided to all public comments within 15 days of receipt? YES

The final plan will be included with the application once the public comment period is complete.

Grant Management Plan

See watershed project level summary

Beneficiary Data

See watershed project level summary

Environmental Clearance

Is this an Aggregate Project (multiple activities)? YES

Type of Aggregation (if applicable): Geographic Aggregation

What is the current status of the project? In Progress

Brief Project Narrative: The project consists of channel widening 7,000-feet of channel C147-00-00 from Sims Bayou to diversion channel C147-02-00. The typical right-of-way width is 215-feet along the entire project reach. The bridge crossings at Tiffany Rd, Fuqua Gardens View Rd, and South Post Oak Rd will be replaced. The recommended alternative preserves the West Fuqua Rd bridge crossing. Basin C547 is proposed to be expanded to 1,020 acre-feet to mitigate the loss of floodplain storage and impacts to Sims Bayou. Project will be developed in multiple phases.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? No

If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: N/A

Is the proposed project site likely to require a historical resources/archaeological assessment? No

If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A

Is the proposed project site listed on the National Register of Historic Places? No

If yes, provide a brief narrative explaining how the historic site will be impacted: N/A

Is the proposed project site in a designated flood hazard area or a designated wetland? Designated special flood hazard area, noted wetlands identified but will not be impacted by project.

Is the applicant participating in the National Flood Insurance Program? Yes

Is the project in a designated Regulatory Floodway? yes

Is the proposed project site located in a known critical habitat for endangered species? No

Is the proposed project site a known hazardous site? No

Is the proposed project site located on federal lands or at a federal installation? No

If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

What level of environmental review is likely needed for the proposed project site? Additional right-of-way to accommodate the channel improvements will likely be acquired to the west from parcels facing Nelson St. Additional soil sampling will be necessary to determine environmental measures required for safe excavation of the soils.

Provide a brief narrative to include any additional detail or information relevant to Environmental Review: A review of historical information available for the site indicates the presence of seven (7) Recognized Environmental Conditions (RECs) warranting further investigation at the site to assess if soil and/or groundwater has been impacted. Based on the potential environmental concerns identified in the ESA, soil and ground water samples were analyzed for total petroleum hydrocarbons, benzene, toluene, ethylbenzene, xylenes, volatile organic compounds, total Resource and Recovery Act metals, and chloride. Borings for the collection and analysis of soil and ground water samples were taken at

each of the seven (7) REC locations. HCFCD submitted a request to the USACE Galveston District for a jurisdictional determination on C147-00-00 and C147-02-00 to address Section 404 Clean Water Act and/or Section 10 of the Rivers and Harbors Act. HCFCD expressed the opinion, based on historical aerial photography, USGS topographic maps, and 2008 elevation data, that the channels may be considered non-jurisdictional. The USACE Galveston District responded with an Approved Jurisdictional Determination (AJD) stating “We have determined that the subject site does not contain waters of the United States” and “no Department of the Army permit is required prior to discharge.”

Based on the February 13, 2019 AJD from the USACE Galveston District, the Terracon report referenced below was ultimately not submitted for further action. HVJ Associates submitted the results of a wetland delineation report for FRRS, HCFCD Project No. C147-00-00-P002, Houston, Harris County, Texas. The wetland delineation was performed to determine the presence of any jurisdictional wetlands on the undeveloped area remaining within the HCFCD tract east of South Post Oak Rd on either side of West Fuqua Rd. The USACE Galveston District responded with an AJD stating “...we concur with the findings that this tract does contain waters of the United States subject to our jurisdiction” and “Any discharge of dredged and/or fill material into these water of the U.S. requires Department of the Army (DA) permit.” Terracon submitted the results of a desktop Cultural Resource Assessment performed in the project area to the Texas Historic Commission (THC). Terracon recommended that the project be allowed to proceed under Title 9, Chapter 191 of the Texas Natural Resources Code without further concern for its effect on historic or archeological sites, deposits, or materials. The THC concurred with the information provided in the desktop assessment and stated, “no archeological survey of the project area is needed.” Terracon submitted the results of a Threatened and Endangered (T&E) Species Habitat Assessment. The purpose of the assessment was to characterize the existing site conditions, observe the site listed T&E species and their habitats, and provide an opinion regarding whether or not the proposed project would have an impact on federal or state listed T&E species.

Affirmatively Furthering Fair Housing

See watershed project level summary

Scoring Criteria

See watershed project level summary

List of Attachments

See watershed project level summary

BENEFIT-COST ANALYSIS

SIMS BAYOU WATERSHED MITIGATION PROJECT

Prepared for:

Harris County Flood Control District

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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APPENDICES

Appendix A: Building Replacement Values

EXECUTIVE SUMMARY

The benefit-cost analysis performed for Sims Bayou Watershed Mitigation Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	\$ 6,649,735	\$ 91,771,306
Displacement, Residential	\$ 176,897	\$ 2,441,312
Displacement, Non-residential	\$ 96,579	\$ 1,332,863
Social (Mental Health & Productivity)	\$ 6,057,957	\$ 83,604,332
Environmental (Ecosystem services of converted land)	\$ 932,732	\$ 12,872,392
Total Expected Benefits (all categories)	\$ 13,913,900	\$ 192,022,205

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the Sims Bayou Watershed Mitigation Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	9380	\$ 2,443	\$ 22,915,340
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	6947	\$ 8,736	\$ 60,688,992
Total Social Benefit			\$ 83,604,332

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The Sims Bayou Watershed Mitigation Project requires some acquisition and conversion of developed land to undeveloped floodplain or detention space. Additionally, a riparian corridor is planned as part of the project. The benefit values for Green Open Space and Riparian land use have been applied to these areas. Environmental benefits of the Sims Bayou Watershed Mitigation Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	78.95	\$8,308	\$ 655,917	\$ 9,052,139
Riparian	7	\$39,545	\$ 276,815	\$ 3,820,254
Wetlands	0	\$6,010	\$ -	\$ -
Forests	0	\$554	\$ -	\$ -
Marine / Estuary	0	\$1,799	\$ -	\$ -
Total Environmental Benefit			\$ 932,732	\$ 12,872,392

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the Sims Bayou Watershed Mitigation Project represents a holistic benefit to its service area, the Sims Bayou Watershed, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event (estimated losses to structural damage are reduced)	2,988
Number of structures removed from 10% AEP (10-year) floodplain	329
Number of structures removed from 1% AEP (100-year) floodplain	1,561
Number of acres removed from 10% AEP (10-year) floodplain	308
Number of acres removed from 1% AEP (100-year) floodplain	1,037
Number of structures removed from risk* in 10% AEP (10-year) event	7
Number of structures removed from risk* in 1% AEP (100-year) event	522

*Structures “at risk” refer to those for which the modeled water surface elevation is at or above finished floor elevation.

The Present Value Benefits, as shown in *Table ES-1* and *Table ES-3*, were developed from Annual Benefits using a 7% discount rate as required by the Office of Management and Budget (OMB) Circular No. A-94¹. (Social benefit unit values are provided as standard Present Value amounts and are discounted using a 7% rate to estimate Annual Benefits.) This discount rate assumes present benefits have much more value than future benefits, which is not necessarily true for flood risk mitigation projects with a 50-year and greater life cycle. A lower discount rate assumes present benefits are only slightly more valuable than future benefits – a more realistic assumption when considering extended life cycle projects that provide the same level of risk reduction from year to year. U.S. Department of Housing and Urban Development (HUD) Notice CPD-16-06, which was created to provide guidance on benefit-cost analyses for Community Development Block Grant Disaster Recovery (CDBG-DR) projects, notes “grantees may additionally calculate benefits and costs using alternate discount rates (no lower than 3%) provided it also includes justification acceptable to HUD based on the nature of the project.” For comparison purposes, Present Value Benefits were also determined using a 3% discount rate.

Project costs as estimated for the Community Development Block Grant Mitigation (CDBG-MIT) grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expected Benefits to Total Project Cost. *Table ES-5* presents the project cost, along with the estimated benefits and benefit-cost ratio resulting from use of both the 7% and 3% discount rates. It is important to note that the Sims Bayou Watershed Mitigation Project will

¹ *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

	7% Discount Rate	3% Discount Rate
Present Value Total Benefits	\$ 192,022,205	\$ 285,735,885
Present Value Total Cost	\$ 106,810,450	\$ 106,810,450
Benefit-Cost Ratio	1.80	2.68

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,² this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
 - a. Calculations should be prepared in accordance with OMB Circular A-94³.
 - b. BCA methodology should follow FEMA standardized methodologies unless
 - 1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
 - 2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
 - 3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
 - a. A BCA is still completed following the methodologies described above.
 - b. The project “serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster.”
 - c. A qualitative description is provided for “benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters.”

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

² Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

³ *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0⁴ (hereafter “FEMA Toolkit”) and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
 - Assess thousands of potentially impacted structures.
 - Utilize spatially variable modeled water surface elevation data.
 - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1*.

⁴ *Benefit Cost Toolkit Version 6.0*. FEMA. October 2019. Available at <https://www.fema.gov/media-library/assets/documents/179903>.

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description
Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	Harris County Flood Control District	parcels and impacted structures to be bought out as part of project
Capital Costs	Harris County Flood Control District	project capital costs
Existing and Proposed Water Surface Elevations	Harris County Flood Control District	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data ⁵	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

The Harris County Flood Control District maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year⁵ data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

⁵ U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services (\$/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values (\$/sq. ft.)	Hazus Technical Manual ⁶
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District ⁷
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District ⁷
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District ⁷

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is

⁶ Hazus-MH MR3 Technical Manual. FEMA.

⁷ *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSV) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study.* U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This method is described in a FEMA guidance document for flood risk assessments⁸. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$\begin{aligned}
 \text{Expected Annual Loss} = & \left(\frac{1}{500} * \text{Loss}_{500\text{yr}} \right) \\
 & + \left(\frac{1}{100} - \frac{1}{500} \right) (\text{Loss}_{100\text{yr}} + \text{Loss}_{500\text{yr}}) \\
 & + \left(\frac{1}{50} - \frac{1}{100} \right) (\text{Loss}_{50\text{yr}} + \text{Loss}_{100\text{yr}}) \\
 & + \left(\frac{1}{25} - \frac{1}{50} \right) (\text{Loss}_{25\text{yr}} + \text{Loss}_{50\text{yr}}) \\
 & + \left(\frac{1}{10} - \frac{1}{25} \right) (\text{Loss}_{10\text{yr}} + \text{Loss}_{25\text{yr}})
 \end{aligned}
 \tag{Equation 1}$$

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions (*Equation 2*).

$$\text{Expected Annual Benefit} = (\text{Expected Annual Loss})_{\text{Existing}} - (\text{Expected Annual Loss})_{\text{Post-mitigation}}
 \tag{Equation 2}$$

1.5 PRESENT VALUE ANALYSIS

Benefits in all categories except Social Benefits were determined on an annualized basis as described in the previous section or using standard annual benefit values. (Social benefit unit values are provided as standard Present Value amounts and are not discounted.) The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$\text{Capital Recovery Factor} \left(\frac{A}{P} \right) = \frac{\text{Annual Value}}{\text{Present Value}} = \frac{i(1+i)^n}{(1+i)^n - 1}
 \tag{Equation 3}$$

$$\text{Uniform Series Present Worth Factor} \left(\frac{P}{A} \right) = \frac{\text{Present Value}}{\text{Annual Value}} = \frac{(1+i)^n - 1}{i(1+i)^n}
 \tag{Equation 4}$$

⁸ "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

BCR

$$= \frac{(\text{Expected Annual Benefits} * \text{Uniform Series Present Worth Factor}) + \text{Present Worth Social Benefits}}{\text{Project Capital Cost}}$$

Equation 5

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single equivalence factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory⁹.

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of \$100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual¹⁰. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology¹¹, a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of

⁹ Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.

¹⁰ Hazus-MH MR3 Technical Manual. FEMA.

¹¹ Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

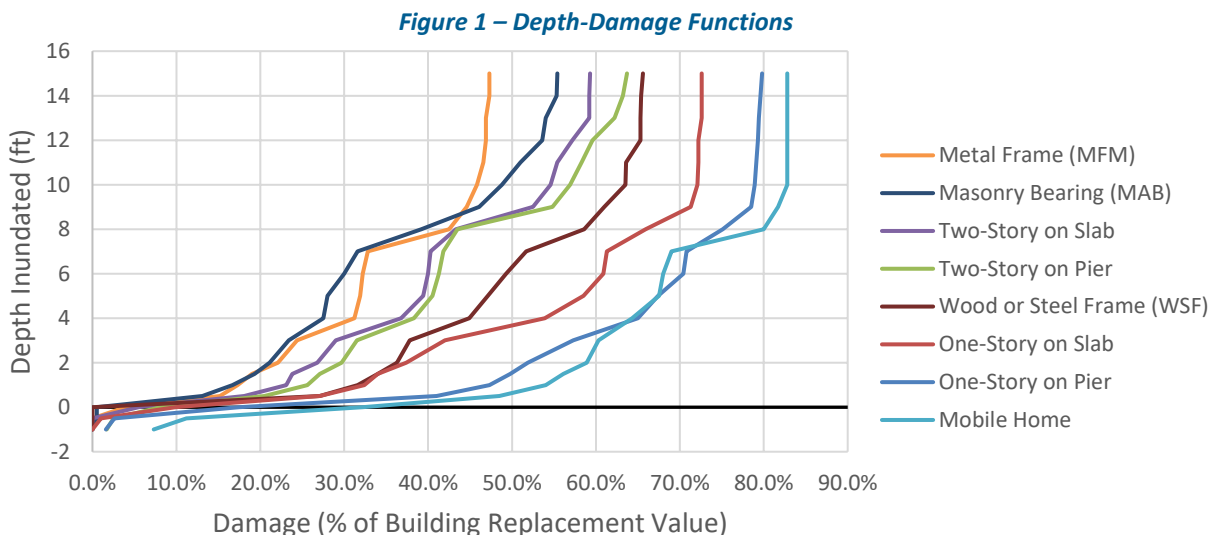
median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size (*Equation 6*). This approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$\text{Total BRV} = \text{Unit BRV } (\$/\text{sf}) * \text{Area } (\text{sf})$$

Equation 6

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*¹² and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District¹³ and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.



¹² R.S. Means, 2005.

¹³ Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios developed by the USACE New Orleans District¹³, which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
\$55	\$7	\$94	\$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment
- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as \$/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (Table 2-2). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor (\$/sf)	Rental Cost Factor (\$/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity (*Table 2-3*). These values are based on studied prevalence, severity, and course of mental effects following a disaster¹⁴. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

¹⁴ *Final Sustainability Benefits Methodology Report*. FEMA. Task order HSEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	\$2,443	Resident of home benefitted by project
Lost productivity	\$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year ¹⁵				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
\$8,308	\$39,545	\$6,010	\$554	\$1,799

¹⁵ Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,¹⁶ as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to “low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster,” including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 65.0% of the beneficiaries of Sims Bayou Watershed Mitigation Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 34.1% of the households in the project service area are considered to be housing cost-burdened, and 16.2% are severely housing cost-burdened¹⁷. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 29.7% of the households in the project service area have no computer and/or no internet subscription¹⁸. Lack of reliable internet access may reduce residents’ ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values decreased significantly from 2017 to 2018 in the Sims Bayou Watershed (*Figure 2*). This decrease could be caused or influenced by flooding due to Hurricane Harvey in 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General

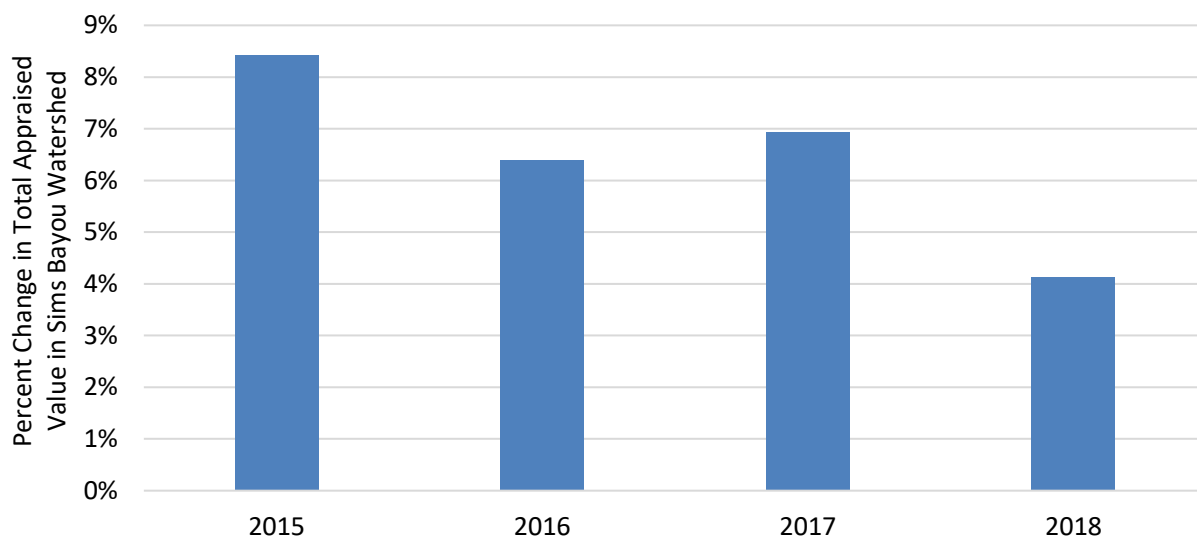
¹⁶ Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

¹⁷ Estimates derived from data in tables B25070 (Gross Rent as a Percentage of Household Income in the Past 12 Months) and B25091 (Mortgage Status by Selected Monthly Owner Costs as a Percentage of Household Income in the Past 12 Months). U.S. Census Bureau. American Community Survey, 2014-2018.

¹⁸ Estimate derived from data in table B28003 (Presence of a Computer and Type of Internet Subscription in Household). U.S. Census Bureau. American Community Survey, 2014-2018.

economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the Sims Bayou Watershed Mitigation Project will remove 1,037 acres from the 100-year floodplain, providing a potential positive impact to property values.

Figure 2 – Year-to-Year Percent Change in Total Appraised Value of Property in Sims Bayou Watershed



3.3 TRANSPORTATION BENEFITS

Street closures due to flooding in the Sims Bayou Watershed during Hurricane Harvey likely impacted a large number of commuters, including those who do not live in the watershed. Frequently, residential streets are inundated and may become impassable without the water level reaching a point of causing any damage to homes. In these scenarios, no quantitative benefits are counted in the BCA as there is no structural damage or displacement of residents. However, the street flooding poses an inconvenience and in some cases a safety risk, as it can inhibit evacuations, potentially trapping residents in homes that may lose power or keeping them from accessing groceries or medical supplies. The Sims Bayou Watershed Mitigation Project will provide some reduction in street inundation as a benefit to residents in the service area.

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work¹⁹. Of workers living within the watershed, 3.6% (4,743 workers) use a bus to commute to work. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 15 bus routes through the watershed were closed for up to 6 days during and after Hurricane Harvey. No methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the Sims Bayou Watershed Covered Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the Sims Bayou Watershed Mitigation Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the Sims Bayou Watershed Covered Project. However, as discussed in **Section 2.1.1**, the use of structural damages in a benefit-cost ratio, while valid, means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

¹⁹ Estimate derived from data in table B08301 (Means of Transportation to Work). U.S. Census Bureau. American Community Survey, 2014-2018.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1

Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

Income Ratio (r) Number of Stories	$r < 0.5$	$0.5 < r < 0.85$	$0.85 \leq r < 1.25$	$1.25 \leq r < 2.0$	$r > 2.0$
1	\$97.28	\$107.21	\$145.17	\$169.60	\$206.28
2	\$103.51	\$110.89	\$141.45	\$166.65	\$196.43
3	\$103.51	\$112.50	\$147.76	\$172.67	\$202.32
split	\$95.14	\$102.70	\$132.88	\$155.34	\$184.21

Table A-2

Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value (\$/sf)
2	\$117.00
3-4	\$128.00
5-9	\$228.00
10-19	\$203.00
20-49	\$200.00
50+	\$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub Class	Unit Building Replacement Value (\$/sf)
Manufactured Housing	Manufactured Housing	\$52.76
Retail Trade	Dept Store, 1 st	\$121.96
Wholesale Trade	Warehouse, medium	\$112.10
Personal and Repair Services	Garage, Repair	\$151.05
Prof./ Tech./Business Services	Office, medium	\$196.93
Banks	Bank	\$282.68
Hospital	Hospital, medium	\$331.04
Medical Office/Clinic	Med. Office, medium	\$242.32
Entertainment & Recreation	Restaurant	\$251.66
Theaters	Movie Theatre	\$180.14
Parking	Parking garage	\$64.53
Heavy	Factory, small	\$130.29
Light	Warehouse, medium	\$112.10
Food/Drugs/Chemicals	College Laboratory	\$214.11
Metals/Minerals Processing	College Laboratory	\$214.11
High Technology	College Laboratory	\$214.11
Construction	Warehouse, medium	\$112.10
Agriculture	Warehouse, medium	\$112.10
Church	Church	\$204.52
General Services	Town Hall, small	\$158.34
Emergency Response	Police Station	\$245.87
Schools/Libraries	High School	\$170.19
Colleges/Universities	College Classroom	\$213.61

ATTACHMENT 7C

PROJECT COST ESTIMATE

MITIGATION ACTIVITY:
STORMWATER DETENTION BASIN AND
CHANNEL CONVEYANCE
IMPROVEMENTS ALONG SALT WATER
DITCH

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



**CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)**

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

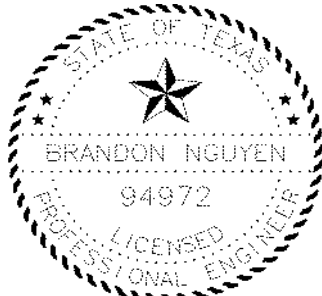
Applicant/Subrecipient:	Harris County Flood Control District					
Site/Activity Title:	Salt Water Ditch					
Eligible Activity:	Flood Control and Drainage Improvements					
Materials/Facilities/Services	\$/Unit	Unit	Quantity	Construction	Acquisition	Total
2x84" SRPE Pipes (including stub-out, equalizer, access manhole)	\$ 1,398.00	LF	4200	\$ 5,871,600.00	\$ -	\$ 5,871,600.00
2x108" SRPE Pipes (including stub-out, equalizer, access manhole)	\$ 1,926.00	LF	1100	\$ 2,118,600.00	\$ -	\$ 2,118,600.00
3x108" SRPE Pipes (including stub-out, equalizer, access manhole)	\$ 2,886.00	LF	5100	\$ 14,718,600.00	\$ -	\$ 14,718,600.00
3x120" SRPE Pipes (including stub-out, equalizer, access manhole)	\$ 3,252.00	LF	7600	\$ 24,715,200.00	\$ -	\$ 24,715,200.00
Dewatering for 2x84" Pipes Construction	\$ 48.00	LF	4200	\$ 201,600.00	\$ -	\$ 201,600.00
Dewatering for 2x108" Pipes Construction	\$ 60.00	LF	1100	\$ 66,000.00	\$ -	\$ 66,000.00
Dewatering for 3x108" Pipes Construction	\$ 72.00	LF	5100	\$ 367,200.00	\$ -	\$ 367,200.00
Dewatering for 3x120" Pipes Construction	\$ 84.00	LF	7600	\$ 638,400.00	\$ -	\$ 638,400.00
Grate Inlet Type A	\$ 4,000.00	EA	58	\$ 232,000.00	\$ -	\$ 232,000.00
Drop Inlet Type E	\$ 6,000.00	EA	9	\$ 54,000.00	\$ -	\$ 54,000.00
Storm Manhole (42" pipe or <)	\$ 7,000.00	EA	56	\$ 392,000.00	\$ -	\$ 392,000.00
Storm Manhole (> 42" pipe)	\$ 9,000.00	EA	4	\$ 36,000.00	\$ -	\$ 36,000.00
Storm Junction Box (90" Pipe)	\$ 30,000.00	EA	1	\$ 30,000.00	\$ -	\$ 30,000.00
Adjust/Relocate Water Lines (4" to 12")	\$ 17,400.00	EA	15	\$ 261,000.00	\$ -	\$ 261,000.00
Adjust/Relocate Sanitary Sewers (6" to 18")	\$ 25,200.00	EA	15	\$ 378,000.00	\$ -	\$ 378,000.00
Clearing & Grubbing along Salt Water Ditch	\$ 15.00	LF	18000	\$ 270,000.00	\$ -	\$ 270,000.00
Hydromulch Seeding along Salt Water Ditch	\$ 3,000.00	AC	24	\$ 72,000.00	\$ -	\$ 72,000.00
6-inch Concrete Channel Lining	\$ 84.00	SY	2000	\$ 168,000.00	\$ -	\$ 168,000.00
Shallow Drainage Swale Grading	\$ 120.00	LF	3600	\$ 432,000.00	\$ -	\$ 432,000.00
Ancillary Drainage Items (Transition Structure, Outfall Structure, etc.)	\$ 1,050,000.00	LS	1	\$ 1,050,000.00	\$ -	\$ 1,050,000.00
Bridge & Roadway Removal at Jutland	\$ 72,000.00	LS	1	\$ 72,000.00	\$ -	\$ 72,000.00
Bridge & Roadway Removal at St Lo	\$ 78,000.00	LS	1	\$ 78,000.00	\$ -	\$ 78,000.00
Bridge & Roadway Removal at Van Fleet	\$ 86,400.00	LS	1	\$ 86,400.00	\$ -	\$ 86,400.00
Culvert & Roadway Removal at MLK	\$ 48,000.00	LS	1	\$ 48,000.00	\$ -	\$ 48,000.00
Bridge & Roadway Removal at SouthBank	\$ 54,000.00	LS	1	\$ 54,000.00	\$ -	\$ 54,000.00
Bridge & Roadway Removal at Crestmont	\$ 108,000.00	LS	1	\$ 108,000.00	\$ -	\$ 108,000.00
Bridge & Roadway Removal at Doulton	\$ 108,000.00	LS	1	\$ 108,000.00	\$ -	\$ 108,000.00
Bridge & Roadway Removal at Bellfort	\$ 216,000.00	LS	1	\$ 216,000.00	\$ -	\$ 216,000.00
Bridge & Roadway Removal at Vasser	\$ 86,400.00	LS	1	\$ 86,400.00	\$ -	\$ 86,400.00
Roadway reconstruction at Jutland (asphalt)	\$ 30,000.00	LS	1	\$ 32,500.00	\$ -	\$ 32,500.00
Roadway reconstruction at St Lo (concrete)	\$ 62,400.00	LS	1	\$ 67,600.00	\$ -	\$ 67,600.00
Roadway reconstruction at Van Fleet (concrete)	\$ 60,000.00	LS	1	\$ 65,000.00	\$ -	\$ 65,000.00
Roadway reconstruction at MLK (concrete)	\$ 288,000.00	LS	1	\$ 312,000.00	\$ -	\$ 312,000.00
Roadway reconstruction at Southbank (asphalt)	\$ 33,600.00	LS	1	\$ 36,400.00	\$ -	\$ 36,400.00
Roadway reconstruction at Crestmont (concrete)	\$ 57,600.00	LS	1	\$ 62,400.00	\$ -	\$ 62,400.00
Roadway reconstruction at Doulton (concrete)	\$ 45,600.00	LS	1	\$ 49,400.00	\$ -	\$ 49,400.00
Roadway reconstruction at Bellfort (asphalt)	\$ 60,000.00	LS	1	\$ 65,000.00	\$ -	\$ 65,000.00
Roadway reconstruction at Vasser (asphalt)	\$ 30,000.00	LS	1	\$ 32,500.00	\$ -	\$ 32,500.00
Remove and replace concrete sidewalk	\$ 78.00	SY	1500	\$ 117,000.00	\$ -	\$ 117,000.00
Detention Pond (300 ac-ft x \$35,000/ac-ft)	\$ 10,500,000.00	LS	1	\$ 10,500,000.00	\$ -	\$ 10,500,000.00
Traffic Controls	\$ 225,000.00	LS	1	\$ 225,000.00	\$ -	\$ 225,000.00
SWPPP	\$ 350,000.00	LS	1	\$ 350,000.00	\$ -	\$ 350,000.00
Tree Protection Plan	\$ 150,000.00	LS	1	\$ 150,000.00	\$ -	\$ 150,000.00
TOTAL				\$ 64,993,800.00	\$ -	\$ 64,993,800.00

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

City of Houston will maintain the storm sewer and mow/clean the area along Salt Water Ditch corridor. HCFCDD will maintain the detention ponds.

2. Identify and explain any special engineering activities.

HCFCDD will periodically assess the conditions of the detention ponds, and inflow/outflow/outfall structures to ensure that they function as intended.



Seal

Date:	9/22/2020
Phone Number:	(713) 988-0145

Signature of Registered Engineer/Architect Responsible For Budget Justification:

ATTACHMENT 7A

PROJECT COST ESTIMATE

MITIGATION ACTIVITY:
SOUTH POST OAK STORMWATER
DETENTION BASIN AND CHANNEL
IMPROVEMENTS (C147-00-00/C547-00-00)

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



**CDBG-MIT: Budget Justification of Retail Costs
(Former Table 2)**

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient: Harris County Flood Control District
Site/Activity Title: South Post Oak SWDB and Channel Improvements (C147-00-00/C547-00-00)
Eligible Activity: Flood Control and Drainage Improvements

Materials/Facilities/Services	\$/Unit	Unit	Quantity	Construction	Acquisition	Total
CENTERPOINT ENERGY COORDINATION	\$ 10,000	LS	4	\$ 40,000.00	\$ -	\$ 40,000.00
TELECOMM COORDINATION	\$ 8,000	LS	1	\$ 8,000.00	\$ -	\$ 8,000.00
TRAFFIC CONTROL (ALT 2)	\$ 400,000	LS	1	\$ 400,000.00	\$ -	\$ 400,000.00
MOBILIZATION OF EQUIPMENT AND MATERIALS (ALT 2)	\$ 600,000	LS	1	\$ 600,000.00	\$ -	\$ 600,000.00
SITE PREPARATION AND RESTORATION FOR CHANNEL (ALT 2)	\$ 500,000	LS	1	\$ 500,000.00	\$ -	\$ 500,000.00
CLEARING & GRUBBING CHANNEL PROP ROW	\$ 4,000	AC	50	\$ 200,000.00	\$ 1,728,130	\$ 1,928,130.00
REMOVE AND DISPOSE OF CONCRETE CHANNEL LINING & LOW FLOW,	\$ 48	SY	12000	\$ 576,000.00	\$ -	\$ 576,000.00
REMOVE AND DISPOSE OF CONCRETE STRUCTURES	\$ 22	CY	350	\$ 7,700.00	\$ -	\$ 7,700.00
REMOVE & DISPOSE OF ALL PIPE	\$ 14	LS	350	\$ 4,900.00	\$ -	\$ 4,900.00
REMOVE & DISPOSE OF ALL PIPE- BLVD OAKS BASIN	\$ 14	LS	1700	\$ 23,800.00	\$ -	\$ 23,800.00
REMOVE & DISPOSE OF STORM SEWER OUTFALL	\$ 38	LS	300	\$ 11,400.00	\$ -	\$ 11,400.00
REMOVE & DISPOSE OF OUTFALL STRUCTURES-BLDV OAKS BASIN	\$ 22	CY	300	\$ 6,600.00	\$ -	\$ 6,600.00
REMOVE & DISPOSE OF CONCRETE BOX CULVERT, ALL SIZES	\$ 40	LF	30	\$ 1,200.00	\$ -	\$ 1,200.00
REMOVE & DISPOSE OF STORM SEWER MANHOLE	\$ 3,000	EA	2	\$ 6,000.00	\$ -	\$ 6,000.00
REMOVE & DISPOSE OF SANITARY SEWER PIPE	\$ 35	LF	1000	\$ 35,000.00	\$ -	\$ 35,000.00
REMOVE & DISPOSE OF SANITARY SEWER MANHOLE	\$ 1,700	EA	15	\$ 25,500.00	\$ -	\$ 25,500.00
REMOVE & DISPOSE OF WATER LINE	\$ 20	LF	2000	\$ 40,000.00	\$ -	\$ 40,000.00
REMOVE FIRE HYDRANT W/6" SERVICE LEAD, BLIND FLANGE @12"	\$ 3,000	EA	2	\$ 6,000.00	\$ -	\$ 6,000.00
TIFFANY BRIDGE REMOVE	\$ 50,000	LS	1	\$ 50,000.00	\$ -	\$ 50,000.00
FUQUA GARDENS VIEW BRIDGE REMOVE	\$ 70,000	LS	1	\$ 70,000.00	\$ -	\$ 70,000.00
SOUTH POST OAK BRIDGE REMOVE	\$ 120,000	LS	1	\$ 120,000.00	\$ -	\$ 120,000.00
SITE PREPARATION AND RESTORATION FOR BASIN (ALT 2)	\$ 500,000	LS	1	\$ 500,000.00	\$ -	\$ 500,000.00
CLEARING & GRUBBING BASIN ROW (SOUTH OF W FUQUA)	\$ 2,500	AC	90	\$ 225,000.00	\$ -	\$ 225,000.00
REMOVE AND DISPOSE OF DETENTION BASIN CONCRETE PILOT	\$ 50	SY	20000	\$ 1,000,000.00	\$ -	\$ 1,000,000.00
EXCAVATION & OFF-SITE DISPOSAL CHANNEL ROW	\$ 15	CY	400000	\$ 6,000,000.00	\$ -	\$ 6,000,000.00
TIFFANY BRIDGE REPLACE (ALT 2 AND 3)	\$ 1,020,000	LS	1	\$ 1,020,000.00	\$ -	\$ 1,020,000.00
TIFFANY BRIDGE APPROACHES REPLACE	\$ 75	SY	3000	\$ 225,000.00	\$ -	\$ 225,000.00
FUQUA GARDENS VIEW BRIDGE REPLACE (ALT 2 AND 3)	\$ 1,087,500	LS	1	\$ 1,087,500.00	\$ -	\$ 1,087,500.00
FUQUA GARDENS VIEW APPROACHES REPLACE	\$ 75	SY	3000	\$ 225,000.00	\$ -	\$ 225,000.00
WEST FUQUA BRIDGE ABUTMENT AND RETAINING WALL MODIFY	\$ 260,000	LS	1	\$ 260,000.00	\$ -	\$ 260,000.00
SOUTH POST OAK BRIDGE REPLACE	\$ 1,100,000	LS	1	\$ 1,100,000.00	\$ -	\$ 1,100,000.00
SOUTH POST OAK APPROACHES REPLACE	\$ 75	SY	6000	\$ 450,000.00	\$ -	\$ 450,000.00
WASTEWATER CROSSING- SIPHON AT FUQUA GARDENS VIEW	\$ 500,000	LS	1	\$ 500,000.00	\$ -	\$ 500,000.00
HCFCO BASIN MODIFICATIONS	\$ 100,000	LS	1	\$ 100,000.00	\$ -	\$ 100,000.00
BLVD OAKS BASIN MODIFICATIONS	\$ 100,000	LS	1	\$ 100,000.00	\$ -	\$ 100,000.00
SWPPP	\$ 70,000	LS	1	\$ 70,000.00	\$ -	\$ 70,000.00
TURF ESTABLISHMENT	\$ 140,000	LS	1	\$ 140,000.00	\$ -	\$ 140,000.00
RIPRAP,GRADATION NO. 1	\$ 80	TON	1200	\$ 96,000.00	\$ -	\$ 96,000.00
EXCAVATION & OFF-SITE DISPOSAL BASIN ROW	\$ 15	CY	565000	\$ 8,475,000.00	\$ -	\$ 8,475,000.00
SWPPP	\$ 66,600	LS	1	\$ 66,600.00	\$ -	\$ 66,600.00
TURF ESTABLISHMENT	\$ 180,000	LS	1	\$ 180,000.00	\$ -	\$ 180,000.00
RIPRAP,GRADATION NO. 1	\$ 80	TON	1200	\$ 96,000.00	\$ -	\$ 96,000.00
	\$ -			\$ -	\$ -	\$ -
	\$ -			\$ -	\$ -	\$ -
	\$ -			\$ -	\$ -	\$ -
	\$ -			\$ -	\$ -	\$ -
	\$ -			\$ -	\$ -	\$ -
	\$ -			\$ -	\$ -	\$ -
TOTAL	\$ 6,897,018.00			\$ 24,648,200.00	\$ 1,728,130.00	\$ 26,376,330.00

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCO CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCO. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCO are included in this budget.

2. Identify and explain any special engineering activities.



Date: 9/29/2020
 Phone Number: 713.462.3178

Timothy E. Buscha
 Signature of Registered Engineer/Architect Responsible For Budget Justification:

ATTACHMENT 7B

PROJECT COST ESTIMATE

MITIGATION ACTIVITY:
SOUTH SHAVER STORMWATER
DETENTION BASIN (C506-01-00-E003)

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



CDBG-MIT: Budget Justification of Retail Costs (Former Table 2)

Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

Applicant/Subrecipient:	Harris County Flood Control District					
Site/Activity Title:	South Shaver Detention Basin					
Eligible Activity:	Flood Control and Drainage Improvements					
Materials/Facilities/Services	\$/Unit	Unit	Quantity	Construction	Acquisition	Total
Excavation & Offsite Disposal	\$ 12	CY	1158178	\$ 13,898,136.00	\$ -	\$ 13,898,136.00
5" Concrete Slope Pavement	\$ 86.40	SY	2000	\$ 172,800.00	\$ -	\$ 172,800.00
Concrete Interceptor Structure	\$ 121.20	SY	280	\$ 33,936.00	\$ -	\$ 33,936.00
Backslope Swale	\$ 3.60	LF	10500	\$ 37,800.00	\$ -	\$ 37,800.00
24" CMP	\$ 60.00	LF	3640	\$ 218,400.00	\$ -	\$ 218,400.00
18" Buried Riprap	\$ 62.40	SY	1200	\$ 74,880.00	\$ -	\$ 74,880.00
Dewatering	\$ 100,000.00	LS	1	\$ 100,000.00	\$ -	\$ 100,000.00
Clearing & Grubbing	\$ 450,000.00	LS	1	\$ 450,000.00	\$ -	\$ 450,000.00
All Weather Access Road	\$ 24.00	SY	8050	\$ 193,200.00	\$ -	\$ 193,200.00
Debris Removal	\$ 14,400.00	LS	1	\$ 14,400.00	\$ -	\$ 14,400.00
Removal & Disposal of Existing Witt Road	\$ 4.80	SY	5000	\$ 24,000.00	\$ -	\$ 24,000.00
Proposed Road	\$ 48.00	SY	3056	\$ 146,688.00	\$ -	\$ 146,688.00
Roadway Excavation & Disposal	\$ 12.00	CY	680	\$ 8,160.00	\$ -	\$ 8,160.00
Roadside Swales	\$ 3.60	LF	2200	\$ 7,920.00	\$ -	\$ 7,920.00
36" RCP Culverts	\$ 120.00	LF	30	\$ 3,600.00	\$ -	\$ 3,600.00
Safety End Treatments	\$ 4,200.00	EA	2	\$ 8,400.00	\$ -	\$ 8,400.00
Removal & Disposal of Existing Concrete Pilot Channels	\$ 12.00	SY	4000	\$ 48,000.00	\$ -	\$ 48,000.00
				\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -
TOTAL	\$ 569,170.00			\$ 15,440,320.00	\$ -	\$ 15,440,320.00

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

This project along with all HCFCO CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCO. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCO are included in this budget.

2. Identify and explain any special engineering activities.

N/A

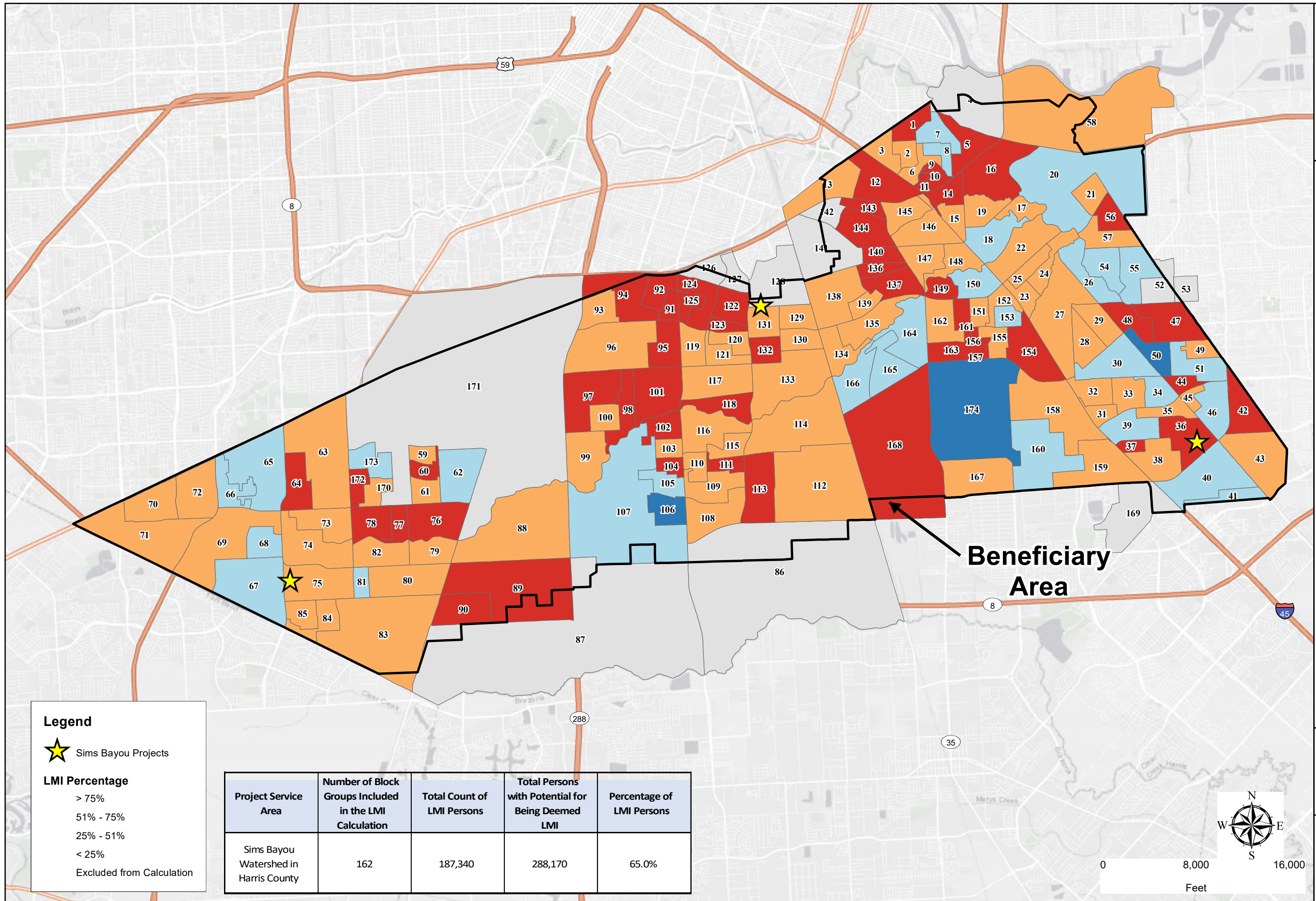


Seal

Date: 9-23-20
Phone Number: 713-283-7789

Jeffrey J. Ebersole
Signature of Registered Engineer/Architect
Responsible For Budget Justification:

9-23-20
Castello, Inc.
TBPE No. 280



Legend

★ Sims Bayou Projects

LMI Percentage

- > 75%
- 51% - 75%
- 25% - 51%
- < 25%
- Excluded from Calculation

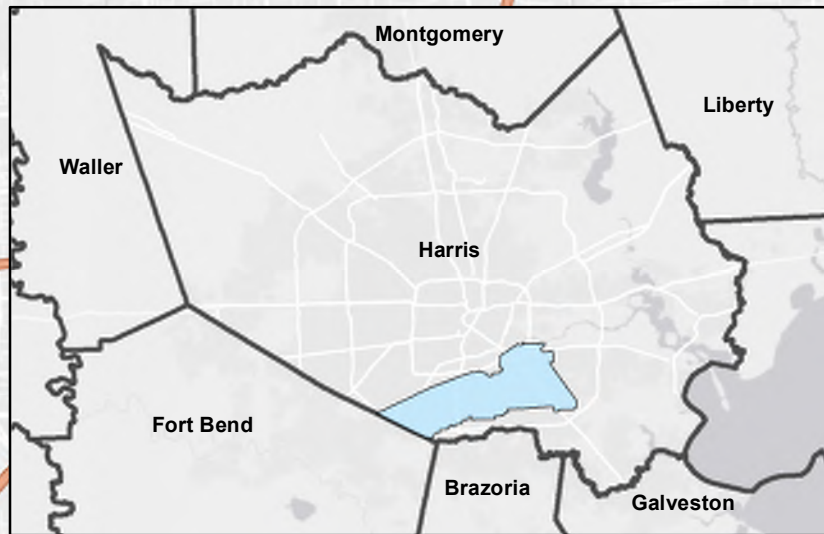
Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Sims Bayou Watershed in Harris County	162	187,340	288,170	65.0%

PROJECT NO: SCC17257
 DATE CREATED: 10/2/2020
 DATA & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
 FILE NAME: Sims_Project_Area_Map_LMI_1
 PREPARED BY: AMJ

STUART CONSULTING GROUP
 CDBG-MIT
Sims Bayou Watershed Beneficiary Area Map



Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482013113001	1,486	1,486	100%	Yes	75.9%
2	482013113002	2,133	2,133	100%	Yes	65.3%
3	482013113003	1,529	1,529	100%	Yes	53.4%
4	482013114001	814	1,541	53%	No	55.8%
5	482013115001	917	919	100%	Yes	94.5%
6	482013115002	1,454	1,457	100%	Yes	55.9%
7	482013115003	3,231	3,231	100%	Yes	48.8%
8	482013115004	1,826	1,826	100%	Yes	43.6%
9	482013116001	1,195	1,195	100%	Yes	78.0%
10	482013116002	2,049	2,049	100%	Yes	85.1%
11	482013116003	554	554	100%	Yes	81.6%
12	482013117001	3,432	3,435	100%	Yes	83.9%
13	482013117002	2,425	2,425	100%	Yes	68.6%
14	482013201001	1,635	1,635	100%	Yes	86.1%
15	482013201002	1,187	1,187	100%	Yes	68.7%
16	482013202001	2,352	2,352	100%	Yes	83.0%
17	482013202002	344	344	100%	Yes	61.7%
18	482013202003	640	642	100%	Yes	42.6%
19	482013202004	2,440	2,440	100%	Yes	63.1%
20	482013205001	2,381	2,381	100%	Yes	48.6%
21	482013205002	2,204	2,204	100%	Yes	55.6%
22	482013206011	2,680	2,680	100%	Yes	65.1%
23	482013206021	1,354	1,354	100%	Yes	63.1%
24	482013206022	1,895	1,895	100%	Yes	67.6%
25	482013206023	1,586	1,586	100%	Yes	62.4%
26	482013207001	3,138	3,138	100%	Yes	47.9%
27	482013207002	1,301	1,301	100%	Yes	69.2%
28	482013208001	1,377	1,377	100%	Yes	74.7%
29	482013208002	1,233	1,233	100%	Yes	68.7%
30	482013208003	2,565	2,565	100%	Yes	46.8%
31	482013209001	1,260	1,260	100%	Yes	69.3%
32	482013209002	2,031	2,031	100%	Yes	74.4%
33	482013209003	1,959	1,959	100%	Yes	63.3%
34	482013209004	2,022	2,022	100%	Yes	30.5%
35	482013210001	1,545	1,545	100%	Yes	69.4%
36	482013210002	1,347	1,347	100%	Yes	84.6%
37	482013210003	2,130	2,130	100%	Yes	93.8%
38	482013210004	1,786	1,786	100%	Yes	65.0%
39	482013210005	2,486	2,486	100%	Yes	41.5%
40	482013211002	3,042	3,042	100%	Yes	41.8%
41	482013211003	1,315	1,315	100%	Yes	48.4%
42	482013212001	2,251	2,251	100%	Yes	88.7%
43	482013212002	1,496	1,496	100%	Yes	72.8%
44	482013213001	3,110	3,110	100%	Yes	81.8%
45	482013213002	1,637	1,637	100%	Yes	73.3%
46	482013213003	2,344	2,344	100%	Yes	44.1%
47	482013214011	3,314	3,314	100%	Yes	83.6%
48	482013214012	1,775	1,775	100%	Yes	79.9%
49	482013214021	968	968	100%	Yes	50.0%
50	482013214022	1,210	1,210	100%	Yes	24.5%
51	482013214023	2,220	2,220	100%	Yes	37.7%
52	482013216003	861	2,093	41%	No	43.7%
53	482013216005	25	776	3%	No	34.8%
54	482013217001	1,674	1,674	100%	Yes	40.9%
55	482013217002	1,633	1,633	100%	Yes	43.1%
56	482013218001	2,464	2,464	100%	Yes	75.7%
57	482013218002	1,810	1,810	100%	Yes	72.4%
58	482013242001	702	1,146	61%	Yes	73.4%
59	482013301001	1,948	1,948	100%	Yes	70.6%
60	482013301002	1,216	1,216	100%	Yes	83.2%
61	482013301003	3,419	3,419	100%	Yes	58.5%
62	482013301004	3,276	3,276	100%	Yes	38.4%
63	482013302001	2,136	2,139	100%	Yes	58.1%
64	482013302002	2,124	2,124	100%	Yes	77.0%
65	482013303011	5,931	5,931	100%	Yes	47.0%
66	482013303012	2,757	2,757	100%	Yes	46.2%
67	482013303021	2,712	2,720	100%	Yes	44.7%
68	482013303022	2,198	2,198	100%	Yes	48.9%
69	482013303023	1,767	1,767	100%	Yes	58.7%
70	482013303031	1,456	1,462	100%	Yes	66.7%
71	482013303032	1,566	1,568	100%	Yes	57.1%
72	482013303033	1,023	1,023	100%	Yes	54.8%
73	482013304001	1,217	1,217	100%	Yes	60.4%
74	482013304002	2,172	2,172	100%	Yes	58.1%
75	482013304003	1,508	1,508	100%	Yes	71.6%
76	482013305001	1,894	1,894	100%	Yes	76.5%
77	482013305002	1,862	1,862	100%	Yes	84.3%
78	482013305003	1,292	1,292	100%	Yes	77.9%
79	482013306001	2,001	2,001	100%	Yes	59.2%
80	482013306002	1,860	1,860	100%	Yes	63.0%
81	482013306003	784	784	100%	Yes	41.3%
82	482013306004	2,710	2,710	100%	Yes	61.7%
83	482013307001	6,054	6,104	99%	Yes	74.3%
84	482013307002	1,438	1,438	100%	Yes	61.4%
85	482013307003	1,651	1,651	100%	Yes	64.2%
86	482013308001	1,191	4,957	24%	No	53.5%
87	482013308002	49	7,692	1%	No	38.4%
88	482013309001	7,393	7,393	100%	Yes	56.0%
89	482013309002	2,790	2,938	95%	Yes	77.2%
90	482013309003	911	911	100%	Yes	88.7%
91	482013311001	583	585	100%	Yes	80.3%
92	482013311002	921	921	100%	Yes	87.2%
93	482013311003	1,064	1,064	100%	Yes	67.2%
94	482013311004	1,533	1,538	100%	Yes	75.6%
95	482013312001	1,309	1,328	99%	Yes	83.7%
96	482013312002	1,957	1,957	100%	Yes	72.4%
97	482013313001	1,584	1,584	100%	Yes	79.2%
98	482013313002	1,110	1,110	100%	Yes	77.1%
99	482013313003	1,266	1,266	100%	Yes	73.4%
100	482013313004	1,500	1,500	100%	Yes	73.3%
101	482013314001	2,421	2,421	100%	Yes	98.7%
102	482013315001	1,068	1,068	100%	Yes	93.5%
103	482013315002	1,021	1,021	100%	Yes	72.4%
104	482013315003	898	898	100%	Yes	93.3%
105	482013315004	1,423	1,423	100%	Yes	34.0%
106	482013315005	1,853	1,853	100%	Yes	23.2%
107	482013315006	3,277	3,467	95%	Yes	30.5%
108	482013316011	1,959	1,959	100%	Yes	54.8%
109	482013316012	2,788	2,788	100%	Yes	66.1%
110	482013316013	1,133	1,133	100%	Yes	69.9%
111	482013316014	1,054	1,054	100%	Yes	83.1%
112	482013316021	872	875	100%	Yes	73.6%
113	482013316022	1,276	1,276	100%	Yes	75.7%
114	482013317001	2,485	2,485	100%	Yes	69.4%
115	482013317002	962	962	100%	Yes	62.9%
116	482013317003	909	909	100%	Yes	66.5%
117	482013318001	3,193	3,193	100%	Yes	58.1%
118	482013318002	1,015	1,015	100%	Yes	98.5%
119	482013319001	1,247	1,247	100%	Yes	56.2%
120	482013319002	1,306	1,306	100%	Yes	66.8%
121	482013319003	1,109	1,112	100%	Yes	71.3%
122	482013320001	2,169	2,169	100%	Yes	83.0%
123	482013320002	1,192	1,192	100%	Yes	92.6%
124	482013320003	2,152	2,152	100%	Yes	89.3%
125	482013320004	678	678	100%	Yes	92.6%
126	482013321001	967	1,728	56%	No	77.9%
127	482013321002	728	1,696	43%	No	83.8%
128	482013322002	488	3,145	16%	No	72.9%
129	482013323001	1,308	1,308	100%	Yes	61.8%
130	482013323002	1,835	1,835	100%	Yes	64.0%
131	482013324001	1,337	1,337	100%	Yes	71.8%
132	482013324002	1,445	1,445	100%	Yes	78.4%
133	482013324003	1,124	1,124	100%	Yes	65.1%
134	482013325001	1,811	1,811	100%	Yes	66.3%
135	482013325002	1,297	1,297	100%	Yes	63.6%
136	482013326001	1,061	1,061	100%	Yes	88.1%
137	482013326002	2,617	2,617	100%	Yes	81.2%
138	482013326003	1,900	1,900	100%	Yes	63.2%
139	482013326004	1,529	1,529	100%	Yes	65.3%
140	482013327001	684	684	100%	Yes	80.0%
141	482013327002	465	1,701	27%	No	74.3%
142	482013328001	591	1,398	42%	No	85.5%
143	482013328002	1,243	1,243	100%	Yes	78.0%
144	482013328003	2,180	2,180	100%	Yes	76.1%
145	482013329001	2,847	2,847	100%	Yes	73.1%
146	482013329002	2,373	2,373	100%	Yes	73.8%
147	482013330001	2,322	2,322	100%	Yes	53.2%
148	482013330002	1,103	1,103	100%	Yes	63.7%
149	482013331001	1,344	1,344	100%	Yes	79.6%
150	482013331002	2,708	2,708	100%	Yes	40.7%
151	482013332011	2,233	2,233	100%	Yes	68.6%
152	482013332012	1,880	1,880	100%	Yes	63.3%
153	482013332013	891	891	100%	Yes	48.8%
154	482013332021	744	744	100%	Yes	78.7%
155	482013332022	1,322	1,322	100%	Yes	50.7%
156	482013332023	1,744	1,744	100%	Yes	76.7%
157	482013332024	1,993	1,993	100%	Yes	77.6%
158	482013333001	1,120	1,122	100%	Yes	65.5%
159	482013333002	7,342	7,342	100%	Yes	72.8%
160	482013333003	2,079	2,082	100%	Yes	47.2%
161	482013335001	2,657	2,657	100%	Yes	83.0%
162	482013335002	1,895	1,895	100%	Yes	68.6%
163	482013335003	1,808	1,808	100%	Yes	85.2%
164	482013336001	1,459	1,459	100%	Yes	37.2%
165	482013336002	1,115	1,115	100%	Yes	39.1%
166	482013336003	1,484	1,484	100%	Yes	34.8%
167	482013337001	2,430	2,430	100%	Yes	52.0%
168	482013337002	822	965	85%	Yes	77.5%
169	482013339021	0	3,615	0%	No	47.7%
170	482013341001	1,602	1,602	100%	Yes	71.8%
171	482013341002	4,399	10,021	44%	No	50.7%
172	4820					



Project Saltwater Ditch

Project C506

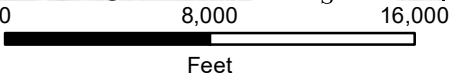
Project C147

Beneficiary Area

Legend

- Sims Project
 - Proposed Detention Improvements
 - Proposed Channel Improvements
 - C100-00-00 (Sims Bayou)
 - Channels
 - Sims Bayou Beneficiary Area
- Total Project Beneficiaries - 309,645

Project Area	Latitude	Longitude
C147	29.61093	-95.46317
Salt Water Ditch	29.67246	-95.33358
C506	29.63708	-95.21676



FN PROJECT NO. SCC17357
 DATE CREATED 10/2/2020
 DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
 FILE NAME Sims_Project_Area_Map
 PREPARED BY ANJ

STUART CONSULTING GROUP
 CDBG-MIT



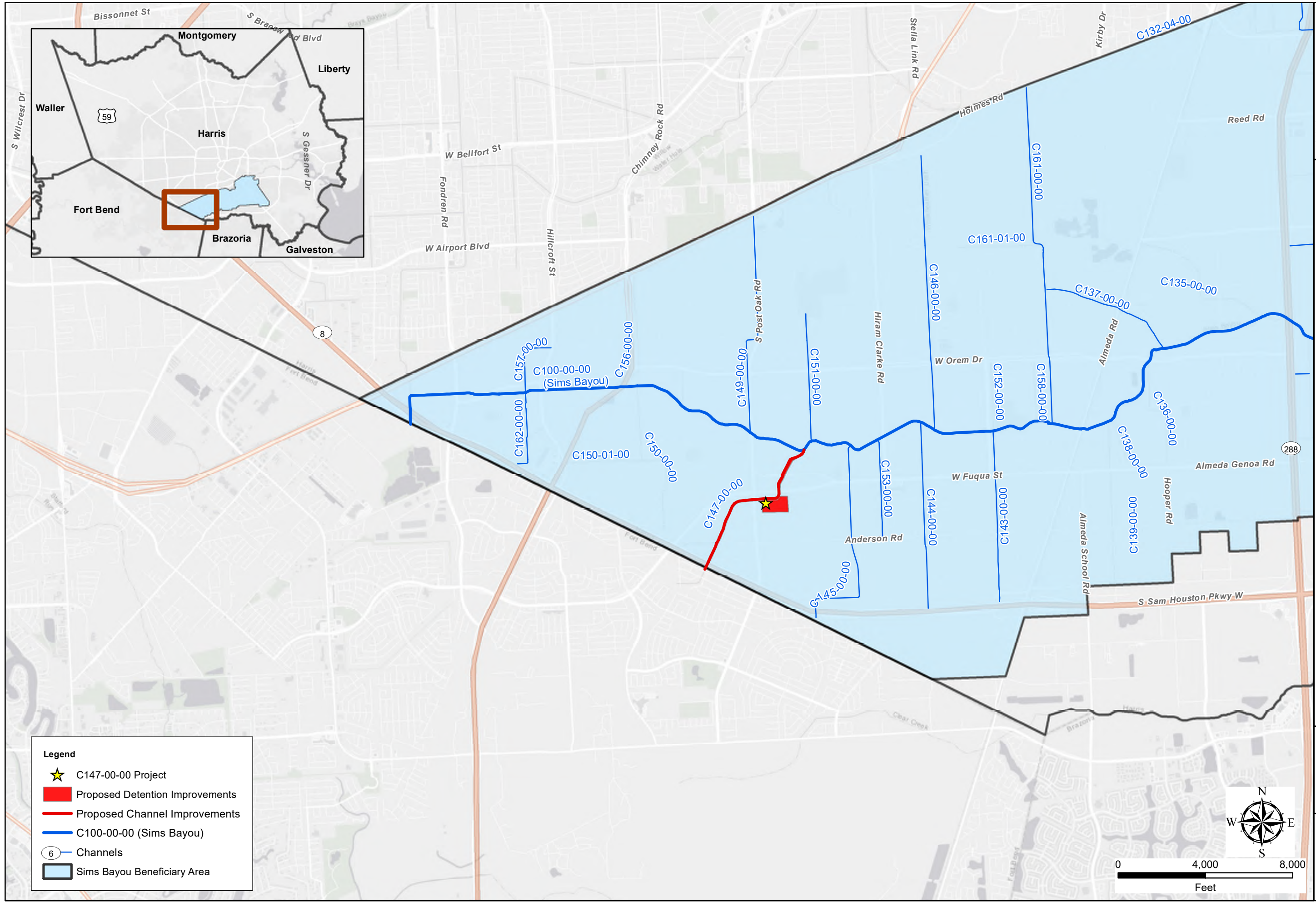
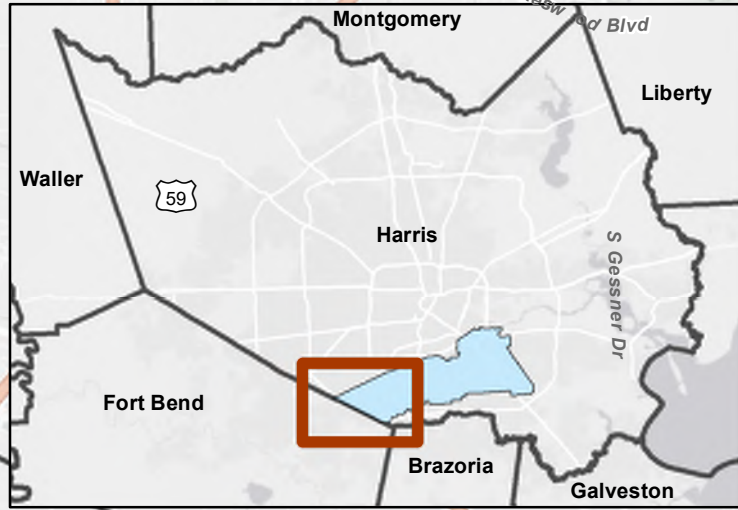
EXHIBIT

ATTACHMENT 2A

PROJECT AREA MAP

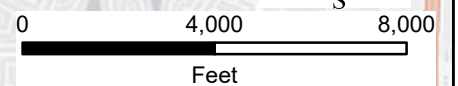
**MITIGATION ACTIVITY:
SOUTH POST OAK STORMWATER
DETENTION BASIN AND CHANNEL
IMPROVEMENTS (C147-00-00/C547-00-00)**

**PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT**



Legend

- C147-00-00 Project
- Proposed Detention Improvements
- Proposed Channel Improvements
- C100-00-00 (Sims Bayou)
- Channels
- Sims Bayou Beneficiary Area



PROJECT NO.	SC21757
DATE CREATED	9/27/2020
DRAWING & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Sims_C147_Project_Benefit
PREPARED BY	AM

STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed - Project C147-00-00



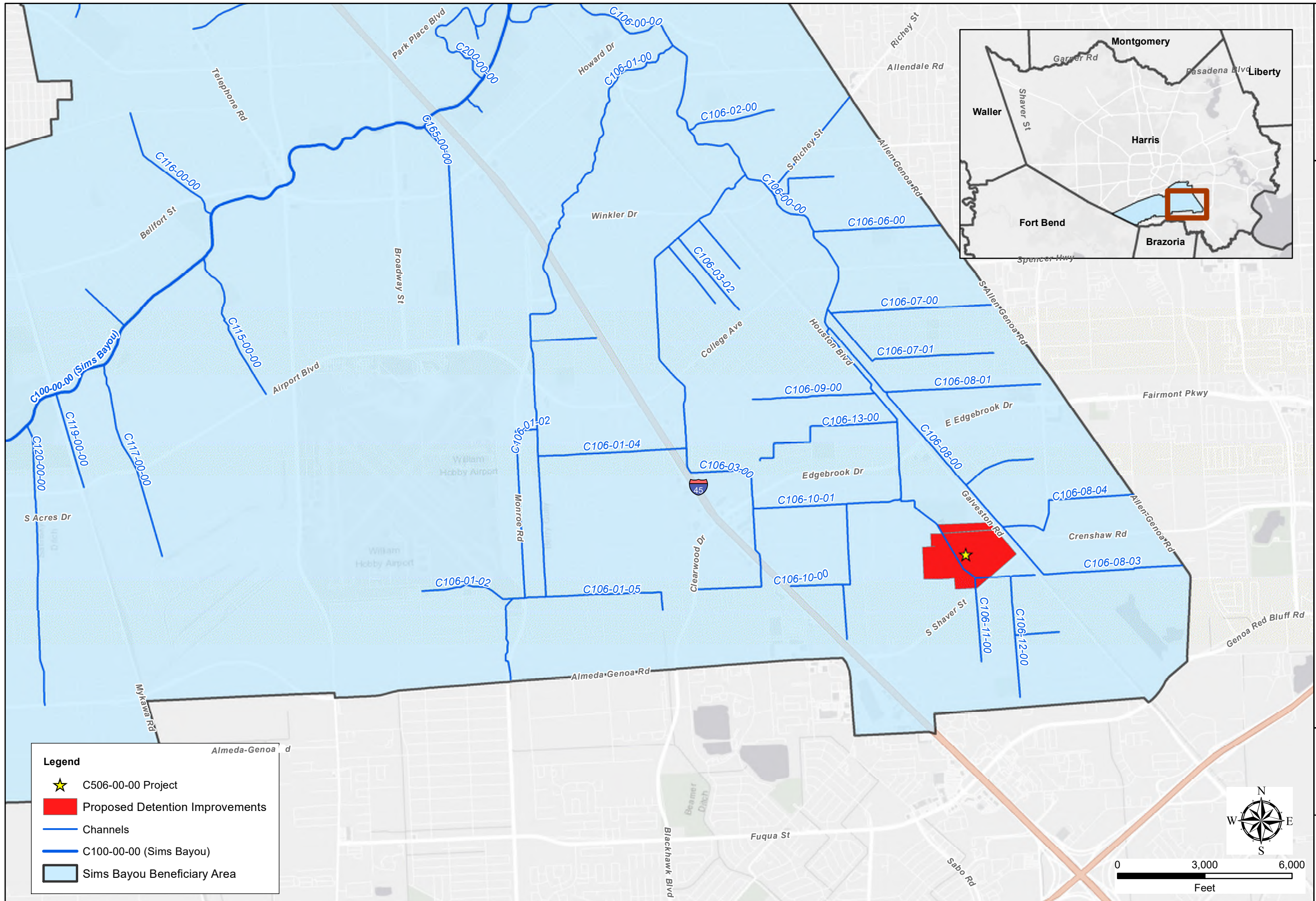
EXHIBIT
3

ATTACHMENT 2B

PROJECT AREA MAP

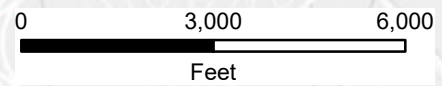
MITIGATION ACTIVITY:
SOUTH SHAVER STORMWATER
DETENTION BASIN (C506-01-00-E003)

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



Legend

- ★ C506-00-00 Project
- Proposed Detention Improvements
- Channels
- C100-00-00 (Sims Bayou)
- Sims Bayou Beneficiary Area



PROJECT NO.	SCC17257
DATE CREATED	9/27/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Sims_C506_Project_Benefit
PREPARED BY	AM

STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed - Project C506-00-00



EXHIBIT

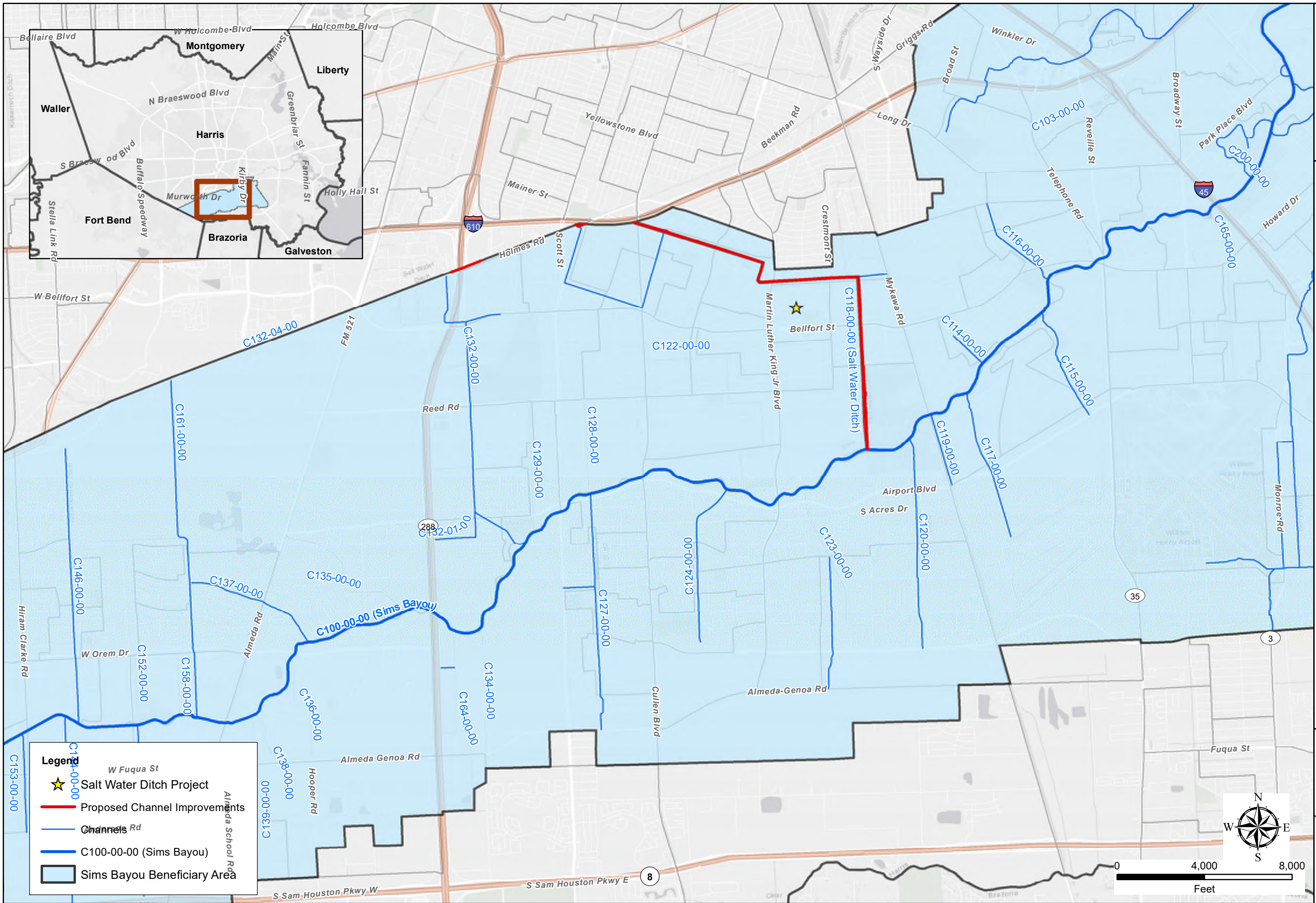
5

ATTACHMENT 2C

PROJECT AREA MAP

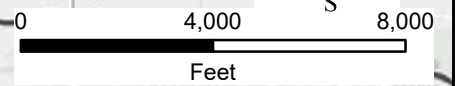
MITIGATION ACTIVITY:
STORMWATER DETENTION BASIN AND
CHANNEL CONVEYANCE
IMPROVEMENTS ALONG SALT WATER
DITCH

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



Legend

- ★ Salt Water Ditch Project
- Proposed Channel Improvements
- Channels
- C100-00-00 (Sims Bayou)
- Sims Bayou Beneficiary Area



PROJECT NO.	SCC17257
DATE CREATED	9/28/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Sims_SWD_Project_Benefit
PREPARED BY	AMJ

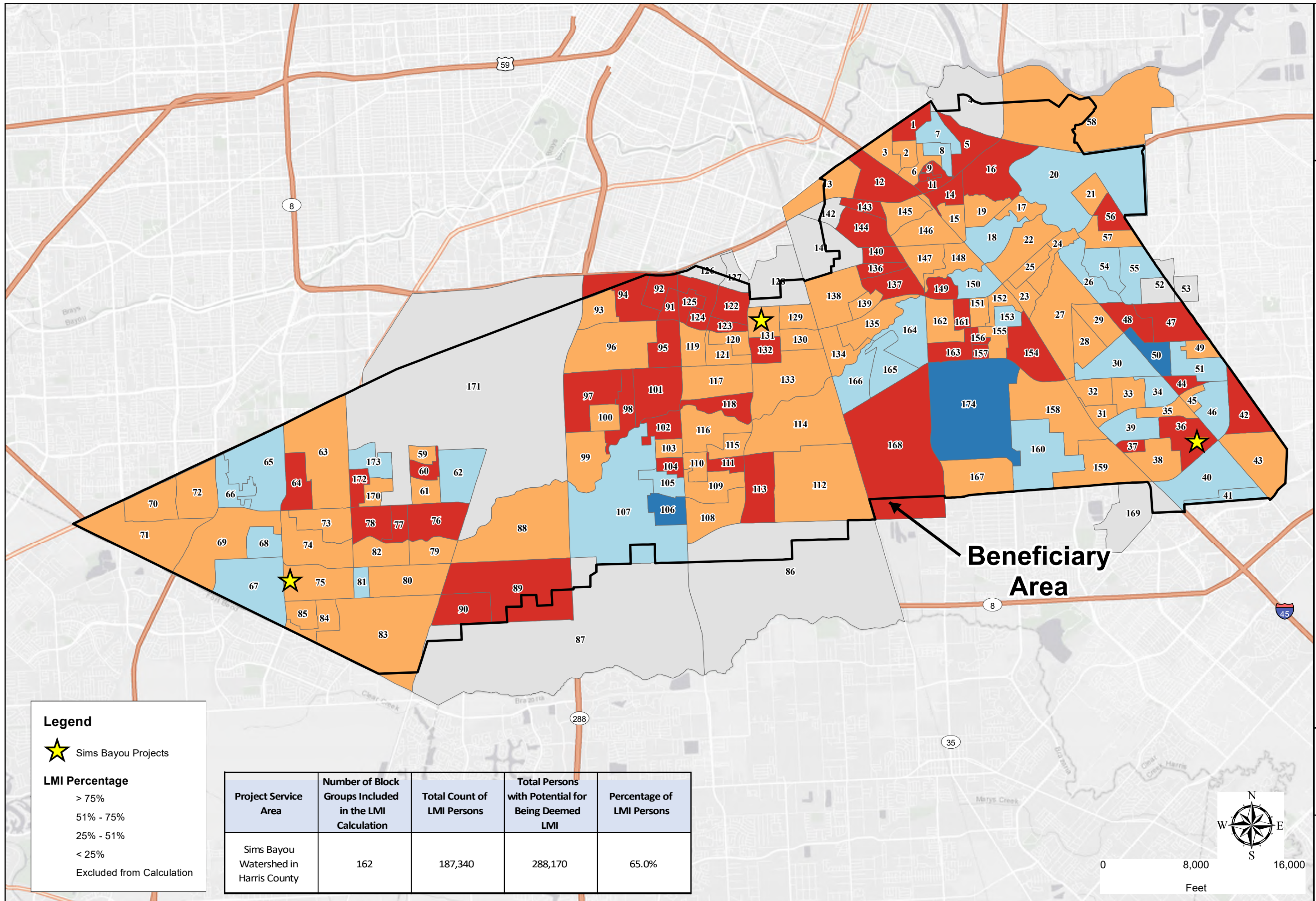
STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed- Project Salt Water Ditch

EXHIBIT
4

ATTACHMENT 3

PROJECT BENEFICIARY MAP



Legend

★ Sims Bayou Projects

LMI Percentage

- > 75%
- 51% - 75%
- 25% - 51%
- < 25%
- Excluded from Calculation

Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
Sims Bayou Watershed in Harris County	162	187,340	288,170	65.0%

PROJECT NO: SCC17357
 DATE CREATED: 9/28/2020
 DATUM & COORDINATE SYSTEM: NAD83 State Plane (feet) Texas South Central
 FILE NAME: Sims_Project_Area_Map_LMI_1
 PREPARED BY: AMJ

STUART CONSULTING GROUP
 CDBG-MIT



EXHIBIT
 2
 (1 of 2)

Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482013113001	1,486	1,486	100%	Yes	75.9%
2	482013113002	2,133	2,133	100%	Yes	65.3%
3	482013113003	1,529	1,529	100%	Yes	53.4%
4	482013114001	814	1,541	53%	No	55.8%
5	482013115001	917	919	100%	Yes	94.5%
6	482013115002	1,454	1,457	100%	Yes	55.9%
7	482013115003	3,231	3,231	100%	Yes	48.8%
8	482013115004	1,826	1,826	100%	Yes	43.6%
9	482013116001	1,195	1,195	100%	Yes	78.0%
10	482013116002	2,049	2,049	100%	Yes	85.1%
11	482013116003	554	554	100%	Yes	81.6%
12	482013117001	3,432	3,435	100%	Yes	83.9%
13	482013117002	2,425	2,425	100%	Yes	68.6%
14	482013201001	1,635	1,635	100%	Yes	86.1%
15	482013201002	1,187	1,187	100%	Yes	68.7%
16	482013202001	2,352	2,352	100%	Yes	83.0%
17	482013202002	344	344	100%	Yes	61.7%
18	482013202003	640	642	100%	Yes	42.6%
19	482013202004	2,440	2,440	100%	Yes	63.1%
20	482013205001	2,381	2,381	100%	Yes	48.6%
21	482013205002	2,204	2,204	100%	Yes	55.6%
22	482013206011	2,680	2,680	100%	Yes	65.1%
23	482013206021	1,354	1,354	100%	Yes	63.1%
24	482013206022	1,895	1,895	100%	Yes	67.6%
25	482013206023	1,586	1,586	100%	Yes	62.4%
26	482013207001	3,138	3,138	100%	Yes	47.9%
27	482013207002	1,301	1,301	100%	Yes	69.2%
28	482013208001	1,377	1,377	100%	Yes	74.7%
29	482013208002	1,233	1,233	100%	Yes	68.7%
30	482013208003	2,565	2,565	100%	Yes	46.8%
31	482013209001	1,260	1,260	100%	Yes	69.3%
32	482013209002	2,031	2,031	100%	Yes	74.4%
33	482013209003	1,959	1,959	100%	Yes	63.3%
34	482013209004	2,022	2,022	100%	Yes	30.5%
35	482013210001	1,545	1,545	100%	Yes	69.4%
36	482013210002	1,347	1,347	100%	Yes	84.6%
37	482013210003	2,130	2,130	100%	Yes	93.8%
38	482013210004	1,786	1,786	100%	Yes	65.0%
39	482013210005	2,486	2,486	100%	Yes	41.5%
40	482013211002	3,042	3,042	100%	Yes	41.8%
41	482013211003	1,315	1,315	100%	Yes	48.4%
42	482013212001	2,251	2,251	100%	Yes	88.7%
43	482013212002	1,496	1,496	100%	Yes	72.8%
44	482013213001	3,110	3,110	100%	Yes	81.8%
45	482013213002	1,637	1,637	100%	Yes	73.3%
46	482013213003	2,344	2,344	100%	Yes	44.1%
47	482013214011	3,314	3,314	100%	Yes	83.6%
48	482013214012	1,775	1,775	100%	Yes	79.9%
49	482013214021	968	968	100%	Yes	50.0%
50	482013214022	1,210	1,210	100%	Yes	24.5%
51	482013214023	2,220	2,220	100%	Yes	37.7%
52	482013216003	861	2,093	41%	No	43.7%
53	482013216005	25	776	3%	No	34.8%
54	482013217001	1,674	1,674	100%	Yes	40.9%
55	482013217002	1,633	1,633	100%	Yes	43.1%
56	482013218001	2,464	2,464	100%	Yes	75.7%
57	482013218002	1,810	1,810	100%	Yes	72.4%
58	482013242001	702	1,146	61%	Yes	73.4%
59	482013301001	1,948	1,948	100%	Yes	70.6%
60	482013301002	1,216	1,216	100%	Yes	83.2%
61	482013301003	3,419	3,419	100%	Yes	58.5%
62	482013301004	3,276	3,276	100%	Yes	38.4%
63	482013302001	2,136	2,136	100%	Yes	58.1%
64	482013302002	2,124	2,124	100%	Yes	77.0%
65	482013303011	5,931	5,931	100%	Yes	47.0%
66	482013303012	2,757	2,757	100%	Yes	46.2%
67	482013303021	2,712	2,720	100%	Yes	44.7%
68	482013303022	2,198	2,198	100%	Yes	48.9%
69	482013303023	1,767	1,767	100%	Yes	58.7%
70	482013303031	1,456	1,462	100%	Yes	66.7%
71	482013303032	1,566	1,568	100%	Yes	57.1%
72	482013303033	1,023	1,023	100%	Yes	54.8%
73	482013304001	1,217	1,217	100%	Yes	60.4%
74	482013304002	2,172	2,172	100%	Yes	58.1%
75	482013304003	1,508	1,508	100%	Yes	71.6%
76	482013305001	1,894	1,894	100%	Yes	76.5%
77	482013305002	1,862	1,862	100%	Yes	84.3%
78	482013305003	1,292	1,292	100%	Yes	77.9%
79	482013306001	2,001	2,001	100%	Yes	59.2%
80	482013306002	1,860	1,860	100%	Yes	63.0%
81	482013306003	784	784	100%	Yes	41.3%
82	482013306004	2,710	2,710	100%	Yes	61.7%
83	482013307001	6,054	6,104	99%	Yes	74.3%
84	482013307002	1,438	1,438	100%	Yes	61.4%
85	482013307003	1,651	1,651	100%	Yes	64.2%
86	482013308001	1,191	4,957	24%	No	53.5%
87	482013308002	49	7,692	1%	No	38.4%
88	482013309001	7,393	7,393	100%	Yes	56.0%
89	482013309002	2,790	2,938	95%	Yes	77.2%
90	482013309003	911	911	100%	Yes	88.7%
91	482013311001	583	585	100%	Yes	80.3%
92	482013311002	921	921	100%	Yes	87.2%
93	482013311003	1,064	1,064	100%	Yes	67.2%
94	482013311004	1,533	1,538	100%	Yes	75.6%
95	482013312001	1,309	1,328	99%	Yes	83.7%
96	482013312002	1,957	1,957	100%	Yes	72.4%
97	482013313001	1,584	1,584	100%	Yes	79.2%
98	482013313002	1,110	1,110	100%	Yes	77.1%
99	482013313003	1,266	1,266	100%	Yes	73.4%
100	482013313004	1,500	1,500	100%	Yes	73.3%
101	482013314001	2,421	2,421	100%	Yes	98.7%
102	482013315001	1,068	1,068	100%	Yes	93.5%
103	482013315002	1,021	1,021	100%	Yes	72.4%
104	482013315003	898	898	100%	Yes	93.3%
105	482013315004	1,423	1,423	100%	Yes	34.0%
106	482013315005	1,853	1,853	100%	Yes	23.2%
107	482013315006	3,277	3,467	95%	Yes	30.5%
108	482013316011	1,959	1,959	100%	Yes	54.8%
109	482013316012	2,788	2,788	100%	Yes	66.1%
110	482013316013	1,133	1,133	100%	Yes	69.9%
111	482013316014	1,054	1,054	100%	Yes	83.1%
112	482013316021	872	875	100%	Yes	73.6%
113	482013316022	1,276	1,276	100%	Yes	75.7%
114	482013317001	2,485	2,485	100%	Yes	69.4%
115	482013317002	962	962	100%	Yes	62.9%
116	482013317003	909	909	100%	Yes	66.5%
117	482013318001	3,193	3,193	100%	Yes	58.1%
118	482013318002	1,015	1,015	100%	Yes	98.5%
119	482013319001	1,247	1,247	100%	Yes	56.2%
120	482013319002	1,306	1,306	100%	Yes	66.8%
121	482013319003	1,109	1,112	100%	Yes	71.3%
122	482013320001	2,169	2,169	100%	Yes	83.0%
123	482013320002	1,192	1,192	100%	Yes	92.6%
124	482013320003	2,152	2,152	100%	Yes	89.3%
125	482013320004	678	678	100%	Yes	92.6%
126	482013321001	967	1,728	56%	No	77.9%
127	482013321002	728	1,696	43%	No	83.8%
128	482013322002	488	3,145	16%	No	72.9%
129	482013323001	1,308	1,308	100%	Yes	61.8%
130	482013323002	1,835	1,835	100%	Yes	64.0%
131	482013324001	1,337	1,337	100%	Yes	71.8%
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133	482013324003	1,124	1,124	100%	Yes	65.1%
134	482013325001	1,811	1,811	100%	Yes	66.3%
135	482013325002	1,297	1,297	100%	Yes	63.6%
136	482013326001	1,061	1,061	100%	Yes	88.1%
137	482013326002	2,617	2,617	100%	Yes	81.2%
138	482013326003	1,900	1,900	100%	Yes	63.2%
139	482013326004	1,529	1,529	100%	Yes	65.3%
140	482013327001	684	684	100%	Yes	80.0%
141	482013327002	465	1,701	27%	No	74.3%
142	482013328001	591	1,398	42%	No	85.5%
143	482013328002	1,243	1,243	100%	Yes	78.0%
144	482013328003	2,180	2,180	100%	Yes	76.1%
145	482013329001	2,847	2,847	100%	Yes	73.1%
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147	482013330001	2,322	2,322	100%	Yes	53.2%
148	482013330002	1,103	1,103	100%	Yes	63.7%
149	482013331001	1,344	1,344	100%	Yes	79.6%
150	482013331002	2,708	2,708	100%	Yes	40.7%
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152	482013332012	1,880	1,880	100%	Yes	63.3%
153	482013332013	891	891	100%	Yes	48.8%
154	482013332021	744	744	100%	Yes	78.7%
155	482013332022	1,322	1,322	100%	Yes	50.7%
156	482013332023	1,744	1,744	100%	Yes	76.7%
157	482013332024	1,993	1,993	100%	Yes	77.6%
158	482013333001	1,120	1,122	100%	Yes	65.5%
159	482013333002	7,342	7,342	100%	Yes	72.8%
160	482013333003	2,079	2,082	100%	Yes	47.2%
161	482013335001	2,657	2,657	100%	Yes	83.0%
162	482013335002	1,895	1,895	100%	Yes	68.6%
163	482013335003	1,808	1,808	100%	Yes	85.2%
164	482013336001	1,459	1,459	100%	Yes	37.2%
165	482013336002	1,115	1,115	100%	Yes	39.1%
166	482013336003	1,484	1,484	100%	Yes	34.8%
167	482013337001	2,430	2,430	100%	Yes	52.0%
168	482013337002	822	965	85%	Yes	77.5%
169	482013339021	0	3,615	0%	No	47.7%
170	482013341001	1,602	1,602	100%	Yes	71.8%
171	482013341002	4,399	10,021	44%	No	50.7%
172	4820					

ATTACHMENT 4

BENEFICIARY DATA

TxCDBG RACE AND ETHNICITY / GENDER CALCULATOR

INSTRUCTIONS AND DATA SOURCE

Data Source: Most Recent ACS 5-year Est. - Table DP05

City Applicants: Enter city-wide data as reflected on Table DP05

County Applicants: Enter census tract data as reflected on Table DP05

APPLICANT: Harris County Flood Control District

Sex and Age	ENTER DP05 DATA HERE
Male:	152475
Female:	157170

One Race	
White:	163200
Black or African American:	98158
American Indian and Alaska Native:	890
Asian:	6252
Native Hawaiian and Other Pacific Islander:	154
Some Other Race:	36287
Two or more races:	4704
-White and Black or African American:	1582
-White and American Indian and Alaska Native:	584
-White and Asian:	322
-Black or African American and American Indian and Alaska Native:	299

Hispanic or Latino and Race	
Hispanic or Latino (of any race):	187348
Not Hispanic or Latino:	122297
-White alone:	16712
-Black or African American alone:	97050
-American Indian and Alaska Native alone:	366
-Asian alone:	6071
-Native Hawaiian and Other Pacific Islander alone:	102
-Some other race alone:	63
-Two or more races:	1934

Enter Number of Project Beneficiaries: 309645

Gender of Project Beneficiaries	
Male	152475
Female	157170

Race and Ethnicity of Project Beneficiaries	Hispanic	Non-Hispanic
White	146488	16712
Black/African American	1108	97050
American Indian/Alaska Native	524	366
Asian	181	6071
Native Hawaiian/Other Pacific Islander	52	102
Some Other Race	36224	63
White and Black/African American	931	651
White and American Indian/Alaska Native	344	240
White and Asian	190	132
Black/African American and American Indian/Alaska Native	176	123
Other multi racial	1129	788
Total:	309645	

Project Information

Project Name	Sims Bayou Watershed Mitigation Project
Project Service Area Description	portion of Sims watershed occurring within Harris County

Beneficiary Data

Beneficiary Population and Project Impact

Total number of project beneficiaries	309,645
Total population within a jurisdiction (Harris County)	4,602,523
Percentage of total project beneficiaries out of the total population within a jurisdiction(s)	6.73%

Total number of project beneficiaries:

Number of residents living in structures located inside the watershed boundary and within Harris County. This is not a sum of block group populations; instead, the number of residents were estimated at the individual structure level.

Total Population Within a Jurisdiction:

Population of Harris County, based on ACS 2014-2018 5-year estimate

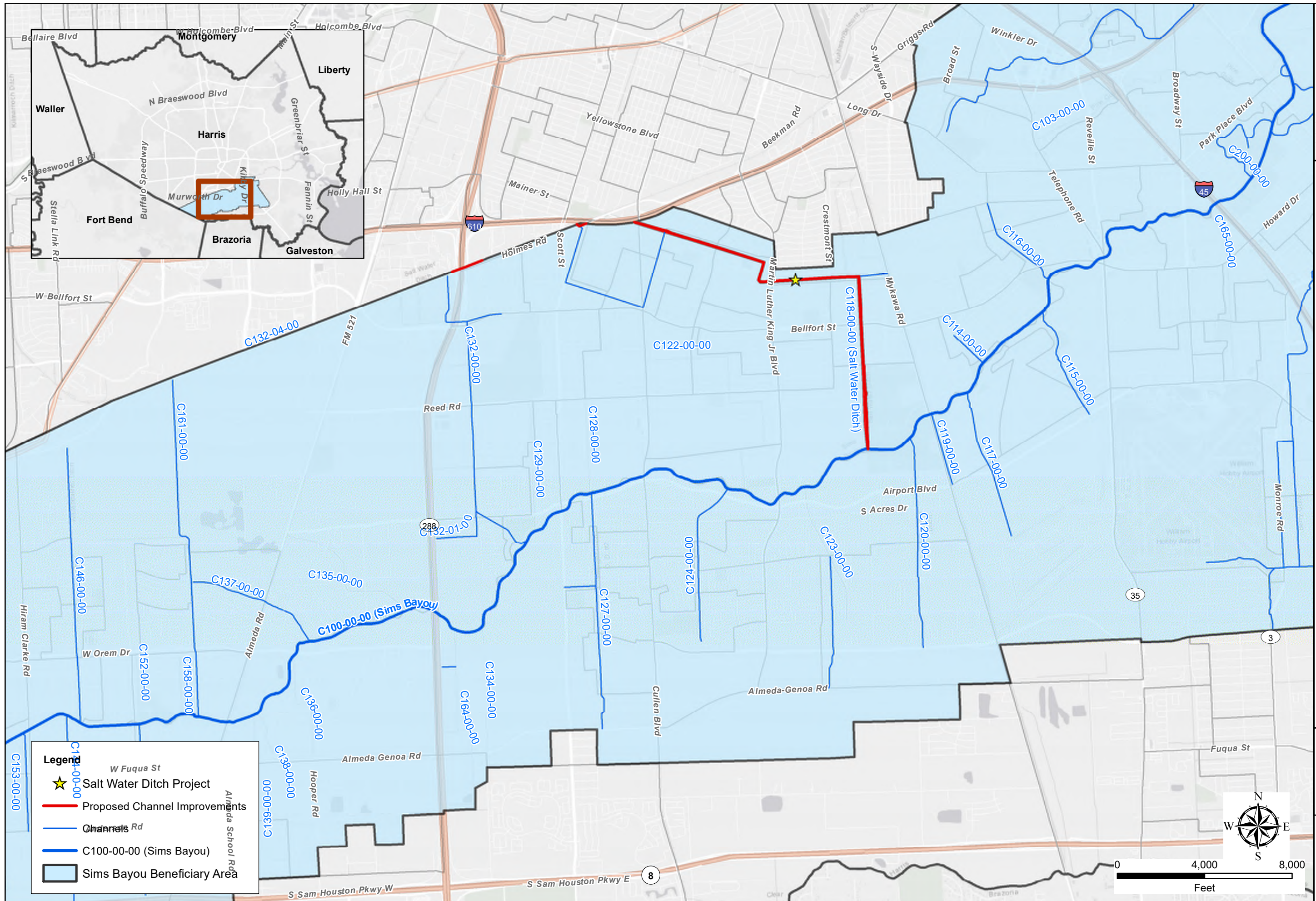
Percentage of total project beneficiaries out of the total population within a jurisdiction(s):

Equal to (total number of project beneficiaries) / (total population of Harris County)

LMI Evaluation

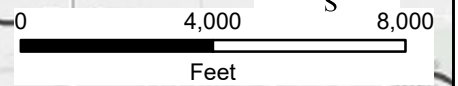
Number of LMI Persons (<i>numerator for LMI %</i>)	187,340
Persons with the potential for being deemed Low-, Moderate- and Middle-income (<i>denominator for LMI %</i>)	288,170
Percent LMI in project beneficiary area	65.0%

HUD guidance indicates that Percent LMI is to be determined with the variable “Persons with the potential for being deemed Low-, Moderate- and Middle-income” as the denominator (**not** total population). Subsequently, this variable was used, rather than the Total Number of Project Beneficiaries, as the denominator in the determination of Percent LMI. Furthermore, all population estimates for this project were estimated from ACS 5-year 2014-2018 data (the most recent ACS data available), but the LMI Spatial Dataset (LMISD) generated by HUD for use in FY 2020 is based on 5-year 2011-2015 ACS data. More information is available at <https://www.hudexchange.info/news/updates-to-low-moderate-income-summary-data-now-available/>. These variables and the process for calculating them is described in further detail in the **LMI Evaluation Attachment**.



Legend

- ★ Salt Water Ditch Project
- Proposed Channel Improvements
- Channels
- C100-00-00 (Sims Bayou)
- Sims Bayou Beneficiary Area



Date Saved: 9/28/2020 8:21:25 PM

Path: H:\STORMWATER\CDBG_MIT_Projects\Working\C100_Sims_Bayou\Sims_Application_Exhibits\Project Benefit Maps\Sims_SWD_Project_Benefit.mxd

PROJECT NO.	SCC17257
DATE CREATED	10/2/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Sims_SWD_Project_Benefit
PREPARED BY	AM

STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed- Project Salt Water Ditch

EXHIBIT
4

FEASIBILITY STUDY FOR
FLOOD DAMAGE REDUCTION
TO SALT WATER DITCH,
HCFCD UNIT C118-00-00

CITY OF HOUSTON
WBS No. M-000100-0012-3

Prepared For:



February 22, 2016

CEI Project No. 325912.00
February 2016

Submitted By:
CivilTech
Engineering, Inc.
Firm Registration No. F-382

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- Exhibit 3 – Physical Watershed Characteristics
- Exhibit 4 – HEC-RAS Cross Sections & Revised Floodplain
- Exhibit 5 – Existing Water Surface Elevation Profile
- Exhibit 6 – Salt Water Ditch Channel Capacity
- Exhibit 7 – Flooded Structures
- Exhibit 8 – Documented Flood Losses
- Exhibit 9 – Salt Water Ditch Reach Segments
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- Appendix A: Existing Channel Right-of-Way and Utility Easements
- Appendix B: Existing Conditions Analysis
- Appendix C: Alternative Analysis
- Appendix D: Quantities and Construction Cost Estimates

Executive Summary

CivilTech Engineering, Inc. (CivilTech) was contracted by the City of Houston Public Works and Engineering Department (City) and Harris County Flood Control District (HCFCD) to perform a study of potential flood mitigation strategies for Salt Water Ditch, HCFCD Unit C118-00-00. An interlocal agreement between the City of Houston (COH Ordinance # 2016-0006) and Harris County Flood Control District (HCFCD Agreement No. 2016-36) was completed to perform this feasibility study. Salt Water Ditch, HCFCD Unit C118-00-00, is a tributary to Sims Bayou, HCFCD Unit C100-00-00, and drains a watershed area of 3.87 square miles. The Sims Bayou watershed drains an area of approximately 93.5 square miles. Salt Water Ditch is located in south-central Harris County within the corporate limits of the City of Houston south of Interstate Highway 610 and east of State Highway 288.

Based on historical aerials from 1944, Salt Water Ditch existed prior to development in the area. In the 1950's construction of residential subdivisions and industrial areas began along the ditch. Development within the Salt Water Ditch subwatershed has continued ever since with no substantial improvements made to the ditch to accommodate the development.

The primary cause of flooding problems in the watershed is the lack of adequate stream capacity to convey floodwaters away from the area. Runoff from rainstorms frequently overflows the channel banks, causing significant damages to many residences and businesses in the floodplain along Salt Water Ditch. The watershed is almost fully developed. This high level of urbanization in the watershed has led to increased flooding along Salt Water Ditch.

In order to effectively quantify the extent and frequency of flooding within the Salt Water Ditch subwatershed, the existing conditions modeling needed to be performed. A hydrologic and hydraulic model for the Salt Water Ditch subwatershed existed; however, the hydrologic model required an update to the watershed parameters based on information available for this study, and the hydraulic model needed to be extended to the upper limit of Salt Water Ditch. The correction to the watershed parameters and the changes to the hydrologic model resulted in a decrease of 1,169 cfs (38% of the Effective flows) at the confluence of Sims Bayou. Using the data from the hydrologic and hydraulic models, the 10-year and 100-year floodplains were mapped. Even though there was a large reduction in flows, the results of the existing conditions hydrologic and hydraulic analysis showed that Salt Water Ditch upstream of Belfort Avenue would experience substantial flooding during both a 10-year and 100-year storm event.

As an extension of existing conditions analysis, the damages associated with flood events in the Salt Water Ditch drainage area were considered using hydraulic modeling results, an inventory of the parcels in the area, and known damage functions. The Harris County Structure Inventory Analysis Tool version 2.0 was used to determine which parcels would be flood-affected by comparing the water-surface elevation from

the Revised Existing HEC-RAS model to the finished floor elevation of the structures. The estimated damages caused by the various flood frequencies were calculated using depth-damage relationships developed for the U.S. Army Corps of Engineers and amended for the Harris County Structure Inventory Analysis Tool by Dannenbaum Engineering. The results from the flood damage estimation reveal the impact of a single 100-year flood event to be approximately \$86.5M and the annualized damages for the Salt Water Ditch area were approximately \$7.3M which has a present value of approximately \$100.0M.

Given the substantial flooding issues, the objective for this feasibility study is flood mitigation in the Salt Water Ditch subwatershed; therefore alternatives were developed to increase the flood carrying capacity of the existing channel and remove excess floodwaters from the subwatershed. Alternatives considered include proposed channel improvements and enclosing a portion of the channel in a closed conduit system. The alternative analysis provides a comparison between the alternatives and estimated construction costs.

Channel improvements, Alternative 1, are proposed that have a flowline approximately 8 feet below the existing channel at the upstream extent. The added depth provides considerable cross-sectional area such that the bottom width of the proposed trapezoidal channel is the minimum of 6 feet with 4H:1V side slopes throughout the proposed improvements. The proposed channel section has a slope of .0006 ft/ft. The capacity is substantially above the proposed flows. This was necessary for two reasons: (1) to provide adequate depth for storm sewer improvements and (2) to lower the 100-year water surface elevations such that they met the freeboard requirements at bridge crossings. This is an issue due to the fact that the Salt Water Ditch subwatershed topography is generally bowl shaped. For instance, the difference between the existing channel bank elevation at the outfall and at the upstream extent, a distance of approximately 3.3 miles, is only 1.0 foot. This leads to water surface elevations well within the channel near the outfall and channel sections with capacities much greater than the proposed flows. In addition, in order to provide the necessary channel depth, improvements must extend to the confluence with Sims Bayou. Upstream of the confluence with Sims Bayou a drop structure is also required to lower the existing slope and thereby velocities in the downstream section.

Alternative 2 was created in order to **limit the number of acquisitions by using a closed conduit drainage** system in lieu of channel improvements for the portion of Salt Water Ditch upstream of Martin Luther King Jr., Boulevard; downstream of Martin Luther King Jr. Boulevard the closed conduit system would transition to the proposed improved channel outlined in the previous section. The size of the closed conduit alternative ranges from 3 – 12'x8' RCB's to 3 – 12' x 10' RCB's.

The increased conveyance of an improved Salt Water Ditch lowers the time of concentration and storage coefficient and thereby increases the peak flows. Detention must be provided to mitigate the peak flow impacts such that Sims Bayou is not affected. The proposed improvements would cause an increase in

peak flows of approximately 1950 cfs and would require approximately 817 ac-ft of detention to mitigate. Three potential detention sites are recommended to provide the necessary storage volume.

The recommended plan for Salt Water Ditch is Alternative 1 which includes channel enlargement from the upstream extent of Salt Water Ditch to the confluence with Sims Bayou. The channel section would have a 6' bottom width and range in depth from 14 at the upstream limit to 24 feet at the confluence with Sims Bayou. The channel slope would be a consistent .0006 ft/ft. This alternative also includes a drop structure in the downstream portion of Salt Water Ditch that lowers the existing slope and thereby the velocities within that portion of the channel. A detention pond with approximately 817 acre-feet of detention will be required to mitigate the peak flow impacts to Sims Bayou. This alternative provides the necessary depth to allow storm sewers to drain into the channel, provides the freeboard required for the new bridges, has the lowest construction cost, and removes all structures from the 100-year floodplain. The annuitized cost of flood damages is \$100,019,989 and the estimated construction cost for Alternative 1 is \$63,574,517 resulting in a net benefit of \$36,445,472 and a benefit-cost ratio of 1.57 giving strong support for implementing the recommended plan.

1. Introduction

This report presents the Feasibility Study for Flood Damage Reduction to Salt Water Ditch. CivilTech Engineering, Inc. (CivilTech) was contracted by the City of Houston Public Works and Engineering Department (City) and Harris County Flood Control District (HCFCD) to perform a study of potential flood mitigation strategies for Salt Water Ditch, HCFCD Unit C118-00-00. An interlocal agreement between the City of Houston (COH Ordinance # 2016-0006) and Harris County Flood Control District (HCFCD Agreement No. 2016-36) was completed to perform this feasibility study. This project was authorized in Work Order No. 12 – “Feasibility Study for Flood Damage Analysis Required for Salt Water Ditch (HCFCD C118-00-00); Including Additional Storm Drainage Analysis Required for Pre-Engineering Need Area M-2014-034,” WBS No. M-000100-0012-3, Contract Number 4600011469. Sub-consultants include Landtech Consultants, Inc. and Watearth, Inc.

1.1 Study Area & the Problem

Salt Water Ditch, HCFCD Unit C118-00-00, is a tributary to Sims Bayou, HCFCD Unit C100-00-00, and drains a watershed area of 3.87 square miles. The Sims Bayou watershed and subwatersheds are shown in **Exhibit 1**. Salt Water Ditch is located in south-central Harris County within the corporate limits of the City of Houston south of Interstate Highway 610 and east of State Highway 288. Based on historical aerials from 1944, Salt Water Ditch existed prior to development in the area. Salt Water Ditch originally drained east into the ditch along Mykawa Road. In the 1950’s as construction of residential subdivisions and industrial areas began along the ditch, the alignment of Salt Water Ditch was realigned 90 degrees directly south to Sims Bayou. Based on the aerials, it was determined that no substantial improvements were made to the ditch to accommodate the surrounding development which has over time led to flooding problems in the Salt Water Ditch subwatershed.

The primary cause of flooding problems in the watershed is the lack of adequate stream capacity to convey floodwaters away from the area. Runoff from rainstorms frequently overflows the channel banks, causing significant damages to many residences and businesses in the floodplain along Salt Water Ditch. The watershed is almost fully developed. This high level of urbanization in the watershed has led to increased flooding along Salt Water Ditch.

1.2 Study Purpose & Scope of Work

The purpose of this study was to evaluate and quantify the existing flooding problems along Salt Water Ditch and to develop alternative flood control solutions to eliminate the existing flooding problems. The following primary task activities were included in the scope of work:

- Project Management
- Project Meetings
- Data Collection and Review

- Topographic Surveys
- Watershed Mapping and Land Uses
- Existing Condition Analysis
- Existing Problems and Needs Assessment
- Alternative Analysis
- Cost Analysis
- Study Report

1.3 Project Survey & Datum

The project datum is the North American Vertical Datum (NAVD) 1988, 2001 adjustment. A topographic survey was conducted in January of 2011 by the Harris County Flood Control District (HCFCD) along Salt Water Ditch, HCFCD Unit C118-00-00. HCFCD supplied the survey data for the analysis of Salt Water Ditch. The topographic survey was tied to the NAVD 1988, 2001 adjustment. The limits of the survey extend from Bellfort Avenue to Calhoun Road. Survey data was collected at roadway crossings and channel cross sections were collected at intervals no greater than 1000 feet. All elevations in this report are referenced to the project datum unless otherwise noted.

1.4 Prior Studies

Previous related planning studies and reports regarding flood control improvements to Salt Water Ditch are summarized as follows:

1. Harris County Flood Control District Internal Recon Report for Salt Water Ditch, prepared by Harris County Flood Control District, June 2010.

This report presented the existing flooding issues along Salt Water Ditch and offered two alternatives with either a 10-year or 25-year level of service (LOS). For the two alternatives, channel improvements were proposed from Martin Luther King Jr. Boulevard to either Vasser Road or the confluence with Sims Bayou.

2. Preliminary Design of Channel Improvements for HCFCD Ditch C118-00-00, prepared by Dodson and Associates, Inc., February 1989.

This report analyzed the existing conditions of Salt Water Ditch and proposed two alternatives to improve the capacity of the channel. The two alternatives consisted of channel improvements from the confluence with Sims Bayou, HCFCD Unit C100-00-00, to the upstream limits of the ditch at Calhoun Street. The majority of channel improvements proposed for both alternatives included a concrete channel section.

1.5 References

The following references and criteria manuals were utilized in performing the feasibility study:

- Hydrology and Hydraulics Guidance Manual, Harris County Flood Control District, December 2009.
- Policy Criteria and Procedure Manual For Approval and Acceptance of Infrastructure, Harris County Flood Control District, December 2010.
- TSARP White Papers, TSARP Technical Committee, Houston, TX, 2002.
- Hydrology for Harris County, Seminar, American Society of Civil Engineers (Texas Section-Houston Branch), Water and Drainage Technical Committee and Harris County Flood Control District, Houston, TX, March 3, 1988.
- Structure Inventory Analysis Tool Version 2.0 – Final Report, Dannenbaum Engineering, Houston, TX, 2011.
- Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVs) in Support of the Jefferson and Orleans Flood Control Feasibility Studies, Gulf Engineers and Consultants, Baton Rouge, LA, 1996.
- Guidelines for Determining Flood Flow Frequency – Bulletin #17B, USGS, 1982.

1.6 Topography & Land Use

Salt Water Ditch extends from its upper limits at Calhoun Road for approximately 3.4 miles to the outfall into Sims Bayou located 0.7 miles west of the Mykawa Road crossing. The topography is generally characterized by mild terrain with the upper portion of the watershed sloping to the east and the lower portion sloping south toward Sims Bayou. The watershed exhibits a gentle overland slope of generally less than 11 feet per mile. The stream gradient from the upstream limits to Vasser Road averages about 3.6 feet per mile. South of Vasser Road, the channel is very steep with an average stream gradient of 19.2 feet per mile. The Salt Water Ditch subwatershed is mostly developed with residential lots making up the majority of the development and some industrial, commercial, schools, and developed green areas. A more detailed description of existing land use is contained in **Section 3 – Existing Conditions Analysis**.

1.7 Right-of-Way

The existing Salt Water Ditch is located within a right-of-way that ranges from a minimum of 30 feet at the upstream limit at Calhoun Road to a maximum of 70 feet at the confluence with Sims Bayou. Any proposed channel improvements would require the acquisition of parcels in order to provide the necessary right-of-way and maintenance access. Along the portions of Salt Water Ditch with residential lots backing up to the ditch, just outside of the existing right-of-way is also located 10' utility easements for sanitary sewers. Along the west bank of Salt Water Ditch south of Doulton Drive is a 100' energy easement owned by CenterPoint Energy. The existing right-of-way maps along Salt Water Ditch are provided in **Appendix A**.

2. Methodology

The hydrologic and hydraulic methodologies used in this analysis are described below. Hydrographs were computed using United States Army Corps of Engineers (USACE) Hydrologic Engineering Center “Hydrologic Modeling System” (HEC-HMS) Version 3.3 and water surface profiles were computed using USACE Hydrologic Engineering Center “River Analysis System” (HEC-RAS) Version 4.1. FEMA Effective hydrologic and hydraulic models were acquired for the studied streams Sims Bayou, HCFCD Unit C100-00-00, and Salt Water Ditch, HCFCD Unit C118-00-00, from the HCFCD Model and Map Management (M3) System. The effective models represent the base models used for the analysis.

2.1 Model Description

The base models for the hydrologic and hydraulic analyses are identified as the FEMA Effective HEC-HMS and HEC-RAS models for Sims Bayou. The following basin models and plans were used in the HEC-HMS and HEC-RAS models for this study:

- Duplicate Effective (Original FEMA Effective HEC-HMS Model)
- Corrected Effective (Watershed characteristics updated using available information for this study)
- Revised Existing (Salt Water Ditch subwatershed divided into two subareas)
- Proposed (Watershed characteristics and cross sections revised for proposed improvements)
- Mitigated (Proposed model conditions with peak flow impacts mitigated)

The base model, represented as the Duplicate Effective condition, analyzed the Salt Water Ditch watershed as one subbasin in the HEC-HMS model and included only the portion of Salt Water Ditch from Belfort Avenue to the outfall in the HEC-RAS model. Based on the information available for this study, the watershed characteristics for the Salt Water Ditch subwatershed were recalculated for the Corrected Effective condition. The Revised Existing model condition analyzes the Salt Water Ditch subwatershed as two subareas and a routing reach and the HEC-RAS model was extended to the upstream limits of Salt Water Ditch. The two subareas are shown in **Exhibit 2**. The proposed model condition represents the proposed improvements for a fully developed watershed.

2.2 Hydrologic Methodology

The hydrologic analysis was performed using the USACE HEC-HMS Version 3.3. The Harris County Flood Control District (HCFCD) hydrologic methodology for developing runoff hydrographs was utilized for this study. The HCFCD hydrologic methodology utilizes a series of watershed characteristics and equations to calculate the Clark Unit Hydrograph parameters, time of concentration (T_c) and storage coefficient (R). The watershed characteristics were measured and computed using topographic data, aerials, survey data, construction drawings, parcel data, USACE HEC-RAS computer program, and information from site visits.

In Harris County, rainfall losses are generally calculated using the Green and Ampt infiltration method. The Green and Ampt method utilizes percent impervious cover and four parameters based upon physical soil properties to calculate losses. The four parameters are initial loss, volume moisture deficit, wetting front suction, and hydraulic conductivity. These four parameters have been established by HCFCD on a watershed wide basis. **Table 1** shows the Green and Ampt parameters used in the analysis.

Table 1: Green and Ampt Parameters

Watershed	Initial Loss	Volume Moisture Deficit	Wetting Front Suction	Hydraulic Conductivity
	(In)	(--)	(In)	(In/hr)
Sims Bayou	0.319	0.385	12.45	0.072

Seven statistical rainfall events were simulated using the USACE HEC-HMS computer model for Sims Bayou. Rainfall data was based on Harris County Hydrologic Region 3 and a 24-hour storm duration was used. Precipitation amounts for the various storm events are provided in **Table 2**.

Table 2: Point Rainfall Depths by Event

Storm Event (years)	Point Rainfall for Given Duration (in)						
	15-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
2	1.1	2.0	2.4	2.7	3.2	3.8	4.5
5	1.4	2.5	3.1	3.5	4.4	5.3	6.4
10	1.5	2.9	3.7	4.2	5.3	6.4	7.8
25	1.7	3.4	4.4	5.1	6.6	8.0	9.8
50	1.9	3.8	5.0	5.9	7.7	9.5	11.6
100	2.1	4.3	5.7	6.8	9.1	11.1	13.5
500	2.5	5.5	7.7	9.4	13.1	15.9	19.3

HCFCD generally uses the Modified Puls flood routing method to simulate the runoff hydrograph movement through a channel, floodplain, or detention system. This routing method utilizes a predefined storage versus discharge relationship as computed using the HEC-RAS program. Due to the large amount of overbank storage volume which exists for severe storm events within the Salt Water Ditch watershed, this methodology was utilized in performing the analysis.

2.3 Hydraulic Methodology

The USACE HEC-RAS computer model Version 4.1 was used to determine the water surface profiles and flooding extents along Salt Water Ditch. The FEMA Effective HEC-RAS model for Salt Water Ditch, HCFCD

Unit C118-00-00, was extended to Calhoun Road using HEC-GeoRAS, 2001 LiDAR topographic data, topographic survey data, and 2012 aerials. The downstream boundary condition was set to normal depth. Manning roughness coefficients were taken from the Harris County Flood Control District Policy Criteria and Procedure Manual, dated December 2010. For the channel portion of the cross sections, a Manning's n-value of 0.04 was used; and for the overbank areas values of 0.08 and 0.14 were used for open areas and residential areas. Contraction and expansion coefficients of 0.3 and 0.5 were used for the two cross sections upstream and one cross section downstream from bridges. Geometric data for the bridges was obtained from the project survey data.

HEC-HMS node peak flows were associated with HEC-RAS cross sections. Flows at cross sections between HEC-HMS nodes were interpolated based on the cross section stationing and a semi-log relationship. The procedure outlined in TSARP Technical White Paper *"Recommendations for Determining Discharges in Upstream Reaches of Subareas"* was used to determine the discharges at the upstream limit of Salt Water Ditch. The upstream peak flow rates were determined by plotting the computed peak flow rates for surrounding subareas in the Sims Bayou watershed on log-log scale and drawing a straight-line approximation through the paired data. The straight-line was extrapolated linearly to define an approximate relationship for smaller areas. Then the extrapolated line was adjusted downward so that it passes through the subarea outlet discharge. The adjusted extrapolated line forms a peak flow rate versus drainage area curve from which flow rates were obtained.

3. Existing Conditions Analysis

In order to effectively quantify the extent and frequency of flooding within the Salt Water Ditch subwatershed, the existing conditions modeling needed to be performed. A hydrologic and hydraulic model for the Salt Water Ditch subwatershed existed; however, the hydrologic model required an update to the watershed parameters based on information available for this study and the hydraulic model needed to be extended to the upper limit of Salt Water Ditch. This section will discuss the reevaluation of the existing conditions.

3.1 Hydrologic Analysis

This sections presents the watershed characteristics, assumptions, and methodology used to perform the hydrologic analysis. The hydrologic analysis was performed using the USACE HEC-HMS “Hydrologic Modeling System” Computer Model (Version 3.3).

Based on the information available for this study, the watershed characteristics for the Salt Water Ditch subwatershed were recalculated representing the Corrected Effective model condition. In looking at the available information for the project, Salt Water Ditch was shown to have two varying subareas. The subareas differ in regards to their respective channel slopes, level of development, and capacity for channel conveyance. The upstream subarea was shown to have a much shallower channel slope (3.0 feet per mile) compared to further downstream (9.0 feet per mile), an almost entirely developed subarea compared to large areas of undeveloped land near the confluence with Sims Bayou, and significantly less channel conveyance capacity. Therefore, to properly evaluate the performance of the subwatershed, it was divided into two subareas with a routing reach. This condition is represented as the Revised Existing condition. The hydrologic results are presented for Duplicate Effective, Corrected Effective, and Revised Existing conditions.

3.1.1 Hydrologic Parameters

The Harris County Flood Control District (HCFCD) hydrologic methodology for developing runoff hydrographs was utilized for this study. The HCFCD hydrologic methodology utilizes a series of watershed characteristics and equations to calculate the Clark Unit Hydrograph parameters, time of concentration (Tc) and storage coefficient (R). The watershed characteristics were corrected using topographic data, aerials, survey data, construction drawings, Harris County Appraisal District (HCAD) parcel data, USACE HEC-RAS model, and information from site visits.

The update to the watershed characteristics represents the Corrected Effective condition. The calculations are provided in **Appendix B**. The physical watershed characteristics are shown in **Exhibit 3** and listed in **Table 3**.

Table 3: Subwatershed Parameters

Subarea	DA (sq mi)	L (mi)	Lca (mi)	S (ft/mi)	So (ft/mi)	DLU (%)	DCI (%)	DCC (%)	DPP (%)	DET (%)	IMP (%)
C118	3.87	5.62	2.62	15.41	6.34	82.40	79	60	0	2.25	52.87
C118_Corrected	3.87	5.91	2.61	3.74	8.20	87.78	79	50	0	2.56	42.34
C118A	1.93	3.66	1.87	2.97	5.48	96.87	100	40	0	2.48	45.47
C118B	1.94	2.34	1.71	9.03	10.92	78.71	68	60	0	2.64	39.21

Where:

DA = Drainage Area in square miles

L = Watershed Length in miles

L_{CA} = Length to Centroid in miles

S = Channel Slope in feet/mile

So = Overland Slope in feet/mile

DLU = Percent Development

DCI = Percent Channel Improvement

DCC = Percent Channel Conveyance

DPP = Percent Ponding

DET = Percent of Area served by detention

IMP = Percent Impervious

Existing land use or percent development (DLU) and percent impervious (IMP) were calculated by assigning one of eleven land use categories outlined in *HCFC D Hydrology and Hydraulic Manual*. The land use categories were assigned based on 2012 aerials from Houston-Galveston Area Council (H-GAC). Existing land uses in Salt Water Ditch subwatershed and the subareas are shown in **Exhibit 2** and the calculations are provided in **Appendix B**.

The channel slope and overland slope were calculated using 2008 LiDAR data and topographic survey data where available. The overland slope was calculated for several overland flow paths for each subarea and averaged. The channel slope is measured as the middle 75% of the watershed length ignoring sudden drops in elevation. A plot of the existing flowline for the watershed lengths for each subarea used to calculate the channel slope is provided in **Appendix B**. The effective model uses a slope of 15.4 feet/mile. Looking at the plots, we can see that this slope is much too high to be representative of the middle 75% of the watershed length for Salt Water Ditch. Based on the topographic survey data, the channel slope was corrected to 3.74 feet/mile for the Salt Water Ditch subwatershed, almost a fifth of the channel slope in the effective model. For the Revised Existing condition, the channel slopes for subarea C118A and C118B were calculated as 2.97 feet/mile and 9.03 feet/mile.

As part of this study, the existing FEMA Effective HEC-RAS model was extended to the upper limit of Salt Water Ditch. The extension of the HEC-RAS model is further discussed in **Section 3.2 – Hydraulic Analysis**. This extended HEC-RAS model was used to calculate the percent channel conveyance (DCC). DCC is measured as the percent of the 1% exceedance event full conveyance discharge that is conveyed within the channel banks. DCC is measured at all cross sections and a weighted average DCC value, based upon channel reach length, is determined. The DCC value is then rounded to the nearest 10 percent. The DCC calculation is provided in **Appendix B**. Based on the results of the calculation, the effective DCC value of

60% is too high. Using the extended model, it was found that Salt Water Ditch has a DCC value of 50% and subarea C118A and C118B have a DCC value of 40% and 60%.

3.1.2 Storage Routing

The Modified Puls Routing Method was used to route the runoff hydrograph from subarea C118A through the routing reach along Salt Water Ditch for the Revised Existing condition. The routing reach extends from downstream of the Martin Luther King Jr. Boulevard crossing to the confluence with Sims Bayou, HCFCU Unit C100-00-00. This routing method utilizes a predefined storage versus discharge relationship as computed using the HEC-RAS computer program. The storage versus outflow is shown in **Table 4**.

Table 4: Revised Existing Storage vs. Outflow for Reach C1180000_0009_R

Storage (ac-ft)	Outflow (cfs)
16.96	134.0
31.61	267.9
64.81	401.9
122.93	535.8
213.44	669.8
314.71	803.8
473.55	1004.7
819.71	1339.6

3.1.3 Results

A hydrologic analysis was performed to determine the peak flows along Salt Water Ditch and Sims Bayou for seven (7) storm frequencies which include the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events. The 10- and 100-year computed peak flows at hydrologic points of interest along Salt Water Ditch and Sims Bayou are listed in **Table 5** and **Table 6**. The hydrologic points of interest are shown in **Exhibit 1**. The HEC-HMS output and a comparison of the 10-, 50-, 100-, and 500-year peak flows are provided in **Appendix B**. A comparison between the duplicate effective, corrected effective, and revised existing condition hydrograph for Salt Water Ditch is shown in **Figure 1** and a comparison with the Sims Bayou hydrograph is shown in **Figure 2**.

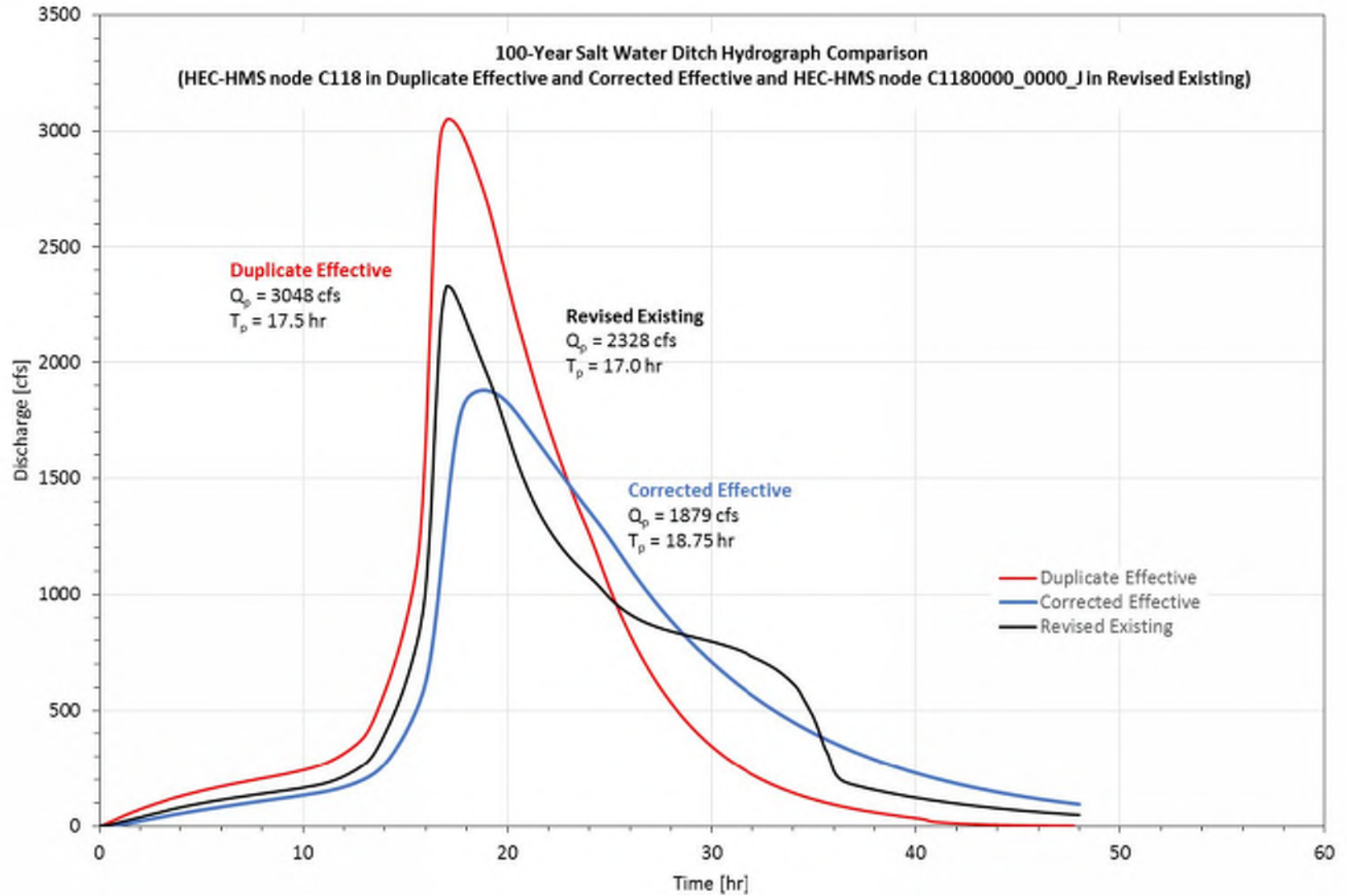


Figure 1: 100-Year Salt Water Ditch Hydrograph Comparison

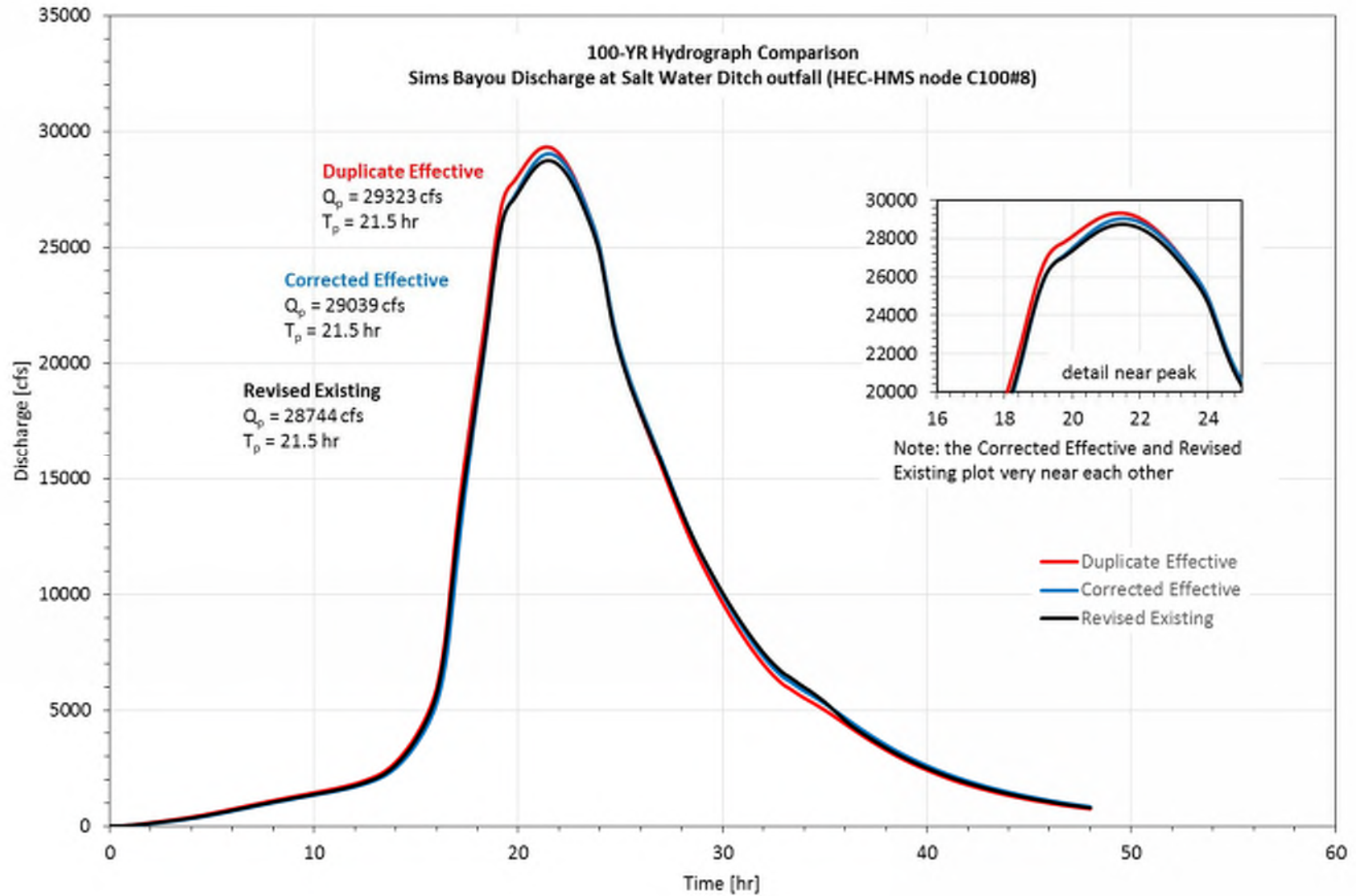


Figure 2: 100-Year Sims Bayou Hydrograph Comparison

The Corrected Effective model computed a 100-year peak flow for the Salt Water Ditch watershed of 1,879 cfs compared to the Duplicate Effective model of 3,048 cfs, a reduction of 1169 cfs or 38%. This resulted in a decrease in peak flows downstream along Sims Bayou ranging from 155 cfs to 656 cfs for the 100-year event. In the Revised Existing condition, the peak flow out of Salt Water Ditch increased 449 cfs compared to the Corrected Effective condition. This increase in flows was due to the splitting of the subwatershed. Even though flow at the outfall from Salt Water Ditch increases, when looking at the impacts along Sims Bayou, peak flows immediately downstream are generally reduced with a minor increase in flow at the outfall of 21 cfs. The reduction in flows can be explained by comparing the flow hydrographs. A comparison of the hydrographs is provided in **Appendix B**. In comparing the hydrographs, it can be seen that the Salt Water Ditch watershed for Revised Existing condition has a time to peak of 17.0 hours and the Corrected Effective condition has a time to peak of 18.75 hours. The Sims Bayou flow hydrograph, at the confluence with Salt Water Ditch, has a time to peak of 21.5 hours; therefore even though the Revised Existing condition has a higher peak flow, due to the timing of the hydrographs this results in less impacts along Salt Water Ditch. The Revised Existing condition model will serve as the point of comparison for the proposed condition model.

Table 5: 10-Year HEC-HMS Peak Flow Comparison

HEC-HMS Node	10-year Peak Flows (cfs)					
	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)	ΔQ (Rev.-Corr.)
Outlet	22903.4	22614.3	22659.2	-289	-244	45
C100#1	22531	22231	22275	-300	-256	44
C100#2	21942	21644	21690	-298	-252	47
C100#3	21760	21478	21518	-282	-242	40
C100#4	17568	17324	17352	-244	-217	28
C100#5	17123	16888	16912	-235	-211	24
C100#6	16837	16607	16624	-230	-213	17
C100#7	15988	15768	15785	-220	-202	18
C100#8	15497	15268	15287	-230	-210	20
C118 outfall	1762	1021	1343	-741	-420	321
C118A	-	-	540	-	-	-
C118B	-	-	1195	-	-	-

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective model and HEC-HMS node C1180000_0000_J in the revised existing model

Table 6: 100-Year HEC-HMS Peak Flow Comparison

HEC-HMS Node	100-year Peak Flows (cfs)					
	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)	ΔQ (Rev.-Corr.)
Outlet	44552.5	43919.1	43939.6	-633	-613	21
C100#1	43765	43124	43125	-641	-640	1
C100#2	42521	41877	41870	-644	-651	-7
C100#3	42049	41394	41373	-656	-676	-21
C100#4	33294	33139	32957	-155	-337	-182
C100#5	32442	32271	32050	-171	-391	-221
C100#6	32056	31722	31450	-334	-606	-272
C100#7	30319	30001	29718	-319	-602	-283
C100#8	29323	29039	28744	-284	-579	-294
C118 outfall	3048	1879	2328	-1169	-720	449
C118A	-	-	983	-	-	-
C118B	-	-	2046	-	-	-

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective model and HEC-HMS node C1180000_0000_J in the revised existing model

3.2 Hydraulic Analysis

A hydraulic analysis was performed along Salt Water Ditch, HCFCU Unit C118-00-00, to determine the water surface profiles and the flooding extents. This section presents the hydraulic modeling and channel capacity analysis. The Corrected Effective condition serves only as a comparison between the Duplicate Effective condition and the reevaluation of the watershed characteristics; therefore, the hydraulic model was run for the Duplicate Effective condition and the Revised Existing condition only.

3.2.1 Hydraulic Modeling

The USACE HEC-RAS computer model was used to perform the hydraulic analysis along Salt Water Ditch. The Effective HEC-RAS model was run in version 3.0.1, however for this study the model was updated to version 4.1. The existing FEMA Effective HEC-RAS model included only the reach between Belfort Avenue and the confluence with Sims Bayou. This study extended the established Effective HEC-RAS model of Salt Water Ditch westward to the limits at Calhoun Road. The cross section data, channel centerline, banklines, and flow lengths were captured using ArcGIS with the 2001 LiDAR DEM. The channel geometry data was exported to HEC-RAS from ArcGIS using the HEC-GeoRAS extension. Survey data was used to adjust the LiDAR-based cross sections and add the bridge crossings and culverts to the model. The HEC-RAS model cross sections are shown in **Exhibit 4**. The HEC-RAS model contains the following plan data:

- FEMA Effective June 2007
- Floodway
- Duplicate Effective
- Revised Existing

The Duplicate Effective plan is a copy of the FEMA Effective June 2007 plan. The Revised Existing plan represents the changes to the model associated with this study which include extending the limits upstream to just east of Calhoun Road, modifying the stream peak flows due to changes in the watershed parameters, and dividing the watershed into two subareas.

3.2.2 Peak Flows

The peak flows used were taken from the HEC-HMS model. The model computed peak flows for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events. HEC-HMS node peak flows were associated with a HEC-RAS cross section. Flows at cross sections between HEC-HMS nodes were interpolated based on the cross section stationing and a semi-log relationship. The HEC-RAS flow distribution is shown in **Appendix B**. Subarea C118A is the uppermost subarea that contributes runoff to Salt Water Ditch. As shown in **Exhibit 2**, the downstream boundary for subarea C118A is Martin Luther King Jr. Boulevard, and Salt Water Ditch extends 1.2 miles upstream. The procedure outlined in TSARP Technical White Paper *“Recommendations for Determining Discharges in Upstream Reaches of Subareas”* was used to determine the discharges at the limit of Salt Water Ditch. The upstream peak flow rates were determined by plotting the computed peak flow rates for various surrounding subareas in the Sims Bayou watershed on log-log scale and drawing a straight-line approximation through the paired data. The straight-line was extrapolated linearly to define an approximate relationship for smaller areas. Then the extrapolated line was adjusted downward so that it passes through the subarea C118A discharge. The adjusted extrapolated line forms a peak flow rate versus drainage area curve for subarea C118A from which flow rates were obtained. The plots used to establish the upstream flow rate are provided in **Appendix B**.

3.2.3 Results

The water surface elevations for the Duplicate Effective and Revised Existing conditions for the 10% (10-year) and 1% (100-year) storm events are compared in **Table 7** and **Table 8**. The channel profile plots and HEC-RAS model output tables for the Duplicate Effective and Revised Existing are provided in **Appendix B**. The hydraulic results show a decrease in water surface elevations compared to the effective model ranging from 0.91 feet to 1.81 feet within the portion of Salt Water Ditch from Belfort Avenue to the confluence with Sims Bayou. This large decrease in water surface elevation is the result of the reduced peak flows associated with the corrected watershed characteristics as discussed in the hydrologic analysis section.

Table 7: 10-Year Water Surface Elevation Comparison

River Station	DISCHARGE (CFS)			WSEL (ft)		
	Duplicate Effective	Revised Existing	ΔQ (Revised-Duplicate)	Duplicate Effective	Revised Existing	ΔWSEL (Revised-Duplicate)
863.9	1762	1343	-419	23.86	22.59	-1.27
1510.0	1400	1214	-186	25.87	24.63	-1.24
2080.7	1400	1214	-186	27.18	26.30	-0.88
2997.8	1400	1125	-275	30.17	29.44	-0.73
3846.7	1400	1026	-374	31.93	31.04	-0.89
4058.0	1400	1026	-374	32.90	31.82	-1.08
4083.6	Vasser St.					
4109.2	1400	1026	-374	34.42	33.00	-1.42
4343.0	1149	877	-272	35.78	34.04	-1.74
5037.2	1149	877	-272	37.46	35.93	-1.53
5550.6	1149	877	-272	38.05	36.73	-1.32
5866.6	1149	877	-272	38.31	37.02	-1.29
5935.4	Bellfort Ave.					
6004.2	1149	877	-272	38.53	37.14	-1.39
6143.9	1149	743	-406	38.62	37.22	-1.40

Table 8: 100-Year Water Surface Elevation Comparison

River Station	DISCHARGE (CFS)			WSEL (ft)		
	Duplicate Effective	Revised Existing	ΔQ (Corrected-Duplicate)	Duplicate Effective	Revised Existing	ΔWSEL (Corrected-Duplicate)
863.9	3048	2328	-720	26.88	25.31	-1.57
1510.0	2422	2116	-306	29.02	27.43	-1.59
2080.7	2422	2116	-306	30.21	29.01	-1.20
2997.8	2422	1969	-453	32.97	32.06	-0.91
3846.7	2422	1805	-617	34.50	33.52	-0.98
4058.0	2422	1805	-617	35.11	34.01	-1.10
4083.6	Vasser St.					
4109.2	2422	1805	-617	36.77	35.17	-1.60
4343.0	1988	1555	-433	38.07	36.26	-1.81
5037.2	1988	1555	-433	39.43	37.99	-1.44
5550.6	1988	1555	-433	39.90	38.71	-1.19
5866.6	1988	1555	-433	40.14	39.03	-1.11
5935.4	Bellfort Ave.					
6004.2	1988	1555	-433	40.43	39.39	-1.04
6143.9	1988	1329	-659	40.53	39.52	-1.01

Based on the profile plot for Salt Water Ditch, it can be seen that just north of Vasser Street the flood levels for the various frequency events begin to exceed the channel banks. Just upstream of Bellfort Avenue it can be seen that the 10-year water surface elevation is above the channel banks. At Van Fleet Street just upstream of Martin Luther King Jr. Blvd., the 2-year water surface elevation is outside the channel banks. The existing water surface elevation profiles for the 10-year and 100-year events are shown on **Exhibit 5** and the HEC-RAS outputs for all seven storm frequencies is provided in **Appendix B**. The results of the analysis shows that there is substantial out-of-bank flooding upstream of Bellfort Avenue along Salt Water Ditch.

3.2.4 Floodplain Delineation

The Revised Existing HEC-RAS plan flood stages were used to develop approximate floodplains for the 10% (10-Year) and 1% (100-Year) exceedance events. The floodplain delineations are shown in **Exhibit 4**. The exhibit shows that during both the 10-year and 100-year event, the areas along Salt Water Ditch upstream of Bellfort Avenue experience significant out-of-bank flooding. It should be noted that the floodplains shown are an approximation intended to help identify deficiencies in the existing channel.

3.2.5 Channel Capacity

A channel capacity analysis was performed along Salt Water Ditch to determine the adequacy of the watercourse in conveying flood flows during an extreme storm event. The existing channel capacity was estimated on the basis of the channel section conveying flood flows below the critical elevation. The critical elevation profile was established using the lower elevation of the following:

- Channel Banks
- Street Flooding
- House Flooding

In most instances, the critical elevation corresponds to the adjacent street grade. It is fairly typical to have adjacent neighborhood streets lower in elevation than the channel banks. This practice is common in Harris County since the streets serve as tertiary drainage systems when a storm event exceeds the capacity of the underground storm sewer system in a development.

Salt Water Ditch was subdivided into ten (10) reaches for the purpose of evaluating the channel capacity. Channel capacity was determined by performing normal depth computations for the channel section. The results, presented in **Table 9** and shown in **Exhibit 6**, show that a significant portion of Salt Water Ditch has a less than 2-year existing channel capacity. This indicates that the flooding problems along Salt Water Ditch are due to a lack of channel capacity to convey flood flows within the channel banks.

Table 9: Salt Water Ditch Capacity Analysis Results

Section Number	Start Station	End Station	Length (ft)	Computed Flows - HEC-RAS Revised Existing Plan						Existing Capacity (cfs)	Storm Frequency (yr)	
				2-YR	5-YR	10-YR	25-YR	50-YR	100-YR			500-YR
1	863	4109	3246	592	834	1026	1310	1545	1805	2524	6730	500-YR
2	4083	5935	1852	506	713	877	1122	1326	1555	2202	650	2-YR
3	5935	7980	2045	427	603	743	952	1129	1329	1906	660	5-YR
4	7979.81	9454.81	1475	377	533	657	843	1002	1182	1712	390	2-YR
5	9454.81	10644.81	1190	342	483	595	765	911	1078	1572	490	5-YR
6	10644.81	12062.81	1418	257	363	447	575	686	814	1196	240	< 2-YR
7	12062.81	13287.81	1225	257	363	447	575	686	814	1196	230	< 2-YR
8	13287.81	14000.81	713	234	331	408	525	626	742	1091	190	< 2-YR
9	14000.81	15904.81	1904	182	258	318	408	487	578	849	170	< 2-YR
10	15904.81	17873.81	1969	143	202	249	320	382	453	666	130	< 2-YR

4. Computed Flood Damages & Historical Flooding

As an extension of existing conditions analysis, the damages associated with flood events in the Salt Water Ditch drainage area were considered using hydraulic modeling results, an inventory of the parcels in the area, and known damage functions. The flooding extent was determined from the Revised Existing HEC-RAS model results (see **Section 3 – Existing Conditions Analysis**). The structure inventory was developed using 2015 Harris County Appraisal District (HCAD) GIS and tabular data. The information from the hydraulic model was associated with the parcels in the structure database by interpolating between the HEC-RAS cross sections. The Harris County Structure Inventory Analysis Tool version 2.0 was used to determine which parcels would be flood-affected by comparing the water-surface elevation from the Revised Existing HEC-RAS model to the finished floor elevation of the structures. The estimated damages caused by the various flood frequencies were calculated using depth-damage relationships developed for the U.S. Army Corps of Engineers and amended for the Harris County Structure Inventory Analysis Tool by Dannenbaum Engineering. In these relationships, the depth of inundation is associated with a fractional value lost for both the structure itself and the contents of the structure. The depth-damage relationships applied to each inundated structure were based on the type of structure, primarily delineated as residential or non-residential. The application of these damage functions was in accordance with the *Structure Inventory Analysis Tool Version 2.0 Final Report* prepared by Dannenbaum Engineering dated August 2011.

4.1 Structure Inventory

HCAD shapefiles and tabular data form the basis of the structure inventory. Specific data collected from HCAD included: land value, land area, improvement value, and construction type for property improvements. Tax year 2015 values were used for all properties where a value was available and 2014 values used elsewhere, e.g., where a protest had been filed and was yet unresolved.

Determining the flood impacts for a particular structure required the ground elevation and an adjustment for the finished floor elevation. The ground elevation at each parcel was obtained from the 2001 Harris County LiDAR data, and a windshield survey of the area was undertaken to record an adjustment for the finished floor elevation relative to the ground elevation. This was measured where visible with Google Street View and verified in the field. For those structures where the foundation was not visible, the adjustment was typically assumed based on other nearby structures or as 4 inches. The field portion of this survey also noted any parcels that were vacant.

While HCAD data was primarily used to amalgamate the value of land and improvements, there were several properties within the study area that have tax exempt status and therefore had no value in the data from HCAD. The land value for these properties was assigned as the median per acre value for those properties in the study area with values appraised by HCAD. For the region of interest the median value was \$80,700 per acre. This value does not factor into this analysis, but was estimated to complete the

database. As for the value of improvements in the exempt class, e.g., churches and schools, the value for Bellfort Seventh-Day Adventist Church (5878 Bellfort Street, Houston, TX 77033, HCAD #0470560000090), for which HCAD had an appraised value, was used as the basis. This property has both a school and church structure which HCAD assigned a combined improvement value of \$2,295,174 for a 24,835 sq. ft. school building and a 13,425 sq. ft. church building. This gives a combined value of approximately \$60/sq. ft. which was assigned as the improvement value of the other churches and schools in the area without data. Though this estimation was based on only one appraised value, it is the only exempt property in the area with a documented valuation. Vehicle values and damages were excluded altogether from this analysis.

For the purposes of this analysis Salt Water Ditch was divided into three reaches: reach A encompassed the area between the confluence of Salt Water Ditch and Sims Bayou to Bellfort Avenue, reach B spanned the area between Bellfort Avenue and Martin Luther King Jr. Boulevard, and reach C extended from Martin Luther King Jr. Boulevard to the upstream extent of the study. A summary of the number and type of structures within each reach is shown in **Table 10**.

Table 10: Breakdown of Number of Structures by Reach

Type of Structure	Number of Structures			
	Reach A	Reach B	Reach C	Total
Residential - Slab Foundation	863	1144	1863	3870
Residential - Pier Foundation	0	3	48	51
Non-Residential - Masonry	1	17	11	29
Non-Residential - Steel or Wood Frame	6	26	80	112
Totals	870	1190	2002	4062

4.2 Depth-Damage Relationships

The relationships between flooded depth and damage inflicted for this analysis were based on those reported by Gulf Engineers & Consultants (see *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVs) in Support of the Jefferson and Orleans Flood Control Feasibility Studies*) as amended for the Harris County Structure Inventory Analysis Tool by Dannenbaum Engineering (see *Structure Inventory Analysis Tool Version 2.0 Final Report*) (see **Table 11** and **Figure 3**). The damage to both the structure itself and the contents therein were estimated as a percentage of the improvement value of the flooded structures. This was done via content-to-structure value ratios, i.e., the value of the contents within a structure were not independently estimated, but were tied to the value of the structure. The content-to-structure value ratios are incorporated into the fractional value lost for contents shown in **Table 11**. In keeping with the content-to-structure value ratios set forth in the Structure Inventory Analysis Tool final report, the ratio for residential structures was 0.69 and for non-residential structures it was the weighted average of all non-residential categories reported by Gulf Engineers and Consultants. The total value lost is given by

$$L_V = (I_V)(F_S) + (I_V)(F_C),$$

where L_V is the value lost by a particular structure, I_V is the value assigned to a particular structure, and F_S and F_C are the fractional value lost by the structure and the contents respectively as a function of inundated depth (**Figure 3**). It is also of note that the depth-damage curves do not start at the finished floor elevation for a residential structure with a pier-and-beam foundation as it loses approximately 4% of value with flooding 1 foot below finished floor (see **Table 11** and **Figure 3**). Damage occurring before floods reach the finished floor elevation is not a major source of overall damage as pier-and-beam foundations only account for approximately 1% of structures in the area.

Table 11: Value Lost, as a Percentage of Structure Value, to the Structure and Contents Therein as a Function of Inundated Depth

Depth of Flooding (ft)	Value Lost (%)					
	RES Pier Foundation	RES Slab Foundation	NONRES Masonry	NONRES Wood or Steel	RES Contents	NONRES Contents
-1.0	4.0	0.0	0.0	0.0	0.0	0.0
-0.5	5.4	0.0	0.0	0.0	0.0	0.0
0.0	20.5	4.2	0.2	3.4	0.0	0.0
0.5	40.5	26.7	6.9	16.3	19.4	13.3
1.0	41.5	33.9	7.6	17.4	28.8	22.3
1.5	45.1	38.6	7.8	17.9	34.0	30.5
2.0	52.3	40.2	8.3	25.7	43.4	44.0
3.0	53.1	41.3	11.4	25.7	56.6	59.6
4.0	57.1	47.0	15.0	39.4	58.4	62.7
5.0	66.8	58.9	15.9	39.4	62.9	65.7
6.0	66.8	58.9	15.9	39.4	62.9	69.6
7.0	66.8	58.9	15.9	39.4	62.9	70.4
8.0	74.3	58.9	22.3	43.0	62.9	72.1
9.0	74.3	69.9	26.7	65.0	62.9	73.7
10.0	84.4	69.9	28.8	65.0	62.9	76.7
11.0	84.4	82.1	28.8	72.5	62.9	76.8
12.0	84.4	82.1	28.8	75.0	62.9	77.5
13.0	84.4	82.1	32.5	77.8	62.9	77.6
14.0	84.4	82.1	39.7	77.8	62.9	77.6
15.0	84.4	82.1	41.2	77.8	62.9	78.2
100.0	84.4	82.1	41.2	77.8	62.9	78.2

Note: Depth of Flooding is relative to the finished floor elevation, RES denotes residential structures, and NONRES denotes nonresidential structures

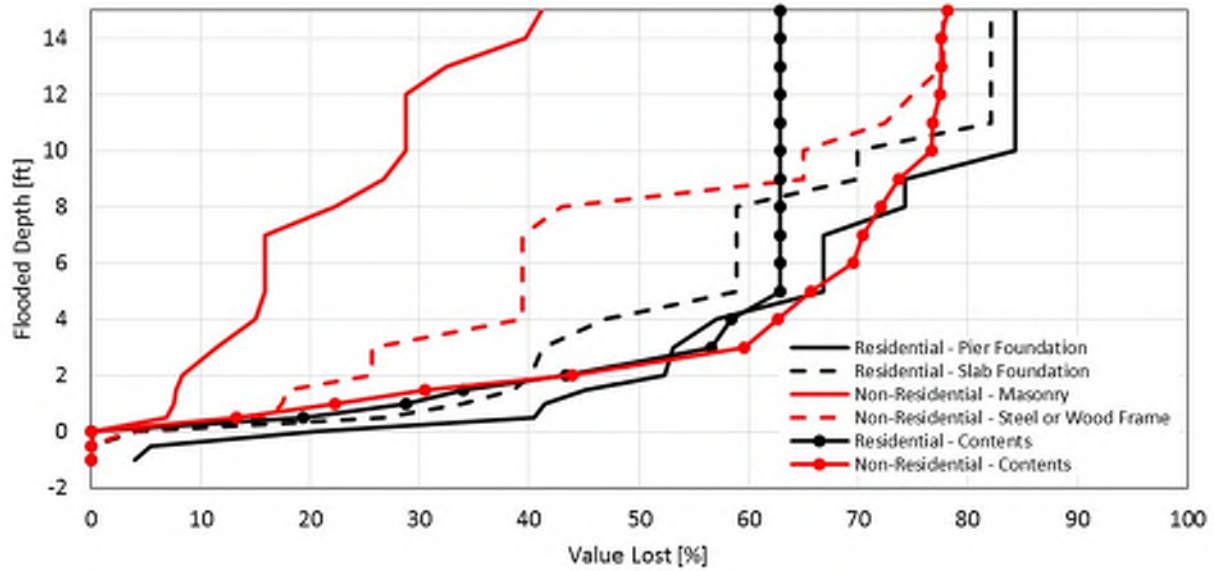


Figure 3: Overview of Depth-Damage Relationships

4.3 Estimated Flood Damages

Figure 4 gives context regarding the number of structures that are flood-affected by the various frequency storm events where the water surface elevation is plotted against the finished floor elevation of nearby structures. A plan view of those structures specifically affected for the 10-year and 100-year storms are presented in Exhibit 7. More specific numbers regarding the number and fraction of flooded structures are shown in Table 12. For the purpose of this study, a structure was considered “flooded” if it accrued damage. The area south of Belfort Avenue (reach A) is relatively unimpacted by flood events, even large ones. Flooding is a much larger issue moving upstream into reach B where 95% of the present structures are inundated during the 100-year flood; reach C is also heavily impacted by flood events with nearly 90% of structures inundated during the 100-year flood.

Table 12: Overview of Flood-Affected Structures

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	5	42	161	506
B	2	85	333	864	1074	1131	1183
C	68	327	580	1108	1551	1763	1947
Total	70	412	913	1977	2667	3055	3636
Fraction of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0.00	0.00	0.00	0.01	0.05	0.19	0.58
B	0.00	0.07	0.28	0.73	0.90	0.95	0.99
C	0.03	0.16	0.29	0.55	0.77	0.88	0.97
Total	0.02	0.10	0.22	0.49	0.66	0.75	0.90

Translating this to economic damages, three values were calculated: (1) single-event damage estimates, (2) annualized damages, and (3) the present value of projected damages. The single-event damage estimates calculate the total expected value lost for a particular flooding event of a particular frequency, e.g., damages associated with an individual 100-year flood event. Taking the analysis a step further, the computation of annualized damages considers the range of probabilistic outcomes in a particular year. The Revised Existing HEC-RAS model provided flood stages for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events. The calculation of annualized damages can be better refined by including flows more frequent than the 2-year flood given the higher probability of occurrence. The flows associated with more frequent flood events, such as the 1.75-year, 1.5-year, 1.1-year, and 1.001-year events, can be extrapolated from the modeled flood flows using the synthetic Log-Pearson Type III distribution. A probability-damage curve is constructed by combining the probability of occurrence with the expected damages of each event. The integral of that curve is the annualized damages, or said another way, the flood damage expected each year. The final quantity calculated is the present value of damages. The present value accounts for the cumulative accrual of damages over a specified time period by applying a discount rate to consolidate expected future damages to a current valuation. For the analysis here, we used a period of 50 years and a discount rate of 7%.

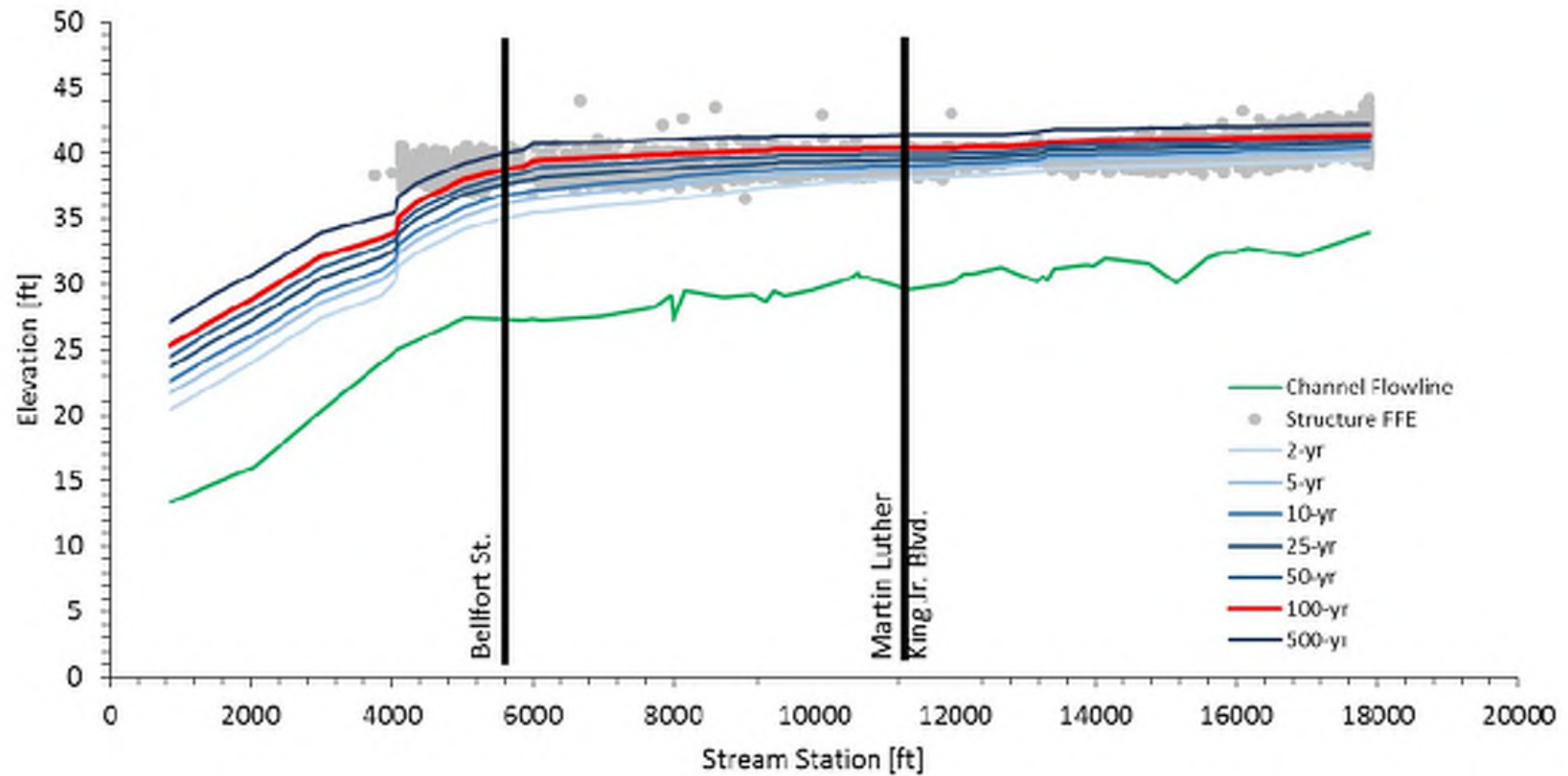


Figure 4: Water Surface Profile for Various Flood Frequencies Relative to the Finished Floor Elevation of Structures along Salt Water Ditch

The results from the flood damage estimation reveal the impact of a single 100-year flood event to be approximately \$86.5M, \$40.8M of which would be concentrated in reach C, as shown in **Table 13**. The annualized damages for the Salt Water Ditch area were approximately \$7.3M which has a present value of approximately \$100.0M (**Table 14**). One caveat to this analysis is that the results only encompass properties where a structure exists, therefore vacant properties were omitted. There are approximately 450 vacant properties within the studied area of which 382 would be inundated during a 100-year flood event.

Table 13: Single Event Damage Estimates for Various Flood Frequencies

Single Event Damages (Structural ONLY) (USD)							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	27,364	263,838	1,171,373	4,930,300
B	404,257	1,291,077	3,178,251	8,441,748	13,334,979	16,269,945	20,038,285
C	455,742	2,784,126	5,070,058	9,401,750	14,786,781	21,799,242	32,289,458
Total	859,998	4,075,203	8,248,309	17,870,863	28,385,598	39,240,560	57,258,043
Single Event Damages (Contents ONLY) (USD)							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	8,443	120,179	772,108	4,253,482
B	817,152	2,748,960	5,766,543	12,904,041	20,685,740	27,426,652	40,047,272
C	158,398	1,765,950	3,533,401	7,023,877	11,737,508	19,073,075	37,158,228
Total	975,550	4,514,910	9,299,943	19,936,361	32,543,426	47,271,835	81,458,983
Single Event Damages (Structural+Contents) (USD)							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	35,807	384,017	1,943,481	9,183,783
B	1,221,409	4,040,037	8,944,794	21,345,789	34,020,719	43,696,598	60,085,557
C	614,140	4,550,076	8,603,459	16,425,627	26,524,288	40,872,317	69,447,686
Total	1,835,549	8,590,113	17,548,253	37,807,223	60,929,025	86,512,395	138,717,026

Table 14: Annualized and Annuitized Costs of Flood Damages

Reach	Annualized Damages (USD)			Present Value
	Structures Only	Contents Only	Total	
A	35,316	26,103	61,419	847,628
B	1,358,398	2,407,409	3,765,807	51,970,944
C	1,976,253	1,443,954	3,420,208	47,201,418
Total	3,369,967	3,877,466	7,247,433	100,019,989

4.4 Historical Flooding

Three sources documenting historical flooding problems in the area were examined to help confirm the widespread flooding outlined in **Section 3 – Existing Conditions Analysis** and the high damage estimates given above: (1) FEMA repetitive flood loss claims, (2) a City of Houston flood damage field survey

following Hurricane Ike, and (3) HCFCF immediate flood reports. FEMA repetitive flood loss claims were obtained from the City of Houston as part of data provided during storm water drainage pre-engineering services. Within the data set, flood loss claims from three recent large events were considered: (1) June 2001 (Tropical Storm Allison), (2) June 2006, and (3) September 2008 (Hurricane Ike). The HCFCF flood report memorandums following several storm events between 1992 and 2010 were examined for documented damage in the Salt Water Ditch subwatershed. These various flood-loss reports were contextualized by using nearby rain gage data. HCFCF rain gage 360 (C100 Sims Bayou @ Martin Luther King Road) was used in conjunction with the HCFCF rainfall frequency and duration table to determine the rainfall exceedance probability in the vicinity of Salt Water Ditch for the various events. This information is summarized in **Table 15** and displayed in **Exhibit 8**.

Table 15: Rainfall Intensities and Flooded Home Counts for Various Recent Storms

Date	(Sims Bayou at Martin Luther King Jr. Blvd.)					Flooded Homes ¹	Event
	1-hr	3-hr	6-hr	12-hr	24-hr		
Jun. 5, 2001	2.4	4.7	6.2	6.9	7.1	26 ²	T.S. Allison
Jun. 9, 2001	3.1	5.3	7.5	10.5	10.7		
Jun. 19, 2006	4.5	5.7	6.6	7.0	7.0	23 ² , >2200 ⁴	
Aug. 16, 2007	3.8	6.6	7.0	7.4	7.5	24 ⁴	T.S. Erin
Sept. 13, 2008	1.1	2.5	4.6	6.0	6.0	14 ² , 16 ³	Hurricane Ike

Color Coding: <10-yr 10-yr 25-yr 50-yr 100-yr

¹These sources only report homes; no non-residential structures included

²Numbers from FEMA repetitive loss claims

³Numbers from City of Houston field survey data

⁴Numbers from Harris County Flood Control District immediate flood reports

The rainfall from Hurricane Ike in September 2008 was approximately a 5-year event. This resulted in 14 and 16 documented damaged homes as reported by FEMA repetitive loss claims and City of Houston field survey results respectively. It is of note that there was no overlap between those two estimates, i.e., none of those reported by City of Houston were reported by FEMA repetitive loss, meaning there were at least 30 damaged homes. This indicates that the watershed experiences substantial flooding even during relatively frequent storms such as the 5-year event encountered during Hurricane Ike.

The storm event with the most documented homes damaged, at least from the data available, occurred in June 2006 where the HCFCF immediate flood report estimated more than 2,200 flooded homes in the upper reach of the Salt Water Ditch subwatershed (C118). The HCFCF published estimate dwarfs that of FEMA flood loss claims, 23 for this event. This may be due to the effective floodplain covering only a small portion of the watershed resulting in fewer homes with flood insurance. This June 2006 storm was 1-hour duration 100-year rainfall event and a 25-year event over 3-hours and 6-hours. The preceding flood damage analysis predicted 1,977 flooded structures for the 25-year event and 2,667 for the 50-year event. The peak flood flow in Salt Water Ditch is most likely somewhere between the 25-year and 50-year events.

Considering that more than 2,200 flooded homes were reported by HCFCF, our flooded-structure estimates compare relatively well with available data.

Tropical Storm Allison in June 2001 was another large event wherein 26 residences were documented as flooded by FEMA repetitive loss claims. As mentioned above, because few homes in this area have flood insurance it is likely that the number of claims substantially underestimates the total number of flooded homes. Evidence for this comes from information in the HCFCF flood report regarding the June 2006 flood discussed above. It documented that most of the homes flooded during that event also flooded during Tropical Storm Allison.

Overall, this area has had historical flooding problems as noted in **Table 15** and the extensive floodplain predicted by the Revised Existing HEC-RAS plan presented in **Section 3 – Existing Conditions Analysis**. Moreover, as shown in **Exhibit 8**, the properties with prior documented flooding problems are not merely those adjacent to Salt Water Ditch, but are widespread throughout the subwatershed.

5. Improvement Alternatives

This section presents the alternative flood reduction strategies considered for Salt Water Ditch subject to several constraints associated with the subwatershed. Alternatives considered include proposed channel improvements and enclosing a portion of the channel in a closed conduit system. The alternative analysis provides a comparison between the alternatives and estimated construction costs. The final recommended plan for Salt Water Ditch was selected based on the feasibility and construction costs for the alternative.

5.1 Constraints

The objective for this feasibility study is flood mitigation in the Salt Water Ditch subwatershed. In developing the flood reduction plans, there were several constraints that limited or dictated the potential solutions. The following are the constraints used in developing the flood reduction plans for Salt Water Ditch:

- Storm Sewer System Drainage – This feasibility study partially originated due to difficulty designing storm sewer system improvements in City of Houston Need Area M-2014-034, located in the upper limit of Salt Water Ditch, during pre-engineering services. That difficulty was due to the existing Salt Water Ditch not having sufficient depth to accommodate improved storm sewer systems that would drain areas with substantial flooding. In order to allow for the storm sewer improvements, any improvements to Salt Water Ditch must substantially lower the flowline to provide sufficient vertical space for storm sewer improvements. By analyzing the storm sewer systems as part of CivilTech’s Pre-Engineering Services for Need Area M-2014-034, it was found that the existing channel flowline must be lowered approximately 8 feet in order to provide the necessary depth.
- Acquisitions – Channel improvements were considered such that parcel acquisitions would be minimized. Furthermore, where possible, existing street ROWs were prioritized so as to not be impacted. Unfortunately, the existing Salt Water Ditch ROW ranges from a minimum of 15 feet to a maximum of 70 feet. The existing channel does not have maintenance berms at any point along the channel. HCFCD criteria requires a 30 foot maintenance berm on both sides of HCFCD maintained channels (20 foot if channel ROW is adjacent to a public road and the maintenance berm drains to the road). Any channel improvements would require a corresponding provision of maintenance access, and because the space required solely for maintenance access is a majority of or exceeds existing ROW, significant acquisitions are unavoidable.
- Salt Water Ditch at Doulton Drive – North of the existing Salt Water Ditch at the Doulton Drive crossing is a 210 acre commercial/industrial tract with railroad tracks that connect the various buildings to the railroad line that runs along Mykawa Road. In addition, several warehouses abut the existing channel ROW. In order to minimize costs, proposed improvements minimized encroachments onto these parcels and thereby avoided any disruption to business activities.

- CenterPoint Energy Easement – A CenterPoint energy easement abuts the west side of the existing Salt Water Ditch from Doulton Drive to Sims Bayou. Proposed channel improvements along an alignment that most closely mimics the existing Salt Water Ditch alignment would impact CenterPoint utility infrastructure. Alternatives were considered that reduce the impact to CenterPoint utilities.
- Jones High School – Jones High School is located along Southwind Street between St. Lo Road and Jutland Road. The existing Salt Water Ditch runs parallel to Southwind Street on the opposite side of the school. All proposed alternatives do not encroach upon Jones High School and do not disrupt street access either along Southwind or St. Lo Road.
- Houston Fire Station 35 – The Houston Fire Department has a fire station on Van Fleet Street near the intersection with Salt Water Ditch; impacts to this facility were avoided in alternatives analysis.

5.2 Existing Right-Of-Way Channel Improvement

The existing Salt Water Ditch right-of-way (ROW) varies between 30 and 70 feet. In order to provide a comparison between the proposed channel sections and demonstrate the severe constraints imposed by the existing ROW, a maximum channel capacity was calculated for the existing ROW. Several assumptions were used for this analysis: (1) maintenance berms, and the associated space required, were omitted, (2) providing the necessary channel depth to accommodate improved storm sewer systems was ignored, (3) the top width of the conceptual channel was taken to equal the existing ROW, (4) the conceptual channel section was trapezoidal with 4H:1V side slopes and a bottom width of 6 feet, and (5) the channel slope and Manning's roughness matched that of the proposed channel. Based on the assumptions, the channel depth is the unknown geometric parameter calculated from the assumed top width and side slopes. The channel capacity was calculated for each reach assuming normal flow conditions with a normal depth equal to bankfull. The results of this exercise are shown in the table. The channel capacity values are vastly insufficient compared to the proposed 100-year flows and in places would even constitute a capacity reduction compared to the existing channel capacity. The reduced capacity relative to existing conditions occurred since much of the existing channel is not in compliance with HCFCD criteria. For example, the existing channel in reach 1 has sides slopes of approximately 2.5H:1V which allows the channel to be deeper than the criteria-bound conceptual improvements. In addition, these conceptual improvements are not constructible as the proposed channel slope of .06% would cause depths at the downstream end greater than the existing ROW would allow. This is due to the previously mentioned issue of the existing channel bank elevations being relatively constant along Salt Water Ditch.

Table 16: Existing ROW Improvement Capacities

Reach	Station From	Station To	Existing ROW (ft)	Proposed Channel Slope	Existing Channel Capacity (cfs)	Proposed 100-YR Flows (cfs)	Proposed Bottom Width (ft)	Channel Depth Available (ft)	Channel Capacity (cfs)
1	175+79	156+09	30	0.0006	130	960	6	3.0	72
2	156+09	137+05	15	0.0006	170	1229	6	3.0	72 ¹
3	137+05	131+28	30	0.0006	190	1583	6	3.0	72
4	131+28	118+70	50	0.0006	230	1709	6	5.5	291
5	118+70	104+51	50	0.0006	240	2083	6	5.5	291
6	104+51	92+58	70	0.0006	490	2250	6	8.0	723
7	92+58	80+25	70	0.0006	390	2434	6	8.0	723
8	80+25	59+24	70	0.0006	660	2734	6	8.0	723
9	59+24	40+53	70	0.0006	650	3037	6	8.0	723
10	40+53	28+94	70	0.0006	6730	3445	6	8.0	723
11	28+94	20+81	70	0.0006	4995	3942	6	8.0	723
12	20+81	0+00	70	0.0006	7515	4274	6	8.0	723

Notes: ¹Channel section matched to those in the vicinity

5.3 Hydrology and Hydraulics

The proposed improvements to Salt Water Ditch required that a proposed conditions hydrologic model be developed from the existing conditions hydrologic model. The creation of the proposed conditions model required an update to the Clark Unit Hydrograph parameters. The watershed parameters used in calculating the Clark Unit Hydrograph parameters include the channel slope (S), channel improvement percentage (DCI), channel conveyance percentage (DCC), and percent development (DLU). The proposed conditions hydrologic model was created assuming a fully developed watershed i.e., DLU = 100, and an improved channel throughout the subwatershed that conveyed the 100-year flows within its banks i.e., DCI = 100 and DCC = 100. In addition, the proposed hydrologic model required an update to the Modified Puls storage-routing relationship. The updated storage vs. outflow is shown in **Table 16** and the proposed Clark Unit Hydrograph Parameters and HEC-HMS output are provided in **Appendix C**.

The proposed flows from the hydrologic model were used in developing the proposed condition for the hydraulic model. The peak flow distribution calculations and the upstream peak flow calculations are provided in **Appendix C**.

Table 17: Proposed Storage vs. Outflow for Reach C1180000_0009_R

Storage (ac-ft)	Discharge (cfs)
0.0	0.0
42.0	397.5
69.9	794.9
94.3	1192.4
116.7	1589.8
137.8	1987.3
158.1	2384.8
187.3	2980.9
235.9	3974.6

5.4 Reach Segments

Salt Water Ditch was subdivided into twelve reach segments for the purpose of evaluating alternative solutions to the flooding problems. For all alternatives, each segment was designed with a consistent channel section. The reach segments are shown in **Exhibit 9** and listed in **Table 17**.

Table 18: Summary of Reach Segments Used in Alternatives

Reach Segment	Reach Start	Reach End	Station From	Station To	Length (ft)
1	Calhoun Road	Jutland Road	175+79	156+09	1,970
2	Jutland Road	St Lo Street	156+09	137+05	1,904
3	St Lo Street	Van Fleet Street	137+05	131+28	577
4	Van Fleet Street	Martin Luther King Jr. Blvd.	131+28	118+70	1,258
5	Martin Luther King Jr. Blvd.	Southbank Street	118+70	104+51	1,418
6	Southbank Street	Crestmont Street	104+51	92+58	1,194
7	Crestmont Street	Doulton Drive	92+58	80+25	1,233
8	Doulton Drive	Bellfort Avenue	80+25	59+24	2,101
9	Bellfort Avenue	Vasser Road	59+24	40+53	1,870
10	Vasser Road	Baseball Fields	40+53	28+94	1,160
11	Baseball Fields	Golf Course	28+94	20+81	813
12	Golf Course	Outfall	20+81	0+00	2,081

5.5 Channel Improvements – Alternative 1

Channel enlargement would increase the flood carrying capacity of the existing channel and remove excess floodwaters from the subwatershed at an increased rate to Sims Bayou. Furthermore, channel enlargement provides the necessary depth to allow storm sewer systems in the upper portions of the watershed to drain into Salt Water Ditch. As mentioned previously, existing channel ROW is limited to the extent that it would not provide the necessary space for the maintenance berms for any proposed channel improvements; therefore, significant acquisitions are required. An earthen trapezoidal channel section with 4H:1V side slopes was considered for this alternative. Concrete lined and partially concrete lined channel sections were not considered for this project due to environmental concerns associated with each. In the future with the necessary permits for such channel sections, the proposed channel ROW may be significantly lessened. For this analysis, the earthen channel section provides the maximum ROW required for channel improvements that meets the project objectives.

Channel improvements are proposed that have a flowline approximately 8 feet below the existing channel at the upstream extent. The added depth provides considerable cross-sectional area such that the bottom width of the proposed trapezoidal channel is the minimum of 6 feet with 4H:1V side slopes throughout the proposed improvements. The proposed channel section will have a slope of .0006 ft/ft. The channel section properties are summarized in **Table 18**. The capacity is substantially above the proposed flows. This was necessary for two reasons: (1) again, to provide adequate depth for storm sewer improvements and (2) to lower the 100-year water surface elevations such that they met the freeboard requirements at bridge crossings. This is an issue due to the fact that the Salt Water Ditch subwatershed topography is generally bowl shaped. For instance, the difference between the existing channel bank elevation at the outfall and at the upstream extent, a distance of approximately 3.3 miles, is only 1.0 foot. This leads to water surface elevations well within the channel near the outfall and channel sections with capacities much greater than the proposed flows. In addition, in order to provide the necessary channel depth, improvements must extend to the confluence with Sims Bayou. Upstream of the confluence with Sims Bayou a drop structure is also required to lower the slope and thereby velocities in the downstream section. The slope downstream of the drop structure would be .001 ft/ft. The HEC-RAS output is provided in **Appendix C**. A plan view of the Alternative 1 layout, acquisitions, and a plot of the water surface profile is provided as **Exhibit 10A**, **Exhibit 10B**, and **Exhibit 11**.

Table 19: Properties of Proposed Channel Improvements

Reach	Station From	Station To	Proposed Depth (ft)	Depth to Critical Elevation ¹ (ft)	Proposed Channel Slope	Proposed 100-YR Flows (cfs)	Left Berm Width (ft)	Right Berm Width (ft)	Proposed Bottom Width (ft)	Top Width (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)	Channel Capacity ¹ (cfs)
1	175+79	156+09	14.0	12.7	0.0006	960	20	30	6	118	30	170	140	2289
2	156+09	137+05	14.5	13.9	0.0006	1229	20	20	6	122	15	170	155	2878
3	137+05	131+28	15.0	14.4	0.0006	1583	30	30	6	126	30	190	160	3147
4	131+28	118+70	16.0	14.6	0.0006	1709	30	30	6	134	50	200	150	3260
5	118+70	104+51	16.5	14.6	0.0006	2083	30	20	6	138	50	190	140	3260
6	104+51	92+58	17.5	15.1	0.0006	2250	30	20	6	146	70	200	130	3552
7	92+58	80+25	17.5	15.3	0.0006	2434	30	20	6	146	70	200	130	3673
8	80+25	59+24	18.5	16.6	0.0006	2734	20	30	6	154	70	210	140	4523
9	59+24	40+53	19.5	17.2	0.0006	3037	20	30	6	162	70	220	150	4953
10	40+53	28+94	19.5	18.6	0.0006	3445	30	30	6	162	70	230	160	6053
11	28+94	20+81	22.0	22.0	0.0006	3942	30	30	6	182	70	250	180	9326
12	20+81	0+00	24.0	24.0	0.0006	4274	30	30	6	198	70	260	190	11680

Note: ¹ Channel Capacity is based on a normal depth equal to the difference between the critical elevation and the flowline elevation. The critical elevation is the minimum of: channel bank, structural flooding, adjacent street flooding.

As discussed previously, acquiring space north of the existing Salt Water Ditch at the existing Doulton Drive crossing would be damaging to the operations of the business that operate out of the warehouses and were therefore avoided. For the proposed alignment to make the 90-degree turn south in the area and mimic the existing channel alignment the surrounding parcels would need to be acquired. A CenterPoint Energy easement is located along the west bank of Salt Water Ditch at the bend. Within the CenterPoint Energy easement at the Doulton Drive intersection is located several transmission towers and a small electric sub-station. An image taken from Google Earth of the transmission towers and electric

sub-station is shown in **Figure 5**. Matching the existing alignment as closely as possible would require the relocation of three CenterPoint transmission towers and an electric sub-station. In order to minimize the impacts to the CenterPoint utilities, two other conceptual alignment options are proposed. One alternative alignment would have a 45-degree bend just east of Wortham Drive and pass between the transmission towers before making another 45-degree bend back into the existing ROW. This alignment does not require the relocation of any CenterPoint utilities, however this alignment would require a larger acquisition of parcels and the construction of a new bridge crossing for Belgard Drive. The other alternative alignment considers abandoning the existing alignment east of the CenterPoint Energy easement and acquiring a new right-of-way that parallels the energy easement to the west. This alignment would run along the existing Belgard Street ROW. This alignment would require significantly more acquisition of properties than the other two alignments, however it removes all conflicts with the CenterPoint Energy easement.



Figure 5: Transmission Towers and Electric Sub-Station Located at Doulton Drive

5.6 Enclosing Channel with Box Storm Sewer – Alternative 2

As noted, one of the objectives for proposed improvements was the minimization of parcel acquisitions. However, the existing ROW is limited such that acquisition is inevitable. One potential alternative to limit the number of acquisitions is to use a closed conduit drainage system in lieu of channel improvements for the portion of Salt Water Ditch upstream of Martin Luther King Jr., Boulevard; downstream of Martin Luther King Jr. Boulevard the closed conduit system would transition to the proposed improved channel

outlined in the previous section. The size of the closed conduit alternative is summarized in **Table 19**. The storm sewers were sized with the Manning's equation using the water surface elevation in the proposed channel section as the tailwater. The calculations are provided in **Appendix C**. A plan view of the Alternative 2 layout, acquisitions, and a plot of the water surface profile is provided as **Exhibit 12A**, **Exhibit 12B**, and **Exhibit 13**.

Table 20: Closed Conduit Alternative

Reach	Station From	Station To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)
1	175+79	156+09	3	12	8	30	65	35
2	156+09	137+05	3	12	8	15	65	50
3	137+05	131+28	3	12	10	30	70	40
4	131+28	118+70	3	12	10	50	70	20

5.7 Detention

The increased conveyance of an improved Salt Water Ditch lowers the time of concentration and storage coefficient of the subbasins and thereby increases the peak flows. Detention must be provided to mitigate the peak flow impacts such that Sims Bayou is not affected. **Figure 6** shows the hydrograph for the Revised Existing condition and for the Proposed condition. There would be approximately 1950 cfs of peak flow impacts with approximately 694 ac-ft of volume between the two hydrographs.

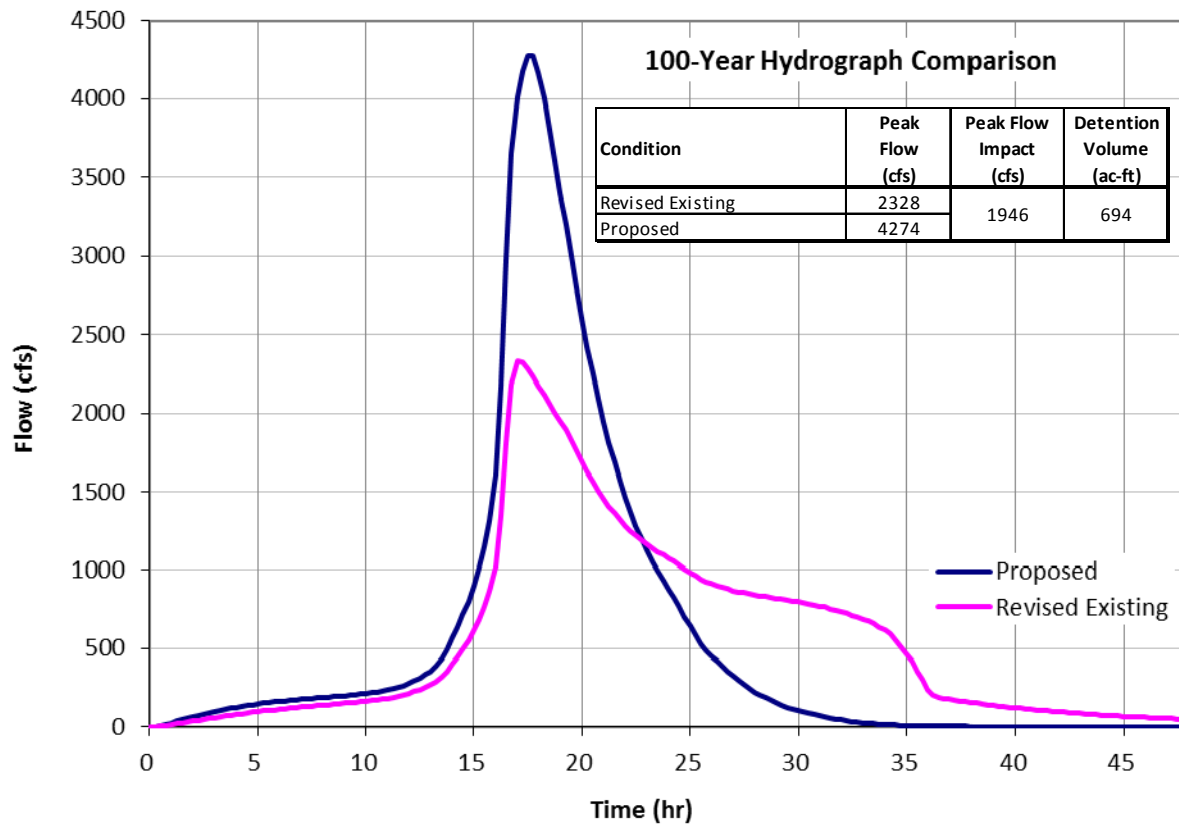


Figure 6: Comparison of Salt Water Ditch 100-Year Hydrographs

A mitigated HEC-HMS model was created that included detention to ensure no peak-flow impacts to Sims Bayou. A lateral weir structure was used in Unsteady HEC-RAS to develop the inflow-diversion relationship and storage-discharge relationship to be used in the Mitigated HEC-HMS model. As this is a preliminary analysis, the weirs were used only in sizing a detention pond to confirm the amount of volume required to mitigate impacts. The stage-storage relationship was developed for each pond assuming a generic trapezoidal pond with 4:1 side slopes. The pond was developed with a top of pond elevation of 35 feet as this is generally the elevation of the land along Sims Bayou at the confluence with Salt Water Ditch. The pond was sized assuming a depth of 24 feet. Based on the analysis, approximately 817 acre-feet of volume is needed to mitigate the impacts to Sims Bayou. The large difference in volume required (817 acre-feet) when compared to the volume between the proposed and revised existing hydrograph (694 acre-feet) is due to the timing of the proposed hydrographs. As shown in **Figure 7**, the proposed Salt Water Ditch hydrograph peaks 17.5 hours into the 24-hour storm event. Sims Bayou does not peak at the confluence with Salt Water Ditch until almost four hours later. Introducing a detention pond along Salt Water Ditch attenuates the proposed hydrograph and moves the time of peak flow closer to that of Sims Bayou; therefore more detention volume is required to mitigate impacts to Sims Bayou. A more efficient mitigation design would let the proposed Salt Water Ditch discharge into Sims Bayou without detention and mitigate impacts by providing detention off Sims Bayou.

There are three potential detention sites that are shown in both **Exhibit 10B** and **Exhibit 12B** that may be used to provide the detention volume. The detention pond may be either an inline pond receiving flows directly from Salt Water Ditch, off-line receiving flows from Salt Water Ditch through a lateral weir structure, or off-line receiving flows from Sims Bayou through a lateral weir structure. The detention calculations are provided in **Appendix C**.

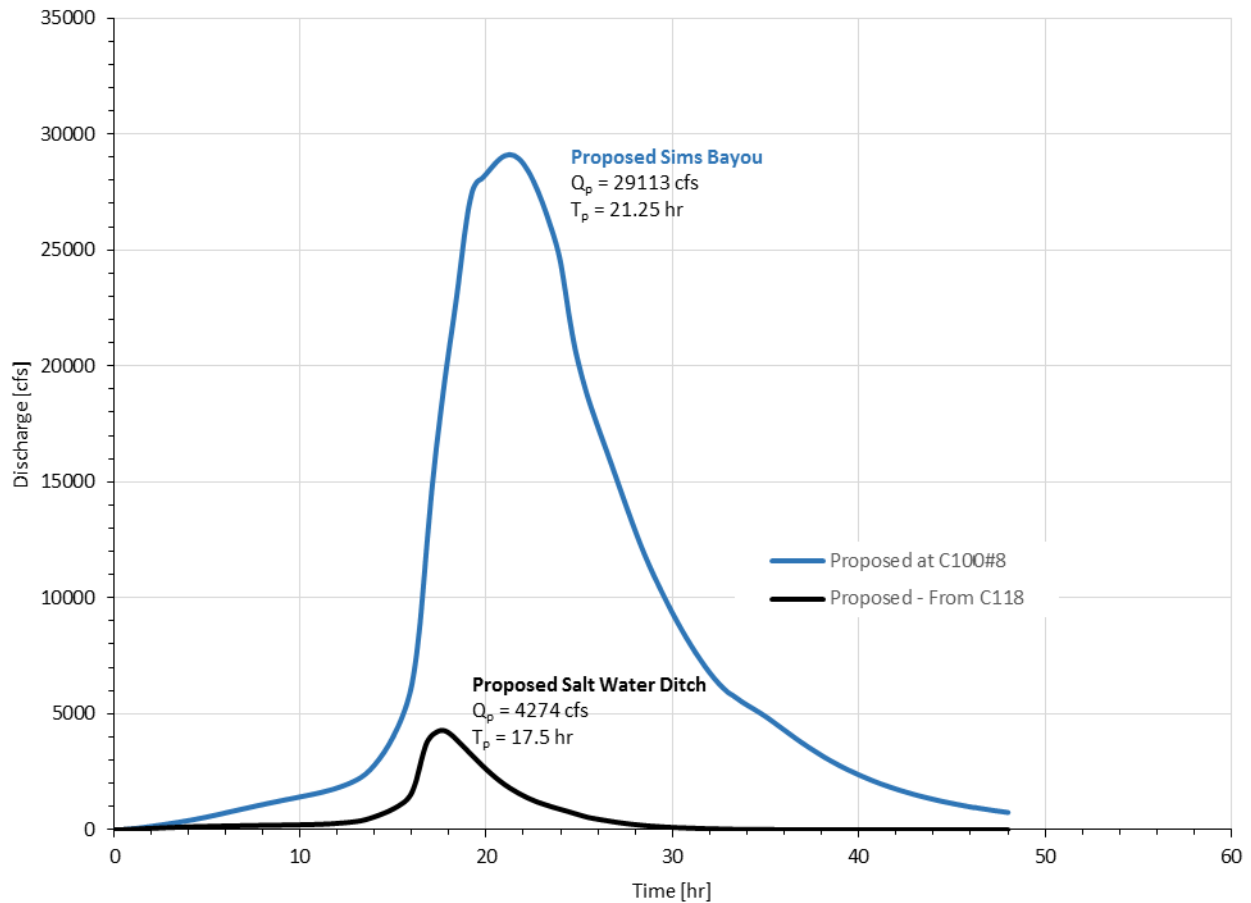


Figure 7: Comparison of Sims Bayou 100-Year Hydrograph

5.8 Other Alternatives Considered

There were several alternatives that were considered, but ultimately rejected due to an evident lack of technical or financial feasibility. One of these alternatives was buyouts of flood-prone structures within the Salt Water Ditch subwatershed. Buyout of flood-prone structures was considered during the early planning stages, and was dismissed since there are 902 homes in the 10-year floodplain with a total Harris County Appraisal District (HCAD) value estimated at over \$48 million, and 3,036 homes in the 100-year floodplain with a total HCAD value estimated at over \$170 million. Buyouts of flood-prone structures was considered to be economically infeasible relative to other alternatives, and would have a significant social impact to residents in the community.

Another alternative that was dismissed considered extending the proposed closed conduit storm sewer system from Martin Luther King Jr. Boulevard to Doulton Drive. The benefit of the closed conduit storm sewer system is that it reduced land acquisition. Upstream of Martin Luther King Jr. Boulevard the closed conduit system offered this benefit, however downstream of Martin Luther King Jr. Boulevard the number and size of pipes would require the full acquisition of parcels along Salt Water Ditch, the same as with the proposed channel option. Since the cost of the closed conduits would be significantly more expensive than the proposed channel options, it was deemed economically infeasible.

Another option that was considered but ultimately rejected looked at diverting flow from Martin Luther King Jr. Boulevard into a closed conduit system that would run south along Martin Luther King Jr. Boulevard and then east along Vasser Road and discharge back into Salt Water Ditch downstream of Vasser Road. The potential benefit with this option would come from the reduction in land acquisitions required for channel improvements. As noted, one of the constraints to any proposed improvements was that they must offer the necessary depth to accommodate future storm sewer improvements. Lowering the flowline in an improved channel section for this purpose necessitates full acquisition of the parcels between Martin Luther King Jr. Boulevard and Doulton Drive. Any cost savings associated with reduced proposed channel sections is dwarfed by the costs associated with adding the parallel closed conduit system.

5.9 Cost Estimate

Unit costs used in the preparation of the construction cost estimates for the alternatives are provided in **Table 20**. Preliminary quantities and cost estimates for each alternative are provided in **Appendix D**. Further coordination with CenterPoint Energy in regards to the relocation of their utilities is required in order to get a more accurate cost estimate. A comparison of the costs, not including Centerpoint utility relocation, for the two alternatives is presented in **Table 21**.

Table 21: Project Unit Costs

Description	Unit	Unit Price
Channel Items		
Clearing and Grubbing	AC	\$4,500
Channel Excavation - Offsite Disposal	CY	\$12
Channel Excavation - Use as Fill	CY	\$8
Relocate Centerpoint Energy Utilities	LS	Further Coordination Required
Bridge Replacement	SF	\$100
Backslope Swale Interceptor	LF	\$3
Riprap	SY	\$31
Anchored Sodding	LF	\$4.30
Dry Seeding	AC	\$1,500
Sheetpile Drop Structure	LS	\$150,000
12' x 8' RCB	LF	\$1,150
12' x 10' RCB	LF	\$1,200
Land Acquisition - Drainage Easements	AC	\$80,700
Land Acquisition - Full Parcel Acquisitions	3x Market Value	
Detention Items		
Clearing and Grubbing	AC	\$4,500
Detention Pond Excavation	AC-FT	\$22,875
Dry Seeding	AC	\$1,500
Control Structure	LS	\$300,000
Land Acquisition - Detention	AC	\$80,700

Table 22: Alternative Cost Comparison

Alternative	Channel Cost	Detention Cost	Contingency	Total Cost
1	\$48,504,389	\$5,369,250	\$9,700,878	\$63,574,517
2	\$54,637,773	\$5,369,250	\$10,927,555	\$70,934,578

5.10 Project Funding Options

FEMA has three grant programs that offer financial assistance for hazard mitigation: (1) Hazard Mitigation Grant Program (HMGP), (2) Pre-Disaster Mitigation (PDM), and (3) Flood Mitigation Assistance (FMA). The money for these programs are annually appropriated by Congress. The funding guidelines for each program are determined annually; the FY2015 programs are used here for a synopsis. The HMGP is expressly to help communities implement hazard mitigation strategies following a major disaster and is therefore not applicable for future work on Salt Water Ditch. The PDM for FY2015 had a total of \$30M for hazard mitigation and limited the federal share to 75% of costs up to a maximum federal share of \$3M. The FMA for FY2015 had a total of \$150M with the maximum to any local entity being \$100K.

5.11 Recommended Plan

The recommended plan for Salt Water Ditch is Alternative 1 which includes channel enlargement from the upstream extent of Salt Water Ditch to the confluence with Sims Bayou. The channel section would have a 6' bottom width and range in depth from 14 at the upstream limit to 24 feet at the confluence with Sims Bayou. The channel slope would be a consistent .0006 ft/ft. This alternative also includes a drop structure in the downstream portion of Salt Water Ditch that lowers the existing slope and thereby the velocities within that portion of the channel. A detention pond with approximately 817 acre-feet of detention will be required to mitigate the peak flow impacts to Sims Bayou. This alternative provides the necessary depth to allow storm sewers to drain into the channel, provides the freeboard required for the new bridges, has the lowest construction cost, and removes all structures from the 100-year floodplain. The annuitized cost of flood damages is \$100,019,989 and the estimated construction cost for Alternative 1 is \$63,574,517 resulting in a net benefit of \$36,445,472 and a benefit-cost ratio of 1.57 giving strong support for implementing the recommended plan.

EXHIBITS

EXHIBIT 1: SIMS BAYOU WATERSHED

EXHIBIT 2: SALT WATER DITCH SUBWATERSHED AND LAND USE

EXHIBIT 3: PHYSICAL WATERSHED CHARACTERISTICS

EXHIBIT 4: HEC-RAS CROSS SECTIONS AND REVISED FLOODPLAIN

EXHIBIT 5: EXISTING WATER SURFACE ELEVATION PROFILE

EXHIBIT 6: SALT WATER DITCH CHANNEL CAPACITY

EXHIBIT 7: FLOODED STRUCTURES

EXHIBIT 8: DOCUMENTED FLOOD LOSSES

EXHIBIT 9: SALT WATER DITCH REACH SEGMENTS

EXHIBIT 10A: ALTERNATIVE 1 LAYOUT

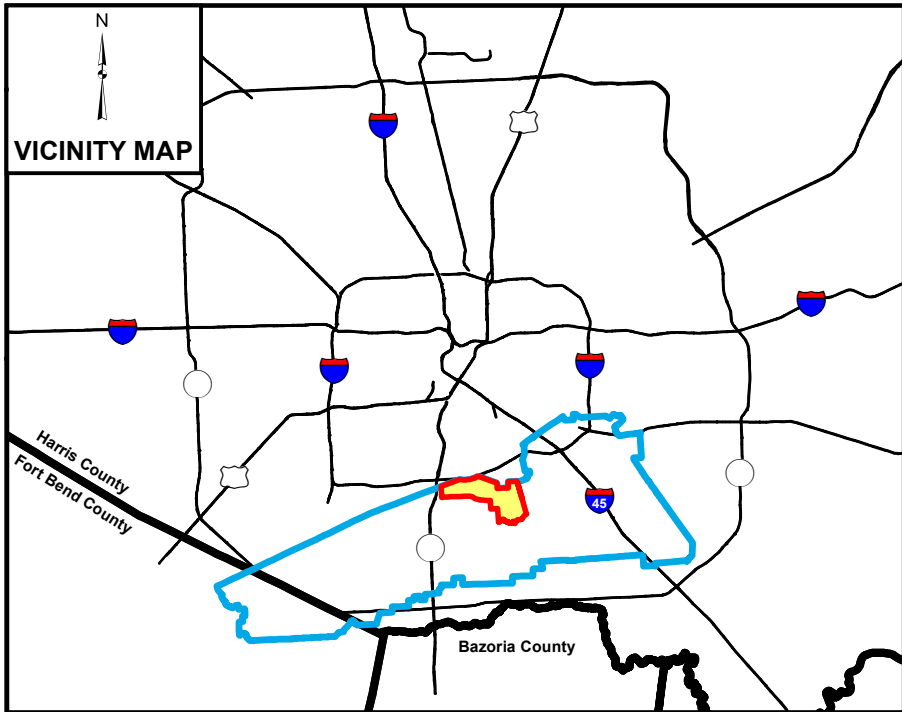
EXHIBIT 10B: ALTERNATIVE 1 LAYOUT

EXHIBIT 11: ALTERNATIVE 1 WATER SURFACE PROFILE

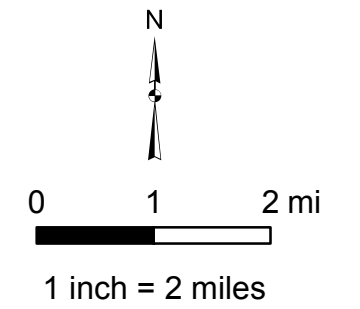
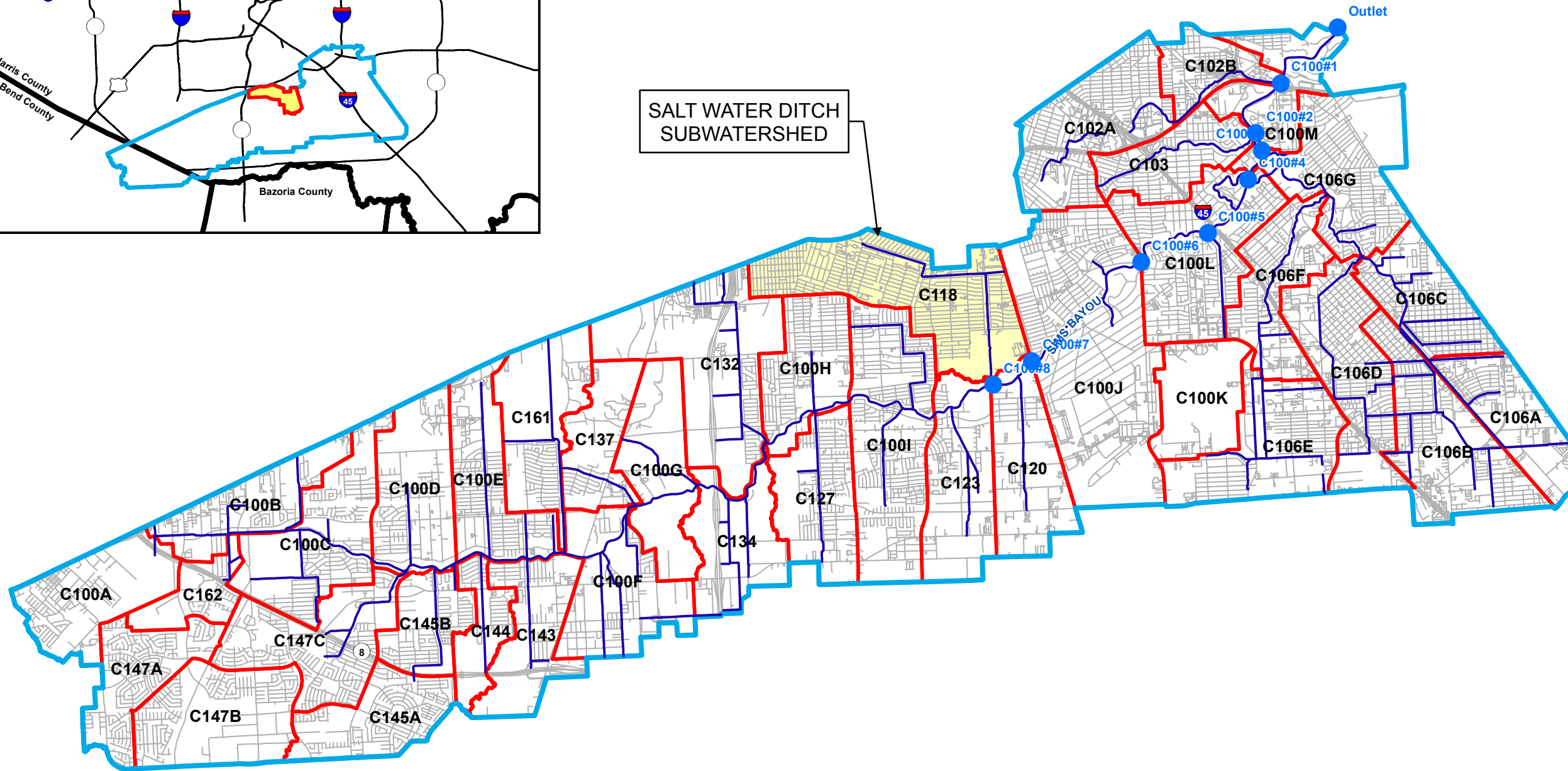
EXHIBIT 12A: ALTERNATIVE 2 LAYOUT

EXHIBIT 12B: ALTERNATIVE 2 LAYOUT






EXHIBIT 13: ALTERNATIVE 2 WATER SURFACE PROFILES



SALT WATER DITCH
SUBWATERSHED



Legend

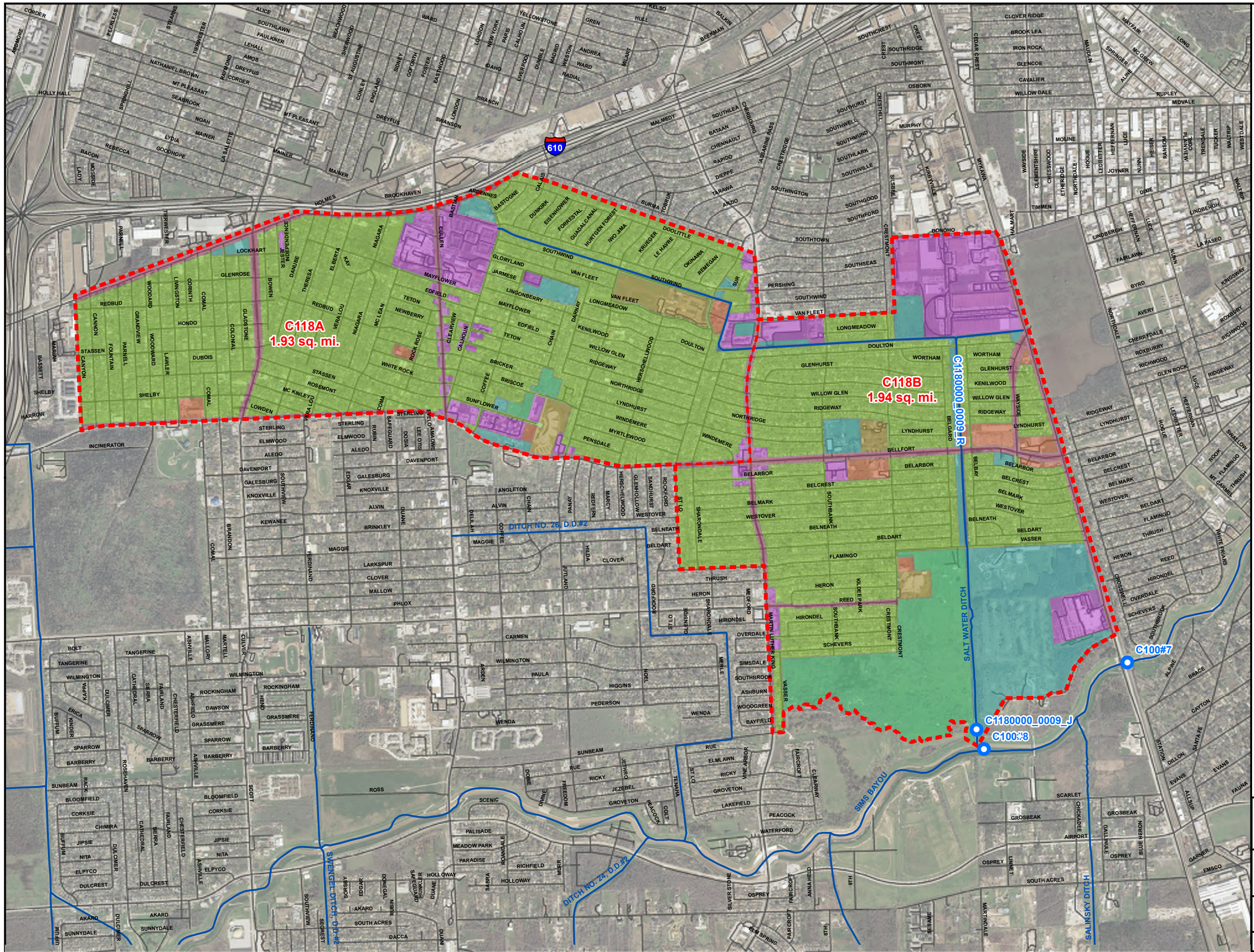
-  Streams
-  HEC-HMS Node
-  Sims Bayou Watershed Boundary
-  Subwatershed Boundary
-  Salt Water Ditch Subwatershed

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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

SIMS BAYOU WATERSHED



0 900 1,800 ft

1 inch = 1,800 feet

Legend

- HEC-HMS Node
- Streams
- Salt Water Ditch
- Subareas

HCFC Land Use Categories

- Developed Green Areas
- High Density
- Light Industrial/Commercial
- Residential
- Schools
- Isolated Transportation
- Undeveloped
- Water

Subarea	A (sq mi)	DLU (%)	IMP (%)
C118	3.87	82.40	52.87
C118_Corrected	3.87	87.78	42.34
C118A	1.93	96.87	45.47
C118B	1.94	78.71	39.21

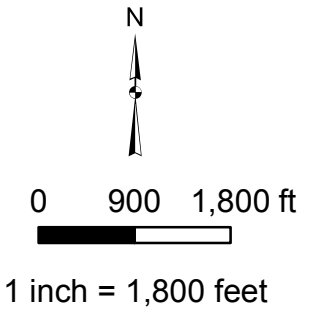
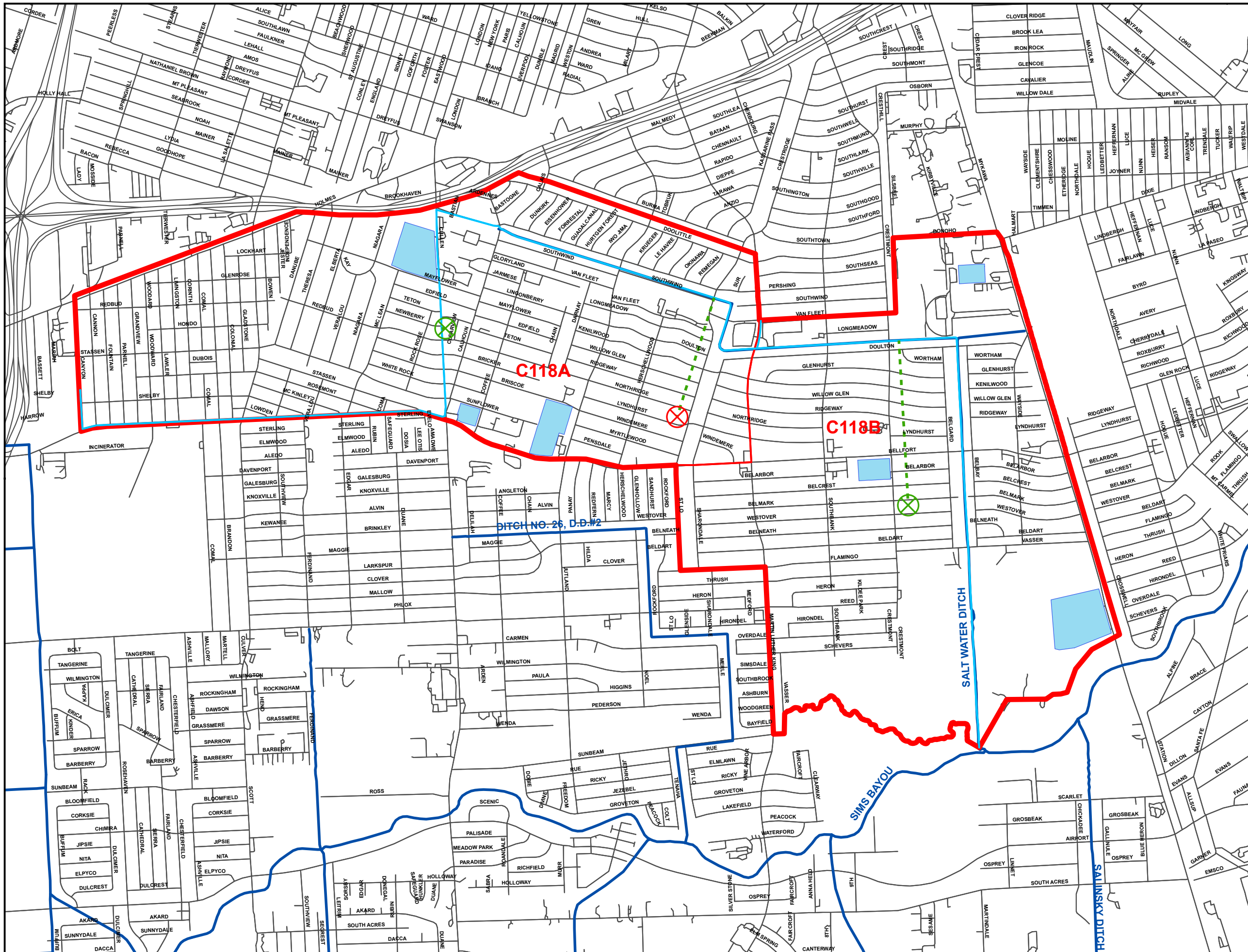
Aerials: 2012 HGAC

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**FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12**

**SALT WATER DITCH
SUBWATERSHED & LAND USE**



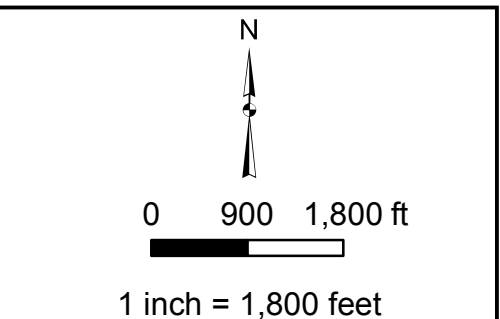
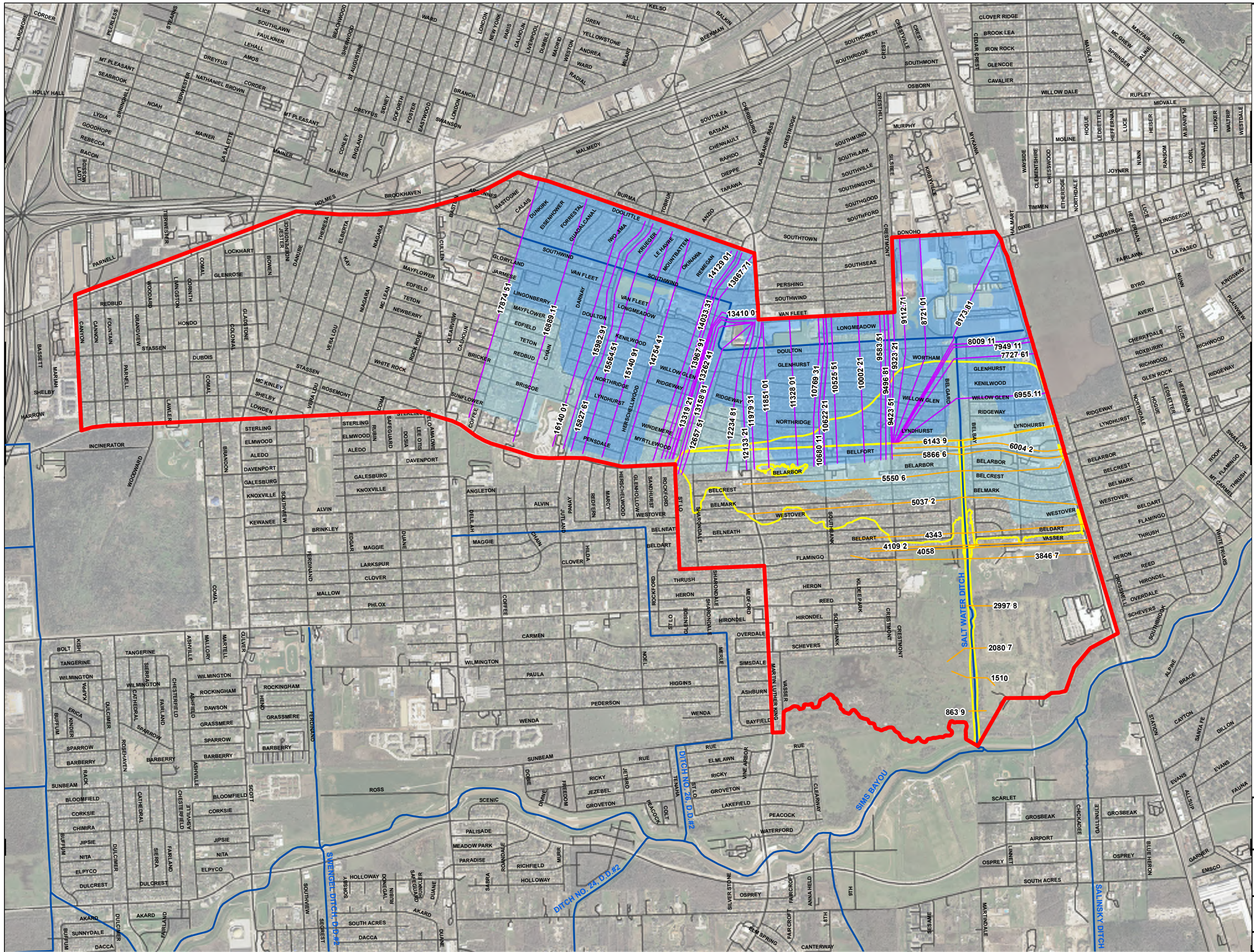
- Legend**
- Length to Centroid
 - Hydraulic Length
 - Stream Centerline
 - DLU Affected by Detention
 - Salt Water Ditch Subwatershed
 - Salt Water Ditch Subareas
- Subwatershed Centroid**
- ⊗ Corrected Effective
 - ⊗ Revised Existing

Subarea	A (sq mi)	L (mi)	Lca (mi)	DCI (%)	DET (%)
C118	3.87	5.62	2.62	79	2.25
C118_Corrected	3.87	5.91	2.61	79	2.56
C118A	1.93	3.66	1.87	100	2.48
C118B	1.94	2.34	1.71	68	2.64

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PHYSICAL WATERSHED CHARACTERISTICS



- Legend**
- Streams
 - FEMA Effective Floodplain
 - Revised Existing 10-Year Delineation
 - Revised Existing 100-Year Delineation
 - Salt Water Ditch Subwatershed
- HEC-RAS Cross Sections**
- Existing
 - Added

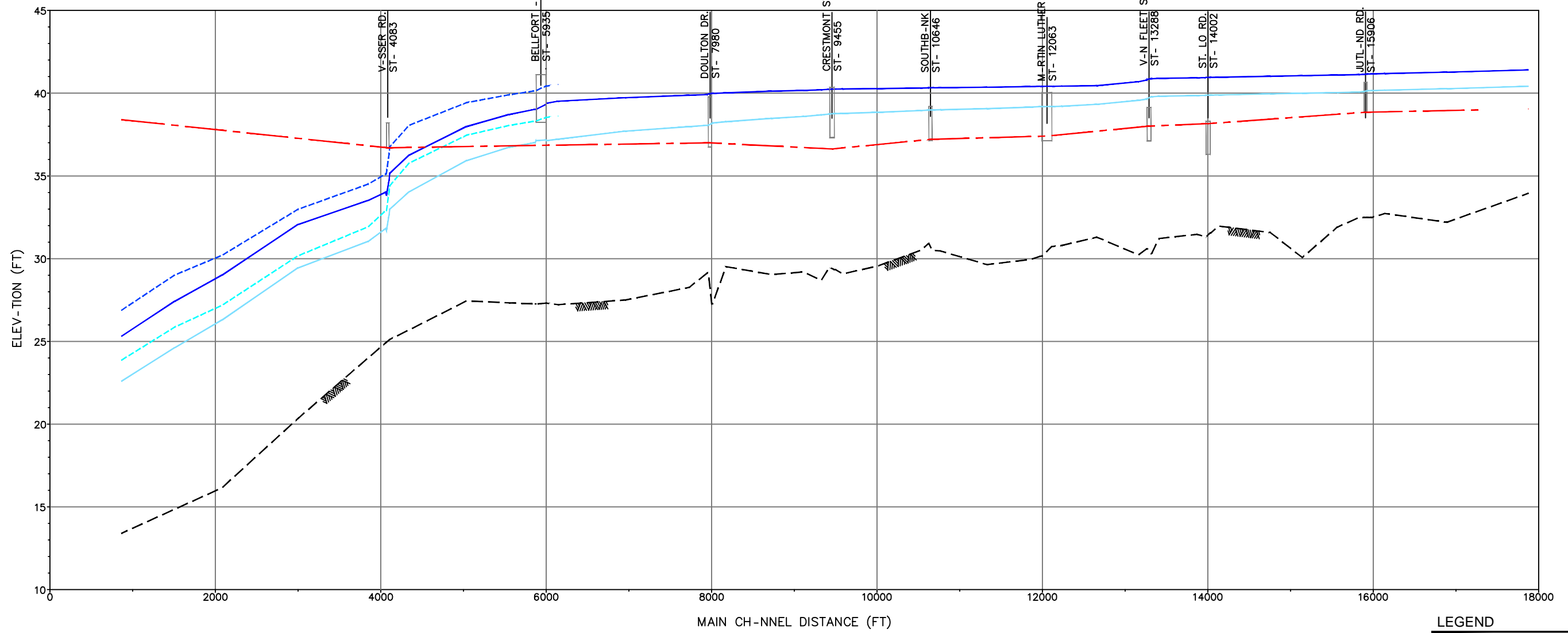
Aerials: 2012 HGAC

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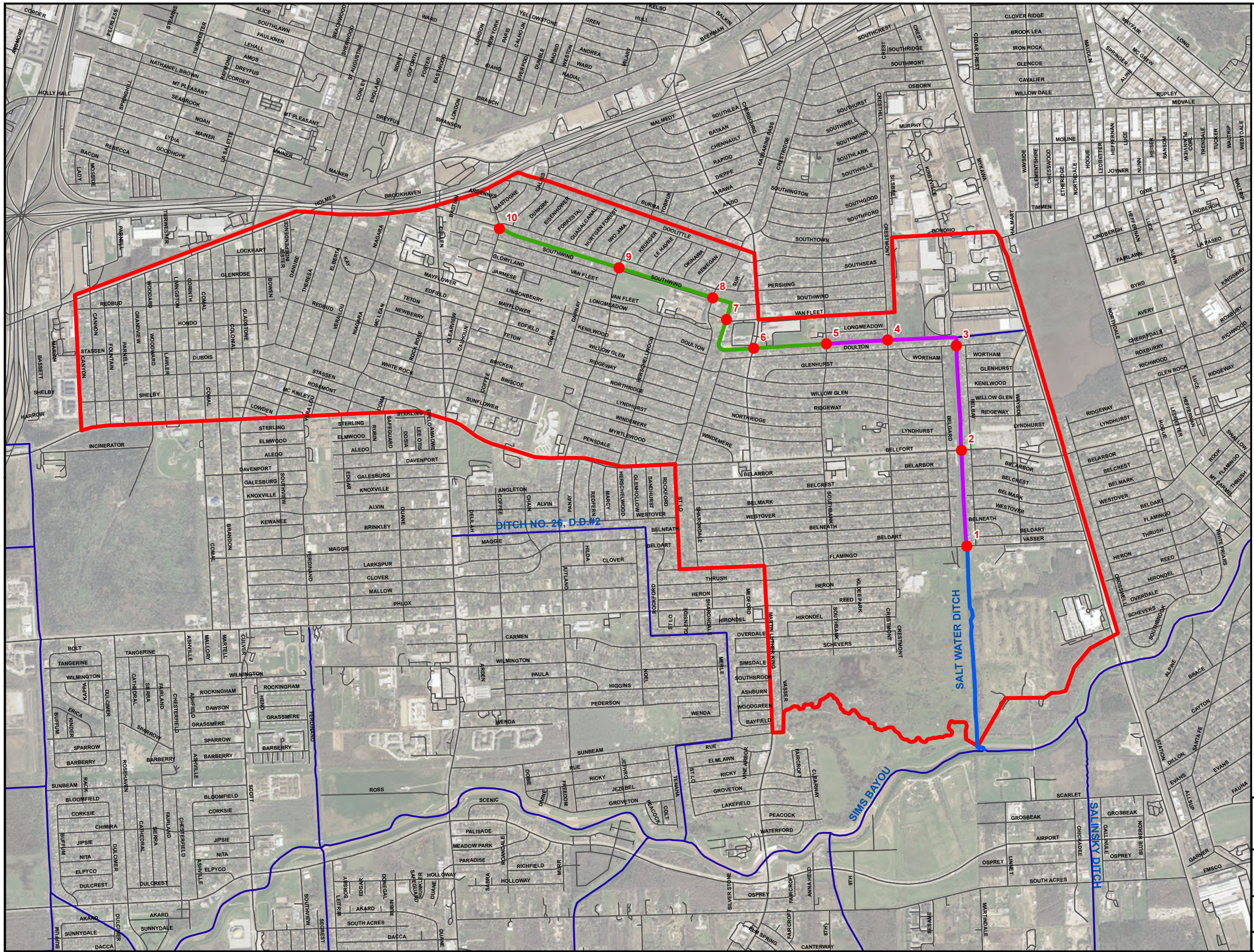
**HEC-RAS CROSS SECTIONS
& REVISED FLOODPLAIN**



LEGEND

	REVISED EXISTING 100-YR WSEL
	REVISED EXISTING 10-YR WSEL
	DUPLICATE EFFECTIVE 100 YR WSEL
	DUPLICATE EFFECTIVE 10 YR WSEL
	EXISTING FLOWLINE
	CRITICAL ELEVATION

CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429. Date: Nov 01, 2015



0 900 1,800 ft

1 inch = 1,800 feet

Legend

- Bridge ID & Location
- Streams
- Salt Water Ditch Subwatershed
- Capacity**
- < 2-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR

Bridge ID	Location
1	Vassar
2	Belfort
3	Doulton
4	Crestmont
5	Southbank
6	Martin Luther King Jr
7	Van Fleet
8	St Lo
9	Jutland
10	Calhoun

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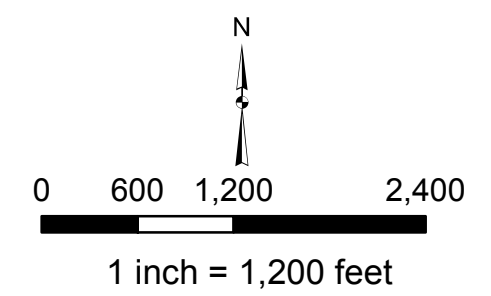
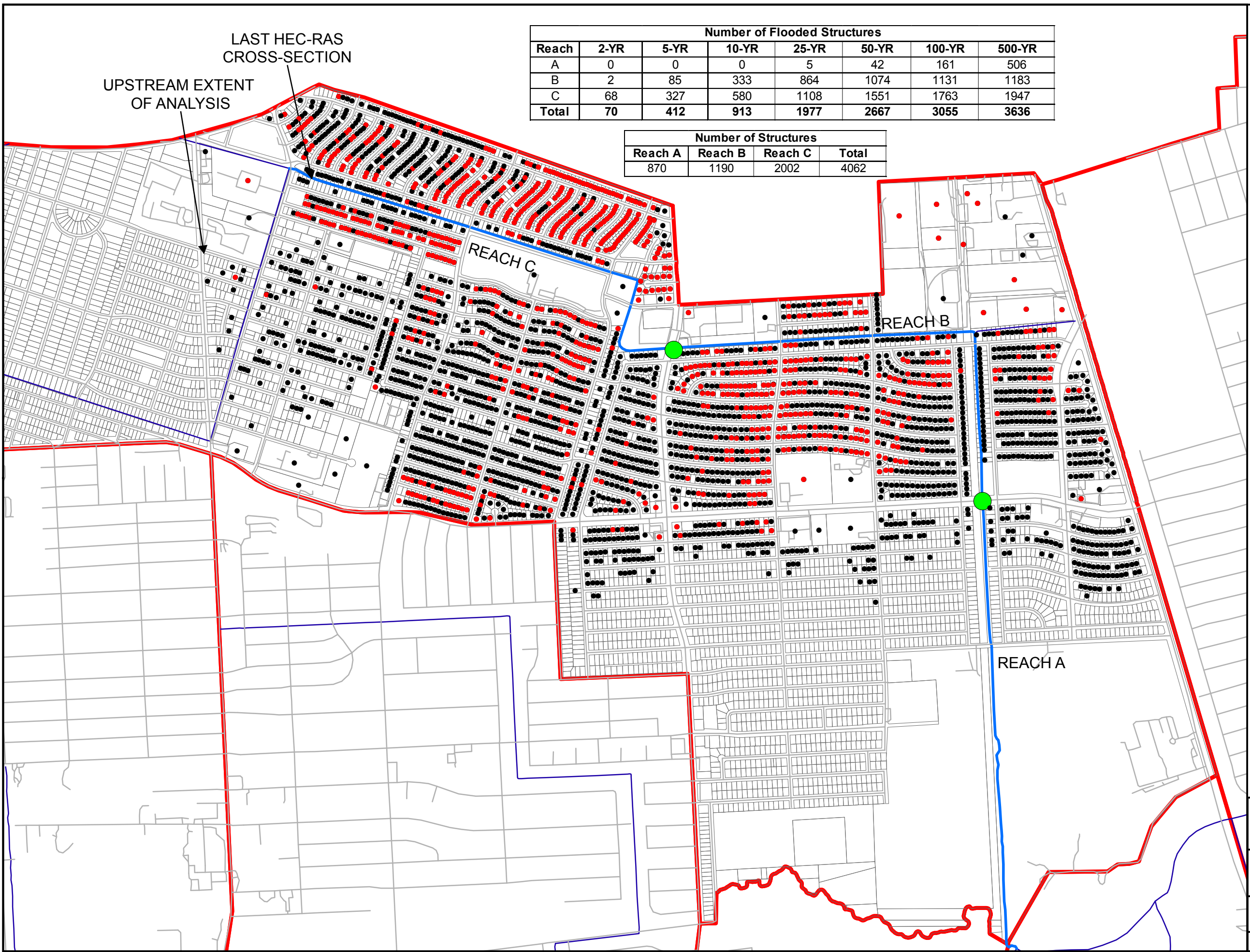
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SALT WATER DITCH CHANNEL CAPACITY

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	5	42	161	506
B	2	85	333	864	1074	1131	1183
C	68	327	580	1108	1551	1763	1947
Total	70	412	913	1977	2667	3055	3636

Number of Structures			
Reach A	Reach B	Reach C	Total
870	1190	2002	4062

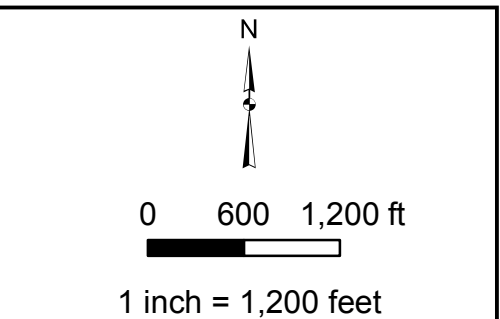
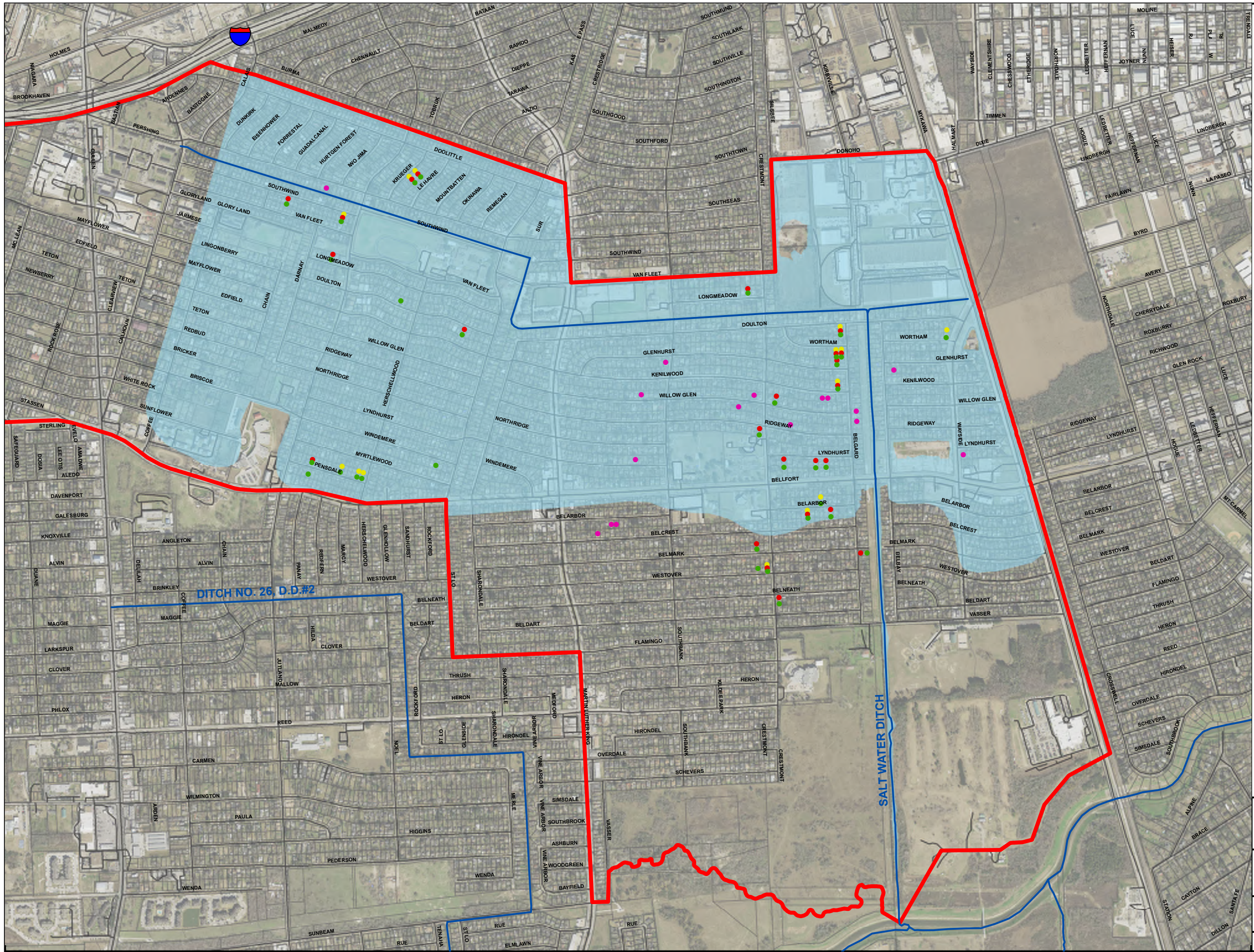


- Legend**
- Flooded Structures in 10-YR Event
 - Flooded Structures in 100-YR Event
 - Reach Breaks
 - Salt Water Ditch
 - Stream Centerline
 - Parcels in Salt Water Ditch Subwatershed
 - Subwatershed Boundary

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FLOODED STRUCTURES

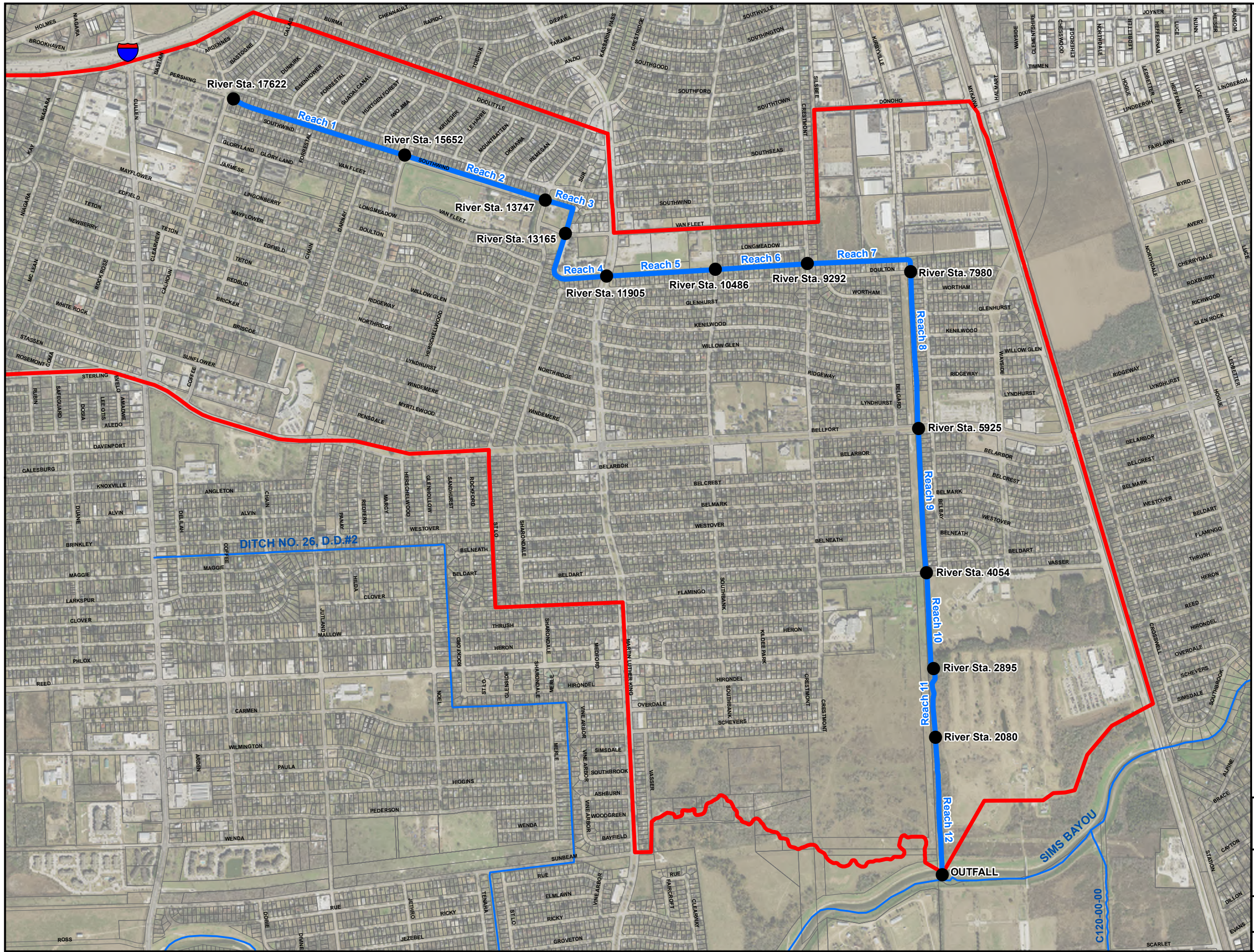


- Legend**
- Streams
 - Salt Water Ditch Watershed
 - Revised 100-Year Delineation
 - Damaged Homes Documented by City of Houston Following Hurricane Ike
- FEMA Losses**
- June 2001 - Tropical Storm Allison
 - June 2006
 - Sept 2008 - Hurricane Ike

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DOCUMENTED FLOOD LOSSES



N

0 600 1,200 ft

1 inch = 1,200 feet

Legend

- Streams
- Reaches
- Salt Water Ditch Watershed

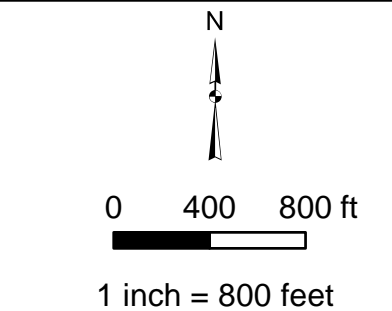
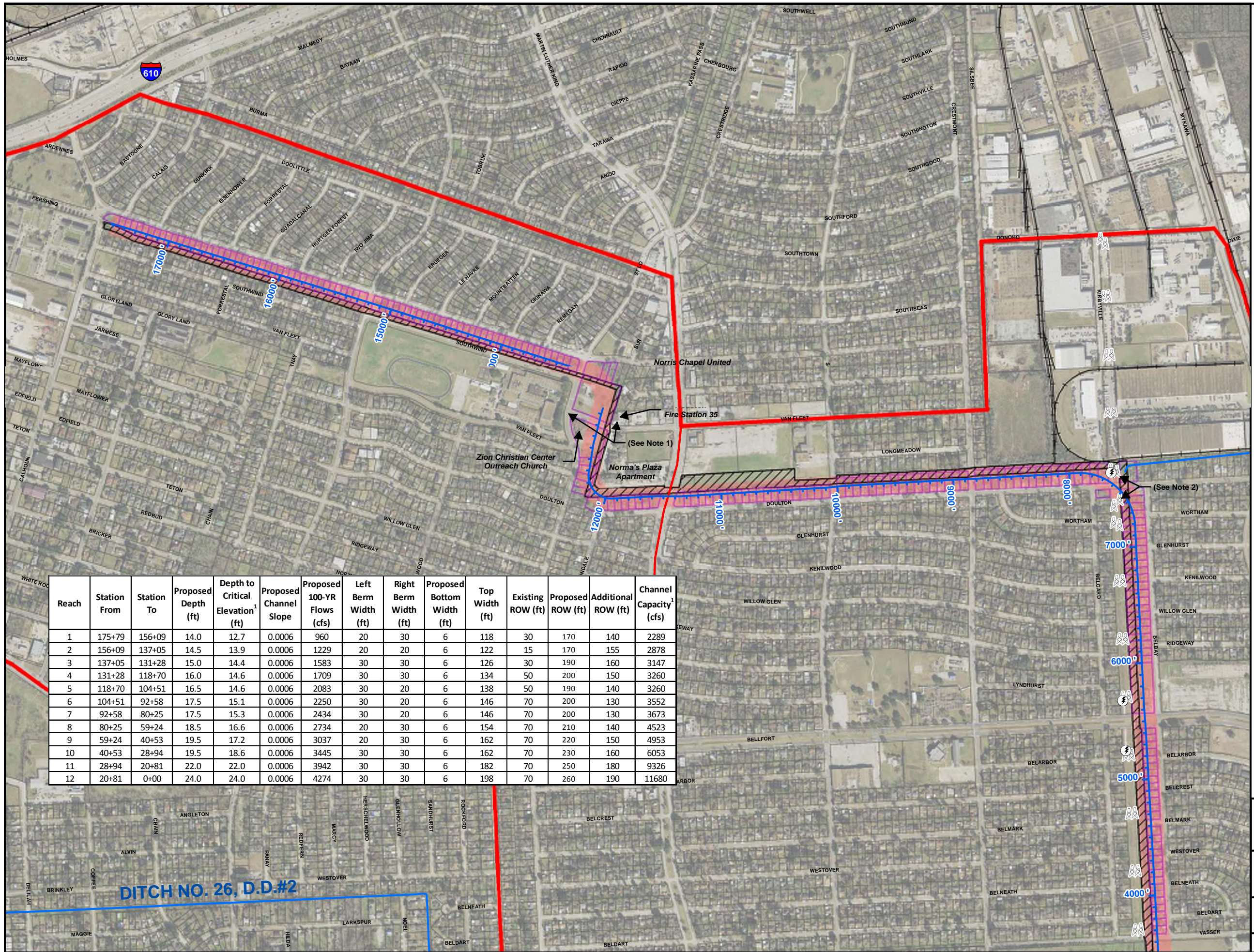
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FEASIBILITY STUDY FOR SALT WATER DITCH
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COH WORK AUTHORIZATION NO. 12

SALT WATER DITCH REACH SEGMENTS

NOVEMBER 2015	Job No: 325912	EXHIBIT 9
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- Legend**
- Streams
 - Railroads
 - Proposed Channel Alignment
 - Existing Channel Right-Of-Way
 - Full Parcel Acquisitions
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

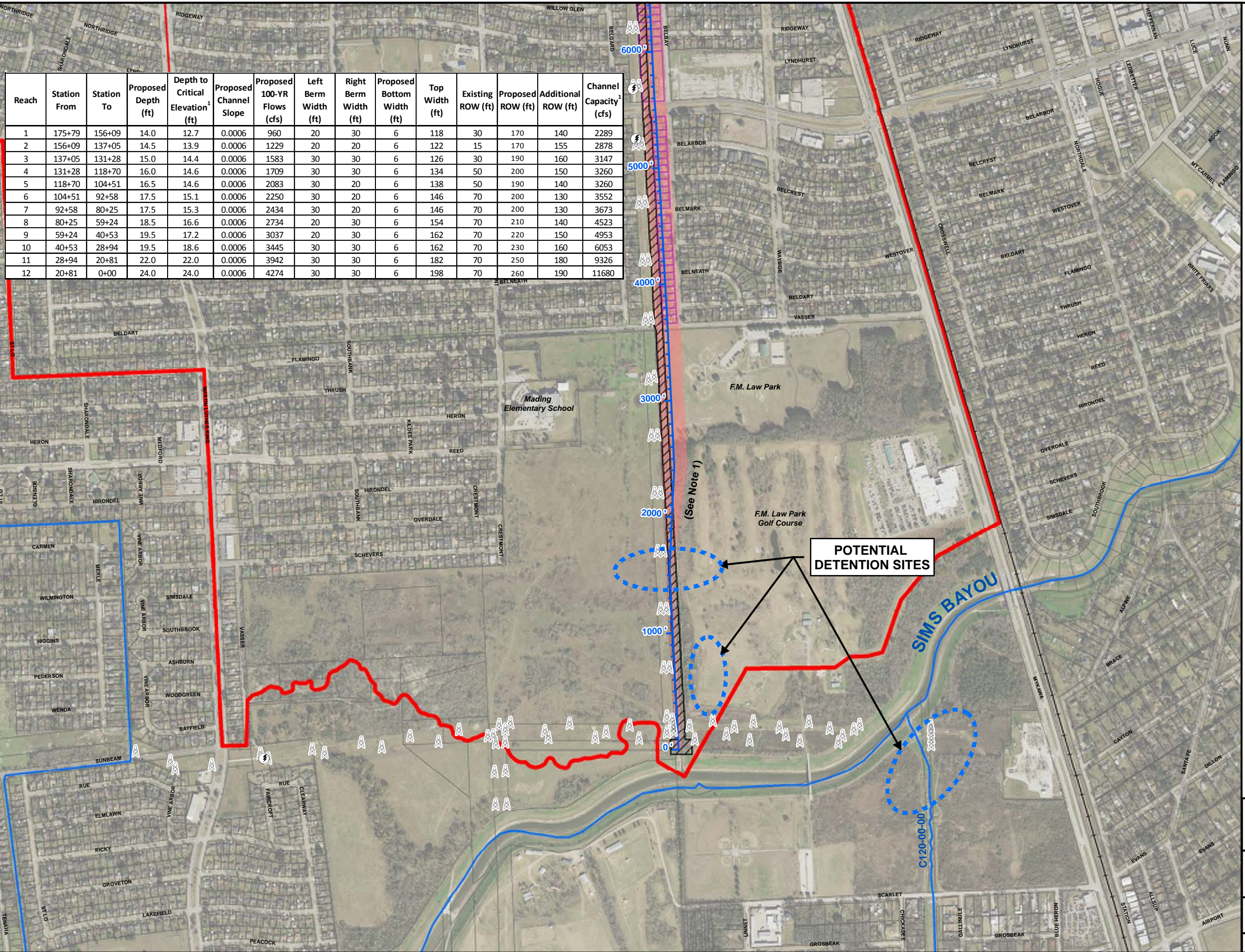
Reach	Station From	Station To	Proposed Depth (ft)	Depth to Critical Elevation ¹ (ft)	Proposed Channel Slope	Proposed 100-YR Flows (cfs)	Left Berm Width (ft)	Right Berm Width (ft)	Proposed Bottom Width (ft)	Top Width (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)	Channel Capacity ¹ (cfs)
1	175+79	156+09	14.0	12.7	0.0006	960	20	30	6	118	30	170	140	2289
2	156+09	137+05	14.5	13.9	0.0006	1229	20	20	6	122	15	170	155	2878
3	137+05	131+28	15.0	14.4	0.0006	1583	30	30	6	126	30	190	160	3147
4	131+28	118+70	16.0	14.6	0.0006	1709	30	30	6	134	50	200	150	3260
5	118+70	104+51	16.5	14.6	0.0006	2083	30	20	6	138	50	190	140	3260
6	104+51	92+58	17.5	15.1	0.0006	2250	30	20	6	146	70	200	130	3552
7	92+58	80+25	17.5	15.3	0.0006	2434	30	20	6	146	70	200	130	3673
8	80+25	59+24	18.5	16.6	0.0006	2734	20	30	6	154	70	210	140	4523
9	59+24	40+53	19.5	17.2	0.0006	3037	20	30	6	162	70	220	150	4953
10	40+53	28+94	19.5	18.6	0.0006	3445	30	30	6	162	70	230	160	6053
11	28+94	20+81	22.0	22.0	0.0006	3942	30	30	6	182	70	250	180	9326
12	20+81	0+00	24.0	24.0	0.0006	4274	30	30	6	198	70	260	190	11680

NOTES:
 1) The fire station, St Lo Road (provides access to Jones High School), and the majority of the apartment complex is preserved.
 2) Centerpoint sub station and transmission lines would need to be relocated.

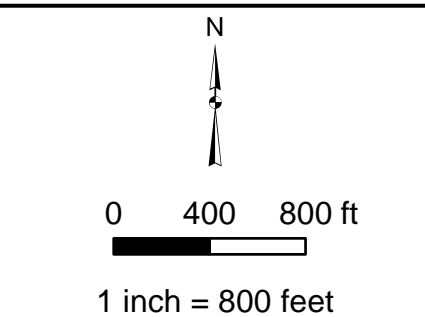
CivilTech Engineering, Inc.
 11821 Telge Rd
 Cypress, Texas 77429
 Tel: 281-304-0200
 Fax: 291-204-0210

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 1 LAYOUT



Reach	Station From	Station To	Proposed Depth (ft)	Depth to Critical Elevation ¹ (ft)	Proposed Channel Slope	Proposed 100-YR Flows (cfs)	Left Berm Width (ft)	Right Berm Width (ft)	Proposed Bottom Width (ft)	Top Width (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)	Channel Capacity ¹ (cfs)
1	175+79	156+09	14.0	12.7	0.0006	960	20	30	6	118	30	170	140	2289
2	156+09	137+05	14.5	13.9	0.0006	1229	20	20	6	122	15	170	155	2878
3	137+05	131+28	15.0	14.4	0.0006	1583	30	30	6	126	30	190	160	3147
4	131+28	118+70	16.0	14.6	0.0006	1709	30	30	6	134	50	200	150	3260
5	118+70	104+51	16.5	14.6	0.0006	2083	30	20	6	138	50	190	140	3260
6	104+51	92+58	17.5	15.1	0.0006	2250	30	20	6	146	70	200	130	3552
7	92+58	80+25	17.5	15.3	0.0006	2434	30	20	6	146	70	200	130	3673
8	80+25	59+24	18.5	16.6	0.0006	2734	20	30	6	154	70	210	140	4523
9	59+24	40+53	19.5	17.2	0.0006	3037	20	30	6	162	70	220	150	4953
10	40+53	28+94	19.5	18.6	0.0006	3445	30	30	6	162	70	230	160	6053
11	28+94	20+81	22.0	22.0	0.0006	3942	30	30	6	182	70	250	180	9326
12	20+81	0+00	24.0	24.0	0.0006	4274	30	30	6	198	70	260	190	11680



- Legend**
- Streams
 - Railroads
 - Proposed Channel
 - Existing Channel Right-Of-Way
 - Full Parcel Acquisitions
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

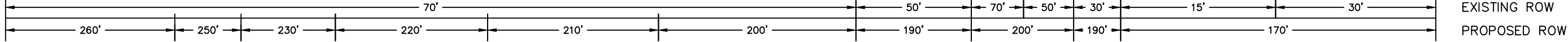
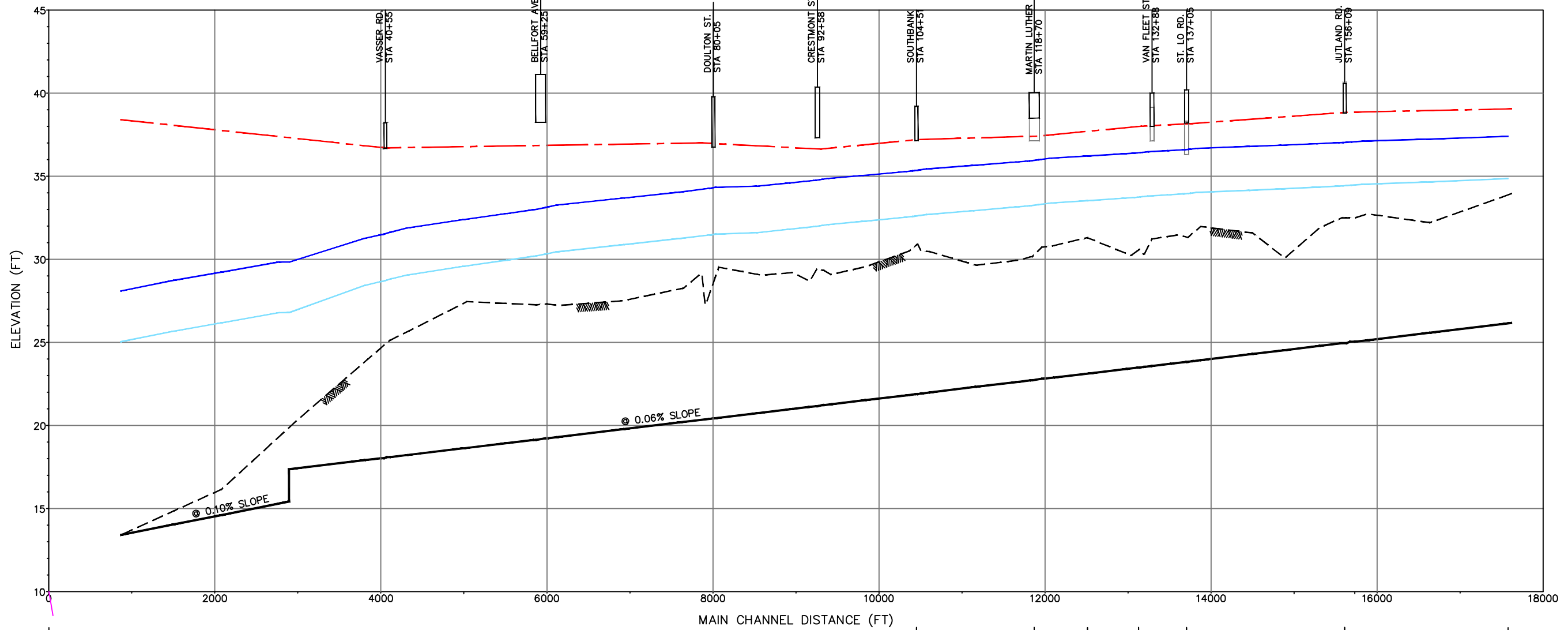
NOTES:
 1) Golf course fairways are preserved.

POTENTIAL DETENTION SITES

CivilTech Engineering, Inc.
 11821 Telge Rd
 Cypress, Texas 77429
 Tel: 281-304-0200
 Fax: 291-204-0210

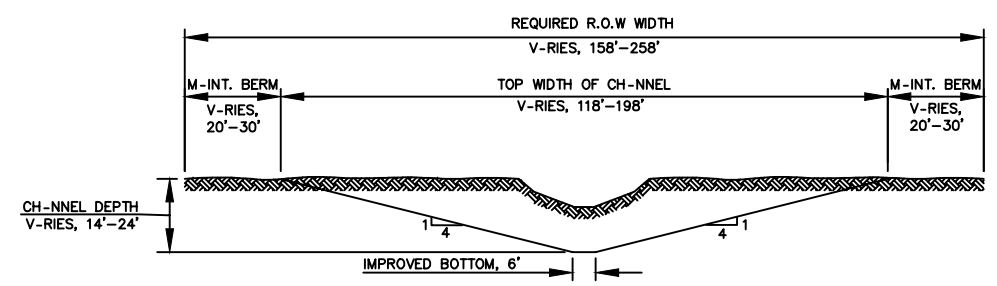
FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFCU UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 1 LAYOUT



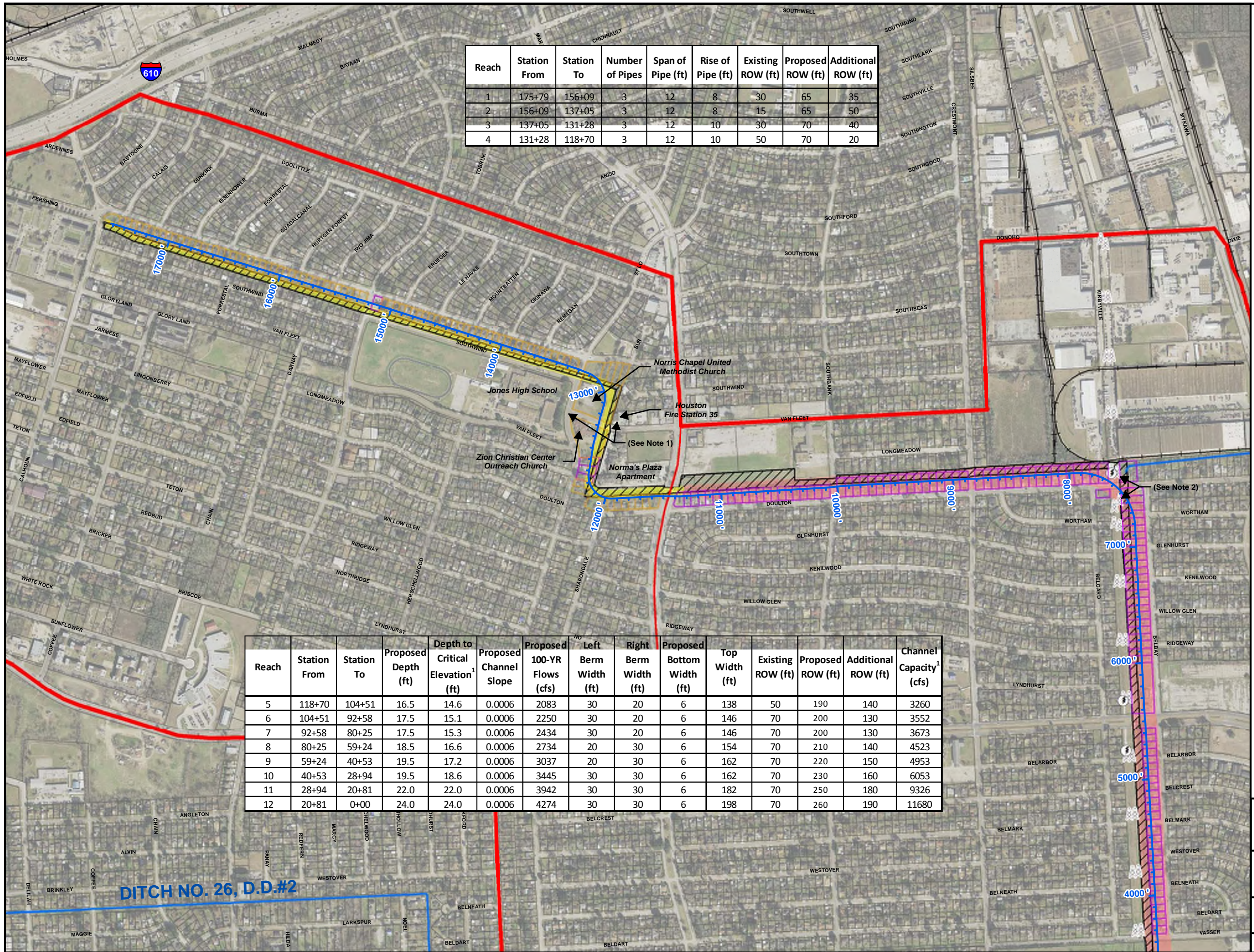
Bridge Crossing	River Station	No. of Bridges	Bridge Length (ft)	Bridge Width (ft)	Proposed 100-YR WSEL (ft)	Top		Bottom	
						Existing Chord Elevation (ft)	Proposed Chord Elevation (ft)	Existing Chord Elevation (ft)	Proposed Chord Elevation (ft)
Jutland Road	156+09	1	120	34	37.02	40.55	40.65	35.90	38.90
St Lu Street	137+05	1	130	34	36.55	38.22	39.50	35.31	38.20
Van Fleet Street	111+28	1	130	34	36.40	39.14	39.14	37.12	38.00
Martin Luther King Jr. Blvd.	118+70	1	140	310	35.97	40.04	40.03	37.10	36.50
Southbank Street	104+51	1	140	34	35.33	39.21	39.20	37.14	37.14
Crestmont Street	92+58	1	150	34	34.75	40.36	40.35	37.32	37.32
Doultton Drive	80+25	1	240	34	34.31	39.78	39.78	36.75	36.75
Belfort Avenue	59+25	2	160	42	33.11	41.12	41.12	38.31	38.31
Vasser Road	40+53	1	170	34	31.56	38.21	38.21	36.81	36.81

Note: * Existing 2' x 7' RCBs



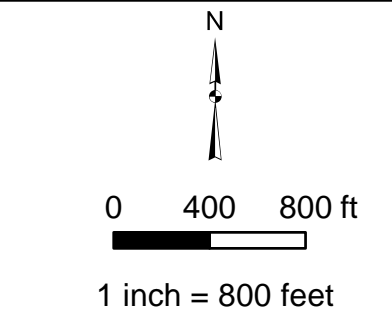
- LEGEND**
- PROPOSED 100-YR WSEL
 - PROPOSED 10-YR WSEL
 - PROPOSED FLOW LINE
 - - - EXISTING FLOW LINE
 - - - CRITICAL ELEVATION

CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429



Reach	Station From	Station To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)
1	175+79	156+09	3	12	8	30	65	35
2	156+09	137+05	3	12	8	15	65	50
3	137+05	131+28	3	12	10	30	70	40
4	131+28	118+70	3	12	10	50	70	20

Reach	Station From	Station To	Proposed Depth (ft)	Depth to Critical Elevation ¹ (ft)	Proposed Channel Slope	Proposed 100-YR Flows (cfs)	Left Berm Width (ft)	Right Berm Width (ft)	Proposed Bottom Width (ft)	Top Width (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)	Channel Capacity ¹ (cfs)
5	118+70	104+51	16.5	14.6	0.0006	2083	30	20	6	138	50	190	140	3260
6	104+51	92+58	17.5	15.1	0.0006	2250	30	20	6	146	70	200	130	3552
7	92+58	80+25	17.5	15.3	0.0006	2434	30	20	6	146	70	200	130	3673
8	80+25	59+24	18.5	16.6	0.0006	2734	20	30	6	154	70	210	140	4523
9	59+24	40+53	19.5	17.2	0.0006	3037	20	30	6	162	70	220	150	4953
10	40+53	28+94	19.5	18.6	0.0006	3445	30	30	6	162	70	230	160	6053
11	28+94	20+81	22.0	22.0	0.0006	3942	30	30	6	182	70	250	180	9326
12	20+81	0+00	24.0	24.0	0.0006	4274	30	30	6	198	70	260	190	11680



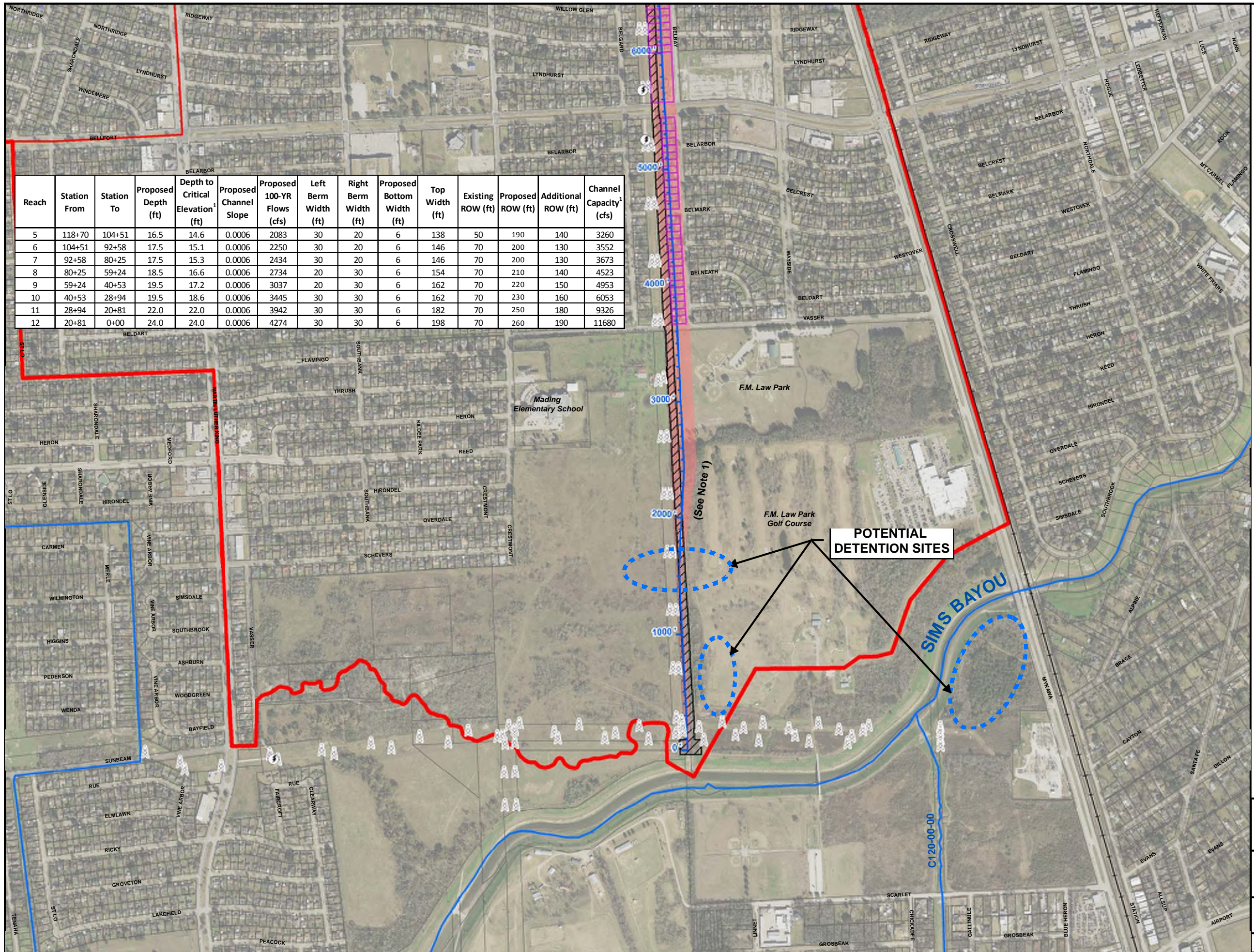
- Legend**
- Streams
 - Railroads
 - Proposed Storm Sewer
 - Proposed Channel
 - Existing Channel Right-Of-Way
 - Partial Parcel Acquisitions
 - Full Parcel Acquisitions
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

NOTES:
 1) The fire station, St Lo Road (provides access to Jones High School), and the majority of the apartment complex is preserved.
 2) Centerpoint sub station and transmission lines would need to be relocated.

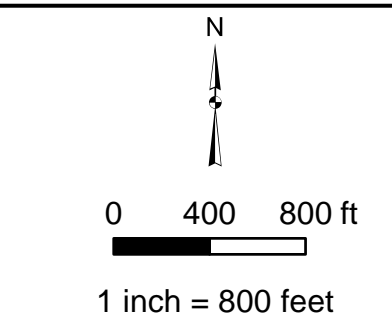
CivilTech Engineering, Inc.
 11821 Telge Rd
 Cypress, Texas 77429
 Tel: 281-304-0200
 Fax: 291-204-0210

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 2 LAYOUT



Reach	Station From	Station To	Proposed Depth (ft)	Depth to Critical Elevation ¹ (ft)	Proposed Channel Slope	Proposed 100-YR Flows (cfs)	Left Berm Width (ft)	Right Berm Width (ft)	Proposed Bottom Width (ft)	Top Width (ft)	Existing ROW (ft)	Proposed ROW (ft)	Additional ROW (ft)	Channel Capacity ¹ (cfs)
5	118+70	104+51	16.5	14.6	0.0006	2083	30	20	6	138	50	190	140	3260
6	104+51	92+58	17.5	15.1	0.0006	2250	30	20	6	146	70	200	130	3552
7	92+58	80+25	17.5	15.3	0.0006	2434	30	20	6	146	70	200	130	3673
8	80+25	59+24	18.5	16.6	0.0006	2734	20	30	6	154	70	210	140	4523
9	59+24	40+53	19.5	17.2	0.0006	3037	20	30	6	162	70	220	150	4953
10	40+53	28+94	19.5	18.6	0.0006	3445	30	30	6	162	70	230	160	6053
11	28+94	20+81	22.0	22.0	0.0006	3942	30	30	6	182	70	250	180	9326
12	20+81	0+00	24.0	24.0	0.0006	4274	30	30	6	198	70	260	190	11680



- Legend**
- Streams
 - Railroads
 - Proposed Storm Sewer
 - Proposed Channel
 - Existing Channel Right-Of-Way
 - Partial Parcel Acquisitions
 - Full Parcel Acquisitions
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

(See Note 1)

POTENTIAL DETENTION SITES

NOTES:
1) Golf course fairways are preserved.

CivilTech Engineering, Inc.
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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 2 LAYOUT

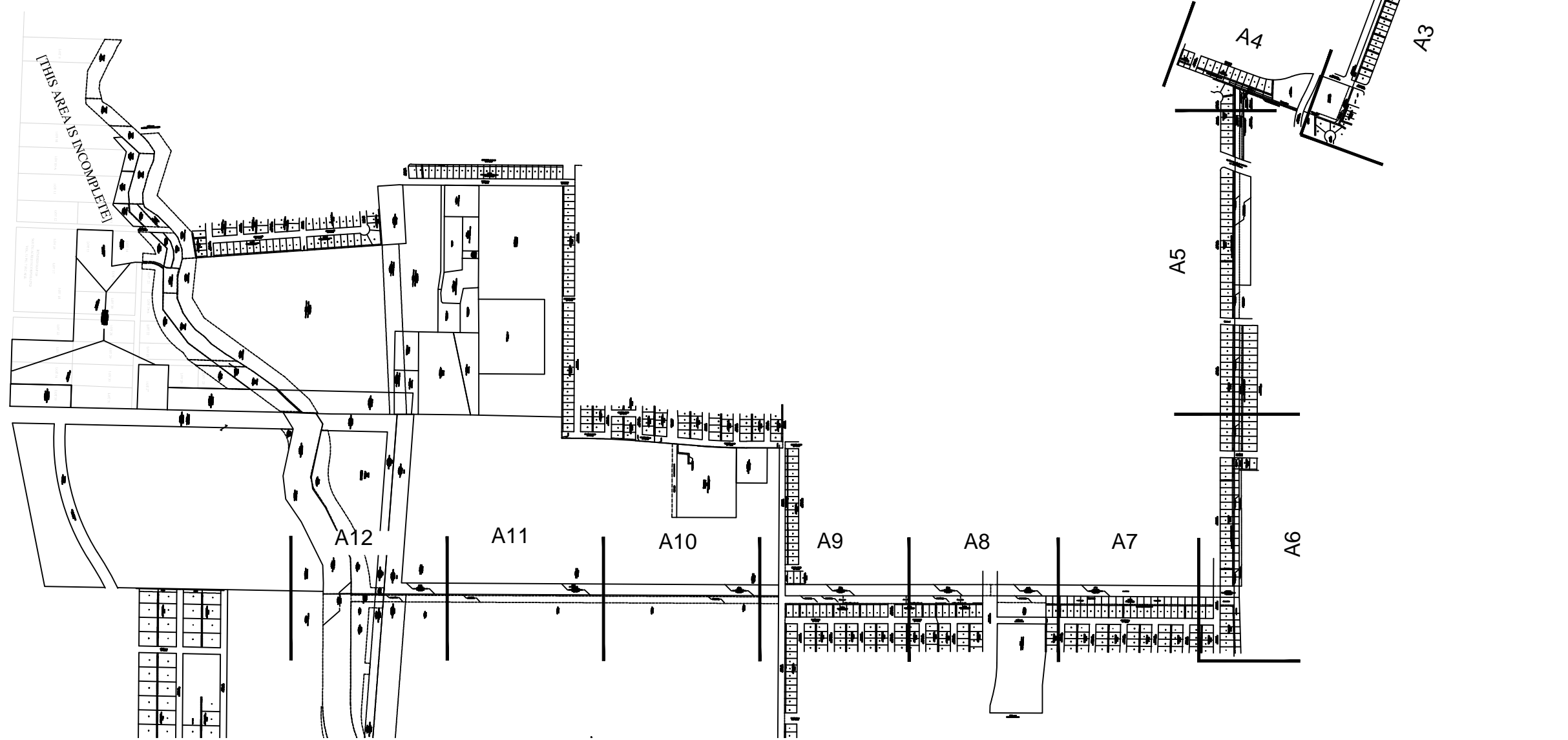
NOVEMBER 2015 Job No: 325912 EXHIBIT 12b

APPENDIX A

EXISTING RIGHT-OF-WAY AND EASEMENTS



SCALE: N.T.S.



CivilTech Engineering, Inc. 11821 Telge Road Cypress, Texas 77429

CivilTech
Engineering, Inc.

11821 TELGE ROAD
CYPRESS, TEXAS 77429
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FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

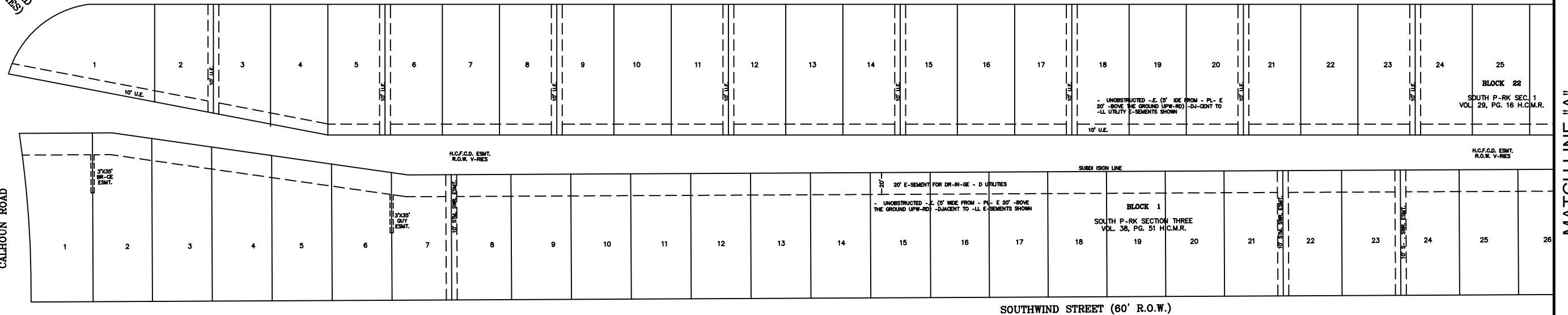
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A1

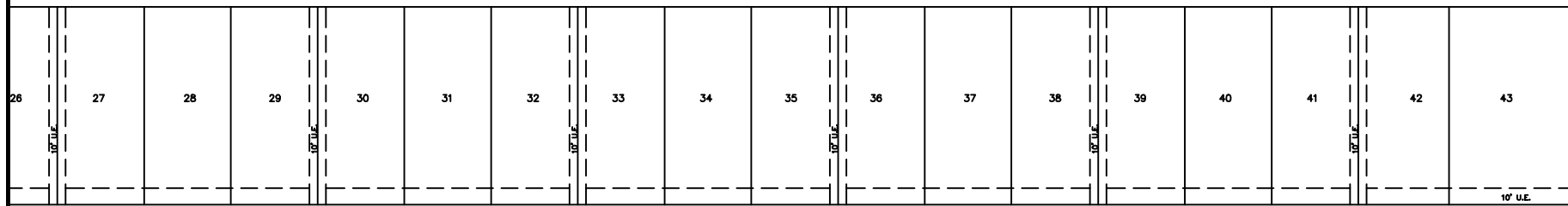
CALHOUN ROAD
(WIDTH VARIES)

PERSHING STREET
(formerly WAINWRIGHT BOULEVARD)
(60' R.O.W.)

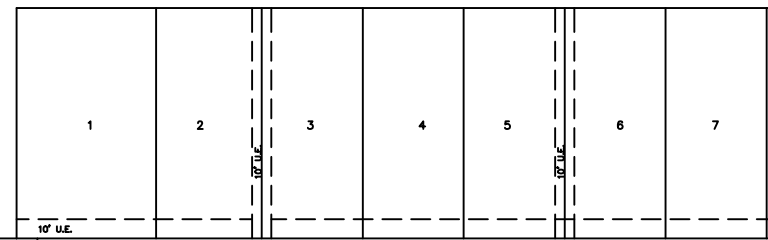


MATCH LINE "A"

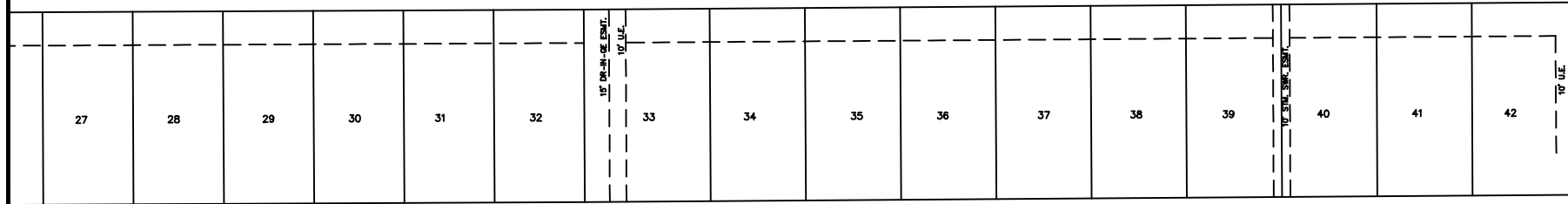
MATCH LINE "A"



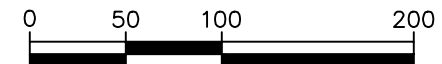
JUTLAND ROAD
(60' R.O.W.)



MATCH LINE "B"



JUTLAND DRIVE
(CALLED 80' R.O.W.)



SCALE IN FEET

CivilTech Engineering, Inc. 11821 TELGE ROAD CYPRESS, TEXAS 77429 PH:(281)304-0200 FX:(281)304-0210 FIRM REGISTRATION NO. F-382

CivilTech Engineering, Inc.

11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH:(281)304-0200
FX:(281)304-0210
FIRM REGISTRATION NO. F-382

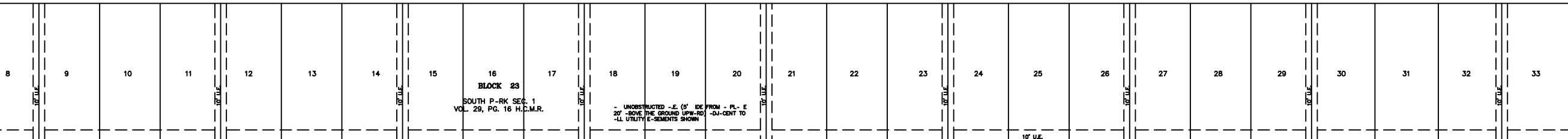
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A2

PERSHING STREET
(formerly WAINWRIGHT BOULEVARD)
(60' R.O.W.)



15' E-SEMENT FOR DR-IN-GE DITCH (VOL. 29, PG. 16 H.C.M.R.)
H.C.F.C.D. UNIT C118-00-00 VOL. 2284, PG. 428 H.C.D.R.
VOL. 29, PG. 16 H.C.M.R.

SOUTHWIND
VOL. 2294, PG.

SOUTHWIND (CALLED 60' R.O.W.)

RESTRICTED RESERVE "A"
RESTRICTED TO SCHOOL SITE

JESSE H. JONES
SENIOR HIGH SCHOOL SITE
VOL. 347, PG. 141 H.C.M.R.

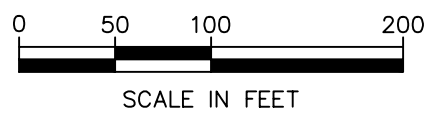
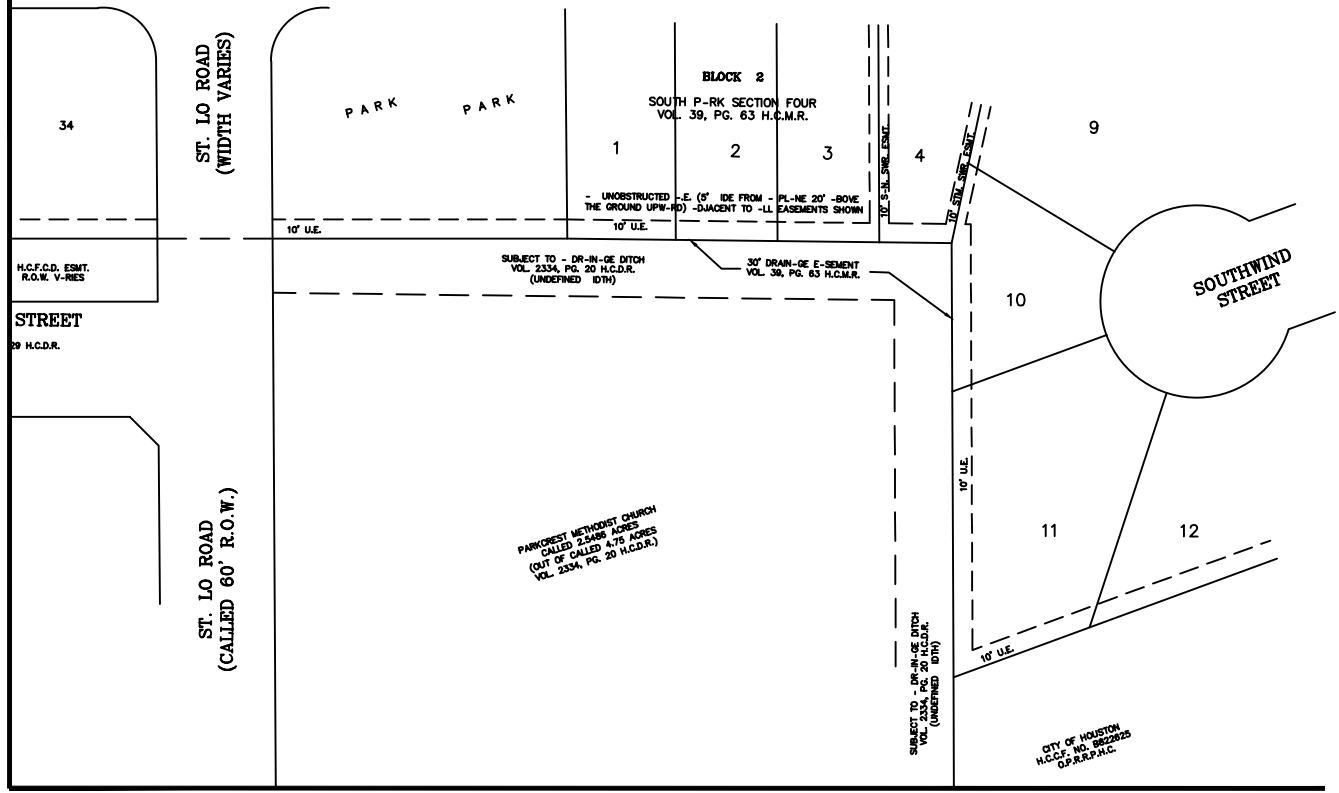
MATCH LINE "B"

MATCH LINE "C"



MATCH LINE "C"

MATCH LINE "D"

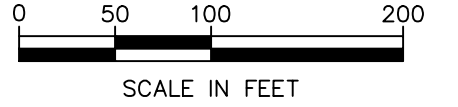
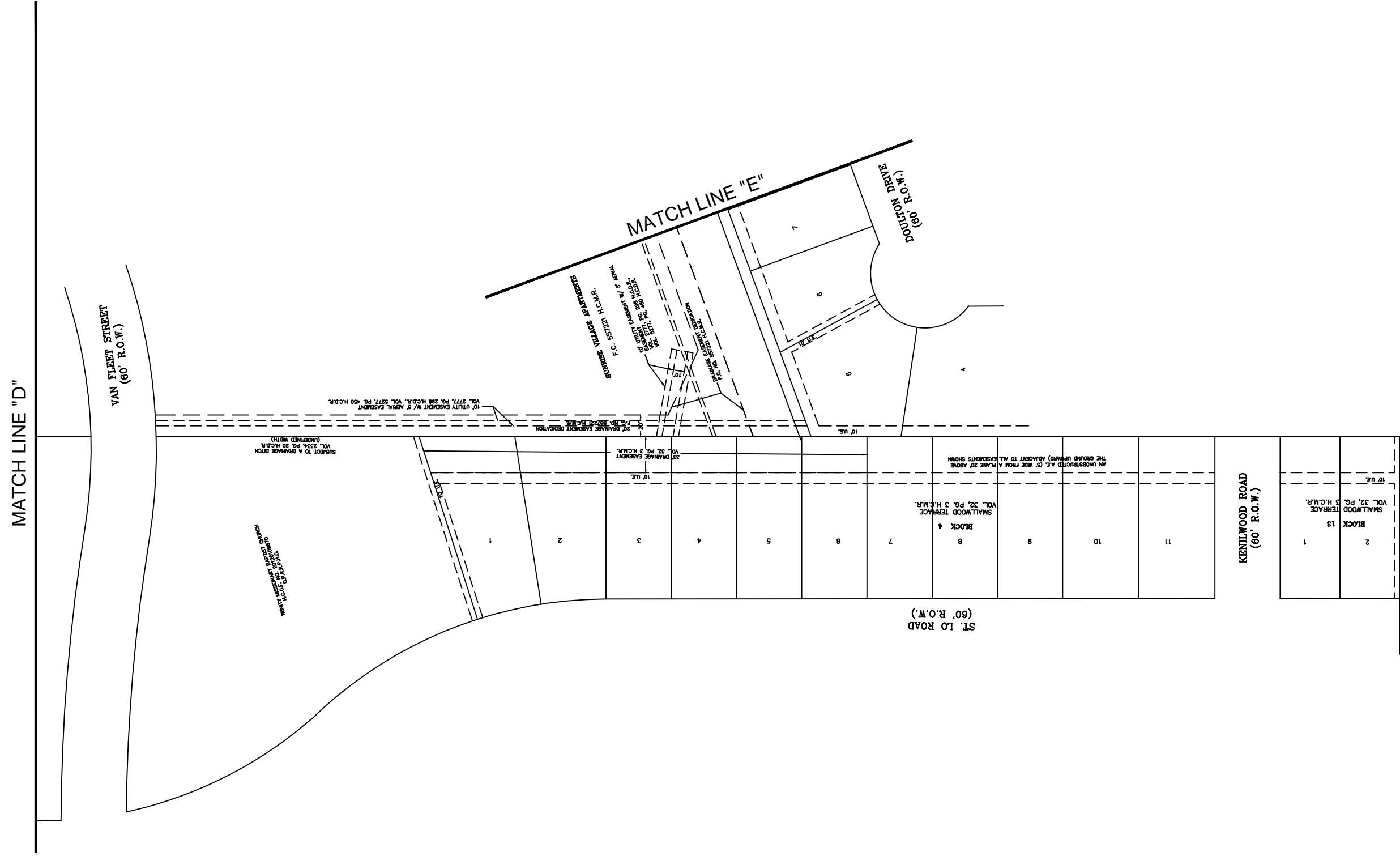
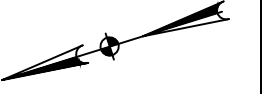


CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429. Date: 11/10/15

CivilTech Engineering, Inc.
11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH: (281) 304-0200
FX: (281) 304-0210
FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC D UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
Date: NOV. 2015
Exhibit No: A3

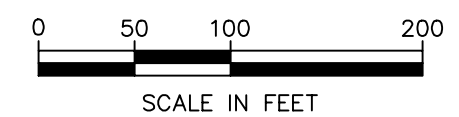
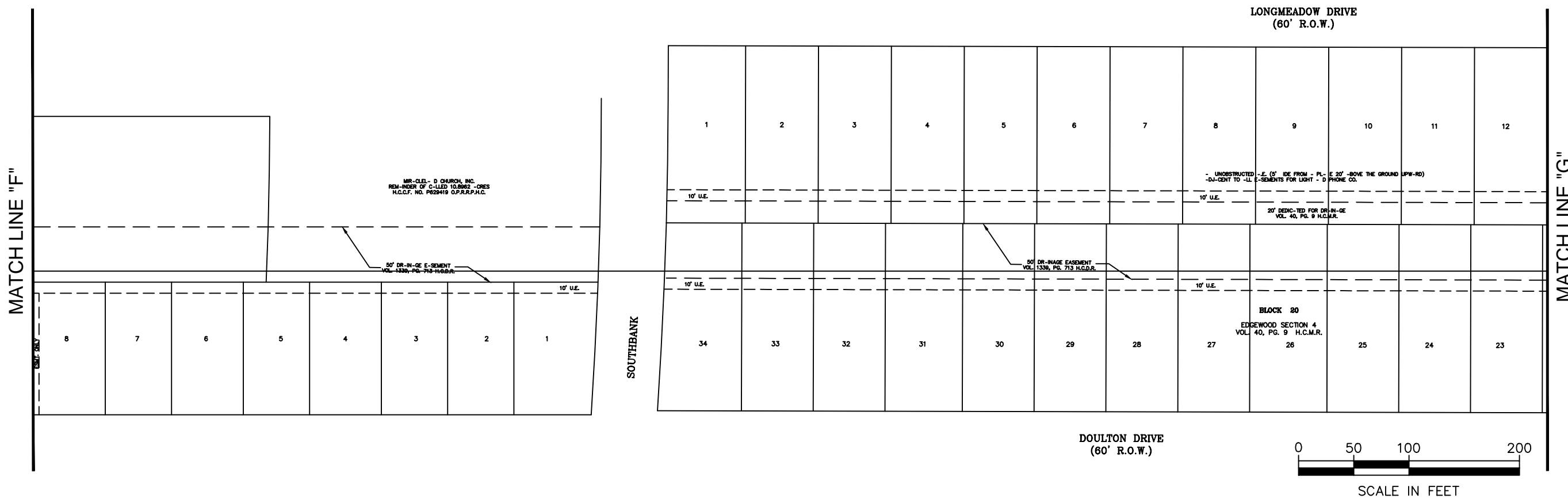
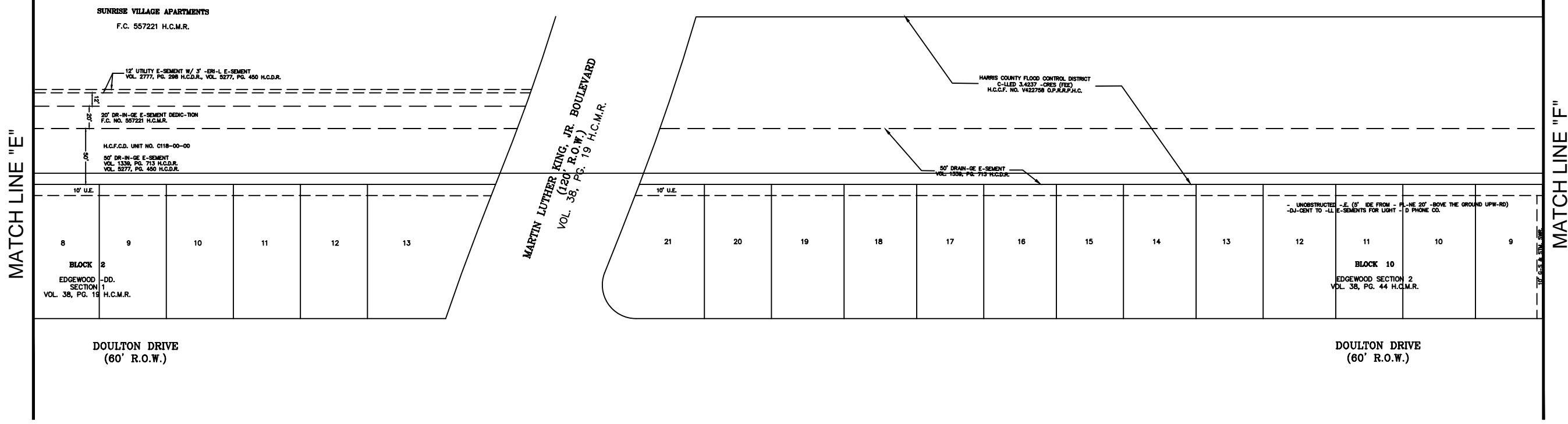


CivilTech Engineering, Inc. - Survey - 2015 - 11/15/2015

CivilTech Engineering, Inc.
 11821 TELGE ROAD
 CYPRESS, TEXAS 77429
 PH: (281) 304-0200
 FX: (281) 304-0210
 FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFCU UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
 Date: NOV. 2015
 Exhibit No: A4



CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429. Date: Nov 10, 2015

CivilTech Engineering, Inc.
11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH:(281)304-0200
FX:(281)304-0210
FIRM REGISTRATION NO. F-382

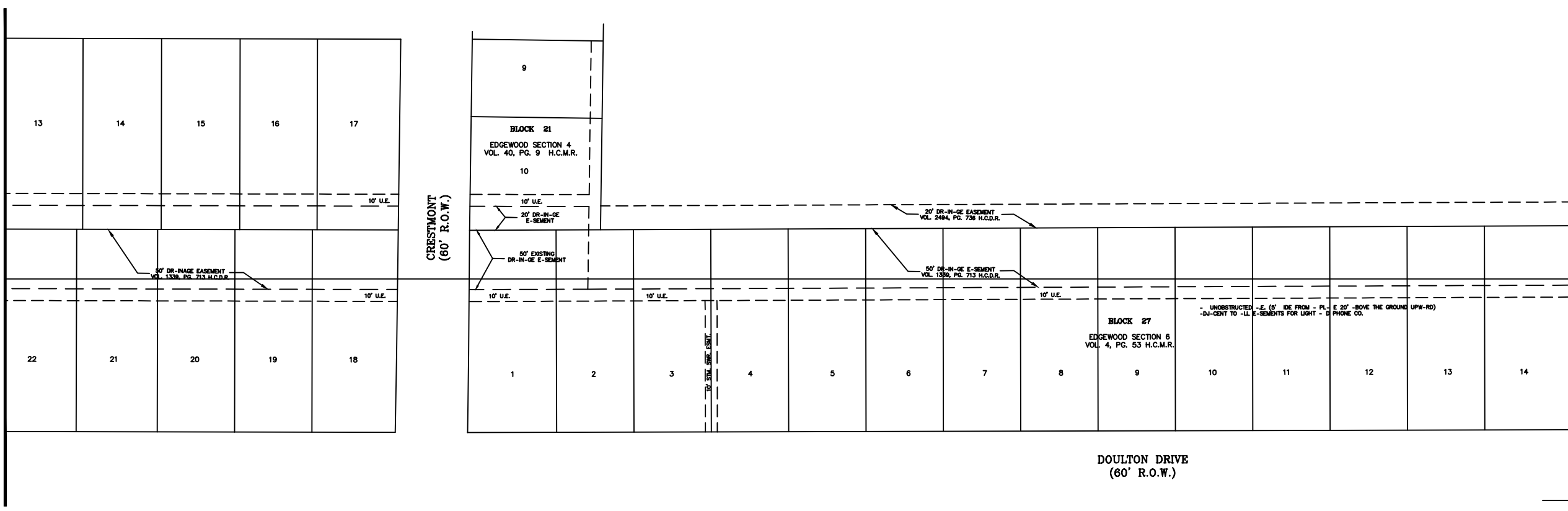
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC D UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
Date: NOV. 2015
Exhibit No: A5



MATCH LINE "G"

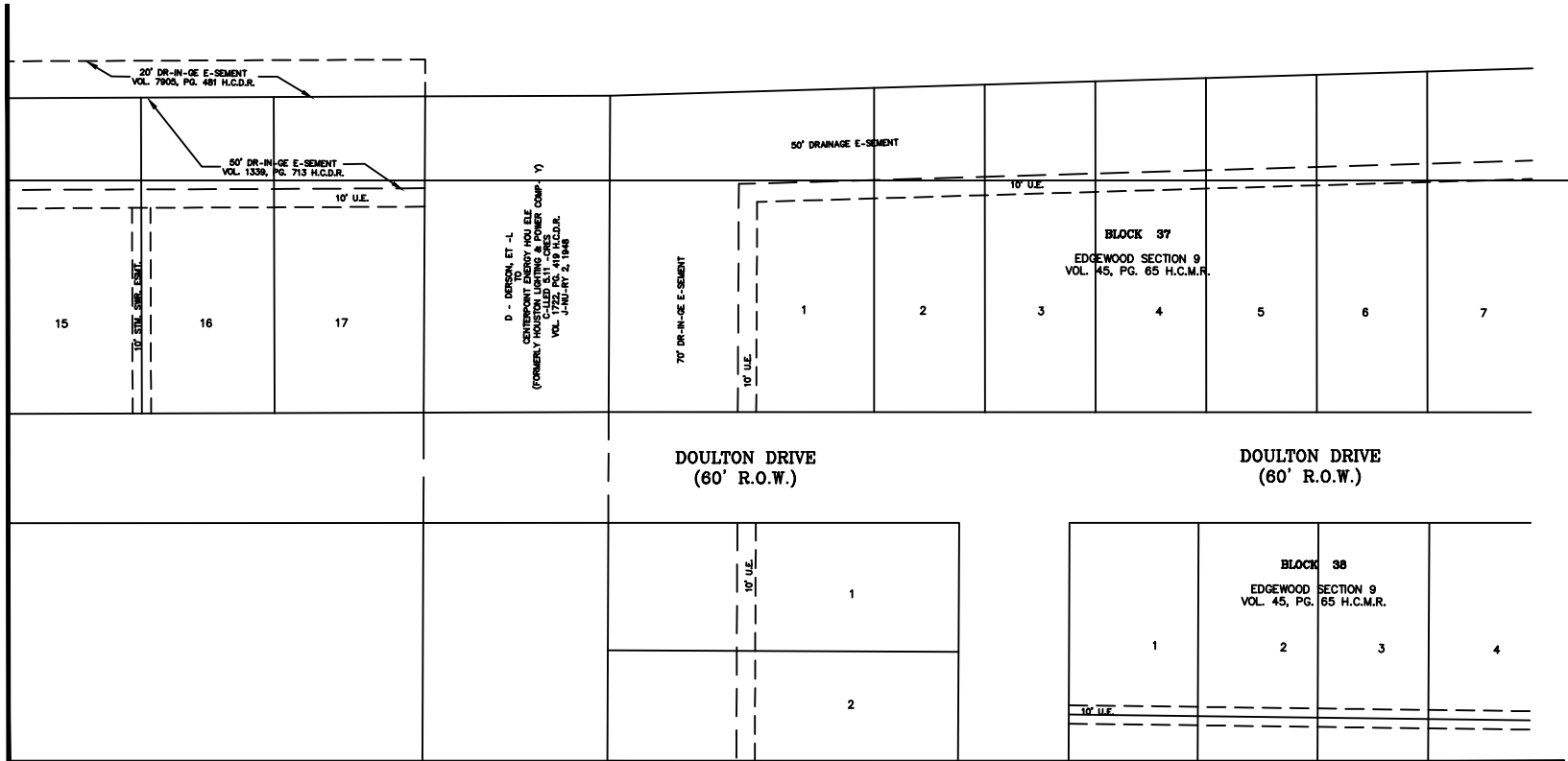
MATCH LINE "H"



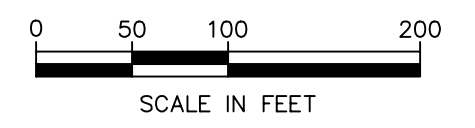
MATCH LINE "H"

DOULTON DRIVE (60' R.O.W.)

DOULTON DRIVE (60' R.O.W.)



MATCH LINE "I"

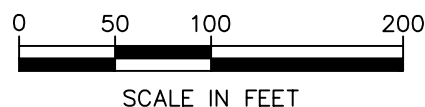
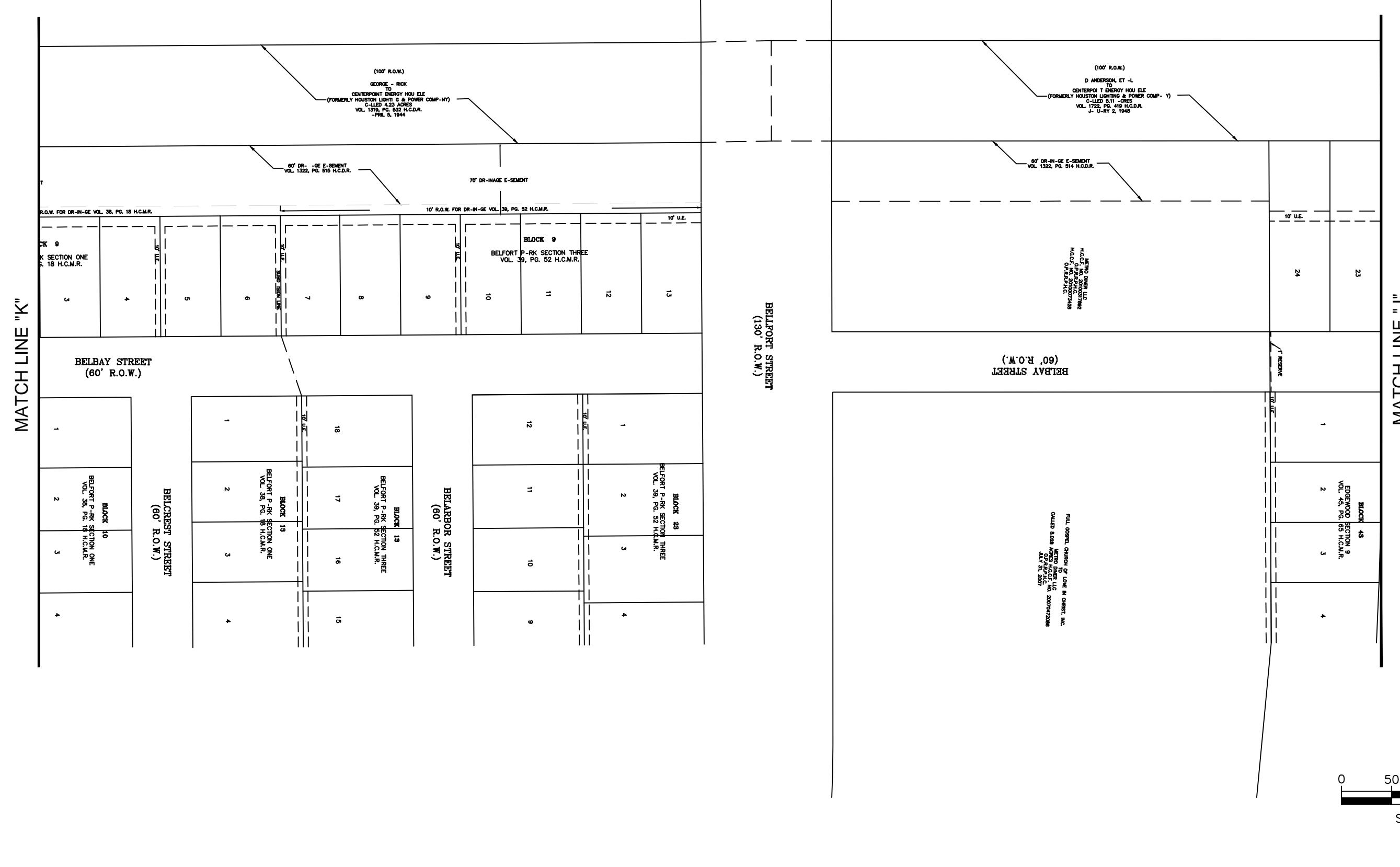
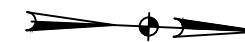


CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429

CivilTech Engineering, Inc.
 11821 TELGE ROAD
 CYPRESS, TEXAS 77429
 PH: (281) 304-0200
 FX: (281) 304-0210
 FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFC UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
 Date: NOV. 2015
 Exhibit No: A6



CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429
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 FIRM REGISTRATION NO. F-382

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Engineering, Inc.

11821 TELGE ROAD
 CYPRESS, TEXAS 77429
 PH:(281)304-0200
 FX:(281)304-0210
 FIRM REGISTRATION NO. F-382

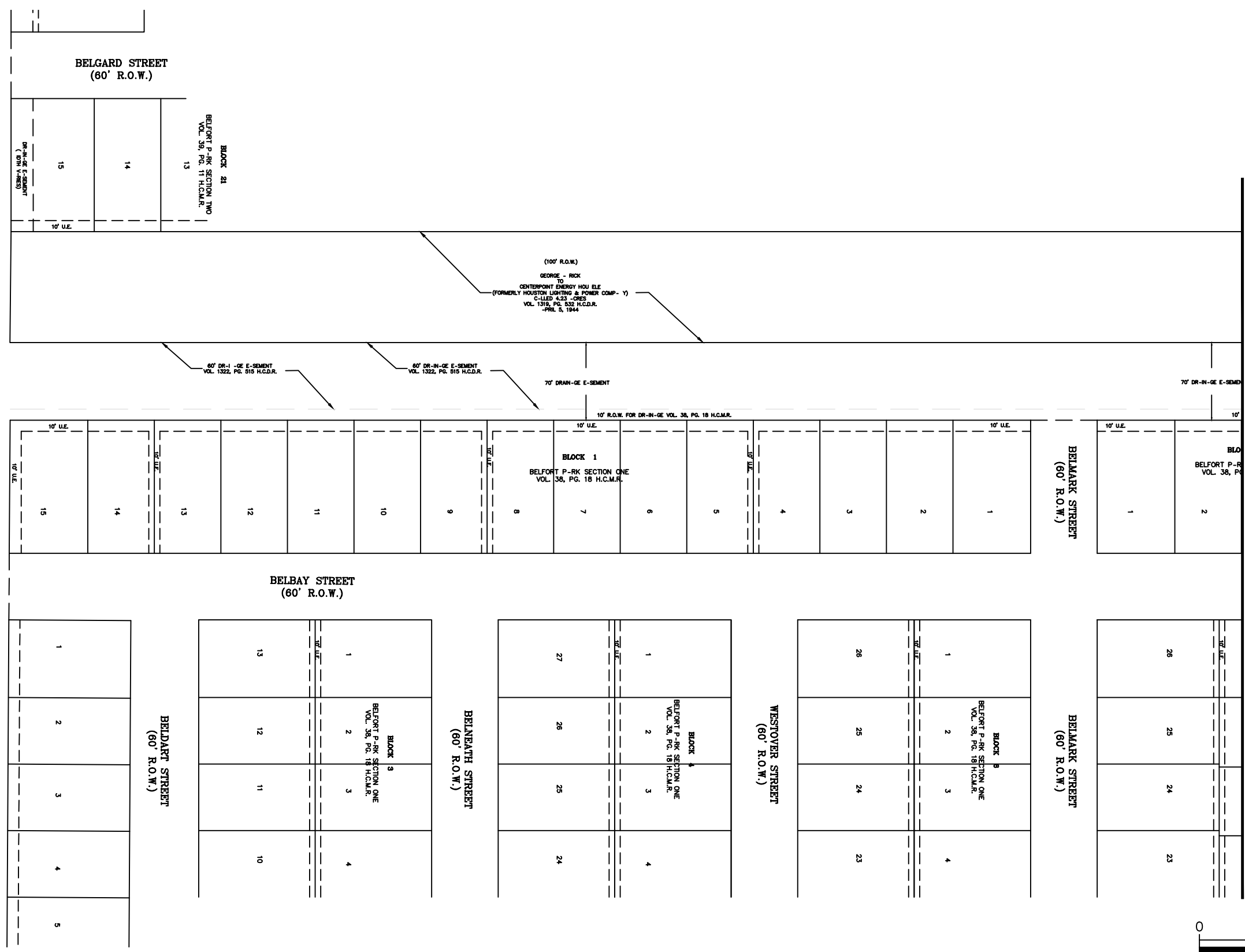
FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFC UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
 Date: NOV. 2015
 Exhibit No: A8



MATCH LINE "L"

MATCH LINE "K"



CivilTech Engineering, Inc. 11821 TELGE ROAD CYPRESS, TEXAS 77429 PH:(281)304-0200 FX:(281)304-0210 FIRM REGISTRATION NO. F-382

CivilTech Engineering, Inc.
11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH:(281)304-0200
FX:(281)304-0210
FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
Date: NOV. 2015
Exhibit No: A9



LONG REALTY COMPANY
TEXAS LAND AND CATTLE COMPANY
H.C.D.P.
MAY 31, 1979

(100' R.O.W.)
J. - - PL - TT, ET - L
TO
CENTERPOINT ENERGY HOU ELE
(FORMERLY HOUSTON LIGHTING & POWER COMP - Y)
G-11ED, 13,305 - DRS
VOL. 1308, PG. 683 H.C.D.R.
M-RCH 24, 1944

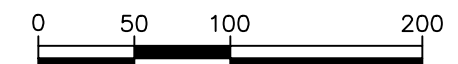
60" DR-IN-GE E-SEMENT
VOL. 1326, PG. 87 H.C.D.R.

CITY OF HOUSTON
CALLED BY JAMES
MAY 2, 1910

CITY OF HOUSTON
CALLED BY JAMES
MAY 2, 1910

MATCH LINE "M"

MATCH LINE "L"



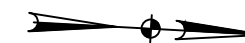
SCALE IN FEET

CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429. Phone: (281) 304-0200. Fax: (281) 304-0210. Firm Registration No. F-382. Date: Nov 2, 2015.

CivilTech
Engineering, Inc.
11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH:(281)304-0200
FX:(281)304-0210
FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS
Date: NOV. 2015
Exhibit No: A10



MATCH LINE "N"

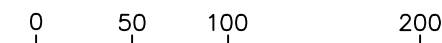
MATCH LINE "M"

LONG REALTY COMPANY
TEXAS LAND AND CATTLE COMPANY
H.C.C.F. NO. 22218 & 22219
JULY 24, 1979

(100' R.O.W.)
CENTERPOINT ENERGY HOU ELE
100' R.O.W.
J. - , PL - TT, ET - L
TO
CENTERPOINT ENERGY HOU ELE
(FORMERLY HOUSTON LIGHTING & POWER COMP - Y)
C-LED 13-200-0183
VOL. 1306, PG. 663 H.C.D.R.
M-REC 24, 1944

60' DR.-IN.-CE E-SEMENT
VOL. 1329, PG. 87 H.C.D.R.

CITY OF HOUSTON
VOL. 2911, PG. 282 H.C.D.R.
JUNE 2, 1951



SCALE IN FEET

CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429
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FIRM REGISTRATION NO. F-382

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Engineering, Inc.

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FIRM REGISTRATION NO. F-382

FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCU UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

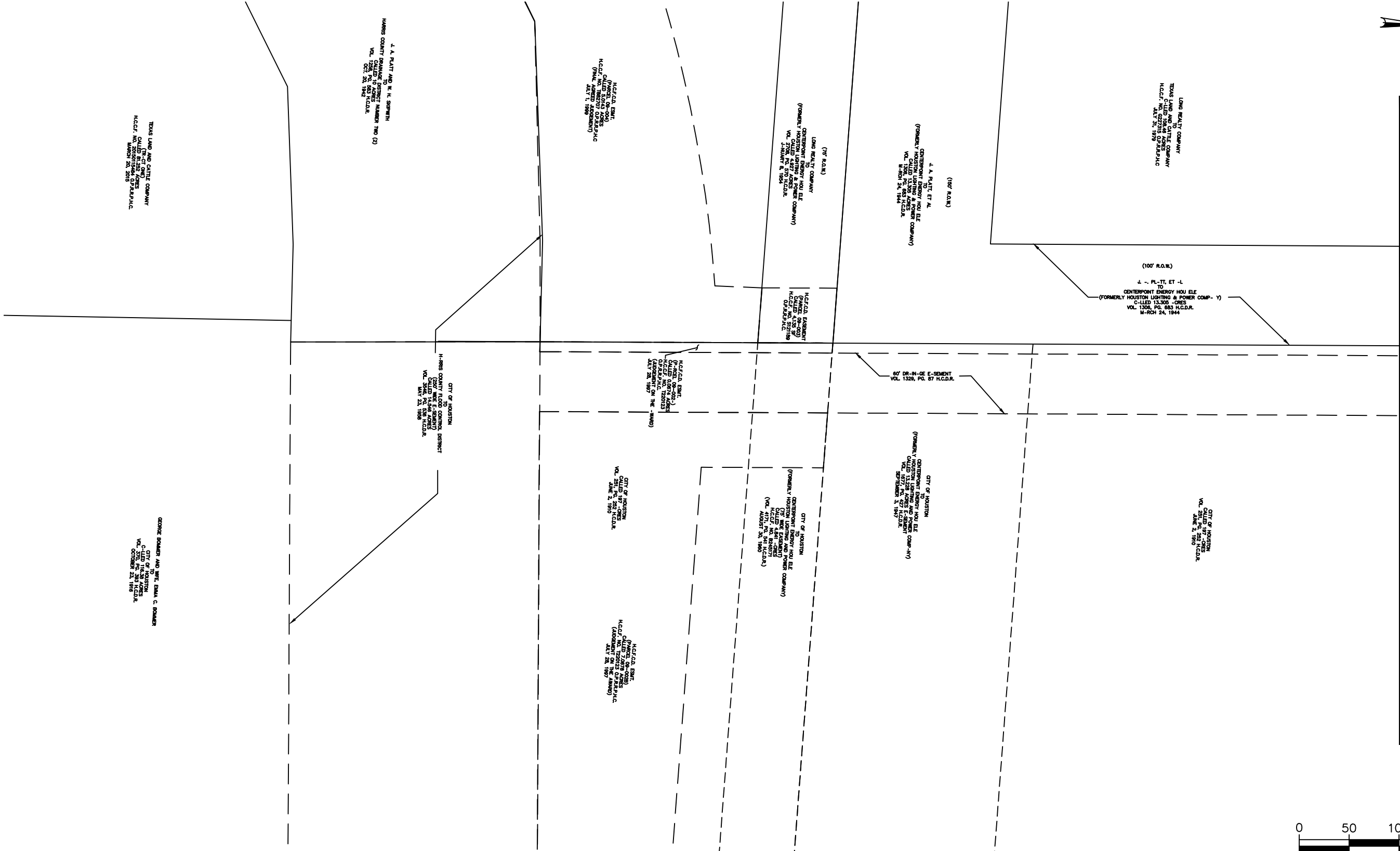
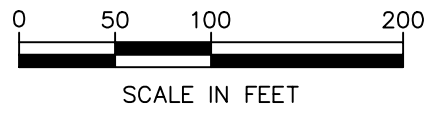
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A11



MATCH LINE "N"



EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A12

FEASIBILITY STUDY FOR SALT WATER DITCH
HCPCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

CivilTech Engineering, Inc.
11821 TELGE ROAD
CYPRESS, TEXAS 77429
PH: (281) 304-0200
FX: (281) 304-0210
FIRM REGISTRATION NO. F-382

CivilTech Engineering, Inc. 11821 Telge Road, Cypress, Texas 77429
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APPENDIX B
EXISTING CONDITIONS

APPENDIX B.1 – CALCULATIONS

APPENDIX B.2 – HEC-HMS OUTPUTS

APPENDIX B.3 – HEC-RAS OUTPUTS

APPENDIX B.4 – PEAK FLOW IMPACTS

APPENDIX B.1

CALCULATIONS

- **LAND USE (DLU) CALCULATION**
- **PERCENT IMPERVIOUS CALCULATION**
- **CHANNEL SLOPE CALCULATION**
- **CHANNEL CONVEYENCE (DCC) CALCULATION**
- **TIME OF CONCENTRATION AND STORAGE COEFFICIENT (TC & R) CALCULATION**
- **UPSTREAM FLOW CALCULATIONS**
- **FLOW DISTRIBUTION**

Salt Water Ditch
Existing Land Use and Percent Land Urbanization (DLU) Calculations

Table ID: B1
 Project #: 325912
 Date: 7/8/2015
 Prepared By: DJ
 Checked By: CM

HCFC D LAND USE TYPES

Drainage Node ID	Drainage Area	Undeveloped	Developed Green Areas	High Density	Industrial Light	Residential Rural	Residential Large Lot	Residential Large Lot Older	Residential Small Lot	School	Isolated Transportation	Water	DLU
(---)	(ac)	0%	50%	100%	100%	0%	100%	50%	100%	50%	100%	100%	
C118	2476.39	170.12	216.56	223.53	39.61	0.00	0.00	0.00	1638.23	48.52	123.91	15.92	87.78
C118A	1236.68	8.93	26.11	90.71	12.16	0.00	0.00	0.00	997.50	33.46	62.54	5.29	96.87
C118B	1239.71	161.19	190.46	132.82	27.46	0.00	0.00	0.00	640.72	15.06	61.37	10.63	78.71

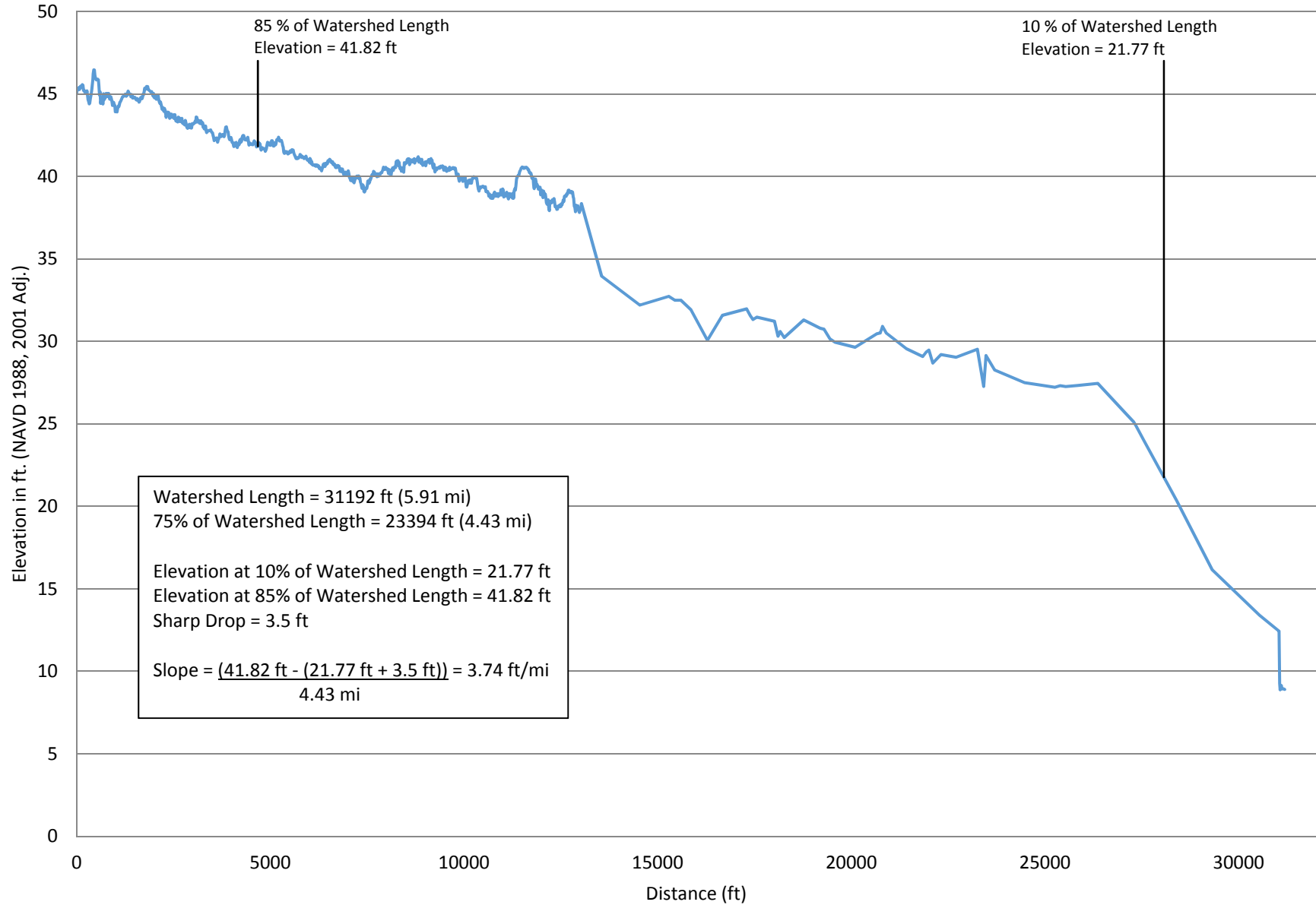
Salt Water Ditch
Existing Land Use and Impervious Percentage Calculations

Table ID: B2
 Project #: 325912
 Date: 7/8/2015
 Prepared By: DJ
 Checked By: CM

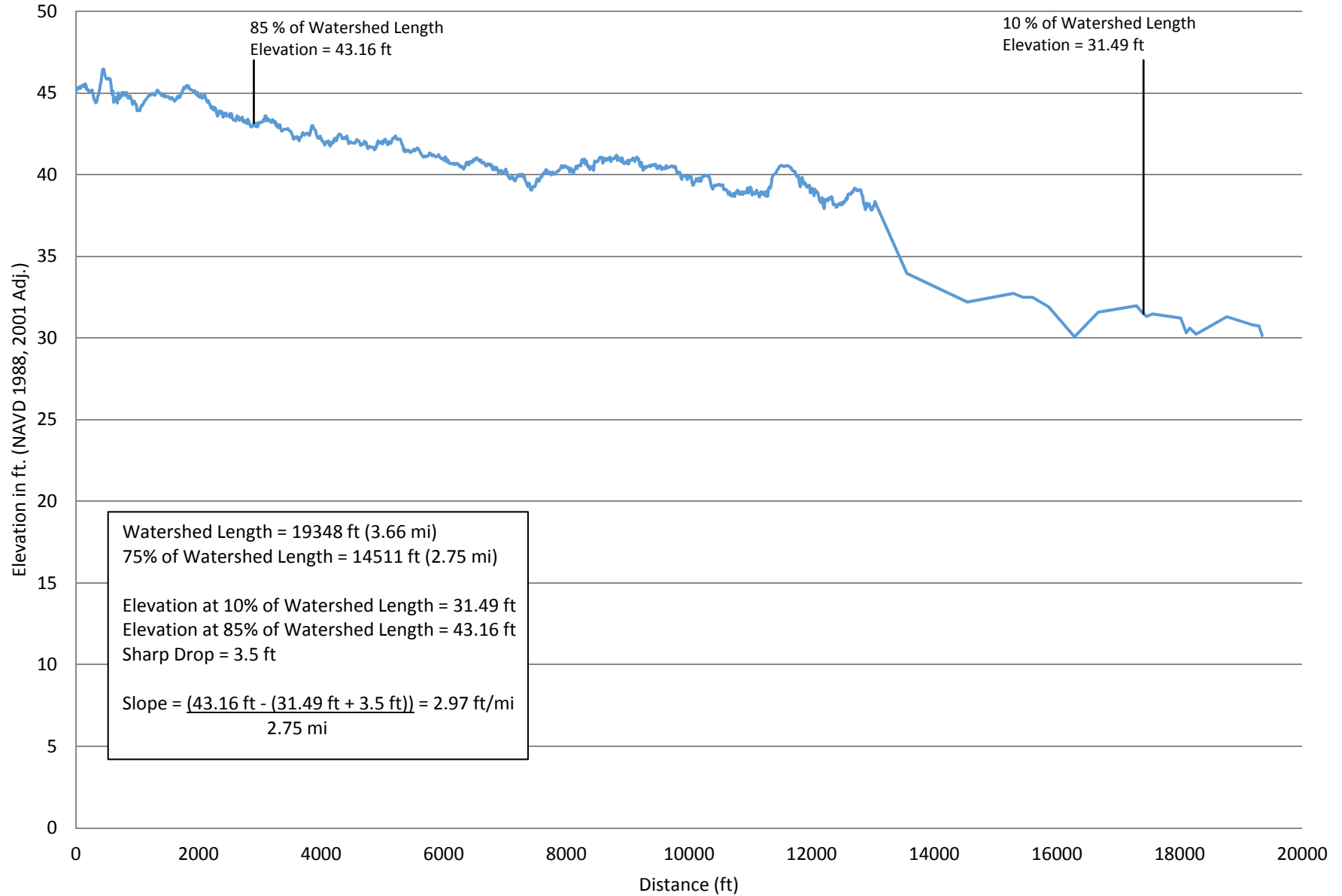
HCFC D LAND USE TYPES

Drainage Node ID	Drainage Area (ac)	Open Areas	Developed Green Areas	High Density	Industrial Light	Residential Rural	Residential Large Lot	Residential Large Lot Older	Residential Small Lot	School	Isolated Transportation	Water	Impervious Percentage
(---)	(ac)	0%	15%	85%	60%	5%	20%	20%	40%	40%	90%	100%	
C118	2476.39	170.12	216.56	223.53	39.61	0.00	0.00	0.00	1638.23	48.52	123.91	15.92	42.34
C118A	1236.68	8.93	26.11	90.71	12.16	0.00	0.00	0.00	997.50	33.46	62.54	5.29	45.47
C118B	1239.71	161.19	190.46	132.82	27.46	0.00	0.00	0.00	640.72	15.06	61.37	10.63	39.21

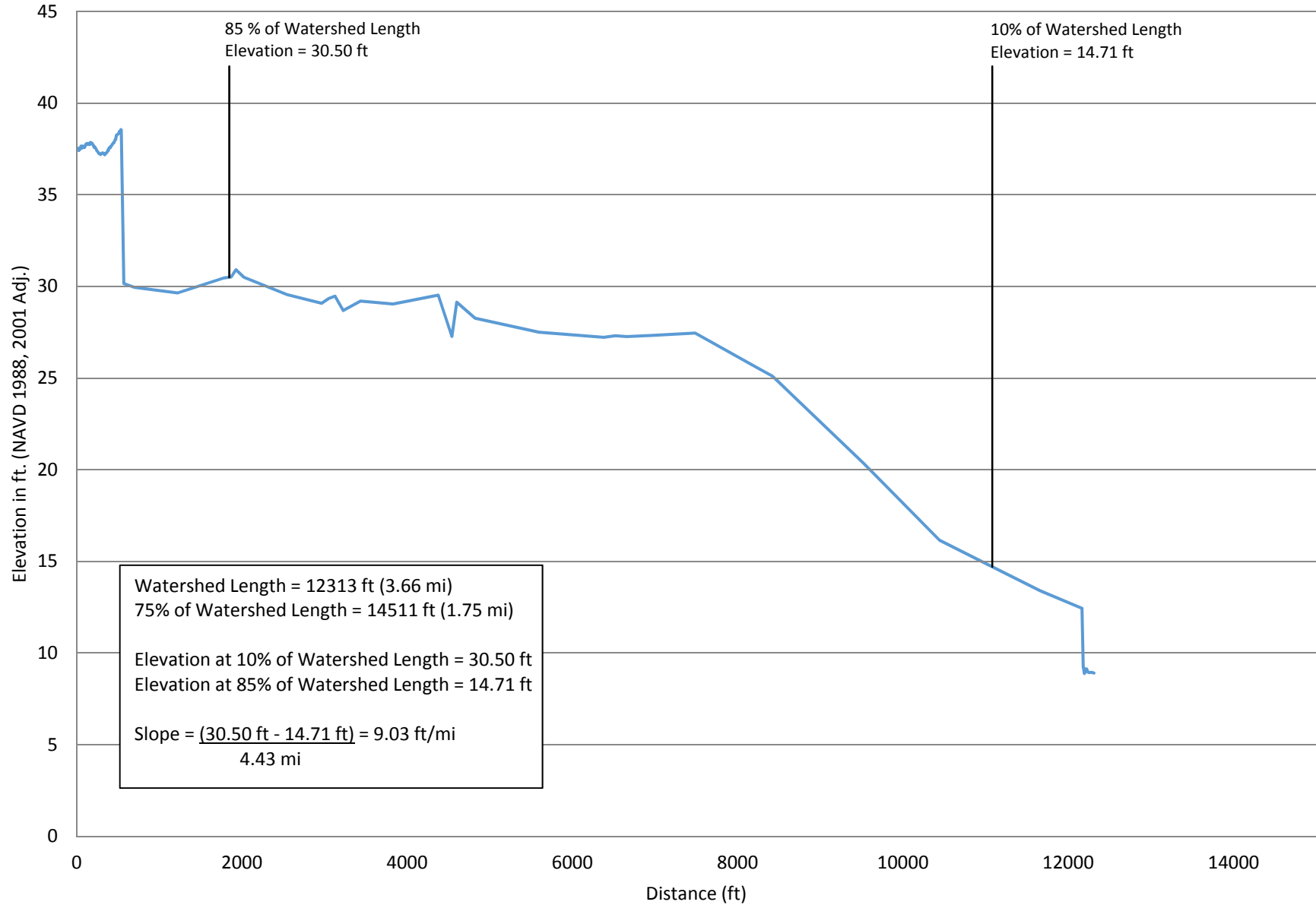
Channel Slope - Subbasin C118



Channel Slope - Subbasin C118A



Channel Slope - Subbasin C118B



SALT WATER DITCH DCC CALCULATION

Table ID: B3
 Project: Salt Water Ditch
 Project #: 325912
 Date: 8/26/2015
 Prepared By: PH
 Checked By: CM

HEC-RAS Station	Drainage Area [ac]	Flow [cfs]
2997	2476	3600
5550	2216	3000
8721	1755	2500
12658	1472	2050
14754	1185	1650
17875	1048	1275

Reach	River Sta	Profile	Q Total (cfs)	Q Perc Chan	Length Chnl (ft)	Corrected Effective	Revised Existing
							Weighted Average DCC
C118-00-00_0009	863.9	DCC_100YR	3600	100			
C118-00-00_0009	1510	DCC_100YR	3600	100	646.1		
C118-00-00_0009	2080.7	DCC_100YR	3600	100	570.7		
C118-00-00_0009	2997.8	DCC_100YR	3600	100	917.1		
C118-00-00_0009	3846.7	DCC_100YR	3000	98.9	848.9		
C118-00-00_0009	4058	DCC_100YR	3000	96.47	211.3		
C118-00-00_0009	4083.6	Bridge					
C118-00-00_0009	4109.2	DCC_100YR	3000	60.77	10		
C118-00-00_0009	4343	DCC_100YR	3000	82.28	233.8		
C118-00-00_0009	5037.2	DCC_100YR	3000	52.19	694.2		
C118-00-00_0009	5550.6	DCC_100YR	3000	54.65	513.4		
C118-00-00_0009	5866.6	DCC_100YR	2500	55.7	316		
C118-00-00_0009	5935.4	Bridge					
C118-00-00_0009	6004.2	DCC_100YR	2500	54.68	10		
C118-00-00_0009	6143.9	DCC_100YR	2500	30.94	139.7		
C118-00-00_0009	6955.11	DCC_100YR	2500	58.91	811.66		
C118-00-00_0009	7727.61	DCC_100YR	2500	47.39	772.48		
C118-00-00_0009	7949.11	DCC_100YR	2500	41.95	221.45		
C118-00-00_0009	7980.41	Bridge					
C118-00-00_0009	8009.11	DCC_100YR	2500	49.26	8.7		
C118-00-00_0009	8173.81	DCC_100YR	2500	49.56	164.74		
C118-00-00_0009	8721.01	DCC_100YR	2500	20.89	547.21		
C118-00-00_0009	9112.71	DCC_100YR	2050	34.51	391.68		
C118-00-00_0009	9323.21	DCC_100YR	2050	41	210.52		
C118-00-00_0009	9423.51	DCC_100YR	2050	18.93	100.22		
C118-00-00_0009	9455.409	Bridge					
C118-00-00_0009	9496.81	DCC_100YR	2050	24.26	14.5		
C118-00-00_0009	9583.51	DCC_100YR	2050	19.42	86.73		
C118-00-00_0009	10002.21	DCC_100YR	2050	19.2	418.67		
C118-00-00_0009	10525.51	DCC_100YR	2050	17.99	523.28		
C118-00-00_0009	10622.21	DCC_100YR	2050	12.97	96.77		
C118-00-00_0009	10645.51	Bridge					
C118-00-00_0009	10680.11	DCC_100YR	2050	15.05	16.4		
C118-00-00_0009	10769.31	DCC_100YR	2050	16.35	89.2		
C118-00-00_0009	11328.01	DCC_100YR	2050	22.02	558.65		
C118-00-00_0009	11851.01	DCC_100YR	2050	21.41	523.04		
C118-00-00_0009	11979.31	DCC_100YR	2050	16.58	128.24		
C118-00-00_0009	12063.01	Culvert					
C118-00-00_0009	12133.21	DCC_100YR	2050	15.96	153.92		
C118-00-00_0009	12234.81	DCC_100YR	2050	20.24	101.65		
C118-00-00_0009	12657.51	DCC_100YR	2050	66.25	422.64		
C118-00-00_0009	13158.81	DCC_100YR	1650	53.35	501.35		
C118-00-00_0009	13262.41	DCC_100YR	1650	41.55	103.56		
C118-00-00_0009	13288.31	Bridge					
C118-00-00_0009	13319.21	DCC_100YR	1650	35.64	8.4		
C118-00-00_0009	13410.01	DCC_100YR	1650	28.62	90.82		
C118-00-00_0009	13867.71	DCC_100YR	1650	27.08	457.71		
C118-00-00_0009	13967.91	DCC_100YR	1650	30.6	100.13		
C118-00-00_0009	14001.71	Bridge					
C118-00-00_0009	14033.31	DCC_100YR	1650	28.53	6.6		
C118-00-00_0009	14129.01	DCC_100YR	1650	34.43	95.72		
C118-00-00_0009	14754.41	DCC_100YR	1650	43.14	625.34		
C118-00-00_0009	15140.91	DCC_100YR	1275	38.15	386.53		
C118-00-00_0009	15565.51	DCC_100YR	1275	31.06	424.59		
C118-00-00_0009	15827.61	DCC_100YR	1275	23.88	262.14		
C118-00-00_0009	15905.71	Bridge					
C118-00-00_0009	15982.91	DCC_100YR	1275	31.91	59		
C118-00-00_0009	16140.01	DCC_100YR	1275	32.91	157.13		
C118-00-00_0009	16889.11	DCC_100YR	1275	34.39	749.06		
C118-00-00_0009	17874.51	DCC_100YR	1275	38.79	985.37		

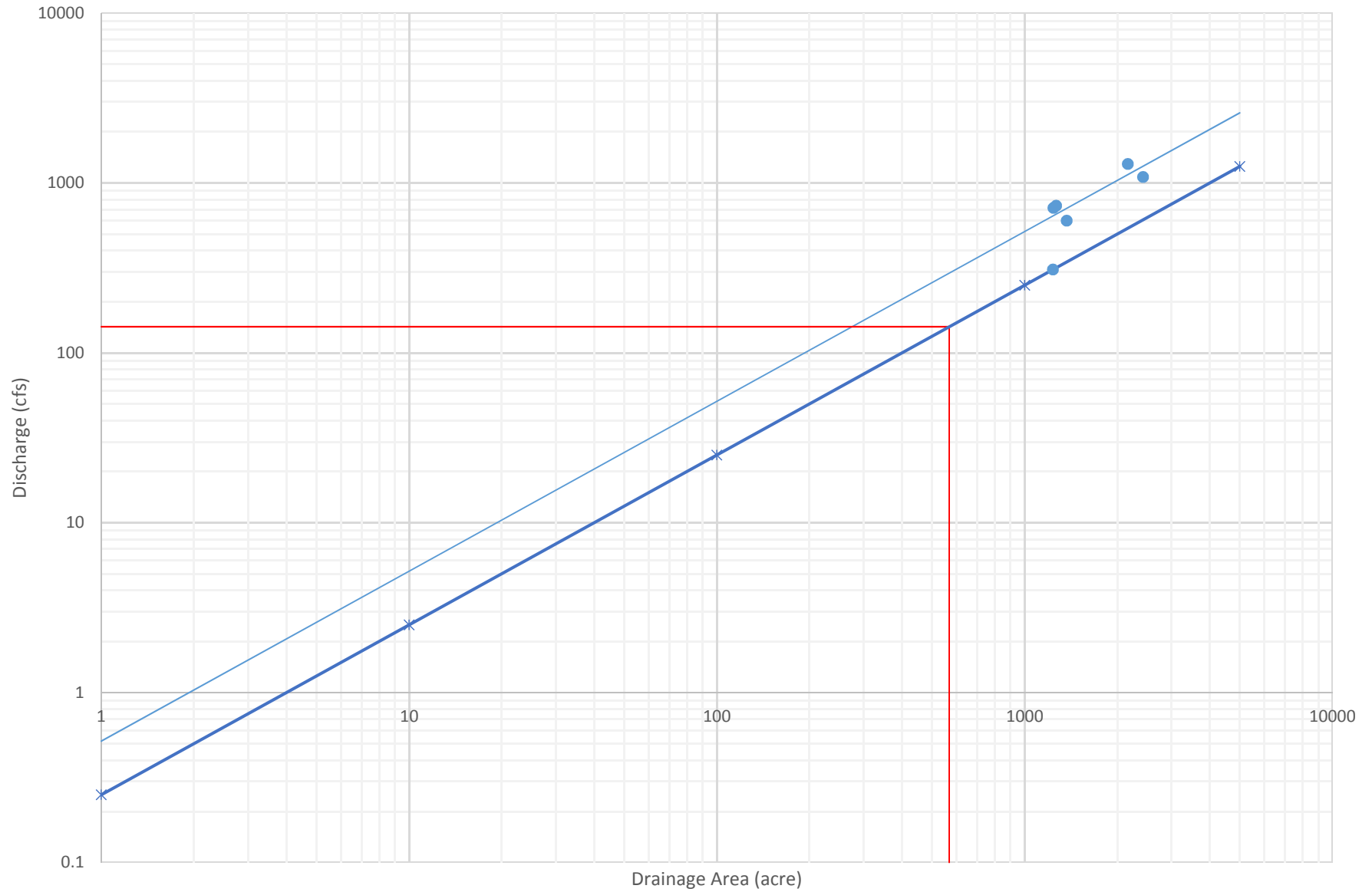


FEMA Effective Model as of June 18, 2007 with modifications for Salt Water Ditch (C118)
TC&R values for FEMA Effective Model, Corrected Effective Model, and Revised Existing Model
Sims Bayou Watershed
HCFCF TC&R Excel Template

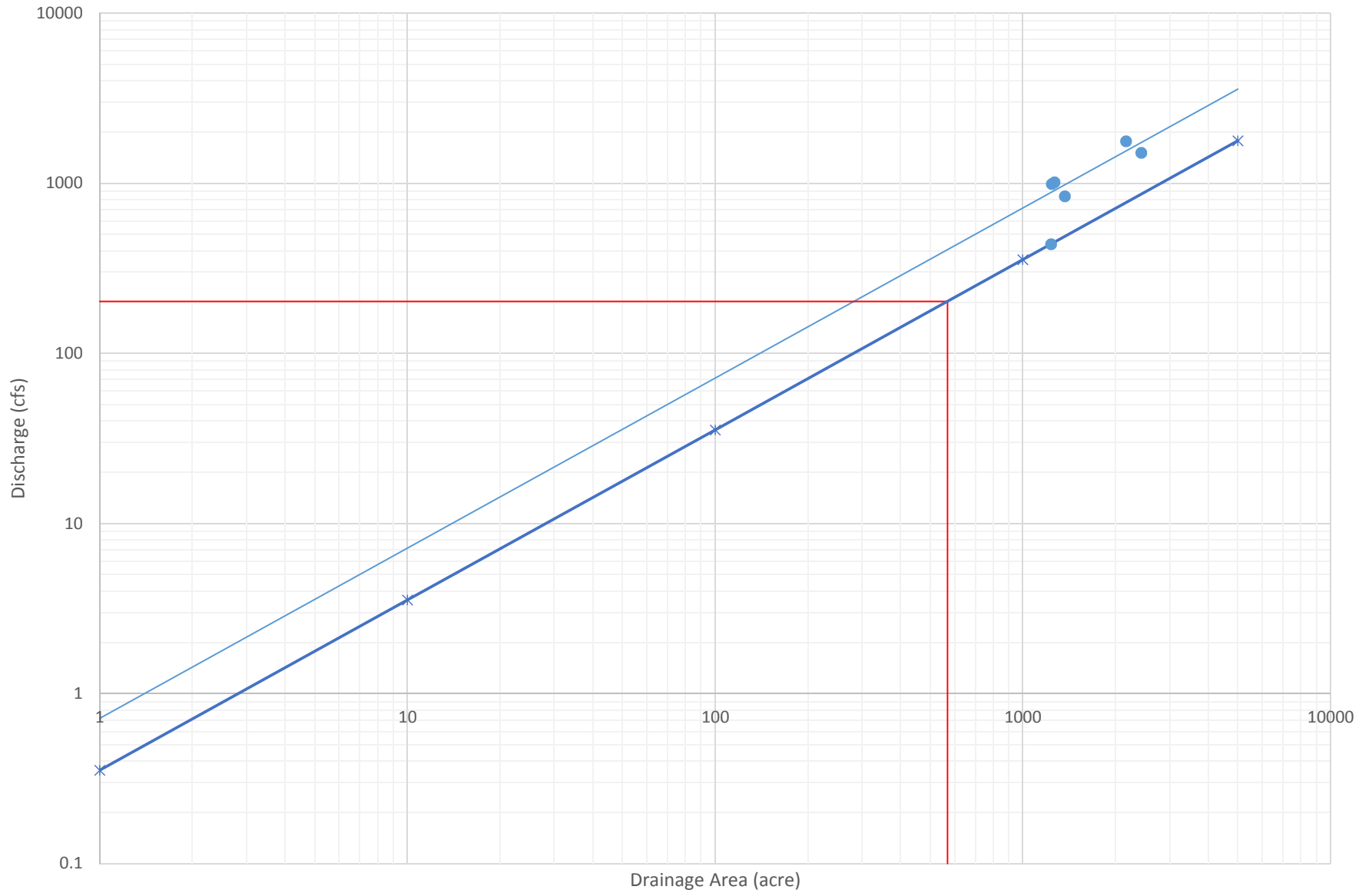
Subwatershed	Drainage Area (acres)	Drainage Area (sq.mi.)	Watershed Length (mi.)	Length to Centroid(mi.)	Channel Slope(ft./mi.)	Overland Slope(ft./mi.)	D	Percent Urban Development 2002	Percent Channel Improvement	Percent Channel Conveyance	Percent Ponding	DLU affected by Detention	Percent Impervious 2002	(TC+R)"	TC"	R"	DLU Minimum	DLU (Detention)
	L	Lca	S	So	DLU	DCI		DCC	DPP	DET								
C100A	1449.5	2.26	3.00	1.25	7.39	7.39	2.46	37.50	100	60	0	0.00	24.34	7.53	0.54	6.99	36.04	37.50
C100B	1179.8	1.84	2.03	0.47	7.21	6.34	2.46	47.03	100	90	0	8.78	36.37	3.84	0.19	3.65	20.39	38.25
C100C	1815.4	2.84	2.81	0.81	7.94	9.50	2.46	30.75	58	90	0	21.33	26.17	7.15	0.47	6.69	20.39	20.39
C100D	1549.3	2.42	3.06	1.14	2.79	3.70	2.46	52.65	100	100	0	7.10	36.90	5.76	0.79	4.97	17.59	45.55
C100E	1433.4	2.24	4.05	2.16	1.51	6.86	2.46	66.84	100	100	0	0.53	46.96	6.75	1.98	4.77	17.59	66.31
C100F	1648.1	2.58	3.02	1.35	4.29	8.45	2.46	38.47	0	100	0	3.84	29.90	5.90	1.46	4.44	17.59	34.63
C100G	1430.0	2.23	2.48	0.61	5.50	12.67	2.46	11.79	18	100	0	1.62	10.25	7.54	0.53	7.01	17.59	11.79
C100H	1268.5	1.98	2.51	1.09	4.75	1.06	2.46	60.79	100	100	0	0.29	41.19	3.42	0.54	2.89	17.59	60.50
C100I	2428.2	3.79	3.45	1.04	3.35	9.50	2.46	65.21	100	100	0	0.43	40.43	4.63	0.60	4.02	17.59	64.78
C100J	4014.6	6.27	4.56	1.88	1.63	9.50	2.46	67.36	100	40	0	0.29	44.77	17.21	1.64	15.58	63.71	67.07
C100K	1126.4	1.76	2.25	1.18	2.64	2.64	2.46	45.62	100	100	0	0.73	38.93	4.77	0.85	3.93	17.59	44.89
C100L	2165.3	3.38	3.46	1.52	4.00	9.50	2.46	82.11	100	100	0	0.10	53.81	3.71	0.76	2.95	17.59	82.01
C100M	1123.3	1.76	3.32	1.39	0.85	8.45	2.46	70.11	100	100	0	0.46	59.93	6.95	1.66	5.30	17.59	69.65
C102A	1857.1	2.90	3.80	1.56	3.17	3.17	2.46	89.05	100	30	0	0.00	63.06	12.38	0.86	11.53	95.43	89.05
C102B	698.3	1.09	1.93	1.08	8.76	14.26	2.46	86.51	100	100	0	0.00	68.48	1.80	0.34	1.45	17.59	86.51
C103	1032.6	1.61	3.01	1.35	11.99	10.03	2.46	92.80	100	100	0	0.00	61.70	2.10	0.36	1.74	17.59	92.80
C106A	1162.9	1.82	2.77	1.34	6.97	3.17	2.46	69.71	100	70	0	0.45	52.05	4.13	0.52	3.60	29.03	69.26
C106B	1931.4	3.02	3.91	1.82	7.83	4.75	2.46	70.76	78	60	0	0.91	48.52	5.83	0.83	5.00	36.04	69.85
C106C	1208.3	1.89	3.04	1.55	9.83	5.28	2.46	80.82	100	100	0	0.00	52.28	2.49	0.48	2.01	17.59	80.82
C106D	1833.5	2.86	4.40	1.92	8.02	7.39	2.46	72.60	100	70	0	1.25	52.49	5.34	0.71	4.63	29.03	71.35
C106E	1781.4	2.78	3.33	1.15	4.01	3.70	2.46	62.97	100	70	0	4.20	45.22	6.39	0.62	5.76	29.03	58.77
C106F	1290.3	2.02	3.68	1.57	3.74	7.92	2.46	73.38	100	70	0	1.51	53.24	6.12	0.85	5.27	29.03	71.87
C106G	1963.2	3.07	3.49	1.59	4.62	6.86	2.46	72.02	100	100	0	0.21	45.67	3.88	0.77	3.11	17.59	71.81
C118	2476.3	3.87	5.62	2.62	15.41	6.34	2.46	82.40	79	60	0	2.25	52.87	5.40	0.81	4.59	36.04	80.15
C118_Corrected	2476.3	3.87	5.91	2.61	3.74	8.20	2.46	87.78	79	50	0	2.56	42.34	10.56	1.69	8.87	46.56	85.22
C118A	1235.2	1.93	3.66	1.87	2.97	5.48	2.46	96.87	100	40	0	2.48	45.47	9.46	1.05	8.41	63.71	94.39
C118B	1241.6	1.94	2.34	1.71	9.03	10.92	2.46	78.71	68	60	0	2.64	39.21	3.64	0.76	2.88	36.04	76.07
C120	1427.8	2.23	3.41	1.55	8.21	12.67	2.46	29.37	100	100	0	0.31	22.53	5.76	0.66	5.10	17.59	29.06
C123	1563.6	2.44	3.72	1.77	7.88	10.56	2.46	32.43	0	100	0	0.90	24.61	5.88	1.42	4.46	17.59	31.53
C127	1368.6	2.14	2.85	1.19	8.68	12.14	2.46	49.91	100	80	0	1.48	30.19	4.37	0.45	3.92	24.06	48.43
C132	2601.9	4.07	5.09	1.30	5.28	5.28	2.46	28.52	83	70	0	6.84	22.35	12.71	0.79	11.92	29.03	28.52
C134	1298.5	2.03	3.11	1.56	1.30	11.09	2.46	18.93	37	100	0	0.81	15.40	14.23	2.76	11.47	17.59	18.12
C137	997.5	1.56	2.26	1.06	11.62	11.62	2.46	36.54	100	60	0	3.83	29.47	5.39	0.36	5.04	36.04	36.04
C143	1266.2	1.98	2.60	1.03	12.14	12.14	2.46	44.76	100	50	0	1.66	32.44	5.90	0.33	5.57	46.56	44.76
C144	650.1	1.02	2.34	1.05	10.56	10.56	2.46	49.34	100	50	0	1.19	28.57	5.61	0.35	5.25	46.56	48.15
C145A	1192.5	1.86	2.63	1.00	5.28	5.28	2.46	76.67	100	40	0	0.00	47.50	7.04	0.43	6.61	63.71	76.67
C145B	882.2	1.38	2.34	0.75	11.62	11.62	2.46	55.90	100	40	0	0.00	35.02	5.56	0.23	5.33	63.71	55.90
C147A	1166.4	1.82	2.91	1.35	6.34	6.34	2.46	75.67	100	40	0	0.00	39.71	7.15	0.54	6.61	63.71	75.67
C147B	1735.7	2.71	2.88	1.18	6.86	6.86	2.46	49.28	43	50	0	0.41	29.35	7.48	0.76	6.72	46.56	48.87
C147C	1684.1	2.63	3.41	1.82	8.26	3.70	2.46	55.59	60	80	0	0.41	34.33	4.62	0.97	3.65	24.06	55.18
C161	1527.2	2.39	3.58	1.92	6.34	6.34	2.46	26.02	52	80	0	3.11	20.46	9.21	1.35	7.86	24.06	24.06
C162	622.8	0.97	2.47	1.34	6.86	6.86	2.46	41.16	100	50	0	0.04	32.32	6.96	0.59	6.36	46.56	41.16

Note: C118 denotes the Salt Water Ditch drainage area for the FEMA Effective model, C118_Corrected denotes the Salt Water Ditch drainage area for the Corrected Effective model, and C118A and C118B are the two subareas used for the Revised Existing model

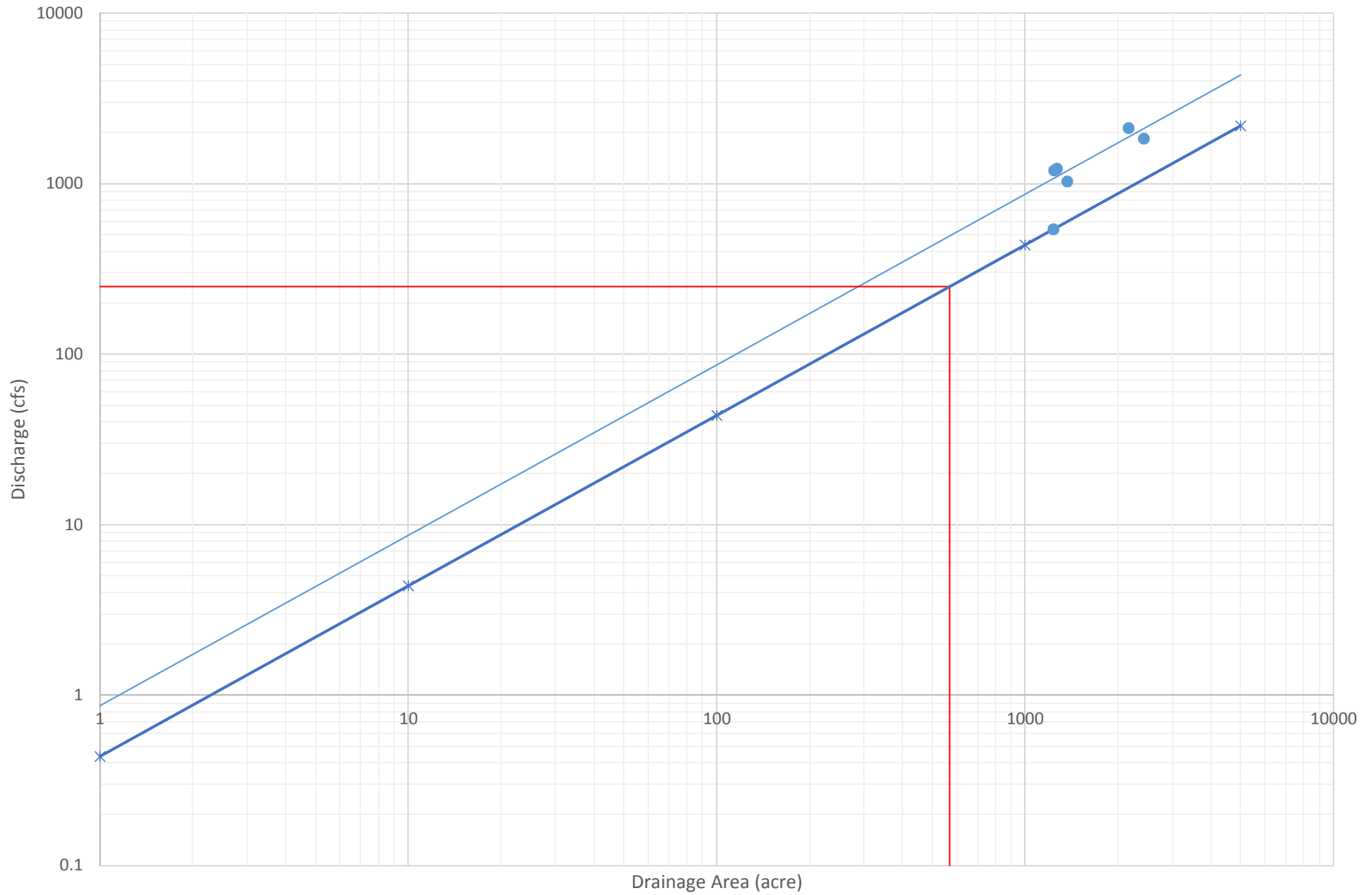
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
2-Year Storm Event



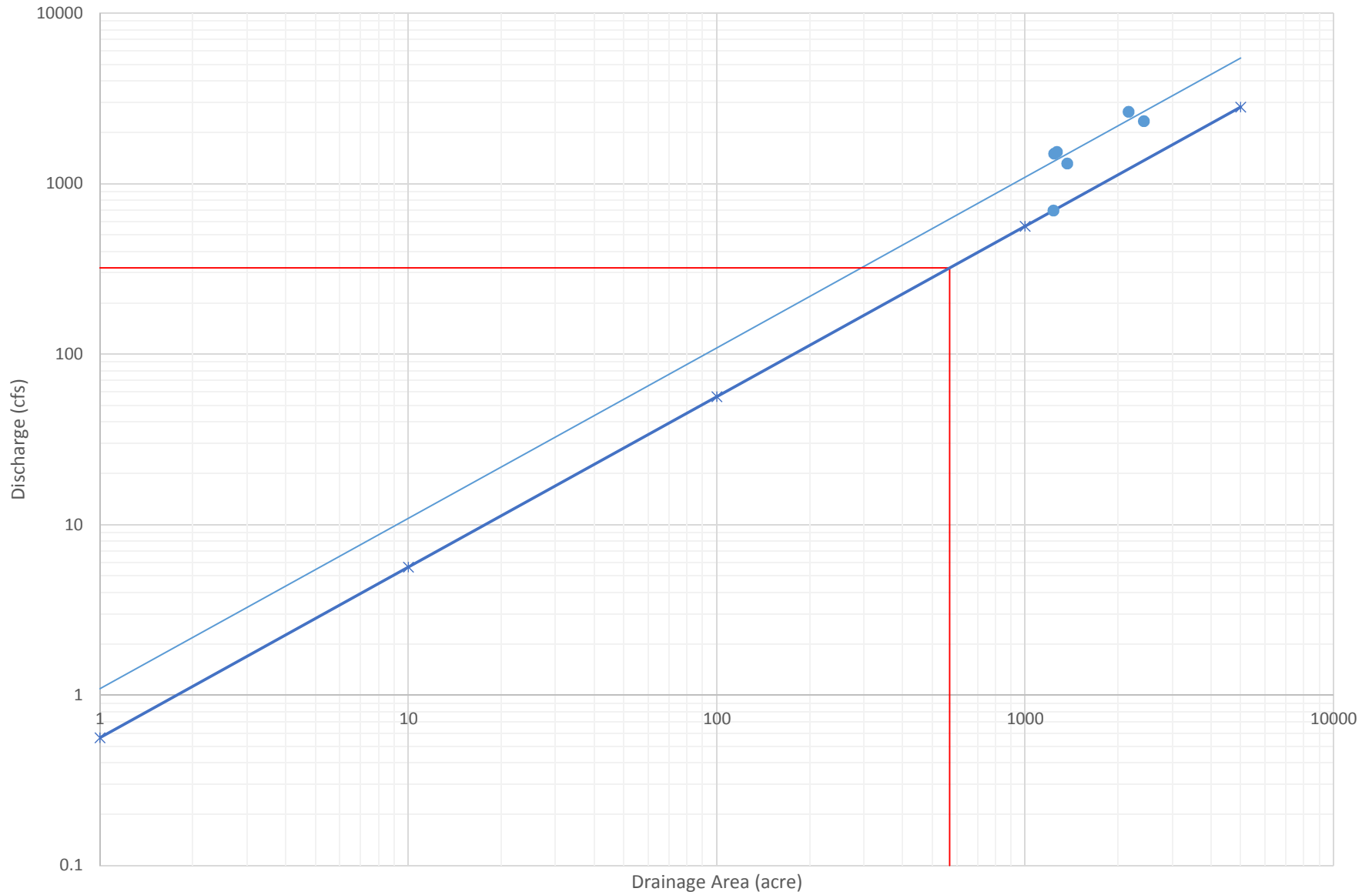
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
5-Year Storm Event



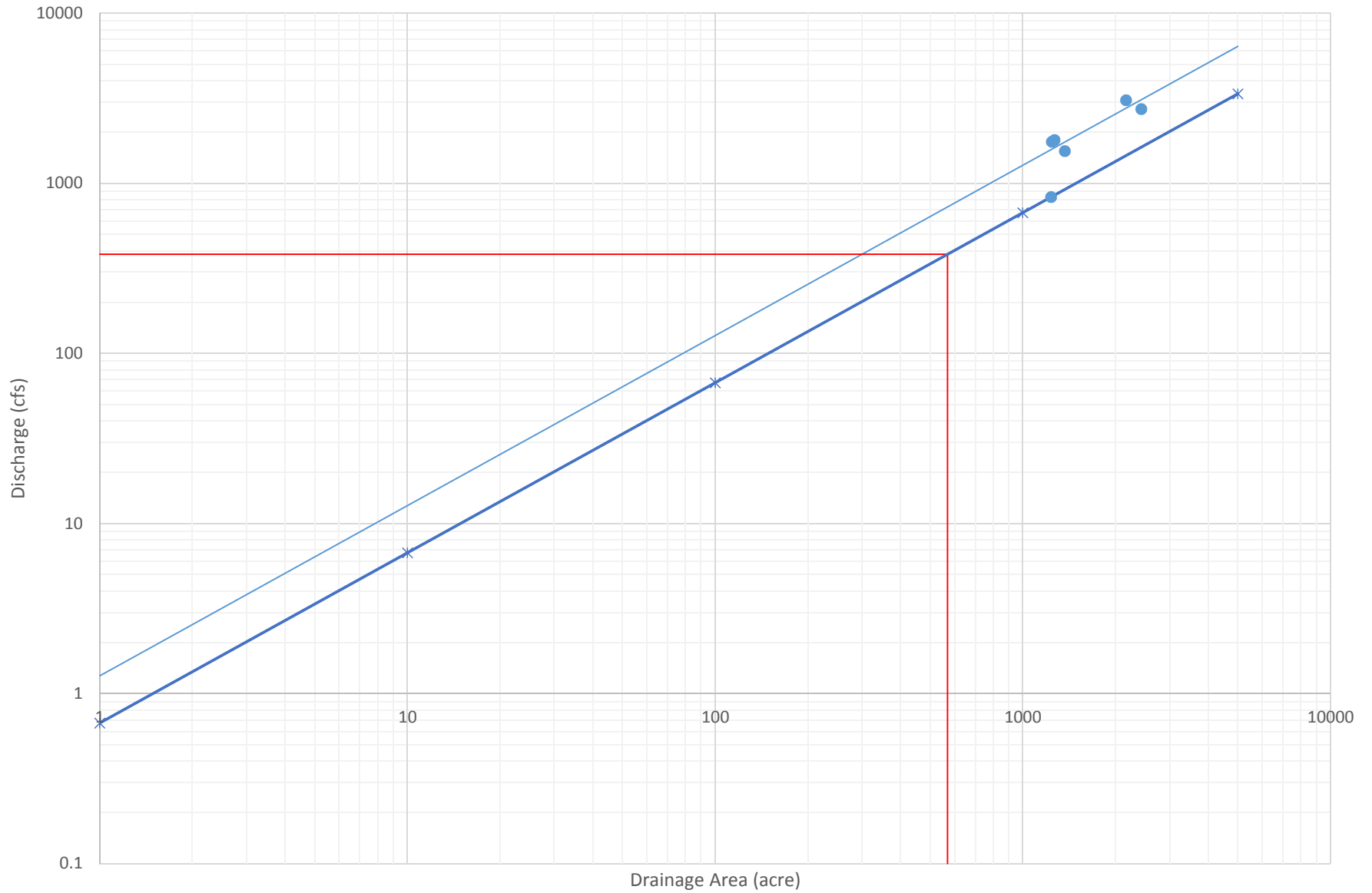
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
10-Year Storm Event



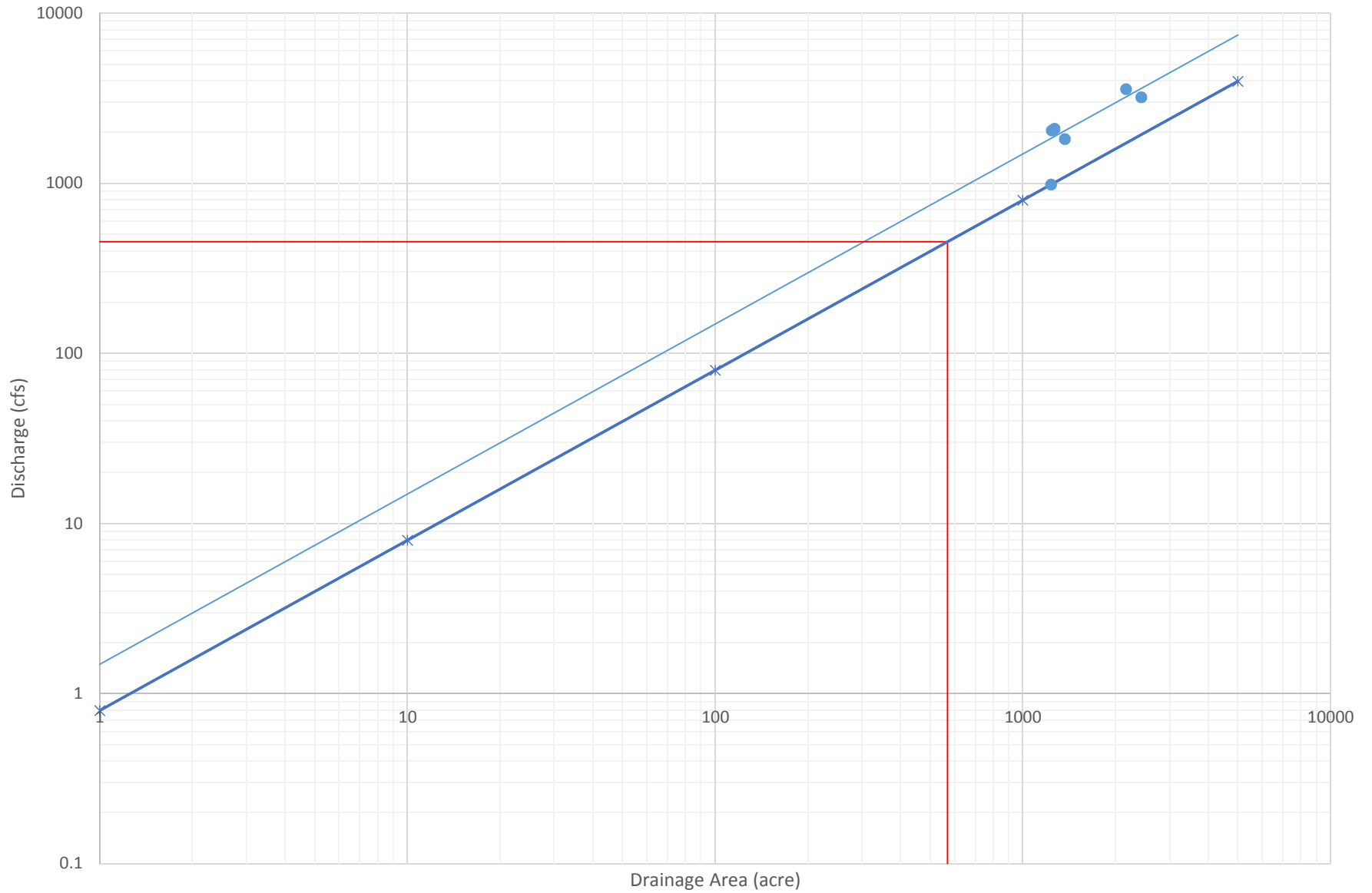
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
25-Year Storm Event



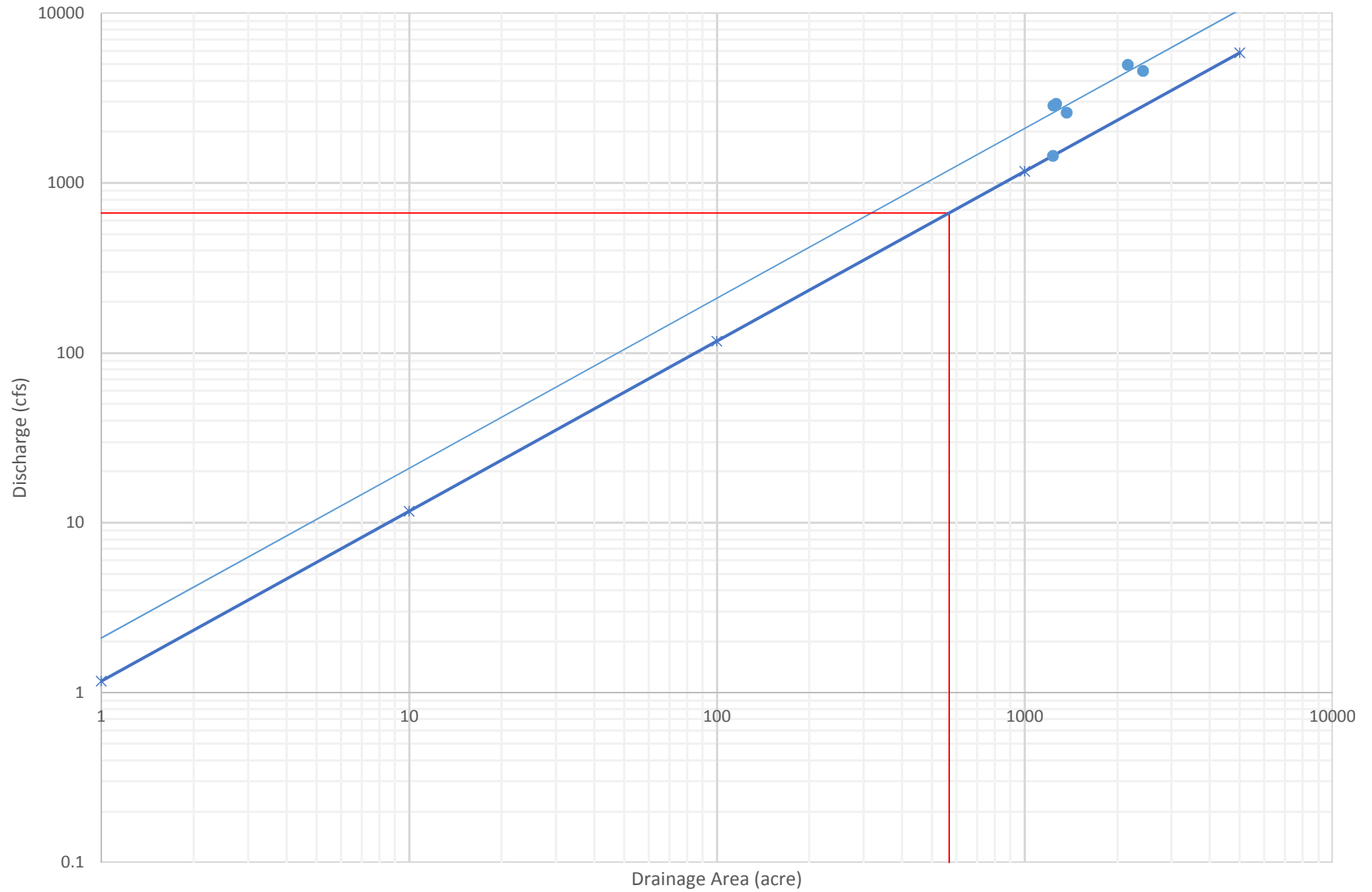
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
50-Year Storm Event



Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
100-year Storm Event



Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
500-Year Storm Event



Salt Water Ditch Flow Distributions

Table ID: B4
 Project: Salt Water Ditch
 Project #: 325912
 Date: 8/26/2015
 Prepared By:
 Checked By:

HEC-HMS Node	C118-00-00 Location	HEC-RAS Station	Return Periods							100-yr % Diff.
			50% (2-yr)	25% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)	0.2% (500-yr)	
C1180000_0009_J	U/S of confluence with C100-00-00	863.9	777	1093	1343	1709	2005	2328	3189	
	interpolated flow	2080.7	702	988	1214	1547	1818	2116	2921	10.02%
	interpolated flow	2997.8	650	915	1125	1435	1689	1969	2735	7.47%
	interpolated flow	4109.2	592	834	1026	1310	1545	1805	2524	9.09%
	interpolated flow	6004.2	506	713	877	1122	1326	1555	2202	16.08%
	interpolated flow	8009.1	427	603	743	952	1129	1329	1906	17.01%
	interpolated flow	9496.8	377	533	657	843	1002	1182	1712	12.44%
	interpolated flow	10680.1	342	483	595	765	911	1078	1572	9.65%
C118A	D/S of Martin Luther King Jr. Street Bridge	11851.0	310	438	540	695	829	983	1445	9.66%
	interpolated flow	13319.2	257	363	447	575	686	814	1196	20.76%
	interpolated flow	14033.3	234	331	408	525	626	742	1091	9.70%
	interpolated flow	15982.9	182	258	318	408	487	578	849	28.37%
Upstream Limit	Beginning of Salt Water Ditch	17874.5	143	202	249	320	382	453	666	27.59%

APPENDIX B.2

HEC-HMS OUTPUTS

- **DUPLICATE EFFECTIVE OUTPUTS**
- **CORRECTED EFFECTIVE OUTPUTS**
- **REVISED EXISTING OUTPUTS**

APPENDIX B.2-1

DUPLICATE EFFECTIVE OUTPUTS

- **10-YEAR**
- **50-YEAR**
- **100-YEAR**
- **500-YEAR**

10-YEAR DUPLICATE EFFECTIVE

Project: C100-00-00 Simulation Run: DuplicateEffective_10

Start of Run: 01Jan2003, 00:00 Basin Model: Duplicate_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(10%flood)
 Compute Time: 19Nov2015, 08:50:50 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	22530.8	01Jan2003, 22:30	5.28
C100#10	44.95	12816.8	01Jan2003, 20:15	5.06
C100#11	42.97	12284.2	01Jan2003, 20:15	5.04
C100#12	40.83	11731.1	01Jan2003, 20:00	5.05
C100#13	34.73	10712.3	01Jan2003, 19:30	5.19
C100#14	32.50	10209.4	01Jan2003, 19:15	5.26
C100#15	28.36	8823.7	01Jan2003, 19:15	5.30
C100#16	23.73	7374.2	01Jan2003, 19:15	5.34
C100#17	21.75	6783.9	01Jan2003, 19:00	5.37
C100#18	20.73	6465.4	01Jan2003, 19:00	5.39
C100#19	18.31	5597.2	01Jan2003, 19:15	5.37
C100#2	87.76	21941.9	01Jan2003, 22:15	5.25
C100#20	15.07	4568.5	01Jan2003, 19:15	5.30
C100#21	7.91	2536.6	01Jan2003, 19:15	5.23
C100#22	5.07	1812.2	01Jan2003, 18:00	5.28
C100#23	3.23	1035.1	01Jan2003, 17:30	5.15
C100#24	2.26	706.0	01Jan2003, 17:15	5.07
C100#3	86.15	21760.1	01Jan2003, 22:15	5.24
C100#4	68.69	17568.2	01Jan2003, 22:30	5.10
C100#5	65.31	17122.9	01Jan2003, 22:00	5.07
C100#6	63.55	16837.3	01Jan2003, 21:30	5.07
C100#7	57.28	15987.6	01Jan2003, 21:00	5.10
C100#8	55.05	15497.1	01Jan2003, 20:45	5.12
C100#9	48.74	13785.0	01Jan2003, 20:45	5.08
C100#D1	5.07	1728.3	01Jan2003, 19:00	5.28

10-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1010.2	01Jan2003, 18:15	5.15
C100A	2.26	706.0	01Jan2003, 17:15	5.07
C100B	1.84	983.6	01Jan2003, 16:45	5.52
C100B REACH#1	3.23	1010.2	01Jan2003, 18:15	5.15
C100B REACH#2	2.26	703.6	01Jan2003, 17:45	5.06
C100C	2.84	925.1	01Jan2003, 17:15	5.14
C100D	2.42	1021.1	01Jan2003, 17:15	5.53
C100D REACH#1	18.31	5598.6	01Jan2003, 19:15	5.37
C100D REACH#2	15.07	4563.5	01Jan2003, 19:15	5.30
C100D REACH#3	7.91	2534.7	01Jan2003, 19:15	5.22
C100E	2.24	945.5	01Jan2003, 18:15	5.65
C100E REACH#1	23.73	7362.8	01Jan2003, 19:15	5.34
C100E REACH#2	21.75	6768.3	01Jan2003, 19:15	5.37
C100E REACH#3	20.73	6459.1	01Jan2003, 19:15	5.39
C100F	2.58	1105.8	01Jan2003, 17:45	4.99
C100F REACH	28.36	8805.2	01Jan2003, 19:30	5.30
C100G	2.23	630.4	01Jan2003, 17:15	4.20
C100G REACH	32.50	10174.7	01Jan2003, 19:30	5.25
C100H	1.98	1222.9	01Jan2003, 17:00	5.43
C100H REACH#1	42.97	12260.0	01Jan2003, 20:30	5.04
C100H REACH#2	40.83	11678.1	01Jan2003, 20:15	5.05
C100I	3.79	1839.5	01Jan2003, 17:00	5.40
C100I REACH	44.95	12755.6	01Jan2003, 20:45	5.05
C100J	6.27	1066.1	01Jan2003, 19:00	4.86
C100J REACH	57.28	15844.9	01Jan2003, 21:30	5.09
C100K	1.76	861.4	01Jan2003, 17:15	5.34
C100K#1	1.76	861.4	01Jan2003, 17:15	5.34
C100L	3.38	2119.1	01Jan2003, 17:00	5.92
C100L REACH#1	65.31	16958.0	01Jan2003, 22:45	5.06
C100L REACH#2	63.55	16748.3	01Jan2003, 22:00	5.06
C100M	1.76	725.6	01Jan2003, 18:00	6.16

10-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	22505.5	01Jan2003, 23:00	5.28
C100M REACH#2	87.76	21844.8	01Jan2003, 22:30	5.25
C100M REACH#3	86.15	21741.2	01Jan2003, 22:15	5.24
C100M REACH#4	68.69	17557.9	01Jan2003, 22:30	5.10
C100 REACH	5.07	1719.6	01Jan2003, 19:30	5.27
C102#1	2.90	679.7	01Jan2003, 18:00	5.92
C102#OULET	3.99	1485.7	01Jan2003, 17:30	6.06
C102A	2.90	679.7	01Jan2003, 18:00	5.92
C102B	1.09	1115.7	01Jan2003, 16:45	6.49
C102B REACH	2.90	679.5	01Jan2003, 18:30	5.89
C103	1.61	1468.1	01Jan2003, 16:45	6.23
C106-00#1	14.39	6539.0	01Jan2003, 17:45	5.82
C106-00#2	9.59	4924.0	01Jan2003, 17:15	5.88
C106-00#3	4.84	2264.4	01Jan2003, 17:15	5.83
C106-00#OUTLET	17.46	7852.4	01Jan2003, 18:30	5.78
C106-01#1	2.78	1044.8	01Jan2003, 17:15	5.58
C106-01#OUTLET	4.80	1812.2	01Jan2003, 18:15	5.72
C106-08#OUTLET	1.82	996.8	01Jan2003, 17:00	5.91
C106A	1.82	996.8	01Jan2003, 17:00	5.91
C106B	3.02	1282.8	01Jan2003, 17:15	5.78
C106C	1.89	1560.1	01Jan2003, 16:45	5.92
C106C REACH	4.84	2247.9	01Jan2003, 17:30	5.83
C106D	2.86	1302.2	01Jan2003, 17:15	5.93
C106E	2.78	1044.8	01Jan2003, 17:15	5.58
C106F	2.02	830.2	01Jan2003, 17:15	5.90
C106F REACH	2.78	1031.2	01Jan2003, 18:30	5.58
C106G	3.07	1816.3	01Jan2003, 17:00	5.60
C106G REACH#1	14.39	6401.2	01Jan2003, 18:45	5.82
C106G REACH#2	9.59	4835.3	01Jan2003, 17:45	5.88
C118	3.87	1762.2	01Jan2003, 17:15	5.89
C120	2.23	852.8	01Jan2003, 17:15	4.70

10-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	15467.1	01Jan2003, 21:00	5.11
C123	2.44	1025.1	01Jan2003, 17:45	4.78
C123 REACH	48.74	13736.2	01Jan2003, 21:00	5.07
C127	2.14	1030.2	01Jan2003, 17:00	5.00
C132	4.07	777.3	01Jan2003, 18:00	4.39
C134	2.03	382.5	01Jan2003, 19:15	4.14
C134 REACH	34.73	10631.8	01Jan2003, 20:00	5.18
C137	1.56	618.0	01Jan2003, 17:00	4.97
C143	1.98	732.7	01Jan2003, 17:00	5.09
C144	1.02	390.2	01Jan2003, 17:00	4.94
C145#1	1.86	652.0	01Jan2003, 17:15	5.88
C145#OUTLET	3.24	1200.4	01Jan2003, 17:15	5.70
C145A	1.86	652.0	01Jan2003, 17:15	5.88
C145B	1.38	551.8	01Jan2003, 17:00	5.47
C147#1	1.82	623.1	01Jan2003, 17:15	5.61
C147#2	2.71	886.5	01Jan2003, 17:30	5.25
C147#OUTLET	7.16	2034.0	01Jan2003, 19:00	5.39
C147A	1.82	623.1	01Jan2003, 17:15	5.61
C147B	2.71	886.5	01Jan2003, 17:30	5.25
C147C	2.63	1382.1	01Jan2003, 17:15	5.45
C147C REACH	4.53	1171.4	01Jan2003, 21:00	5.36
C147 DETENTION	4.53	1175.5	01Jan2003, 20:30	5.37
C161	2.39	636.4	01Jan2003, 18:00	4.56
C162	0.97	334.7	01Jan2003, 17:15	5.36
DET#1	4.53	1175.5	01Jan2003, 20:30	5.37
DET#2	4.53	1508.0	01Jan2003, 17:30	5.39
DETENTION REACH#1	5.07	1728.3	01Jan2003, 19:00	5.28
DETENTION REACH#2	3.23	1003.1	01Jan2003, 18:45	5.15
Outlet	93.51	22903.4	01Jan2003, 23:00	5.29

50-YEAR DUPLICATE EFFECTIVE

Project: C100-00-00 Simulation Run: DuplicateEffective_50

Start of Run: 01Jan2003, 00:00 Basin Model: Duplicate_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(2%flood)
 Compute Time: 19Nov2015, 08:55:03 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	37816.1	01Jan2003, 22:00	8.75
C100#10	44.95	20717.4	01Jan2003, 20:15	8.53
C100#11	42.97	19799.2	01Jan2003, 20:15	8.52
C100#12	40.83	18837.4	01Jan2003, 20:15	8.53
C100#13	34.73	17084.1	01Jan2003, 19:45	8.72
C100#14	32.50	16224.1	01Jan2003, 19:30	8.80
C100#15	28.36	14052.1	01Jan2003, 19:30	8.86
C100#16	23.73	11798.6	01Jan2003, 19:30	8.92
C100#17	21.75	10869.3	01Jan2003, 19:15	8.95
C100#18	20.73	10368.9	01Jan2003, 19:15	8.98
C100#19	18.31	9035.7	01Jan2003, 19:15	8.96
C100#2	87.76	36828.5	01Jan2003, 21:00	8.72
C100#20	15.07	7445.3	01Jan2003, 19:30	8.88
C100#21	7.91	3993.0	01Jan2003, 19:15	8.80
C100#22	5.07	2789.2	01Jan2003, 18:15	8.86
C100#23	3.23	1595.5	01Jan2003, 17:45	8.71
C100#24	2.26	1089.5	01Jan2003, 17:45	8.62
C100#3	86.15	36369.7	01Jan2003, 20:45	8.70
C100#4	68.69	28921.4	01Jan2003, 22:30	8.53
C100#5	65.31	28089.5	01Jan2003, 22:00	8.49
C100#6	63.55	27543.0	01Jan2003, 21:30	8.49
C100#7	57.28	26150.2	01Jan2003, 20:45	8.57
C100#8	55.05	25265.5	01Jan2003, 20:30	8.60
C100#9	48.74	22280.0	01Jan2003, 20:15	8.55
C100#D1	5.07	2699.4	01Jan2003, 19:00	8.86

50-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1572.6	01Jan2003, 18:30	8.71
C100A	2.26	1089.5	01Jan2003, 17:45	8.62
C100B	1.84	1445.6	01Jan2003, 16:45	9.14
C100B REACH#1	3.23	1572.6	01Jan2003, 18:30	8.71
C100B REACH#2	2.26	1088.1	01Jan2003, 18:00	8.61
C100C	2.84	1419.9	01Jan2003, 17:30	8.70
C100D	2.42	1527.4	01Jan2003, 17:30	9.16
C100D REACH#1	18.31	9032.6	01Jan2003, 19:30	8.96
C100D REACH#2	15.07	7437.2	01Jan2003, 19:30	8.88
C100D REACH#3	7.91	3986.0	01Jan2003, 19:15	8.80
C100E	2.24	1427.8	01Jan2003, 18:15	9.23
C100E REACH#1	23.73	11777.0	01Jan2003, 19:30	8.92
C100E REACH#2	21.75	10843.2	01Jan2003, 19:30	8.95
C100E REACH#3	20.73	10355.7	01Jan2003, 19:30	8.98
C100F	2.58	1684.1	01Jan2003, 17:45	8.47
C100F REACH	28.36	14025.6	01Jan2003, 19:45	8.85
C100G	2.23	1000.0	01Jan2003, 17:45	7.54
C100G REACH	32.50	16192.9	01Jan2003, 19:45	8.80
C100H	1.98	1793.0	01Jan2003, 17:00	8.97
C100H REACH#1	42.97	19778.4	01Jan2003, 20:30	8.51
C100H REACH#2	40.83	18796.6	01Jan2003, 20:30	8.52
C100I	3.79	2731.3	01Jan2003, 17:15	8.94
C100I REACH	44.95	20566.4	01Jan2003, 21:00	8.52
C100J	6.27	1681.0	01Jan2003, 19:30	7.95
C100J REACH	57.28	25931.0	01Jan2003, 21:30	8.55
C100K	1.76	1284.0	01Jan2003, 17:15	8.87
C100K#1	1.76	1284.0	01Jan2003, 17:15	8.87
C100L	3.38	3071.4	01Jan2003, 17:00	9.54
C100L REACH#1	65.31	27882.5	01Jan2003, 22:45	8.48
C100L REACH#2	63.55	27444.8	01Jan2003, 22:00	8.48
C100M	1.76	1080.3	01Jan2003, 18:00	9.81

50-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	37786.1	01Jan2003, 22:30	8.73
C100M REACH#2	87.76	36648.7	01Jan2003, 22:00	8.71
C100M REACH#3	86.15	36330.6	01Jan2003, 21:15	8.70
C100M REACH#4	68.69	28920.5	01Jan2003, 22:30	8.53
C100 REACH	5.07	2686.8	01Jan2003, 19:30	8.85
C102#1	2.90	1036.8	01Jan2003, 18:30	9.36
C102#OULET	3.99	2223.1	01Jan2003, 17:15	9.56
C102A	2.90	1036.8	01Jan2003, 18:30	9.36
C102B	1.09	1554.3	01Jan2003, 16:45	10.19
C102B REACH	2.90	1036.2	01Jan2003, 19:00	9.32
C103	1.61	2068.1	01Jan2003, 16:45	9.89
C106-00#1	14.39	9648.0	01Jan2003, 17:45	9.44
C106-00#2	9.59	7236.2	01Jan2003, 17:15	9.51
C106-00#3	4.84	3350.0	01Jan2003, 17:15	9.45
C106-00#OUTLET	17.46	11634.1	01Jan2003, 18:30	9.39
C106-01#1	2.78	1572.4	01Jan2003, 17:30	9.15
C106-01#OUTLET	4.80	2649.2	01Jan2003, 19:00	9.30
C106-08#OUTLET	1.82	1456.8	01Jan2003, 17:00	9.55
C106A	1.82	1456.8	01Jan2003, 17:00	9.55
C106B	3.02	1910.4	01Jan2003, 17:30	9.40
C106C	1.89	2219.8	01Jan2003, 16:45	9.56
C106C REACH	4.84	3328.7	01Jan2003, 17:30	9.45
C106D	2.86	1924.6	01Jan2003, 17:15	9.57
C106E	2.78	1572.4	01Jan2003, 17:30	9.15
C106F	2.02	1236.7	01Jan2003, 17:30	9.51
C106F REACH	2.78	1536.0	01Jan2003, 19:30	9.14
C106G	3.07	2656.3	01Jan2003, 17:00	9.17
C106G REACH#1	14.39	9454.3	01Jan2003, 18:45	9.44
C106G REACH#2	9.59	7166.0	01Jan2003, 17:45	9.51
C118	3.87	2604.1	01Jan2003, 17:15	9.49
C120	2.23	1307.0	01Jan2003, 17:15	8.14

50-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	25216.4	01Jan2003, 20:45	8.59
C123	2.44	1571.4	01Jan2003, 17:45	8.23
C123 REACH	48.74	22251.9	01Jan2003, 20:45	8.54
C127	2.14	1545.0	01Jan2003, 17:00	8.48
C132	4.07	1251.0	01Jan2003, 18:30	7.59
C134	2.03	623.3	01Jan2003, 19:30	7.30
C134 REACH	34.73	17022.9	01Jan2003, 20:15	8.71
C137	1.56	938.3	01Jan2003, 17:15	8.45
C143	1.98	1115.3	01Jan2003, 17:15	8.58
C144	1.02	594.6	01Jan2003, 17:15	8.41
C145#1	1.86	979.6	01Jan2003, 17:30	9.53
C145#OUTLET	3.24	1803.9	01Jan2003, 17:30	9.34
C145A	1.86	979.6	01Jan2003, 17:30	9.53
C145B	1.38	828.1	01Jan2003, 17:15	9.08
C147#1	1.82	943.2	01Jan2003, 17:30	9.23
C147#2	2.71	1358.6	01Jan2003, 17:45	8.82
C147#OUTLET	7.16	3460.6	01Jan2003, 19:45	8.98
C147A	1.82	943.2	01Jan2003, 17:30	9.23
C147B	2.71	1358.6	01Jan2003, 17:45	8.82
C147C	2.63	2043.8	01Jan2003, 17:15	9.06
C147C REACH	4.53	2038.8	01Jan2003, 20:30	8.93
C147 DETENTION	4.53	2070.2	01Jan2003, 19:45	8.94
C161	2.39	1006.6	01Jan2003, 18:15	7.93
C162	0.97	509.4	01Jan2003, 17:30	8.96
DET#1	4.53	2070.2	01Jan2003, 19:45	8.94
DET#2	4.53	2301.3	01Jan2003, 17:45	8.99
DETENTION REACH#1	5.07	2699.4	01Jan2003, 19:00	8.86
DETENTION REACH#2	3.23	1559.6	01Jan2003, 19:00	8.70
Outlet	93.51	38495.4	01Jan2003, 22:15	8.75

100-YEAR DUPLICATE EFFECTIVE

Project: C100-00-00 Simulation Run: DuplicateEffective_100

Start of Run: 01Jan2003, 00:00 Basin Model: Duplicate_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(1%flood)
 Compute Time: 19Nov2015, 08:53:53 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	43764.8	01Jan2003, 22:00	10.52
C100#10	44.95	24835.5	01Jan2003, 20:30	10.31
C100#11	42.97	23878.3	01Jan2003, 20:30	10.29
C100#12	40.83	22760.2	01Jan2003, 20:15	10.30
C100#13	34.73	20618.8	01Jan2003, 19:45	10.52
C100#14	32.50	19577.7	01Jan2003, 19:45	10.61
C100#15	28.36	17000.6	01Jan2003, 19:30	10.66
C100#16	23.73	14318.3	01Jan2003, 19:30	10.73
C100#17	21.75	13216.6	01Jan2003, 19:30	10.77
C100#18	20.73	12609.2	01Jan2003, 19:30	10.80
C100#19	18.31	11037.7	01Jan2003, 19:30	10.77
C100#2	87.76	42520.5	01Jan2003, 21:45	10.49
C100#20	15.07	9162.5	01Jan2003, 19:30	10.69
C100#21	7.91	4779.7	01Jan2003, 19:15	10.60
C100#22	5.07	3306.4	01Jan2003, 18:15	10.67
C100#23	3.23	1890.7	01Jan2003, 18:00	10.52
C100#24	2.26	1292.4	01Jan2003, 17:45	10.41
C100#3	86.15	42049.3	01Jan2003, 21:30	10.47
C100#4	68.69	33294.3	01Jan2003, 22:45	10.29
C100#5	65.31	32441.6	01Jan2003, 23:00	10.25
C100#6	63.55	32055.5	01Jan2003, 22:15	10.25
C100#7	57.28	30319.3	01Jan2003, 21:30	10.35
C100#8	55.05	29322.8	01Jan2003, 21:30	10.38
C100#9	48.74	26316.6	01Jan2003, 21:15	10.33
C100#D1	5.07	3219.9	01Jan2003, 19:00	10.66

100-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1868.9	01Jan2003, 18:30	10.51
C100A	2.26	1292.4	01Jan2003, 17:45	10.41
C100B	1.84	1688.3	01Jan2003, 16:45	10.96
C100B REACH#1	3.23	1868.9	01Jan2003, 18:30	10.51
C100B REACH#2	2.26	1291.1	01Jan2003, 18:00	10.41
C100C	2.84	1681.9	01Jan2003, 17:45	10.51
C100D	2.42	1793.9	01Jan2003, 17:30	10.98
C100D REACH#1	18.31	11035.4	01Jan2003, 19:30	10.77
C100D REACH#2	15.07	9134.6	01Jan2003, 19:45	10.69
C100D REACH#3	7.91	4771.4	01Jan2003, 19:30	10.60
C100E	2.24	1680.6	01Jan2003, 18:15	11.05
C100E REACH#1	23.73	14302.3	01Jan2003, 19:45	10.73
C100E REACH#2	21.75	13178.7	01Jan2003, 19:45	10.76
C100E REACH#3	20.73	12610.1	01Jan2003, 19:30	10.79
C100F	2.58	1987.1	01Jan2003, 17:45	10.27
C100F REACH	28.36	16963.7	01Jan2003, 20:00	10.66
C100G	2.23	1198.8	01Jan2003, 17:45	9.30
C100G REACH	32.50	19551.1	01Jan2003, 20:00	10.60
C100H	1.98	2092.4	01Jan2003, 17:00	10.79
C100H REACH#1	42.97	23787.9	01Jan2003, 20:45	10.29
C100H REACH#2	40.83	22699.7	01Jan2003, 20:30	10.29
C100I	3.79	3204.3	01Jan2003, 17:15	10.75
C100I REACH	44.95	24497.0	01Jan2003, 21:30	10.29
C100J	6.27	2014.1	01Jan2003, 19:45	9.53
C100J REACH	57.28	30171.8	01Jan2003, 22:15	10.33
C100K	1.76	1505.9	01Jan2003, 17:15	10.68
C100K#1	1.76	1505.9	01Jan2003, 17:15	10.68
C100L	3.38	3572.6	01Jan2003, 17:00	11.37
C100L REACH#1	65.31	32273.9	01Jan2003, 23:45	10.23
C100L REACH#2	63.55	31797.2	01Jan2003, 23:00	10.24
C100M	1.76	1265.5	01Jan2003, 18:00	11.65

100-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	43730.6	01Jan2003, 22:30	10.50
C100M REACH#2	87.76	42379.0	01Jan2003, 22:00	10.48
C100M REACH#3	86.15	42026.1	01Jan2003, 21:45	10.47
C100M REACH#4	68.69	33296.3	01Jan2003, 22:45	10.28
C100 REACH	5.07	3206.2	01Jan2003, 19:30	10.66
C102#1	2.90	1228.5	01Jan2003, 19:00	11.10
C102#OULET	3.99	2572.3	01Jan2003, 17:15	11.32
C102A	2.90	1228.5	01Jan2003, 19:00	11.10
C102B	1.09	1785.4	01Jan2003, 16:45	12.05
C102B REACH	2.90	1227.5	01Jan2003, 19:15	11.05
C103	1.61	2384.0	01Jan2003, 16:45	11.73
C106-00#1	14.39	11149.2	01Jan2003, 17:45	11.27
C106-00#2	9.59	8442.8	01Jan2003, 17:15	11.34
C106-00#3	4.84	3918.0	01Jan2003, 17:15	11.29
C106-00#OUTLET	17.46	13574.6	01Jan2003, 18:30	11.22
C106-01#1	2.78	1850.7	01Jan2003, 17:30	10.97
C106-01#OUTLET	4.80	3129.3	01Jan2003, 19:15	11.12
C106-08#OUTLET	1.82	1698.5	01Jan2003, 17:00	11.38
C106A	1.82	1698.5	01Jan2003, 17:00	11.38
C106B	3.02	2240.6	01Jan2003, 17:30	11.23
C106C	1.89	2566.6	01Jan2003, 16:45	11.39
C106C REACH	4.84	3896.6	01Jan2003, 17:45	11.29
C106D	2.86	2250.3	01Jan2003, 17:15	11.40
C106E	2.78	1850.7	01Jan2003, 17:30	10.97
C106F	2.02	1449.7	01Jan2003, 17:30	11.34
C106F REACH	2.78	1813.1	01Jan2003, 19:30	10.96
C106G	3.07	3098.4	01Jan2003, 17:00	10.99
C106G REACH#1	14.39	11001.9	01Jan2003, 18:45	11.27
C106G REACH#2	9.59	8379.4	01Jan2003, 17:45	11.34
C118	3.87	3047.8	01Jan2003, 17:30	11.33
C120	2.23	1548.9	01Jan2003, 17:30	9.92

100-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	29302.0	01Jan2003, 21:30	10.37
C123	2.44	1857.8	01Jan2003, 17:45	10.02
C123 REACH	48.74	26213.2	01Jan2003, 21:45	10.32
C127	2.14	1815.9	01Jan2003, 17:00	10.28
C132	4.07	1511.3	01Jan2003, 19:00	9.25
C134	2.03	755.1	01Jan2003, 19:45	8.96
C134 REACH	34.73	20554.2	01Jan2003, 20:15	10.51
C137	1.56	1108.1	01Jan2003, 17:15	10.24
C143	1.98	1317.3	01Jan2003, 17:30	10.38
C144	1.02	702.7	01Jan2003, 17:15	10.20
C145#1	1.86	1151.7	01Jan2003, 17:45	11.36
C145#OUTLET	3.24	2122.3	01Jan2003, 17:30	11.17
C145A	1.86	1151.7	01Jan2003, 17:45	11.36
C145B	1.38	973.5	01Jan2003, 17:15	10.91
C147#1	1.82	1112.3	01Jan2003, 17:45	11.05
C147#2	2.71	1606.8	01Jan2003, 17:45	10.63
C147#OUTLET	7.16	4391.1	01Jan2003, 19:30	10.79
C147A	1.82	1112.3	01Jan2003, 17:45	11.05
C147B	2.71	1606.8	01Jan2003, 17:45	10.63
C147C	2.63	2389.8	01Jan2003, 17:15	10.88
C147C REACH	4.53	2558.7	01Jan2003, 20:00	10.73
C147 DETENTION	4.53	2597.3	01Jan2003, 19:15	10.75
C161	2.39	1204.8	01Jan2003, 18:30	9.69
C162	0.97	601.6	01Jan2003, 17:45	10.77
DET#1	4.53	2597.3	01Jan2003, 19:15	10.75
DET#2	4.53	2719.1	01Jan2003, 17:45	10.80
DETENTION REACH#1	5.07	3219.9	01Jan2003, 19:00	10.66
DETENTION REACH#2	3.23	1856.7	01Jan2003, 19:00	10.50
Outlet	93.51	44552.5	01Jan2003, 22:30	10.52

500-YEAR DUPLICATE EFFECTIVE

Project: C100-00-00 Simulation Run: DuplicateEffective_500

Start of Run: 01Jan2003, 00:00 Basin Model: Duplicate_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(.2%flood)
 Compute Time: 19Nov2015, 09:01:11 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	57455.0	01Jan2003, 20:30	15.96
C100#10	44.95	32724.3	01Jan2003, 23:30	15.80
C100#11	42.97	32224.7	01Jan2003, 22:45	15.78
C100#12	40.83	31522.5	01Jan2003, 22:00	15.79
C100#13	34.73	28736.2	01Jan2003, 21:00	16.07
C100#14	32.50	27579.1	01Jan2003, 19:45	16.17
C100#15	28.36	23908.4	01Jan2003, 20:15	16.24
C100#16	23.73	20247.6	01Jan2003, 20:30	16.32
C100#17	21.75	19484.0	01Jan2003, 19:45	16.36
C100#18	20.73	18654.0	01Jan2003, 19:30	16.39
C100#19	18.31	16469.5	01Jan2003, 19:15	16.36
C100#2	87.76	55973.1	01Jan2003, 19:30	15.95
C100#20	15.07	13901.1	01Jan2003, 19:00	16.27
C100#21	7.91	6992.1	01Jan2003, 19:15	16.19
C100#22	5.07	4708.6	01Jan2003, 18:30	16.26
C100#23	3.23	2767.8	01Jan2003, 18:15	16.09
C100#24	2.26	1896.8	01Jan2003, 18:00	15.98
C100#3	86.15	54409.7	01Jan2003, 19:45	15.93
C100#4	68.69	39974.1	02Jan2003, 01:15	15.70
C100#5	65.31	39208.5	02Jan2003, 00:30	15.66
C100#6	63.55	38617.4	01Jan2003, 23:30	15.67
C100#7	57.28	36598.2	01Jan2003, 20:30	15.84
C100#8	55.05	35315.1	01Jan2003, 19:30	15.87
C100#9	48.74	32542.1	02Jan2003, 01:30	15.81
C100#D1	5.07	4641.7	01Jan2003, 19:00	16.25

500-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	2677.9	01Jan2003, 19:30	16.08
C100A	2.26	1896.8	01Jan2003, 18:00	15.98
C100B	1.84	2381.2	01Jan2003, 17:00	16.60
C100B REACH#1	3.23	2677.9	01Jan2003, 19:30	16.08
C100B REACH#2	2.26	1894.8	01Jan2003, 18:15	15.97
C100C	2.84	2460.9	01Jan2003, 18:00	16.09
C100D	2.42	2573.3	01Jan2003, 17:45	16.62
C100D REACH#1	18.31	16360.2	01Jan2003, 19:45	16.36
C100D REACH#2	15.07	13616.8	01Jan2003, 19:45	16.27
C100D REACH#3	7.91	6982.1	01Jan2003, 19:15	16.18
C100E	2.24	2412.9	01Jan2003, 18:15	16.65
C100E REACH#1	23.73	20210.5	01Jan2003, 21:00	16.31
C100E REACH#2	21.75	18749.0	01Jan2003, 20:45	16.35
C100E REACH#3	20.73	18596.7	01Jan2003, 19:45	16.39
C100F	2.58	2868.0	01Jan2003, 18:00	15.81
C100F REACH	28.36	23888.7	01Jan2003, 20:45	16.23
C100G	2.23	1792.4	01Jan2003, 18:00	14.73
C100G REACH	32.50	27260.4	01Jan2003, 21:15	16.16
C100H	1.98	2928.3	01Jan2003, 17:00	16.37
C100H REACH#1	42.97	31916.5	01Jan2003, 23:45	15.77
C100H REACH#2	40.83	31091.8	01Jan2003, 23:15	15.78
C100I	3.79	4565.8	01Jan2003, 17:15	16.33
C100I REACH	44.95	31347.7	02Jan2003, 01:45	15.77
C100J	6.27	3006.7	01Jan2003, 19:45	14.40
C100J REACH	57.28	35924.3	01Jan2003, 23:45	15.81
C100K	1.76	2144.8	01Jan2003, 17:30	16.26
C100K#1	1.76	2144.8	01Jan2003, 17:30	16.26
C100L	3.38	4970.3	01Jan2003, 17:15	17.00
C100L REACH#1	65.31	39075.3	02Jan2003, 01:30	15.63
C100L REACH#2	63.55	38483.2	02Jan2003, 00:45	15.64
C100M	1.76	1810.8	01Jan2003, 18:15	17.30

500-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	57063.4	01Jan2003, 21:15	15.94
C100M REACH#2	87.76	55003.1	01Jan2003, 20:30	15.93
C100M REACH#3	86.15	54341.1	01Jan2003, 19:30	15.92
C100M REACH#4	68.69	39984.4	02Jan2003, 01:15	15.70
C100 REACH	5.07	4630.1	01Jan2003, 19:30	16.24
C102#1	2.90	1802.6	01Jan2003, 19:15	16.42
C102#OULET	3.99	3584.9	01Jan2003, 17:15	16.73
C102A	2.90	1802.6	01Jan2003, 19:15	16.42
C102B	1.09	2400.3	01Jan2003, 16:45	17.73
C102B REACH	2.90	1798.9	01Jan2003, 19:45	16.36
C103	1.61	3230.8	01Jan2003, 16:45	17.39
C106-00#1	14.39	15757.6	01Jan2003, 18:15	16.89
C106-00#2	9.59	11907.0	01Jan2003, 17:30	16.98
C106-00#3	4.84	5566.8	01Jan2003, 17:30	16.92
C106-00#OUTLET	17.46	18806.0	01Jan2003, 19:15	16.84
C106-01#1	2.78	2677.2	01Jan2003, 17:45	16.56
C106-01#OUTLET	4.80	4549.1	01Jan2003, 19:15	16.72
C106-08#OUTLET	1.82	2383.7	01Jan2003, 17:15	17.02
C106A	1.82	2383.7	01Jan2003, 17:15	17.02
C106B	3.02	3208.9	01Jan2003, 17:45	16.85
C106C	1.89	3497.2	01Jan2003, 16:45	17.03
C106C REACH	4.84	5544.1	01Jan2003, 17:45	16.92
C106D	2.86	3205.1	01Jan2003, 17:30	17.04
C106E	2.78	2677.2	01Jan2003, 17:45	16.56
C106F	2.02	2079.0	01Jan2003, 17:45	16.97
C106F REACH	2.78	2637.2	01Jan2003, 19:45	16.55
C106G	3.07	4348.7	01Jan2003, 17:15	16.59
C106G REACH#1	14.39	15405.7	01Jan2003, 19:45	16.89
C106G REACH#2	9.59	11807.1	01Jan2003, 17:45	16.98
C118	3.87	4344.3	01Jan2003, 17:30	16.95
C120	2.23	2258.8	01Jan2003, 17:45	15.44

500-YEAR DUPLICATE EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	34816.2	01Jan2003, 20:45	15.86
C123	2.44	2689.3	01Jan2003, 18:00	15.54
C123 REACH	48.74	32358.1	02Jan2003, 02:15	15.80
C127	2.14	2595.0	01Jan2003, 17:15	15.82
C132	4.07	2294.7	01Jan2003, 19:15	14.39
C134	2.03	1149.1	01Jan2003, 20:00	14.08
C134 REACH	34.73	28429.8	01Jan2003, 22:15	16.05
C137	1.56	1608.0	01Jan2003, 17:30	15.78
C143	1.98	1918.1	01Jan2003, 17:30	15.93
C144	1.02	1022.7	01Jan2003, 17:30	15.74
C145#1	1.86	1664.3	01Jan2003, 18:00	17.00
C145#OUTLET	3.24	3062.5	01Jan2003, 17:45	16.80
C145A	1.86	1664.3	01Jan2003, 18:00	17.00
C145B	1.38	1403.0	01Jan2003, 17:30	16.54
C147#1	1.82	1614.2	01Jan2003, 18:00	16.67
C147#2	2.71	2347.9	01Jan2003, 18:15	16.22
C147#OUTLET	7.16	7018.3	01Jan2003, 18:45	16.38
C147A	1.82	1614.2	01Jan2003, 18:00	16.67
C147B	2.71	2347.9	01Jan2003, 18:15	16.22
C147C	2.63	3379.6	01Jan2003, 17:30	16.51
C147C REACH	4.53	3936.0	01Jan2003, 19:00	16.30
C147 DETENTION	4.53	3948.9	01Jan2003, 18:30	16.32
C161	2.39	1800.1	01Jan2003, 18:45	15.11
C162	0.97	875.2	01Jan2003, 18:00	16.38
DET#1	4.53	3948.9	01Jan2003, 18:30	16.32
DET#2	4.53	3962.0	01Jan2003, 18:00	16.40
DETENTION REACH#1	5.07	4641.7	01Jan2003, 19:00	16.25
DETENTION REACH#2	3.23	2668.6	01Jan2003, 19:45	16.07
Outlet	93.51	58494.7	01Jan2003, 21:15	15.97

APPENDIX B.2-2

CORRECTED EFFECTIVE OUTPUTS

- **2-YEAR**
- **5-YEAR**
- **10-YEAR**
- **25-YEAR**
- **50-YEAR**
- **100-YEAR**
- **500-YEAR**

2-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_2

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(50%Flood)
 Compute Time: 03Sep2015, 14:49:51 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	11058.9	01Jan2003, 23:15	2.76
C100#10	44.95	6627.7	01Jan2003, 20:30	2.59
C100#11	42.97	6381.2	01Jan2003, 20:30	2.58
C100#12	40.83	6140.8	01Jan2003, 20:00	2.58
C100#13	34.73	5677.4	01Jan2003, 19:30	2.66
C100#14	32.50	5450.8	01Jan2003, 19:00	2.71
C100#15	28.36	4730.0	01Jan2003, 18:45	2.73
C100#16	23.73	3933.8	01Jan2003, 19:00	2.75
C100#17	21.75	3622.5	01Jan2003, 18:45	2.76
C100#18	20.73	3453.6	01Jan2003, 18:45	2.77
C100#19	18.31	2975.4	01Jan2003, 19:00	2.76
C100#2	87.76	10749.6	01Jan2003, 23:00	2.74
C100#20	15.07	2417.1	01Jan2003, 19:15	2.71
C100#21	7.91	1334.3	01Jan2003, 19:00	2.65
C100#22	5.07	973.8	01Jan2003, 18:15	2.69
C100#23	3.23	577.3	01Jan2003, 17:30	2.60
C100#24	2.26	396.0	01Jan2003, 17:00	2.53
C100#3	86.15	10691.0	01Jan2003, 23:00	2.73
C100#4	68.69	8656.4	01Jan2003, 23:00	2.63
C100#5	65.31	8452.6	01Jan2003, 22:45	2.60
C100#6	63.55	8343.8	01Jan2003, 22:15	2.60
C100#7	57.28	7942.6	01Jan2003, 21:30	2.60
C100#8	55.05	7728.2	01Jan2003, 21:15	2.62
C100#9	48.74	7049.9	01Jan2003, 21:00	2.61
C100#D1	5.07	928.0	01Jan2003, 18:45	2.69

2-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	548.0	01Jan2003, 18:15	2.59
C100A	2.26	396.0	01Jan2003, 17:00	2.53
C100B	1.84	585.4	01Jan2003, 16:45	2.86
C100B REACH#1	3.23	548.0	01Jan2003, 18:15	2.59
C100B REACH#2	2.26	389.8	01Jan2003, 17:30	2.53
C100C	2.84	521.8	01Jan2003, 17:00	2.58
C100D	2.42	592.3	01Jan2003, 17:15	2.87
C100D REACH#1	18.31	2974.4	01Jan2003, 19:00	2.76
C100D REACH#2	15.07	2417.1	01Jan2003, 19:15	2.71
C100D REACH#3	7.91	1330.6	01Jan2003, 19:15	2.65
C100E	2.24	546.7	01Jan2003, 18:00	3.04
C100E REACH#1	23.73	3926.2	01Jan2003, 19:00	2.75
C100E REACH#2	21.75	3611.2	01Jan2003, 19:00	2.76
C100E REACH#3	20.73	3449.3	01Jan2003, 18:45	2.77
C100F	2.58	623.0	01Jan2003, 17:45	2.57
C100F REACH	28.36	4712.8	01Jan2003, 19:15	2.73
C100G	2.23	341.4	01Jan2003, 17:00	2.01
C100G REACH	32.50	5423.0	01Jan2003, 19:30	2.71
C100H	1.98	736.3	01Jan2003, 16:45	2.88
C100H REACH#1	42.97	6354.1	01Jan2003, 20:45	2.58
C100H REACH#2	40.83	6092.9	01Jan2003, 20:30	2.58
C100I	3.79	1084.5	01Jan2003, 17:00	2.86
C100I REACH	44.95	6548.8	01Jan2003, 21:15	2.59
C100J	6.27	591.5	01Jan2003, 18:15	2.60
C100J REACH	57.28	7830.2	01Jan2003, 22:15	2.60
C100K	1.76	501.7	01Jan2003, 17:15	2.82
C100K#1	1.76	501.7	01Jan2003, 17:15	2.82
C100L	3.38	1294.7	01Jan2003, 17:00	3.23
C100L REACH#1	65.31	8378.4	01Jan2003, 23:15	2.60
C100L REACH#2	63.55	8285.8	01Jan2003, 22:45	2.59
C100M	1.76	429.3	01Jan2003, 17:45	3.39

2-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	11032.2	01Jan2003, 23:30	2.76
C100M REACH#2	87.76	10698.2	01Jan2003, 23:15	2.73
C100M REACH#3	86.15	10663.4	01Jan2003, 23:00	2.72
C100M REACH#4	68.69	8654.9	01Jan2003, 23:15	2.63
C100 REACH	5.07	919.9	01Jan2003, 19:30	2.69
C102#1	2.90	395.6	01Jan2003, 17:45	3.28
C102#OULET	3.99	869.3	01Jan2003, 16:45	3.36
C102A	2.90	395.6	01Jan2003, 17:45	3.28
C102B	1.09	717.1	01Jan2003, 16:45	3.63
C102B REACH	2.90	393.1	01Jan2003, 18:30	3.26
C103	1.61	929.4	01Jan2003, 16:45	3.44
C106-00#1	14.39	3803.9	01Jan2003, 17:45	3.14
C106-00#2	9.59	2914.0	01Jan2003, 17:15	3.17
C106-00#3	4.84	1347.3	01Jan2003, 17:00	3.14
C106-00#OUTLET	17.46	4511.1	01Jan2003, 18:30	3.12
C106-01#1	2.78	610.5	01Jan2003, 17:00	2.99
C106-01#OUTLET	4.80	1034.8	01Jan2003, 18:15	3.08
C106-08#OUTLET	1.82	601.5	01Jan2003, 16:45	3.20
C106A	1.82	601.5	01Jan2003, 16:45	3.20
C106B	3.02	755.7	01Jan2003, 17:15	3.10
C106C	1.89	973.8	01Jan2003, 16:45	3.21
C106C REACH	4.84	1323.3	01Jan2003, 17:30	3.14
C106D	2.86	778.0	01Jan2003, 17:00	3.21
C106E	2.78	610.5	01Jan2003, 17:00	2.99
C106F	2.02	492.5	01Jan2003, 17:15	3.21
C106F REACH	2.78	591.8	01Jan2003, 18:30	2.99
C106G	3.07	1093.9	01Jan2003, 17:00	3.00
C106G REACH#1	14.39	3714.4	01Jan2003, 18:30	3.14
C106G REACH#2	9.59	2842.0	01Jan2003, 17:45	3.17
C118	3.87	577.7	01Jan2003, 18:00	2.84
C120	2.23	481.5	01Jan2003, 17:00	2.36

2-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	7707.3	01Jan2003, 21:30	2.61
C123	2.44	571.9	01Jan2003, 17:30	2.42
C123 REACH	48.74	6987.9	01Jan2003, 21:30	2.61
C127	2.14	599.8	01Jan2003, 16:45	2.58
C132	4.07	419.3	01Jan2003, 17:15	2.20
C134	2.03	198.2	01Jan2003, 19:00	2.03
C134 REACH	34.73	5597.6	01Jan2003, 20:15	2.66
C137	1.56	354.4	01Jan2003, 16:45	2.56
C143	1.98	420.4	01Jan2003, 16:45	2.64
C144	1.02	223.0	01Jan2003, 16:45	2.53
C145#1	1.86	381.2	01Jan2003, 17:00	3.13
C145#OUTLET	3.24	698.8	01Jan2003, 17:00	3.00
C145A	1.86	381.2	01Jan2003, 17:00	3.13
C145B	1.38	321.0	01Jan2003, 16:45	2.82
C147#1	1.82	359.8	01Jan2003, 17:00	2.93
C147#2	2.71	501.9	01Jan2003, 17:15	2.67
C147#OUTLET	7.16	1102.1	01Jan2003, 18:30	2.77
C147A	1.82	359.8	01Jan2003, 17:00	2.93
C147B	2.71	501.9	01Jan2003, 17:15	2.67
C147C	2.63	810.1	01Jan2003, 17:15	2.81
C147C REACH	4.53	605.4	01Jan2003, 21:00	2.76
C147 DETENTION	4.53	606.8	01Jan2003, 20:30	2.76
C161	2.39	346.0	01Jan2003, 17:45	2.27
C162	0.97	191.1	01Jan2003, 17:00	2.75
DET#1	4.53	606.8	01Jan2003, 20:30	2.76
DET#2	4.53	859.9	01Jan2003, 17:15	2.77
DETENTION REACH#1	5.07	928.0	01Jan2003, 18:45	2.69
DETENTION REACH#2	3.23	539.8	01Jan2003, 18:45	2.59
Outlet	93.51	11236.5	01Jan2003, 23:30	2.77

5-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_5

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(20%Flood)
 Compute Time: 03Sep2015, 14:50:34 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	17579.6	01Jan2003, 22:30	4.17
C100#10	44.95	10135.7	01Jan2003, 20:15	3.97
C100#11	42.97	9727.8	01Jan2003, 20:15	3.96
C100#12	40.83	9303.6	01Jan2003, 20:00	3.96
C100#13	34.73	8508.3	01Jan2003, 19:30	4.08
C100#14	32.50	8121.1	01Jan2003, 19:15	4.14
C100#15	28.36	7029.7	01Jan2003, 19:15	4.17
C100#16	23.73	5882.2	01Jan2003, 19:15	4.21
C100#17	21.75	5420.4	01Jan2003, 19:00	4.23
C100#18	20.73	5174.8	01Jan2003, 19:00	4.24
C100#19	18.31	4478.9	01Jan2003, 19:00	4.23
C100#2	87.76	17070.4	01Jan2003, 22:15	4.14
C100#20	15.07	3648.4	01Jan2003, 19:15	4.16
C100#21	7.91	2023.2	01Jan2003, 19:15	4.09
C100#22	5.07	1452.6	01Jan2003, 18:15	4.14
C100#23	3.23	835.9	01Jan2003, 17:30	4.02
C100#24	2.26	569.2	01Jan2003, 17:15	3.94
C100#3	86.15	16925.2	01Jan2003, 22:15	4.12
C100#4	68.69	13598.3	01Jan2003, 22:45	3.99
C100#5	65.31	13236.2	01Jan2003, 22:15	3.96
C100#6	63.55	13022.4	01Jan2003, 21:45	3.96
C100#7	57.28	12349.6	01Jan2003, 21:15	3.98
C100#8	55.05	11992.0	01Jan2003, 21:00	3.99
C100#9	48.74	10867.5	01Jan2003, 20:45	3.99
C100#D1	5.07	1383.6	01Jan2003, 19:00	4.14

5-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	809.3	01Jan2003, 18:15	4.02
C100A	2.26	569.2	01Jan2003, 17:15	3.94
C100B	1.84	812.6	01Jan2003, 16:45	4.35
C100B REACH#1	3.23	809.3	01Jan2003, 18:15	4.02
C100B REACH#2	2.26	566.1	01Jan2003, 17:30	3.94
C100C	2.84	746.5	01Jan2003, 17:15	4.01
C100D	2.42	835.2	01Jan2003, 17:15	4.37
C100D REACH#1	18.31	4478.6	01Jan2003, 19:15	4.23
C100D REACH#2	15.07	3645.5	01Jan2003, 19:15	4.16
C100D REACH#3	7.91	2022.2	01Jan2003, 19:15	4.09
C100E	2.24	771.1	01Jan2003, 18:15	4.52
C100E REACH#1	23.73	5869.7	01Jan2003, 19:30	4.20
C100E REACH#2	21.75	5405.2	01Jan2003, 19:15	4.22
C100E REACH#3	20.73	5168.9	01Jan2003, 19:15	4.24
C100F	2.58	894.4	01Jan2003, 17:45	3.92
C100F REACH	28.36	7014.5	01Jan2003, 19:30	4.17
C100G	2.23	499.2	01Jan2003, 17:15	3.20
C100G REACH	32.50	8097.9	01Jan2003, 19:30	4.14
C100H	1.98	1012.2	01Jan2003, 16:45	4.32
C100H REACH#1	42.97	9703.3	01Jan2003, 20:30	3.95
C100H REACH#2	40.83	9255.5	01Jan2003, 20:15	3.96
C100I	3.79	1512.1	01Jan2003, 17:00	4.29
C100I REACH	44.95	10064.0	01Jan2003, 21:00	3.96
C100J	6.27	857.0	01Jan2003, 18:45	3.87
C100J REACH	57.28	12239.5	01Jan2003, 21:45	3.97
C100K	1.76	704.9	01Jan2003, 17:15	4.24
C100K#1	1.76	704.9	01Jan2003, 17:15	4.24
C100L	3.38	1766.8	01Jan2003, 17:00	4.76
C100L REACH#1	65.31	13133.9	01Jan2003, 22:45	3.95
C100L REACH#2	63.55	12954.9	01Jan2003, 22:15	3.95
C100M	1.76	597.0	01Jan2003, 18:00	4.98

5-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	17558.7	01Jan2003, 23:00	4.16
C100M REACH#2	87.76	17014.5	01Jan2003, 22:30	4.13
C100M REACH#3	86.15	16908.1	01Jan2003, 22:15	4.12
C100M REACH#4	68.69	13597.5	01Jan2003, 22:45	3.99
C100 REACH	5.07	1376.1	01Jan2003, 19:30	4.13
C102#1	2.90	556.0	01Jan2003, 18:00	4.79
C102#OULET	3.99	1179.8	01Jan2003, 16:45	4.91
C102A	2.90	556.0	01Jan2003, 18:00	4.79
C102B	1.09	948.2	01Jan2003, 16:45	5.28
C102B REACH	2.90	558.1	01Jan2003, 18:00	4.77
C103	1.61	1241.1	01Jan2003, 16:45	5.04
C106-00#1	14.39	5342.8	01Jan2003, 18:00	4.67
C106-00#2	9.59	4039.9	01Jan2003, 17:15	4.71
C106-00#3	4.84	1861.8	01Jan2003, 17:00	4.67
C106-00#OUTLET	17.46	6409.0	01Jan2003, 18:30	4.63
C106-01#1	2.78	853.1	01Jan2003, 17:15	4.46
C106-01#OUTLET	4.80	1477.0	01Jan2003, 18:15	4.58
C106-08#OUTLET	1.82	825.3	01Jan2003, 17:00	4.75
C106A	1.82	825.3	01Jan2003, 17:00	4.75
C106B	3.02	1054.2	01Jan2003, 17:15	4.62
C106C	1.89	1314.1	01Jan2003, 16:45	4.75
C106C REACH	4.84	1845.2	01Jan2003, 17:30	4.67
C106D	2.86	1072.7	01Jan2003, 17:00	4.76
C106E	2.78	853.1	01Jan2003, 17:15	4.46
C106F	2.02	683.8	01Jan2003, 17:15	4.74
C106F REACH	2.78	839.3	01Jan2003, 18:30	4.46
C106G	3.07	1506.5	01Jan2003, 17:00	4.48
C106G REACH#1	14.39	5239.1	01Jan2003, 18:30	4.67
C106G REACH#2	9.59	3963.3	01Jan2003, 17:45	4.71
C118	3.87	825.4	01Jan2003, 18:15	4.25
C120	2.23	686.7	01Jan2003, 17:00	3.66

5-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	11964.2	01Jan2003, 21:15	3.99
C123	2.44	825.2	01Jan2003, 17:45	3.73
C123 REACH	48.74	10806.8	01Jan2003, 21:00	3.99
C127	2.14	839.2	01Jan2003, 17:00	3.93
C132	4.07	615.9	01Jan2003, 17:45	3.41
C134	2.03	300.1	01Jan2003, 19:00	3.18
C134 REACH	34.73	8450.5	01Jan2003, 20:00	4.07
C137	1.56	501.0	01Jan2003, 17:00	3.90
C143	1.98	594.5	01Jan2003, 17:00	4.01
C144	1.02	316.0	01Jan2003, 17:00	3.87
C145#1	1.86	533.3	01Jan2003, 17:15	4.70
C145#OUTLET	3.24	982.7	01Jan2003, 17:00	4.53
C145A	1.86	533.3	01Jan2003, 17:15	4.70
C145B	1.38	450.0	01Jan2003, 17:00	4.31
C147#1	1.82	507.7	01Jan2003, 17:15	4.44
C147#2	2.71	717.2	01Jan2003, 17:15	4.11
C147#OUTLET	7.16	1630.0	01Jan2003, 19:00	4.24
C147A	1.82	507.7	01Jan2003, 17:15	4.44
C147B	2.71	717.2	01Jan2003, 17:15	4.11
C147C	2.63	1135.9	01Jan2003, 17:15	4.29
C147C REACH	4.53	909.0	01Jan2003, 21:15	4.22
C147 DETENTION	4.53	911.0	01Jan2003, 20:45	4.22
C161	2.39	507.3	01Jan2003, 17:45	3.53
C162	0.97	271.7	01Jan2003, 17:15	4.21
DET#1	4.53	911.0	01Jan2003, 20:45	4.22
DET#2	4.53	1225.0	01Jan2003, 17:15	4.24
DETENTION REACH#1	5.07	1383.6	01Jan2003, 19:00	4.14
DETENTION REACH#2	3.23	802.3	01Jan2003, 18:45	4.02
Outlet	93.51	17887.2	01Jan2003, 22:45	4.18

10-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_10

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(10%flood)
 Compute Time: 03Sep2015, 14:49:34 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	22231.3	01Jan2003, 22:45	5.26
C100#10	44.95	12816.8	01Jan2003, 20:15	5.06
C100#11	42.97	12284.2	01Jan2003, 20:15	5.04
C100#12	40.83	11731.1	01Jan2003, 20:00	5.05
C100#13	34.73	10712.3	01Jan2003, 19:30	5.19
C100#14	32.50	10209.4	01Jan2003, 19:15	5.26
C100#15	28.36	8823.7	01Jan2003, 19:15	5.30
C100#16	23.73	7374.2	01Jan2003, 19:15	5.34
C100#17	21.75	6783.9	01Jan2003, 19:00	5.37
C100#18	20.73	6465.4	01Jan2003, 19:00	5.39
C100#19	18.31	5597.2	01Jan2003, 19:15	5.37
C100#2	87.76	21643.7	01Jan2003, 22:15	5.23
C100#20	15.07	4568.5	01Jan2003, 19:15	5.30
C100#21	7.91	2536.6	01Jan2003, 19:15	5.23
C100#22	5.07	1812.2	01Jan2003, 18:00	5.28
C100#23	3.23	1035.1	01Jan2003, 17:30	5.15
C100#24	2.26	706.0	01Jan2003, 17:15	5.07
C100#3	86.15	21478.3	01Jan2003, 22:15	5.21
C100#4	68.69	17323.8	01Jan2003, 22:30	5.07
C100#5	65.31	16888.3	01Jan2003, 22:00	5.03
C100#6	63.55	16607.4	01Jan2003, 21:45	5.03
C100#7	57.28	15767.5	01Jan2003, 21:00	5.06
C100#8	55.05	15267.5	01Jan2003, 20:45	5.08
C100#9	48.74	13785.0	01Jan2003, 20:45	5.08
C100#D1	5.07	1728.3	01Jan2003, 19:00	5.28

10-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1010.2	01Jan2003, 18:15	5.15
C100A	2.26	706.0	01Jan2003, 17:15	5.07
C100B	1.84	983.6	01Jan2003, 16:45	5.52
C100B REACH#1	3.23	1010.2	01Jan2003, 18:15	5.15
C100B REACH#2	2.26	703.6	01Jan2003, 17:45	5.06
C100C	2.84	925.1	01Jan2003, 17:15	5.14
C100D	2.42	1021.1	01Jan2003, 17:15	5.53
C100D REACH#1	18.31	5598.6	01Jan2003, 19:15	5.37
C100D REACH#2	15.07	4563.5	01Jan2003, 19:15	5.30
C100D REACH#3	7.91	2534.7	01Jan2003, 19:15	5.22
C100E	2.24	945.5	01Jan2003, 18:15	5.65
C100E REACH#1	23.73	7362.8	01Jan2003, 19:15	5.34
C100E REACH#2	21.75	6768.3	01Jan2003, 19:15	5.37
C100E REACH#3	20.73	6459.1	01Jan2003, 19:15	5.39
C100F	2.58	1105.8	01Jan2003, 17:45	4.99
C100F REACH	28.36	8805.2	01Jan2003, 19:30	5.30
C100G	2.23	630.4	01Jan2003, 17:15	4.20
C100G REACH	32.50	10174.7	01Jan2003, 19:30	5.25
C100H	1.98	1222.9	01Jan2003, 17:00	5.43
C100H REACH#1	42.97	12260.0	01Jan2003, 20:30	5.04
C100H REACH#2	40.83	11678.1	01Jan2003, 20:15	5.05
C100I	3.79	1839.5	01Jan2003, 17:00	5.40
C100I REACH	44.95	12755.6	01Jan2003, 20:45	5.05
C100J	6.27	1066.1	01Jan2003, 19:00	4.86
C100J REACH	57.28	15625.8	01Jan2003, 21:45	5.05
C100K	1.76	861.4	01Jan2003, 17:15	5.34
C100K#1	1.76	861.4	01Jan2003, 17:15	5.34
C100L	3.38	2119.1	01Jan2003, 17:00	5.92
C100L REACH#1	65.31	16742.3	01Jan2003, 22:45	5.02
C100L REACH#2	63.55	16513.9	01Jan2003, 22:15	5.02
C100M	1.76	725.6	01Jan2003, 18:00	6.16

10-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	22216.4	01Jan2003, 23:00	5.25
C100M REACH#2	87.76	21560.7	01Jan2003, 22:45	5.22
C100M REACH#3	86.15	21450.0	01Jan2003, 22:30	5.21
C100M REACH#4	68.69	17327.6	01Jan2003, 22:45	5.07
C100 REACH	5.07	1719.6	01Jan2003, 19:30	5.27
C102#1	2.90	679.7	01Jan2003, 18:00	5.92
C102#OULET	3.99	1485.7	01Jan2003, 17:30	6.06
C102A	2.90	679.7	01Jan2003, 18:00	5.92
C102B	1.09	1115.7	01Jan2003, 16:45	6.49
C102B REACH	2.90	679.5	01Jan2003, 18:30	5.89
C103	1.61	1468.1	01Jan2003, 16:45	6.23
C106-00#1	14.39	6539.0	01Jan2003, 17:45	5.82
C106-00#2	9.59	4924.0	01Jan2003, 17:15	5.88
C106-00#3	4.84	2264.4	01Jan2003, 17:15	5.83
C106-00#OUTLET	17.46	7852.4	01Jan2003, 18:30	5.78
C106-01#1	2.78	1044.8	01Jan2003, 17:15	5.58
C106-01#OUTLET	4.80	1812.2	01Jan2003, 18:15	5.72
C106-08#OUTLET	1.82	996.8	01Jan2003, 17:00	5.91
C106A	1.82	996.8	01Jan2003, 17:00	5.91
C106B	3.02	1282.8	01Jan2003, 17:15	5.78
C106C	1.89	1560.1	01Jan2003, 16:45	5.92
C106C REACH	4.84	2247.9	01Jan2003, 17:30	5.83
C106D	2.86	1302.2	01Jan2003, 17:15	5.93
C106E	2.78	1044.8	01Jan2003, 17:15	5.58
C106F	2.02	830.2	01Jan2003, 17:15	5.90
C106F REACH	2.78	1031.2	01Jan2003, 18:30	5.58
C106G	3.07	1816.3	01Jan2003, 17:00	5.60
C106G REACH#1	14.39	6401.2	01Jan2003, 18:45	5.82
C106G REACH#2	9.59	4835.3	01Jan2003, 17:45	5.88
C118	3.87	1021.4	01Jan2003, 18:15	5.34
C120	2.23	852.8	01Jan2003, 17:15	4.70

10-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	15247.0	01Jan2003, 21:00	5.08
C123	2.44	1025.1	01Jan2003, 17:45	4.78
C123 REACH	48.74	13736.2	01Jan2003, 21:00	5.07
C127	2.14	1030.2	01Jan2003, 17:00	5.00
C132	4.07	777.3	01Jan2003, 18:00	4.39
C134	2.03	382.5	01Jan2003, 19:15	4.14
C134 REACH	34.73	10631.8	01Jan2003, 20:00	5.18
C137	1.56	618.0	01Jan2003, 17:00	4.97
C143	1.98	732.7	01Jan2003, 17:00	5.09
C144	1.02	390.2	01Jan2003, 17:00	4.94
C145#1	1.86	652.0	01Jan2003, 17:15	5.88
C145#OUTLET	3.24	1200.4	01Jan2003, 17:15	5.70
C145A	1.86	652.0	01Jan2003, 17:15	5.88
C145B	1.38	551.8	01Jan2003, 17:00	5.47
C147#1	1.82	623.1	01Jan2003, 17:15	5.61
C147#2	2.71	886.5	01Jan2003, 17:30	5.25
C147#OUTLET	7.16	2034.0	01Jan2003, 19:00	5.39
C147A	1.82	623.1	01Jan2003, 17:15	5.61
C147B	2.71	886.5	01Jan2003, 17:30	5.25
C147C	2.63	1382.1	01Jan2003, 17:15	5.45
C147C REACH	4.53	1171.4	01Jan2003, 21:00	5.36
C147 DETENTION	4.53	1175.5	01Jan2003, 20:30	5.37
C161	2.39	636.4	01Jan2003, 18:00	4.56
C162	0.97	334.7	01Jan2003, 17:15	5.36
DET#1	4.53	1175.5	01Jan2003, 20:30	5.37
DET#2	4.53	1508.0	01Jan2003, 17:30	5.39
DETENTION REACH#1	5.07	1728.3	01Jan2003, 19:00	5.28
DETENTION REACH#2	3.23	1003.1	01Jan2003, 18:45	5.15
Outlet	93.51	22614.3	01Jan2003, 23:00	5.27

25-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_25

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(4%Flood)
 Compute Time: 03Sep2015, 14:50:16 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	30972.7	01Jan2003, 22:00	7.08
C100#10	44.95	17049.9	01Jan2003, 20:15	6.89
C100#11	42.97	16317.3	01Jan2003, 20:15	6.87
C100#12	40.83	15544.5	01Jan2003, 20:15	6.88
C100#13	34.73	14132.6	01Jan2003, 19:45	7.05
C100#14	32.50	13432.4	01Jan2003, 19:30	7.13
C100#15	28.36	11627.1	01Jan2003, 19:15	7.18
C100#16	23.73	9740.1	01Jan2003, 19:15	7.23
C100#17	21.75	8968.6	01Jan2003, 19:15	7.27
C100#18	20.73	8549.1	01Jan2003, 19:15	7.29
C100#19	18.31	7434.1	01Jan2003, 19:15	7.27
C100#2	87.76	30121.5	01Jan2003, 21:45	7.05
C100#20	15.07	6096.7	01Jan2003, 19:30	7.20
C100#21	7.91	3329.4	01Jan2003, 19:15	7.12
C100#22	5.07	2350.6	01Jan2003, 18:15	7.17
C100#23	3.23	1336.1	01Jan2003, 17:45	7.04
C100#24	2.26	911.1	01Jan2003, 17:30	6.94
C100#3	86.15	29815.1	01Jan2003, 21:45	7.03
C100#4	68.69	23680.6	01Jan2003, 22:00	6.87
C100#5	65.31	22868.3	01Jan2003, 21:45	6.83
C100#6	63.55	22376.5	01Jan2003, 21:30	6.83
C100#7	57.28	21182.8	01Jan2003, 20:45	6.88
C100#8	55.05	20465.8	01Jan2003, 20:45	6.90
C100#9	48.74	18406.6	01Jan2003, 20:30	6.90
C100#D1	5.07	2257.8	01Jan2003, 19:00	7.17

25-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1311.3	01Jan2003, 18:30	7.03
C100A	2.26	911.1	01Jan2003, 17:30	6.94
C100B	1.84	1236.7	01Jan2003, 16:45	7.44
C100B REACH#1	3.23	1311.3	01Jan2003, 18:30	7.03
C100B REACH#2	2.26	909.7	01Jan2003, 17:45	6.94
C100C	2.84	1189.5	01Jan2003, 17:30	7.02
C100D	2.42	1294.7	01Jan2003, 17:15	7.45
C100D REACH#1	18.31	7426.6	01Jan2003, 19:30	7.27
C100D REACH#2	15.07	6096.7	01Jan2003, 19:30	7.20
C100D REACH#3	7.91	3323.3	01Jan2003, 19:15	7.11
C100E	2.24	1207.2	01Jan2003, 18:15	7.54
C100E REACH#1	23.73	9730.3	01Jan2003, 19:30	7.23
C100E REACH#2	21.75	8947.6	01Jan2003, 19:30	7.26
C100E REACH#3	20.73	8543.3	01Jan2003, 19:15	7.29
C100F	2.58	1420.2	01Jan2003, 17:45	6.81
C100F REACH	28.36	11601.1	01Jan2003, 19:45	7.17
C100G	2.23	828.4	01Jan2003, 17:30	5.93
C100G REACH	32.50	13410.5	01Jan2003, 19:45	7.12
C100H	1.98	1536.0	01Jan2003, 17:00	7.29
C100H REACH#1	42.97	16296.5	01Jan2003, 20:30	6.87
C100H REACH#2	40.83	15501.7	01Jan2003, 20:30	6.87
C100I	3.79	2326.5	01Jan2003, 17:00	7.26
C100I REACH	44.95	16999.7	01Jan2003, 20:45	6.88
C100J	6.27	1397.5	01Jan2003, 19:30	6.49
C100J REACH	57.28	21052.8	01Jan2003, 21:30	6.87
C100K	1.76	1092.2	01Jan2003, 17:15	7.20
C100K#1	1.76	1092.2	01Jan2003, 17:15	7.20
C100L	3.38	2641.7	01Jan2003, 17:00	7.83
C100L REACH#1	65.31	22753.7	01Jan2003, 22:15	6.82
C100L REACH#2	63.55	22327.0	01Jan2003, 21:45	6.82
C100M	1.76	917.8	01Jan2003, 18:00	8.09

25-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	30895.9	01Jan2003, 22:30	7.07
C100M REACH#2	87.76	30021.3	01Jan2003, 22:00	7.04
C100M REACH#3	86.15	29797.3	01Jan2003, 21:45	7.03
C100M REACH#4	68.69	23664.7	01Jan2003, 22:00	6.86
C100 REACH	5.07	2246.8	01Jan2003, 19:30	7.17
C102#1	2.90	872.1	01Jan2003, 18:30	7.74
C102#OULET	3.99	1907.8	01Jan2003, 17:15	7.91
C102A	2.90	872.1	01Jan2003, 18:30	7.74
C102B	1.09	1358.9	01Jan2003, 16:45	8.46
C102B REACH	2.90	871.4	01Jan2003, 19:00	7.71
C103	1.61	1800.2	01Jan2003, 16:45	8.17
C106-00#1	14.39	8278.1	01Jan2003, 17:45	7.73
C106-00#2	9.59	6186.6	01Jan2003, 17:15	7.80
C106-00#3	4.84	2855.3	01Jan2003, 17:15	7.75
C106-00#OUTLET	17.46	10009.5	01Jan2003, 18:30	7.69
C106-01#1	2.78	1328.7	01Jan2003, 17:15	7.46
C106-01#OUTLET	4.80	2279.8	01Jan2003, 18:15	7.60
C106-08#OUTLET	1.82	1248.5	01Jan2003, 17:00	7.84
C106A	1.82	1248.5	01Jan2003, 17:00	7.84
C106B	3.02	1621.2	01Jan2003, 17:15	7.69
C106C	1.89	1924.6	01Jan2003, 16:45	7.85
C106C REACH	4.84	2836.2	01Jan2003, 17:30	7.75
C106D	2.86	1640.8	01Jan2003, 17:15	7.86
C106E	2.78	1328.7	01Jan2003, 17:15	7.46
C106F	2.02	1049.9	01Jan2003, 17:30	7.80
C106F REACH	2.78	1302.9	01Jan2003, 19:15	7.46
C106G	3.07	2277.1	01Jan2003, 17:00	7.48
C106G REACH#1	14.39	8125.8	01Jan2003, 18:45	7.73
C106G REACH#2	9.59	6103.2	01Jan2003, 17:45	7.80
C118	3.87	1321.6	01Jan2003, 18:30	7.16
C120	2.23	1099.8	01Jan2003, 17:15	6.50

25-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	20429.9	01Jan2003, 20:45	6.90
C123	2.44	1322.1	01Jan2003, 17:45	6.58
C123 REACH	48.74	18361.4	01Jan2003, 20:45	6.90
C127	2.14	1311.7	01Jan2003, 17:00	6.82
C132	4.07	1031.0	01Jan2003, 18:30	6.06
C134	2.03	512.0	01Jan2003, 19:30	5.79
C134 REACH	34.73	14066.5	01Jan2003, 20:15	7.04
C137	1.56	791.2	01Jan2003, 17:00	6.79
C143	1.98	939.0	01Jan2003, 17:15	6.92
C144	1.02	500.3	01Jan2003, 17:00	6.75
C145#1	1.86	827.0	01Jan2003, 17:30	7.82
C145#OUTLET	3.24	1526.3	01Jan2003, 17:15	7.63
C145A	1.86	827.0	01Jan2003, 17:30	7.82
C145B	1.38	700.9	01Jan2003, 17:00	7.38
C147#1	1.82	794.7	01Jan2003, 17:30	7.53
C147#2	2.71	1138.9	01Jan2003, 17:30	7.14
C147#OUTLET	7.16	2775.5	01Jan2003, 19:30	7.29
C147A	1.82	794.7	01Jan2003, 17:30	7.53
C147B	2.71	1138.9	01Jan2003, 17:30	7.14
C147C	2.63	1743.4	01Jan2003, 17:15	7.36
C147C REACH	4.53	1621.3	01Jan2003, 20:45	7.25
C147 DETENTION	4.53	1630.5	01Jan2003, 20:15	7.26
C161	2.39	834.8	01Jan2003, 18:00	6.32
C162	0.97	428.3	01Jan2003, 17:30	7.27
DET#1	4.53	1630.5	01Jan2003, 20:15	7.26
DET#2	4.53	1933.6	01Jan2003, 17:30	7.30
DETENTION REACH#1	5.07	2257.8	01Jan2003, 19:00	7.17
DETENTION REACH#2	3.23	1305.6	01Jan2003, 18:45	7.03
Outlet	93.51	31480.4	01Jan2003, 22:15	7.09

50-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_50

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(2%flood)
 Compute Time: 03Sep2015, 14:50:48 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	37449.0	01Jan2003, 22:00	8.71
C100#10	44.95	20717.4	01Jan2003, 20:15	8.53
C100#11	42.97	19799.2	01Jan2003, 20:15	8.52
C100#12	40.83	18837.4	01Jan2003, 20:15	8.53
C100#13	34.73	17084.1	01Jan2003, 19:45	8.72
C100#14	32.50	16224.1	01Jan2003, 19:30	8.80
C100#15	28.36	14052.1	01Jan2003, 19:30	8.86
C100#16	23.73	11798.6	01Jan2003, 19:30	8.92
C100#17	21.75	10869.3	01Jan2003, 19:15	8.95
C100#18	20.73	10368.9	01Jan2003, 19:15	8.98
C100#19	18.31	9035.7	01Jan2003, 19:15	8.96
C100#2	87.76	36500.0	01Jan2003, 21:15	8.69
C100#20	15.07	7445.3	01Jan2003, 19:30	8.88
C100#21	7.91	3993.0	01Jan2003, 19:15	8.80
C100#22	5.07	2789.2	01Jan2003, 18:15	8.86
C100#23	3.23	1595.5	01Jan2003, 17:45	8.71
C100#24	2.26	1089.5	01Jan2003, 17:45	8.62
C100#3	86.15	36054.3	01Jan2003, 21:15	8.67
C100#4	68.69	28564.2	01Jan2003, 22:30	8.49
C100#5	65.31	27727.4	01Jan2003, 22:00	8.45
C100#6	63.55	27166.4	01Jan2003, 21:30	8.45
C100#7	57.28	25751.3	01Jan2003, 20:45	8.52
C100#8	55.05	24854.8	01Jan2003, 20:30	8.55
C100#9	48.74	22280.0	01Jan2003, 20:15	8.55
C100#D1	5.07	2699.4	01Jan2003, 19:00	8.86

50-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1572.6	01Jan2003, 18:30	8.71
C100A	2.26	1089.5	01Jan2003, 17:45	8.62
C100B	1.84	1445.6	01Jan2003, 16:45	9.14
C100B REACH#1	3.23	1572.6	01Jan2003, 18:30	8.71
C100B REACH#2	2.26	1088.1	01Jan2003, 18:00	8.61
C100C	2.84	1419.9	01Jan2003, 17:30	8.70
C100D	2.42	1527.4	01Jan2003, 17:30	9.16
C100D REACH#1	18.31	9032.6	01Jan2003, 19:30	8.96
C100D REACH#2	15.07	7437.2	01Jan2003, 19:30	8.88
C100D REACH#3	7.91	3986.0	01Jan2003, 19:15	8.80
C100E	2.24	1427.8	01Jan2003, 18:15	9.23
C100E REACH#1	23.73	11777.0	01Jan2003, 19:30	8.92
C100E REACH#2	21.75	10843.2	01Jan2003, 19:30	8.95
C100E REACH#3	20.73	10355.7	01Jan2003, 19:30	8.98
C100F	2.58	1684.1	01Jan2003, 17:45	8.47
C100F REACH	28.36	14025.6	01Jan2003, 19:45	8.85
C100G	2.23	1000.0	01Jan2003, 17:45	7.54
C100G REACH	32.50	16192.9	01Jan2003, 19:45	8.80
C100H	1.98	1793.0	01Jan2003, 17:00	8.97
C100H REACH#1	42.97	19778.4	01Jan2003, 20:30	8.51
C100H REACH#2	40.83	18796.6	01Jan2003, 20:30	8.52
C100I	3.79	2731.3	01Jan2003, 17:15	8.94
C100I REACH	44.95	20566.4	01Jan2003, 21:00	8.52
C100J	6.27	1681.0	01Jan2003, 19:30	7.95
C100J REACH	57.28	25554.4	01Jan2003, 21:30	8.50
C100K	1.76	1284.0	01Jan2003, 17:15	8.87
C100K#1	1.76	1284.0	01Jan2003, 17:15	8.87
C100L	3.38	3071.4	01Jan2003, 17:00	9.54
C100L REACH#1	65.31	27536.2	01Jan2003, 22:45	8.43
C100L REACH#2	63.55	27082.7	01Jan2003, 22:00	8.44
C100M	1.76	1080.3	01Jan2003, 18:00	9.81

50-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	37414.7	01Jan2003, 22:30	8.70
C100M REACH#2	87.76	36281.6	01Jan2003, 22:00	8.67
C100M REACH#3	86.15	36018.5	01Jan2003, 21:30	8.66
C100M REACH#4	68.69	28559.4	01Jan2003, 22:30	8.48
C100 REACH	5.07	2686.8	01Jan2003, 19:30	8.85
C102#1	2.90	1036.8	01Jan2003, 18:30	9.36
C102#OULET	3.99	2223.1	01Jan2003, 17:15	9.56
C102A	2.90	1036.8	01Jan2003, 18:30	9.36
C102B	1.09	1554.3	01Jan2003, 16:45	10.19
C102B REACH	2.90	1036.2	01Jan2003, 19:00	9.32
C103	1.61	2068.1	01Jan2003, 16:45	9.89
C106-00#1	14.39	9648.0	01Jan2003, 17:45	9.44
C106-00#2	9.59	7236.2	01Jan2003, 17:15	9.51
C106-00#3	4.84	3350.0	01Jan2003, 17:15	9.45
C106-00#OUTLET	17.46	11634.1	01Jan2003, 18:30	9.39
C106-01#1	2.78	1572.4	01Jan2003, 17:30	9.15
C106-01#OUTLET	4.80	2649.2	01Jan2003, 19:00	9.30
C106-08#OUTLET	1.82	1456.8	01Jan2003, 17:00	9.55
C106A	1.82	1456.8	01Jan2003, 17:00	9.55
C106B	3.02	1910.4	01Jan2003, 17:30	9.40
C106C	1.89	2219.8	01Jan2003, 16:45	9.56
C106C REACH	4.84	3328.7	01Jan2003, 17:30	9.45
C106D	2.86	1924.6	01Jan2003, 17:15	9.57
C106E	2.78	1572.4	01Jan2003, 17:30	9.15
C106F	2.02	1236.7	01Jan2003, 17:30	9.51
C106F REACH	2.78	1536.0	01Jan2003, 19:30	9.14
C106G	3.07	2656.3	01Jan2003, 17:00	9.17
C106G REACH#1	14.39	9454.3	01Jan2003, 18:45	9.44
C106G REACH#2	9.59	7166.0	01Jan2003, 17:45	9.51
C118	3.87	1579.7	01Jan2003, 18:30	8.79
C120	2.23	1307.0	01Jan2003, 17:15	8.14

50-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	24817.5	01Jan2003, 20:45	8.54
C123	2.44	1571.4	01Jan2003, 17:45	8.23
C123 REACH	48.74	22251.9	01Jan2003, 20:45	8.54
C127	2.14	1545.0	01Jan2003, 17:00	8.48
C132	4.07	1251.0	01Jan2003, 18:30	7.59
C134	2.03	623.3	01Jan2003, 19:30	7.30
C134 REACH	34.73	17022.9	01Jan2003, 20:15	8.71
C137	1.56	938.3	01Jan2003, 17:15	8.45
C143	1.98	1115.3	01Jan2003, 17:15	8.58
C144	1.02	594.6	01Jan2003, 17:15	8.41
C145#1	1.86	979.6	01Jan2003, 17:30	9.53
C145#OUTLET	3.24	1803.9	01Jan2003, 17:30	9.34
C145A	1.86	979.6	01Jan2003, 17:30	9.53
C145B	1.38	828.1	01Jan2003, 17:15	9.08
C147#1	1.82	943.2	01Jan2003, 17:30	9.23
C147#2	2.71	1358.6	01Jan2003, 17:45	8.82
C147#OUTLET	7.16	3460.6	01Jan2003, 19:45	8.98
C147A	1.82	943.2	01Jan2003, 17:30	9.23
C147B	2.71	1358.6	01Jan2003, 17:45	8.82
C147C	2.63	2043.8	01Jan2003, 17:15	9.06
C147C REACH	4.53	2038.8	01Jan2003, 20:30	8.93
C147 DETENTION	4.53	2070.2	01Jan2003, 19:45	8.94
C161	2.39	1006.6	01Jan2003, 18:15	7.93
C162	0.97	509.4	01Jan2003, 17:30	8.96
DET#1	4.53	2070.2	01Jan2003, 19:45	8.94
DET#2	4.53	2301.3	01Jan2003, 17:45	8.99
DETENTION REACH#1	5.07	2699.4	01Jan2003, 19:00	8.86
DETENTION REACH#2	3.23	1559.6	01Jan2003, 19:00	8.70
Outlet	93.51	38105.5	01Jan2003, 22:30	8.72

100-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_100

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(1%flood)
 Compute Time: 03Sep2015, 14:48:50 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	43124.1	01Jan2003, 22:00	10.48
C100#10	44.95	24835.5	01Jan2003, 20:30	10.31
C100#11	42.97	23878.3	01Jan2003, 20:30	10.29
C100#12	40.83	22760.2	01Jan2003, 20:15	10.30
C100#13	34.73	20618.8	01Jan2003, 19:45	10.52
C100#14	32.50	19577.7	01Jan2003, 19:45	10.61
C100#15	28.36	17000.6	01Jan2003, 19:30	10.66
C100#16	23.73	14318.3	01Jan2003, 19:30	10.73
C100#17	21.75	13216.6	01Jan2003, 19:30	10.77
C100#18	20.73	12609.2	01Jan2003, 19:30	10.80
C100#19	18.31	11037.7	01Jan2003, 19:30	10.77
C100#2	87.76	41876.8	01Jan2003, 21:45	10.45
C100#20	15.07	9162.5	01Jan2003, 19:30	10.69
C100#21	7.91	4779.7	01Jan2003, 19:15	10.60
C100#22	5.07	3306.4	01Jan2003, 18:15	10.67
C100#23	3.23	1890.7	01Jan2003, 18:00	10.52
C100#24	2.26	1292.4	01Jan2003, 17:45	10.41
C100#3	86.15	41393.5	01Jan2003, 21:30	10.43
C100#4	68.69	33139.4	01Jan2003, 23:15	10.24
C100#5	65.31	32271.1	01Jan2003, 22:45	10.20
C100#6	63.55	31721.7	01Jan2003, 22:15	10.20
C100#7	57.28	30000.8	01Jan2003, 21:30	10.30
C100#8	55.05	29038.6	01Jan2003, 21:30	10.32
C100#9	48.74	26316.6	01Jan2003, 21:15	10.33
C100#D1	5.07	3219.9	01Jan2003, 19:00	10.66

100-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	1868.9	01Jan2003, 18:30	10.51
C100A	2.26	1292.4	01Jan2003, 17:45	10.41
C100B	1.84	1688.3	01Jan2003, 16:45	10.96
C100B REACH#1	3.23	1868.9	01Jan2003, 18:30	10.51
C100B REACH#2	2.26	1291.1	01Jan2003, 18:00	10.41
C100C	2.84	1681.9	01Jan2003, 17:45	10.51
C100D	2.42	1793.9	01Jan2003, 17:30	10.98
C100D REACH#1	18.31	11035.4	01Jan2003, 19:30	10.77
C100D REACH#2	15.07	9134.6	01Jan2003, 19:45	10.69
C100D REACH#3	7.91	4771.4	01Jan2003, 19:30	10.60
C100E	2.24	1680.6	01Jan2003, 18:15	11.05
C100E REACH#1	23.73	14302.3	01Jan2003, 19:45	10.73
C100E REACH#2	21.75	13178.7	01Jan2003, 19:45	10.76
C100E REACH#3	20.73	12610.1	01Jan2003, 19:30	10.79
C100F	2.58	1987.1	01Jan2003, 17:45	10.27
C100F REACH	28.36	16963.7	01Jan2003, 20:00	10.66
C100G	2.23	1198.8	01Jan2003, 17:45	9.30
C100G REACH	32.50	19551.1	01Jan2003, 20:00	10.60
C100H	1.98	2092.4	01Jan2003, 17:00	10.79
C100H REACH#1	42.97	23787.9	01Jan2003, 20:45	10.29
C100H REACH#2	40.83	22699.7	01Jan2003, 20:30	10.29
C100I	3.79	3204.3	01Jan2003, 17:15	10.75
C100I REACH	44.95	24497.0	01Jan2003, 21:30	10.29
C100J	6.27	2014.1	01Jan2003, 19:45	9.53
C100J REACH	57.28	29839.4	01Jan2003, 22:30	10.27
C100K	1.76	1505.9	01Jan2003, 17:15	10.68
C100K#1	1.76	1505.9	01Jan2003, 17:15	10.68
C100L	3.38	3572.6	01Jan2003, 17:00	11.37
C100L REACH#1	65.31	32100.5	01Jan2003, 23:30	10.18
C100L REACH#2	63.55	31602.3	01Jan2003, 23:00	10.18
C100M	1.76	1265.5	01Jan2003, 18:00	11.65

100-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	43097.2	01Jan2003, 22:30	10.46
C100M REACH#2	87.76	41754.3	01Jan2003, 22:15	10.44
C100M REACH#3	86.15	41382.3	01Jan2003, 21:45	10.43
C100M REACH#4	68.69	33140.4	01Jan2003, 23:15	10.23
C100 REACH	5.07	3206.2	01Jan2003, 19:30	10.66
C102#1	2.90	1228.5	01Jan2003, 19:00	11.10
C102#OULET	3.99	2572.3	01Jan2003, 17:15	11.32
C102A	2.90	1228.5	01Jan2003, 19:00	11.10
C102B	1.09	1785.4	01Jan2003, 16:45	12.05
C102B REACH	2.90	1227.5	01Jan2003, 19:15	11.05
C103	1.61	2384.0	01Jan2003, 16:45	11.73
C106-00#1	14.39	11149.2	01Jan2003, 17:45	11.27
C106-00#2	9.59	8442.8	01Jan2003, 17:15	11.34
C106-00#3	4.84	3918.0	01Jan2003, 17:15	11.29
C106-00#OUTLET	17.46	13574.6	01Jan2003, 18:30	11.22
C106-01#1	2.78	1850.7	01Jan2003, 17:30	10.97
C106-01#OUTLET	4.80	3129.3	01Jan2003, 19:15	11.12
C106-08#OUTLET	1.82	1698.5	01Jan2003, 17:00	11.38
C106A	1.82	1698.5	01Jan2003, 17:00	11.38
C106B	3.02	2240.6	01Jan2003, 17:30	11.23
C106C	1.89	2566.6	01Jan2003, 16:45	11.39
C106C REACH	4.84	3896.6	01Jan2003, 17:45	11.29
C106D	2.86	2250.3	01Jan2003, 17:15	11.40
C106E	2.78	1850.7	01Jan2003, 17:30	10.97
C106F	2.02	1449.7	01Jan2003, 17:30	11.34
C106F REACH	2.78	1813.1	01Jan2003, 19:30	10.96
C106G	3.07	3098.4	01Jan2003, 17:00	10.99
C106G REACH#1	14.39	11001.9	01Jan2003, 18:45	11.27
C106G REACH#2	9.59	8379.4	01Jan2003, 17:45	11.34
C118	3.87	1879.1	01Jan2003, 18:45	10.56
C120	2.23	1548.9	01Jan2003, 17:30	9.92

100-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	29008.2	01Jan2003, 21:45	10.31
C123	2.44	1857.8	01Jan2003, 17:45	10.02
C123 REACH	48.74	26213.2	01Jan2003, 21:45	10.32
C127	2.14	1815.9	01Jan2003, 17:00	10.28
C132	4.07	1511.3	01Jan2003, 19:00	9.25
C134	2.03	755.1	01Jan2003, 19:45	8.96
C134 REACH	34.73	20554.2	01Jan2003, 20:15	10.51
C137	1.56	1108.1	01Jan2003, 17:15	10.24
C143	1.98	1317.3	01Jan2003, 17:30	10.38
C144	1.02	702.7	01Jan2003, 17:15	10.20
C145#1	1.86	1151.7	01Jan2003, 17:45	11.36
C145#OUTLET	3.24	2122.3	01Jan2003, 17:30	11.17
C145A	1.86	1151.7	01Jan2003, 17:45	11.36
C145B	1.38	973.5	01Jan2003, 17:15	10.91
C147#1	1.82	1112.3	01Jan2003, 17:45	11.05
C147#2	2.71	1606.8	01Jan2003, 17:45	10.63
C147#OUTLET	7.16	4391.1	01Jan2003, 19:30	10.79
C147A	1.82	1112.3	01Jan2003, 17:45	11.05
C147B	2.71	1606.8	01Jan2003, 17:45	10.63
C147C	2.63	2389.8	01Jan2003, 17:15	10.88
C147C REACH	4.53	2558.7	01Jan2003, 20:00	10.73
C147 DETENTION	4.53	2597.3	01Jan2003, 19:15	10.75
C161	2.39	1204.8	01Jan2003, 18:30	9.69
C162	0.97	601.6	01Jan2003, 17:45	10.77
DET#1	4.53	2597.3	01Jan2003, 19:15	10.75
DET#2	4.53	2719.1	01Jan2003, 17:45	10.80
DETENTION REACH#1	5.07	3219.9	01Jan2003, 19:00	10.66
DETENTION REACH#2	3.23	1856.7	01Jan2003, 19:00	10.50
Outlet	93.51	43919.1	01Jan2003, 22:30	10.48

500-YEAR CORRECTED EFFECTIVE

Project: C100-00-00 Simulation Run: CorrectedEffective_500

Start of Run: 01Jan2003, 00:00 Basin Model: Corrected_Effective
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(.2%flood)
 Compute Time: 03Sep2015, 14:51:05 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	56758.2	01Jan2003, 20:45	15.92
C100#10	44.95	32724.3	01Jan2003, 23:30	15.80
C100#11	42.97	32224.7	01Jan2003, 22:45	15.78
C100#12	40.83	31522.5	01Jan2003, 22:00	15.79
C100#13	34.73	28736.2	01Jan2003, 21:00	16.07
C100#14	32.50	27579.1	01Jan2003, 19:45	16.17
C100#15	28.36	23908.4	01Jan2003, 20:15	16.24
C100#16	23.73	20247.6	01Jan2003, 20:30	16.32
C100#17	21.75	19484.0	01Jan2003, 19:45	16.36
C100#18	20.73	18654.0	01Jan2003, 19:30	16.39
C100#19	18.31	16469.5	01Jan2003, 19:15	16.36
C100#2	87.76	55534.9	01Jan2003, 19:45	15.90
C100#20	15.07	13901.1	01Jan2003, 19:00	16.27
C100#21	7.91	6992.1	01Jan2003, 19:15	16.19
C100#22	5.07	4708.6	01Jan2003, 18:30	16.26
C100#23	3.23	2767.8	01Jan2003, 18:15	16.09
C100#24	2.26	1896.8	01Jan2003, 18:00	15.98
C100#3	86.15	54030.2	01Jan2003, 19:45	15.88
C100#4	68.69	38929.3	02Jan2003, 02:15	15.64
C100#5	65.31	38534.7	02Jan2003, 01:30	15.60
C100#6	63.55	38071.2	02Jan2003, 00:30	15.60
C100#7	57.28	35733.9	02Jan2003, 01:00	15.78
C100#8	55.05	34959.9	02Jan2003, 01:15	15.80
C100#9	48.74	32542.1	02Jan2003, 01:30	15.81
C100#D1	5.07	4641.7	01Jan2003, 19:00	16.25

500-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#D2	3.23	2677.9	01Jan2003, 19:30	16.08
C100A	2.26	1896.8	01Jan2003, 18:00	15.98
C100B	1.84	2381.2	01Jan2003, 17:00	16.60
C100B REACH#1	3.23	2677.9	01Jan2003, 19:30	16.08
C100B REACH#2	2.26	1894.8	01Jan2003, 18:15	15.97
C100C	2.84	2460.9	01Jan2003, 18:00	16.09
C100D	2.42	2573.3	01Jan2003, 17:45	16.62
C100D REACH#1	18.31	16360.2	01Jan2003, 19:45	16.36
C100D REACH#2	15.07	13616.8	01Jan2003, 19:45	16.27
C100D REACH#3	7.91	6982.1	01Jan2003, 19:15	16.18
C100E	2.24	2412.9	01Jan2003, 18:15	16.65
C100E REACH#1	23.73	20210.5	01Jan2003, 21:00	16.31
C100E REACH#2	21.75	18749.0	01Jan2003, 20:45	16.35
C100E REACH#3	20.73	18596.7	01Jan2003, 19:45	16.39
C100F	2.58	2868.0	01Jan2003, 18:00	15.81
C100F REACH	28.36	23888.7	01Jan2003, 20:45	16.23
C100G	2.23	1792.4	01Jan2003, 18:00	14.73
C100G REACH	32.50	27260.4	01Jan2003, 21:15	16.16
C100H	1.98	2928.3	01Jan2003, 17:00	16.37
C100H REACH#1	42.97	31916.5	01Jan2003, 23:45	15.77
C100H REACH#2	40.83	31091.8	01Jan2003, 23:15	15.78
C100I	3.79	4565.8	01Jan2003, 17:15	16.33
C100I REACH	44.95	31347.7	02Jan2003, 01:45	15.77
C100J	6.27	3006.7	01Jan2003, 19:45	14.40
C100J REACH	57.28	35654.1	02Jan2003, 02:45	15.74
C100K	1.76	2144.8	01Jan2003, 17:30	16.26
C100K#1	1.76	2144.8	01Jan2003, 17:30	16.26
C100L	3.38	4970.3	01Jan2003, 17:15	17.00
C100L REACH#1	65.31	38395.0	02Jan2003, 03:30	15.57
C100L REACH#2	63.55	38012.1	02Jan2003, 02:15	15.58
C100M	1.76	1810.8	01Jan2003, 18:15	17.30

500-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#1	91.75	56314.5	01Jan2003, 21:15	15.89
C100M REACH#2	87.76	54386.7	01Jan2003, 20:45	15.88
C100M REACH#3	86.15	54051.9	01Jan2003, 19:45	15.87
C100M REACH#4	68.69	38929.7	02Jan2003, 02:30	15.63
C100 REACH	5.07	4630.1	01Jan2003, 19:30	16.24
C102#1	2.90	1802.6	01Jan2003, 19:15	16.42
C102#OULET	3.99	3584.9	01Jan2003, 17:15	16.73
C102A	2.90	1802.6	01Jan2003, 19:15	16.42
C102B	1.09	2400.3	01Jan2003, 16:45	17.73
C102B REACH	2.90	1798.9	01Jan2003, 19:45	16.36
C103	1.61	3230.8	01Jan2003, 16:45	17.39
C106-00#1	14.39	15757.6	01Jan2003, 18:15	16.89
C106-00#2	9.59	11907.0	01Jan2003, 17:30	16.98
C106-00#3	4.84	5566.8	01Jan2003, 17:30	16.92
C106-00#OUTLET	17.46	18806.0	01Jan2003, 19:15	16.84
C106-01#1	2.78	2677.2	01Jan2003, 17:45	16.56
C106-01#OUTLET	4.80	4549.1	01Jan2003, 19:15	16.72
C106-08#OUTLET	1.82	2383.7	01Jan2003, 17:15	17.02
C106A	1.82	2383.7	01Jan2003, 17:15	17.02
C106B	3.02	3208.9	01Jan2003, 17:45	16.85
C106C	1.89	3497.2	01Jan2003, 16:45	17.03
C106C REACH	4.84	5544.1	01Jan2003, 17:45	16.92
C106D	2.86	3205.1	01Jan2003, 17:30	17.04
C106E	2.78	2677.2	01Jan2003, 17:45	16.56
C106F	2.02	2079.0	01Jan2003, 17:45	16.97
C106F REACH	2.78	2637.2	01Jan2003, 19:45	16.55
C106G	3.07	4348.7	01Jan2003, 17:15	16.59
C106G REACH#1	14.39	15405.7	01Jan2003, 19:45	16.89
C106G REACH#2	9.59	11807.1	01Jan2003, 17:45	16.98
C118	3.87	2776.4	01Jan2003, 19:15	16.01
C120	2.23	2258.8	01Jan2003, 17:45	15.44

500-YEAR CORRECTED EFFECTIVE

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120 REACH	55.05	34906.5	02Jan2003, 01:45	15.79
C123	2.44	2689.3	01Jan2003, 18:00	15.54
C123 REACH	48.74	32358.1	02Jan2003, 02:15	15.80
C127	2.14	2595.0	01Jan2003, 17:15	15.82
C132	4.07	2294.7	01Jan2003, 19:15	14.39
C134	2.03	1149.1	01Jan2003, 20:00	14.08
C134 REACH	34.73	28429.8	01Jan2003, 22:15	16.05
C137	1.56	1608.0	01Jan2003, 17:30	15.78
C143	1.98	1918.1	01Jan2003, 17:30	15.93
C144	1.02	1022.7	01Jan2003, 17:30	15.74
C145#1	1.86	1664.3	01Jan2003, 18:00	17.00
C145#OUTLET	3.24	3062.5	01Jan2003, 17:45	16.80
C145A	1.86	1664.3	01Jan2003, 18:00	17.00
C145B	1.38	1403.0	01Jan2003, 17:30	16.54
C147#1	1.82	1614.2	01Jan2003, 18:00	16.67
C147#2	2.71	2347.9	01Jan2003, 18:15	16.22
C147#OUTLET	7.16	7018.3	01Jan2003, 18:45	16.38
C147A	1.82	1614.2	01Jan2003, 18:00	16.67
C147B	2.71	2347.9	01Jan2003, 18:15	16.22
C147C	2.63	3379.6	01Jan2003, 17:30	16.51
C147C REACH	4.53	3936.0	01Jan2003, 19:00	16.30
C147 DETENTION	4.53	3948.9	01Jan2003, 18:30	16.32
C161	2.39	1800.1	01Jan2003, 18:45	15.11
C162	0.97	875.2	01Jan2003, 18:00	16.38
DET#1	4.53	3948.9	01Jan2003, 18:30	16.32
DET#2	4.53	3962.0	01Jan2003, 18:00	16.40
DETENTION REACH#1	5.07	4641.7	01Jan2003, 19:00	16.25
DETENTION REACH#2	3.23	2668.6	01Jan2003, 19:45	16.07
Outlet	93.51	57745.8	01Jan2003, 21:15	15.92

APPENDIX B.3-2

REVISED EXISTING OUTPUTS

- **2-YEAR**
- **5-YEAR**
- **10-YEAR**
- **25-YEAR**
- **50-YEAR**
- **100-YEAR**
- **500-YEAR**

2-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_2

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(50%Flood)
 Compute Time: 04Sep2015, 09:16:39 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	11124.1	01Jan2003, 23:15	2.76
C100#10	44.95	6627.7	01Jan2003, 20:30	2.59
C100#11	42.97	6381.2	01Jan2003, 20:30	2.58
C100#12	40.83	6140.8	01Jan2003, 20:00	2.58
C100#13	34.73	5677.4	01Jan2003, 19:30	2.66
C100#14	32.50	5450.8	01Jan2003, 19:00	2.71
C100#15	28.36	4730.0	01Jan2003, 18:45	2.73
C100#16	23.73	3933.8	01Jan2003, 19:00	2.75
C100#17	21.75	3622.5	01Jan2003, 18:45	2.76
C100#18	20.73	3453.6	01Jan2003, 18:45	2.77
C100#19	18.31	2975.4	01Jan2003, 19:00	2.76
C100#2	87.76	10814.3	01Jan2003, 23:00	2.74
C100#20	15.07	2417.1	01Jan2003, 19:15	2.71
C100#21	7.91	1334.3	01Jan2003, 19:00	2.65
C100#22	5.07	973.8	01Jan2003, 18:15	2.69
C100#23	3.23	577.3	01Jan2003, 17:30	2.60
C100#24	2.26	396.0	01Jan2003, 17:00	2.53
C100#3	86.15	10732.7	01Jan2003, 23:00	2.73
C100#4	68.69	8700.7	01Jan2003, 23:00	2.63
C100#5	65.31	8484.2	01Jan2003, 22:30	2.60
C100#6	63.55	8375.4	01Jan2003, 22:15	2.60
C100#7	57.28	7976.0	01Jan2003, 21:30	2.61
C100#8	55.05	7764.7	01Jan2003, 21:15	2.62
C100#9	48.74	7049.9	01Jan2003, 21:00	2.61
C100#D1	5.07	928.0	01Jan2003, 18:45	2.69
C100#D2	3.23	548.0	01Jan2003, 18:15	2.59

2-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	396.0	01Jan2003, 17:00	2.53
C100B	1.84	585.4	01Jan2003, 16:45	2.86
C100B REACH#1	3.23	548.0	01Jan2003, 18:15	2.59
C100B REACH#2	2.26	389.8	01Jan2003, 17:30	2.53
C100C	2.84	521.8	01Jan2003, 17:00	2.58
C100D	2.42	592.3	01Jan2003, 17:15	2.87
C100D REACH#1	18.31	2974.4	01Jan2003, 19:00	2.76
C100D REACH#2	15.07	2417.1	01Jan2003, 19:15	2.71
C100D REACH#3	7.91	1330.6	01Jan2003, 19:15	2.65
C100E	2.24	546.7	01Jan2003, 18:00	3.04
C100E REACH#1	23.73	3926.2	01Jan2003, 19:00	2.75
C100E REACH#2	21.75	3611.2	01Jan2003, 19:00	2.76
C100E REACH#3	20.73	3449.3	01Jan2003, 18:45	2.77
C100F	2.58	623.0	01Jan2003, 17:45	2.57
C100F REACH	28.36	4712.8	01Jan2003, 19:15	2.73
C100G	2.23	341.4	01Jan2003, 17:00	2.01
C100G REACH	32.50	5423.0	01Jan2003, 19:30	2.71
C100H	1.98	736.3	01Jan2003, 16:45	2.88
C100H REACH#1	42.97	6354.1	01Jan2003, 20:45	2.58
C100H REACH#2	40.83	6092.9	01Jan2003, 20:30	2.58
C100I	3.79	1084.5	01Jan2003, 17:00	2.86
C100I REACH	44.95	6548.8	01Jan2003, 21:15	2.59
C100J	6.27	591.5	01Jan2003, 18:15	2.60
C100J REACH	57.28	7861.8	01Jan2003, 22:15	2.60
C100K	1.76	501.7	01Jan2003, 17:15	2.82
C100K#1	1.76	501.7	01Jan2003, 17:15	2.82
C100L	3.38	1294.7	01Jan2003, 17:00	3.23
C100L REACH#1	65.31	8408.8	01Jan2003, 23:00	2.60
C100L REACH#2	63.55	8313.6	01Jan2003, 22:45	2.60
C100M	1.76	429.3	01Jan2003, 17:45	3.39
C100M REACH#1	91.75	11104.6	01Jan2003, 23:30	2.76
C100M REACH#2	87.76	10763.4	01Jan2003, 23:15	2.74

2-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	10728.1	01Jan2003, 23:00	2.73
C100M REACH#4	68.69	8696.5	01Jan2003, 23:00	2.63
C100 REACH	5.07	919.9	01Jan2003, 19:30	2.69
C102#1	2.90	395.6	01Jan2003, 17:45	3.28
C102#OULET	3.99	869.3	01Jan2003, 16:45	3.36
C102A	2.90	395.6	01Jan2003, 17:45	3.28
C102B	1.09	717.1	01Jan2003, 16:45	3.63
C102B REACH	2.90	393.1	01Jan2003, 18:30	3.26
C103	1.61	929.4	01Jan2003, 16:45	3.44
C106-00#1	14.39	3803.9	01Jan2003, 17:45	3.14
C106-00#2	9.59	2914.0	01Jan2003, 17:15	3.17
C106-00#3	4.84	1347.3	01Jan2003, 17:00	3.14
C106-00#OUTLET	17.46	4511.1	01Jan2003, 18:30	3.12
C106-01#1	2.78	610.5	01Jan2003, 17:00	2.99
C106-01#OUTLET	4.80	1034.8	01Jan2003, 18:15	3.08
C106-08#OUTLET	1.82	601.5	01Jan2003, 16:45	3.20
C106A	1.82	601.5	01Jan2003, 16:45	3.20
C106B	3.02	755.7	01Jan2003, 17:15	3.10
C106C	1.89	973.8	01Jan2003, 16:45	3.21
C106C REACH	4.84	1323.3	01Jan2003, 17:30	3.14
C106D	2.86	778.0	01Jan2003, 17:00	3.21
C106E	2.78	610.5	01Jan2003, 17:00	2.99
C106F	2.02	492.5	01Jan2003, 17:15	3.21
C106F REACH	2.78	591.8	01Jan2003, 18:30	2.99
C106G	3.07	1093.9	01Jan2003, 17:00	3.00
C106G REACH#1	14.39	3714.4	01Jan2003, 18:30	3.14
C106G REACH#2	9.59	2842.0	01Jan2003, 17:45	3.17
C118	3.87	580.9	01Jan2003, 18:00	2.84
C1180000_0009_J	3.87	777.1	01Jan2003, 17:00	2.88
C1180000_0009_R	1.93	293.6	01Jan2003, 19:45	2.93
C118A	1.93	309.5	01Jan2003, 17:30	2.94
C118B	1.94	714.0	01Jan2003, 17:00	2.82

2-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	481.5	01Jan2003, 17:00	2.36
C120 REACH	55.05	7740.7	01Jan2003, 21:30	2.62
C123	2.44	571.9	01Jan2003, 17:30	2.42
C123 REACH	48.74	6987.9	01Jan2003, 21:30	2.61
C127	2.14	599.8	01Jan2003, 16:45	2.58
C132	4.07	419.3	01Jan2003, 17:15	2.20
C134	2.03	198.2	01Jan2003, 19:00	2.03
C134 REACH	34.73	5597.6	01Jan2003, 20:15	2.66
C137	1.56	354.4	01Jan2003, 16:45	2.56
C143	1.98	420.4	01Jan2003, 16:45	2.64
C144	1.02	223.0	01Jan2003, 16:45	2.53
C145#1	1.86	381.2	01Jan2003, 17:00	3.13
C145#OUTLET	3.24	698.8	01Jan2003, 17:00	3.00
C145A	1.86	381.2	01Jan2003, 17:00	3.13
C145B	1.38	321.0	01Jan2003, 16:45	2.82
C147#1	1.82	359.8	01Jan2003, 17:00	2.93
C147#2	2.71	501.9	01Jan2003, 17:15	2.67
C147#OUTLET	7.16	1102.1	01Jan2003, 18:30	2.77
C147A	1.82	359.8	01Jan2003, 17:00	2.93
C147B	2.71	501.9	01Jan2003, 17:15	2.67
C147C	2.63	810.1	01Jan2003, 17:15	2.81
C147C REACH	4.53	605.4	01Jan2003, 21:00	2.76
C147 DETENTION	4.53	606.8	01Jan2003, 20:30	2.76
C161	2.39	346.0	01Jan2003, 17:45	2.27
C162	0.97	191.1	01Jan2003, 17:00	2.75
DET#1	4.53	606.8	01Jan2003, 20:30	2.76
DET#2	4.53	859.9	01Jan2003, 17:15	2.77
DETENTION REACH#1	5.07	928.0	01Jan2003, 18:45	2.69
DETENTION REACH#2	3.23	539.8	01Jan2003, 18:45	2.59
Outlet	93.51	11308.9	01Jan2003, 23:30	2.77

5-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_5

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(20%Flood)
 Compute Time: 04Sep2015, 09:18:46 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	17640.4	01Jan2003, 22:30	4.17
C100#10	44.95	10135.7	01Jan2003, 20:15	3.97
C100#11	42.97	9727.8	01Jan2003, 20:15	3.96
C100#12	40.83	9303.6	01Jan2003, 20:00	3.96
C100#13	34.73	8508.3	01Jan2003, 19:30	4.08
C100#14	32.50	8121.1	01Jan2003, 19:15	4.14
C100#15	28.36	7029.7	01Jan2003, 19:15	4.17
C100#16	23.73	5882.2	01Jan2003, 19:15	4.21
C100#17	21.75	5420.4	01Jan2003, 19:00	4.23
C100#18	20.73	5174.8	01Jan2003, 19:00	4.24
C100#19	18.31	4478.9	01Jan2003, 19:00	4.23
C100#2	87.76	17128.8	01Jan2003, 22:15	4.14
C100#20	15.07	3648.4	01Jan2003, 19:15	4.16
C100#21	7.91	2023.2	01Jan2003, 19:15	4.09
C100#22	5.07	1452.6	01Jan2003, 18:15	4.14
C100#23	3.23	835.9	01Jan2003, 17:30	4.02
C100#24	2.26	569.2	01Jan2003, 17:15	3.94
C100#3	86.15	16976.0	01Jan2003, 22:15	4.13
C100#4	68.69	13645.8	01Jan2003, 22:45	4.00
C100#5	65.31	13285.1	01Jan2003, 22:15	3.97
C100#6	63.55	13073.0	01Jan2003, 21:45	3.96
C100#7	57.28	12400.2	01Jan2003, 21:00	3.98
C100#8	55.05	12039.7	01Jan2003, 21:00	4.00
C100#9	48.74	10867.5	01Jan2003, 20:45	3.99
C100#D1	5.07	1383.6	01Jan2003, 19:00	4.14
C100#D2	3.23	809.3	01Jan2003, 18:15	4.02

5-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	569.2	01Jan2003, 17:15	3.94
C100B	1.84	812.6	01Jan2003, 16:45	4.35
C100B REACH#1	3.23	809.3	01Jan2003, 18:15	4.02
C100B REACH#2	2.26	566.1	01Jan2003, 17:30	3.94
C100C	2.84	746.5	01Jan2003, 17:15	4.01
C100D	2.42	835.2	01Jan2003, 17:15	4.37
C100D REACH#1	18.31	4478.6	01Jan2003, 19:15	4.23
C100D REACH#2	15.07	3645.5	01Jan2003, 19:15	4.16
C100D REACH#3	7.91	2022.2	01Jan2003, 19:15	4.09
C100E	2.24	771.1	01Jan2003, 18:15	4.52
C100E REACH#1	23.73	5869.7	01Jan2003, 19:30	4.20
C100E REACH#2	21.75	5405.2	01Jan2003, 19:15	4.22
C100E REACH#3	20.73	5168.9	01Jan2003, 19:15	4.24
C100F	2.58	894.4	01Jan2003, 17:45	3.92
C100F REACH	28.36	7014.5	01Jan2003, 19:30	4.17
C100G	2.23	499.2	01Jan2003, 17:15	3.20
C100G REACH	32.50	8097.9	01Jan2003, 19:30	4.14
C100H	1.98	1012.2	01Jan2003, 16:45	4.32
C100H REACH#1	42.97	9703.3	01Jan2003, 20:30	3.95
C100H REACH#2	40.83	9255.5	01Jan2003, 20:15	3.96
C100I	3.79	1512.1	01Jan2003, 17:00	4.29
C100I REACH	44.95	10064.0	01Jan2003, 21:00	3.96
C100J	6.27	857.0	01Jan2003, 18:45	3.87
C100J REACH	57.28	12290.1	01Jan2003, 21:45	3.97
C100K	1.76	704.9	01Jan2003, 17:15	4.24
C100K#1	1.76	704.9	01Jan2003, 17:15	4.24
C100L	3.38	1766.8	01Jan2003, 17:00	4.76
C100L REACH#1	65.31	13181.3	01Jan2003, 22:45	3.96
C100L REACH#2	63.55	13003.8	01Jan2003, 22:15	3.96
C100M	1.76	597.0	01Jan2003, 18:00	4.98
C100M REACH#1	91.75	17618.1	01Jan2003, 22:45	4.16
C100M REACH#2	87.76	17075.2	01Jan2003, 22:30	4.14
C100M REACH#3	86.15	16966.5	01Jan2003, 22:15	4.12

5-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	13646.1	01Jan2003, 22:45	4.00
C100 REACH	5.07	1376.1	01Jan2003, 19:30	4.13
C102#1	2.90	556.0	01Jan2003, 18:00	4.79
C102#OULET	3.99	1179.8	01Jan2003, 16:45	4.91
C102A	2.90	556.0	01Jan2003, 18:00	4.79
C102B	1.09	948.2	01Jan2003, 16:45	5.28
C102B REACH	2.90	558.1	01Jan2003, 18:00	4.77
C103	1.61	1241.1	01Jan2003, 16:45	5.04
C106-00#1	14.39	5342.8	01Jan2003, 18:00	4.67
C106-00#2	9.59	4039.9	01Jan2003, 17:15	4.71
C106-00#3	4.84	1861.8	01Jan2003, 17:00	4.67
C106-00#OUTLET	17.46	6409.0	01Jan2003, 18:30	4.63
C106-01#1	2.78	853.1	01Jan2003, 17:15	4.46
C106-01#OUTLET	4.80	1477.0	01Jan2003, 18:15	4.58
C106-08#OUTLET	1.82	825.3	01Jan2003, 17:00	4.75
C106A	1.82	825.3	01Jan2003, 17:00	4.75
C106B	3.02	1054.2	01Jan2003, 17:15	4.62
C106C	1.89	1314.1	01Jan2003, 16:45	4.75
C106C REACH	4.84	1845.2	01Jan2003, 17:30	4.67
C106D	2.86	1072.7	01Jan2003, 17:00	4.76
C106E	2.78	853.1	01Jan2003, 17:15	4.46
C106F	2.02	683.8	01Jan2003, 17:15	4.74
C106F REACH	2.78	839.3	01Jan2003, 18:30	4.46
C106G	3.07	1506.5	01Jan2003, 17:00	4.48
C106G REACH#1	14.39	5239.1	01Jan2003, 18:30	4.67
C106G REACH#2	9.59	3963.3	01Jan2003, 17:45	4.71
C118	3.87	829.8	01Jan2003, 18:00	4.25
C1180000_0009_J	3.87	1092.5	01Jan2003, 17:15	4.31
C1180000_0009_R	1.93	391.5	01Jan2003, 22:15	4.36
C118A	1.93	438.3	01Jan2003, 17:45	4.39
C118B	1.94	988.8	01Jan2003, 17:00	4.25
C120	2.23	686.7	01Jan2003, 17:00	3.66
C120 REACH	55.05	12011.1	01Jan2003, 21:15	3.99

5-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C123	2.44	825.2	01Jan2003, 17:45	3.73
C123 REACH	48.74	10806.8	01Jan2003, 21:00	3.99
C127	2.14	839.2	01Jan2003, 17:00	3.93
C132	4.07	615.9	01Jan2003, 17:45	3.41
C134	2.03	300.1	01Jan2003, 19:00	3.18
C134 REACH	34.73	8450.5	01Jan2003, 20:00	4.07
C137	1.56	501.0	01Jan2003, 17:00	3.90
C143	1.98	594.5	01Jan2003, 17:00	4.01
C144	1.02	316.0	01Jan2003, 17:00	3.87
C145#1	1.86	533.3	01Jan2003, 17:15	4.70
C145#OUTLET	3.24	982.7	01Jan2003, 17:00	4.53
C145A	1.86	533.3	01Jan2003, 17:15	4.70
C145B	1.38	450.0	01Jan2003, 17:00	4.31
C147#1	1.82	507.7	01Jan2003, 17:15	4.44
C147#2	2.71	717.2	01Jan2003, 17:15	4.11
C147#OUTLET	7.16	1630.0	01Jan2003, 19:00	4.24
C147A	1.82	507.7	01Jan2003, 17:15	4.44
C147B	2.71	717.2	01Jan2003, 17:15	4.11
C147C	2.63	1135.9	01Jan2003, 17:15	4.29
C147C REACH	4.53	909.0	01Jan2003, 21:15	4.22
C147 DETENTION	4.53	911.0	01Jan2003, 20:45	4.22
C161	2.39	507.3	01Jan2003, 17:45	3.53
C162	0.97	271.7	01Jan2003, 17:15	4.21
DET#1	4.53	911.0	01Jan2003, 20:45	4.22
DET#2	4.53	1225.0	01Jan2003, 17:15	4.24
DETENTION REACH#1	5.07	1383.6	01Jan2003, 19:00	4.14
DETENTION REACH#2	3.23	802.3	01Jan2003, 18:45	4.02
Outlet	93.51	17951.9	01Jan2003, 22:45	4.18

10-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_10

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(10%flood)
 Compute Time: 04Sep2015, 09:19:53 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	22275.1	01Jan2003, 22:30	5.26
C100#10	44.95	12816.8	01Jan2003, 20:15	5.06
C100#11	42.97	12284.2	01Jan2003, 20:15	5.04
C100#12	40.83	11731.1	01Jan2003, 20:00	5.05
C100#13	34.73	10712.3	01Jan2003, 19:30	5.19
C100#14	32.50	10209.4	01Jan2003, 19:15	5.26
C100#15	28.36	8823.7	01Jan2003, 19:15	5.30
C100#16	23.73	7374.2	01Jan2003, 19:15	5.34
C100#17	21.75	6783.9	01Jan2003, 19:00	5.37
C100#18	20.73	6465.4	01Jan2003, 19:00	5.39
C100#19	18.31	5597.2	01Jan2003, 19:15	5.37
C100#2	87.76	21690.2	01Jan2003, 22:15	5.23
C100#20	15.07	4568.5	01Jan2003, 19:15	5.30
C100#21	7.91	2536.6	01Jan2003, 19:15	5.23
C100#22	5.07	1812.2	01Jan2003, 18:00	5.28
C100#23	3.23	1035.1	01Jan2003, 17:30	5.15
C100#24	2.26	706.0	01Jan2003, 17:15	5.07
C100#3	86.15	21517.8	01Jan2003, 22:15	5.22
C100#4	68.69	17351.7	01Jan2003, 22:30	5.07
C100#5	65.31	16911.8	01Jan2003, 22:00	5.04
C100#6	63.55	16624.3	01Jan2003, 21:45	5.04
C100#7	57.28	15785.2	01Jan2003, 21:00	5.07
C100#8	55.05	15287.2	01Jan2003, 20:45	5.08
C100#9	48.74	13785.0	01Jan2003, 20:45	5.08
C100#D1	5.07	1728.3	01Jan2003, 19:00	5.28
C100#D2	3.23	1010.2	01Jan2003, 18:15	5.15

10-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	706.0	01Jan2003, 17:15	5.07
C100B	1.84	983.6	01Jan2003, 16:45	5.52
C100B REACH#1	3.23	1010.2	01Jan2003, 18:15	5.15
C100B REACH#2	2.26	703.6	01Jan2003, 17:45	5.06
C100C	2.84	925.1	01Jan2003, 17:15	5.14
C100D	2.42	1021.1	01Jan2003, 17:15	5.53
C100D REACH#1	18.31	5598.6	01Jan2003, 19:15	5.37
C100D REACH#2	15.07	4563.5	01Jan2003, 19:15	5.30
C100D REACH#3	7.91	2534.7	01Jan2003, 19:15	5.22
C100E	2.24	945.5	01Jan2003, 18:15	5.65
C100E REACH#1	23.73	7362.8	01Jan2003, 19:15	5.34
C100E REACH#2	21.75	6768.3	01Jan2003, 19:15	5.37
C100E REACH#3	20.73	6459.1	01Jan2003, 19:15	5.39
C100F	2.58	1105.8	01Jan2003, 17:45	4.99
C100F REACH	28.36	8805.2	01Jan2003, 19:30	5.30
C100G	2.23	630.4	01Jan2003, 17:15	4.20
C100G REACH	32.50	10174.7	01Jan2003, 19:30	5.25
C100H	1.98	1222.9	01Jan2003, 17:00	5.43
C100H REACH#1	42.97	12260.0	01Jan2003, 20:30	5.04
C100H REACH#2	40.83	11678.1	01Jan2003, 20:15	5.05
C100I	3.79	1839.5	01Jan2003, 17:00	5.40
C100I REACH	44.95	12755.6	01Jan2003, 20:45	5.05
C100J	6.27	1066.1	01Jan2003, 19:00	4.86
C100J REACH	57.28	15642.7	01Jan2003, 21:45	5.06
C100K	1.76	861.4	01Jan2003, 17:15	5.34
C100K#1	1.76	861.4	01Jan2003, 17:15	5.34
C100L	3.38	2119.1	01Jan2003, 17:00	5.92
C100L REACH#1	65.31	16762.2	01Jan2003, 22:45	5.03
C100L REACH#2	63.55	16537.2	01Jan2003, 22:00	5.03
C100M	1.76	725.6	01Jan2003, 18:00	6.16
C100M REACH#1	91.75	22261.3	01Jan2003, 23:00	5.25
C100M REACH#2	87.76	21601.3	01Jan2003, 22:45	5.23

10-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	21489.5	01Jan2003, 22:15	5.21
C100M REACH#4	68.69	17349.2	01Jan2003, 22:45	5.07
C100 REACH	5.07	1719.6	01Jan2003, 19:30	5.27
C102#1	2.90	679.7	01Jan2003, 18:00	5.92
C102#OULET	3.99	1485.7	01Jan2003, 17:30	6.06
C102A	2.90	679.7	01Jan2003, 18:00	5.92
C102B	1.09	1115.7	01Jan2003, 16:45	6.49
C102B REACH	2.90	679.5	01Jan2003, 18:30	5.89
C103	1.61	1468.1	01Jan2003, 16:45	6.23
C106-00#1	14.39	6539.0	01Jan2003, 17:45	5.82
C106-00#2	9.59	4924.0	01Jan2003, 17:15	5.88
C106-00#3	4.84	2264.4	01Jan2003, 17:15	5.83
C106-00#OUTLET	17.46	7852.4	01Jan2003, 18:30	5.78
C106-01#1	2.78	1044.8	01Jan2003, 17:15	5.58
C106-01#OUTLET	4.80	1812.2	01Jan2003, 18:15	5.72
C106-08#OUTLET	1.82	996.8	01Jan2003, 17:00	5.91
C106A	1.82	996.8	01Jan2003, 17:00	5.91
C106B	3.02	1282.8	01Jan2003, 17:15	5.78
C106C	1.89	1560.1	01Jan2003, 16:45	5.92
C106C REACH	4.84	2247.9	01Jan2003, 17:30	5.83
C106D	2.86	1302.2	01Jan2003, 17:15	5.93
C106E	2.78	1044.8	01Jan2003, 17:15	5.58
C106F	2.02	830.2	01Jan2003, 17:15	5.90
C106F REACH	2.78	1031.2	01Jan2003, 18:30	5.58
C106G	3.07	1816.3	01Jan2003, 17:00	5.60
C106G REACH#1	14.39	6401.2	01Jan2003, 18:45	5.82
C106G REACH#2	9.59	4835.3	01Jan2003, 17:45	5.88
C118	3.87	1027.0	01Jan2003, 18:15	5.34
C1180000_0009_J	3.87	1342.7	01Jan2003, 17:15	5.41
C1180000_0009_R	1.93	460.5	02Jan2003, 00:30	5.47
C118A	1.93	540.2	01Jan2003, 17:45	5.49
C118B	1.94	1195.3	01Jan2003, 17:00	5.35

10-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	852.8	01Jan2003, 17:15	4.70
C120 REACH	55.05	15264.7	01Jan2003, 21:00	5.08
C123	2.44	1025.1	01Jan2003, 17:45	4.78
C123 REACH	48.74	13736.2	01Jan2003, 21:00	5.07
C127	2.14	1030.2	01Jan2003, 17:00	5.00
C132	4.07	777.3	01Jan2003, 18:00	4.39
C134	2.03	382.5	01Jan2003, 19:15	4.14
C134 REACH	34.73	10631.8	01Jan2003, 20:00	5.18
C137	1.56	618.0	01Jan2003, 17:00	4.97
C143	1.98	732.7	01Jan2003, 17:00	5.09
C144	1.02	390.2	01Jan2003, 17:00	4.94
C145#1	1.86	652.0	01Jan2003, 17:15	5.88
C145#OUTLET	3.24	1200.4	01Jan2003, 17:15	5.70
C145A	1.86	652.0	01Jan2003, 17:15	5.88
C145B	1.38	551.8	01Jan2003, 17:00	5.47
C147#1	1.82	623.1	01Jan2003, 17:15	5.61
C147#2	2.71	886.5	01Jan2003, 17:30	5.25
C147#OUTLET	7.16	2034.0	01Jan2003, 19:00	5.39
C147A	1.82	623.1	01Jan2003, 17:15	5.61
C147B	2.71	886.5	01Jan2003, 17:30	5.25
C147C	2.63	1382.1	01Jan2003, 17:15	5.45
C147C REACH	4.53	1171.4	01Jan2003, 21:00	5.36
C147 DETENTION	4.53	1175.5	01Jan2003, 20:30	5.37
C161	2.39	636.4	01Jan2003, 18:00	4.56
C162	0.97	334.7	01Jan2003, 17:15	5.36
DET#1	4.53	1175.5	01Jan2003, 20:30	5.37
DET#2	4.53	1508.0	01Jan2003, 17:30	5.39
DETENTION REACH#1	5.07	1728.3	01Jan2003, 19:00	5.28
DETENTION REACH#2	3.23	1003.1	01Jan2003, 18:45	5.15
Outlet	93.51	22659.2	01Jan2003, 23:00	5.27

25-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_25

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(4%Flood)
 Compute Time: 04Sep2015, 09:21:04 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	30968.3	01Jan2003, 22:00	7.08
C100#10	44.95	17049.9	01Jan2003, 20:15	6.89
C100#11	42.97	16317.3	01Jan2003, 20:15	6.87
C100#12	40.83	15544.5	01Jan2003, 20:15	6.88
C100#13	34.73	14132.6	01Jan2003, 19:45	7.05
C100#14	32.50	13432.4	01Jan2003, 19:30	7.13
C100#15	28.36	11627.1	01Jan2003, 19:15	7.18
C100#16	23.73	9740.1	01Jan2003, 19:15	7.23
C100#17	21.75	8968.6	01Jan2003, 19:15	7.27
C100#18	20.73	8549.1	01Jan2003, 19:15	7.29
C100#19	18.31	7434.1	01Jan2003, 19:15	7.27
C100#2	87.76	30114.2	01Jan2003, 21:45	7.05
C100#20	15.07	6096.7	01Jan2003, 19:30	7.20
C100#21	7.91	3329.4	01Jan2003, 19:15	7.12
C100#22	5.07	2350.6	01Jan2003, 18:15	7.17
C100#23	3.23	1336.1	01Jan2003, 17:45	7.04
C100#24	2.26	911.1	01Jan2003, 17:30	6.94
C100#3	86.15	29801.5	01Jan2003, 21:45	7.04
C100#4	68.69	23636.6	01Jan2003, 22:00	6.87
C100#5	65.31	22811.0	01Jan2003, 21:45	6.83
C100#6	63.55	22314.4	01Jan2003, 21:30	6.83
C100#7	57.28	21131.4	01Jan2003, 20:45	6.89
C100#8	55.05	20405.7	01Jan2003, 20:45	6.91
C100#9	48.74	18406.6	01Jan2003, 20:30	6.90
C100#D1	5.07	2257.8	01Jan2003, 19:00	7.17
C100#D2	3.23	1311.3	01Jan2003, 18:30	7.03

25-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	911.1	01Jan2003, 17:30	6.94
C100B	1.84	1236.7	01Jan2003, 16:45	7.44
C100B REACH#1	3.23	1311.3	01Jan2003, 18:30	7.03
C100B REACH#2	2.26	909.7	01Jan2003, 17:45	6.94
C100C	2.84	1189.5	01Jan2003, 17:30	7.02
C100D	2.42	1294.7	01Jan2003, 17:15	7.45
C100D REACH#1	18.31	7426.6	01Jan2003, 19:30	7.27
C100D REACH#2	15.07	6096.7	01Jan2003, 19:30	7.20
C100D REACH#3	7.91	3323.3	01Jan2003, 19:15	7.11
C100E	2.24	1207.2	01Jan2003, 18:15	7.54
C100E REACH#1	23.73	9730.3	01Jan2003, 19:30	7.23
C100E REACH#2	21.75	8947.6	01Jan2003, 19:30	7.26
C100E REACH#3	20.73	8543.3	01Jan2003, 19:15	7.29
C100F	2.58	1420.2	01Jan2003, 17:45	6.81
C100F REACH	28.36	11601.1	01Jan2003, 19:45	7.17
C100G	2.23	828.4	01Jan2003, 17:30	5.93
C100G REACH	32.50	13410.5	01Jan2003, 19:45	7.12
C100H	1.98	1536.0	01Jan2003, 17:00	7.29
C100H REACH#1	42.97	16296.5	01Jan2003, 20:30	6.87
C100H REACH#2	40.83	15501.7	01Jan2003, 20:30	6.87
C100I	3.79	2326.5	01Jan2003, 17:00	7.26
C100I REACH	44.95	16999.7	01Jan2003, 20:45	6.88
C100J	6.27	1397.5	01Jan2003, 19:30	6.49
C100J REACH	57.28	20990.8	01Jan2003, 21:30	6.87
C100K	1.76	1092.2	01Jan2003, 17:15	7.20
C100K#1	1.76	1092.2	01Jan2003, 17:15	7.20
C100L	3.38	2641.7	01Jan2003, 17:00	7.83
C100L REACH#1	65.31	22695.5	01Jan2003, 22:00	6.82
C100L REACH#2	63.55	22269.7	01Jan2003, 21:45	6.82
C100M	1.76	917.8	01Jan2003, 18:00	8.09
C100M REACH#1	91.75	30906.4	01Jan2003, 22:15	7.07
C100M REACH#2	87.76	30017.0	01Jan2003, 22:00	7.05

25-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	29789.9	01Jan2003, 21:45	7.03
C100M REACH#4	68.69	23624.7	01Jan2003, 22:00	6.87
C100 REACH	5.07	2246.8	01Jan2003, 19:30	7.17
C102#1	2.90	872.1	01Jan2003, 18:30	7.74
C102#OULET	3.99	1907.8	01Jan2003, 17:15	7.91
C102A	2.90	872.1	01Jan2003, 18:30	7.74
C102B	1.09	1358.9	01Jan2003, 16:45	8.46
C102B REACH	2.90	871.4	01Jan2003, 19:00	7.71
C103	1.61	1800.2	01Jan2003, 16:45	8.17
C106-00#1	14.39	8278.1	01Jan2003, 17:45	7.73
C106-00#2	9.59	6186.6	01Jan2003, 17:15	7.80
C106-00#3	4.84	2855.3	01Jan2003, 17:15	7.75
C106-00#OUTLET	17.46	10009.5	01Jan2003, 18:30	7.69
C106-01#1	2.78	1328.7	01Jan2003, 17:15	7.46
C106-01#OUTLET	4.80	2279.8	01Jan2003, 18:15	7.60
C106-08#OUTLET	1.82	1248.5	01Jan2003, 17:00	7.84
C106A	1.82	1248.5	01Jan2003, 17:00	7.84
C106B	3.02	1621.2	01Jan2003, 17:15	7.69
C106C	1.89	1924.6	01Jan2003, 16:45	7.85
C106C REACH	4.84	2836.2	01Jan2003, 17:30	7.75
C106D	2.86	1640.8	01Jan2003, 17:15	7.86
C106E	2.78	1328.7	01Jan2003, 17:15	7.46
C106F	2.02	1049.9	01Jan2003, 17:30	7.80
C106F REACH	2.78	1302.9	01Jan2003, 19:15	7.46
C106G	3.07	2277.1	01Jan2003, 17:00	7.48
C106G REACH#1	14.39	8125.8	01Jan2003, 18:45	7.73
C106G REACH#2	9.59	6103.2	01Jan2003, 17:45	7.80
C118	3.87	1328.4	01Jan2003, 18:30	7.16
C1180000_0009_J	3.87	1709.3	01Jan2003, 17:15	7.25
C1180000_0009_R	1.93	565.9	02Jan2003, 02:30	7.30
C118A	1.93	695.1	01Jan2003, 18:00	7.33
C118B	1.94	1501.5	01Jan2003, 17:00	7.21

25-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1099.8	01Jan2003, 17:15	6.50
C120 REACH	55.05	20378.5	01Jan2003, 20:45	6.90
C123	2.44	1322.1	01Jan2003, 17:45	6.58
C123 REACH	48.74	18361.4	01Jan2003, 20:45	6.90
C127	2.14	1311.7	01Jan2003, 17:00	6.82
C132	4.07	1031.0	01Jan2003, 18:30	6.06
C134	2.03	512.0	01Jan2003, 19:30	5.79
C134 REACH	34.73	14066.5	01Jan2003, 20:15	7.04
C137	1.56	791.2	01Jan2003, 17:00	6.79
C143	1.98	939.0	01Jan2003, 17:15	6.92
C144	1.02	500.3	01Jan2003, 17:00	6.75
C145#1	1.86	827.0	01Jan2003, 17:30	7.82
C145#OUTLET	3.24	1526.3	01Jan2003, 17:15	7.63
C145A	1.86	827.0	01Jan2003, 17:30	7.82
C145B	1.38	700.9	01Jan2003, 17:00	7.38
C147#1	1.82	794.7	01Jan2003, 17:30	7.53
C147#2	2.71	1138.9	01Jan2003, 17:30	7.14
C147#OUTLET	7.16	2775.5	01Jan2003, 19:30	7.29
C147A	1.82	794.7	01Jan2003, 17:30	7.53
C147B	2.71	1138.9	01Jan2003, 17:30	7.14
C147C	2.63	1743.4	01Jan2003, 17:15	7.36
C147C REACH	4.53	1621.3	01Jan2003, 20:45	7.25
C147 DETENTION	4.53	1630.5	01Jan2003, 20:15	7.26
C161	2.39	834.8	01Jan2003, 18:00	6.32
C162	0.97	428.3	01Jan2003, 17:30	7.27
DET#1	4.53	1630.5	01Jan2003, 20:15	7.26
DET#2	4.53	1933.6	01Jan2003, 17:30	7.30
DETENTION REACH#1	5.07	2257.8	01Jan2003, 19:00	7.17
DETENTION REACH#2	3.23	1305.6	01Jan2003, 18:45	7.03
Outlet	93.51	31491.5	01Jan2003, 22:15	7.09

50-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_50

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(2%flood)
 Compute Time: 04Sep2015, 09:22:38 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	37454.1	01Jan2003, 21:45	8.72
C100#10	44.95	20717.4	01Jan2003, 20:15	8.53
C100#11	42.97	19799.2	01Jan2003, 20:15	8.52
C100#12	40.83	18837.4	01Jan2003, 20:15	8.53
C100#13	34.73	17084.1	01Jan2003, 19:45	8.72
C100#14	32.50	16224.1	01Jan2003, 19:30	8.80
C100#15	28.36	14052.1	01Jan2003, 19:30	8.86
C100#16	23.73	11798.6	01Jan2003, 19:30	8.92
C100#17	21.75	10869.3	01Jan2003, 19:15	8.95
C100#18	20.73	10368.9	01Jan2003, 19:15	8.98
C100#19	18.31	9035.7	01Jan2003, 19:15	8.96
C100#2	87.76	36515.6	01Jan2003, 21:15	8.69
C100#20	15.07	7445.3	01Jan2003, 19:30	8.88
C100#21	7.91	3993.0	01Jan2003, 19:15	8.80
C100#22	5.07	2789.2	01Jan2003, 18:15	8.86
C100#23	3.23	1595.5	01Jan2003, 17:45	8.71
C100#24	2.26	1089.5	01Jan2003, 17:45	8.62
C100#3	86.15	36065.5	01Jan2003, 21:15	8.67
C100#4	68.69	28471.0	01Jan2003, 22:30	8.50
C100#5	65.31	27616.7	01Jan2003, 22:00	8.46
C100#6	63.55	27055.9	01Jan2003, 21:30	8.46
C100#7	57.28	25631.3	01Jan2003, 20:45	8.53
C100#8	55.05	24740.9	01Jan2003, 20:30	8.55
C100#9	48.74	22280.0	01Jan2003, 20:15	8.55
C100#D1	5.07	2699.4	01Jan2003, 19:00	8.86
C100#D2	3.23	1572.6	01Jan2003, 18:30	8.71

50-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1089.5	01Jan2003, 17:45	8.62
C100B	1.84	1445.6	01Jan2003, 16:45	9.14
C100B REACH#1	3.23	1572.6	01Jan2003, 18:30	8.71
C100B REACH#2	2.26	1088.1	01Jan2003, 18:00	8.61
C100C	2.84	1419.9	01Jan2003, 17:30	8.70
C100D	2.42	1527.4	01Jan2003, 17:30	9.16
C100D REACH#1	18.31	9032.6	01Jan2003, 19:30	8.96
C100D REACH#2	15.07	7437.2	01Jan2003, 19:30	8.88
C100D REACH#3	7.91	3986.0	01Jan2003, 19:15	8.80
C100E	2.24	1427.8	01Jan2003, 18:15	9.23
C100E REACH#1	23.73	11777.0	01Jan2003, 19:30	8.92
C100E REACH#2	21.75	10843.2	01Jan2003, 19:30	8.95
C100E REACH#3	20.73	10355.7	01Jan2003, 19:30	8.98
C100F	2.58	1684.1	01Jan2003, 17:45	8.47
C100F REACH	28.36	14025.6	01Jan2003, 19:45	8.85
C100G	2.23	1000.0	01Jan2003, 17:45	7.54
C100G REACH	32.50	16192.9	01Jan2003, 19:45	8.80
C100H	1.98	1793.0	01Jan2003, 17:00	8.97
C100H REACH#1	42.97	19778.4	01Jan2003, 20:30	8.51
C100H REACH#2	40.83	18796.6	01Jan2003, 20:30	8.52
C100I	3.79	2731.3	01Jan2003, 17:15	8.94
C100I REACH	44.95	20566.4	01Jan2003, 21:00	8.52
C100J	6.27	1681.0	01Jan2003, 19:30	7.95
C100J REACH	57.28	25443.8	01Jan2003, 21:30	8.51
C100K	1.76	1284.0	01Jan2003, 17:15	8.87
C100K#1	1.76	1284.0	01Jan2003, 17:15	8.87
C100L	3.38	3071.4	01Jan2003, 17:00	9.54
C100L REACH#1	65.31	27420.9	01Jan2003, 22:30	8.44
C100L REACH#2	63.55	26972.0	01Jan2003, 22:00	8.44
C100M	1.76	1080.3	01Jan2003, 18:00	9.81
C100M REACH#1	91.75	37418.5	01Jan2003, 22:30	8.71
C100M REACH#2	87.76	36286.3	01Jan2003, 22:00	8.68
C100M REACH#3	86.15	36028.7	01Jan2003, 21:15	8.67

50-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	28468.8	01Jan2003, 22:30	8.49
C100 REACH	5.07	2686.8	01Jan2003, 19:30	8.85
C102#1	2.90	1036.8	01Jan2003, 18:30	9.36
C102#OULET	3.99	2223.1	01Jan2003, 17:15	9.56
C102A	2.90	1036.8	01Jan2003, 18:30	9.36
C102B	1.09	1554.3	01Jan2003, 16:45	10.19
C102B REACH	2.90	1036.2	01Jan2003, 19:00	9.32
C103	1.61	2068.1	01Jan2003, 16:45	9.89
C106-00#1	14.39	9648.0	01Jan2003, 17:45	9.44
C106-00#2	9.59	7236.2	01Jan2003, 17:15	9.51
C106-00#3	4.84	3350.0	01Jan2003, 17:15	9.45
C106-00#OUTLET	17.46	11634.1	01Jan2003, 18:30	9.39
C106-01#1	2.78	1572.4	01Jan2003, 17:30	9.15
C106-01#OUTLET	4.80	2649.2	01Jan2003, 19:00	9.30
C106-08#OUTLET	1.82	1456.8	01Jan2003, 17:00	9.55
C106A	1.82	1456.8	01Jan2003, 17:00	9.55
C106B	3.02	1910.4	01Jan2003, 17:30	9.40
C106C	1.89	2219.8	01Jan2003, 16:45	9.56
C106C REACH	4.84	3328.7	01Jan2003, 17:30	9.45
C106D	2.86	1924.6	01Jan2003, 17:15	9.57
C106E	2.78	1572.4	01Jan2003, 17:30	9.15
C106F	2.02	1236.7	01Jan2003, 17:30	9.51
C106F REACH	2.78	1536.0	01Jan2003, 19:30	9.14
C106G	3.07	2656.3	01Jan2003, 17:00	9.17
C106G REACH#1	14.39	9454.3	01Jan2003, 18:45	9.44
C106G REACH#2	9.59	7166.0	01Jan2003, 17:45	9.51
C118	3.87	1587.9	01Jan2003, 18:30	8.80
C1180000_0009_J	3.87	2004.6	01Jan2003, 17:15	8.91
C1180000_0009_R	1.93	642.2	02Jan2003, 04:45	8.94
C118A	1.93	829.1	01Jan2003, 18:15	8.99
C118B	1.94	1752.6	01Jan2003, 17:00	8.88
C120	2.23	1307.0	01Jan2003, 17:15	8.14
C120 REACH	55.05	24697.5	01Jan2003, 20:45	8.55

50-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C123	2.44	1571.4	01Jan2003, 17:45	8.23
C123 REACH	48.74	22251.9	01Jan2003, 20:45	8.54
C127	2.14	1545.0	01Jan2003, 17:00	8.48
C132	4.07	1251.0	01Jan2003, 18:30	7.59
C134	2.03	623.3	01Jan2003, 19:30	7.30
C134 REACH	34.73	17022.9	01Jan2003, 20:15	8.71
C137	1.56	938.3	01Jan2003, 17:15	8.45
C143	1.98	1115.3	01Jan2003, 17:15	8.58
C144	1.02	594.6	01Jan2003, 17:15	8.41
C145#1	1.86	979.6	01Jan2003, 17:30	9.53
C145#OUTLET	3.24	1803.9	01Jan2003, 17:30	9.34
C145A	1.86	979.6	01Jan2003, 17:30	9.53
C145B	1.38	828.1	01Jan2003, 17:15	9.08
C147#1	1.82	943.2	01Jan2003, 17:30	9.23
C147#2	2.71	1358.6	01Jan2003, 17:45	8.82
C147#OUTLET	7.16	3460.6	01Jan2003, 19:45	8.98
C147A	1.82	943.2	01Jan2003, 17:30	9.23
C147B	2.71	1358.6	01Jan2003, 17:45	8.82
C147C	2.63	2043.8	01Jan2003, 17:15	9.06
C147C REACH	4.53	2038.8	01Jan2003, 20:30	8.93
C147 DETENTION	4.53	2070.2	01Jan2003, 19:45	8.94
C161	2.39	1006.6	01Jan2003, 18:15	7.93
C162	0.97	509.4	01Jan2003, 17:30	8.96
DET#1	4.53	2070.2	01Jan2003, 19:45	8.94
DET#2	4.53	2301.3	01Jan2003, 17:45	8.99
DETENTION REACH#1	5.07	2699.4	01Jan2003, 19:00	8.86
DETENTION REACH#2	3.23	1559.6	01Jan2003, 19:00	8.70
Outlet	93.51	38128.9	01Jan2003, 22:15	8.73

100-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_100

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(1%flood)
 Compute Time: 19Nov2015, 08:08:28 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	43125.2	01Jan2003, 22:00	10.49
C100#10	44.95	24835.5	01Jan2003, 20:30	10.31
C100#11	42.97	23878.3	01Jan2003, 20:30	10.29
C100#12	40.83	22760.2	01Jan2003, 20:15	10.30
C100#13	34.73	20618.8	01Jan2003, 19:45	10.52
C100#14	32.50	19577.7	01Jan2003, 19:45	10.61
C100#15	28.36	17000.6	01Jan2003, 19:30	10.66
C100#16	23.73	14318.3	01Jan2003, 19:30	10.73
C100#17	21.75	13216.6	01Jan2003, 19:30	10.77
C100#18	20.73	12609.2	01Jan2003, 19:30	10.80
C100#19	18.31	11037.7	01Jan2003, 19:30	10.77
C100#2	87.76	41869.6	01Jan2003, 21:30	10.46
C100#20	15.07	9162.5	01Jan2003, 19:30	10.69
C100#21	7.91	4779.7	01Jan2003, 19:15	10.60
C100#22	5.07	3306.4	01Jan2003, 18:15	10.67
C100#23	3.23	1890.7	01Jan2003, 18:00	10.52
C100#24	2.26	1292.4	01Jan2003, 17:45	10.41
C100#3	86.15	41373.0	01Jan2003, 21:30	10.44
C100#4	68.69	32957.3	01Jan2003, 23:15	10.25
C100#5	65.31	32050.4	01Jan2003, 22:45	10.21
C100#6	63.55	31449.9	01Jan2003, 22:15	10.21
C100#7	57.28	29717.5	01Jan2003, 21:30	10.31
C100#8	55.05	28744.3	01Jan2003, 21:30	10.33
C100#9	48.74	26316.6	01Jan2003, 21:15	10.33
C100#D1	5.07	3219.9	01Jan2003, 19:00	10.66
C100#D2	3.23	1868.9	01Jan2003, 18:30	10.51

100-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1292.4	01Jan2003, 17:45	10.41
C100B	1.84	1688.3	01Jan2003, 16:45	10.96
C100B REACH#1	3.23	1868.9	01Jan2003, 18:30	10.51
C100B REACH#2	2.26	1291.1	01Jan2003, 18:00	10.41
C100C	2.84	1681.9	01Jan2003, 17:45	10.51
C100D	2.42	1793.9	01Jan2003, 17:30	10.98
C100D REACH#1	18.31	11035.4	01Jan2003, 19:30	10.77
C100D REACH#2	15.07	9134.6	01Jan2003, 19:45	10.69
C100D REACH#3	7.91	4771.4	01Jan2003, 19:30	10.60
C100E	2.24	1680.6	01Jan2003, 18:15	11.05
C100E REACH#1	23.73	14302.3	01Jan2003, 19:45	10.73
C100E REACH#2	21.75	13178.7	01Jan2003, 19:45	10.76
C100E REACH#3	20.73	12610.1	01Jan2003, 19:30	10.79
C100F	2.58	1987.1	01Jan2003, 17:45	10.27
C100F REACH	28.36	16963.7	01Jan2003, 20:00	10.66
C100G	2.23	1198.8	01Jan2003, 17:45	9.30
C100G REACH	32.50	19551.1	01Jan2003, 20:00	10.60
C100H	1.98	2092.4	01Jan2003, 17:00	10.79
C100H REACH#1	42.97	23787.9	01Jan2003, 20:45	10.29
C100H REACH#2	40.83	22699.7	01Jan2003, 20:30	10.29
C100I	3.79	3204.3	01Jan2003, 17:15	10.75
C100I REACH	44.95	24497.0	01Jan2003, 21:30	10.29
C100J	6.27	2014.1	01Jan2003, 19:45	9.53
C100J REACH	57.28	29566.2	01Jan2003, 22:15	10.29
C100K	1.76	1505.9	01Jan2003, 17:15	10.68
C100K#1	1.76	1505.9	01Jan2003, 17:15	10.68
C100L	3.38	3572.6	01Jan2003, 17:00	11.37
C100L REACH#1	65.31	31899.3	01Jan2003, 23:15	10.19
C100L REACH#2	63.55	31375.2	01Jan2003, 22:45	10.20
C100M	1.76	1265.5	01Jan2003, 18:00	11.65
C100M REACH#1	91.75	43096.2	01Jan2003, 22:30	10.47
C100M REACH#2	87.76	41739.3	01Jan2003, 22:00	10.45

100-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	41350.8	01Jan2003, 21:45	10.44
C100M REACH#4	68.69	32960.0	01Jan2003, 23:15	10.25
C100 REACH	5.07	3206.2	01Jan2003, 19:30	10.66
C102#1	2.90	1228.5	01Jan2003, 19:00	11.10
C102#OULET	3.99	2572.3	01Jan2003, 17:15	11.32
C102A	2.90	1228.5	01Jan2003, 19:00	11.10
C102B	1.09	1785.4	01Jan2003, 16:45	12.05
C102B REACH	2.90	1227.5	01Jan2003, 19:15	11.05
C103	1.61	2384.0	01Jan2003, 16:45	11.73
C106-00#1	14.39	11149.2	01Jan2003, 17:45	11.27
C106-00#2	9.59	8442.8	01Jan2003, 17:15	11.34
C106-00#3	4.84	3918.0	01Jan2003, 17:15	11.29
C106-00#OUTLET	17.46	13574.6	01Jan2003, 18:30	11.22
C106-01#1	2.78	1850.7	01Jan2003, 17:30	10.97
C106-01#OUTLET	4.80	3129.3	01Jan2003, 19:15	11.12
C106-08#OUTLET	1.82	1698.5	01Jan2003, 17:00	11.38
C106A	1.82	1698.5	01Jan2003, 17:00	11.38
C106B	3.02	2240.6	01Jan2003, 17:30	11.23
C106C	1.89	2566.6	01Jan2003, 16:45	11.39
C106C REACH	4.84	3896.6	01Jan2003, 17:45	11.29
C106D	2.86	2250.3	01Jan2003, 17:15	11.40
C106E	2.78	1850.7	01Jan2003, 17:30	10.97
C106F	2.02	1449.7	01Jan2003, 17:30	11.34
C106F REACH	2.78	1813.1	01Jan2003, 19:30	10.96
C106G	3.07	3098.4	01Jan2003, 17:00	10.99
C106G REACH#1	14.39	11001.9	01Jan2003, 18:45	11.27
C106G REACH#2	9.59	8379.4	01Jan2003, 17:45	11.34
C118	3.87	1888.5	01Jan2003, 18:45	10.57
C1180000_0009_J	3.87	2327.8	01Jan2003, 17:00	10.71
C1180000_0009_R	1.93	736.6	02Jan2003, 06:00	10.72
C118A	1.93	983.0	01Jan2003, 18:15	10.77
C118B	1.94	2045.5	01Jan2003, 17:00	10.69

100-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1548.9	01Jan2003, 17:30	9.92
C120 REACH	55.05	28712.1	01Jan2003, 21:45	10.33
C123	2.44	1857.8	01Jan2003, 17:45	10.02
C123 REACH	48.74	26213.2	01Jan2003, 21:45	10.32
C127	2.14	1815.9	01Jan2003, 17:00	10.28
C132	4.07	1511.3	01Jan2003, 19:00	9.25
C134	2.03	755.1	01Jan2003, 19:45	8.96
C134 REACH	34.73	20554.2	01Jan2003, 20:15	10.51
C137	1.56	1108.1	01Jan2003, 17:15	10.24
C143	1.98	1317.3	01Jan2003, 17:30	10.38
C144	1.02	702.7	01Jan2003, 17:15	10.20
C145#1	1.86	1151.7	01Jan2003, 17:45	11.36
C145#OUTLET	3.24	2122.3	01Jan2003, 17:30	11.17
C145A	1.86	1151.7	01Jan2003, 17:45	11.36
C145B	1.38	973.5	01Jan2003, 17:15	10.91
C147#1	1.82	1112.3	01Jan2003, 17:45	11.05
C147#2	2.71	1606.8	01Jan2003, 17:45	10.63
C147#OUTLET	7.16	4391.1	01Jan2003, 19:30	10.79
C147A	1.82	1112.3	01Jan2003, 17:45	11.05
C147B	2.71	1606.8	01Jan2003, 17:45	10.63
C147C	2.63	2389.8	01Jan2003, 17:15	10.88
C147C REACH	4.53	2558.7	01Jan2003, 20:00	10.73
C147 DETENTION	4.53	2597.3	01Jan2003, 19:15	10.75
C161	2.39	1204.8	01Jan2003, 18:30	9.69
C162	0.97	601.6	01Jan2003, 17:45	10.77
DET#1	4.53	2597.3	01Jan2003, 19:15	10.75
DET#2	4.53	2719.1	01Jan2003, 17:45	10.80
DETENTION REACH#1	5.07	3219.9	01Jan2003, 19:00	10.66
DETENTION REACH#2	3.23	1856.7	01Jan2003, 19:00	10.50
Outlet	93.51	43939.6	01Jan2003, 22:15	10.49

500-YEAR REVISED EXISTING

Project: C100-00-00 Simulation Run: RevisedExisting_500

Start of Run: 01Jan2003, 00:00 Basin Model: Revised_Existing
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(.2%flood)
 Compute Time: 04Sep2015, 09:25:28 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	57116.4	01Jan2003, 20:30	15.93
C100#10	44.95	32724.3	01Jan2003, 23:30	15.80
C100#11	42.97	32224.7	01Jan2003, 22:45	15.78
C100#12	40.83	31522.5	01Jan2003, 22:00	15.79
C100#13	34.73	28736.2	01Jan2003, 21:00	16.07
C100#14	32.50	27579.1	01Jan2003, 19:45	16.17
C100#15	28.36	23908.4	01Jan2003, 20:15	16.24
C100#16	23.73	20247.6	01Jan2003, 20:30	16.32
C100#17	21.75	19484.0	01Jan2003, 19:45	16.36
C100#18	20.73	18654.0	01Jan2003, 19:30	16.39
C100#19	18.31	16469.5	01Jan2003, 19:15	16.36
C100#2	87.76	55645.5	01Jan2003, 19:45	15.91
C100#20	15.07	13901.1	01Jan2003, 19:00	16.27
C100#21	7.91	6992.1	01Jan2003, 19:15	16.19
C100#22	5.07	4708.6	01Jan2003, 18:30	16.26
C100#23	3.23	2767.8	01Jan2003, 18:15	16.09
C100#24	2.26	1896.8	01Jan2003, 18:00	15.98
C100#3	86.15	54234.1	01Jan2003, 19:45	15.89
C100#4	68.69	38601.9	02Jan2003, 01:30	15.66
C100#5	65.31	38077.7	02Jan2003, 00:45	15.61
C100#6	63.55	37567.6	01Jan2003, 23:45	15.62
C100#7	57.28	35372.5	01Jan2003, 20:30	15.79
C100#8	55.05	34422.0	02Jan2003, 01:30	15.82
C100#9	48.74	32542.1	02Jan2003, 01:30	15.81
C100#D1	5.07	4641.7	01Jan2003, 19:00	16.25
C100#D2	3.23	2677.9	01Jan2003, 19:30	16.08

500-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1896.8	01Jan2003, 18:00	15.98
C100B	1.84	2381.2	01Jan2003, 17:00	16.60
C100B REACH#1	3.23	2677.9	01Jan2003, 19:30	16.08
C100B REACH#2	2.26	1894.8	01Jan2003, 18:15	15.97
C100C	2.84	2460.9	01Jan2003, 18:00	16.09
C100D	2.42	2573.3	01Jan2003, 17:45	16.62
C100D REACH#1	18.31	16360.2	01Jan2003, 19:45	16.36
C100D REACH#2	15.07	13616.8	01Jan2003, 19:45	16.27
C100D REACH#3	7.91	6982.1	01Jan2003, 19:15	16.18
C100E	2.24	2412.9	01Jan2003, 18:15	16.65
C100E REACH#1	23.73	20210.5	01Jan2003, 21:00	16.31
C100E REACH#2	21.75	18749.0	01Jan2003, 20:45	16.35
C100E REACH#3	20.73	18596.7	01Jan2003, 19:45	16.39
C100F	2.58	2868.0	01Jan2003, 18:00	15.81
C100F REACH	28.36	23888.7	01Jan2003, 20:45	16.23
C100G	2.23	1792.4	01Jan2003, 18:00	14.73
C100G REACH	32.50	27260.4	01Jan2003, 21:15	16.16
C100H	1.98	2928.3	01Jan2003, 17:00	16.37
C100H REACH#1	42.97	31916.5	01Jan2003, 23:45	15.77
C100H REACH#2	40.83	31091.8	01Jan2003, 23:15	15.78
C100I	3.79	4565.8	01Jan2003, 17:15	16.33
C100I REACH	44.95	31347.7	02Jan2003, 01:45	15.77
C100J	6.27	3006.7	01Jan2003, 19:45	14.40
C100J REACH	57.28	35070.2	02Jan2003, 03:00	15.75
C100K	1.76	2144.8	01Jan2003, 17:30	16.26
C100K#1	1.76	2144.8	01Jan2003, 17:30	16.26
C100L	3.38	4970.3	01Jan2003, 17:15	17.00
C100L REACH#1	65.31	37924.7	02Jan2003, 03:00	15.59
C100L REACH#2	63.55	37461.8	02Jan2003, 02:00	15.60
C100M	1.76	1810.8	01Jan2003, 18:15	17.30
C100M REACH#1	91.75	56743.8	01Jan2003, 21:15	15.90
C100M REACH#2	87.76	54664.5	01Jan2003, 20:30	15.89
C100M REACH#3	86.15	54177.1	01Jan2003, 20:00	15.89

500-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	38600.8	02Jan2003, 01:30	15.65
C100 REACH	5.07	4630.1	01Jan2003, 19:30	16.24
C102#1	2.90	1802.6	01Jan2003, 19:15	16.42
C102#OULET	3.99	3584.9	01Jan2003, 17:15	16.73
C102A	2.90	1802.6	01Jan2003, 19:15	16.42
C102B	1.09	2400.3	01Jan2003, 16:45	17.73
C102B REACH	2.90	1798.9	01Jan2003, 19:45	16.36
C103	1.61	3230.8	01Jan2003, 16:45	17.39
C106-00#1	14.39	15757.6	01Jan2003, 18:15	16.89
C106-00#2	9.59	11907.0	01Jan2003, 17:30	16.98
C106-00#3	4.84	5566.8	01Jan2003, 17:30	16.92
C106-00#OUTLET	17.46	18806.0	01Jan2003, 19:15	16.84
C106-01#1	2.78	2677.2	01Jan2003, 17:45	16.56
C106-01#OUTLET	4.80	4549.1	01Jan2003, 19:15	16.72
C106-08#OUTLET	1.82	2383.7	01Jan2003, 17:15	17.02
C106A	1.82	2383.7	01Jan2003, 17:15	17.02
C106B	3.02	3208.9	01Jan2003, 17:45	16.85
C106C	1.89	3497.2	01Jan2003, 16:45	17.03
C106C REACH	4.84	5544.1	01Jan2003, 17:45	16.92
C106D	2.86	3205.1	01Jan2003, 17:30	17.04
C106E	2.78	2677.2	01Jan2003, 17:45	16.56
C106F	2.02	2079.0	01Jan2003, 17:45	16.97
C106F REACH	2.78	2637.2	01Jan2003, 19:45	16.55
C106G	3.07	4348.7	01Jan2003, 17:15	16.59
C106G REACH#1	14.39	15405.7	01Jan2003, 19:45	16.89
C106G REACH#2	9.59	11807.1	01Jan2003, 17:45	16.98
C118	3.87	2789.1	01Jan2003, 19:15	16.02
C1180000_0009_J	3.87	3188.8	01Jan2003, 17:15	16.23
C1180000_0009_R	1.93	1034.2	02Jan2003, 07:15	16.18
C118A	1.93	1445.2	01Jan2003, 18:45	16.26
C118B	1.94	2857.9	01Jan2003, 17:15	16.27
C120	2.23	2258.8	01Jan2003, 17:45	15.44
C120 REACH	55.05	34370.4	02Jan2003, 02:00	15.81

500-YEAR REVISED EXISTING

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C123	2.44	2689.3	01Jan2003, 18:00	15.54
C123 REACH	48.74	32358.1	02Jan2003, 02:15	15.80
C127	2.14	2595.0	01Jan2003, 17:15	15.82
C132	4.07	2294.7	01Jan2003, 19:15	14.39
C134	2.03	1149.1	01Jan2003, 20:00	14.08
C134 REACH	34.73	28429.8	01Jan2003, 22:15	16.05
C137	1.56	1608.0	01Jan2003, 17:30	15.78
C143	1.98	1918.1	01Jan2003, 17:30	15.93
C144	1.02	1022.7	01Jan2003, 17:30	15.74
C145#1	1.86	1664.3	01Jan2003, 18:00	17.00
C145#OUTLET	3.24	3062.5	01Jan2003, 17:45	16.80
C145A	1.86	1664.3	01Jan2003, 18:00	17.00
C145B	1.38	1403.0	01Jan2003, 17:30	16.54
C147#1	1.82	1614.2	01Jan2003, 18:00	16.67
C147#2	2.71	2347.9	01Jan2003, 18:15	16.22
C147#OUTLET	7.16	7018.3	01Jan2003, 18:45	16.38
C147A	1.82	1614.2	01Jan2003, 18:00	16.67
C147B	2.71	2347.9	01Jan2003, 18:15	16.22
C147C	2.63	3379.6	01Jan2003, 17:30	16.51
C147C REACH	4.53	3936.0	01Jan2003, 19:00	16.30
C147 DETENTION	4.53	3948.9	01Jan2003, 18:30	16.32
C161	2.39	1800.1	01Jan2003, 18:45	15.11
C162	0.97	875.2	01Jan2003, 18:00	16.38
DET#1	4.53	3948.9	01Jan2003, 18:30	16.32
DET#2	4.53	3962.0	01Jan2003, 18:00	16.40
DETENTION REACH#1	5.07	4641.7	01Jan2003, 19:00	16.25
DETENTION REACH#2	3.23	2668.6	01Jan2003, 19:45	16.07
Outlet	93.51	58175.1	01Jan2003, 21:15	15.93

APPENDIX B.3

HEC-RAS OUTPUTS

- **DUPLICATE EFFECTIVE OUTPUTS**
- **REVISED EXISTING OUTPUTS**

DUPLICATE EFFECTIVE MODEL

HEC-RAS Plan: DupEff River: C118-00-00 Reach: C118-00-00_0009

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00_0009	863.9	10PCT_10yr	1762.00	13.40	23.86	20.55	24.61	0.003501	6.93	254.22	38.49	0.48
C118-00-00_0009	863.9	2PCT_50yr	2604.00	13.40	25.95	22.14	26.86	0.003501	7.65	340.40	44.14	0.49
C118-00-00_0009	863.9	1PCT_100yr	3048.00	13.40	26.88	22.88	27.86	0.003506	7.96	382.75	46.66	0.49
C118-00-00_0009	863.9	0.2PCT_500yr	4344.00	13.40	29.22	24.69	30.39	0.003506	8.70	499.35	53.05	0.50
C118-00-00_0009	1510.0	10PCT_10yr	1400.00	14.86	25.87		26.27	0.001778	5.08	275.75	39.98	0.34
C118-00-00_0009	1510.0	2PCT_50yr	2069.00	14.86	28.04		28.53	0.001783	5.61	368.89	45.85	0.35
C118-00-00_0009	1510.0	1PCT_100yr	2422.00	14.86	29.01		29.54	0.001786	5.84	414.84	48.49	0.35
C118-00-00_0009	1510.0	0.2PCT_500yr	3452.00	14.86	31.55		32.16	0.001955	6.28	549.35	62.30	0.37
C118-00-00_0009	2080.7	10PCT_10yr	1400.00	16.15	27.18		28.04	0.005365	7.45	187.86	34.20	0.56
C118-00-00_0009	2080.7	2PCT_50yr	2069.00	16.15	29.26		30.21	0.004572	7.79	265.48	39.95	0.53
C118-00-00_0009	2080.7	1PCT_100yr	2422.00	16.15	30.20		31.19	0.004300	7.97	303.91	42.01	0.52
C118-00-00_0009	2080.7	0.2PCT_500yr	3452.00	16.15	32.72		33.79	0.003655	8.28	416.76	47.54	0.49
C118-00-00_0009	2997.8	10PCT_10yr	1400.00	20.34	30.17		30.47	0.001523	4.44	315.63	54.40	0.32
C118-00-00_0009	2997.8	2PCT_50yr	2069.00	20.34	32.10		32.46	0.001464	4.82	429.14	63.31	0.33
C118-00-00_0009	2997.8	1PCT_100yr	2422.00	20.34	32.98		33.36	0.001433	4.98	486.80	67.38	0.33
C118-00-00_0009	2997.8	0.2PCT_500yr	3452.00	20.34	35.31		35.74	0.001312	5.26	656.06	78.11	0.32
C118-00-00_0009	3846.7	10PCT_10yr	1400.00	24.00	31.92	29.60	32.40	0.003495	5.55	252.40	59.73	0.48
C118-00-00_0009	3846.7	2PCT_50yr	2069.00	24.00	33.72	30.77	34.18	0.002884	5.43	381.06	81.34	0.44
C118-00-00_0009	3846.7	1PCT_100yr	2422.00	24.00	34.51	31.27	34.96	0.002502	5.42	448.43	93.66	0.42
C118-00-00_0009	3846.7	0.2PCT_500yr	3452.00	24.00	36.55	32.59	37.00	0.001694	5.43	709.04	225.66	0.36
C118-00-00_0009	4058.0	10PCT_10yr	1400.00	24.91	32.90	31.58	33.88	0.011606	7.95	176.16	41.01	0.68
C118-00-00_0009	4058.0	2PCT_50yr	2069.00	24.91	34.46	32.90	35.55	0.010616	8.37	247.13	50.08	0.66
C118-00-00_0009	4058.0	1PCT_100yr	2422.00	24.91	35.11	33.48	36.26	0.010446	8.63	280.75	53.85	0.67
C118-00-00_0009	4058.0	0.2PCT_500yr	3452.00	24.91	36.93	34.89	37.93	0.007291	8.33	846.26	923.97	0.58
C118-00-00_0009	4083.6		Bridge									
C118-00-00_0009	4109.2	10PCT_10yr	1400.00	25.12	34.42	31.79	34.97	0.005564	5.97	234.56	48.60	0.48
C118-00-00_0009	4109.2	2PCT_50yr	2069.00	25.12	36.04	33.11	36.68	0.005327	6.45	321.18	186.87	0.48
C118-00-00_0009	4109.2	1PCT_100yr	2422.00	25.12	36.76	33.68	37.45	0.005037	6.65	368.67	534.48	0.48
C118-00-00_0009	4109.2	0.2PCT_500yr	3452.00	25.12	39.11	35.09	39.18	0.000717	3.12	5702.55	3208.10	0.19
C118-00-00_0009	4343.0	10PCT_10yr	1149.00	25.70	35.78	32.13	36.12	0.003803	4.70	254.37	144.52	0.38
C118-00-00_0009	4343.0	2PCT_50yr	1699.00	25.70	37.37	33.39	37.75	0.003295	5.00	536.20	1495.51	0.37
C118-00-00_0009	4343.0	1PCT_100yr	1988.00	25.70	38.06	33.98	38.45	0.002891	5.06	1049.83	3432.25	0.36
C118-00-00_0009	4343.0	0.2PCT_500yr	2834.00	25.70	39.29	35.59	39.51	0.001775	4.46	7828.83	4265.97	0.29
C118-00-00_0009	5037.2	10PCT_10yr	1149.00	27.45	37.46	33.58	37.68	0.001474	3.86	564.37	2198.75	0.29
C118-00-00_0009	5037.2	2PCT_50yr	1699.00	27.45	38.86	34.65	39.08	0.001222	4.07	1648.32	6483.94	0.27
C118-00-00_0009	5037.2	1PCT_100yr	1988.00	27.45	39.43	35.14	39.64	0.001112	4.09	2220.07	6539.60	0.26
C118-00-00_0009	5037.2	0.2PCT_500yr	2834.00	27.45	40.12	36.43	40.20	0.000632	3.26	16962.96	7594.93	0.20
C118-00-00_0009	5550.6	10PCT_10yr	1149.00	27.33	38.05	33.46	38.23	0.000792	3.44	754.49	3682.38	0.24
C118-00-00_0009	5550.6	2PCT_50yr	1699.00	27.33	39.37	34.53	39.55	0.000687	3.63	2077.42	7329.22	0.23
C118-00-00_0009	5550.6	1PCT_100yr	1988.00	27.33	39.91	35.02	40.08	0.000668	3.74	2608.15	7372.65	0.23
C118-00-00_0009	5550.6	0.2PCT_500yr	2834.00	27.33	40.40	36.27	40.50	0.000511	3.40	17165.99	7451.52	0.20
C118-00-00_0009	5866.6	10PCT_10yr	1149.00	27.26	38.31	32.15	38.43	0.000422	2.83	1530.93	5821.84	0.18
C118-00-00_0009	5866.6	2PCT_50yr	1699.00	27.26	39.61	33.28	39.73	0.000399	3.05	2830.67	6968.56	0.18
C118-00-00_0009	5866.6	1PCT_100yr	1988.00	27.26	40.14	33.80	40.26	0.000401	3.18	3357.36	7148.12	0.18
C118-00-00_0009	5866.6	0.2PCT_500yr	2834.00	27.26	40.57	35.11	40.63	0.000295	2.81	21163.70	7154.93	0.16
C118-00-00_0009	5935.4		Bridge									
C118-00-00_0009	6004.2	10PCT_10yr	1149.00	27.31	38.54	32.21	38.64	0.000375	2.71	1706.36	6096.52	0.17
C118-00-00_0009	6004.2	2PCT_50yr	1699.00	27.31	39.90	33.33	39.99	0.000347	2.90	3061.06	7127.29	0.17
C118-00-00_0009	6004.2	1PCT_100yr	1988.00	27.31	40.43	33.84	40.53	0.000351	3.02	3594.33	7152.93	0.17
C118-00-00_0009	6004.2	0.2PCT_500yr	2834.00	27.31	40.71	35.16	40.76	0.000277	2.73	21797.07	7155.61	0.15
C118-00-00_0009	6143.9	10PCT_10yr	1149.00	27.22	38.62	33.97	38.71	0.000508	2.71	1497.38	5678.35	0.19
C118-00-00_0009	6143.9	2PCT_50yr	1699.00	27.22	39.99	35.13	40.05	0.000346	2.56	2870.65	7231.95	0.16
C118-00-00_0009	6143.9	1PCT_100yr	1988.00	27.22	40.53	35.64	40.59	0.000323	2.59	3409.59	7260.59	0.16
C118-00-00_0009	6143.9	0.2PCT_500yr	2834.00	27.22	40.79	37.70	40.80	0.000149	1.79	19890.73	7261.42	0.11

REVISED EXISTING MODEL

HEC-RAS Plan: RevEx River: C118-00-00 Reach: C118-00-00_0009

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00_0009	863.9	50PCT_2yr	777.00	13.40	20.44	17.99	20.93	0.003500	5.62	138.36	29.23	0.45
C118-00-00_0009	863.9	25PCT_5yr	1093.00	13.40	21.72	18.94	22.31	0.003500	6.13	178.17	32.71	0.46
C118-00-00_0009	863.9	10PCT_10yr	1343.00	13.40	22.59	19.58	23.24	0.003501	6.47	207.63	35.06	0.47
C118-00-00_0009	863.9	4PCT_25yr	1709.00	13.40	23.71	20.44	24.45	0.003501	6.88	248.49	38.08	0.47
C118-00-00_0009	863.9	2PCT_50yr	2005.00	13.40	24.51	21.05	25.31	0.003504	7.16	279.87	40.25	0.48
C118-00-00_0009	863.9	1PCT_100yr	2328.00	13.40	25.31	21.64	26.17	0.003502	7.44	313.00	42.42	0.48
C118-00-00_0009	863.9	0.2PCT_500yr	3189.00	13.40	27.16	23.10	28.17	0.003504	8.05	396.03	47.43	0.49
C118-00-00_0009	1510.0	50PCT_2yr	702.00	14.86	22.40		22.72	0.002169	4.58	153.21	30.57	0.36
C118-00-00_0009	1510.0	25PCT_5yr	988.00	14.86	23.73		24.12	0.002204	5.03	196.28	34.17	0.37
C118-00-00_0009	1510.0	10PCT_10yr	1214.00	14.86	24.63		25.07	0.002223	5.32	228.09	36.61	0.38
C118-00-00_0009	1510.0	4PCT_25yr	1547.00	14.86	25.78		26.28	0.002249	5.69	272.10	39.73	0.38
C118-00-00_0009	1510.0	2PCT_50yr	1818.00	14.86	26.61		27.15	0.002270	5.94	305.92	41.97	0.39
C118-00-00_0009	1510.0	1PCT_100yr	2116.00	14.86	27.43		28.03	0.002292	6.20	341.48	44.20	0.39
C118-00-00_0009	1510.0	0.2PCT_500yr	2921.00	14.86	29.33		30.05	0.002348	6.79	430.45	49.20	0.40
C118-00-00_0009	2080.7	50PCT_2yr	702.00	16.15	24.17		24.95	0.007435	7.08	99.15	24.67	0.62
C118-00-00_0009	2080.7	25PCT_5yr	988.00	16.15	25.44		26.29	0.006720	7.43	133.01	28.68	0.61
C118-00-00_0009	2080.7	10PCT_10yr	1214.00	16.15	26.30		27.20	0.006313	7.64	158.87	31.40	0.60
C118-00-00_0009	2080.7	4PCT_25yr	1547.00	16.15	27.41		28.38	0.005866	7.90	195.79	34.92	0.59
C118-00-00_0009	2080.7	2PCT_50yr	1818.00	16.15	28.21		29.23	0.005583	8.09	224.73	37.29	0.58
C118-00-00_0009	2080.7	1PCT_100yr	2116.00	16.15	29.01		30.08	0.005328	8.29	255.40	39.39	0.57
C118-00-00_0009	2080.7	0.2PCT_500yr	2921.00	16.15	30.86		32.06	0.004888	8.79	332.20	43.46	0.56
C118-00-00_0009	2997.8	50PCT_2yr	650.00	20.34	27.40		27.60	0.001415	3.56	182.80	41.61	0.30
C118-00-00_0009	2997.8	25PCT_5yr	915.00	20.34	28.62		28.85	0.001401	3.86	236.86	47.23	0.30
C118-00-00_0009	2997.8	10PCT_10yr	1125.00	20.34	29.44		29.70	0.001389	4.06	277.33	51.04	0.31
C118-00-00_0009	2997.8	4PCT_25yr	1435.00	20.34	30.51		30.79	0.001372	4.29	334.33	55.96	0.31
C118-00-00_0009	2997.8	2PCT_50yr	1689.00	20.34	31.28		31.59	0.001359	4.46	379.06	59.54	0.31
C118-00-00_0009	2997.8	1PCT_100yr	1969.00	20.34	32.06		32.39	0.001345	4.61	426.78	63.13	0.31
C118-00-00_0009	2997.8	0.2PCT_500yr	2735.00	20.34	33.90		34.28	0.001314	4.97	550.78	71.63	0.32
C118-00-00_0009	3846.7	50PCT_2yr	592.00	24.00	29.15	27.44	29.54	0.004271	5.02	117.95	37.30	0.50
C118-00-00_0009	3846.7	25PCT_5yr	834.00	24.00	30.28	28.20	30.68	0.003666	5.05	165.21	46.43	0.47
C118-00-00_0009	3846.7	10PCT_10yr	1026.00	24.00	31.04	28.75	31.44	0.003290	5.06	202.90	52.59	0.45
C118-00-00_0009	3846.7	4PCT_25yr	1310.00	24.00	32.03	29.42	32.43	0.002868	5.06	258.80	60.59	0.43
C118-00-00_0009	3846.7	2PCT_50yr	1545.00	24.00	32.80	29.89	33.19	0.002786	4.99	309.86	73.11	0.43
C118-00-00_0009	3846.7	1PCT_100yr	1805.00	24.00	33.52	30.34	33.90	0.002470	4.95	364.51	79.50	0.41
C118-00-00_0009	3846.7	0.2PCT_500yr	2524.00	24.00	35.20	31.40	35.58	0.001836	4.96	518.57	107.11	0.37
C118-00-00_0009	4058.0	50PCT_2yr	592.00	24.91	30.22	29.34	30.97	0.008689	6.92	85.59	27.32	0.69
C118-00-00_0009	4058.0	25PCT_5yr	834.00	24.91	31.17	30.15	32.01	0.008173	7.34	113.56	31.73	0.68
C118-00-00_0009	4058.0	10PCT_10yr	1026.00	24.91	31.82	30.69	32.71	0.007827	7.60	134.99	34.73	0.68
C118-00-00_0009	4058.0	4PCT_25yr	1310.00	24.91	32.67	31.38	33.63	0.007460	7.85	166.92	39.68	0.67
C118-00-00_0009	4058.0	2PCT_50yr	1545.00	24.91	33.39	31.89	34.35	0.006805	7.85	196.91	43.86	0.65
C118-00-00_0009	4058.0	1PCT_100yr	1805.00	24.91	34.01	32.42	35.01	0.006575	8.02	225.20	47.47	0.65
C118-00-00_0009	4058.0	0.2PCT_500yr	2524.00	24.91	35.49	33.63	36.58	0.006010	8.36	301.85	72.06	0.64
C118-00-00_0009	4083.6		Bridge									
C118-00-00_0009	4109.2	50PCT_2yr	592.00	25.12	31.34	29.55	31.77	0.004238	5.27	112.33	31.55	0.49
C118-00-00_0009	4109.2	25PCT_5yr	834.00	25.12	32.33	30.36	32.83	0.004266	5.73	145.67	36.43	0.50
C118-00-00_0009	4109.2	10PCT_10yr	1026.00	25.12	33.00	30.90	33.56	0.004270	5.98	171.52	40.35	0.51
C118-00-00_0009	4109.2	4PCT_25yr	1310.00	25.12	33.87	31.59	34.48	0.004197	6.27	209.02	45.44	0.51
C118-00-00_0009	4109.2	2PCT_50yr	1545.00	25.12	34.54	32.10	35.18	0.004052	6.42	240.80	49.34	0.51
C118-00-00_0009	4109.2	1PCT_100yr	1805.00	25.12	35.17	32.63	35.85	0.004008	6.62	272.62	52.96	0.51
C118-00-00_0009	4109.2	0.2PCT_500yr	2524.00	25.12	36.69	33.85	37.46	0.003642	7.02	363.68	65.68	0.50
C118-00-00_0009	4343.0	50PCT_2yr	506.00	25.70	32.34	29.93	32.67	0.003154	4.56	110.97	29.19	0.41
C118-00-00_0009	4343.0	25PCT_5yr	713.00	25.70	33.35	30.71	33.74	0.003217	5.01	142.33	32.93	0.42
C118-00-00_0009	4343.0	10PCT_10yr	877.00	25.70	34.04	31.26	34.48	0.003315	5.28	166.06	36.49	0.44
C118-00-00_0009	4343.0	4PCT_25yr	1122.00	25.70	34.97	32.06	35.44	0.003583	5.49	204.22	46.06	0.46
C118-00-00_0009	4343.0	2PCT_50yr	1326.00	25.70	35.63	32.57	36.12	0.003518	5.60	242.41	50.02	0.46
C118-00-00_0009	4343.0	1PCT_100yr	1555.00	25.70	36.26	33.09	36.77	0.003429	5.74	313.13	55.86	0.46
C118-00-00_0009	4343.0	0.2PCT_500yr	2202.00	25.70	37.71	34.50	38.28	0.002878	6.08	425.49	65.64	0.44
C118-00-00_0009	5037.2	50PCT_2yr	506.00	27.45	34.20	31.83	34.41	0.002040	3.70	136.84	39.04	0.35
C118-00-00_0009	5037.2	25PCT_5yr	713.00	27.45	35.22	32.49	35.47	0.001950	3.97	179.47	45.90	0.35
C118-00-00_0009	5037.2	10PCT_10yr	877.00	27.45	35.93	32.94	36.19	0.001879	4.13	224.42	51.62	0.35
C118-00-00_0009	5037.2	4PCT_25yr	1122.00	27.45	36.83	33.53	37.11	0.001709	4.32	297.53	61.76	0.34
C118-00-00_0009	5037.2	2PCT_50yr	1326.00	27.45	37.41	33.95	37.72	0.001608	4.51	356.56	71.79	0.33
C118-00-00_0009	5037.2	1PCT_100yr	1555.00	27.45	37.99	34.39	38.32	0.001543	4.71	418.88	81.95	0.33
C118-00-00_0009	5037.2	0.2PCT_500yr	2202.00	27.45	39.27	35.46	39.57	0.001259	4.82	556.65	103.07	0.31
C118-00-00_0009	5550.6	50PCT_2yr	506.00	27.33	35.02	31.71	35.15	0.001038	2.88	176.53	47.41	0.25
C118-00-00_0009	5550.6	25PCT_5yr	713.00	27.33	36.05	32.37	36.20	0.001070	3.18	239.50	57.60	0.26
C118-00-00_0009	5550.6	10PCT_10yr	877.00	27.33	36.73	32.81	36.90	0.001035	3.37	321.73	69.64	0.26
C118-00-00_0009	5550.6	4PCT_25yr	1122.00	27.33	37.58	33.40	37.78	0.000986	3.64	493.78	87.20	0.26
C118-00-00_0009	5550.6	2PCT_50yr	1326.00	27.33	38.14	33.83	38.37	0.000990	3.88	645.54	109.88	0.27
C118-00-00_0009	5550.6	1PCT_100yr	1555.00	27.33	38.71	34.27	38.93	0.000909	3.93	841.61	139.88	0.26
C118-00-00_0009	5550.6	0.2PCT_500yr	2202.00	27.33	39.88	35.36	40.10	0.000831	4.17	1108.89	176.40	0.26
C118-00-00_0009	5866.6	50PCT_2yr	506.00	27.26	35.29	30.40	35.37	0.000437	2.21	228.53	43.71	0.17
C118-00-00_0009	5866.6	25PCT_5yr	713.00	27.26	36.34	31.04	36.45	0.000515	2.58	285.03	53.19	0.19
C118-00-00_0009	5866.6	10PCT_10yr	877.00	27.26	37.02	31.49	37.14	0.000533	2.82	360.26	64.44	0.20

REVISED EXISTING MODEL

HEC-RAS Plan: RevEx River: C118-00-00 Reach: C118-00-00_0009 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude #	Chl
C118-00-00_0009	5866.6	4PCT_25yr	1122.00	27.26	37.88	32.09	38.02	0.000531	3.06	1102.04	3107.25	0.20	
C118-00-00_0009	5866.6	2PCT_50yr	1326.00	27.26	38.48	32.54	38.61	0.000504	3.14	1691.78	3265.23	0.20	
C118-00-00_0009	5866.6	1PCT_100yr	1555.00	27.26	39.03	33.01	39.16	0.000483	3.21	2241.04	3308.17	0.19	
C118-00-00_0009	5866.6	0.2PCT_500yr	2202.00	27.26	40.18	34.15	40.32	0.000481	3.49	3394.58	3336.51	0.20	
C118-00-00_0009	5935.4		Bridge										
C118-00-00_0009	6004.2	50PCT_2yr	506.00	27.31	35.46	30.44	35.53	0.000411	2.16	233.78	44.15	0.17	
C118-00-00_0009	6004.2	25PCT_5yr	713.00	27.31	36.49	31.09	36.59	0.000488	2.54	295.57	624.13	0.18	
C118-00-00_0009	6004.2	10PCT_10yr	877.00	27.31	37.14	31.54	37.26	0.000515	2.79	532.28	1756.44	0.19	
C118-00-00_0009	6004.2	4PCT_25yr	1122.00	27.31	38.00	32.14	38.13	0.000510	3.02	1165.81	3052.33	0.19	
C118-00-00_0009	6004.2	2PCT_50yr	1326.00	27.31	38.79	32.60	38.91	0.000422	2.94	1959.13	3220.40	0.18	
C118-00-00_0009	6004.2	1PCT_100yr	1555.00	27.31	39.39	33.06	39.50	0.000395	2.98	2560.56	3264.01	0.18	
C118-00-00_0009	6004.2	0.2PCT_500yr	2202.00	27.31	40.67	34.20	40.73	0.000242	2.55	11877.21	3289.71	0.14	
C118-00-00_0009	6143.9	50PCT_2yr	427.00	27.22	35.53	31.80	35.62	0.000814	2.47	173.12	45.31	0.22	
C118-00-00_0009	6143.9	25PCT_5yr	603.00	27.22	36.57	32.47	36.68	0.000807	2.69	232.69	545.48	0.23	
C118-00-00_0009	6143.9	10PCT_10yr	743.00	27.22	37.22	32.91	37.34	0.000762	2.81	409.07	1125.15	0.22	
C118-00-00_0009	6143.9	4PCT_25yr	952.00	27.22	38.12	33.49	38.22	0.000555	2.68	1004.86	2915.73	0.20	
C118-00-00_0009	6143.9	2PCT_50yr	1129.00	27.22	38.91	33.92	38.98	0.000372	2.39	1794.33	3199.19	0.17	
C118-00-00_0009	6143.9	1PCT_100yr	1329.00	27.22	39.52	34.38	39.57	0.000307	2.31	2396.08	3211.16	0.15	
C118-00-00_0009	6143.9	0.2PCT_500yr	1906.00	27.22	40.75	35.49	40.76	0.000085	1.35	10745.06	3215.03	0.08	
C118-00-00_0009	6955.11	50PCT_2yr	427.00	27.50	36.00	31.36	36.05	0.000370	1.87	244.18	145.96	0.16	
C118-00-00_0009	6955.11	25PCT_5yr	603.00	27.50	37.08	31.98	37.14	0.000413	1.99	430.37	599.08	0.17	
C118-00-00_0009	6955.11	10PCT_10yr	743.00	27.50	37.70	32.40	37.77	0.000379	2.07	596.73	2189.67	0.16	
C118-00-00_0009	6955.11	4PCT_25yr	952.00	27.50	38.49	32.95	38.55	0.000326	2.11	999.06	3176.01	0.15	
C118-00-00_0009	6955.11	2PCT_50yr	1129.00	27.50	39.17	33.36	39.22	0.000252	1.99	1397.54	3195.13	0.14	
C118-00-00_0009	6955.11	1PCT_100yr	1329.00	27.50	39.73	33.77	39.77	0.000223	1.98	1725.98	3202.40	0.13	
C118-00-00_0009	6955.11	0.2PCT_500yr	1906.00	27.50	40.83	34.81	40.87	0.000215	2.14	2372.38	3202.40	0.13	
C118-00-00_0009	7727.61	50PCT_2yr	427.00	28.26	36.31	32.25	36.37	0.000461	1.97	287.23	443.44	0.17	
C118-00-00_0009	7727.61	25PCT_5yr	603.00	28.26	37.38	32.85	37.43	0.000370	2.00	543.94	1794.01	0.16	
C118-00-00_0009	7727.61	10PCT_10yr	743.00	28.26	37.98	33.26	38.03	0.000339	2.07	814.99	3207.03	0.16	
C118-00-00_0009	7727.61	4PCT_25yr	952.00	28.26	38.72	33.78	38.77	0.000273	2.02	1334.44	3452.69	0.14	
C118-00-00_0009	7727.61	2PCT_50yr	1129.00	28.26	39.34	34.18	39.38	0.000214	1.90	1773.14	3477.26	0.13	
C118-00-00_0009	7727.61	1PCT_100yr	1329.00	28.26	39.88	34.58	39.91	0.000189	1.88	2151.43	3493.82	0.12	
C118-00-00_0009	7727.61	0.2PCT_500yr	1906.00	28.26	40.97	35.61	41.00	0.000178	2.00	2919.86	3561.97	0.12	
C118-00-00_0009	7949.11	50PCT_2yr	427.00	29.14	36.44	33.46	36.54	0.001039	2.56	206.84	396.99	0.25	
C118-00-00_0009	7949.11	25PCT_5yr	603.00	29.14	37.47	34.09	37.56	0.000753	2.49	455.67	1915.11	0.22	
C118-00-00_0009	7949.11	10PCT_10yr	743.00	29.14	38.06	34.50	38.14	0.000639	2.51	733.79	3503.87	0.20	
C118-00-00_0009	7949.11	4PCT_25yr	952.00	29.14	38.78	35.03	38.84	0.000425	2.25	1269.82	3689.12	0.17	
C118-00-00_0009	7949.11	2PCT_50yr	1129.00	29.14	39.39	35.41	39.43	0.000308	2.06	1717.67	3695.43	0.15	
C118-00-00_0009	7949.11	1PCT_100yr	1329.00	29.14	39.92	35.88	39.95	0.000257	1.99	2108.98	3695.43	0.14	
C118-00-00_0009	7949.11	0.2PCT_500yr	1906.00	29.14	41.00	37.06	41.03	0.000221	2.04	2912.07	3695.43	0.13	
C118-00-00_0009	7980.41		Bridge										
C118-00-00_0009	8009.11	50PCT_2yr	427.00	27.27	36.54	32.16	36.60	0.000496	2.00	224.06	327.54	0.18	
C118-00-00_0009	8009.11	25PCT_5yr	603.00	27.27	37.62	32.89	37.68	0.000447	2.07	449.59	2422.32	0.17	
C118-00-00_0009	8009.11	10PCT_10yr	743.00	27.27	38.20	33.35	38.26	0.000412	2.15	737.41	3587.96	0.17	
C118-00-00_0009	8009.11	4PCT_25yr	952.00	27.27	38.88	33.92	38.93	0.000327	2.08	1232.68	3724.61	0.15	
C118-00-00_0009	8009.11	2PCT_50yr	1129.00	27.27	39.46	34.35	39.50	0.000256	1.96	1670.24	3733.42	0.14	
C118-00-00_0009	8009.11	1PCT_100yr	1329.00	27.27	39.98	34.77	40.02	0.000221	1.92	2063.00	3734.48	0.13	
C118-00-00_0009	8009.11	0.2PCT_500yr	1906.00	27.27	41.05	35.78	41.08	0.000200	2.01	2863.22	3734.48	0.13	
C118-00-00_0009	8173.81	50PCT_2yr	377.00	29.52	36.63	33.13	36.68	0.000490	1.90	223.01	280.67	0.18	
C118-00-00_0009	8173.81	25PCT_5yr	533.00	29.52	37.70	33.66	37.75	0.000378	1.90	468.70	2590.75	0.16	
C118-00-00_0009	8173.81	10PCT_10yr	657.00	29.52	38.28	34.02	38.33	0.000335	1.93	748.12	4215.78	0.15	
C118-00-00_0009	8173.81	4PCT_25yr	843.00	29.52	38.94	34.47	38.98	0.000271	1.89	1154.01	4433.44	0.14	
C118-00-00_0009	8173.81	2PCT_50yr	1002.00	29.52	39.51	34.83	39.54	0.000218	1.81	1508.61	4451.28	0.13	
C118-00-00_0009	8173.81	1PCT_100yr	1182.00	29.52	40.02	35.19	40.05	0.000192	1.79	1830.78	4473.62	0.12	
C118-00-00_0009	8173.81	0.2PCT_500yr	1712.00	29.52	41.08	36.07	41.11	0.000181	1.92	2493.20	4477.37	0.12	
C118-00-00_0009	8721.01	50PCT_2yr	377.00	29.04	36.93	33.11	37.03	0.000809	2.50	185.07	286.45	0.22	
C118-00-00_0009	8721.01	25PCT_5yr	533.00	29.04	37.93	33.86	38.00	0.000520	2.31	627.25	3086.73	0.18	
C118-00-00_0009	8721.01	10PCT_10yr	657.00	29.04	38.48	34.33	38.51	0.000297	1.87	1181.21	3946.70	0.14	
C118-00-00_0009	8721.01	4PCT_25yr	843.00	29.04	39.09	34.95	39.11	0.000180	1.56	1822.03	4006.16	0.11	
C118-00-00_0009	8721.01	2PCT_50yr	1002.00	29.04	39.62	35.41	39.63	0.000125	1.37	2378.48	4125.46	0.09	
C118-00-00_0009	8721.01	1PCT_100yr	1182.00	29.04	40.12	35.87	40.13	0.000099	1.28	2898.99	4125.46	0.08	
C118-00-00_0009	8721.01	0.2PCT_500yr	1712.00	29.04	41.17	38.12	41.18	0.000080	1.26	3995.73	4125.46	0.08	
C118-00-00_0009	9112.71	50PCT_2yr	377.00	29.20	37.24	33.14	37.30	0.000595	2.00	219.29	933.16	0.19	
C118-00-00_0009	9112.71	25PCT_5yr	533.00	29.20	38.13	33.81	38.19	0.000488	2.10	440.97	2585.37	0.18	
C118-00-00_0009	9112.71	10PCT_10yr	657.00	29.20	38.60	34.25	38.65	0.000420	2.08	730.61	3254.04	0.17	
C118-00-00_0009	9112.71	4PCT_25yr	843.00	29.20	39.16	34.81	39.20	0.000314	1.94	1179.06	3409.29	0.15	
C118-00-00_0009	9112.71	2PCT_50yr	1002.00	29.20	39.68	35.23	39.71	0.000244	1.82	1617.05	3593.97	0.13	
C118-00-00_0009	9112.71	1PCT_100yr	1182.00	29.20	40.16	35.65	40.19	0.000191	1.70	2095.84	3659.33	0.12	
C118-00-00_0009	9112.71	0.2PCT_500yr	1712.00	29.20	41.21	36.95	41.22	0.000139	1.60	3142.70	3725.43	0.10	
C118-00-00_0009	9323.21	50PCT_2yr	377.00	28.68	37.36	33.03	37.41	0.000449	1.88	351.57	742.71	0.17	
C118-00-00_0009	9323.21	25PCT_5yr	533.00	28.68	38.24	33.75	38.28	0.000341	1.82	813.94	1979.64	0.15	
C118-00-00_0009	9323.21	10PCT_10yr	657.00	28.68	38.69	34.21	38.73	0.000310	1.85	1126.42	2531.49	0.14	
C118-00-00_0009	9323.21	4PCT_25yr	843.00	28.68	39.23	34.79	39.26	0.000275	1.86	1530.34	2533.45	0.14	

REVISED EXISTING MODEL

HEC-RAS Plan: RevEx River: C118-00-00 Reach: C118-00-00_0009 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00_0009	9323.21	2PCT_50yr	1002.00	28.68	39.73	35.21	39.75	0.000236	1.82	1898.83	2533.45	0.13
C118-00-00_0009	9323.21	1PCT_100yr	1182.00	28.68	40.20	35.65	40.23	0.000214	1.82	2253.67	2533.45	0.12
C118-00-00_0009	9323.21	0.2PCT_500yr	1712.00	28.68	41.23	37.27	41.26	0.000205	1.96	3021.41	2533.45	0.12
C118-00-00_0009	9423.51	50PCT_2yr	377.00	29.47	37.42	32.83	37.45	0.000298	1.62	578.67	800.66	0.14
C118-00-00_0009	9423.51	25PCT_5yr	533.00	29.47	38.29	33.47	38.31	0.000182	1.38	1892.68	2644.81	0.11
C118-00-00_0009	9423.51	10PCT_10yr	657.00	29.47	38.74	33.90	38.75	0.000119	1.18	2930.02	2778.82	0.09
C118-00-00_0009	9423.51	4PCT_25yr	843.00	29.47	39.28	34.46	39.29	0.000083	1.05	4184.71	2840.59	0.08
C118-00-00_0009	9423.51	2PCT_50yr	1002.00	29.47	39.77	34.88	39.77	0.000061	0.95	5328.72	2840.59	0.07
C118-00-00_0009	9423.51	1PCT_100yr	1182.00	29.47	40.24	35.31	40.24	0.000050	0.90	6436.59	2840.59	0.06
C118-00-00_0009	9423.51	0.2PCT_500yr	1712.00	29.47	41.27	37.16	41.27	0.000041	0.89	8850.03	2840.59	0.06
C118-00-00_0009	9455.409		Bridge									
C118-00-00_0009	9496.81	50PCT_2yr	377.00	29.34	37.48	32.95	37.51	0.000247	1.41	531.40	724.87	0.13
C118-00-00_0009	9496.81	25PCT_5yr	533.00	29.34	38.33	33.52	38.35	0.000181	1.33	1542.70	2246.62	0.11
C118-00-00_0009	9496.81	10PCT_10yr	657.00	29.34	38.77	33.90	38.78	0.000137	1.22	2506.29	2836.84	0.10
C118-00-00_0009	9496.81	4PCT_25yr	843.00	29.34	39.29	34.39	39.30	0.000094	1.08	3744.62	2842.35	0.08
C118-00-00_0009	9496.81	2PCT_50yr	1002.00	29.34	39.78	34.76	39.78	0.000069	0.98	4877.40	2842.35	0.07
C118-00-00_0009	9496.81	1PCT_100yr	1182.00	29.34	40.25	35.14	40.25	0.000055	0.92	5979.70	2842.35	0.06
C118-00-00_0009	9496.81	0.2PCT_500yr	1712.00	29.34	41.28	36.11	41.28	0.000044	0.91	8388.36	2842.35	0.06
C118-00-00_0009	9583.51	50PCT_2yr	342.00	29.08	37.50	32.68	37.54	0.000276	1.62	472.33	696.33	0.13
C118-00-00_0009	9583.51	25PCT_5yr	483.00	29.08	38.34	33.35	38.37	0.000197	1.51	1367.33	2079.97	0.11
C118-00-00_0009	9583.51	10PCT_10yr	595.00	29.08	38.78	33.79	38.79	0.000153	1.40	2313.78	2820.57	0.10
C118-00-00_0009	9583.51	4PCT_25yr	765.00	29.08	39.30	34.36	39.31	0.000101	1.21	3548.38	2844.62	0.08
C118-00-00_0009	9583.51	2PCT_50yr	911.00	29.08	39.78	34.79	39.79	0.000072	1.07	4679.37	2844.62	0.07
C118-00-00_0009	9583.51	1PCT_100yr	1078.00	29.08	40.25	35.22	40.26	0.000056	0.99	5782.03	2844.62	0.06
C118-00-00_0009	9583.51	0.2PCT_500yr	1572.00	29.08	41.28	36.29	41.28	0.000044	0.95	8195.14	2844.62	0.06
C118-00-00_0009	10002.21	50PCT_2yr	342.00	29.55	37.63	33.51	37.67	0.000353	1.70	389.07	410.97	0.15
C118-00-00_0009	10002.21	25PCT_5yr	483.00	29.55	38.43	34.13	38.46	0.000265	1.65	1192.43	2306.79	0.13
C118-00-00_0009	10002.21	10PCT_10yr	595.00	29.55	38.84	34.53	38.86	0.000197	1.50	2134.03	2795.50	0.12
C118-00-00_0009	10002.21	4PCT_25yr	765.00	29.55	39.35	35.07	39.36	0.000126	1.28	3328.44	2866.86	0.09
C118-00-00_0009	10002.21	2PCT_50yr	911.00	29.55	39.81	35.46	39.82	0.000087	1.11	4443.88	2866.86	0.08
C118-00-00_0009	10002.21	1PCT_100yr	1078.00	29.55	40.28	35.87	40.28	0.000066	1.02	5546.28	2866.86	0.07
C118-00-00_0009	10002.21	0.2PCT_500yr	1572.00	29.55	41.30	37.26	41.30	0.000049	0.96	7980.87	2866.86	0.06
C118-00-00_0009	10525.51	50PCT_2yr	342.00	30.50	37.82	33.95	37.85	0.000344	1.65	583.63	799.42	0.15
C118-00-00_0009	10525.51	25PCT_5yr	483.00	30.50	38.57	34.55	38.59	0.000235	1.52	1532.68	2344.32	0.12
C118-00-00_0009	10525.51	10PCT_10yr	595.00	30.50	38.95	34.95	38.96	0.000173	1.37	2387.01	2742.04	0.11
C118-00-00_0009	10525.51	4PCT_25yr	765.00	30.50	39.41	35.47	39.42	0.000120	1.22	3484.94	2851.80	0.09
C118-00-00_0009	10525.51	2PCT_50yr	911.00	30.50	39.86	35.86	39.87	0.000085	1.08	4541.06	2861.71	0.08
C118-00-00_0009	10525.51	1PCT_100yr	1078.00	30.50	40.31	36.26	40.32	0.000066	1.00	5608.13	2861.71	0.07
C118-00-00_0009	10525.51	0.2PCT_500yr	1572.00	30.50	41.32	37.86	41.33	0.000049	0.95	7999.06	2861.71	0.06
C118-00-00_0009	10622.21	50PCT_2yr	342.00	30.91	37.87	34.07	37.89	0.000311	1.54	1012.28	1872.62	0.14
C118-00-00_0009	10622.21	25PCT_5yr	483.00	30.91	38.61	34.73	38.62	0.000122	1.05	2639.93	2829.41	0.09
C118-00-00_0009	10622.21	10PCT_10yr	595.00	30.91	38.98	35.16	38.98	0.000088	0.94	3512.73	2874.41	0.07
C118-00-00_0009	10622.21	4PCT_25yr	765.00	30.91	39.43	35.73	39.44	0.000068	0.87	4602.66	2888.88	0.07
C118-00-00_0009	10622.21	2PCT_50yr	911.00	30.91	39.87	36.31	39.88	0.000052	0.81	5657.12	2888.88	0.06
C118-00-00_0009	10622.21	1PCT_100yr	1078.00	30.91	40.32	37.41	40.33	0.000043	0.77	6729.57	2888.88	0.05
C118-00-00_0009	10622.21	0.2PCT_500yr	1572.00	30.91	41.33	37.97	41.33	0.000035	0.77	9143.52	2888.88	0.05
C118-00-00_0009	10645.51		Bridge									
C118-00-00_0009	10680.11	50PCT_2yr	342.00	30.51	37.92	33.96	37.94	0.000219	1.37	891.77	1102.64	0.12
C118-00-00_0009	10680.11	25PCT_5yr	483.00	30.51	38.63	34.51	38.64	0.000145	1.21	2218.77	2650.29	0.10
C118-00-00_0009	10680.11	10PCT_10yr	595.00	30.51	38.99	34.87	39.00	0.000106	1.09	3226.33	2867.65	0.08
C118-00-00_0009	10680.11	4PCT_25yr	765.00	30.51	39.44	35.35	39.45	0.000075	0.97	4533.63	2894.67	0.07
C118-00-00_0009	10680.11	2PCT_50yr	911.00	30.51	39.88	35.72	39.88	0.000054	0.87	5803.05	2894.67	0.06
C118-00-00_0009	10680.11	1PCT_100yr	1078.00	30.51	40.33	36.11	40.33	0.000042	0.80	7097.66	2894.67	0.06
C118-00-00_0009	10680.11	0.2PCT_500yr	1572.00	30.51	41.34	37.48	41.34	0.000032	0.77	10016.92	2894.67	0.05
C118-00-00_0009	10769.31	50PCT_2yr	310.00	30.46	37.95	33.96	37.96	0.000204	1.27	799.84	817.18	0.11
C118-00-00_0009	10769.31	25PCT_5yr	438.00	30.46	38.64	34.62	38.66	0.000166	1.27	1734.49	2150.02	0.10
C118-00-00_0009	10769.31	10PCT_10yr	540.00	30.46	39.00	34.91	39.01	0.000125	1.16	2581.97	2525.85	0.09
C118-00-00_0009	10769.31	4PCT_25yr	695.00	30.46	39.45	35.45	39.45	0.000090	1.05	3737.23	2647.27	0.08
C118-00-00_0009	10769.31	2PCT_50yr	829.00	30.46	39.89	35.89	39.89	0.000064	0.93	4947.46	2856.50	0.07
C118-00-00_0009	10769.31	1PCT_100yr	983.00	30.46	40.33	36.11	40.33	0.000049	0.85	6240.33	2911.41	0.06
C118-00-00_0009	10769.31	0.2PCT_500yr	1445.00	30.46	41.34	37.48	41.34	0.000034	0.78	9173.81	2911.41	0.05
C118-00-00_0009	11328.01	50PCT_2yr	310.00	29.64	38.05	33.03	38.07	0.000191	1.34	498.04	635.41	0.11
C118-00-00_0009	11328.01	25PCT_5yr	438.00	29.64	38.73	33.62	38.75	0.000177	1.41	1151.94	1651.55	0.11
C118-00-00_0009	11328.01	10PCT_10yr	540.00	29.64	39.06	34.04	39.09	0.000169	1.43	1787.07	2403.92	0.11
C118-00-00_0009	11328.01	4PCT_25yr	695.00	29.64	39.50	34.57	39.51	0.000133	1.34	2777.77	2602.50	0.10
C118-00-00_0009	11328.01	2PCT_50yr	829.00	29.64	39.92	34.93	39.93	0.000096	1.19	3792.43	2775.74	0.08
C118-00-00_0009	11328.01	1PCT_100yr	983.00	29.64	40.36	35.31	40.36	0.000072	1.08	4915.46	2858.98	0.07
C118-00-00_0009	11328.01	0.2PCT_500yr	1445.00	29.64	41.36	36.30	41.36	0.000049	0.97	7485.75	2858.98	0.06
C118-00-00_0009	11851.01	50PCT_2yr	310.00	29.95	38.15	33.60	38.17	0.000185	1.27	658.75	1074.25	0.11
C118-00-00_0009	11851.01	25PCT_5yr	438.00	29.95	38.82	34.19	38.84	0.000166	1.30	1338.26	1779.76	0.10
C118-00-00_0009	11851.01	10PCT_10yr	540.00	29.95	39.16	34.57	39.18	0.000166	1.37	1968.52	2598.56	0.11
C118-00-00_0009	11851.01	4PCT_25yr	695.00	29.95	39.57	35.08	39.58	0.000131	1.28	2919.16	2758.86	0.10
C118-00-00_0009	11851.01	2PCT_50yr	829.00	29.95	39.97	35.44	39.98	0.000096	1.15	3896.43	2812.79	0.08

REVISED EXISTING MODEL

HEC-RAS Plan: RevEx River: C118-00-00 Reach: C118-00-00_0009 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00_0009	11851.01	1PCT_100yr	983.00	29.95	40.40	35.81	40.40	0.000073	1.05	4933.12	2812.79	0.07
C118-00-00_0009	11851.01	0.2PCT_500yr	1445.00	29.95	41.38	37.16	41.39	0.000051	0.97	7342.20	2812.79	0.06
C118-00-00_0009	11979.31	50PCT_2yr	257.00	30.15	38.18	33.83	38.20	0.000163	1.15	777.49	1496.38	0.10
C118-00-00_0009	11979.31	25PCT_5yr	363.00	30.15	38.86	34.27	38.87	0.000104	0.99	1933.32	2620.83	0.08
C118-00-00_0009	11979.31	10PCT_10yr	447.00	30.15	39.20	34.59	39.20	0.000080	0.91	2708.50	2775.04	0.07
C118-00-00_0009	11979.31	4PCT_25yr	575.00	30.15	39.60	35.00	39.60	0.000064	0.85	3689.43	2865.74	0.07
C118-00-00_0009	11979.31	2PCT_50yr	686.00	30.15	39.99	35.33	40.00	0.000048	0.78	4665.64	2865.74	0.06
C118-00-00_0009	11979.31	1PCT_100yr	814.00	30.15	40.41	35.69	40.42	0.000038	0.73	5703.53	2865.74	0.05
C118-00-00_0009	11979.31	0.2PCT_500yr	1196.00	30.15	41.40	36.60	41.40	0.000028	0.69	8133.66	2865.74	0.05
C118-00-00_0009	12063.01		Culvert									
C118-00-00_0009	12133.21	50PCT_2yr	257.00	30.74	38.21	33.60	38.23	0.000201	1.27	643.04	1080.04	0.11
C118-00-00_0009	12133.21	25PCT_5yr	363.00	30.74	38.86	34.11	38.87	0.000181	1.21	1475.42	2515.54	0.10
C118-00-00_0009	12133.21	10PCT_10yr	447.00	30.74	39.19	34.46	39.20	0.000135	1.10	2259.87	2890.23	0.09
C118-00-00_0009	12133.21	4PCT_25yr	575.00	30.74	39.60	34.95	39.61	0.000093	0.97	3270.41	2897.40	0.08
C118-00-00_0009	12133.21	2PCT_50yr	686.00	30.74	40.00	35.32	40.00	0.000065	0.85	4249.93	2897.40	0.07
C118-00-00_0009	12133.21	1PCT_100yr	814.00	30.74	40.42	35.72	40.42	0.000049	0.78	5299.89	2897.40	0.06
C118-00-00_0009	12133.21	0.2PCT_500yr	1196.00	30.74	41.40	37.85	41.40	0.000034	0.72	7733.46	2897.40	0.05
C118-00-00_0009	12234.81	50PCT_2yr	257.00	30.80	38.23	34.28	38.26	0.000318	1.53	342.98	630.63	0.14
C118-00-00_0009	12234.81	25PCT_5yr	363.00	30.80	38.88	34.79	38.90	0.000264	1.48	874.21	1440.00	0.13
C118-00-00_0009	12234.81	10PCT_10yr	447.00	30.80	39.21	35.14	39.23	0.000242	1.49	1334.80	1974.98	0.13
C118-00-00_0009	12234.81	4PCT_25yr	575.00	30.80	39.61	35.60	39.63	0.000197	1.42	2168.79	2686.86	0.11
C118-00-00_0009	12234.81	2PCT_50yr	686.00	30.80	40.00	35.96	40.01	0.000132	1.23	3115.17	2857.84	0.10
C118-00-00_0009	12234.81	1PCT_100yr	814.00	30.80	40.42	36.32	40.43	0.000090	1.07	4153.69	2888.00	0.08
C118-00-00_0009	12234.81	0.2PCT_500yr	1196.00	30.80	41.40	37.25	41.41	0.000053	0.91	6617.06	2928.24	0.06
C118-00-00_0009	12657.51	50PCT_2yr	257.00	31.30	38.37	34.35	38.41	0.000366	1.53	169.24	232.84	0.15
C118-00-00_0009	12657.51	25PCT_5yr	363.00	31.30	39.00	34.96	39.05	0.000441	1.77	225.29	590.73	0.16
C118-00-00_0009	12657.51	10PCT_10yr	447.00	31.30	39.33	35.35	39.39	0.000499	1.96	276.61	1312.61	0.18
C118-00-00_0009	12657.51	4PCT_25yr	575.00	31.30	39.71	35.82	39.78	0.000572	2.22	352.25	2673.25	0.19
C118-00-00_0009	12657.51	2PCT_50yr	686.00	31.30	40.06	36.18	40.14	0.000570	2.34	454.27	3053.66	0.19
C118-00-00_0009	12657.51	1PCT_100yr	814.00	31.30	40.45	36.54	40.53	0.000548	2.42	603.45	3183.25	0.19
C118-00-00_0009	12657.51	0.2PCT_500yr	1196.00	31.30	41.41	37.41	41.48	0.000460	2.50	1168.64	3336.84	0.18
C118-00-00_0009	13158.81	50PCT_2yr	257.00	30.23	38.55	34.12	38.60	0.000389	1.75	148.21	224.00	0.15
C118-00-00_0009	13158.81	25PCT_5yr	363.00	30.23	39.22	34.77	39.29	0.000477	2.09	198.45	718.38	0.17
C118-00-00_0009	13158.81	10PCT_10yr	447.00	30.23	39.57	35.19	39.65	0.000539	2.34	262.27	1796.01	0.19
C118-00-00_0009	13158.81	4PCT_25yr	575.00	30.23	39.97	35.73	40.07	0.000601	2.60	398.08	2902.39	0.20
C118-00-00_0009	13158.81	2PCT_50yr	686.00	30.23	40.32	36.14	40.41	0.000594	2.70	556.16	3371.11	0.20
C118-00-00_0009	13158.81	1PCT_100yr	814.00	30.23	40.70	36.55	40.78	0.000556	2.72	769.30	3616.12	0.20
C118-00-00_0009	13158.81	0.2PCT_500yr	1196.00	30.23	41.60	37.58	41.67	0.000475	2.76	1292.14	3616.12	0.18
C118-00-00_0009	13262.41	50PCT_2yr	257.00	30.60	38.59	34.08	38.65	0.000435	1.89	145.81	823.94	0.16
C118-00-00_0009	13262.41	25PCT_5yr	363.00	30.60	39.28	34.70	39.34	0.000468	2.08	353.23	1956.85	0.17
C118-00-00_0009	13262.41	10PCT_10yr	447.00	30.60	39.64	35.11	39.70	0.000460	2.16	531.77	2904.55	0.17
C118-00-00_0009	13262.41	4PCT_25yr	575.00	30.60	40.07	35.67	40.13	0.000433	2.22	778.98	3499.77	0.17
C118-00-00_0009	13262.41	2PCT_50yr	686.00	30.60	40.42	36.09	40.47	0.000401	2.22	980.40	3590.35	0.16
C118-00-00_0009	13262.41	1PCT_100yr	814.00	30.60	40.79	36.53	40.84	0.000373	2.23	1192.33	3590.35	0.16
C118-00-00_0009	13262.41	0.2PCT_500yr	1196.00	30.60	41.68	37.63	41.72	0.000340	2.33	1700.78	3590.35	0.15
C118-00-00_0009	13288.31		Bridge									
C118-00-00_0009	13319.21	50PCT_2yr	257.00	30.31	38.80	34.06	38.83	0.000257	1.51	320.59	1665.43	0.13
C118-00-00_0009	13319.21	25PCT_5yr	363.00	30.31	39.46	34.69	39.49	0.000219	1.53	637.34	3057.08	0.12
C118-00-00_0009	13319.21	10PCT_10yr	447.00	30.31	39.78	35.11	39.81	0.000228	1.63	831.14	3545.71	0.12
C118-00-00_0009	13319.21	4PCT_25yr	575.00	30.31	40.18	35.65	40.21	0.000225	1.69	1086.41	3648.54	0.12
C118-00-00_0009	13319.21	2PCT_50yr	686.00	30.31	40.51	36.06	40.54	0.000217	1.72	1298.84	3648.54	0.12
C118-00-00_0009	13319.21	1PCT_100yr	814.00	30.31	40.87	36.48	40.89	0.000208	1.75	1625.90	3648.54	0.12
C118-00-00_0009	13319.21	0.2PCT_500yr	1196.00	30.31	41.74	37.52	41.76	0.000201	1.87	2080.95	3648.54	0.12
C118-00-00_0009	13410.01	50PCT_2yr	234.00	31.22	38.83	34.49	38.85	0.000150	1.08	477.30	1156.72	0.10
C118-00-00_0009	13410.01	25PCT_5yr	331.00	31.22	39.50	35.04	39.51	0.000106	1.01	1096.33	2518.99	0.08
C118-00-00_0009	13410.01	10PCT_10yr	408.00	31.22	39.82	35.39	39.83	0.000097	1.01	1461.90	3339.70	0.08
C118-00-00_0009	13410.01	4PCT_25yr	525.00	31.22	40.21	35.82	40.22	0.000088	1.02	1922.31	3716.67	0.08
C118-00-00_0009	13410.01	2PCT_50yr	626.00	31.22	40.55	36.15	40.55	0.000081	1.01	2304.58	3716.67	0.08
C118-00-00_0009	13410.01	1PCT_100yr	742.00	31.22	40.90	36.49	40.91	0.000075	1.01	2713.54	3716.67	0.07
C118-00-00_0009	13410.01	0.2PCT_500yr	1091.00	31.22	41.77	37.39	41.77	0.000068	1.06	3716.56	3716.67	0.07
C118-00-00_0009	13867.71	50PCT_2yr	234.00	31.47	38.89	34.40	38.91	0.000131	1.09	552.82	1467.34	0.09
C118-00-00_0009	13867.71	25PCT_5yr	331.00	31.47	39.54	34.91	39.55	0.000106	1.07	1087.10	2952.04	0.08
C118-00-00_0009	13867.71	10PCT_10yr	408.00	31.47	39.85	35.25	39.86	0.000096	1.07	1434.05	3693.13	0.08
C118-00-00_0009	13867.71	4PCT_25yr	525.00	31.47	40.25	35.69	40.26	0.000089	1.08	1867.62	4353.13	0.08
C118-00-00_0009	13867.71	2PCT_50yr	626.00	31.47	40.58	36.03	40.58	0.000083	1.08	2227.83	4353.13	0.08
C118-00-00_0009	13867.71	1PCT_100yr	742.00	31.47	40.93	36.37	40.93	0.000077	1.08	2614.05	4353.13	0.08
C118-00-00_0009	13867.71	0.2PCT_500yr	1091.00	31.47	41.79	37.24	41.80	0.000071	1.13	3565.23	4353.13	0.07
C118-00-00_0009	13967.91	50PCT_2yr	234.00	31.32	38.91	34.42	38.92	0.000102	0.95	832.59	1900.76	0.08
C118-00-00_0009	13967.91	25PCT_5yr	331.00	31.32	39.56	34.94	39.56	0.000081	0.92	1373.31	3130.69	0.07
C118-00-00_0009	13967.91	10PCT_10yr	408.00	31.32	39.87	35.28	39.88	0.000080	0.96	1650.71	3820.87	0.07
C118-00-00_0009	13967.91	4PCT_25yr	525.00	31.32	40.26	35.73	40.27	0.000082	1.02	1998.14	4204.77	0.08
C118-00-00_0009	13967.91	2PCT_50yr	626.00	31.32	40.59	36.06	40.60	0.000082	1.06	2286.81	4287.30	0.08
C118-00-00_0009	13967.91	1PCT_100yr	742.00	31.32	40.94	36.41	40.95	0.000082	1.10	2596.82	4287.30	0.08

REVISED EXISTING MODEL

HEC-RAS Plan: RevEx River: C118-00-00 Reach: C118-00-00_0009 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00_0009	13967.91	0.2PCT_500yr	1091.00	31.32	41.80	37.70	41.81	0.000085	1.22	3361.70	4287.30	0.08
C118-00-00_0009	14001.71		Bridge									
C118-00-00_0009	14033.31	50PCT_2yr	234.00	31.55	38.95	33.94	38.96	0.000089	1.00	767.46	1728.79	0.08
C118-00-00_0009	14033.31	25PCT_5yr	331.00	31.55	39.57	34.43	39.58	0.000076	1.00	1299.19	3402.01	0.07
C118-00-00_0009	14033.31	10PCT_10yr	408.00	31.55	39.89	34.77	39.89	0.000078	1.04	1575.14	3763.71	0.07
C118-00-00_0009	14033.31	4PCT_25yr	525.00	31.55	40.28	35.24	40.29	0.000081	1.11	1922.13	4200.10	0.08
C118-00-00_0009	14033.31	2PCT_50yr	626.00	31.55	40.60	35.59	40.61	0.000082	1.15	2210.49	4303.15	0.08
C118-00-00_0009	14033.31	1PCT_100yr	742.00	31.55	40.95	35.96	40.96	0.000081	1.19	2520.38	4303.15	0.08
C118-00-00_0009	14033.31	0.2PCT_500yr	1091.00	31.55	41.82	36.90	41.83	0.000085	1.31	3286.20	4303.15	0.08
C118-00-00_0009	14129.01	50PCT_2yr	182.00	31.97	38.96	34.52	38.97	0.000104	0.93	393.11	1461.61	0.08
C118-00-00_0009	14129.01	25PCT_5yr	258.00	31.97	39.58	34.97	39.59	0.000094	0.97	788.36	3010.95	0.08
C118-00-00_0009	14129.01	10PCT_10yr	318.00	31.97	39.90	35.27	39.91	0.000092	1.00	1062.95	3734.41	0.08
C118-00-00_0009	14129.01	4PCT_25yr	408.00	31.97	40.29	35.66	40.30	0.000088	1.03	1408.44	4157.49	0.08
C118-00-00_0009	14129.01	2PCT_50yr	487.00	31.97	40.61	35.96	40.62	0.000084	1.05	1695.08	4358.55	0.08
C118-00-00_0009	14129.01	1PCT_100yr	578.00	31.97	40.97	36.26	40.97	0.000079	1.06	2003.13	4358.55	0.08
C118-00-00_0009	14129.01	0.2PCT_500yr	849.00	31.97	41.83	37.03	41.84	0.000075	1.12	2764.73	4358.55	0.08
C118-00-00_0009	14754.41	50PCT_2yr	182.00	31.58	39.03	34.51	39.04	0.000127	0.95	341.44	1251.31	0.09
C118-00-00_0009	14754.41	25PCT_5yr	258.00	31.58	39.65	34.98	39.66	0.000121	1.03	603.51	3468.53	0.09
C118-00-00_0009	14754.41	10PCT_10yr	318.00	31.58	39.96	35.29	39.98	0.000136	1.14	783.39	3997.94	0.10
C118-00-00_0009	14754.41	4PCT_25yr	408.00	31.58	40.35	35.71	40.37	0.000138	1.22	1047.46	4221.29	0.10
C118-00-00_0009	14754.41	2PCT_50yr	487.00	31.58	40.68	36.02	40.69	0.000139	1.28	1320.81	4528.16	0.10
C118-00-00_0009	14754.41	1PCT_100yr	578.00	31.58	41.02	36.35	41.04	0.000129	1.28	1623.77	4528.16	0.10
C118-00-00_0009	14754.41	0.2PCT_500yr	849.00	31.58	41.88	37.23	41.90	0.000114	1.33	2376.46	4528.16	0.09
C118-00-00_0009	15140.91	50PCT_2yr	182.00	30.07	39.06	33.23	39.07	0.000050	0.78	388.23	1220.76	0.06
C118-00-00_0009	15140.91	25PCT_5yr	258.00	30.07	39.68	33.66	39.69	0.000058	0.90	645.85	3218.78	0.06
C118-00-00_0009	15140.91	10PCT_10yr	318.00	30.07	40.00	33.97	40.01	0.000062	0.97	836.72	3941.86	0.07
C118-00-00_0009	15140.91	4PCT_25yr	408.00	30.07	40.39	34.38	40.40	0.000068	1.05	1090.29	4298.91	0.07
C118-00-00_0009	15140.91	2PCT_50yr	487.00	30.07	40.72	34.70	40.73	0.000070	1.10	1324.07	4450.85	0.07
C118-00-00_0009	15140.91	1PCT_100yr	578.00	30.07	41.06	35.03	41.07	0.000070	1.13	1597.55	4516.64	0.07
C118-00-00_0009	15140.91	0.2PCT_500yr	849.00	30.07	41.92	35.99	41.93	0.000064	1.17	2340.37	4572.72	0.07
C118-00-00_0009	15565.51	50PCT_2yr	182.00	31.91	39.10	34.91	39.11	0.000179	0.99	340.12	1400.64	0.10
C118-00-00_0009	15565.51	25PCT_5yr	258.00	31.91	39.72	35.39	39.73	0.000148	1.02	621.94	2833.95	0.09
C118-00-00_0009	15565.51	10PCT_10yr	318.00	31.91	40.04	35.71	40.05	0.000132	1.02	845.65	3763.50	0.09
C118-00-00_0009	15565.51	4PCT_25yr	408.00	31.91	40.43	36.13	40.44	0.000115	1.01	1133.25	4471.26	0.09
C118-00-00_0009	15565.51	2PCT_50yr	487.00	31.91	40.76	36.44	40.77	0.000102	1.01	1376.95	4552.63	0.08
C118-00-00_0009	15565.51	1PCT_100yr	578.00	31.91	41.10	36.77	41.11	0.000093	1.00	1641.98	4577.07	0.08
C118-00-00_0009	15565.51	0.2PCT_500yr	849.00	31.91	41.95	37.79	41.96	0.000079	1.03	2347.95	4655.01	0.08
C118-00-00_0009	15827.61	50PCT_2yr	182.00	32.49	39.14	35.42	39.17	0.000247	1.31	256.46	1139.83	0.12
C118-00-00_0009	15827.61	25PCT_5yr	258.00	32.49	39.76	35.92	39.78	0.000222	1.37	486.10	2550.35	0.12
C118-00-00_0009	15827.61	10PCT_10yr	318.00	32.49	40.07	36.25	40.09	0.000207	1.39	670.40	3949.63	0.12
C118-00-00_0009	15827.61	4PCT_25yr	408.00	32.49	40.46	36.66	40.48	0.000186	1.39	972.62	4620.12	0.11
C118-00-00_0009	15827.61	2PCT_50yr	487.00	32.49	40.78	36.98	40.80	0.000154	1.32	1252.27	4762.29	0.10
C118-00-00_0009	15827.61	1PCT_100yr	578.00	32.49	41.12	37.33	41.13	0.000125	1.24	1555.23	4762.29	0.09
C118-00-00_0009	15827.61	0.2PCT_500yr	849.00	32.49	41.97	38.36	41.98	0.000089	1.15	2311.36	4762.29	0.08
C118-00-00_0009	15905.71		Bridge									
C118-00-00_0009	15982.91	50PCT_2yr	182.00	32.49	39.24	35.77	39.26	0.000290	1.20	361.92	1058.51	0.13
C118-00-00_0009	15982.91	25PCT_5yr	258.00	32.49	39.85	36.27	39.86	0.000196	1.12	664.03	2108.99	0.11
C118-00-00_0009	15982.91	10PCT_10yr	318.00	32.49	40.16	36.59	40.17	0.000184	1.15	841.84	3572.15	0.11
C118-00-00_0009	15982.91	4PCT_25yr	408.00	32.49	40.53	37.00	40.55	0.000173	1.20	1085.20	4348.51	0.10
C118-00-00_0009	15982.91	2PCT_50yr	487.00	32.49	40.84	37.32	40.85	0.000161	1.21	1289.44	4685.19	0.10
C118-00-00_0009	15982.91	1PCT_100yr	578.00	32.49	41.17	37.65	41.18	0.000148	1.22	1508.02	4762.29	0.10
C118-00-00_0009	15982.91	0.2PCT_500yr	849.00	32.49	42.00	39.11	42.01	0.000129	1.26	2066.71	4762.29	0.09
C118-00-00_0009	16140.01	50PCT_2yr	143.00	32.73	39.28	35.23	39.30	0.000140	1.06	363.19	1620.47	0.09
C118-00-00_0009	16140.01	25PCT_5yr	202.00	32.73	39.88	35.70	39.89	0.000116	1.06	681.39	2808.75	0.09
C118-00-00_0009	16140.01	10PCT_10yr	249.00	32.73	40.18	36.00	40.19	0.000115	1.10	871.70	3106.38	0.09
C118-00-00_0009	16140.01	4PCT_25yr	320.00	32.73	40.56	36.39	40.57	0.000112	1.14	1113.29	3382.48	0.09
C118-00-00_0009	16140.01	2PCT_50yr	382.00	32.73	40.87	36.70	40.88	0.000110	1.17	1306.94	3451.49	0.09
C118-00-00_0009	16140.01	1PCT_100yr	453.00	32.73	41.19	37.01	41.20	0.000107	1.20	1513.81	3545.01	0.09
C118-00-00_0009	16140.01	0.2PCT_500yr	666.00	32.73	42.02	37.77	42.03	0.000103	1.28	2043.82	3863.74	0.09
C118-00-00_0009	16889.11	50PCT_2yr	143.00	32.20	39.38	34.80	39.39	0.000123	1.01	336.94	693.52	0.09
C118-00-00_0009	16889.11	25PCT_5yr	202.00	32.20	39.96	35.30	39.98	0.000122	1.09	608.46	1720.56	0.09
C118-00-00_0009	16889.11	10PCT_10yr	249.00	32.20	40.27	35.63	40.28	0.000124	1.15	799.29	2343.33	0.09
C118-00-00_0009	16889.11	4PCT_25yr	320.00	32.20	40.65	36.07	40.66	0.000122	1.19	1040.21	3523.67	0.09
C118-00-00_0009	16889.11	2PCT_50yr	382.00	32.20	40.95	36.40	40.96	0.000119	1.22	1232.92	3804.50	0.09
C118-00-00_0009	16889.11	1PCT_100yr	453.00	32.20	41.27	36.72	41.28	0.000115	1.25	1438.71	4040.83	0.09
C118-00-00_0009	16889.11	0.2PCT_500yr	666.00	32.20	42.10	37.55	42.11	0.000111	1.33	1967.54	4749.23	0.09
C118-00-00_0009	17874.51	50PCT_2yr	143.00	33.95	39.54	36.11	39.55	0.000214	1.03	298.62	770.12	0.11
C118-00-00_0009	17874.51	25PCT_5yr	202.00	33.95	40.11	36.52	40.12	0.000183	1.08	514.78	1972.53	0.10
C118-00-00_0009	17874.51	10PCT_10yr	249.00	33.95	40.42	36.80	40.43	0.000182	1.14	669.45	2724.53	0.11
C118-00-00_0009	17874.51	4PCT_25yr	320.00	33.95	40.79	37.17	40.80	0.000179	1.21	898.60	3356.12	0.11
C118-00-00_0009	17874.51	2PCT_50yr	382.00	33.95	41.09	37.45	41.10	0.000166	1.22	1087.82	3894.55	0.10
C118-00-00_0009	17874.51	1PCT_100yr	453.00	33.95	41.40	37.76	41.41					

APPENDIX B.4

PEAK FLOW IMPACTS

- **10-YEAR AND 50-YEAR IMPACTS**
- **100-YEAR AND 500-YEAR IMPACTS**

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: B5
Project: Salt Water Ditch
Project #: 325912
Date: 8/27/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	10-year Peak Flows (cfs)					50-year Peak Flows (cfs)				
	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)
Outlet	22903	22614	22659	-289	-244	38495	38106	38129	-390	-367
C100#1	22531	22231	22275	-300	-256	37816	37449	37454	-367	-362
C100#2	21942	21644	21690	-298	-252	36829	36500	36516	-329	-313
C100#3	21760	21478	21518	-282	-242	36370	36054	36066	-315	-304
C100#4	17568	17324	17352	-244	-217	28921	28564	28471	-357	-450
C100#5	17123	16888	16912	-235	-211	28090	27727	27617	-362	-473
C100#6	16837	16607	16624	-230	-213	27543	27166	27056	-377	-487
C100#7	15988	15768	15785	-220	-202	26150	25751	25631	-399	-519
C100#8	15497	15268	15287	-230	-210	25266	24855	24741	-411	-525
C118 outfall	1762	1021	1343	-741	-420	2604	1580	2005	-1024	-600
C118A	-	-	540	-	-	-	-	829	-	-
C118B	-	-	1195	-	-	-	-	1753	-	-

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective models and HEC-HMS node C1180000_0000_J in the revised existing model

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: B6
Project: Salt Water Ditch
Project #: 325912
Date: 8/27/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	100-year Peak Flows (cfs)					500-year Peak Flows (cfs)				
	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)	Duplicate Effective	Corrected Effective	Revised Existing	ΔQ (Corr.-Dup.)	ΔQ (Rev.-Dup.)
Outlet	44553	43919	43940	-633	-613	58495	57746	58175	-749	-320
C100#1	43765	43124	43125	-641	-640	57455	56758	57116	-697	-339
C100#2	42521	41877	41870	-644	-651	55973	55535	55646	-438	-328
C100#3	42049	41394	41373	-656	-676	54410	54030	54234	-380	-176
C100#4	33294	33139	32957	-155	-337	39974	38929	38602	-1045	-1372
C100#5	32442	32271	32050	-171	-391	39209	38535	38078	-674	-1131
C100#6	32056	31722	31450	-334	-606	38617	38071	37568	-546	-1050
C100#7	30319	30001	29718	-319	-602	36598	35734	35373	-864	-1226
C100#8	29323	29039	28744	-284	-579	35315	34960	34422	-355	-893
C118 outfall	3048	1879	2328	-1169	-720	4344	2776	3189	-1568	-1156
C118A	-	-	983	-	-	-	-	1445	-	-
C118B	-	-	2046	-	-	-	-	2858	-	-

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective models and HEC-HMS node C1180000_0000_J in the revised existing model

APPENDIX C
PROPOSED CONDITIONS

APPENDIX C.1 – CALCULATIONS

APPENDIX C.2 – HEC-HMS OUTPUTS

APPENDIX C.3 – HEC-RAS OUTPUTS

APPENDIX C.4 – STORM SEWER ALTERNATIVE TABLES

APPENDIX C.5 – PEAK FLOW IMPACTS

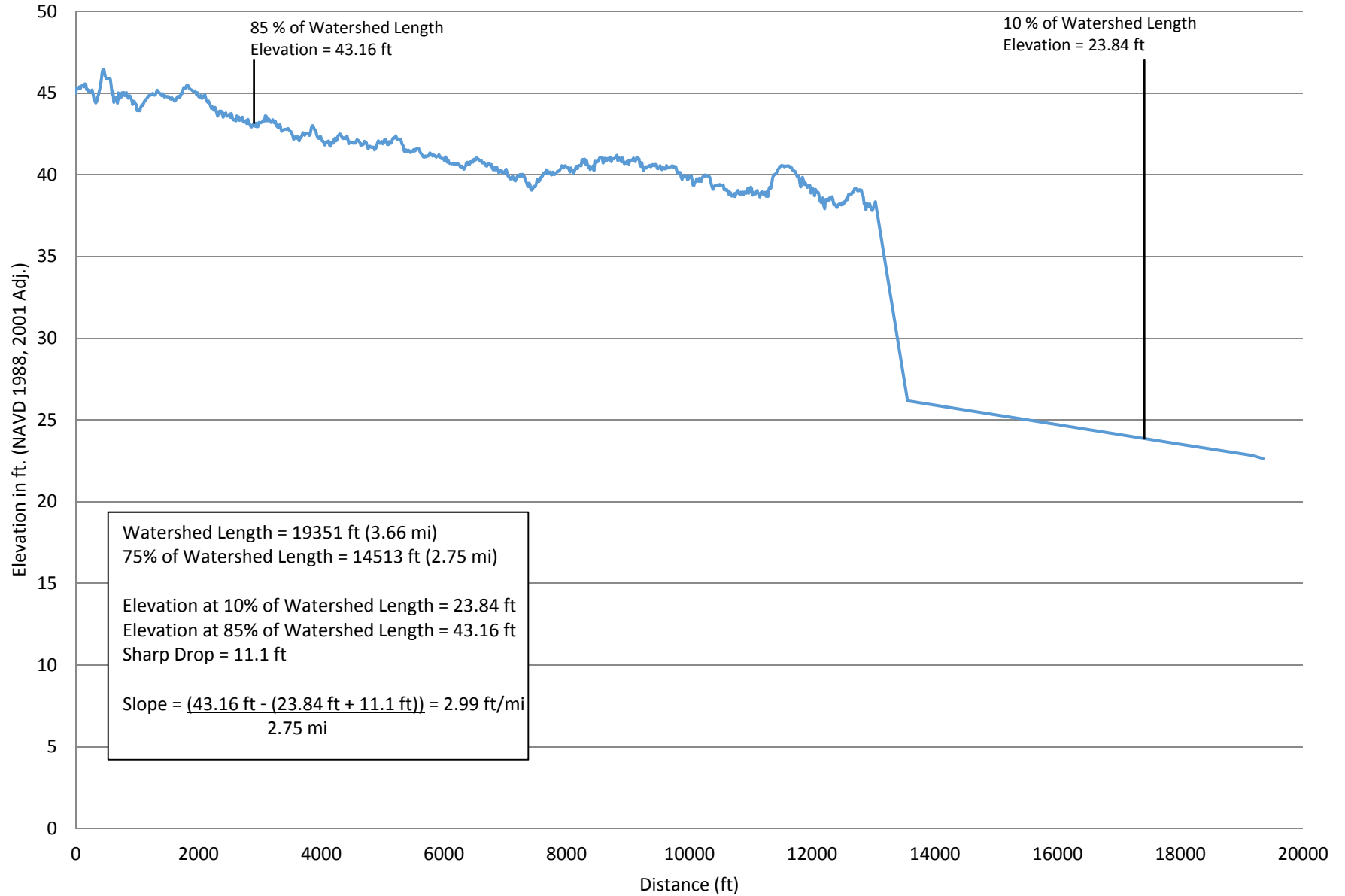
APPENDIX C.6 – DETENTION AND MITIGATION

APPENDIX C.1

CALCULATIONS

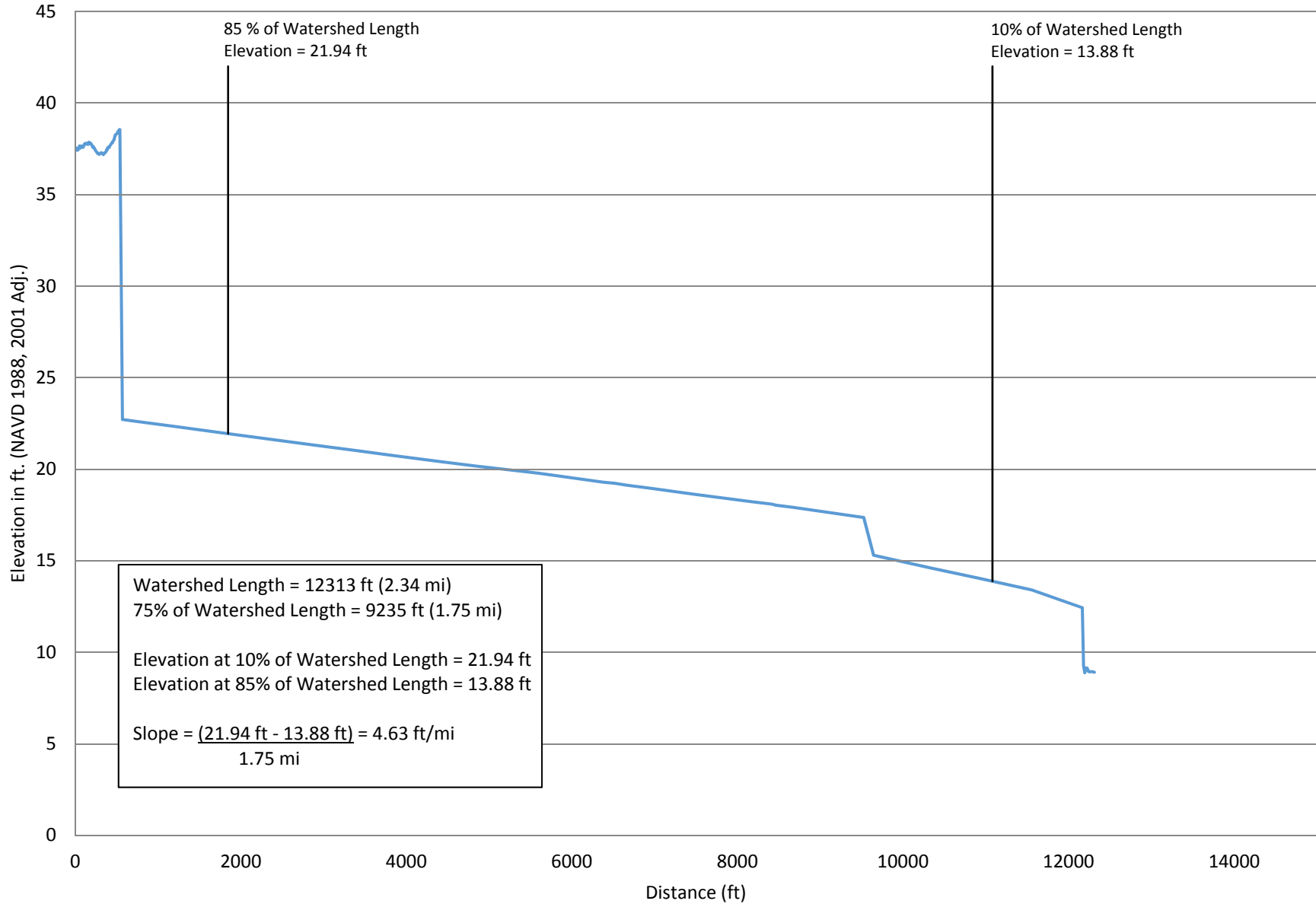
- **CHANNEL SLOPE CALCULATION**
- **TIME OF CONCENTRATION AND STORAGE COEFFICIENT (TC & R) CALCULATION**
- **UPSTREAM FLOW**
- **FLOW DISTRIBUTION**

Channel Slope - Subbasin C118A



Q:\2012\325912\Calculations\channel_design\Alternatives\100\Channel Slope.xlsx

Channel Slope - Subbasin C118B





FEMA Effective Model as of June 18, 2007

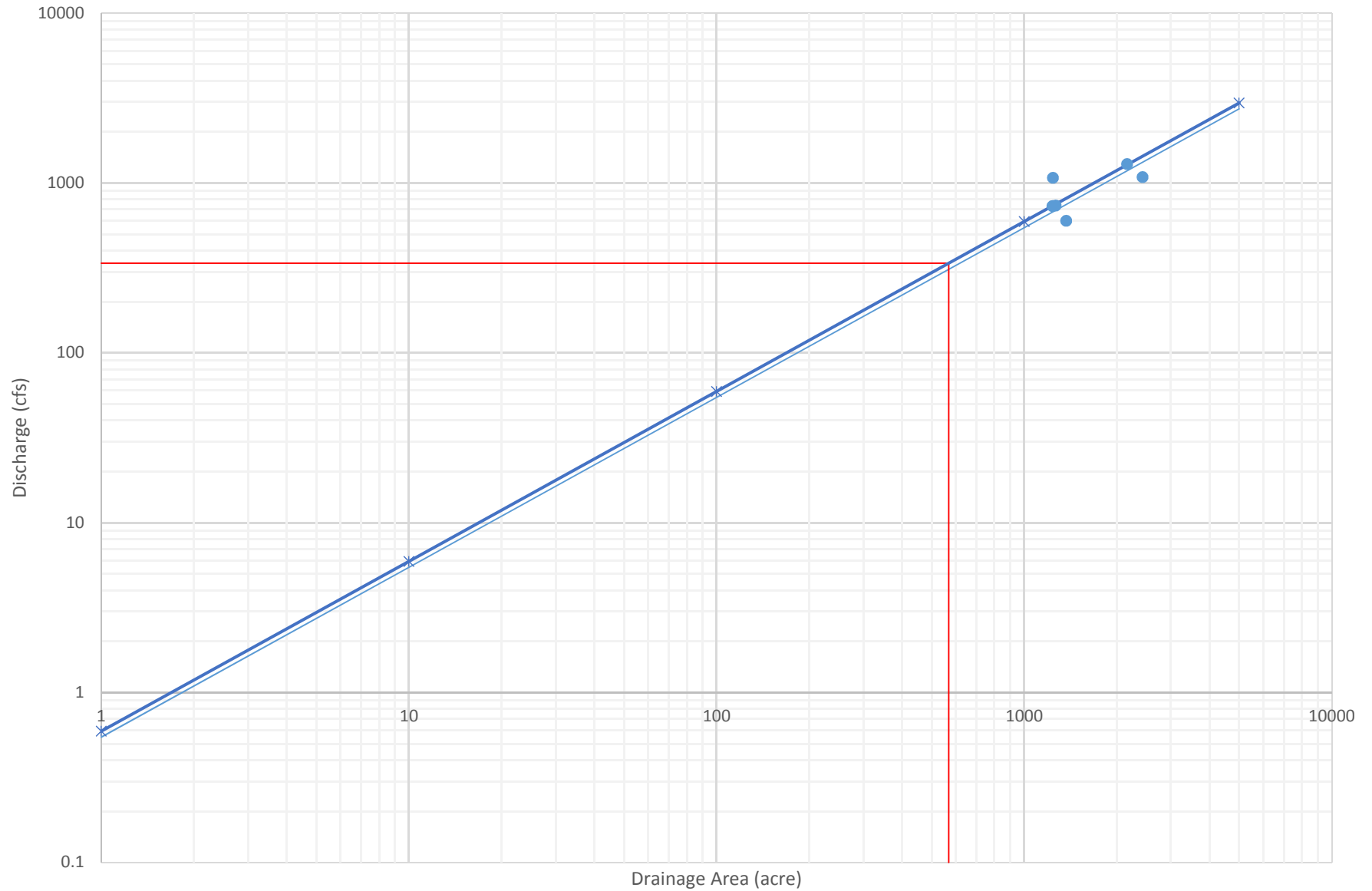
TC&R values for FEMA Effective Model

Sims Bayou Watershed

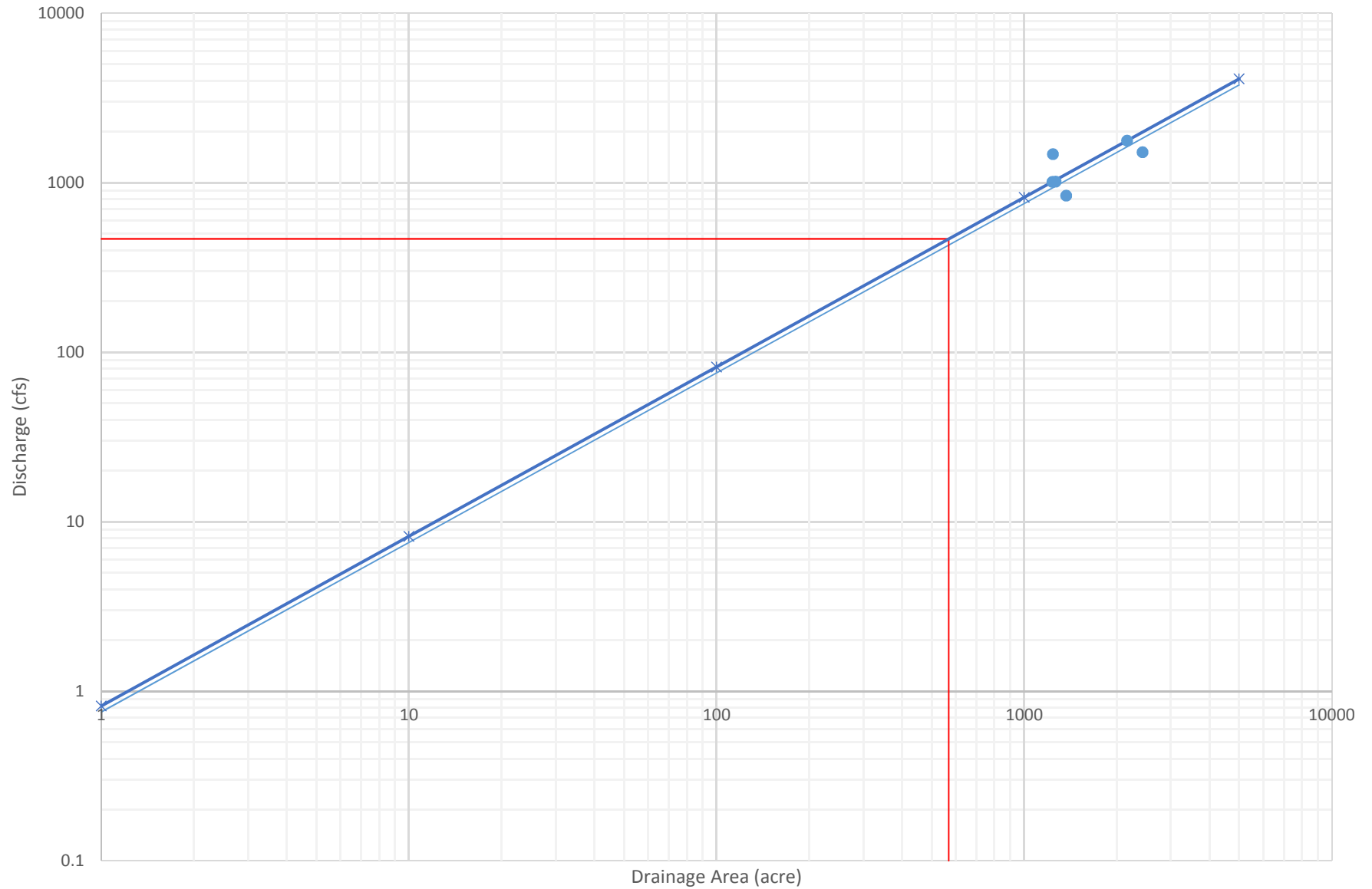
HCFCF TC&R Excel Template

Subwatershed	Drainage Area (acres)	Drainage Area (sq.mi.)	Watershed Length (mi.)	Length to Centroid(mi.)	Channel Slope(ft./mi.)	Overland Slope(ft./mi.)	D	Percent Urban Development 2002	Percent Channel Improvement	Percent Channel Conveyance	Percent Ponding	DLU affected by Detention	Percent Impervious 2002	(TC+R)"	TC"	R"	DLU Minimum	DLU (Detention)
	L	Lca	S	So	DLU	DCI		DCC	DPP	DET								
C100A	1449.5	2.26	3.00	1.25	7.39	7.39	2.46	37.50	100	60	0	0.00	24.34	7.53	0.54	6.99	36.04	37.50
C100B	1179.8	1.84	2.03	0.47	7.21	6.34	2.46	47.03	100	90	0	8.78	36.37	3.84	0.19	3.65	20.39	38.25
C100C	1815.4	2.84	2.81	0.81	7.94	9.50	2.46	30.75	58	90	0	21.33	26.17	7.15	0.47	6.69	20.39	20.39
C100D	1549.3	2.42	3.06	1.14	2.79	3.70	2.46	52.65	100	100	0	7.10	36.90	5.76	0.79	4.97	17.59	45.55
C100E	1433.4	2.24	4.05	2.16	1.51	6.86	2.46	66.84	100	100	0	0.53	46.96	6.75	1.98	4.77	17.59	66.31
C100F	1648.1	2.58	3.02	1.35	4.29	8.45	2.46	38.47	0	100	0	3.84	29.90	5.90	1.46	4.44	17.59	34.63
C100G	1430.0	2.23	2.48	0.61	5.50	12.67	2.46	11.79	18	100	0	1.62	10.25	7.54	0.53	7.01	17.59	11.79
C100H	1268.5	1.98	2.51	1.09	4.75	1.06	2.46	60.79	100	100	0	0.29	41.19	3.42	0.54	2.89	17.59	60.50
C100I	2428.2	3.79	3.45	1.04	3.35	9.50	2.46	65.21	100	100	0	0.43	40.43	4.63	0.60	4.02	17.59	64.78
C100J	4014.6	6.27	4.56	1.88	1.63	9.50	2.46	67.36	100	40	0	0.29	44.77	17.21	1.64	15.58	63.71	67.07
C100K	1126.4	1.76	2.25	1.18	2.64	2.64	2.46	45.62	100	100	0	0.73	38.93	4.77	0.85	3.93	17.59	44.89
C100L	2165.3	3.38	3.46	1.52	4.00	9.50	2.46	82.11	100	100	0	0.10	53.81	3.71	0.76	2.95	17.59	82.01
C100M	1123.3	1.76	3.32	1.39	0.85	8.45	2.46	70.11	100	100	0	0.46	59.93	6.95	1.66	5.30	17.59	69.65
C102A	1857.1	2.90	3.80	1.56	3.17	3.17	2.46	89.05	100	30	0	0.00	63.06	12.38	0.86	11.53	95.43	89.05
C102B	698.3	1.09	1.93	1.08	8.76	14.26	2.46	86.51	100	100	0	0.00	68.48	1.80	0.34	1.45	17.59	86.51
C103	1032.6	1.61	3.01	1.35	11.99	10.03	2.46	92.80	100	100	0	0.00	61.70	2.10	0.36	1.74	17.59	92.80
C106A	1162.9	1.82	2.77	1.34	6.97	3.17	2.46	69.71	100	70	0	0.45	52.05	4.13	0.52	3.60	29.03	69.26
C106B	1931.4	3.02	3.91	1.82	7.83	4.75	2.46	70.76	78	60	0	0.91	48.52	5.83	0.83	5.00	36.04	69.85
C106C	1208.3	1.89	3.04	1.55	9.83	5.28	2.46	80.82	100	100	0	0.00	52.28	2.49	0.48	2.01	17.59	80.82
C106D	1833.5	2.86	4.40	1.92	8.02	7.39	2.46	72.60	100	70	0	1.25	52.49	5.34	0.71	4.63	29.03	71.35
C106E	1781.4	2.78	3.33	1.15	4.01	3.70	2.46	62.97	100	70	0	4.20	45.22	6.39	0.62	5.76	29.03	58.77
C106F	1290.3	2.02	3.68	1.57	3.74	7.92	2.46	73.38	100	70	0	1.51	53.24	6.12	0.85	5.27	29.03	71.87
C106G	1963.2	3.07	3.49	1.59	4.62	6.86	2.46	72.02	100	100	0	0.21	45.67	3.88	0.77	3.11	17.59	71.81
C118	2476.3	3.87	5.62	2.62	2.64	6.34	2.46	82.40	79	60	0	2.25	52.87	10.07	2.07	8.00	36.04	80.15
C118A	1235.2	1.93	3.66	1.87	2.99	5.48	2.46	100.00	100	100	0	2.48	45.47	3.80	1.03	2.78	17.59	97.52
C118B	1241.6	1.94	2.34	1.71	4.63	10.92	2.46	100.00	100	100	0	2.64	39.21	2.38	0.74	1.64	17.59	97.36
C120	1427.8	2.23	3.41	1.55	8.21	12.67	2.46	29.37	100	100	0	0.31	22.53	5.76	0.66	5.10	17.59	29.06
C123	1563.6	2.44	3.72	1.77	7.88	10.56	2.46	32.43	0	100	0	0.90	24.61	5.88	1.42	4.46	17.59	31.53
C127	1368.6	2.14	2.85	1.19	8.68	12.14	2.46	49.91	100	80	0	1.48	30.19	4.37	0.45	3.92	24.06	48.43
C132	2601.9	4.07	5.09	1.3	5.28	5.28	2.46	28.52	83	70	0	6.84	22.35	12.71	0.79	11.92	29.03	28.52
C134	1298.5	2.03	3.11	1.56	1.30	11.09	2.46	18.93	37	100	0	0.81	15.40	14.23	2.76	11.47	17.59	18.12
C137	997.5	1.56	2.26	1.06	11.62	11.62	2.46	36.54	100	60	0	3.83	29.47	5.39	0.36	5.04	36.04	36.04
C143	1266.2	1.98	2.60	1.03	12.14	12.14	2.46	44.76	100	50	0	1.66	32.44	5.90	0.33	5.57	46.56	44.76
C144	650.1	1.02	2.34	1.05	10.56	10.56	2.46	49.34	100	50	0	1.19	28.57	5.61	0.35	5.25	46.56	48.15
C145A	1192.5	1.86	2.63	1	5.28	5.28	2.46	76.67	100	40	0	0.00	47.50	7.04	0.43	6.61	63.71	76.67
C145B	882.2	1.38	2.34	0.75	11.62	11.62	2.46	55.90	100	40	0	0.00	35.02	5.56	0.23	5.33	63.71	55.90
C147A	1166.4	1.82	2.91	1.35	6.34	6.34	2.46	75.67	100	40	0	0.00	39.71	7.15	0.54	6.61	63.71	75.67
C147B	1735.7	2.71	2.88	1.18	6.86	6.86	2.46	49.28	43	50	0	0.41	29.35	7.48	0.76	6.72	46.56	48.87
C147C	1684.1	2.63	3.41	1.82	8.26	3.70	2.46	55.59	60	80	0	0.41	34.33	4.62	0.97	3.65	24.06	55.18
C161	1527.2	2.39	3.58	1.92	6.34	6.34	2.46	26.02	52	80	0	3.11	20.46	9.21	1.35	7.86	24.06	24.06
C162	622.8	0.97	2.47	1.34	6.86	6.86	2.46	41.16	100	50	0	0.04	32.32	6.96	0.59	6.36	46.56	41.16

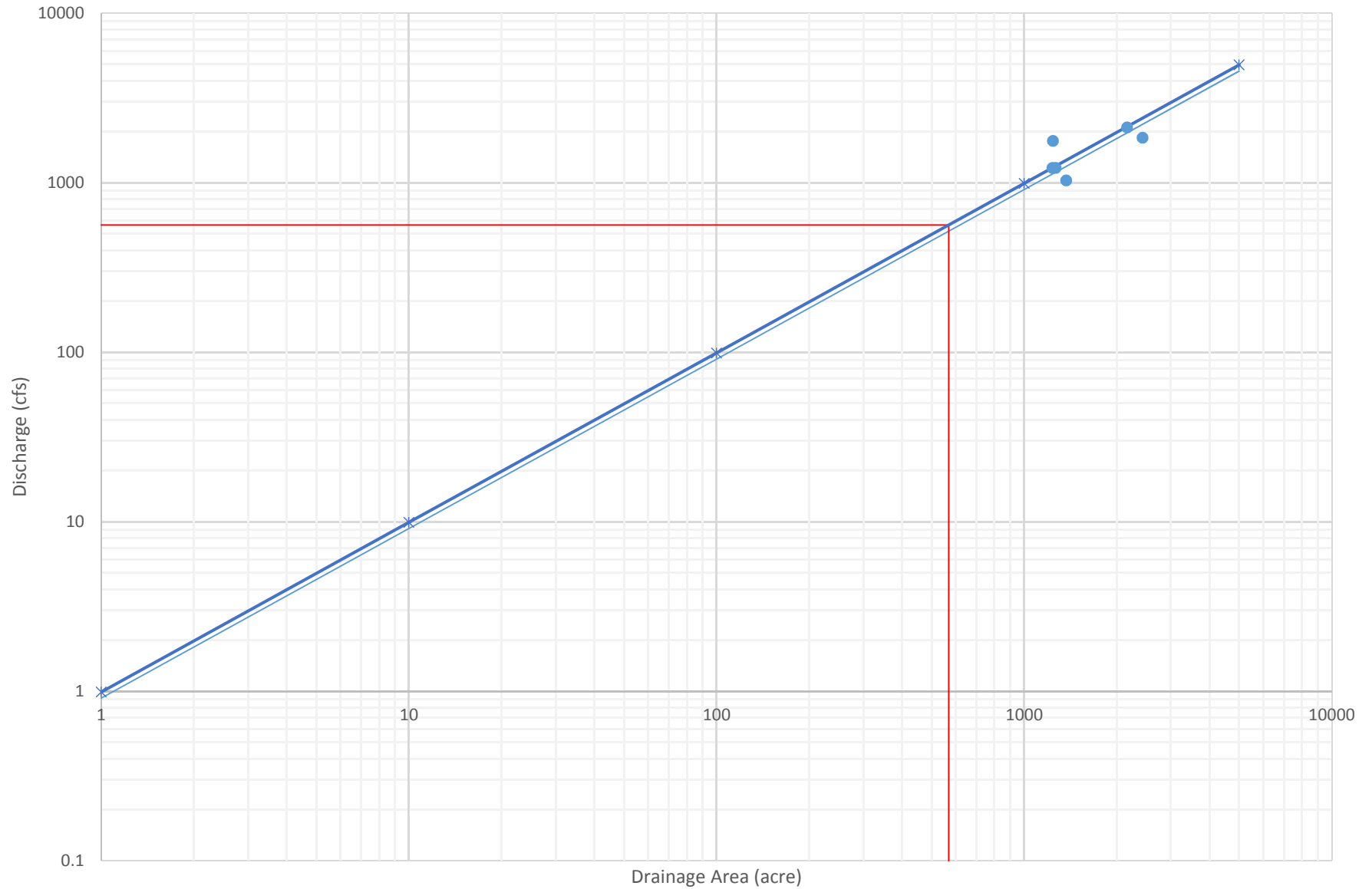
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
2-Year Storm Event



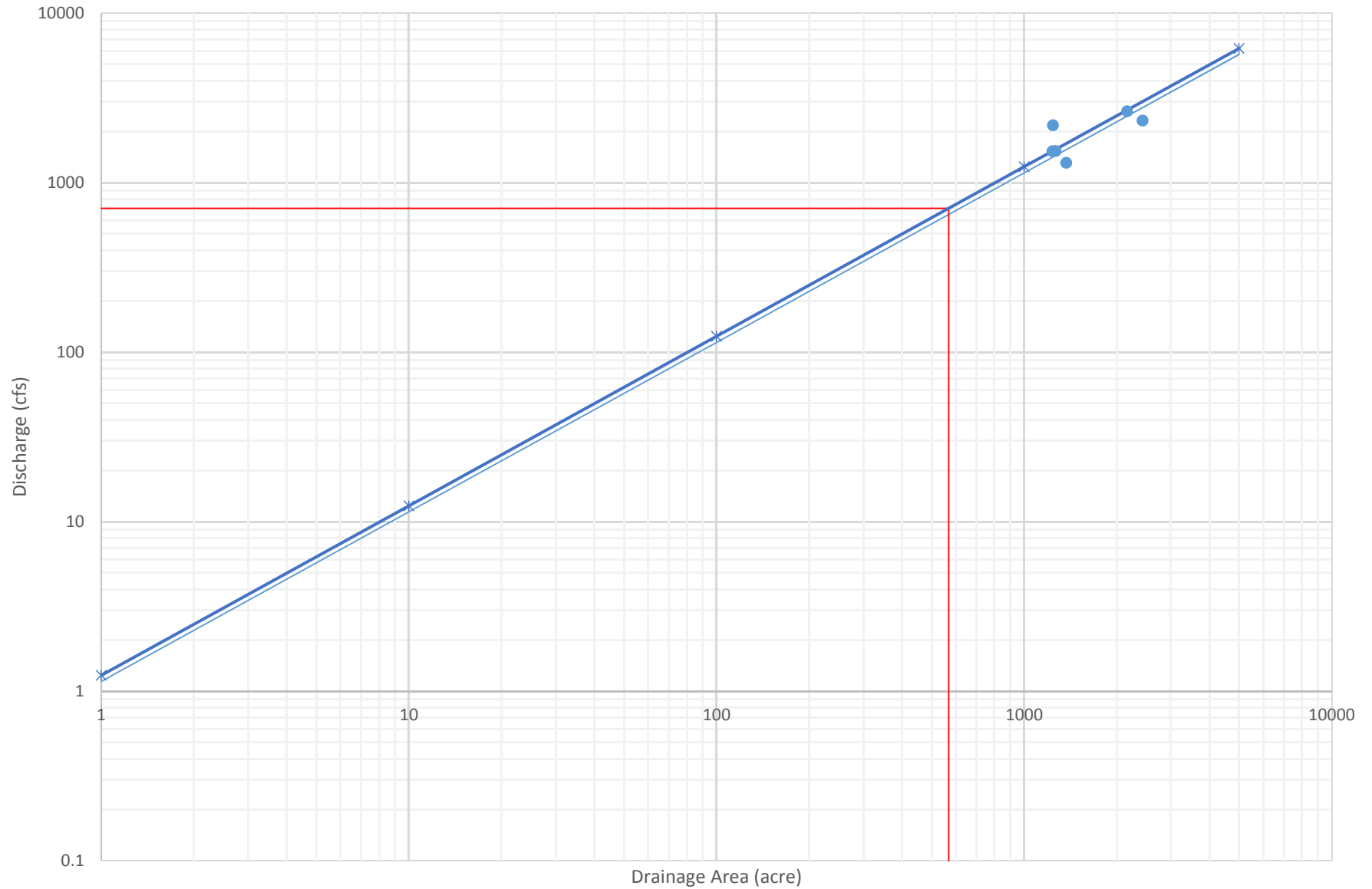
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
5-Year Storm Event



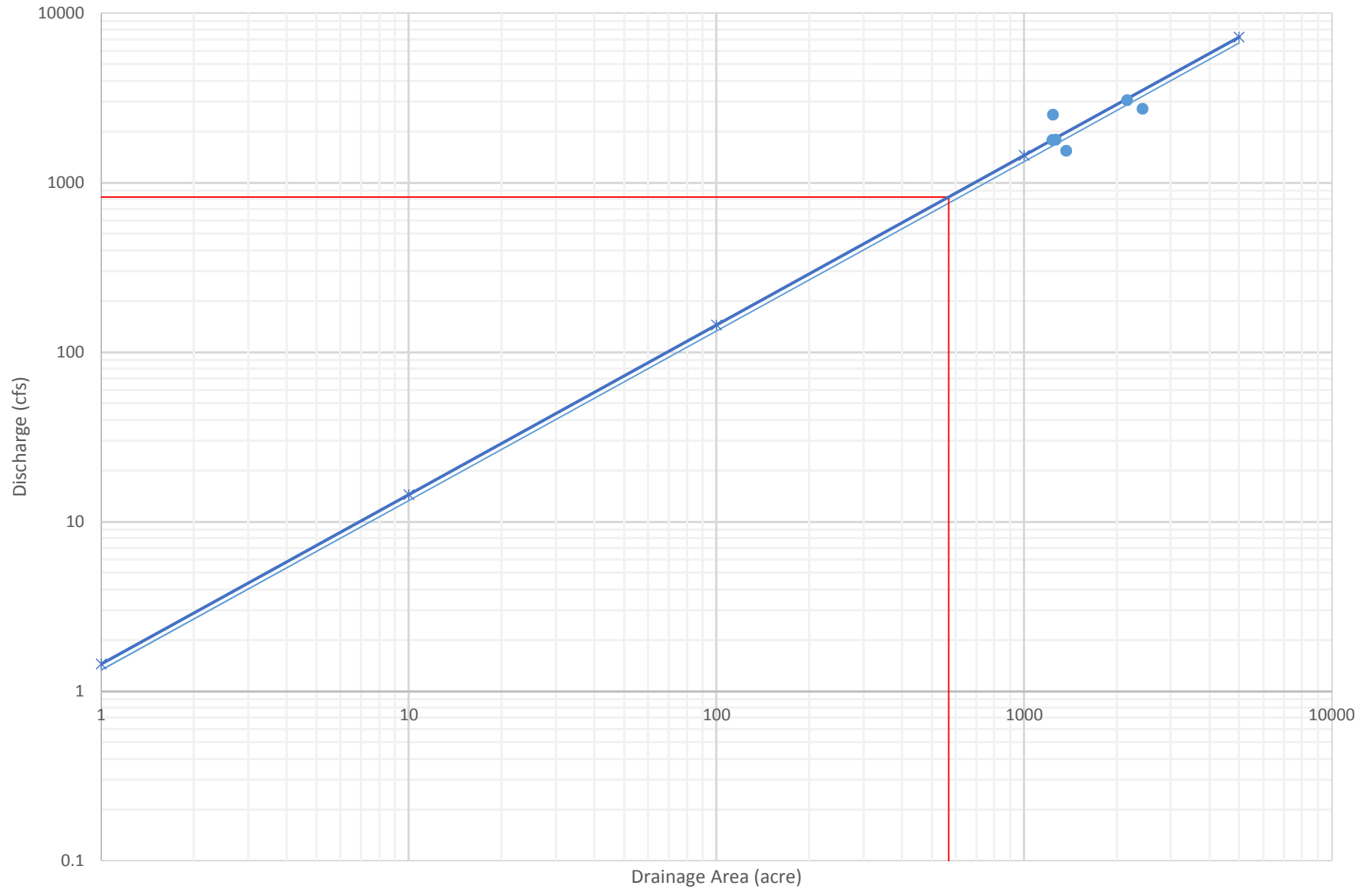
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
10-Year Storm Event



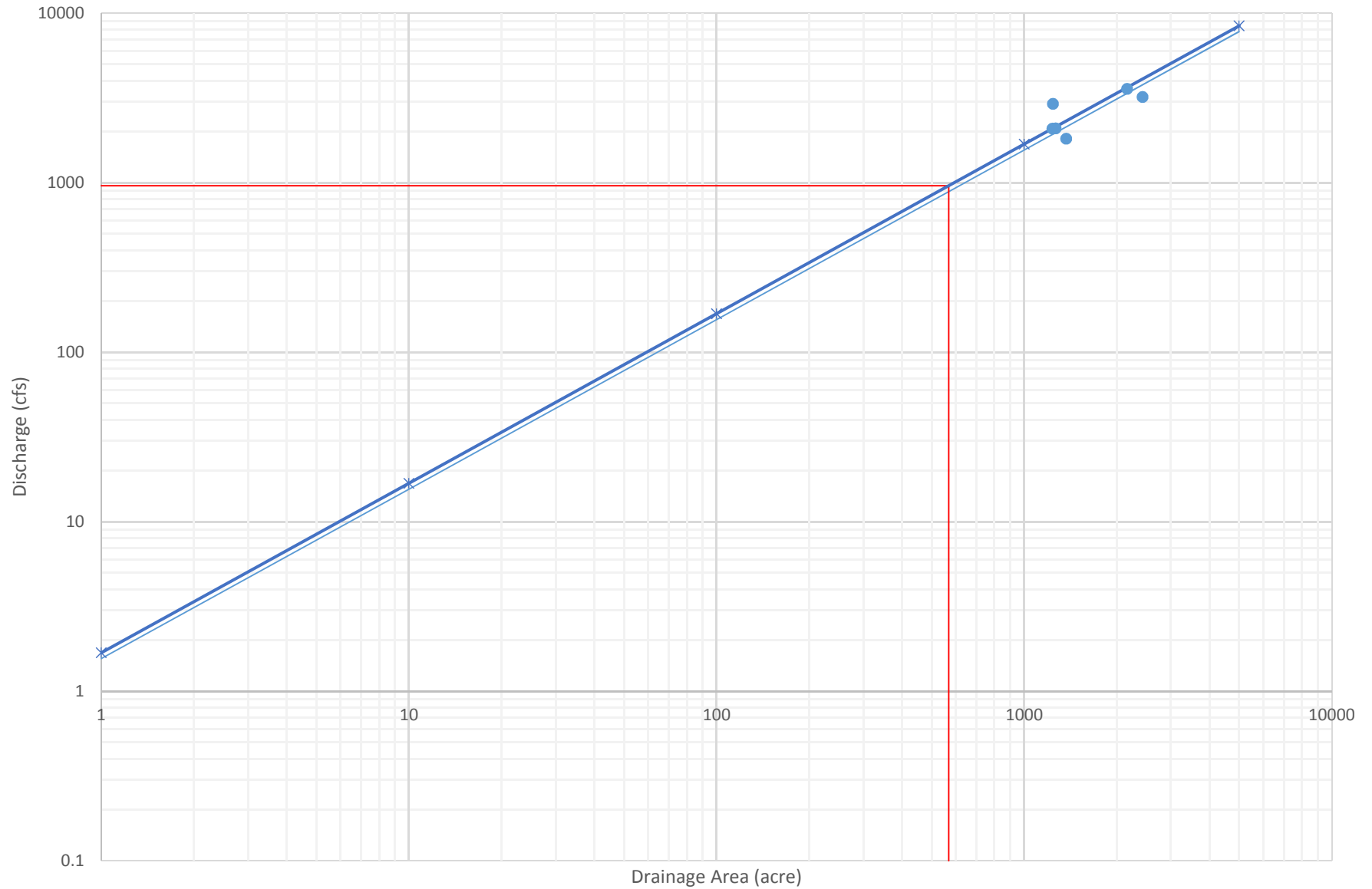
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
25-Year Storm Event



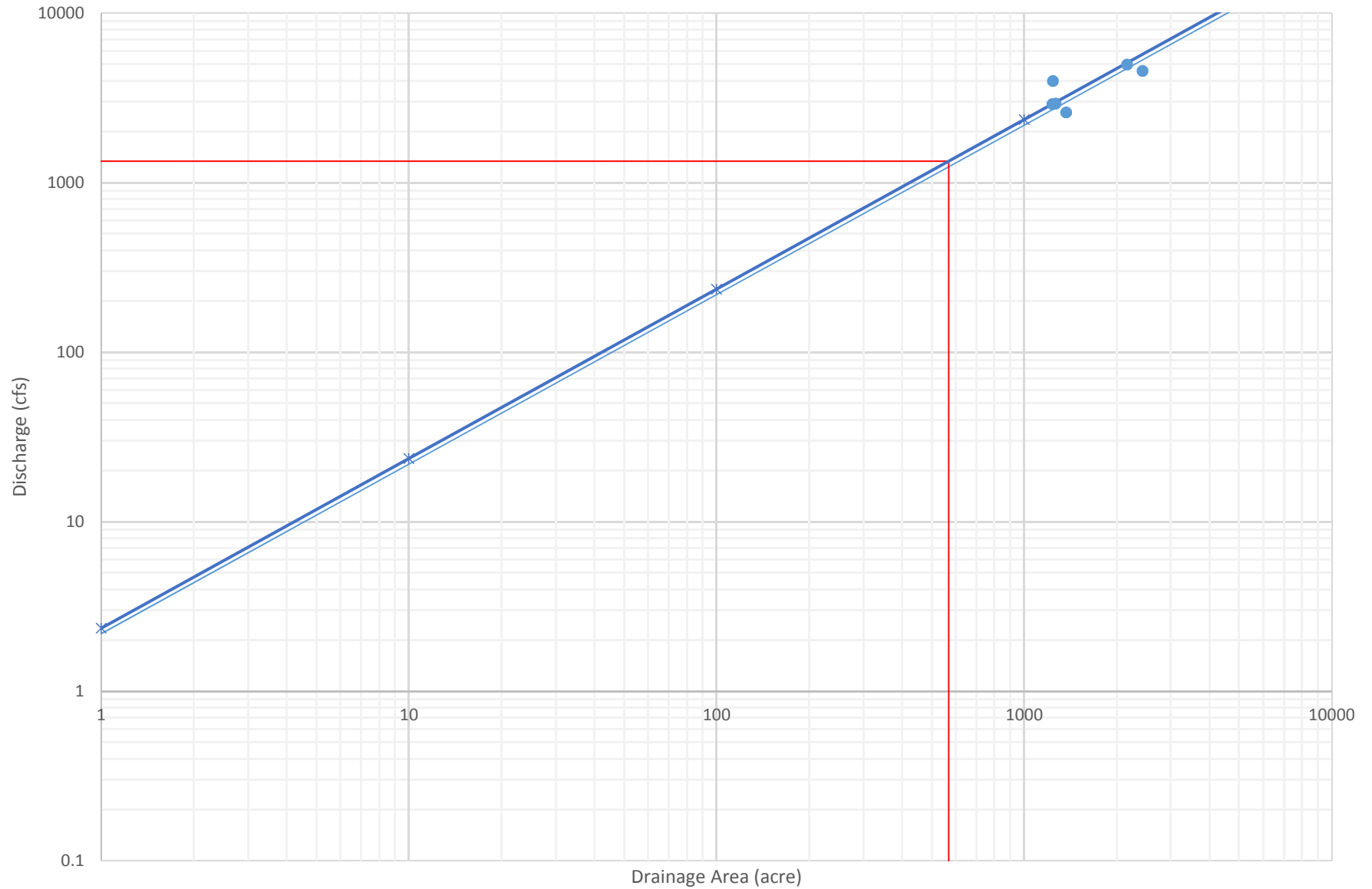
Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
50-Year Storm Event



Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
100-year Storm Event



Log-Log Graph of Drainage Area vs. Discharge for Sub-Areas Surrounding Salt Water Ditch
500-Year Storm Event



Salt Water Ditch Flow Distributions

Table ID: C1
Project: Salt Water Ditch
Project #: 325912
Date: 8/26/2015
Prepared By:
Checked By:

HEC-HMS Node	C118-00-00 Location	HEC-RAS Station	Return Period							100-yr % Diff.
			50% (2-yr)	25% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)	0.2% (500-yr)	
C1180000_0009_J	U/S of confluence with C100-00-00	862.93	1269	1887	2371	3063	3628	4274	6117	
	interploated flow	2080.80	1193	1759	2201	2833	3350	3942	5627	10.02%
	interploated flow	2894.54	1144	1679	2094	2690	3176	3735	5321	7.47%
	interploated flow	4110.80	1076	1565	1944	2488	2934	3445	4895	9.09%
	interploated flow	6011.34	977	1403	1731	2203	2591	3037	4296	16.08%
	interploated flow	7593.43	901	1281	1571	1991	2336	2734	3854	17.01%
	interploated flow	9343.84	825	1158	1411	1780	2083	2434	3418	12.44%
	interploated flow	10526.48	777	1082	1313	1650	1928	2250	3151	9.65%
C118A	D/S of Martin Luther King Jr. Street Bridge	11687.74	732	1012	1223	1532	1787	2083	2910	9.66%
	interploated flow	13204.23	600	830	1003	1257	1466	1709	2387	20.76%
	interploated flow	13788.08	556	769	929	1165	1358	1583	2211	9.70%
	interploated flow	15729.16	432	597	721	904	1054	1229	1716	28.37%
Upstream Limit	Beginning of Salt Water Ditch	17621.74	337	466	563	706	823	960	1340	27.59%

APPENDIX C.2

HEC-HMS OUTPUTS

- **2-YEAR**
- **5-YEAR**
- **10-YEAR**
- **25-YEAR**
- **50-YEAR**
- **100-YEAR**
- **500-YEAR**

2-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_2

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(50%Flood)
 Compute Time: 20Nov2015, 06:46:55 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	11150.2	01Jan2003, 23:15	2.77
C100#10	44.95	6627.7	01Jan2003, 20:30	2.59
C100#11	42.97	6381.2	01Jan2003, 20:30	2.58
C100#12	40.83	6140.8	01Jan2003, 20:00	2.58
C100#13	34.73	5677.4	01Jan2003, 19:30	2.66
C100#14	32.50	5450.8	01Jan2003, 19:00	2.71
C100#15	28.36	4730.0	01Jan2003, 18:45	2.73
C100#16	23.73	3933.8	01Jan2003, 19:00	2.75
C100#17	21.75	3622.5	01Jan2003, 18:45	2.76
C100#18	20.73	3453.6	01Jan2003, 18:45	2.77
C100#19	18.31	2975.4	01Jan2003, 19:00	2.76
C100#2	87.76	10836.1	01Jan2003, 23:00	2.74
C100#20	15.07	2417.1	01Jan2003, 19:15	2.71
C100#21	7.91	1334.3	01Jan2003, 19:00	2.65
C100#22	5.07	973.8	01Jan2003, 18:15	2.69
C100#23	3.23	577.3	01Jan2003, 17:30	2.60
C100#24	2.26	396.0	01Jan2003, 17:00	2.53
C100#3	86.15	10765.4	01Jan2003, 22:45	2.73
C100#4	68.69	8702.1	01Jan2003, 23:00	2.63
C100#5	65.31	8483.0	01Jan2003, 22:30	2.61
C100#6	63.55	8363.5	01Jan2003, 22:15	2.60
C100#7	57.28	7967.6	01Jan2003, 21:30	2.61
C100#8	55.05	7759.8	01Jan2003, 21:15	2.62
C100#9	48.74	7049.9	01Jan2003, 21:00	2.61
C100#D1	5.07	928.0	01Jan2003, 18:45	2.69
C100#D2	3.23	548.0	01Jan2003, 18:15	2.59

2-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	396.0	01Jan2003, 17:00	2.53
C100B	1.84	585.4	01Jan2003, 16:45	2.86
C100B REACH#1	3.23	548.0	01Jan2003, 18:15	2.59
C100B REACH#2	2.26	389.8	01Jan2003, 17:30	2.53
C100C	2.84	521.8	01Jan2003, 17:00	2.58
C100D	2.42	592.3	01Jan2003, 17:15	2.87
C100D REACH#1	18.31	2974.4	01Jan2003, 19:00	2.76
C100D REACH#2	15.07	2417.1	01Jan2003, 19:15	2.71
C100D REACH#3	7.91	1330.6	01Jan2003, 19:15	2.65
C100E	2.24	546.7	01Jan2003, 18:00	3.04
C100E REACH#1	23.73	3926.2	01Jan2003, 19:00	2.75
C100E REACH#2	21.75	3611.2	01Jan2003, 19:00	2.76
C100E REACH#3	20.73	3449.3	01Jan2003, 18:45	2.77
C100F	2.58	623.0	01Jan2003, 17:45	2.57
C100F REACH	28.36	4712.8	01Jan2003, 19:15	2.73
C100G	2.23	341.4	01Jan2003, 17:00	2.01
C100G REACH	32.50	5423.0	01Jan2003, 19:30	2.71
C100H	1.98	736.3	01Jan2003, 16:45	2.88
C100H REACH#1	42.97	6354.1	01Jan2003, 20:45	2.58
C100H REACH#2	40.83	6092.9	01Jan2003, 20:30	2.58
C100I	3.79	1084.5	01Jan2003, 17:00	2.86
C100I REACH	44.95	6548.8	01Jan2003, 21:15	2.59
C100J	6.27	591.5	01Jan2003, 18:15	2.60
C100J REACH	57.28	7849.8	01Jan2003, 22:15	2.60
C100K	1.76	501.7	01Jan2003, 17:15	2.82
C100K#1	1.76	501.7	01Jan2003, 17:15	2.82
C100L	3.38	1294.7	01Jan2003, 17:00	3.23
C100L REACH#1	65.31	8410.2	01Jan2003, 23:00	2.60
C100L REACH#2	63.55	8307.4	01Jan2003, 22:30	2.60
C100M	1.76	429.3	01Jan2003, 17:45	3.39
C100M REACH#1	91.75	11139.6	01Jan2003, 23:30	2.76
C100M REACH#2	87.76	10789.5	01Jan2003, 23:15	2.74

2-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	10749.9	01Jan2003, 23:00	2.73
C100M REACH#4	68.69	8697.7	01Jan2003, 23:00	2.63
C100 REACH	5.07	919.9	01Jan2003, 19:30	2.69
C102#1	2.90	395.6	01Jan2003, 17:45	3.28
C102#OULET	3.99	869.3	01Jan2003, 16:45	3.36
C102A	2.90	395.6	01Jan2003, 17:45	3.28
C102B	1.09	717.1	01Jan2003, 16:45	3.63
C102B REACH	2.90	393.1	01Jan2003, 18:30	3.26
C103	1.61	929.4	01Jan2003, 16:45	3.44
C106-00#1	14.39	3803.9	01Jan2003, 17:45	3.14
C106-00#2	9.59	2914.0	01Jan2003, 17:15	3.17
C106-00#3	4.84	1347.3	01Jan2003, 17:00	3.14
C106-00#OUTLET	17.46	4511.1	01Jan2003, 18:30	3.12
C106-01#1	2.78	610.5	01Jan2003, 17:00	2.99
C106-01#OUTLET	4.80	1034.8	01Jan2003, 18:15	3.08
C106-08#OUTLET	1.82	601.5	01Jan2003, 16:45	3.20
C106A	1.82	601.5	01Jan2003, 16:45	3.20
C106B	3.02	755.7	01Jan2003, 17:15	3.10
C106C	1.89	973.8	01Jan2003, 16:45	3.21
C106C REACH	4.84	1323.3	01Jan2003, 17:30	3.14
C106D	2.86	778.0	01Jan2003, 17:00	3.21
C106E	2.78	610.5	01Jan2003, 17:00	2.99
C106F	2.02	492.5	01Jan2003, 17:15	3.21
C106F REACH	2.78	591.8	01Jan2003, 18:30	2.99
C106G	3.07	1093.9	01Jan2003, 17:00	3.00
C106G REACH#1	14.39	3714.4	01Jan2003, 18:30	3.14
C106G REACH#2	9.59	2842.0	01Jan2003, 17:45	3.17
C118	3.87	1085.9	01Jan2003, 17:30	2.91
C1180000_0009_J	3.87	1268.7	01Jan2003, 17:45	2.91
C1180000_0009_R	1.93	631.8	01Jan2003, 18:30	3.00
C118A	1.93	731.7	01Jan2003, 17:15	3.00
C118B	1.94	1055.3	01Jan2003, 17:00	2.82

2-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	481.5	01Jan2003, 17:00	2.36
C120 REACH	55.05	7732.3	01Jan2003, 21:30	2.62
C123	2.44	571.9	01Jan2003, 17:30	2.42
C123 REACH	48.74	6987.9	01Jan2003, 21:30	2.61
C127	2.14	599.8	01Jan2003, 16:45	2.58
C132	4.07	419.3	01Jan2003, 17:15	2.20
C134	2.03	198.2	01Jan2003, 19:00	2.03
C134 REACH	34.73	5597.6	01Jan2003, 20:15	2.66
C137	1.56	354.4	01Jan2003, 16:45	2.56
C143	1.98	420.4	01Jan2003, 16:45	2.64
C144	1.02	223.0	01Jan2003, 16:45	2.53
C145#1	1.86	381.2	01Jan2003, 17:00	3.13
C145#OUTLET	3.24	698.8	01Jan2003, 17:00	3.00
C145A	1.86	381.2	01Jan2003, 17:00	3.13
C145B	1.38	321.0	01Jan2003, 16:45	2.82
C147#1	1.82	359.8	01Jan2003, 17:00	2.93
C147#2	2.71	501.9	01Jan2003, 17:15	2.67
C147#OUTLET	7.16	1102.1	01Jan2003, 18:30	2.77
C147A	1.82	359.8	01Jan2003, 17:00	2.93
C147B	2.71	501.9	01Jan2003, 17:15	2.67
C147C	2.63	810.1	01Jan2003, 17:15	2.81
C147C REACH	4.53	605.4	01Jan2003, 21:00	2.76
C147 DETENTION	4.53	606.8	01Jan2003, 20:30	2.76
C161	2.39	346.0	01Jan2003, 17:45	2.27
C162	0.97	191.1	01Jan2003, 17:00	2.75
DET#1	4.53	606.8	01Jan2003, 20:30	2.76
DET#2	4.53	859.9	01Jan2003, 17:15	2.77
DETENTION REACH#1	5.07	928.0	01Jan2003, 18:45	2.69
DETENTION REACH#2	3.23	539.8	01Jan2003, 18:45	2.59
Outlet	93.51	11344.0	01Jan2003, 23:30	2.77

5-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_5

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(20%Flood)
 Compute Time: 20Nov2015, 06:50:18 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	17776.4	01Jan2003, 22:30	4.17
C100#10	44.95	10135.7	01Jan2003, 20:15	3.97
C100#11	42.97	9727.8	01Jan2003, 20:15	3.96
C100#12	40.83	9303.6	01Jan2003, 20:00	3.96
C100#13	34.73	8508.3	01Jan2003, 19:30	4.08
C100#14	32.50	8121.1	01Jan2003, 19:15	4.14
C100#15	28.36	7029.7	01Jan2003, 19:15	4.17
C100#16	23.73	5882.2	01Jan2003, 19:15	4.21
C100#17	21.75	5420.4	01Jan2003, 19:00	4.23
C100#18	20.73	5174.8	01Jan2003, 19:00	4.24
C100#19	18.31	4478.9	01Jan2003, 19:00	4.23
C100#2	87.76	17253.6	01Jan2003, 22:15	4.14
C100#20	15.07	3648.4	01Jan2003, 19:15	4.16
C100#21	7.91	2023.2	01Jan2003, 19:15	4.09
C100#22	5.07	1452.6	01Jan2003, 18:15	4.14
C100#23	3.23	835.9	01Jan2003, 17:30	4.02
C100#24	2.26	569.2	01Jan2003, 17:15	3.94
C100#3	86.15	17102.1	01Jan2003, 22:00	4.13
C100#4	68.69	13693.8	01Jan2003, 22:30	4.00
C100#5	65.31	13317.2	01Jan2003, 22:00	3.97
C100#6	63.55	13108.9	01Jan2003, 21:45	3.97
C100#7	57.28	12451.5	01Jan2003, 21:00	3.99
C100#8	55.05	12065.8	01Jan2003, 20:45	4.00
C100#9	48.74	10867.5	01Jan2003, 20:45	3.99
C100#D1	5.07	1383.6	01Jan2003, 19:00	4.14
C100#D2	3.23	809.3	01Jan2003, 18:15	4.02

5-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	569.2	01Jan2003, 17:15	3.94
C100B	1.84	812.6	01Jan2003, 16:45	4.35
C100B REACH#1	3.23	809.3	01Jan2003, 18:15	4.02
C100B REACH#2	2.26	566.1	01Jan2003, 17:30	3.94
C100C	2.84	746.5	01Jan2003, 17:15	4.01
C100D	2.42	835.2	01Jan2003, 17:15	4.37
C100D REACH#1	18.31	4478.6	01Jan2003, 19:15	4.23
C100D REACH#2	15.07	3645.5	01Jan2003, 19:15	4.16
C100D REACH#3	7.91	2022.2	01Jan2003, 19:15	4.09
C100E	2.24	771.1	01Jan2003, 18:15	4.52
C100E REACH#1	23.73	5869.7	01Jan2003, 19:30	4.20
C100E REACH#2	21.75	5405.2	01Jan2003, 19:15	4.22
C100E REACH#3	20.73	5168.9	01Jan2003, 19:15	4.24
C100F	2.58	894.4	01Jan2003, 17:45	3.92
C100F REACH	28.36	7014.5	01Jan2003, 19:30	4.17
C100G	2.23	499.2	01Jan2003, 17:15	3.20
C100G REACH	32.50	8097.9	01Jan2003, 19:30	4.14
C100H	1.98	1012.2	01Jan2003, 16:45	4.32
C100H REACH#1	42.97	9703.3	01Jan2003, 20:30	3.95
C100H REACH#2	40.83	9255.5	01Jan2003, 20:15	3.96
C100I	3.79	1512.1	01Jan2003, 17:00	4.29
C100I REACH	44.95	10064.0	01Jan2003, 21:00	3.96
C100J	6.27	857.0	01Jan2003, 18:45	3.87
C100J REACH	57.28	12326.0	01Jan2003, 21:45	3.98
C100K	1.76	704.9	01Jan2003, 17:15	4.24
C100K#1	1.76	704.9	01Jan2003, 17:15	4.24
C100L	3.38	1766.8	01Jan2003, 17:00	4.76
C100L REACH#1	65.31	13216.5	01Jan2003, 22:45	3.96
C100L REACH#2	63.55	13030.0	01Jan2003, 22:15	3.96
C100M	1.76	597.0	01Jan2003, 18:00	4.98
C100M REACH#1	91.75	17764.5	01Jan2003, 22:45	4.17
C100M REACH#2	87.76	17211.2	01Jan2003, 22:30	4.14

5-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	17091.2	01Jan2003, 22:15	4.13
C100M REACH#4	68.69	13688.6	01Jan2003, 22:45	4.00
C100 REACH	5.07	1376.1	01Jan2003, 19:30	4.13
C102#1	2.90	556.0	01Jan2003, 18:00	4.79
C102#OULET	3.99	1179.8	01Jan2003, 16:45	4.91
C102A	2.90	556.0	01Jan2003, 18:00	4.79
C102B	1.09	948.2	01Jan2003, 16:45	5.28
C102B REACH	2.90	558.1	01Jan2003, 18:00	4.77
C103	1.61	1241.1	01Jan2003, 16:45	5.04
C106-00#1	14.39	5342.8	01Jan2003, 18:00	4.67
C106-00#2	9.59	4039.9	01Jan2003, 17:15	4.71
C106-00#3	4.84	1861.8	01Jan2003, 17:00	4.67
C106-00#OUTLET	17.46	6409.0	01Jan2003, 18:30	4.63
C106-01#1	2.78	853.1	01Jan2003, 17:15	4.46
C106-01#OUTLET	4.80	1477.0	01Jan2003, 18:15	4.58
C106-08#OUTLET	1.82	825.3	01Jan2003, 17:00	4.75
C106A	1.82	825.3	01Jan2003, 17:00	4.75
C106B	3.02	1054.2	01Jan2003, 17:15	4.62
C106C	1.89	1314.1	01Jan2003, 16:45	4.75
C106C REACH	4.84	1845.2	01Jan2003, 17:30	4.67
C106D	2.86	1072.7	01Jan2003, 17:00	4.76
C106E	2.78	853.1	01Jan2003, 17:15	4.46
C106F	2.02	683.8	01Jan2003, 17:15	4.74
C106F REACH	2.78	839.3	01Jan2003, 18:30	4.46
C106G	3.07	1506.5	01Jan2003, 17:00	4.48
C106G REACH#1	14.39	5239.1	01Jan2003, 18:30	4.67
C106G REACH#2	9.59	3963.3	01Jan2003, 17:45	4.71
C118	3.87	1521.5	01Jan2003, 17:30	4.36
C1180000_0009_J	3.87	1886.9	01Jan2003, 17:45	4.36
C1180000_0009_R	1.93	912.9	01Jan2003, 18:15	4.47
C118A	1.93	1011.5	01Jan2003, 17:15	4.47
C118B	1.94	1446.5	01Jan2003, 17:00	4.25

5-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	686.7	01Jan2003, 17:00	3.66
C120 REACH	55.05	12049.1	01Jan2003, 21:00	4.00
C123	2.44	825.2	01Jan2003, 17:45	3.73
C123 REACH	48.74	10806.8	01Jan2003, 21:00	3.99
C127	2.14	839.2	01Jan2003, 17:00	3.93
C132	4.07	615.9	01Jan2003, 17:45	3.41
C134	2.03	300.1	01Jan2003, 19:00	3.18
C134 REACH	34.73	8450.5	01Jan2003, 20:00	4.07
C137	1.56	501.0	01Jan2003, 17:00	3.90
C143	1.98	594.5	01Jan2003, 17:00	4.01
C144	1.02	316.0	01Jan2003, 17:00	3.87
C145#1	1.86	533.3	01Jan2003, 17:15	4.70
C145#OUTLET	3.24	982.7	01Jan2003, 17:00	4.53
C145A	1.86	533.3	01Jan2003, 17:15	4.70
C145B	1.38	450.0	01Jan2003, 17:00	4.31
C147#1	1.82	507.7	01Jan2003, 17:15	4.44
C147#2	2.71	717.2	01Jan2003, 17:15	4.11
C147#OUTLET	7.16	1630.0	01Jan2003, 19:00	4.24
C147A	1.82	507.7	01Jan2003, 17:15	4.44
C147B	2.71	717.2	01Jan2003, 17:15	4.11
C147C	2.63	1135.9	01Jan2003, 17:15	4.29
C147C REACH	4.53	909.0	01Jan2003, 21:15	4.22
C147 DETENTION	4.53	911.0	01Jan2003, 20:45	4.22
C161	2.39	507.3	01Jan2003, 17:45	3.53
C162	0.97	271.7	01Jan2003, 17:15	4.21
DET#1	4.53	911.0	01Jan2003, 20:45	4.22
DET#2	4.53	1225.0	01Jan2003, 17:15	4.24
DETENTION REACH#1	5.07	1383.6	01Jan2003, 19:00	4.14
DETENTION REACH#2	3.23	802.3	01Jan2003, 18:45	4.02
Outlet	93.51	18098.3	01Jan2003, 22:45	4.18

10-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_10

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(10%flood)
 Compute Time: 20Nov2015, 06:44:45 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	22578.1	01Jan2003, 22:30	5.27
C100#10	44.95	12816.8	01Jan2003, 20:15	5.06
C100#11	42.97	12284.2	01Jan2003, 20:15	5.04
C100#12	40.83	11731.1	01Jan2003, 20:00	5.05
C100#13	34.73	10712.3	01Jan2003, 19:30	5.19
C100#14	32.50	10209.4	01Jan2003, 19:15	5.26
C100#15	28.36	8823.7	01Jan2003, 19:15	5.30
C100#16	23.73	7374.2	01Jan2003, 19:15	5.34
C100#17	21.75	6783.9	01Jan2003, 19:00	5.37
C100#18	20.73	6465.4	01Jan2003, 19:00	5.39
C100#19	18.31	5597.2	01Jan2003, 19:15	5.37
C100#2	87.76	21970.9	01Jan2003, 22:15	5.24
C100#20	15.07	4568.5	01Jan2003, 19:15	5.30
C100#21	7.91	2536.6	01Jan2003, 19:15	5.23
C100#22	5.07	1812.2	01Jan2003, 18:00	5.28
C100#23	3.23	1035.1	01Jan2003, 17:30	5.15
C100#24	2.26	706.0	01Jan2003, 17:15	5.07
C100#3	86.15	21783.8	01Jan2003, 22:00	5.22
C100#4	68.69	17517.1	01Jan2003, 22:30	5.08
C100#5	65.31	17054.9	01Jan2003, 22:00	5.04
C100#6	63.55	16775.7	01Jan2003, 21:30	5.04
C100#7	57.28	15933.6	01Jan2003, 20:45	5.07
C100#8	55.05	15418.8	01Jan2003, 20:45	5.09
C100#9	48.74	13785.0	01Jan2003, 20:45	5.08
C100#D1	5.07	1728.3	01Jan2003, 19:00	5.28
C100#D2	3.23	1010.2	01Jan2003, 18:15	5.15

10-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	706.0	01Jan2003, 17:15	5.07
C100B	1.84	983.6	01Jan2003, 16:45	5.52
C100B REACH#1	3.23	1010.2	01Jan2003, 18:15	5.15
C100B REACH#2	2.26	703.6	01Jan2003, 17:45	5.06
C100C	2.84	925.1	01Jan2003, 17:15	5.14
C100D	2.42	1021.1	01Jan2003, 17:15	5.53
C100D REACH#1	18.31	5598.6	01Jan2003, 19:15	5.37
C100D REACH#2	15.07	4563.5	01Jan2003, 19:15	5.30
C100D REACH#3	7.91	2534.7	01Jan2003, 19:15	5.22
C100E	2.24	945.5	01Jan2003, 18:15	5.65
C100E REACH#1	23.73	7362.8	01Jan2003, 19:15	5.34
C100E REACH#2	21.75	6768.3	01Jan2003, 19:15	5.37
C100E REACH#3	20.73	6459.1	01Jan2003, 19:15	5.39
C100F	2.58	1105.8	01Jan2003, 17:45	4.99
C100F REACH	28.36	8805.2	01Jan2003, 19:30	5.30
C100G	2.23	630.4	01Jan2003, 17:15	4.20
C100G REACH	32.50	10174.7	01Jan2003, 19:30	5.25
C100H	1.98	1222.9	01Jan2003, 17:00	5.43
C100H REACH#1	42.97	12260.0	01Jan2003, 20:30	5.04
C100H REACH#2	40.83	11678.1	01Jan2003, 20:15	5.05
C100I	3.79	1839.5	01Jan2003, 17:00	5.40
C100I REACH	44.95	12755.6	01Jan2003, 20:45	5.05
C100J	6.27	1066.1	01Jan2003, 19:00	4.86
C100J REACH	57.28	15783.3	01Jan2003, 21:30	5.06
C100K	1.76	861.4	01Jan2003, 17:15	5.34
C100K#1	1.76	861.4	01Jan2003, 17:15	5.34
C100L	3.38	2119.1	01Jan2003, 17:00	5.92
C100L REACH#1	65.31	16903.5	01Jan2003, 22:30	5.03
C100L REACH#2	63.55	16680.3	01Jan2003, 22:00	5.03
C100M	1.76	725.6	01Jan2003, 18:00	6.16
C100M REACH#1	91.75	22555.7	01Jan2003, 22:45	5.26
C100M REACH#2	87.76	21892.1	01Jan2003, 22:30	5.23

10-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	21770.3	01Jan2003, 22:15	5.22
C100M REACH#4	68.69	17516.0	01Jan2003, 22:30	5.08
C100 REACH	5.07	1719.6	01Jan2003, 19:30	5.27
C102#1	2.90	679.7	01Jan2003, 18:00	5.92
C102#OULET	3.99	1485.7	01Jan2003, 17:30	6.06
C102A	2.90	679.7	01Jan2003, 18:00	5.92
C102B	1.09	1115.7	01Jan2003, 16:45	6.49
C102B REACH	2.90	679.5	01Jan2003, 18:30	5.89
C103	1.61	1468.1	01Jan2003, 16:45	6.23
C106-00#1	14.39	6539.0	01Jan2003, 17:45	5.82
C106-00#2	9.59	4924.0	01Jan2003, 17:15	5.88
C106-00#3	4.84	2264.4	01Jan2003, 17:15	5.83
C106-00#OUTLET	17.46	7852.4	01Jan2003, 18:30	5.78
C106-01#1	2.78	1044.8	01Jan2003, 17:15	5.58
C106-01#OUTLET	4.80	1812.2	01Jan2003, 18:15	5.72
C106-08#OUTLET	1.82	996.8	01Jan2003, 17:00	5.91
C106A	1.82	996.8	01Jan2003, 17:00	5.91
C106B	3.02	1282.8	01Jan2003, 17:15	5.78
C106C	1.89	1560.1	01Jan2003, 16:45	5.92
C106C REACH	4.84	2247.9	01Jan2003, 17:30	5.83
C106D	2.86	1302.2	01Jan2003, 17:15	5.93
C106E	2.78	1044.8	01Jan2003, 17:15	5.58
C106F	2.02	830.2	01Jan2003, 17:15	5.90
C106F REACH	2.78	1031.2	01Jan2003, 18:30	5.58
C106G	3.07	1816.3	01Jan2003, 17:00	5.60
C106G REACH#1	14.39	6401.2	01Jan2003, 18:45	5.82
C106G REACH#2	9.59	4835.3	01Jan2003, 17:45	5.88
C118	3.87	1856.1	01Jan2003, 17:30	5.48
C1180000_0009_J	3.87	2370.6	01Jan2003, 17:45	5.47
C1180000_0009_R	1.93	1125.2	01Jan2003, 18:15	5.60
C118A	1.93	1222.8	01Jan2003, 17:15	5.60
C118B	1.94	1732.3	01Jan2003, 17:00	5.35

10-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	852.8	01Jan2003, 17:15	4.70
C120 REACH	55.05	15389.9	01Jan2003, 20:45	5.09
C123	2.44	1025.1	01Jan2003, 17:45	4.78
C123 REACH	48.74	13736.2	01Jan2003, 21:00	5.07
C127	2.14	1030.2	01Jan2003, 17:00	5.00
C132	4.07	777.3	01Jan2003, 18:00	4.39
C134	2.03	382.5	01Jan2003, 19:15	4.14
C134 REACH	34.73	10631.8	01Jan2003, 20:00	5.18
C137	1.56	618.0	01Jan2003, 17:00	4.97
C143	1.98	732.7	01Jan2003, 17:00	5.09
C144	1.02	390.2	01Jan2003, 17:00	4.94
C145#1	1.86	652.0	01Jan2003, 17:15	5.88
C145#OUTLET	3.24	1200.4	01Jan2003, 17:15	5.70
C145A	1.86	652.0	01Jan2003, 17:15	5.88
C145B	1.38	551.8	01Jan2003, 17:00	5.47
C147#1	1.82	623.1	01Jan2003, 17:15	5.61
C147#2	2.71	886.5	01Jan2003, 17:30	5.25
C147#OUTLET	7.16	2034.0	01Jan2003, 19:00	5.39
C147A	1.82	623.1	01Jan2003, 17:15	5.61
C147B	2.71	886.5	01Jan2003, 17:30	5.25
C147C	2.63	1382.1	01Jan2003, 17:15	5.45
C147C REACH	4.53	1171.4	01Jan2003, 21:00	5.36
C147 DETENTION	4.53	1175.5	01Jan2003, 20:30	5.37
C161	2.39	636.4	01Jan2003, 18:00	4.56
C162	0.97	334.7	01Jan2003, 17:15	5.36
DET#1	4.53	1175.5	01Jan2003, 20:30	5.37
DET#2	4.53	1508.0	01Jan2003, 17:30	5.39
DETENTION REACH#1	5.07	1728.3	01Jan2003, 19:00	5.28
DETENTION REACH#2	3.23	1003.1	01Jan2003, 18:45	5.15
Outlet	93.51	22967.9	01Jan2003, 22:45	5.27

25-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_25

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(4%Flood)
 Compute Time: 20Nov2015, 06:47:59 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	31561.1	01Jan2003, 21:45	7.09
C100#10	44.95	17049.9	01Jan2003, 20:15	6.89
C100#11	42.97	16317.3	01Jan2003, 20:15	6.87
C100#12	40.83	15544.5	01Jan2003, 20:15	6.88
C100#13	34.73	14132.6	01Jan2003, 19:45	7.05
C100#14	32.50	13432.4	01Jan2003, 19:30	7.13
C100#15	28.36	11627.1	01Jan2003, 19:15	7.18
C100#16	23.73	9740.1	01Jan2003, 19:15	7.23
C100#17	21.75	8968.6	01Jan2003, 19:15	7.27
C100#18	20.73	8549.1	01Jan2003, 19:15	7.29
C100#19	18.31	7434.1	01Jan2003, 19:15	7.27
C100#2	87.76	30666.1	01Jan2003, 21:30	7.06
C100#20	15.07	6096.7	01Jan2003, 19:30	7.20
C100#21	7.91	3329.4	01Jan2003, 19:15	7.12
C100#22	5.07	2350.6	01Jan2003, 18:15	7.17
C100#23	3.23	1336.1	01Jan2003, 17:45	7.04
C100#24	2.26	911.1	01Jan2003, 17:30	6.94
C100#3	86.15	30350.4	01Jan2003, 21:30	7.04
C100#4	68.69	23988.6	01Jan2003, 22:00	6.88
C100#5	65.31	23152.2	01Jan2003, 21:30	6.84
C100#6	63.55	22654.9	01Jan2003, 21:15	6.84
C100#7	57.28	21452.4	01Jan2003, 20:45	6.90
C100#8	55.05	20724.1	01Jan2003, 20:30	6.92
C100#9	48.74	18406.6	01Jan2003, 20:30	6.90
C100#D1	5.07	2257.8	01Jan2003, 19:00	7.17
C100#D2	3.23	1311.3	01Jan2003, 18:30	7.03

25-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	911.1	01Jan2003, 17:30	6.94
C100B	1.84	1236.7	01Jan2003, 16:45	7.44
C100B REACH#1	3.23	1311.3	01Jan2003, 18:30	7.03
C100B REACH#2	2.26	909.7	01Jan2003, 17:45	6.94
C100C	2.84	1189.5	01Jan2003, 17:30	7.02
C100D	2.42	1294.7	01Jan2003, 17:15	7.45
C100D REACH#1	18.31	7426.6	01Jan2003, 19:30	7.27
C100D REACH#2	15.07	6096.7	01Jan2003, 19:30	7.20
C100D REACH#3	7.91	3323.3	01Jan2003, 19:15	7.11
C100E	2.24	1207.2	01Jan2003, 18:15	7.54
C100E REACH#1	23.73	9730.3	01Jan2003, 19:30	7.23
C100E REACH#2	21.75	8947.6	01Jan2003, 19:30	7.26
C100E REACH#3	20.73	8543.3	01Jan2003, 19:15	7.29
C100F	2.58	1420.2	01Jan2003, 17:45	6.81
C100F REACH	28.36	11601.1	01Jan2003, 19:45	7.17
C100G	2.23	828.4	01Jan2003, 17:30	5.93
C100G REACH	32.50	13410.5	01Jan2003, 19:45	7.12
C100H	1.98	1536.0	01Jan2003, 17:00	7.29
C100H REACH#1	42.97	16296.5	01Jan2003, 20:30	6.87
C100H REACH#2	40.83	15501.7	01Jan2003, 20:30	6.87
C100I	3.79	2326.5	01Jan2003, 17:00	7.26
C100I REACH	44.95	16999.7	01Jan2003, 20:45	6.88
C100J	6.27	1397.5	01Jan2003, 19:30	6.49
C100J REACH	57.28	21318.6	01Jan2003, 21:15	6.88
C100K	1.76	1092.2	01Jan2003, 17:15	7.20
C100K#1	1.76	1092.2	01Jan2003, 17:15	7.20
C100L	3.38	2641.7	01Jan2003, 17:00	7.83
C100L REACH#1	65.31	23047.5	01Jan2003, 22:00	6.83
C100L REACH#2	63.55	22583.0	01Jan2003, 21:30	6.83
C100M	1.76	917.8	01Jan2003, 18:00	8.09
C100M REACH#1	91.75	31502.6	01Jan2003, 22:15	7.08
C100M REACH#2	87.76	30583.8	01Jan2003, 21:45	7.05

25-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	30318.9	01Jan2003, 21:45	7.04
C100M REACH#4	68.69	23997.7	01Jan2003, 22:00	6.88
C100 REACH	5.07	2246.8	01Jan2003, 19:30	7.17
C102#1	2.90	872.1	01Jan2003, 18:30	7.74
C102#OULET	3.99	1907.8	01Jan2003, 17:15	7.91
C102A	2.90	872.1	01Jan2003, 18:30	7.74
C102B	1.09	1358.9	01Jan2003, 16:45	8.46
C102B REACH	2.90	871.4	01Jan2003, 19:00	7.71
C103	1.61	1800.2	01Jan2003, 16:45	8.17
C106-00#1	14.39	8278.1	01Jan2003, 17:45	7.73
C106-00#2	9.59	6186.6	01Jan2003, 17:15	7.80
C106-00#3	4.84	2855.3	01Jan2003, 17:15	7.75
C106-00#OUTLET	17.46	10009.5	01Jan2003, 18:30	7.69
C106-01#1	2.78	1328.7	01Jan2003, 17:15	7.46
C106-01#OUTLET	4.80	2279.8	01Jan2003, 18:15	7.60
C106-08#OUTLET	1.82	1248.5	01Jan2003, 17:00	7.84
C106A	1.82	1248.5	01Jan2003, 17:00	7.84
C106B	3.02	1621.2	01Jan2003, 17:15	7.69
C106C	1.89	1924.6	01Jan2003, 16:45	7.85
C106C REACH	4.84	2836.2	01Jan2003, 17:30	7.75
C106D	2.86	1640.8	01Jan2003, 17:15	7.86
C106E	2.78	1328.7	01Jan2003, 17:15	7.46
C106F	2.02	1049.9	01Jan2003, 17:30	7.80
C106F REACH	2.78	1302.9	01Jan2003, 19:15	7.46
C106G	3.07	2277.1	01Jan2003, 17:00	7.48
C106G REACH#1	14.39	8125.8	01Jan2003, 18:45	7.73
C106G REACH#2	9.59	6103.2	01Jan2003, 17:45	7.80
C118	3.87	2356.3	01Jan2003, 17:45	7.34
C1180000_0009_J	3.87	3062.5	01Jan2003, 17:45	7.34
C1180000_0009_R	1.93	1436.3	01Jan2003, 18:15	7.47
C118A	1.93	1532.4	01Jan2003, 17:15	7.47
C118B	1.94	2144.8	01Jan2003, 17:00	7.21

25-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1099.8	01Jan2003, 17:15	6.50
C120 REACH	55.05	20699.5	01Jan2003, 20:45	6.91
C123	2.44	1322.1	01Jan2003, 17:45	6.58
C123 REACH	48.74	18361.4	01Jan2003, 20:45	6.90
C127	2.14	1311.7	01Jan2003, 17:00	6.82
C132	4.07	1031.0	01Jan2003, 18:30	6.06
C134	2.03	512.0	01Jan2003, 19:30	5.79
C134 REACH	34.73	14066.5	01Jan2003, 20:15	7.04
C137	1.56	791.2	01Jan2003, 17:00	6.79
C143	1.98	939.0	01Jan2003, 17:15	6.92
C144	1.02	500.3	01Jan2003, 17:00	6.75
C145#1	1.86	827.0	01Jan2003, 17:30	7.82
C145#OUTLET	3.24	1526.3	01Jan2003, 17:15	7.63
C145A	1.86	827.0	01Jan2003, 17:30	7.82
C145B	1.38	700.9	01Jan2003, 17:00	7.38
C147#1	1.82	794.7	01Jan2003, 17:30	7.53
C147#2	2.71	1138.9	01Jan2003, 17:30	7.14
C147#OUTLET	7.16	2775.5	01Jan2003, 19:30	7.29
C147A	1.82	794.7	01Jan2003, 17:30	7.53
C147B	2.71	1138.9	01Jan2003, 17:30	7.14
C147C	2.63	1743.4	01Jan2003, 17:15	7.36
C147C REACH	4.53	1621.3	01Jan2003, 20:45	7.25
C147 DETENTION	4.53	1630.5	01Jan2003, 20:15	7.26
C161	2.39	834.8	01Jan2003, 18:00	6.32
C162	0.97	428.3	01Jan2003, 17:30	7.27
DET#1	4.53	1630.5	01Jan2003, 20:15	7.26
DET#2	4.53	1933.6	01Jan2003, 17:30	7.30
DETENTION REACH#1	5.07	2257.8	01Jan2003, 19:00	7.17
DETENTION REACH#2	3.23	1305.6	01Jan2003, 18:45	7.03
Outlet	93.51	32087.7	01Jan2003, 22:15	7.10

50-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_50

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(2%flood)
 Compute Time: 20Nov2015, 06:51:30 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	38046.3	01Jan2003, 21:45	8.73
C100#10	44.95	20717.4	01Jan2003, 20:15	8.53
C100#11	42.97	19799.2	01Jan2003, 20:15	8.52
C100#12	40.83	18837.4	01Jan2003, 20:15	8.53
C100#13	34.73	17084.1	01Jan2003, 19:45	8.72
C100#14	32.50	16224.1	01Jan2003, 19:30	8.80
C100#15	28.36	14052.1	01Jan2003, 19:30	8.86
C100#16	23.73	11798.6	01Jan2003, 19:30	8.92
C100#17	21.75	10869.3	01Jan2003, 19:15	8.95
C100#18	20.73	10368.9	01Jan2003, 19:15	8.98
C100#19	18.31	9035.7	01Jan2003, 19:15	8.96
C100#2	87.76	37057.6	01Jan2003, 21:00	8.70
C100#20	15.07	7445.3	01Jan2003, 19:30	8.88
C100#21	7.91	3993.0	01Jan2003, 19:15	8.80
C100#22	5.07	2789.2	01Jan2003, 18:15	8.86
C100#23	3.23	1595.5	01Jan2003, 17:45	8.71
C100#24	2.26	1089.5	01Jan2003, 17:45	8.62
C100#3	86.15	36560.8	01Jan2003, 21:00	8.68
C100#4	68.69	28933.4	01Jan2003, 22:30	8.50
C100#5	65.31	28087.4	01Jan2003, 21:45	8.46
C100#6	63.55	27525.0	01Jan2003, 21:30	8.47
C100#7	57.28	26171.1	01Jan2003, 20:30	8.54
C100#8	55.05	25247.9	01Jan2003, 20:30	8.56
C100#9	48.74	22280.0	01Jan2003, 20:15	8.55
C100#D1	5.07	2699.4	01Jan2003, 19:00	8.86
C100#D2	3.23	1572.6	01Jan2003, 18:30	8.71

50-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1089.5	01Jan2003, 17:45	8.62
C100B	1.84	1445.6	01Jan2003, 16:45	9.14
C100B REACH#1	3.23	1572.6	01Jan2003, 18:30	8.71
C100B REACH#2	2.26	1088.1	01Jan2003, 18:00	8.61
C100C	2.84	1419.9	01Jan2003, 17:30	8.70
C100D	2.42	1527.4	01Jan2003, 17:30	9.16
C100D REACH#1	18.31	9032.6	01Jan2003, 19:30	8.96
C100D REACH#2	15.07	7437.2	01Jan2003, 19:30	8.88
C100D REACH#3	7.91	3986.0	01Jan2003, 19:15	8.80
C100E	2.24	1427.8	01Jan2003, 18:15	9.23
C100E REACH#1	23.73	11777.0	01Jan2003, 19:30	8.92
C100E REACH#2	21.75	10843.2	01Jan2003, 19:30	8.95
C100E REACH#3	20.73	10355.7	01Jan2003, 19:30	8.98
C100F	2.58	1684.1	01Jan2003, 17:45	8.47
C100F REACH	28.36	14025.6	01Jan2003, 19:45	8.85
C100G	2.23	1000.0	01Jan2003, 17:45	7.54
C100G REACH	32.50	16192.9	01Jan2003, 19:45	8.80
C100H	1.98	1793.0	01Jan2003, 17:00	8.97
C100H REACH#1	42.97	19778.4	01Jan2003, 20:30	8.51
C100H REACH#2	40.83	18796.6	01Jan2003, 20:30	8.52
C100I	3.79	2731.3	01Jan2003, 17:15	8.94
C100I REACH	44.95	20566.4	01Jan2003, 21:00	8.52
C100J	6.27	1681.0	01Jan2003, 19:30	7.95
C100J REACH	57.28	25913.0	01Jan2003, 21:30	8.52
C100K	1.76	1284.0	01Jan2003, 17:15	8.87
C100K#1	1.76	1284.0	01Jan2003, 17:15	8.87
C100L	3.38	3071.4	01Jan2003, 17:00	9.54
C100L REACH#1	65.31	27883.3	01Jan2003, 22:30	8.45
C100L REACH#2	63.55	27421.6	01Jan2003, 22:00	8.45
C100M	1.76	1080.3	01Jan2003, 18:00	9.81
C100M REACH#1	91.75	38018.2	01Jan2003, 22:15	8.71
C100M REACH#2	87.76	36849.5	01Jan2003, 21:45	8.69

50-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	36531.1	01Jan2003, 21:15	8.68
C100M REACH#4	68.69	28939.0	01Jan2003, 22:30	8.50
C100 REACH	5.07	2686.8	01Jan2003, 19:30	8.85
C102#1	2.90	1036.8	01Jan2003, 18:30	9.36
C102#OULET	3.99	2223.1	01Jan2003, 17:15	9.56
C102A	2.90	1036.8	01Jan2003, 18:30	9.36
C102B	1.09	1554.3	01Jan2003, 16:45	10.19
C102B REACH	2.90	1036.2	01Jan2003, 19:00	9.32
C103	1.61	2068.1	01Jan2003, 16:45	9.89
C106-00#1	14.39	9648.0	01Jan2003, 17:45	9.44
C106-00#2	9.59	7236.2	01Jan2003, 17:15	9.51
C106-00#3	4.84	3350.0	01Jan2003, 17:15	9.45
C106-00#OUTLET	17.46	11634.1	01Jan2003, 18:30	9.39
C106-01#1	2.78	1572.4	01Jan2003, 17:30	9.15
C106-01#OUTLET	4.80	2649.2	01Jan2003, 19:00	9.30
C106-08#OUTLET	1.82	1456.8	01Jan2003, 17:00	9.55
C106A	1.82	1456.8	01Jan2003, 17:00	9.55
C106B	3.02	1910.4	01Jan2003, 17:30	9.40
C106C	1.89	2219.8	01Jan2003, 16:45	9.56
C106C REACH	4.84	3328.7	01Jan2003, 17:30	9.45
C106D	2.86	1924.6	01Jan2003, 17:15	9.57
C106E	2.78	1572.4	01Jan2003, 17:30	9.15
C106F	2.02	1236.7	01Jan2003, 17:30	9.51
C106F REACH	2.78	1536.0	01Jan2003, 19:30	9.14
C106G	3.07	2656.3	01Jan2003, 17:00	9.17
C106G REACH#1	14.39	9454.3	01Jan2003, 18:45	9.44
C106G REACH#2	9.59	7166.0	01Jan2003, 17:45	9.51
C118	3.87	2779.1	01Jan2003, 17:45	9.02
C1180000_0009_J	3.87	3627.7	01Jan2003, 17:45	9.02
C1180000_0009_R	1.93	1692.0	01Jan2003, 18:15	9.16
C118A	1.93	1787.1	01Jan2003, 17:15	9.16
C118B	1.94	2477.4	01Jan2003, 17:00	8.88

50-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1307.0	01Jan2003, 17:15	8.14
C120 REACH	55.05	25203.1	01Jan2003, 20:30	8.56
C123	2.44	1571.4	01Jan2003, 17:45	8.23
C123 REACH	48.74	22251.9	01Jan2003, 20:45	8.54
C127	2.14	1545.0	01Jan2003, 17:00	8.48
C132	4.07	1251.0	01Jan2003, 18:30	7.59
C134	2.03	623.3	01Jan2003, 19:30	7.30
C134 REACH	34.73	17022.9	01Jan2003, 20:15	8.71
C137	1.56	938.3	01Jan2003, 17:15	8.45
C143	1.98	1115.3	01Jan2003, 17:15	8.58
C144	1.02	594.6	01Jan2003, 17:15	8.41
C145#1	1.86	979.6	01Jan2003, 17:30	9.53
C145#OUTLET	3.24	1803.9	01Jan2003, 17:30	9.34
C145A	1.86	979.6	01Jan2003, 17:30	9.53
C145B	1.38	828.1	01Jan2003, 17:15	9.08
C147#1	1.82	943.2	01Jan2003, 17:30	9.23
C147#2	2.71	1358.6	01Jan2003, 17:45	8.82
C147#OUTLET	7.16	3460.6	01Jan2003, 19:45	8.98
C147A	1.82	943.2	01Jan2003, 17:30	9.23
C147B	2.71	1358.6	01Jan2003, 17:45	8.82
C147C	2.63	2043.8	01Jan2003, 17:15	9.06
C147C REACH	4.53	2038.8	01Jan2003, 20:30	8.93
C147 DETENTION	4.53	2070.2	01Jan2003, 19:45	8.94
C161	2.39	1006.6	01Jan2003, 18:15	7.93
C162	0.97	509.4	01Jan2003, 17:30	8.96
DET#1	4.53	2070.2	01Jan2003, 19:45	8.94
DET#2	4.53	2301.3	01Jan2003, 17:45	8.99
DETENTION REACH#1	5.07	2699.4	01Jan2003, 19:00	8.86
DETENTION REACH#2	3.23	1559.6	01Jan2003, 19:00	8.70
Outlet	93.51	38732.0	01Jan2003, 22:15	8.73

100-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_100

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(1%flood)
 Compute Time: 20Nov2015, 06:42:24 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	44185.1	01Jan2003, 21:45	10.50
C100#10	44.95	24835.5	01Jan2003, 20:30	10.31
C100#11	42.97	23878.3	01Jan2003, 20:30	10.29
C100#12	40.83	22760.2	01Jan2003, 20:15	10.30
C100#13	34.73	20618.8	01Jan2003, 19:45	10.52
C100#14	32.50	19577.7	01Jan2003, 19:45	10.61
C100#15	28.36	17000.6	01Jan2003, 19:30	10.66
C100#16	23.73	14318.3	01Jan2003, 19:30	10.73
C100#17	21.75	13216.6	01Jan2003, 19:30	10.77
C100#18	20.73	12609.2	01Jan2003, 19:30	10.80
C100#19	18.31	11037.7	01Jan2003, 19:30	10.77
C100#2	87.76	42937.5	01Jan2003, 21:30	10.47
C100#20	15.07	9162.5	01Jan2003, 19:30	10.69
C100#21	7.91	4779.7	01Jan2003, 19:15	10.60
C100#22	5.07	3306.4	01Jan2003, 18:15	10.67
C100#23	3.23	1890.7	01Jan2003, 18:00	10.52
C100#24	2.26	1292.4	01Jan2003, 17:45	10.41
C100#3	86.15	42435.2	01Jan2003, 21:30	10.45
C100#4	68.69	33345.6	01Jan2003, 22:30	10.26
C100#5	65.31	32390.2	01Jan2003, 22:30	10.22
C100#6	63.55	31898.2	01Jan2003, 22:00	10.22
C100#7	57.28	30119.4	01Jan2003, 21:15	10.32
C100#8	55.05	29112.8	01Jan2003, 21:15	10.34
C100#9	48.74	26316.6	01Jan2003, 21:15	10.33
C100#D1	5.07	3219.9	01Jan2003, 19:00	10.66
C100#D2	3.23	1868.9	01Jan2003, 18:30	10.51

100-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1292.4	01Jan2003, 17:45	10.41
C100B	1.84	1688.3	01Jan2003, 16:45	10.96
C100B REACH#1	3.23	1868.9	01Jan2003, 18:30	10.51
C100B REACH#2	2.26	1291.1	01Jan2003, 18:00	10.41
C100C	2.84	1681.9	01Jan2003, 17:45	10.51
C100D	2.42	1793.9	01Jan2003, 17:30	10.98
C100D REACH#1	18.31	11035.4	01Jan2003, 19:30	10.77
C100D REACH#2	15.07	9134.6	01Jan2003, 19:45	10.69
C100D REACH#3	7.91	4771.4	01Jan2003, 19:30	10.60
C100E	2.24	1680.6	01Jan2003, 18:15	11.05
C100E REACH#1	23.73	14302.3	01Jan2003, 19:45	10.73
C100E REACH#2	21.75	13178.7	01Jan2003, 19:45	10.76
C100E REACH#3	20.73	12610.1	01Jan2003, 19:30	10.79
C100F	2.58	1987.1	01Jan2003, 17:45	10.27
C100F REACH	28.36	16963.7	01Jan2003, 20:00	10.66
C100G	2.23	1198.8	01Jan2003, 17:45	9.30
C100G REACH	32.50	19551.1	01Jan2003, 20:00	10.60
C100H	1.98	2092.4	01Jan2003, 17:00	10.79
C100H REACH#1	42.97	23787.9	01Jan2003, 20:45	10.29
C100H REACH#2	40.83	22699.7	01Jan2003, 20:30	10.29
C100I	3.79	3204.3	01Jan2003, 17:15	10.75
C100I REACH	44.95	24497.0	01Jan2003, 21:30	10.29
C100J	6.27	2014.1	01Jan2003, 19:45	9.53
C100J REACH	57.28	29997.4	01Jan2003, 22:00	10.30
C100K	1.76	1505.9	01Jan2003, 17:15	10.68
C100K#1	1.76	1505.9	01Jan2003, 17:15	10.68
C100L	3.38	3572.6	01Jan2003, 17:00	11.37
C100L REACH#1	65.31	32235.5	01Jan2003, 23:30	10.20
C100L REACH#2	63.55	31705.5	01Jan2003, 22:45	10.21
C100M	1.76	1265.5	01Jan2003, 18:00	11.65
C100M REACH#1	91.75	44147.8	01Jan2003, 22:15	10.48
C100M REACH#2	87.76	42781.0	01Jan2003, 22:00	10.46

100-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	42402.8	01Jan2003, 21:30	10.45
C100M REACH#4	68.69	33344.8	01Jan2003, 22:30	10.26
C100 REACH	5.07	3206.2	01Jan2003, 19:30	10.66
C102#1	2.90	1228.5	01Jan2003, 19:00	11.10
C102#OULET	3.99	2572.3	01Jan2003, 17:15	11.32
C102A	2.90	1228.5	01Jan2003, 19:00	11.10
C102B	1.09	1785.4	01Jan2003, 16:45	12.05
C102B REACH	2.90	1227.5	01Jan2003, 19:15	11.05
C103	1.61	2384.0	01Jan2003, 16:45	11.73
C106-00#1	14.39	11149.2	01Jan2003, 17:45	11.27
C106-00#2	9.59	8442.8	01Jan2003, 17:15	11.34
C106-00#3	4.84	3918.0	01Jan2003, 17:15	11.29
C106-00#OUTLET	17.46	13574.6	01Jan2003, 18:30	11.22
C106-01#1	2.78	1850.7	01Jan2003, 17:30	10.97
C106-01#OUTLET	4.80	3129.3	01Jan2003, 19:15	11.12
C106-08#OUTLET	1.82	1698.5	01Jan2003, 17:00	11.38
C106A	1.82	1698.5	01Jan2003, 17:00	11.38
C106B	3.02	2240.6	01Jan2003, 17:30	11.23
C106C	1.89	2566.6	01Jan2003, 16:45	11.39
C106C REACH	4.84	3896.6	01Jan2003, 17:45	11.29
C106D	2.86	2250.3	01Jan2003, 17:15	11.40
C106E	2.78	1850.7	01Jan2003, 17:30	10.97
C106F	2.02	1449.7	01Jan2003, 17:30	11.34
C106F REACH	2.78	1813.1	01Jan2003, 19:30	10.96
C106G	3.07	3098.4	01Jan2003, 17:00	10.99
C106G REACH#1	14.39	11001.9	01Jan2003, 18:45	11.27
C106G REACH#2	9.59	8379.4	01Jan2003, 17:45	11.34
C118	3.87	3263.6	01Jan2003, 17:45	10.84
C1180000_0009_J	3.87	4273.9	01Jan2003, 17:30	10.84
C1180000_0009_R	1.93	1984.1	01Jan2003, 18:15	10.98
C118A	1.93	2083.1	01Jan2003, 17:15	10.98
C118B	1.94	2866.2	01Jan2003, 17:00	10.69

100-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1548.9	01Jan2003, 17:30	9.92
C120 REACH	55.05	29086.9	01Jan2003, 21:30	10.34
C123	2.44	1857.8	01Jan2003, 17:45	10.02
C123 REACH	48.74	26213.2	01Jan2003, 21:45	10.32
C127	2.14	1815.9	01Jan2003, 17:00	10.28
C132	4.07	1511.3	01Jan2003, 19:00	9.25
C134	2.03	755.1	01Jan2003, 19:45	8.96
C134 REACH	34.73	20554.2	01Jan2003, 20:15	10.51
C137	1.56	1108.1	01Jan2003, 17:15	10.24
C143	1.98	1317.3	01Jan2003, 17:30	10.38
C144	1.02	702.7	01Jan2003, 17:15	10.20
C145#1	1.86	1151.7	01Jan2003, 17:45	11.36
C145#OUTLET	3.24	2122.3	01Jan2003, 17:30	11.17
C145A	1.86	1151.7	01Jan2003, 17:45	11.36
C145B	1.38	973.5	01Jan2003, 17:15	10.91
C147#1	1.82	1112.3	01Jan2003, 17:45	11.05
C147#2	2.71	1606.8	01Jan2003, 17:45	10.63
C147#OUTLET	7.16	4391.1	01Jan2003, 19:30	10.79
C147A	1.82	1112.3	01Jan2003, 17:45	11.05
C147B	2.71	1606.8	01Jan2003, 17:45	10.63
C147C	2.63	2389.8	01Jan2003, 17:15	10.88
C147C REACH	4.53	2558.7	01Jan2003, 20:00	10.73
C147 DETENTION	4.53	2597.3	01Jan2003, 19:15	10.75
C161	2.39	1204.8	01Jan2003, 18:30	9.69
C162	0.97	601.6	01Jan2003, 17:45	10.77
DET#1	4.53	2597.3	01Jan2003, 19:15	10.75
DET#2	4.53	2719.1	01Jan2003, 17:45	10.80
DETENTION REACH#1	5.07	3219.9	01Jan2003, 19:00	10.66
DETENTION REACH#2	3.23	1856.7	01Jan2003, 19:00	10.50
Outlet	93.51	44997.4	01Jan2003, 22:15	10.50

500-YEAR PROPOSED

Project: C100-00-00 Simulation Run: Proposed_500

Start of Run: 01Jan2003, 00:00 Basin Model: Proposed
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(.2%flood)
 Compute Time: 20Nov2015, 06:52:42 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	57870.6	01Jan2003, 20:30	15.94
C100#10	44.95	32724.3	01Jan2003, 23:30	15.80
C100#11	42.97	32224.7	01Jan2003, 22:45	15.78
C100#12	40.83	31522.5	01Jan2003, 22:00	15.79
C100#13	34.73	28736.2	01Jan2003, 21:00	16.07
C100#14	32.50	27579.1	01Jan2003, 19:45	16.17
C100#15	28.36	23908.4	01Jan2003, 20:15	16.24
C100#16	23.73	20247.6	01Jan2003, 20:30	16.32
C100#17	21.75	19484.0	01Jan2003, 19:45	16.36
C100#18	20.73	18654.0	01Jan2003, 19:30	16.39
C100#19	18.31	16469.5	01Jan2003, 19:15	16.36
C100#2	87.76	56217.1	01Jan2003, 19:30	15.93
C100#20	15.07	13901.1	01Jan2003, 19:00	16.27
C100#21	7.91	6992.1	01Jan2003, 19:15	16.19
C100#22	5.07	4708.6	01Jan2003, 18:30	16.26
C100#23	3.23	2767.8	01Jan2003, 18:15	16.09
C100#24	2.26	1896.8	01Jan2003, 18:00	15.98
C100#3	86.15	54622.8	01Jan2003, 19:45	15.90
C100#4	68.69	40374.8	02Jan2003, 00:30	15.67
C100#5	65.31	39435.4	01Jan2003, 23:45	15.63
C100#6	63.55	38834.5	01Jan2003, 22:45	15.63
C100#7	57.28	37130.3	01Jan2003, 20:00	15.80
C100#8	55.05	35901.7	01Jan2003, 19:30	15.83
C100#9	48.74	32542.1	02Jan2003, 01:30	15.81
C100#D1	5.07	4641.7	01Jan2003, 19:00	16.25
C100#D2	3.23	2677.9	01Jan2003, 19:30	16.08

500-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1896.8	01Jan2003, 18:00	15.98
C100B	1.84	2381.2	01Jan2003, 17:00	16.60
C100B REACH#1	3.23	2677.9	01Jan2003, 19:30	16.08
C100B REACH#2	2.26	1894.8	01Jan2003, 18:15	15.97
C100C	2.84	2460.9	01Jan2003, 18:00	16.09
C100D	2.42	2573.3	01Jan2003, 17:45	16.62
C100D REACH#1	18.31	16360.2	01Jan2003, 19:45	16.36
C100D REACH#2	15.07	13616.8	01Jan2003, 19:45	16.27
C100D REACH#3	7.91	6982.1	01Jan2003, 19:15	16.18
C100E	2.24	2412.9	01Jan2003, 18:15	16.65
C100E REACH#1	23.73	20210.5	01Jan2003, 21:00	16.31
C100E REACH#2	21.75	18749.0	01Jan2003, 20:45	16.35
C100E REACH#3	20.73	18596.7	01Jan2003, 19:45	16.39
C100F	2.58	2868.0	01Jan2003, 18:00	15.81
C100F REACH	28.36	23888.7	01Jan2003, 20:45	16.23
C100G	2.23	1792.4	01Jan2003, 18:00	14.73
C100G REACH	32.50	27260.4	01Jan2003, 21:15	16.16
C100H	1.98	2928.3	01Jan2003, 17:00	16.37
C100H REACH#1	42.97	31916.5	01Jan2003, 23:45	15.77
C100H REACH#2	40.83	31091.8	01Jan2003, 23:15	15.78
C100I	3.79	4565.8	01Jan2003, 17:15	16.33
C100I REACH	44.95	31347.7	02Jan2003, 01:45	15.77
C100J	6.27	3006.7	01Jan2003, 19:45	14.40
C100J REACH	57.28	36055.6	01Jan2003, 22:45	15.77
C100K	1.76	2144.8	01Jan2003, 17:30	16.26
C100K#1	1.76	2144.8	01Jan2003, 17:30	16.26
C100L	3.38	4970.3	01Jan2003, 17:15	17.00
C100L REACH#1	65.31	39253.8	02Jan2003, 00:45	15.60
C100L REACH#2	63.55	38601.5	02Jan2003, 00:00	15.61
C100M	1.76	1810.8	01Jan2003, 18:15	17.30
C100M REACH#1	91.75	57576.1	01Jan2003, 21:00	15.92
C100M REACH#2	87.76	55418.7	01Jan2003, 20:30	15.91

500-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#3	86.15	54627.1	01Jan2003, 19:45	15.90
C100M REACH#4	68.69	40378.1	02Jan2003, 00:45	15.67
C100 REACH	5.07	4630.1	01Jan2003, 19:30	16.24
C102#1	2.90	1802.6	01Jan2003, 19:15	16.42
C102#OULET	3.99	3584.9	01Jan2003, 17:15	16.73
C102A	2.90	1802.6	01Jan2003, 19:15	16.42
C102B	1.09	2400.3	01Jan2003, 16:45	17.73
C102B REACH	2.90	1798.9	01Jan2003, 19:45	16.36
C103	1.61	3230.8	01Jan2003, 16:45	17.39
C106-00#1	14.39	15757.6	01Jan2003, 18:15	16.89
C106-00#2	9.59	11907.0	01Jan2003, 17:30	16.98
C106-00#3	4.84	5566.8	01Jan2003, 17:30	16.92
C106-00#OUTLET	17.46	18806.0	01Jan2003, 19:15	16.84
C106-01#1	2.78	2677.2	01Jan2003, 17:45	16.56
C106-01#OUTLET	4.80	4549.1	01Jan2003, 19:15	16.72
C106-08#OUTLET	1.82	2383.7	01Jan2003, 17:15	17.02
C106A	1.82	2383.7	01Jan2003, 17:15	17.02
C106B	3.02	3208.9	01Jan2003, 17:45	16.85
C106C	1.89	3497.2	01Jan2003, 16:45	17.03
C106C REACH	4.84	5544.1	01Jan2003, 17:45	16.92
C106D	2.86	3205.1	01Jan2003, 17:30	17.04
C106E	2.78	2677.2	01Jan2003, 17:45	16.56
C106F	2.02	2079.0	01Jan2003, 17:45	16.97
C106F REACH	2.78	2637.2	01Jan2003, 19:45	16.55
C106G	3.07	4348.7	01Jan2003, 17:15	16.59
C106G REACH#1	14.39	15405.7	01Jan2003, 19:45	16.89
C106G REACH#2	9.59	11807.1	01Jan2003, 17:45	16.98
C118	3.87	4658.7	01Jan2003, 17:45	16.43
C1180000_0009_J	3.87	6116.9	01Jan2003, 17:30	16.43
C1180000_0009_R	1.93	2822.1	01Jan2003, 18:00	16.58
C118A	1.93	2909.8	01Jan2003, 17:15	16.58
C118B	1.94	3916.1	01Jan2003, 17:00	16.27

500-YEAR PROPOSED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	2258.8	01Jan2003, 17:45	15.44
C120 REACH	55.05	35236.8	01Jan2003, 20:15	15.82
C123	2.44	2689.3	01Jan2003, 18:00	15.54
C123 REACH	48.74	32358.1	02Jan2003, 02:15	15.80
C127	2.14	2595.0	01Jan2003, 17:15	15.82
C132	4.07	2294.7	01Jan2003, 19:15	14.39
C134	2.03	1149.1	01Jan2003, 20:00	14.08
C134 REACH	34.73	28429.8	01Jan2003, 22:15	16.05
C137	1.56	1608.0	01Jan2003, 17:30	15.78
C143	1.98	1918.1	01Jan2003, 17:30	15.93
C144	1.02	1022.7	01Jan2003, 17:30	15.74
C145#1	1.86	1664.3	01Jan2003, 18:00	17.00
C145#OUTLET	3.24	3062.5	01Jan2003, 17:45	16.80
C145A	1.86	1664.3	01Jan2003, 18:00	17.00
C145B	1.38	1403.0	01Jan2003, 17:30	16.54
C147#1	1.82	1614.2	01Jan2003, 18:00	16.67
C147#2	2.71	2347.9	01Jan2003, 18:15	16.22
C147#OUTLET	7.16	7018.3	01Jan2003, 18:45	16.38
C147A	1.82	1614.2	01Jan2003, 18:00	16.67
C147B	2.71	2347.9	01Jan2003, 18:15	16.22
C147C	2.63	3379.6	01Jan2003, 17:30	16.51
C147C REACH	4.53	3936.0	01Jan2003, 19:00	16.30
C147 DETENTION	4.53	3948.9	01Jan2003, 18:30	16.32
C161	2.39	1800.1	01Jan2003, 18:45	15.11
C162	0.97	875.2	01Jan2003, 18:00	16.38
DET#1	4.53	3948.9	01Jan2003, 18:30	16.32
DET#2	4.53	3962.0	01Jan2003, 18:00	16.40
DETENTION REACH#1	5.07	4641.7	01Jan2003, 19:00	16.25
DETENTION REACH#2	3.23	2668.6	01Jan2003, 19:45	16.07
Outlet	93.51	59053.6	01Jan2003, 21:00	15.94

APPENDIX C.3

HEC-RAS OUTPUT

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	862.93	50PCT_2yr	1269.00	13.40	22.46	18.43	22.63	0.001002	3.32	382.49	78.46	0.26
C118-00-00	862.93	25PCT_5yr	1887.00	13.40	24.02	19.41	24.23	0.001001	3.66	515.09	90.98	0.27
C118-00-00	862.93	10PCT_10yr	2371.00	13.40	25.04	20.06	25.27	0.001000	3.88	611.44	99.09	0.28
C118-00-00	862.93	4PCT_25yr	3063.00	13.40	26.28	20.85	26.54	0.001001	4.14	740.54	109.02	0.28
C118-00-00	862.93	2PCT_50yr	3628.00	13.40	27.17	21.41	27.46	0.001001	4.31	840.97	116.15	0.28
C118-00-00	862.93	1PCT_100yr	4274.00	13.40	28.09	22.02	28.40	0.001000	4.49	950.96	123.50	0.29
C118-00-00	862.93	0.2PCT_500yr	6117.00	13.40	30.30	23.42	30.68	0.001000	4.92	1244.34	141.23	0.29
C118-00-00	1508.93	50PCT_2yr	1193.00	14.05	23.09		23.24	0.000894	3.13	381.08	78.32	0.25
C118-00-00	1508.93	25PCT_5yr	1759.00	14.05	24.66		24.84	0.000876	3.42	513.67	90.86	0.25
C118-00-00	1508.93	10PCT_10yr	2201.00	14.05	25.67		25.88	0.000867	3.61	610.11	98.98	0.26
C118-00-00	1508.93	4PCT_25yr	2833.00	14.05	26.92		27.15	0.000859	3.83	739.60	108.95	0.26
C118-00-00	1508.93	2PCT_50yr	3350.00	14.05	27.81		28.06	0.000855	3.99	840.35	116.11	0.26
C118-00-00	1508.93	1PCT_100yr	3942.00	14.05	28.74		29.00	0.000851	4.15	950.78	123.48	0.26
C118-00-00	1508.93	0.2PCT_500yr	5627.00	14.05	30.96		31.28	0.000844	4.52	1245.61	141.30	0.27
C118-00-00	2080.80	50PCT_2yr	1193.00	14.60	23.60		23.76	0.000912	3.15	378.19	78.01	0.25
C118-00-00	2080.80	25PCT_5yr	1759.00	14.60	25.16		25.35	0.000896	3.45	509.43	90.47	0.26
C118-00-00	2080.80	10PCT_10yr	2201.00	14.60	26.17		26.38	0.000887	3.64	604.93	98.55	0.26
C118-00-00	2080.80	4PCT_25yr	2833.00	14.60	27.41		27.64	0.000879	3.86	733.38	108.48	0.26
C118-00-00	2080.80	2PCT_50yr	3350.00	14.60	28.31		28.56	0.000874	4.02	833.36	115.61	0.26
C118-00-00	2080.80	1PCT_100yr	3942.00	14.60	29.22		29.50	0.000870	4.18	943.07	122.97	0.27
C118-00-00	2080.80	0.2PCT_500yr	5627.00	14.60	31.45		31.77	0.000862	4.55	1236.05	140.74	0.27
C118-00-00	2774.54	50PCT_2yr	1144.00	15.30	24.23		24.38	0.000873	3.07	372.68	77.45	0.25
C118-00-00	2774.54	25PCT_5yr	1679.00	15.30	25.78		25.95	0.000848	3.34	502.11	89.83	0.25
C118-00-00	2774.54	10PCT_10yr	2094.00	15.30	26.78		26.98	0.000833	3.51	596.45	97.87	0.25
C118-00-00	2774.54	4PCT_25yr	2690.00	15.30	28.02		28.24	0.000821	3.72	723.65	107.77	0.25
C118-00-00	2774.54	2PCT_50yr	3176.00	15.30	28.91		29.14	0.000813	3.86	822.78	114.89	0.25
C118-00-00	2774.54	1PCT_100yr	3735.00	15.30	29.83		30.08	0.000807	4.01	931.70	122.24	0.26
C118-00-00	2774.54	0.2PCT_500yr	5321.00	15.30	32.05		32.35	0.000793	4.35	1222.91	140.01	0.26
C118-00-00	2894.54	50PCT_2yr	1144.00	17.36	24.25		24.63	0.003128	4.95	231.02	61.09	0.45
C118-00-00	2894.54	25PCT_5yr	1679.00	17.36	25.79		26.18	0.002502	5.02	334.79	73.43	0.41
C118-00-00	2894.54	10PCT_10yr	2094.00	17.36	26.79		27.19	0.002231	5.08	412.40	81.45	0.40
C118-00-00	2894.54	4PCT_25yr	2690.00	17.36	28.03		28.44	0.001994	5.18	518.97	91.32	0.38
C118-00-00	2894.54	2PCT_50yr	3176.00	17.36	28.91		29.34	0.001860	5.27	603.21	98.42	0.37
C118-00-00	2894.54	1PCT_100yr	3735.00	17.36	29.83		30.28	0.001751	5.36	696.75	105.75	0.37
C118-00-00	2894.54	0.2PCT_500yr	5321.00	17.36	32.05		32.53	0.001552	5.60	950.70	123.47	0.36
C118-00-00	3809.70	50PCT_2yr	1076.00	17.91	26.14		26.31	0.001159	3.36	320.03	71.81	0.28
C118-00-00	3809.70	25PCT_5yr	1565.00	17.91	27.50		27.71	0.001146	3.68	425.53	82.73	0.29
C118-00-00	3809.70	10PCT_10yr	1944.00	17.91	28.41		28.64	0.001128	3.86	503.68	89.97	0.29
C118-00-00	3809.70	4PCT_25yr	2488.00	17.91	29.54		29.80	0.001102	4.07	611.26	99.08	0.29
C118-00-00	3809.70	2PCT_50yr	2934.00	17.91	30.37		30.65	0.001083	4.21	696.16	105.71	0.29
C118-00-00	3809.70	1PCT_100yr	3445.00	17.91	31.24		31.53	0.001064	4.36	790.65	112.64	0.29
C118-00-00	3809.70	0.2PCT_500yr	4895.00	17.91	33.35		33.69	0.001016	4.68	1046.74	129.56	0.29
C118-00-00	4005.66	50PCT_2yr	1076.00	18.03	26.36		26.53	0.001086	3.28	327.89	72.68	0.27
C118-00-00	4005.66	25PCT_5yr	1565.00	18.03	27.73		27.93	0.001084	3.60	434.47	83.59	0.28
C118-00-00	4005.66	10PCT_10yr	1944.00	18.03	28.63		28.85	0.001073	3.79	513.13	90.81	0.28
C118-00-00	4005.66	4PCT_25yr	2488.00	18.03	29.76		30.01	0.001056	4.01	621.21	99.88	0.28
C118-00-00	4005.66	2PCT_50yr	2934.00	18.03	30.59		30.86	0.001042	4.15	706.40	106.48	0.28
C118-00-00	4005.66	1PCT_100yr	3445.00	18.03	31.45		31.74	0.001027	4.30	801.14	113.38	0.29
C118-00-00	4005.66	0.2PCT_500yr	4895.00	18.03	33.56		33.89	0.000988	4.63	1057.59	130.22	0.29
C118-00-00	4054.40		Bridge									
C118-00-00	4110.80	50PCT_2yr	1076.00	18.09	26.48		22.78	0.001050	3.24	332.13	73.15	0.27
C118-00-00	4110.80	25PCT_5yr	1565.00	18.09	27.85		23.64	0.001052	3.56	439.38	84.06	0.27
C118-00-00	4110.80	10PCT_10yr	1944.00	18.09	28.75		24.20	0.001045	3.75	518.37	91.27	0.28
C118-00-00	4110.80	4PCT_25yr	2488.00	18.09	29.88		24.90	0.001031	3.97	626.80	100.33	0.28
C118-00-00	4110.80	2PCT_50yr	2934.00	18.09	30.70		25.40	0.001019	4.12	712.22	106.92	0.28
C118-00-00	4110.80	1PCT_100yr	3445.00	18.09	31.56		25.93	0.001007	4.27	807.16	113.80	0.28
C118-00-00	4110.80	0.2PCT_500yr	4895.00	18.09	33.67		27.22	0.000973	4.60	1063.98	130.62	0.28
C118-00-00	4319.51	50PCT_2yr	977.00	18.22	26.71		26.84	0.000816	2.88	339.59	73.96	0.24
C118-00-00	4319.51	25PCT_5yr	1403.00	18.22	28.09		28.24	0.000799	3.13	448.81	84.96	0.24
C118-00-00	4319.51	10PCT_10yr	1731.00	18.22	28.99		29.16	0.000784	3.27	529.08	92.21	0.24
C118-00-00	4319.51	4PCT_25yr	2203.00	18.22	30.13		30.32	0.000767	3.45	639.15	101.31	0.24
C118-00-00	4319.51	2PCT_50yr	2591.00	18.22	30.96		31.16	0.000756	3.57	725.76	107.93	0.24
C118-00-00	4319.51	1PCT_100yr	3037.00	18.22	31.82		32.04	0.000745	3.69	821.96	114.84	0.24
C118-00-00	4319.51	0.2PCT_500yr	4296.00	18.22	33.93		34.18	0.000716	3.97	1081.98	131.72	0.24
C118-00-00	4993.80	50PCT_2yr	977.00	18.62	27.25		27.37	0.000754	2.79	349.75	75.05	0.23
C118-00-00	4993.80	25PCT_5yr	1403.00	18.62	28.62		28.76	0.000749	3.05	459.85	85.99	0.23
C118-00-00	4993.80	10PCT_10yr	1731.00	18.62	29.52		29.68	0.000741	3.20	540.31	93.17	0.23
C118-00-00	4993.80	4PCT_25yr	2203.00	18.62	30.64		30.82	0.000732	3.39	650.52	102.20	0.24
C118-00-00	4993.80	2PCT_50yr	2591.00	18.62	31.47		31.66	0.000725	3.51	737.19	108.77	0.24

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	4993.80	1PCT_100yr	3037.00	18.62	32.32		32.53	0.000718	3.64	833.39	115.63	0.24
C118-00-00	4993.80	0.2PCT_500yr	4296.00	18.62	34.42		34.66	0.000698	3.93	1092.73	132.36	0.24
C118-00-00	5520.06	50PCT_2yr	977.00	18.94	27.64		27.76	0.000723	2.75	355.22	75.63	0.22
C118-00-00	5520.06	25PCT_5yr	1403.00	18.94	29.01		29.15	0.000723	3.01	466.01	86.56	0.23
C118-00-00	5520.06	10PCT_10yr	1731.00	18.94	29.90		30.06	0.000719	3.17	546.70	93.72	0.23
C118-00-00	5520.06	4PCT_25yr	2203.00	18.94	31.03		31.20	0.000712	3.35	657.10	102.72	0.23
C118-00-00	5520.06	2PCT_50yr	2591.00	18.94	31.85		32.04	0.000708	3.48	743.85	109.26	0.24
C118-00-00	5520.06	1PCT_100yr	3037.00	18.94	32.70		32.90	0.000703	3.62	840.10	116.10	0.24
C118-00-00	5520.06	0.2PCT_500yr	4296.00	18.94	34.78		35.02	0.000687	3.91	1099.09	132.75	0.24
C118-00-00	5840.19	50PCT_2yr	977.00	19.13	27.87		27.99	0.000707	2.73	358.25	75.94	0.22
C118-00-00	5840.19	25PCT_5yr	1403.00	19.13	29.24		29.38	0.000709	2.99	469.49	86.87	0.23
C118-00-00	5840.19	10PCT_10yr	1731.00	19.13	30.13		30.29	0.000706	3.15	550.35	94.02	0.23
C118-00-00	5840.19	4PCT_25yr	2203.00	19.13	31.26		31.43	0.000701	3.33	660.91	103.00	0.23
C118-00-00	5840.19	2PCT_50yr	2591.00	19.13	32.07		32.26	0.000698	3.47	747.74	109.53	0.23
C118-00-00	5840.19	1PCT_100yr	3037.00	19.13	32.93		33.13	0.000694	3.60	844.05	116.35	0.24
C118-00-00	5840.19	0.2PCT_500yr	4296.00	19.13	35.00		35.24	0.000681	3.90	1102.89	132.96	0.24
C118-00-00	5925.11		Bridge									
C118-00-00	6011.34	50PCT_2yr	977.00	19.23	28.00		23.72	0.000698	2.71	359.95	76.12	0.22
C118-00-00	6011.34	25PCT_5yr	1403.00	19.23	29.36		24.51	0.000701	2.98	471.48	87.06	0.23
C118-00-00	6011.34	10PCT_10yr	1731.00	19.23	30.26		25.03	0.000699	3.13	552.47	94.21	0.23
C118-00-00	6011.34	4PCT_25yr	2203.00	19.23	31.38		25.69	0.000695	3.32	663.18	103.18	0.23
C118-00-00	6011.34	2PCT_50yr	2591.00	19.23	32.19		26.16	0.000692	3.45	750.10	109.71	0.23
C118-00-00	6011.34	1PCT_100yr	3037.00	19.23	33.05		26.66	0.000689	3.59	846.49	116.53	0.23
C118-00-00	6011.34	0.2PCT_500yr	4296.00	19.23	35.12		27.87	0.000677	3.89	1105.40	133.12	0.24
C118-00-00	6118.08	50PCT_2yr	901.00	19.29	28.08		28.18	0.000585	2.49	362.08	76.34	0.20
C118-00-00	6118.08	25PCT_5yr	1281.00	19.29	29.46		29.57	0.000574	2.70	474.45	87.33	0.20
C118-00-00	6118.08	10PCT_10yr	1571.00	19.29	30.36		30.48	0.000566	2.83	556.06	94.51	0.21
C118-00-00	6118.08	4PCT_25yr	1991.00	19.29	31.48		31.62	0.000558	2.98	667.57	103.52	0.21
C118-00-00	6118.08	2PCT_50yr	2336.00	19.29	32.30		32.45	0.000553	3.09	755.17	110.08	0.21
C118-00-00	6118.08	1PCT_100yr	2734.00	19.29	33.16		33.32	0.000548	3.21	852.26	116.92	0.21
C118-00-00	6118.08	0.2PCT_500yr	3854.00	19.29	35.24		35.42	0.000535	3.46	1113.01	133.57	0.21
C118-00-00	6927.41	50PCT_2yr	901.00	19.78	28.56		24.11	0.000589	2.50	360.95	76.23	0.20
C118-00-00	6927.41	25PCT_5yr	1281.00	19.78	29.92		24.85	0.000581	2.71	472.48	87.15	0.21
C118-00-00	6927.41	10PCT_10yr	1571.00	19.78	30.81		25.34	0.000573	2.84	553.29	94.28	0.21
C118-00-00	6927.41	4PCT_25yr	1991.00	19.78	31.93		25.96	0.000566	3.00	663.90	103.24	0.21
C118-00-00	6927.41	2PCT_50yr	2336.00	19.78	32.75		26.41	0.000561	3.11	750.82	109.77	0.21
C118-00-00	6927.41	1PCT_100yr	2734.00	19.78	33.60		26.88	0.000557	3.23	847.22	116.58	0.21
C118-00-00	6927.41	0.2PCT_500yr	3854.00	19.78	35.67		28.03	0.000544	3.49	1105.78	133.15	0.21
C118-00-00	7593.43	50PCT_2yr	901.00	20.18	28.95		24.51	0.000592	2.50	360.37	76.17	0.20
C118-00-00	7593.43	25PCT_5yr	1281.00	20.18	30.31		25.25	0.000584	2.72	471.36	87.05	0.21
C118-00-00	7593.43	10PCT_10yr	1571.00	20.18	31.20		25.74	0.000578	2.85	551.61	94.13	0.21
C118-00-00	7593.43	4PCT_25yr	1991.00	20.18	32.31		26.36	0.000571	3.01	661.57	103.06	0.21
C118-00-00	7593.43	2PCT_50yr	2336.00	20.18	33.13		26.81	0.000567	3.12	747.99	109.56	0.21
C118-00-00	7593.43	1PCT_100yr	2734.00	20.18	33.97		27.28	0.000563	3.24	843.88	116.35	0.21
C118-00-00	7593.43	0.2PCT_500yr	3854.00	20.18	36.04		28.42	0.000550	3.50	1112.18	173.24	0.21
C118-00-00	8014.81	50PCT_2yr	825.00	20.43	29.20		24.58	0.000497	2.29	360.14	76.15	0.19
C118-00-00	8014.81	25PCT_5yr	1158.00	20.43	30.56		25.28	0.000478	2.46	471.13	87.04	0.19
C118-00-00	8014.81	10PCT_10yr	1411.00	20.43	31.44		25.73	0.000467	2.56	551.35	94.12	0.19
C118-00-00	8014.81	4PCT_25yr	1780.00	20.43	32.56		26.31	0.000457	2.69	661.40	114.67	0.19
C118-00-00	8014.81	2PCT_50yr	2083.00	20.43	33.37		26.73	0.000451	2.79	747.91	131.35	0.19
C118-00-00	8014.81	1PCT_100yr	2434.00	20.43	34.22		27.18	0.000446	2.88	844.10	150.75	0.19
C118-00-00	8014.81	0.2PCT_500yr	3418.00	20.43	36.29		28.26	0.000426	3.08	1164.94	245.48	0.19
C118-00-00	8554.65	50PCT_2yr	825.00	20.75	29.47		24.90	0.000511	2.32	356.37	75.75	0.19
C118-00-00	8554.65	25PCT_5yr	1158.00	20.75	30.82		25.60	0.000493	2.49	465.90	86.55	0.19
C118-00-00	8554.65	10PCT_10yr	1411.00	20.75	31.70		26.05	0.000481	2.59	545.10	93.58	0.19
C118-00-00	8554.65	4PCT_25yr	1780.00	20.75	32.81		26.62	0.000471	2.72	653.98	102.47	0.19
C118-00-00	8554.65	2PCT_50yr	2083.00	20.75	33.62		27.05	0.000465	2.82	739.63	108.95	0.19
C118-00-00	8554.65	1PCT_100yr	2434.00	20.75	34.47		27.50	0.000459	2.92	834.82	115.73	0.19
C118-00-00	8554.65	0.2PCT_500yr	3418.00	20.75	36.52		28.58	0.000445	3.14	1089.61	162.58	0.19
C118-00-00	8956.95	50PCT_2yr	825.00	20.99	29.68		25.14	0.000521	2.33	353.88	75.49	0.19
C118-00-00	8956.95	25PCT_5yr	1158.00	20.99	31.02		25.84	0.000503	2.50	462.44	86.23	0.19
C118-00-00	8956.95	10PCT_10yr	1411.00	20.99	31.89		26.29	0.000491	2.61	540.91	93.23	0.19
C118-00-00	8956.95	4PCT_25yr	1780.00	20.99	33.00		26.87	0.000481	2.74	648.98	102.08	0.19
C118-00-00	8956.95	2PCT_50yr	2083.00	20.99	33.81		27.29	0.000474	2.84	734.01	108.54	0.19
C118-00-00	8956.95	1PCT_100yr	2434.00	20.99	34.65		27.74	0.000469	2.94	828.60	115.31	0.19
C118-00-00	8956.95	0.2PCT_500yr	3418.00	20.99	36.70		28.81	0.000453	3.16	1091.35	266.77	0.19
C118-00-00	9160.19	50PCT_2yr	825.00	21.11	29.78		25.26	0.000525	2.34	352.78	75.37	0.19
C118-00-00	9160.19	25PCT_5yr	1158.00	21.11	31.12		25.95	0.000507	2.51	460.84	86.08	0.19

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	9160.19	10PCT_10yr	1411.00	21.11	31.99	26.41	32.10	0.000496	2.62	538.96	93.06	0.19
C118-00-00	9160.19	4PCT_25yr	1780.00	21.11	33.10	26.99	33.21	0.000486	2.75	646.61	101.89	0.19
C118-00-00	9160.19	2PCT_50yr	2083.00	21.11	33.90	27.41	34.03	0.000479	2.85	731.34	108.34	0.19
C118-00-00	9160.19	1PCT_100yr	2434.00	21.11	34.75	27.86	34.88	0.000473	2.95	825.62	115.09	0.19
C118-00-00	9160.19	0.2PCT_500yr	3418.00	21.11	36.79	28.94	36.95	0.000456	3.17	1113.87	284.14	0.19
C118-00-00	9248.35	50PCT_2yr	825.00	21.16	29.83		29.91	0.000526	2.34	352.50	75.34	0.19
C118-00-00	9248.35	25PCT_5yr	1158.00	21.16	31.16		31.26	0.000509	2.52	460.39	86.04	0.19
C118-00-00	9248.35	10PCT_10yr	1411.00	21.16	32.04		32.14	0.000497	2.62	538.38	93.01	0.19
C118-00-00	9248.35	4PCT_25yr	1780.00	21.16	33.14		33.26	0.000487	2.76	645.88	101.83	0.19
C118-00-00	9248.35	2PCT_50yr	2083.00	21.16	33.94		34.07	0.000480	2.85	730.50	108.28	0.19
C118-00-00	9248.35	1PCT_100yr	2434.00	21.16	34.79		34.92	0.000474	2.95	824.67	115.02	0.19
C118-00-00	9248.35	0.2PCT_500yr	3418.00	21.16	36.83		36.99	0.000457	3.17	1116.43	234.84	0.19
C118-00-00	9292.44	Bridge										
C118-00-00	9343.84	50PCT_2yr	825.00	21.22	29.88	25.37	29.96	0.000529	2.35	351.78	75.26	0.19
C118-00-00	9343.84	25PCT_5yr	1158.00	21.22	31.21	26.05	31.31	0.000512	2.52	459.39	85.94	0.19
C118-00-00	9343.84	10PCT_10yr	1411.00	21.22	32.08	26.50	32.19	0.000500	2.63	537.20	92.90	0.19
C118-00-00	9343.84	4PCT_25yr	1780.00	21.22	33.19	27.09	33.30	0.000490	2.76	644.48	101.72	0.19
C118-00-00	9343.84	2PCT_50yr	2083.00	21.22	33.99	27.52	34.12	0.000483	2.86	728.93	108.16	0.19
C118-00-00	9343.84	1PCT_100yr	2434.00	21.22	34.83	27.97	34.97	0.000477	2.96	822.93	114.90	0.19
C118-00-00	9343.84	0.2PCT_500yr	3418.00	21.22	36.88	29.04	37.03	0.000456	3.16	1156.80	295.27	0.19
C118-00-00	9420.02	50PCT_2yr	777.00	21.27	29.93		30.00	0.000470	2.21	351.70	75.25	0.18
C118-00-00	9420.02	25PCT_5yr	1082.00	21.27	31.26		31.35	0.000446	2.36	459.44	85.95	0.18
C118-00-00	9420.02	10PCT_10yr	1313.00	21.27	32.13		32.23	0.000433	2.44	537.35	92.92	0.18
C118-00-00	9420.02	4PCT_25yr	1650.00	21.27	33.24		33.34	0.000420	2.56	644.82	101.75	0.18
C118-00-00	9420.02	2PCT_50yr	1928.00	21.27	34.04		34.15	0.000413	2.64	729.42	108.20	0.18
C118-00-00	9420.02	1PCT_100yr	2250.00	21.27	34.89		35.00	0.000407	2.73	823.61	114.95	0.18
C118-00-00	9420.02	0.2PCT_500yr	3151.00	21.27	36.94		37.07	0.000390	2.92	1116.33	268.03	0.18
C118-00-00	9838.22	50PCT_2yr	777.00	21.52	30.12		30.20	0.000484	2.23	347.81	74.84	0.18
C118-00-00	9838.22	25PCT_5yr	1082.00	21.52	31.45		31.54	0.000461	2.38	454.15	85.45	0.18
C118-00-00	9838.22	10PCT_10yr	1313.00	21.52	32.32		32.41	0.000447	2.47	531.08	92.38	0.18
C118-00-00	9838.22	4PCT_25yr	1650.00	21.52	33.42		33.52	0.000433	2.59	637.40	101.16	0.18
C118-00-00	9838.22	2PCT_50yr	1928.00	21.52	34.22		34.33	0.000426	2.67	721.18	107.59	0.18
C118-00-00	9838.22	1PCT_100yr	2250.00	21.52	35.06		35.18	0.000419	2.76	814.53	114.32	0.18
C118-00-00	9838.22	0.2PCT_500yr	3151.00	21.52	37.10		37.23	0.000403	2.96	1064.25	130.63	0.18
C118-00-00	10361.38	50PCT_2yr	777.00	21.83	30.38		30.46	0.000499	2.26	343.79	74.41	0.19
C118-00-00	10361.38	25PCT_5yr	1082.00	21.83	31.70		31.79	0.000476	2.41	448.50	84.93	0.19
C118-00-00	10361.38	10PCT_10yr	1313.00	21.83	32.55		32.65	0.000462	2.50	524.30	91.79	0.18
C118-00-00	10361.38	4PCT_25yr	1650.00	21.83	33.64		33.75	0.000449	2.62	629.24	100.52	0.18
C118-00-00	10361.38	2PCT_50yr	1928.00	21.83	34.44		34.56	0.000440	2.71	712.05	106.91	0.18
C118-00-00	10361.38	1PCT_100yr	2250.00	21.83	35.28		35.40	0.000433	2.80	804.42	113.61	0.19
C118-00-00	10361.38	0.2PCT_500yr	3151.00	21.83	37.31		37.45	0.000413	2.98	1112.92	298.81	0.18
C118-00-00	10439.77	50PCT_2yr	777.00	21.88	30.42		30.50	0.000502	2.27	342.96	74.32	0.19
C118-00-00	10439.77	25PCT_5yr	1082.00	21.88	31.73		31.82	0.000479	2.42	447.39	84.82	0.19
C118-00-00	10439.77	10PCT_10yr	1313.00	21.88	32.59		32.69	0.000465	2.51	522.99	91.67	0.19
C118-00-00	10439.77	4PCT_25yr	1650.00	21.88	33.68		33.79	0.000452	2.63	627.70	100.40	0.19
C118-00-00	10439.77	2PCT_50yr	1928.00	21.88	34.48		34.59	0.000443	2.71	710.34	106.78	0.19
C118-00-00	10439.77	1PCT_100yr	2250.00	21.88	35.31		35.44	0.000436	2.80	802.52	113.47	0.19
C118-00-00	10439.77	0.2PCT_500yr	3151.00	21.88	37.34		37.48	0.000411	2.98	1154.44	339.27	0.18
C118-00-00	10485.91	Bridge										
C118-00-00	10526.48	50PCT_2yr	777.00	21.93	30.46	25.97	30.54	0.000504	2.27	342.51	74.27	0.19
C118-00-00	10526.48	25PCT_5yr	1082.00	21.93	31.77	26.63	31.87	0.000481	2.42	446.68	84.75	0.19
C118-00-00	10526.48	10PCT_10yr	1313.00	21.93	32.63	27.06	32.73	0.000467	2.51	522.12	91.60	0.19
C118-00-00	10526.48	4PCT_25yr	1650.00	21.93	33.72	27.61	33.83	0.000454	2.63	626.62	100.31	0.19
C118-00-00	10526.48	2PCT_50yr	1928.00	21.93	34.52	28.01	34.63	0.000445	2.72	709.11	106.69	0.19
C118-00-00	10526.48	1PCT_100yr	2250.00	21.93	35.35	28.44	35.47	0.000438	2.81	801.15	113.38	0.19
C118-00-00	10526.48	0.2PCT_500yr	3151.00	21.93	37.42	29.48	37.56	0.000408	2.97	1150.52	316.25	0.18
C118-00-00	10607.88	50PCT_2yr	732.00	21.98	30.51		30.58	0.000448	2.14	342.47	74.28	0.18
C118-00-00	10607.88	25PCT_5yr	1012.00	21.98	31.82		31.90	0.000421	2.27	446.71	84.76	0.17
C118-00-00	10607.88	10PCT_10yr	1223.00	21.98	32.68		32.76	0.000405	2.34	522.21	91.61	0.17
C118-00-00	10607.88	4PCT_25yr	1532.00	21.98	33.77		33.86	0.000391	2.44	626.82	100.34	0.17
C118-00-00	10607.88	2PCT_50yr	1787.00	21.98	34.57		34.67	0.000382	2.52	709.41	106.72	0.17
C118-00-00	10607.88	1PCT_100yr	2083.00	21.98	35.40		35.51	0.000375	2.60	801.58	113.42	0.17
C118-00-00	10607.88	0.2PCT_500yr	2910.00	21.98	37.48		37.59	0.000346	2.74	1158.09	294.45	0.17
C118-00-00	11166.57	50PCT_2yr	732.00	22.32	30.77	26.25	30.84	0.000471	2.18	336.05	73.57	0.18
C118-00-00	11166.57	25PCT_5yr	1012.00	22.32	32.06	26.88	32.15	0.000444	2.31	438.06	83.93	0.18
C118-00-00	11166.57	10PCT_10yr	1223.00	22.32	32.91	27.29	33.00	0.000427	2.39	512.01	90.70	0.18
C118-00-00	11166.57	4PCT_25yr	1532.00	22.32	33.99	27.82	34.09	0.000411	2.49	614.77	99.35	0.18
C118-00-00	11166.57	2PCT_50yr	1787.00	22.32	34.78	28.21	34.89	0.000402	2.57	696.04	105.69	0.18

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	11166.57	1PCT_100yr	2083.00	22.32	35.62	28.62	35.73	0.000394	2.65	786.84	112.36	0.18
C118-00-00	11166.57	0.2PCT_500yr	2910.00	22.32	37.67	29.62	37.79	0.000370	2.81	1049.51	191.29	0.17
C118-00-00	11687.74	50PCT_2yr	732.00	22.63	31.02	26.56	31.09	0.000488	2.21	331.57	73.08	0.18
C118-00-00	11687.74	25PCT_5yr	1012.00	22.63	32.30	27.19	32.38	0.000461	2.34	431.76	83.33	0.18
C118-00-00	11687.74	10PCT_10yr	1223.00	22.63	33.13	27.60	33.23	0.000445	2.42	504.42	90.04	0.18
C118-00-00	11687.74	4PCT_25yr	1532.00	22.63	34.21	28.12	34.31	0.000428	2.53	605.62	98.62	0.18
C118-00-00	11687.74	2PCT_50yr	1787.00	22.63	34.99	28.53	35.10	0.000418	2.61	685.76	104.92	0.18
C118-00-00	11687.74	1PCT_100yr	2083.00	22.63	35.82	28.93	35.94	0.000410	2.69	775.42	111.55	0.18
C118-00-00	11687.74	0.2PCT_500yr	2910.00	22.63	37.87	29.93	37.99	0.000367	2.79	1214.32	466.63	0.17
C118-00-00	11824.75	50PCT_2yr	600.00	22.71	31.10	26.30	31.15	0.000327	1.81	331.77	73.10	0.15
C118-00-00	11824.75	25PCT_5yr	830.00	22.71	32.38	26.87	32.44	0.000310	1.92	432.01	83.36	0.15
C118-00-00	11824.75	10PCT_10yr	1003.00	22.71	33.22	27.25	33.28	0.000299	1.99	504.72	90.06	0.15
C118-00-00	11824.75	4PCT_25yr	1257.00	22.71	34.29	27.74	34.36	0.000288	2.07	606.05	98.65	0.15
C118-00-00	11824.75	2PCT_50yr	1466.00	22.71	35.08	28.10	35.15	0.000281	2.14	686.33	104.96	0.15
C118-00-00	11824.75	1PCT_100yr	1709.00	22.71	35.91	28.48	35.99	0.000275	2.20	776.17	111.60	0.15
C118-00-00	11824.75	0.2PCT_500yr	2387.00	22.71	37.95	29.40	38.03	0.000250	2.30	1200.65	541.01	0.14
C118-00-00	11904.58		Bridge									
C118-00-00	11984.79	50PCT_2yr	600.00	22.81	31.15	26.39	31.20	0.000337	1.83	328.35	72.74	0.15
C118-00-00	11984.79	25PCT_5yr	830.00	22.81	32.43	26.98	32.49	0.000318	1.94	427.87	82.96	0.15
C118-00-00	11984.79	10PCT_10yr	1003.00	22.81	33.27	27.35	33.33	0.000306	2.01	500.09	89.66	0.15
C118-00-00	11984.79	4PCT_25yr	1257.00	22.81	34.34	27.84	34.41	0.000295	2.09	600.81	98.24	0.15
C118-00-00	11984.79	2PCT_50yr	1466.00	22.81	35.13	28.20	35.20	0.000287	2.15	680.64	104.54	0.15
C118-00-00	11984.79	1PCT_100yr	1709.00	22.81	35.95	28.58	36.03	0.000281	2.22	770.02	111.17	0.15
C118-00-00	11984.79	0.2PCT_500yr	2387.00	22.81	37.99	29.50	38.07	0.000254	2.33	1148.10	416.44	0.14
C118-00-00	12107.03	50PCT_2yr	600.00	22.88	31.19		31.24	0.000342	1.84	326.25	72.50	0.15
C118-00-00	12107.03	25PCT_5yr	830.00	22.88	32.47		32.53	0.000323	1.95	425.28	82.71	0.15
C118-00-00	12107.03	10PCT_10yr	1003.00	22.88	33.30		33.37	0.000311	2.02	497.16	89.40	0.15
C118-00-00	12107.03	4PCT_25yr	1257.00	22.88	34.37		34.44	0.000299	2.10	597.44	97.96	0.15
C118-00-00	12107.03	2PCT_50yr	1466.00	22.88	35.16		35.23	0.000291	2.17	676.96	104.25	0.15
C118-00-00	12107.03	1PCT_100yr	1709.00	22.88	35.99		36.07	0.000285	2.23	766.02	110.88	0.15
C118-00-00	12107.03	0.2PCT_500yr	2387.00	22.88	38.02		38.11	0.000265	2.36	1062.82	284.40	0.15
C118-00-00	12547.66	50PCT_2yr	600.00	23.14	31.35		31.40	0.000365	1.88	318.54	71.64	0.16
C118-00-00	12547.66	25PCT_5yr	830.00	23.14	32.61		32.67	0.000343	2.00	415.71	81.77	0.16
C118-00-00	12547.66	10PCT_10yr	1003.00	23.14	33.44		33.51	0.000330	2.06	486.30	88.41	0.15
C118-00-00	12547.66	4PCT_25yr	1257.00	23.14	34.51		34.58	0.000316	2.15	584.98	96.93	0.15
C118-00-00	12547.66	2PCT_50yr	1466.00	23.14	35.29		35.37	0.000308	2.21	663.31	103.19	0.15
C118-00-00	12547.66	1PCT_100yr	1709.00	23.14	36.11		36.19	0.000300	2.28	751.14	109.79	0.15
C118-00-00	12547.66	0.2PCT_500yr	2387.00	23.14	38.14		38.23	0.000280	2.41	989.72	125.98	0.15
C118-00-00	12987.90	50PCT_2yr	600.00	23.40	31.51		31.57	0.000387	1.92	311.69	70.87	0.16
C118-00-00	12987.90	25PCT_5yr	830.00	23.40	32.77		32.83	0.000363	2.04	407.07	80.93	0.16
C118-00-00	12987.90	10PCT_10yr	1003.00	23.40	33.59		33.66	0.000348	2.11	476.41	87.51	0.16
C118-00-00	12987.90	4PCT_25yr	1257.00	23.40	34.65		34.72	0.000333	2.19	573.54	95.98	0.16
C118-00-00	12987.90	2PCT_50yr	1466.00	23.40	35.43		35.51	0.000324	2.25	650.72	102.21	0.16
C118-00-00	12987.90	1PCT_100yr	1709.00	23.40	36.25		36.33	0.000315	2.32	737.35	108.78	0.16
C118-00-00	12987.90	0.2PCT_500yr	2387.00	23.40	38.26		38.36	0.000291	2.45	1003.75	243.78	0.15
C118-00-00	13118.48	50PCT_2yr	600.00	23.48	31.56		31.62	0.000394	1.94	309.58	70.63	0.16
C118-00-00	13118.48	25PCT_5yr	830.00	23.48	32.81		32.88	0.000369	2.05	404.40	80.66	0.16
C118-00-00	13118.48	10PCT_10yr	1003.00	23.48	33.63		33.70	0.000354	2.12	473.34	87.23	0.16
C118-00-00	13118.48	4PCT_25yr	1257.00	23.48	34.69		34.77	0.000339	2.21	569.98	95.68	0.16
C118-00-00	13118.48	2PCT_50yr	1466.00	23.48	35.47		35.55	0.000329	2.27	646.79	101.90	0.16
C118-00-00	13118.48	1PCT_100yr	1709.00	23.48	36.29		36.37	0.000320	2.33	733.04	108.46	0.16
C118-00-00	13118.48	0.2PCT_500yr	2387.00	23.48	38.30		38.39	0.000290	2.45	1036.34	405.26	0.15
C118-00-00	13164.82		Bridge									
C118-00-00	13204.23	50PCT_2yr	600.00	23.53	31.59		31.65	0.000398	1.95	308.46	70.51	0.16
C118-00-00	13204.23	25PCT_5yr	830.00	23.53	32.84		32.91	0.000373	2.06	402.94	80.52	0.16
C118-00-00	13204.23	10PCT_10yr	1003.00	23.53	33.66		33.73	0.000358	2.13	471.66	87.08	0.16
C118-00-00	13204.23	4PCT_25yr	1257.00	23.53	34.72		34.80	0.000342	2.21	568.00	95.52	0.16
C118-00-00	13204.23	2PCT_50yr	1466.00	23.53	35.50		35.58	0.000332	2.27	644.60	101.73	0.16
C118-00-00	13204.23	1PCT_100yr	1709.00	23.53	36.32		36.40	0.000323	2.34	730.63	108.29	0.16
C118-00-00	13204.23	0.2PCT_500yr	2387.00	23.53	38.40		38.48	0.000249	2.34	1469.94	864.71	0.14
C118-00-00	13276.30	50PCT_2yr	556.00	23.57	31.63		31.68	0.000342	1.80	308.18	70.48	0.15
C118-00-00	13276.30	25PCT_5yr	769.00	23.57	32.88		32.94	0.000321	1.91	402.59	80.49	0.15
C118-00-00	13276.30	10PCT_10yr	929.00	23.57	33.70		33.76	0.000308	1.97	471.25	87.04	0.15
C118-00-00	13276.30	4PCT_25yr	1165.00	23.57	34.75		34.82	0.000295	2.05	567.54	95.49	0.15
C118-00-00	13276.30	2PCT_50yr	1358.00	23.57	35.53		35.60	0.000286	2.11	644.11	101.70	0.15
C118-00-00	13276.30	1PCT_100yr	1583.00	23.57	36.35		36.42	0.000278	2.17	730.13	108.25	0.15
C118-00-00	13276.30	0.2PCT_500yr	2211.00	23.57	38.42		38.50	0.000249	2.27	1021.19	320.38	0.14

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	13516.75	50PCT_2yr	556.00	23.71	31.71	27.17	31.76	0.000355	1.83	304.12	70.01	0.15
C118-00-00	13516.75	25PCT_5yr	769.00	23.71	32.96	27.73	33.02	0.000332	1.93	397.51	79.97	0.15
C118-00-00	13516.75	10PCT_10yr	929.00	23.71	33.77	28.10	33.84	0.000318	2.00	465.47	86.50	0.15
C118-00-00	13516.75	4PCT_25yr	1165.00	23.71	34.83	28.57	34.89	0.000304	2.08	560.88	94.92	0.15
C118-00-00	13516.75	2PCT_50yr	1358.00	23.71	35.60	28.92	35.67	0.000294	2.13	636.78	101.11	0.15
C118-00-00	13516.75	1PCT_100yr	1583.00	23.71	36.42	29.29	36.49	0.000286	2.19	722.10	107.65	0.15
C118-00-00	13516.75	0.2PCT_500yr	2211.00	23.71	38.49	30.18	38.56	0.000238	2.20	1280.35	615.50	0.14
C118-00-00	13706.00	50PCT_2yr	556.00	23.82	31.78	27.28	31.83	0.000364	1.85	301.13	69.67	0.16
C118-00-00	13706.00	25PCT_5yr	769.00	23.82	33.02	27.84	33.08	0.000340	1.95	393.75	79.60	0.15
C118-00-00	13706.00	10PCT_10yr	929.00	23.82	33.83	28.20	33.90	0.000326	2.01	461.16	86.10	0.15
C118-00-00	13706.00	4PCT_25yr	1165.00	23.82	34.88	28.68	34.95	0.000311	2.10	555.89	94.50	0.15
C118-00-00	13706.00	2PCT_50yr	1358.00	23.82	35.66	29.03	35.73	0.000301	2.15	631.28	100.68	0.15
C118-00-00	13706.00	1PCT_100yr	1583.00	23.82	36.47	29.40	36.55	0.000292	2.21	716.07	107.20	0.15
C118-00-00	13706.00	0.2PCT_500yr	2211.00	23.82	38.53	30.29	38.61	0.000258	2.31	1028.91	541.84	0.15
C118-00-00	13747.91	Bridge										
C118-00-00	13788.08	50PCT_2yr	556.00	23.87	31.81	27.33	31.86	0.000369	1.85	299.76	69.51	0.16
C118-00-00	13788.08	25PCT_5yr	769.00	23.87	33.05	27.89	33.11	0.000344	1.96	392.01	79.42	0.16
C118-00-00	13788.08	10PCT_10yr	929.00	23.87	33.86	28.26	33.92	0.000330	2.02	459.18	85.92	0.15
C118-00-00	13788.08	4PCT_25yr	1165.00	23.87	34.91	28.73	34.98	0.000315	2.10	553.60	94.31	0.15
C118-00-00	13788.08	2PCT_50yr	1358.00	23.87	35.68	29.08	35.75	0.000305	2.16	628.76	100.48	0.15
C118-00-00	13788.08	1PCT_100yr	1583.00	23.87	36.50	29.44	36.57	0.000296	2.22	713.32	107.00	0.15
C118-00-00	13788.08	0.2PCT_500yr	2211.00	23.87	38.62	30.33	38.69	0.000231	2.23	1342.09	832.10	0.14
C118-00-00	13872.70	50PCT_2yr	432.00	23.92	31.86	26.99	31.89	0.000223	1.44	299.63	69.50	0.12
C118-00-00	13872.70	25PCT_5yr	597.00	23.92	33.10	27.50	33.13	0.000208	1.52	391.97	79.42	0.12
C118-00-00	13872.70	10PCT_10yr	721.00	23.92	33.91	27.83	33.95	0.000199	1.57	459.19	85.93	0.12
C118-00-00	13872.70	4PCT_25yr	904.00	23.92	34.96	28.25	35.00	0.000189	1.63	553.75	94.32	0.12
C118-00-00	13872.70	2PCT_50yr	1054.00	23.92	35.73	28.56	35.78	0.000183	1.68	629.01	100.50	0.12
C118-00-00	13872.70	1PCT_100yr	1229.00	23.92	36.55	28.90	36.59	0.000178	1.72	713.71	107.03	0.12
C118-00-00	13872.70	0.2PCT_500yr	1716.00	23.92	38.66	29.70	38.71	0.000148	1.76	1113.66	739.26	0.11
C118-00-00	14501.31	50PCT_2yr	432.00	24.30	32.00	27.37	32.04	0.000258	1.52	283.73	67.65	0.13
C118-00-00	14501.31	25PCT_5yr	597.00	24.30	33.23	27.88	33.27	0.000237	1.60	372.92	77.48	0.13
C118-00-00	14501.31	10PCT_10yr	721.00	24.30	34.04	28.21	34.08	0.000225	1.65	438.01	83.94	0.13
C118-00-00	14501.31	4PCT_25yr	904.00	24.30	35.08	28.63	35.13	0.000213	1.71	529.86	92.28	0.13
C118-00-00	14501.31	2PCT_50yr	1054.00	24.30	35.85	28.94	35.90	0.000205	1.75	603.11	98.42	0.12
C118-00-00	14501.31	1PCT_100yr	1229.00	24.30	36.66	29.28	36.71	0.000198	1.79	685.70	104.92	0.12
C118-00-00	14501.31	0.2PCT_500yr	1716.00	24.30	38.76	30.08	38.81	0.000161	1.83	1075.63	417.84	0.11
C118-00-00	14885.75	50PCT_2yr	432.00	24.53	32.11	27.60	32.14	0.000280	1.57	275.05	66.61	0.14
C118-00-00	14885.75	25PCT_5yr	597.00	24.53	33.33	28.11	33.37	0.000256	1.65	362.30	76.37	0.13
C118-00-00	14885.75	10PCT_10yr	721.00	24.53	34.13	28.43	34.17	0.000242	1.69	426.08	82.78	0.13
C118-00-00	14885.75	4PCT_25yr	904.00	24.53	35.17	28.86	35.21	0.000228	1.75	516.27	91.08	0.13
C118-00-00	14885.75	2PCT_50yr	1054.00	24.53	35.93	29.17	35.98	0.000219	1.79	588.27	97.20	0.13
C118-00-00	14885.75	1PCT_100yr	1229.00	24.53	36.74	29.51	36.79	0.000211	1.84	669.56	103.67	0.13
C118-00-00	14885.75	0.2PCT_500yr	1716.00	24.53	38.82	30.31	38.88	0.000173	1.88	1031.00	486.57	0.12
C118-00-00	15311.15	50PCT_2yr	432.00	24.79	32.23	27.86	32.27	0.000306	1.62	265.98	65.51	0.14
C118-00-00	15311.15	25PCT_5yr	597.00	24.79	33.44	28.37	33.48	0.000279	1.70	351.06	75.18	0.14
C118-00-00	15311.15	10PCT_10yr	721.00	24.79	34.23	28.70	34.28	0.000263	1.74	413.38	81.54	0.14
C118-00-00	15311.15	4PCT_25yr	904.00	24.79	35.26	29.13	35.32	0.000246	1.80	501.70	89.79	0.13
C118-00-00	15311.15	2PCT_50yr	1054.00	24.79	36.03	29.44	36.08	0.000236	1.84	572.31	95.88	0.13
C118-00-00	15311.15	1PCT_100yr	1229.00	24.79	36.83	29.77	36.89	0.000226	1.88	652.14	102.32	0.13
C118-00-00	15311.15	0.2PCT_500yr	1716.00	24.79	38.90	30.58	38.95	0.000180	1.90	1049.75	710.20	0.12
C118-00-00	15573.56	50PCT_2yr	432.00	24.95	32.31	28.02	32.35	0.000322	1.66	260.88	64.89	0.15
C118-00-00	15573.56	25PCT_5yr	597.00	24.95	33.51	28.52	33.56	0.000293	1.73	344.66	74.51	0.14
C118-00-00	15573.56	10PCT_10yr	721.00	24.95	34.30	28.85	34.35	0.000276	1.78	406.09	80.83	0.14
C118-00-00	15573.56	4PCT_25yr	904.00	24.95	35.33	29.28	35.38	0.000258	1.83	493.27	89.05	0.14
C118-00-00	15573.56	2PCT_50yr	1054.00	24.95	36.09	29.60	36.14	0.000246	1.87	563.04	95.11	0.14
C118-00-00	15573.56	1PCT_100yr	1229.00	24.95	36.89	29.93	36.95	0.000236	1.91	641.99	101.53	0.13
C118-00-00	15573.56	0.2PCT_500yr	1716.00	24.95	38.94	30.73	39.00	0.000201	1.95	964.22	435.08	0.13
C118-00-00	15651.91	Bridge										
C118-00-00	15729.16	50PCT_2yr	432.00	25.04	32.36	28.11	32.40	0.000331	1.67	258.31	64.57	0.15
C118-00-00	15729.16	25PCT_5yr	597.00	25.04	33.56	28.62	33.61	0.000300	1.75	341.35	74.15	0.14
C118-00-00	15729.16	10PCT_10yr	721.00	25.04	34.35	28.95	34.40	0.000283	1.79	402.27	80.45	0.14
C118-00-00	15729.16	4PCT_25yr	904.00	25.04	35.37	29.37	35.42	0.000264	1.85	488.81	88.64	0.14
C118-00-00	15729.16	2PCT_50yr	1054.00	25.04	36.13	29.69	36.18	0.000252	1.89	558.09	94.69	0.14
C118-00-00	15729.16	1PCT_100yr	1229.00	25.04	36.93	30.02	36.99	0.000241	1.93	636.54	101.10	0.14
C118-00-00	15729.16	0.2PCT_500yr	1716.00	25.04	39.00	30.82	39.06	0.000204	1.96	1009.02	589.11	0.13
C118-00-00	15887.18	50PCT_2yr	337.00	25.13	32.42	27.86	32.45	0.000206	1.31	256.39	64.33	0.12
C118-00-00	15887.18	25PCT_5yr	466.00	25.13	33.62	28.32	33.65	0.000186	1.37	338.98	73.89	0.11
C118-00-00	15887.18	10PCT_10yr	563.00	25.13	34.40	28.61	34.43	0.000175	1.41	399.60	80.18	0.11

PROPOSED MODEL

HEC-RAS Plan: Proposed River: C118-00-00 Reach: C118-00-00 (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
C118-00-00	15887.18	4PCT_25yr	706.00	25.13	35.43	29.00	35.46	0.000164	1.45	485.78	88.37	0.11
C118-00-00	15887.18	2PCT_50yr	823.00	25.13	36.18	29.28	36.22	0.000156	1.48	554.80	94.41	0.11
C118-00-00	15887.18	1PCT_100yr	960.00	25.13	36.98	29.58	37.02	0.000149	1.52	632.99	100.82	0.11
C118-00-00	15887.18	0.2PCT_500yr	1340.00	25.13	39.05	30.31	39.09	0.000126	1.54	998.42	686.57	0.10
C118-00-00	16635.91	50PCT_2yr	337.00	25.58	32.59	28.30	32.62	0.000249	1.41	238.45	62.06	0.13
C118-00-00	16635.91	25PCT_5yr	466.00	25.58	33.77	28.77	33.80	0.000223	1.47	317.13	71.48	0.12
C118-00-00	16635.91	10PCT_10yr	563.00	25.58	34.54	29.06	34.58	0.000208	1.50	375.10	77.70	0.12
C118-00-00	16635.91	4PCT_25yr	706.00	25.58	35.56	29.44	35.59	0.000192	1.54	457.88	85.80	0.12
C118-00-00	16635.91	2PCT_50yr	823.00	25.58	36.30	29.73	36.34	0.000182	1.57	524.36	91.79	0.12
C118-00-00	16635.91	1PCT_100yr	960.00	25.58	37.10	30.03	37.14	0.000173	1.60	599.88	98.15	0.11
C118-00-00	16635.91	0.2PCT_500yr	1340.00	25.58	39.15	30.76	39.19	0.000142	1.61	965.77	441.89	0.11
C118-00-00	17621.74	50PCT_2yr	337.00	26.17	32.86	28.90	32.89	0.000313	1.54	219.06	59.51	0.14
C118-00-00	17621.74	25PCT_5yr	466.00	26.17	34.01	29.36	34.04	0.000276	1.59	292.60	68.69	0.14
C118-00-00	17621.74	10PCT_10yr	563.00	26.17	34.77	29.65	34.81	0.000255	1.62	347.11	74.77	0.13
C118-00-00	17621.74	4PCT_25yr	706.00	26.17	35.76	30.04	35.80	0.000233	1.66	425.39	82.72	0.13
C118-00-00	17621.74	2PCT_50yr	823.00	26.17	36.50	30.32	36.54	0.000219	1.68	488.52	88.62	0.13
C118-00-00	17621.74	1PCT_100yr	960.00	26.17	37.28	30.62	37.33	0.000207	1.71	560.53	94.90	0.12
C118-00-00	17621.74	0.2PCT_500yr	1340.00	26.17	39.29	31.34	39.34	0.000164	1.71	920.85	481.33	0.11

APPENDIX C.4

STORM SEWER ALTERNATIVE TABLES

- **2-YEAR**
- **5-YEAR**
- **10-YEAR**
- **25-YEAR**
- **50-YEAR**
- **100-YEAR**
- **500-YEAR**

Storm Sewer - 2-yr

Table: C2
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	337.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	1.17	0.00	0.10	31.48	31.37	39.1	38.9	
Jutland	St Lo	432.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	1.50	0.01	0.14	31.37	31.24	38.9	38.1	
St Lo	Van Fleet	556.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	1.54	0.01	0.04	31.24	31.19	38.1	38.6	
Van Fleet	Martin Luther King	600.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	1.67	0.01	0.09	31.19	31.10	38.6	38.0	

Storm Sewer - 5-yr

Table: C3
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Dnstrm (ft)			
Calhoun	Jutland	466.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	1.62	0.01	0.20	33.10	32.90	39.1	38.9	
Jutland	St Lo	597.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	2.07	0.01	0.26	32.90	32.64	38.9	38.1	
St Lo	Van Fleet	769.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	2.14	0.01	0.08	32.64	32.56	38.1	38.6	
Van Fleet	Martin Luther King	830.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	2.31	0.01	0.18	32.56	32.38	38.6	38.0	

Storm Sewer - 10-yr

Table: C4
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	563.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	1.95	0.01	0.29	34.28	33.99	39.1	38.9	
Jutland	St Lo	721.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	2.50	0.02	0.38	33.99	33.60	38.9	38.1	
St Lo	Van Fleet	929.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	2.58	0.02	0.12	33.60	33.48	38.1	38.6	
Van Fleet	Martin Luther King	1003.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	2.79	0.02	0.26	33.48	33.22	38.6	38.0	

Storm Sewer - 25-yr

Table: CS
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	706.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	2.45	0.02	0.46	35.95	35.49	39.5	38.9	
Jutland	St Lo	904.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	3.14	0.03	0.60	35.49	34.89	38.9	38.1	
St Lo	Van Fleet	1165.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	3.24	0.03	0.19	34.89	34.71	38.1	38.6	
Van Fleet	Martin Luther King	1257.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	3.49	0.03	0.42	34.71	34.29	38.6	38.0	

Storm Sewer - 50-yr

Table: C5
Project: Salt Water Ditch
Project No: 325912
Date: 9/9/2015
Prepared By: DJ
Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	823.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	2.86	0.03	0.62	37.34	36.72	39.1	38.9	
Jutland	St Lo	1054.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	3.66	0.04	0.81	36.72	35.90	38.9	38.1	
St Lo	Van Fleet	1358.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	3.77	0.04	0.26	35.90	35.65	38.1	38.6	
Van Fleet	Martin Luther King	1466.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	4.07	0.04	0.57	35.65	35.08	38.6	38.0	

Storm Sewer - 100-yr

Table: C7
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	960.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	3.33	0.04	0.85	38.99	38.14	39.1	38.9	
Jutland	St Lo	1229.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	4.27	0.06	1.11	38.14	37.04	38.9	38.1	
St Lo	Van Fleet	1583.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	4.40	0.05	0.35	37.04	36.69	38.1	38.6	
Van Fleet	Martin Luther King	1709.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	4.75	0.06	0.77	36.69	35.92	38.6	38.0	

Storm Sewer - 500-yr

Table: C8
 Project: Salt Water Ditch
 Project No: 325912
 Date: 9/9/2015
 Prepared By: DJ
 Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Fall (ft)	Manhole Drop (ft)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road												Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstrm (ft)	Dnstrm (ft)	
Calhoun	Jutland	1340.00	2401	3	12	8	0.05	0.015	1143.65	3.97	1.20	0.00	26.84	25.64	4.65	0.07	1.65	43.94	42.30	39.1	38.9	
Jutland	St Lo	1716.00	1915	3	12	8	0.05	0.015	1143.65	3.97	0.96	0.00	25.64	24.69	5.96	0.11	2.16	42.30	40.14	38.9	38.1	
St Lo	Van Fleet	2211.00	675	3	12	10	0.05	0.015	1556.74	4.32	0.34	0.00	24.69	24.35	6.14	0.10	0.68	40.14	39.46	38.1	38.6	
Van Fleet	Martin Luther King	2387.00	1275	3	12	10	0.05	0.015	1556.74	4.32	0.64	0.00	24.35	23.71	6.63	0.12	1.50	39.46	37.96	38.6	38.0	

APPENDIX C.5

PEAK FLOW IMPACTS

- **10-YEAR AND 50-YEAR IMPACTS**
- **100-YEAR AND 500-YEAR IMPACTS**

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: C9
Project: Salt Water Ditch
Project #: 325912
Date: 11/19/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	10-year Peak Flows (cfs)			50-year Peak Flows (cfs)		
	Revised Existing	Proposed	Impact (Prop.-Rev.)	Revised Existing	Proposed	Impact (Prop.-Rev.)
Outlet	22659	22968	309	38129	38732	603
C100#1	22275	22578	303	37454	38046	592
C100#2	21690	21971	281	36516	37058	542
C100#3	21518	21784	266	36066	36561	495
C100#4	17352	17517	165	28471	28933	462
C100#5	16912	17055	143	27617	28087	471
C100#6	16624	16776	151	27056	27525	469
C100#7	15785	15934	148	25631	26171	540
C100#8	15287	15419	132	24741	25248	507
C118 outfall	1343	2371	1028	2005	3628	1623
C118A	540	1223	683	829	1787	958
C118B	1195	1732	537	1753	2477	725

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective models and HEC-HMS node C1180000_0000_J in the revised existing model

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: C10
Project: Salt Water Ditch
Project #: 325912
Date: 11/19/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	100-year Peak Flows (cfs)			500-year Peak Flows (cfs)		
	Revised Existing	Proposed	Impact (Prop.-Rev.)	Revised Existing	Proposed	Impact (Prop.-Rev.)
Outlet	43940	44997	1058	58175	59054	879
C100#1	43125	44185	1060	57116	57871	754
C100#2	41870	42938	1068	55646	56217	572
C100#3	41373	42435	1062	54234	54623	389
C100#4	32957	33346	388	38602	40375	1773
C100#5	32050	32390	340	38078	39435	1358
C100#6	31450	31898	448	37568	38835	1267
C100#7	29718	30119	402	35373	37130	1758
C100#8	28744	29113	369	34422	35902	1480
C118 outfall	2328	4274	1946	3189	6117	2928
C118A	983	2083	1100	1445	2910	1465
C118B	2046	2866	821	2858	3916	1058

Note: The C118 outfall is HEC-HMS node C118 in the duplicate effective and corrected effective models and HEC-HMS node C1180000_0000_J in the revised existing model

APPENDIX C.6

DETENTION AND MITIGATION

- **DETENTION VOLUME ESTIMATE**
- **MITIGATED HEC-HMS OUTPUTS**
 - **2-YEAR**
 - **5-YEAR**
 - **10-YEAR**
 - **25-YEAR**
 - **50-YEAR**
 - **100-YEAR**
 - **500-YEAR**
- **10-YEAR AND 50-YEAR PEAK FLOW IMPACTS AND MITIGATION**
- **100-YEAR AND 500-YEAR PEAK FLOW IMPACTS AND MITIGATION**

C118-00-00 Hydrograph Comparison

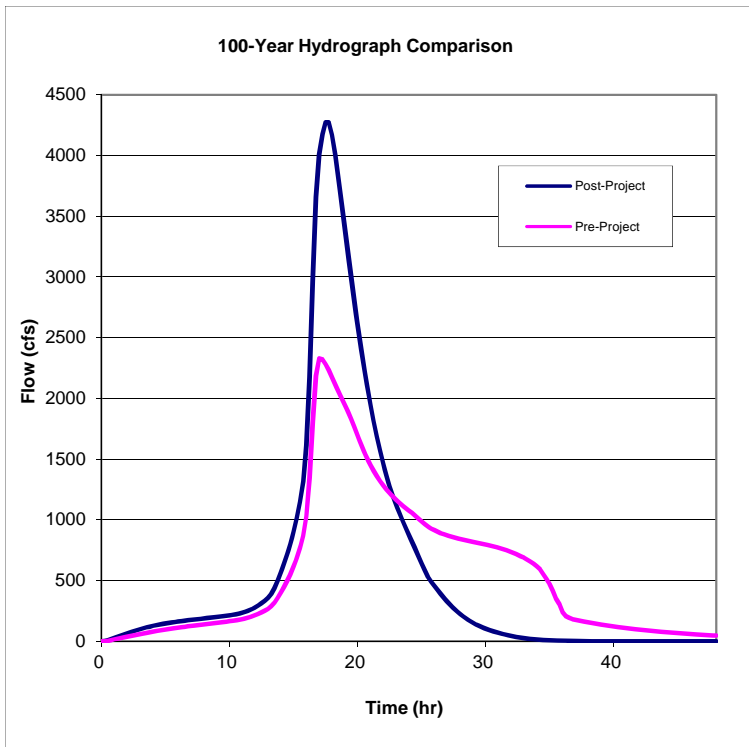
Project Name: Salt Water Ditch
 Project No.: 325912
 Location: Houston, Texas
 Date: 11/20/15
 Performed By: CM
 Checked By: DJ

Watershed: Sims Bayou
HCFC Unit: C100-00-00
Drainage System ID: C118-00-00
Alternative: 1 and 2

Computation Parameters:

Design Storm = 100 year
 Storm Duration = 24 hours
 Drainage Area = 2477 acres

Condition	Peak Flow (cfs)	Peak Flow Impact (cfs)	Detention Volume (ac-ft)
Pre-Project	2327.8	1946.1	694.18
Post-Project	4273.9		



Project Name: Salt Water Ditch
 Project No.: 325912
 Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

Time (minutes)	Time (hours)	Runoff Hydrographs			Runoff Volumes	
		Proposed Runoff Q (cfs)	Existing Runoff Q (cfs)	Flow Difference Qp-Qe (cfs)	Incremental Volume (ac-ft)	Cumulative Volume (ac-ft)
0	0.00	0	0	0.0	0	0
15	0.25	1.6	0.9	0.7	0.01	0.01
30	0.50	7.1	4	3.1	0.04	0.05
45	0.75	16.1	9.4	6.7	0.10	0.15
60	1.00	25.8	15.3	10.5	0.18	0.33
75	1.25	35.1	20.9	14.2	0.26	0.58
90	1.50	44.3	26.3	18.0	0.33	0.91
105	1.75	53.5	31.8	21.7	0.41	1.32
120	2.00	62.7	37.2	25.5	0.49	1.81
135	2.25	71.9	42.8	29.1	0.56	2.38
150	2.50	80.8	48.4	32.4	0.64	3.01
165	2.75	89.4	53.9	35.5	0.70	3.71
180	3.00	97.6	59.4	38.2	0.76	4.47
195	3.25	105.3	64.7	40.6	0.81	5.29
210	3.50	112.5	69.9	42.6	0.86	6.15
225	3.75	119.2	74.8	44.4	0.90	7.05
240	4.00	125.5	79.6	45.9	0.93	7.98
255	4.25	131.4	84.2	47.2	0.96	8.94
270	4.50	136.8	88.7	48.1	0.98	9.92
285	4.75	141.9	93	48.9	1.00	10.93
300	5.00	146.7	97.1	49.6	1.02	11.94
315	5.25	151.2	101.1	50.1	1.03	12.97
330	5.50	155.4	105	50.4	1.04	14.01
345	5.75	159.4	108.8	50.6	1.04	15.06
360	6.00	163.1	112.5	50.6	1.05	16.10
375	6.25	166.8	116	50.8	1.05	17.15
390	6.50	170.2	119.5	50.7	1.05	18.20
405	6.75	173.5	123	50.5	1.05	19.24
420	7.00	176.7	126.3	50.4	1.04	20.29
435	7.25	179.8	129.6	50.2	1.04	21.32
450	7.50	182.8	132.8	50.0	1.04	22.36
465	7.75	185.7	136	49.7	1.03	23.39
480	8.00	188.6	139.1	49.5	1.02	24.41
495	8.25	191.4	142.2	49.2	1.02	25.43
510	8.50	194.2	145.3	48.9	1.01	26.45
525	8.75	197.1	148.4	48.7	1.01	27.46
540	9.00	200.1	151.6	48.5	1.00	28.46
555	9.25	203.3	154.8	48.5	1.00	29.46
570	9.50	206.6	158.2	48.4	1.00	30.46
585	9.75	210.1	161.6	48.5	1.00	31.46
600	10.00	213.8	165.2	48.6	1.00	32.47
615	10.25	217.8	169	48.8	1.01	33.47
630	10.50	222.2	172.9	49.3	1.01	34.49
645	10.75	227.4	177.3	50.1	1.03	35.51
660	11.00	233.8	182.5	51.3	1.05	36.56
675	11.25	242.1	188.7	53.4	1.08	37.64
690	11.50	252.3	196.1	56.2	1.13	38.77

Project Name: Salt Water Ditch
 Project No.: 325912
 Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

Time (minutes)	Time (hours)	Runoff Hydrographs			Runoff Volumes	
		Proposed Runoff Q (cfs)	Existing Runoff Q (cfs)	Flow Difference Qp-Qe (cfs)	Incremental Volume (ac-ft)	Cumulative Volume (ac-ft)
705	11.75	264.4	204.6	59.8	1.20	39.97
720	12.00	278.4	214.4	64.0	1.28	41.25
735	12.25	294.5	225.5	69.0	1.37	42.63
750	12.50	312.7	237.9	74.8	1.49	44.11
765	12.75	333.2	251.7	81.5	1.61	45.73
780	13.00	356.2	267.2	89.0	1.76	47.49
795	13.25	387.1	287.3	99.8	1.95	49.44
810	13.50	433.9	316.8	117.1	2.24	51.68
825	13.75	495.8	355.9	139.9	2.65	54.33
840	14.00	564.5	399.8	164.7	3.15	57.48
855	14.25	636.8	446.1	190.7	3.67	61.15
870	14.50	714.8	496	218.8	4.23	65.38
885	14.75	801.4	551.2	250.2	4.85	70.23
900	15.00	900.4	614.1	286.3	5.54	75.77
915	15.25	1013.6	685.8	327.8	6.34	82.11
930	15.50	1145.6	767.2	378.4	7.30	89.41
945	15.75	1316.7	867.4	449.3	8.55	97.96
960	16.00	1611.4	1027	584.4	10.68	108.64
975	16.25	2172.9	1345.3	827.6	14.59	123.23
990	16.50	2977.8	1806	1171.8	20.65	143.88
1005	16.75	3658.7	2184.5	1474.2	27.33	171.21
1020	17.00	4007.3	2327.8	1679.5	32.58	203.79
1035	17.25	4174.8	2323.1	1851.7	36.48	240.27
1050	17.50	4273.9	2282.5	1991.4	39.70	279.98
1065	17.75	4272.1	2231.4	2040.7	41.65	321.63
1080	18.00	4169.4	2175.2	1994.2	41.68	363.31
1095	18.25	4002.6	2116.7	1885.9	40.08	403.40
1110	18.50	3806.9	2058.6	1748.3	37.54	440.94
1125	18.75	3603.2	2002.4	1600.8	34.60	475.54
1140	19.00	3401.4	1947.9	1453.5	31.55	507.09
1155	19.25	3201.6	1892.3	1309.3	28.54	535.63
1170	19.50	2998.8	1830.4	1168.4	25.60	561.23
1185	19.75	2796.4	1762.4	1034.0	22.75	583.98
1200	20.00	2605.5	1694.9	910.6	20.09	604.07
1215	20.25	2424	1627.4	796.6	17.64	621.70
1230	20.50	2251.8	1563.8	688.0	15.34	637.04
1245	20.75	2090.5	1505.6	584.9	13.15	650.19
1260	21.00	1942.4	1452.4	490.0	11.10	661.30
1275	21.25	1810	1403.9	406.1	9.26	670.55
1290	21.50	1687.3	1359.8	327.5	7.58	678.13
1305	21.75	1572.3	1319.6	252.7	5.99	684.13
1320	22.00	1465.7	1283.1	182.6	4.50	688.62
1335	22.25	1367.3	1249.9	117.4	3.10	691.72
1350	22.50	1276.9	1219.2	57.7	1.81	693.53
1365	22.75	1195.8	1190.7	5.1	0.65	694.18
1380	23.00	1126.1	1164.5	-38.4	-0.34	693.83
1395	23.25	1058.9	1140.5	-81.6	-1.24	692.60
1410	23.50	994.8	1118.6	-123.8	-2.12	690.47

Project Name: Salt Water Ditch
 Project No.: 325912
 Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

Time (minutes)	Time (hours)	Runoff Hydrographs			Runoff Volumes	
		Proposed Runoff Q (cfs)	Existing Runoff Q (cfs)	Flow Difference Qp-Qe (cfs)	Incremental Volume (ac-ft)	Cumulative Volume (ac-ft)
1425	23.75	934.6	1097.3	-162.7	-2.96	687.51
1440	24.00	878.4	1076.4	-198.0	-3.73	683.79
1455	24.25	823.2	1056	-232.8	-4.45	679.34
1470	24.50	764.3	1033.3	-269.0	-5.18	674.15
1485	24.75	702.2	1008.5	-306.3	-5.94	668.21
1500	25.00	641.7	984.7	-343.0	-6.71	661.50
1515	25.25	584.1	963.6	-379.5	-7.46	654.04
1530	25.50	529.8	945	-415.2	-8.21	645.83
1545	25.75	489.3	928.4	-439.1	-8.83	637.00
1560	26.00	456.1	913.8	-457.7	-9.26	627.74
1575	26.25	422.6	900.9	-478.3	-9.67	618.07
1590	26.50	389.4	889.4	-500.0	-10.11	607.96
1605	26.75	357.2	879.2	-522.0	-10.56	597.40
1620	27.00	326.6	870.1	-543.5	-11.01	586.40
1635	27.25	297.8	861.8	-564.0	-11.44	574.96
1650	27.50	271.1	854.4	-583.3	-11.85	563.10
1665	27.75	246.5	847.6	-601.1	-12.24	550.87
1680	28.00	223.9	841.2	-617.3	-12.59	538.28
1695	28.25	203.3	835.3	-632.0	-12.91	525.38
1710	28.50	184.7	829.7	-645.0	-13.19	512.18
1725	28.75	167.7	824.3	-656.6	-13.45	498.74
1740	29.00	152.3	818.9	-666.6	-13.67	485.07
1755	29.25	138.3	813.5	-675.2	-13.86	471.21
1770	29.50	125.5	808	-682.5	-14.03	457.18
1785	29.75	113.9	802.5	-688.6	-14.16	443.02
1800	30.00	103.3	796.8	-693.5	-14.28	428.74
1815	30.25	93.6	790.8	-697.2	-14.37	414.37
1830	30.50	84.8	784.5	-699.7	-14.43	399.94
1845	30.75	76.8	777.8	-701.0	-14.47	385.47
1860	31.00	69.4	770.7	-701.3	-14.49	370.98
1875	31.25	62.6	763.1	-700.5	-14.48	356.50
1890	31.50	56.3	754.7	-698.4	-14.45	342.05
1905	31.75	50.2	744.6	-694.4	-14.39	327.66
1920	32.00	44.3	732	-687.7	-14.28	313.39
1935	32.25	38.8	721.9	-683.1	-14.16	299.22
1950	32.50	33.7	711.3	-677.6	-14.06	285.17
1965	32.75	29.2	699.8	-670.6	-13.93	271.24
1980	33.00	25.3	687.4	-662.1	-13.77	257.47
1995	33.25	21.8	673.3	-651.5	-13.57	243.90
2010	33.50	19	656.7	-637.7	-13.32	230.58
2025	33.75	16.6	637.9	-621.3	-13.01	217.58
2040	34.00	14.4	617.1	-602.7	-12.64	204.93
2055	34.25	12.6	592.1	-579.5	-12.21	192.72
2070	34.50	11	553.2	-542.2	-11.59	181.13
2085	34.75	9.6	512.8	-503.2	-10.80	170.33
2100	35.00	8.4	471.4	-463.0	-9.98	160.35
2115	35.25	7.4	416.6	-409.2	-9.01	151.34
2130	35.50	6.4	351.1	-344.7	-7.79	143.55

Project Name: Salt Water Ditch
 Project No.: 325912
 Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

Time (minutes)	Time (hours)	Runoff Hydrographs		Flow Difference Qp-Qe (cfs)	Runoff Volumes	
		Proposed Runoff Q (cfs)	Existing Runoff Q (cfs)		Incremental Volume (ac-ft)	Cumulative Volume (ac-ft)
2145	35.75	5.6	303.1	-297.5	-6.63	136.92
2160	36.00	4.9	237.9	-233.0	-5.48	131.44
2175	36.25	4.3	206.3	-202.0	-4.49	126.94
2190	36.50	3.8	191.7	-187.9	-4.03	122.92
2205	36.75	3.3	183.1	-179.8	-3.80	119.12
2220	37.00	2.9	176.6	-173.7	-3.65	115.47
2235	37.25	2.5	170.9	-168.4	-3.53	111.93
2250	37.50	2.1	165.7	-163.6	-3.43	108.50
2265	37.75	1.8	160.6	-158.8	-3.33	105.17
2280	38.00	1.6	155.8	-154.2	-3.23	101.94
2295	38.25	1.3	151.1	-149.8	-3.14	98.80
2310	38.50	1.1	146.5	-145.4	-3.05	95.75
2325	38.75	0.9	142	-141.1	-2.96	92.79
2340	39.00	0.8	137.7	-136.9	-2.87	89.92
2355	39.25	0.6	133.6	-133.0	-2.79	87.13
2370	39.50	0.5	129.6	-129.1	-2.71	84.42
2385	39.75	0.3	125.7	-125.4	-2.63	81.79
2400	40.00	0.3	122	-121.7	-2.55	79.24
2415	40.25	0.2	118.5	-118.3	-2.48	76.76
2430	40.50	0.1	115	-114.9	-2.41	74.35
2445	40.75	0.1	111.6	-111.5	-2.34	72.01
2460	41.00	0.1	108.4	-108.3	-2.27	69.74
2475	41.25	0	105.2	-105.2	-2.21	67.54
2490	41.50	0	102.1	-102.1	-2.14	65.39
2505	41.75	0	99.1	-99.1	-2.08	63.32
2520	42.00	0	96.2	-96.2	-2.02	61.30
2535	42.25	0	93.4	-93.4	-1.96	59.34
2550	42.50	0	90.7	-90.7	-1.90	57.44
2565	42.75	0	88	-88.0	-1.85	55.59
2580	43.00	0	85.4	-85.4	-1.79	53.80
2595	43.25	0	82.9	-82.9	-1.74	52.06
2610	43.50	0	80.5	-80.5	-1.69	50.37
2625	43.75	0	78.1	-78.1	-1.64	48.73
2640	44.00	0	75.8	-75.8	-1.59	47.14
2655	44.25	0	73.6	-73.6	-1.54	45.60
2670	44.50	0	71.5	-71.5	-1.50	44.10
2685	44.75	0	69.4	-69.4	-1.46	42.65
2700	45.00	0	67.3	-67.3	-1.41	41.23
2715	45.25	0	65.4	-65.4	-1.37	39.86
2730	45.50	0	63.5	-63.5	-1.33	38.53
2745	45.75	0	61.6	-61.6	-1.29	37.24
2760	46.00	0	59.8	-59.8	-1.25	35.99
2775	46.25	0	58	-58.0	-1.22	34.77
2790	46.50	0	56.3	-56.3	-1.18	33.59
2805	46.75	0	54.7	-54.7	-1.15	32.44
2820	47.00	0	53.1	-53.1	-1.11	31.33
2835	47.25	0	51.5	-51.5	-1.08	30.25
2850	47.50	0	50	-50.0	-1.05	29.20

2-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-2

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(50%Flood)
 Compute Time: 01Dec2015, 11:13:38 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	10962.9	01Jan2003, 23:15	2.73
C100#10	44.95	6627.7	01Jan2003, 20:30	2.59
C100#11	42.97	6381.2	01Jan2003, 20:30	2.58
C100#12	40.83	6140.8	01Jan2003, 20:00	2.58
C100#13	34.73	5677.4	01Jan2003, 19:30	2.66
C100#14	32.50	5450.8	01Jan2003, 19:00	2.71
C100#15	28.36	4730.0	01Jan2003, 18:45	2.73
C100#16	23.73	3933.8	01Jan2003, 19:00	2.75
C100#17	21.75	3622.5	01Jan2003, 18:45	2.76
C100#18	20.73	3453.6	01Jan2003, 18:45	2.77
C100#19	18.31	2975.4	01Jan2003, 19:00	2.76
C100#2	87.76	10649.6	01Jan2003, 23:00	2.70
C100#20	15.07	2417.1	01Jan2003, 19:15	2.71
C100#21	7.91	1334.3	01Jan2003, 19:00	2.65
C100#22	5.07	973.8	01Jan2003, 18:15	2.69
C100#23	3.23	577.3	01Jan2003, 17:30	2.60
C100#24	2.26	396.0	01Jan2003, 17:00	2.53
C100#3	86.15	10579.7	01Jan2003, 23:00	2.69
C100#4	68.69	8562.4	01Jan2003, 23:00	2.58
C100#5	65.31	8355.8	01Jan2003, 22:45	2.55
C100#6	63.55	8250.2	01Jan2003, 22:15	2.54
C100#7	57.28	7851.3	01Jan2003, 21:30	2.54
C100#8	55.05	7637.9	01Jan2003, 21:15	2.55
C100#9	48.74	7049.9	01Jan2003, 21:00	2.61
C100#D1	5.07	928.0	01Jan2003, 18:45	2.69
C100#D2	3.23	548.0	01Jan2003, 18:15	2.59

2-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	396.0	01Jan2003, 17:00	2.53
C100B	1.84	585.4	01Jan2003, 16:45	2.86
C100B REACH#1	3.23	548.0	01Jan2003, 18:15	2.59
C100B REACH#2	2.26	389.8	01Jan2003, 17:30	2.53
C100C	2.84	521.8	01Jan2003, 17:00	2.58
C100D	2.42	592.3	01Jan2003, 17:15	2.87
C100D REACH#1	18.31	2974.4	01Jan2003, 19:00	2.76
C100D REACH#2	15.07	2417.1	01Jan2003, 19:15	2.71
C100D REACH#3	7.91	1330.6	01Jan2003, 19:15	2.65
C100E	2.24	546.7	01Jan2003, 18:00	3.04
C100E REACH#1	23.73	3926.2	01Jan2003, 19:00	2.75
C100E REACH#2	21.75	3611.2	01Jan2003, 19:00	2.76
C100E REACH#3	20.73	3449.3	01Jan2003, 18:45	2.77
C100F	2.58	623.0	01Jan2003, 17:45	2.57
C100F REACH	28.36	4712.8	01Jan2003, 19:15	2.73
C100G	2.23	341.4	01Jan2003, 17:00	2.01
C100G REACH	32.50	5423.0	01Jan2003, 19:30	2.71
C100H	1.98	736.3	01Jan2003, 16:45	2.88
C100H REACH#1	42.97	6354.1	01Jan2003, 20:45	2.58
C100H REACH#2	40.83	6092.9	01Jan2003, 20:30	2.58
C100I	3.79	1084.5	01Jan2003, 17:00	2.86
C100I REACH	44.95	6548.8	01Jan2003, 21:15	2.59
C100J	6.27	591.5	01Jan2003, 18:15	2.60
C100J REACH	57.28	7736.6	01Jan2003, 22:15	2.54
C100K	1.76	501.7	01Jan2003, 17:15	2.82
C100K#1	1.76	501.7	01Jan2003, 17:15	2.82
C100L	3.38	1294.7	01Jan2003, 17:00	3.23
C100L REACH#1	65.31	8279.4	01Jan2003, 23:15	2.54
C100L REACH#2	63.55	8189.0	01Jan2003, 22:45	2.54
C100M	1.76	429.3	01Jan2003, 17:45	3.39
C100M REACH#1	91.75	10939.2	01Jan2003, 23:30	2.72
C100M REACH#2	87.76	10602.2	01Jan2003, 23:15	2.70
C100M REACH#3	86.15	10563.4	01Jan2003, 23:00	2.69

2-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	8564.1	01Jan2003, 23:15	2.58
C100 REACH	5.07	919.9	01Jan2003, 19:30	2.69
C102#1	2.90	395.6	01Jan2003, 17:45	3.28
C102#OULET	3.99	869.3	01Jan2003, 16:45	3.36
C102A	2.90	395.6	01Jan2003, 17:45	3.28
C102B	1.09	717.1	01Jan2003, 16:45	3.63
C102B REACH	2.90	393.1	01Jan2003, 18:30	3.26
C103	1.61	929.4	01Jan2003, 16:45	3.44
C106-00#1	14.39	3803.9	01Jan2003, 17:45	3.14
C106-00#2	9.59	2914.0	01Jan2003, 17:15	3.17
C106-00#3	4.84	1347.3	01Jan2003, 17:00	3.14
C106-00#OUTLET	17.46	4511.1	01Jan2003, 18:30	3.12
C106-01#1	2.78	610.5	01Jan2003, 17:00	2.99
C106-01#OUTLET	4.80	1034.8	01Jan2003, 18:15	3.08
C106-08#OUTLET	1.82	601.5	01Jan2003, 16:45	3.20
C106A	1.82	601.5	01Jan2003, 16:45	3.20
C106B	3.02	755.7	01Jan2003, 17:15	3.10
C106C	1.89	973.8	01Jan2003, 16:45	3.21
C106C REACH	4.84	1323.3	01Jan2003, 17:30	3.14
C106D	2.86	778.0	01Jan2003, 17:00	3.21
C106E	2.78	610.5	01Jan2003, 17:00	2.99
C106F	2.02	492.5	01Jan2003, 17:15	3.21
C106F REACH	2.78	591.8	01Jan2003, 18:30	2.99
C106G	3.07	1093.9	01Jan2003, 17:00	3.00
C106G REACH#1	14.39	3714.4	01Jan2003, 18:30	3.14
C106G REACH#2	9.59	2842.0	01Jan2003, 17:45	3.17
C118	3.87	1085.9	01Jan2003, 17:30	2.91
C118_Diversion	3.87	677.1	01Jan2003, 17:45	1.94
C118_Pond	0.00	0.4	02Jan2003, 10:15	
C1180000_0009_J	3.87	677.3	01Jan2003, 17:45	1.94
C1180000_0009_R	1.93	631.8	01Jan2003, 18:30	3.00
C118A	1.93	731.7	01Jan2003, 17:15	3.00
C118B	1.94	1055.3	01Jan2003, 17:00	2.82

2-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	481.5	01Jan2003, 17:00	2.36
C120 REACH	55.05	7616.0	01Jan2003, 21:30	2.55
C123	2.44	571.9	01Jan2003, 17:30	2.42
C123 REACH	48.74	6987.9	01Jan2003, 21:30	2.61
C127	2.14	599.8	01Jan2003, 16:45	2.58
C132	4.07	419.3	01Jan2003, 17:15	2.20
C134	2.03	198.2	01Jan2003, 19:00	2.03
C134 REACH	34.73	5597.6	01Jan2003, 20:15	2.66
C137	1.56	354.4	01Jan2003, 16:45	2.56
C143	1.98	420.4	01Jan2003, 16:45	2.64
C144	1.02	223.0	01Jan2003, 16:45	2.53
C145#1	1.86	381.2	01Jan2003, 17:00	3.13
C145#OUTLET	3.24	698.8	01Jan2003, 17:00	3.00
C145A	1.86	381.2	01Jan2003, 17:00	3.13
C145B	1.38	321.0	01Jan2003, 16:45	2.82
C147#1	1.82	359.8	01Jan2003, 17:00	2.93
C147#2	2.71	501.9	01Jan2003, 17:15	2.67
C147#OUTLET	7.16	1102.1	01Jan2003, 18:30	2.77
C147A	1.82	359.8	01Jan2003, 17:00	2.93
C147B	2.71	501.9	01Jan2003, 17:15	2.67
C147C	2.63	810.1	01Jan2003, 17:15	2.81
C147C REACH	4.53	605.4	01Jan2003, 21:00	2.76
C147 DETENTION	4.53	606.8	01Jan2003, 20:30	2.76
C161	2.39	346.0	01Jan2003, 17:45	2.27
C162	0.97	191.1	01Jan2003, 17:00	2.75
DET#1	4.53	606.8	01Jan2003, 20:30	2.76
DET#2	4.53	859.9	01Jan2003, 17:15	2.77
DETENTION REACH#1	5.07	928.0	01Jan2003, 18:45	2.69
DETENTION REACH#2	3.23	539.8	01Jan2003, 18:45	2.59
Outlet	93.51	11143.6	01Jan2003, 23:30	2.73

5-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-5

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(20%Flood)
 Compute Time: 01Dec2015, 11:16:06 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	17425.1	01Jan2003, 22:30	4.10
C100#10	44.95	10135.7	01Jan2003, 20:15	3.97
C100#11	42.97	9727.8	01Jan2003, 20:15	3.96
C100#12	40.83	9303.6	01Jan2003, 20:00	3.96
C100#13	34.73	8508.3	01Jan2003, 19:30	4.08
C100#14	32.50	8121.1	01Jan2003, 19:15	4.14
C100#15	28.36	7029.7	01Jan2003, 19:15	4.17
C100#16	23.73	5882.2	01Jan2003, 19:15	4.21
C100#17	21.75	5420.4	01Jan2003, 19:00	4.23
C100#18	20.73	5174.8	01Jan2003, 19:00	4.24
C100#19	18.31	4478.9	01Jan2003, 19:00	4.23
C100#2	87.76	16914.4	01Jan2003, 22:15	4.07
C100#20	15.07	3648.4	01Jan2003, 19:15	4.16
C100#21	7.91	2023.2	01Jan2003, 19:15	4.09
C100#22	5.07	1452.6	01Jan2003, 18:15	4.14
C100#23	3.23	835.9	01Jan2003, 17:30	4.02
C100#24	2.26	569.2	01Jan2003, 17:15	3.94
C100#3	86.15	16773.9	01Jan2003, 22:15	4.05
C100#4	68.69	13399.9	01Jan2003, 22:30	3.91
C100#5	65.31	13023.3	01Jan2003, 22:15	3.87
C100#6	63.55	12806.2	01Jan2003, 21:45	3.87
C100#7	57.28	12131.9	01Jan2003, 21:00	3.87
C100#8	55.05	11769.7	01Jan2003, 21:00	3.88
C100#9	48.74	10867.5	01Jan2003, 20:45	3.99
C100#D1	5.07	1383.6	01Jan2003, 19:00	4.14
C100#D2	3.23	809.3	01Jan2003, 18:15	4.02

5-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	569.2	01Jan2003, 17:15	3.94
C100B	1.84	812.6	01Jan2003, 16:45	4.35
C100B REACH#1	3.23	809.3	01Jan2003, 18:15	4.02
C100B REACH#2	2.26	566.1	01Jan2003, 17:30	3.94
C100C	2.84	746.5	01Jan2003, 17:15	4.01
C100D	2.42	835.2	01Jan2003, 17:15	4.37
C100D REACH#1	18.31	4478.6	01Jan2003, 19:15	4.23
C100D REACH#2	15.07	3645.5	01Jan2003, 19:15	4.16
C100D REACH#3	7.91	2022.2	01Jan2003, 19:15	4.09
C100E	2.24	771.1	01Jan2003, 18:15	4.52
C100E REACH#1	23.73	5869.7	01Jan2003, 19:30	4.20
C100E REACH#2	21.75	5405.2	01Jan2003, 19:15	4.22
C100E REACH#3	20.73	5168.9	01Jan2003, 19:15	4.24
C100F	2.58	894.4	01Jan2003, 17:45	3.92
C100F REACH	28.36	7014.5	01Jan2003, 19:30	4.17
C100G	2.23	499.2	01Jan2003, 17:15	3.20
C100G REACH	32.50	8097.9	01Jan2003, 19:30	4.14
C100H	1.98	1012.2	01Jan2003, 16:45	4.32
C100H REACH#1	42.97	9703.3	01Jan2003, 20:30	3.95
C100H REACH#2	40.83	9255.5	01Jan2003, 20:15	3.96
C100I	3.79	1512.1	01Jan2003, 17:00	4.29
C100I REACH	44.95	10064.0	01Jan2003, 21:00	3.96
C100J	6.27	857.0	01Jan2003, 18:45	3.87
C100J REACH	57.28	12023.3	01Jan2003, 21:45	3.87
C100K	1.76	704.9	01Jan2003, 17:15	4.24
C100K#1	1.76	704.9	01Jan2003, 17:15	4.24
C100L	3.38	1766.8	01Jan2003, 17:00	4.76
C100L REACH#1	65.31	12935.2	01Jan2003, 22:45	3.86
C100L REACH#2	63.55	12741.9	01Jan2003, 22:15	3.86
C100M	1.76	597.0	01Jan2003, 18:00	4.98
C100M REACH#1	91.75	17398.7	01Jan2003, 22:45	4.10
C100M REACH#2	87.76	16859.9	01Jan2003, 22:30	4.07
C100M REACH#3	86.15	16752.1	01Jan2003, 22:15	4.05

5-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	13402.5	01Jan2003, 22:45	3.91
C100 REACH	5.07	1376.1	01Jan2003, 19:30	4.13
C102#1	2.90	556.0	01Jan2003, 18:00	4.79
C102#OULET	3.99	1179.8	01Jan2003, 16:45	4.91
C102A	2.90	556.0	01Jan2003, 18:00	4.79
C102B	1.09	948.2	01Jan2003, 16:45	5.28
C102B REACH	2.90	558.1	01Jan2003, 18:00	4.77
C103	1.61	1241.1	01Jan2003, 16:45	5.04
C106-00#1	14.39	5342.8	01Jan2003, 18:00	4.67
C106-00#2	9.59	4039.9	01Jan2003, 17:15	4.71
C106-00#3	4.84	1861.8	01Jan2003, 17:00	4.67
C106-00#OUTLET	17.46	6409.0	01Jan2003, 18:30	4.63
C106-01#1	2.78	853.1	01Jan2003, 17:15	4.46
C106-01#OUTLET	4.80	1477.0	01Jan2003, 18:15	4.58
C106-08#OUTLET	1.82	825.3	01Jan2003, 17:00	4.75
C106A	1.82	825.3	01Jan2003, 17:00	4.75
C106B	3.02	1054.2	01Jan2003, 17:15	4.62
C106C	1.89	1314.1	01Jan2003, 16:45	4.75
C106C REACH	4.84	1845.2	01Jan2003, 17:30	4.67
C106D	2.86	1072.7	01Jan2003, 17:00	4.76
C106E	2.78	853.1	01Jan2003, 17:15	4.46
C106F	2.02	683.8	01Jan2003, 17:15	4.74
C106F REACH	2.78	839.3	01Jan2003, 18:30	4.46
C106G	3.07	1506.5	01Jan2003, 17:00	4.48
C106G REACH#1	14.39	5239.1	01Jan2003, 18:30	4.67
C106G REACH#2	9.59	3963.3	01Jan2003, 17:45	4.71
C118	3.87	1521.5	01Jan2003, 17:30	4.36
C118_Diversion	3.87	903.8	01Jan2003, 17:45	2.69
C118_Pond	0.00	0.8	02Jan2003, 10:00	
C1180000_0009_J	3.87	904.1	01Jan2003, 17:45	2.70
C1180000_0009_R	1.93	912.9	01Jan2003, 18:15	4.47
C118A	1.93	1011.5	01Jan2003, 17:15	4.47
C118B	1.94	1446.5	01Jan2003, 17:00	4.25

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Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	686.7	01Jan2003, 17:00	3.66
C120 REACH	55.05	11738.4	01Jan2003, 21:15	3.88
C123	2.44	825.2	01Jan2003, 17:45	3.73
C123 REACH	48.74	10806.8	01Jan2003, 21:00	3.99
C127	2.14	839.2	01Jan2003, 17:00	3.93
C132	4.07	615.9	01Jan2003, 17:45	3.41
C134	2.03	300.1	01Jan2003, 19:00	3.18
C134 REACH	34.73	8450.5	01Jan2003, 20:00	4.07
C137	1.56	501.0	01Jan2003, 17:00	3.90
C143	1.98	594.5	01Jan2003, 17:00	4.01
C144	1.02	316.0	01Jan2003, 17:00	3.87
C145#1	1.86	533.3	01Jan2003, 17:15	4.70
C145#OUTLET	3.24	982.7	01Jan2003, 17:00	4.53
C145A	1.86	533.3	01Jan2003, 17:15	4.70
C145B	1.38	450.0	01Jan2003, 17:00	4.31
C147#1	1.82	507.7	01Jan2003, 17:15	4.44
C147#2	2.71	717.2	01Jan2003, 17:15	4.11
C147#OUTLET	7.16	1630.0	01Jan2003, 19:00	4.24
C147A	1.82	507.7	01Jan2003, 17:15	4.44
C147B	2.71	717.2	01Jan2003, 17:15	4.11
C147C	2.63	1135.9	01Jan2003, 17:15	4.29
C147C REACH	4.53	909.0	01Jan2003, 21:15	4.22
C147 DETENTION	4.53	911.0	01Jan2003, 20:45	4.22
C161	2.39	507.3	01Jan2003, 17:45	3.53
C162	0.97	271.7	01Jan2003, 17:15	4.21
DET#1	4.53	911.0	01Jan2003, 20:45	4.22
DET#2	4.53	1225.0	01Jan2003, 17:15	4.24
DETENTION REACH#1	5.07	1383.6	01Jan2003, 19:00	4.14
DETENTION REACH#2	3.23	802.3	01Jan2003, 18:45	4.02
Outlet	93.51	17732.5	01Jan2003, 22:45	4.11

10-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-10

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(10%flood)
 Compute Time: 01Dec2015, 11:04:54 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	21977.8	01Jan2003, 22:30	5.17
C100#10	44.95	12816.8	01Jan2003, 20:15	5.06
C100#11	42.97	12284.2	01Jan2003, 20:15	5.04
C100#12	40.83	11731.1	01Jan2003, 20:00	5.05
C100#13	34.73	10712.3	01Jan2003, 19:30	5.19
C100#14	32.50	10209.4	01Jan2003, 19:15	5.26
C100#15	28.36	8823.7	01Jan2003, 19:15	5.30
C100#16	23.73	7374.2	01Jan2003, 19:15	5.34
C100#17	21.75	6783.9	01Jan2003, 19:00	5.37
C100#18	20.73	6465.4	01Jan2003, 19:00	5.39
C100#19	18.31	5597.2	01Jan2003, 19:15	5.37
C100#2	87.76	21388.0	01Jan2003, 22:15	5.14
C100#20	15.07	4568.5	01Jan2003, 19:15	5.30
C100#21	7.91	2536.6	01Jan2003, 19:15	5.23
C100#22	5.07	1812.2	01Jan2003, 18:00	5.28
C100#23	3.23	1035.1	01Jan2003, 17:30	5.15
C100#24	2.26	706.0	01Jan2003, 17:15	5.07
C100#3	86.15	21210.9	01Jan2003, 22:15	5.12
C100#4	68.69	17031.2	01Jan2003, 22:30	4.95
C100#5	65.31	16587.6	01Jan2003, 22:00	4.91
C100#6	63.55	16298.0	01Jan2003, 21:30	4.91
C100#7	57.28	15456.3	01Jan2003, 21:00	4.92
C100#8	55.05	14960.9	01Jan2003, 20:45	4.94
C100#9	48.74	13785.0	01Jan2003, 20:45	5.08
C100#D1	5.07	1728.3	01Jan2003, 19:00	5.28
C100#D2	3.23	1010.2	01Jan2003, 18:15	5.15

10-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	706.0	01Jan2003, 17:15	5.07
C100B	1.84	983.6	01Jan2003, 16:45	5.52
C100B REACH#1	3.23	1010.2	01Jan2003, 18:15	5.15
C100B REACH#2	2.26	703.6	01Jan2003, 17:45	5.06
C100C	2.84	925.1	01Jan2003, 17:15	5.14
C100D	2.42	1021.1	01Jan2003, 17:15	5.53
C100D REACH#1	18.31	5598.6	01Jan2003, 19:15	5.37
C100D REACH#2	15.07	4563.5	01Jan2003, 19:15	5.30
C100D REACH#3	7.91	2534.7	01Jan2003, 19:15	5.22
C100E	2.24	945.5	01Jan2003, 18:15	5.65
C100E REACH#1	23.73	7362.8	01Jan2003, 19:15	5.34
C100E REACH#2	21.75	6768.3	01Jan2003, 19:15	5.37
C100E REACH#3	20.73	6459.1	01Jan2003, 19:15	5.39
C100F	2.58	1105.8	01Jan2003, 17:45	4.99
C100F REACH	28.36	8805.2	01Jan2003, 19:30	5.30
C100G	2.23	630.4	01Jan2003, 17:15	4.20
C100G REACH	32.50	10174.7	01Jan2003, 19:30	5.25
C100H	1.98	1222.9	01Jan2003, 17:00	5.43
C100H REACH#1	42.97	12260.0	01Jan2003, 20:30	5.04
C100H REACH#2	40.83	11678.1	01Jan2003, 20:15	5.05
C100I	3.79	1839.5	01Jan2003, 17:00	5.40
C100I REACH	44.95	12755.6	01Jan2003, 20:45	5.05
C100J	6.27	1066.1	01Jan2003, 19:00	4.86
C100J REACH	57.28	15312.1	01Jan2003, 21:45	4.91
C100K	1.76	861.4	01Jan2003, 17:15	5.34
C100K#1	1.76	861.4	01Jan2003, 17:15	5.34
C100L	3.38	2119.1	01Jan2003, 17:00	5.92
C100L REACH#1	65.31	16434.1	01Jan2003, 22:45	4.90
C100L REACH#2	63.55	16213.0	01Jan2003, 22:00	4.90
C100M	1.76	725.6	01Jan2003, 18:00	6.16
C100M REACH#1	91.75	21957.4	01Jan2003, 23:00	5.17
C100M REACH#2	87.76	21293.3	01Jan2003, 22:45	5.13
C100M REACH#3	86.15	21187.4	01Jan2003, 22:15	5.12

10-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	17022.6	01Jan2003, 22:45	4.95
C100 REACH	5.07	1719.6	01Jan2003, 19:30	5.27
C102#1	2.90	679.7	01Jan2003, 18:00	5.92
C102#OULET	3.99	1485.7	01Jan2003, 17:30	6.06
C102A	2.90	679.7	01Jan2003, 18:00	5.92
C102B	1.09	1115.7	01Jan2003, 16:45	6.49
C102B REACH	2.90	679.5	01Jan2003, 18:30	5.89
C103	1.61	1468.1	01Jan2003, 16:45	6.23
C106-00#1	14.39	6539.0	01Jan2003, 17:45	5.82
C106-00#2	9.59	4924.0	01Jan2003, 17:15	5.88
C106-00#3	4.84	2264.4	01Jan2003, 17:15	5.83
C106-00#OUTLET	17.46	7852.4	01Jan2003, 18:30	5.78
C106-01#1	2.78	1044.8	01Jan2003, 17:15	5.58
C106-01#OUTLET	4.80	1812.2	01Jan2003, 18:15	5.72
C106-08#OUTLET	1.82	996.8	01Jan2003, 17:00	5.91
C106A	1.82	996.8	01Jan2003, 17:00	5.91
C106B	3.02	1282.8	01Jan2003, 17:15	5.78
C106C	1.89	1560.1	01Jan2003, 16:45	5.92
C106C REACH	4.84	2247.9	01Jan2003, 17:30	5.83
C106D	2.86	1302.2	01Jan2003, 17:15	5.93
C106E	2.78	1044.8	01Jan2003, 17:15	5.58
C106F	2.02	830.2	01Jan2003, 17:15	5.90
C106F REACH	2.78	1031.2	01Jan2003, 18:30	5.58
C106G	3.07	1816.3	01Jan2003, 17:00	5.60
C106G REACH#1	14.39	6401.2	01Jan2003, 18:45	5.82
C106G REACH#2	9.59	4835.3	01Jan2003, 17:45	5.88
C118	3.87	1856.1	01Jan2003, 17:30	5.48
C118_Diversion	3.87	1077.1	01Jan2003, 17:45	3.23
C118_Pond	0.00	13.9	02Jan2003, 04:45	
C1180000_0009_J	3.87	1077.5	01Jan2003, 17:45	3.30
C1180000_0009_R	1.93	1125.2	01Jan2003, 18:15	5.60
C118A	1.93	1222.8	01Jan2003, 17:15	5.60
C118B	1.94	1732.3	01Jan2003, 17:00	5.35

10-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	852.8	01Jan2003, 17:15	4.70
C120 REACH	55.05	14935.7	01Jan2003, 21:00	4.93
C123	2.44	1025.1	01Jan2003, 17:45	4.78
C123 REACH	48.74	13736.2	01Jan2003, 21:00	5.07
C127	2.14	1030.2	01Jan2003, 17:00	5.00
C132	4.07	777.3	01Jan2003, 18:00	4.39
C134	2.03	382.5	01Jan2003, 19:15	4.14
C134 REACH	34.73	10631.8	01Jan2003, 20:00	5.18
C137	1.56	618.0	01Jan2003, 17:00	4.97
C143	1.98	732.7	01Jan2003, 17:00	5.09
C144	1.02	390.2	01Jan2003, 17:00	4.94
C145#1	1.86	652.0	01Jan2003, 17:15	5.88
C145#OUTLET	3.24	1200.4	01Jan2003, 17:15	5.70
C145A	1.86	652.0	01Jan2003, 17:15	5.88
C145B	1.38	551.8	01Jan2003, 17:00	5.47
C147#1	1.82	623.1	01Jan2003, 17:15	5.61
C147#2	2.71	886.5	01Jan2003, 17:30	5.25
C147#OUTLET	7.16	2034.0	01Jan2003, 19:00	5.39
C147A	1.82	623.1	01Jan2003, 17:15	5.61
C147B	2.71	886.5	01Jan2003, 17:30	5.25
C147C	2.63	1382.1	01Jan2003, 17:15	5.45
C147C REACH	4.53	1171.4	01Jan2003, 21:00	5.36
C147 DETENTION	4.53	1175.5	01Jan2003, 20:30	5.37
C161	2.39	636.4	01Jan2003, 18:00	4.56
C162	0.97	334.7	01Jan2003, 17:15	5.36
DET#1	4.53	1175.5	01Jan2003, 20:30	5.37
DET#2	4.53	1508.0	01Jan2003, 17:30	5.39
DETENTION REACH#1	5.07	1728.3	01Jan2003, 19:00	5.28
DETENTION REACH#2	3.23	1003.1	01Jan2003, 18:45	5.15
Outlet	93.51	22355.3	01Jan2003, 23:00	5.18

25-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-25

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(4%Flood)
 Compute Time: 01Dec2015, 11:14:54 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	30631.5	01Jan2003, 22:00	7.00
C100#10	44.95	17049.9	01Jan2003, 20:15	6.89
C100#11	42.97	16317.3	01Jan2003, 20:15	6.87
C100#12	40.83	15544.5	01Jan2003, 20:15	6.88
C100#13	34.73	14132.6	01Jan2003, 19:45	7.05
C100#14	32.50	13432.4	01Jan2003, 19:30	7.13
C100#15	28.36	11627.1	01Jan2003, 19:15	7.18
C100#16	23.73	9740.1	01Jan2003, 19:15	7.23
C100#17	21.75	8968.6	01Jan2003, 19:15	7.27
C100#18	20.73	8549.1	01Jan2003, 19:15	7.29
C100#19	18.31	7434.1	01Jan2003, 19:15	7.27
C100#2	87.76	29785.2	01Jan2003, 21:45	6.96
C100#20	15.07	6096.7	01Jan2003, 19:30	7.20
C100#21	7.91	3329.4	01Jan2003, 19:15	7.12
C100#22	5.07	2350.6	01Jan2003, 18:15	7.17
C100#23	3.23	1336.1	01Jan2003, 17:45	7.04
C100#24	2.26	911.1	01Jan2003, 17:30	6.94
C100#3	86.15	29475.3	01Jan2003, 21:45	6.94
C100#4	68.69	23352.8	01Jan2003, 22:00	6.75
C100#5	65.31	22543.8	01Jan2003, 21:45	6.71
C100#6	63.55	22052.1	01Jan2003, 21:30	6.71
C100#7	57.28	20859.6	01Jan2003, 20:45	6.75
C100#8	55.05	20141.3	01Jan2003, 20:45	6.76
C100#9	48.74	18406.6	01Jan2003, 20:30	6.90
C100#D1	5.07	2257.8	01Jan2003, 19:00	7.17
C100#D2	3.23	1311.3	01Jan2003, 18:30	7.03

25-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	911.1	01Jan2003, 17:30	6.94
C100B	1.84	1236.7	01Jan2003, 16:45	7.44
C100B REACH#1	3.23	1311.3	01Jan2003, 18:30	7.03
C100B REACH#2	2.26	909.7	01Jan2003, 17:45	6.94
C100C	2.84	1189.5	01Jan2003, 17:30	7.02
C100D	2.42	1294.7	01Jan2003, 17:15	7.45
C100D REACH#1	18.31	7426.6	01Jan2003, 19:30	7.27
C100D REACH#2	15.07	6096.7	01Jan2003, 19:30	7.20
C100D REACH#3	7.91	3323.3	01Jan2003, 19:15	7.11
C100E	2.24	1207.2	01Jan2003, 18:15	7.54
C100E REACH#1	23.73	9730.3	01Jan2003, 19:30	7.23
C100E REACH#2	21.75	8947.6	01Jan2003, 19:30	7.26
C100E REACH#3	20.73	8543.3	01Jan2003, 19:15	7.29
C100F	2.58	1420.2	01Jan2003, 17:45	6.81
C100F REACH	28.36	11601.1	01Jan2003, 19:45	7.17
C100G	2.23	828.4	01Jan2003, 17:30	5.93
C100G REACH	32.50	13410.5	01Jan2003, 19:45	7.12
C100H	1.98	1536.0	01Jan2003, 17:00	7.29
C100H REACH#1	42.97	16296.5	01Jan2003, 20:30	6.87
C100H REACH#2	40.83	15501.7	01Jan2003, 20:30	6.87
C100I	3.79	2326.5	01Jan2003, 17:00	7.26
C100I REACH	44.95	16999.7	01Jan2003, 20:45	6.88
C100J	6.27	1397.5	01Jan2003, 19:30	6.49
C100J REACH	57.28	20728.5	01Jan2003, 21:30	6.73
C100K	1.76	1092.2	01Jan2003, 17:15	7.20
C100K#1	1.76	1092.2	01Jan2003, 17:15	7.20
C100L	3.38	2641.7	01Jan2003, 17:00	7.83
C100L REACH#1	65.31	22428.1	01Jan2003, 22:15	6.70
C100L REACH#2	63.55	22002.4	01Jan2003, 21:45	6.70
C100M	1.76	917.8	01Jan2003, 18:00	8.09
C100M REACH#1	91.75	30560.6	01Jan2003, 22:30	6.98
C100M REACH#2	87.76	29680.2	01Jan2003, 22:00	6.95
C100M REACH#3	86.15	29461.0	01Jan2003, 21:45	6.94

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Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	23337.2	01Jan2003, 22:00	6.75
C100 REACH	5.07	2246.8	01Jan2003, 19:30	7.17
C102#1	2.90	872.1	01Jan2003, 18:30	7.74
C102#OULET	3.99	1907.8	01Jan2003, 17:15	7.91
C102A	2.90	872.1	01Jan2003, 18:30	7.74
C102B	1.09	1358.9	01Jan2003, 16:45	8.46
C102B REACH	2.90	871.4	01Jan2003, 19:00	7.71
C103	1.61	1800.2	01Jan2003, 16:45	8.17
C106-00#1	14.39	8278.1	01Jan2003, 17:45	7.73
C106-00#2	9.59	6186.6	01Jan2003, 17:15	7.80
C106-00#3	4.84	2855.3	01Jan2003, 17:15	7.75
C106-00#OUTLET	17.46	10009.5	01Jan2003, 18:30	7.69
C106-01#1	2.78	1328.7	01Jan2003, 17:15	7.46
C106-01#OUTLET	4.80	2279.8	01Jan2003, 18:15	7.60
C106-08#OUTLET	1.82	1248.5	01Jan2003, 17:00	7.84
C106A	1.82	1248.5	01Jan2003, 17:00	7.84
C106B	3.02	1621.2	01Jan2003, 17:15	7.69
C106C	1.89	1924.6	01Jan2003, 16:45	7.85
C106C REACH	4.84	2836.2	01Jan2003, 17:30	7.75
C106D	2.86	1640.8	01Jan2003, 17:15	7.86
C106E	2.78	1328.7	01Jan2003, 17:15	7.46
C106F	2.02	1049.9	01Jan2003, 17:30	7.80
C106F REACH	2.78	1302.9	01Jan2003, 19:15	7.46
C106G	3.07	2277.1	01Jan2003, 17:00	7.48
C106G REACH#1	14.39	8125.8	01Jan2003, 18:45	7.73
C106G REACH#2	9.59	6103.2	01Jan2003, 17:45	7.80
C118	3.87	2356.3	01Jan2003, 17:45	7.34
C118_Diversion	3.87	1312.5	01Jan2003, 17:45	4.09
C118_Pond	0.00	242.8	01Jan2003, 23:15	
C1180000_0009_J	3.87	1313.0	01Jan2003, 17:45	5.14
C1180000_0009_R	1.93	1436.3	01Jan2003, 18:15	7.47
C118A	1.93	1532.4	01Jan2003, 17:15	7.47
C118B	1.94	2144.8	01Jan2003, 17:00	7.21

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Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1099.8	01Jan2003, 17:15	6.50
C120 REACH	55.05	20106.7	01Jan2003, 20:45	6.76
C123	2.44	1322.1	01Jan2003, 17:45	6.58
C123 REACH	48.74	18361.4	01Jan2003, 20:45	6.90
C127	2.14	1311.7	01Jan2003, 17:00	6.82
C132	4.07	1031.0	01Jan2003, 18:30	6.06
C134	2.03	512.0	01Jan2003, 19:30	5.79
C134 REACH	34.73	14066.5	01Jan2003, 20:15	7.04
C137	1.56	791.2	01Jan2003, 17:00	6.79
C143	1.98	939.0	01Jan2003, 17:15	6.92
C144	1.02	500.3	01Jan2003, 17:00	6.75
C145#1	1.86	827.0	01Jan2003, 17:30	7.82
C145#OUTLET	3.24	1526.3	01Jan2003, 17:15	7.63
C145A	1.86	827.0	01Jan2003, 17:30	7.82
C145B	1.38	700.9	01Jan2003, 17:00	7.38
C147#1	1.82	794.7	01Jan2003, 17:30	7.53
C147#2	2.71	1138.9	01Jan2003, 17:30	7.14
C147#OUTLET	7.16	2775.5	01Jan2003, 19:30	7.29
C147A	1.82	794.7	01Jan2003, 17:30	7.53
C147B	2.71	1138.9	01Jan2003, 17:30	7.14
C147C	2.63	1743.4	01Jan2003, 17:15	7.36
C147C REACH	4.53	1621.3	01Jan2003, 20:45	7.25
C147 DETENTION	4.53	1630.5	01Jan2003, 20:15	7.26
C161	2.39	834.8	01Jan2003, 18:00	6.32
C162	0.97	428.3	01Jan2003, 17:30	7.27
DET#1	4.53	1630.5	01Jan2003, 20:15	7.26
DET#2	4.53	1933.6	01Jan2003, 17:30	7.30
DETENTION REACH#1	5.07	2257.8	01Jan2003, 19:00	7.17
DETENTION REACH#2	3.23	1305.6	01Jan2003, 18:45	7.03
Outlet	93.51	31130.7	01Jan2003, 22:15	7.01

50-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-50

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(2%flood)
 Compute Time: 01Dec2015, 11:17:23 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	37321.9	01Jan2003, 22:00	8.63
C100#10	44.95	20717.4	01Jan2003, 20:15	8.53
C100#11	42.97	19799.2	01Jan2003, 20:15	8.52
C100#12	40.83	18837.4	01Jan2003, 20:15	8.53
C100#13	34.73	17084.1	01Jan2003, 19:45	8.72
C100#14	32.50	16224.1	01Jan2003, 19:30	8.80
C100#15	28.36	14052.1	01Jan2003, 19:30	8.86
C100#16	23.73	11798.6	01Jan2003, 19:30	8.92
C100#17	21.75	10869.3	01Jan2003, 19:15	8.95
C100#18	20.73	10368.9	01Jan2003, 19:15	8.98
C100#19	18.31	9035.7	01Jan2003, 19:15	8.96
C100#2	87.76	36391.6	01Jan2003, 21:15	8.60
C100#20	15.07	7445.3	01Jan2003, 19:30	8.88
C100#21	7.91	3993.0	01Jan2003, 19:15	8.80
C100#22	5.07	2789.2	01Jan2003, 18:15	8.86
C100#23	3.23	1595.5	01Jan2003, 17:45	8.71
C100#24	2.26	1089.5	01Jan2003, 17:45	8.62
C100#3	86.15	35961.5	01Jan2003, 21:00	8.58
C100#4	68.69	28401.7	01Jan2003, 22:30	8.38
C100#5	65.31	27559.9	01Jan2003, 22:00	8.33
C100#6	63.55	27000.1	01Jan2003, 21:30	8.33
C100#7	57.28	25582.1	01Jan2003, 20:45	8.39
C100#8	55.05	24691.1	01Jan2003, 20:30	8.41
C100#9	48.74	22280.0	01Jan2003, 20:15	8.55
C100#D1	5.07	2699.4	01Jan2003, 19:00	8.86
C100#D2	3.23	1572.6	01Jan2003, 18:30	8.71

50-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1089.5	01Jan2003, 17:45	8.62
C100B	1.84	1445.6	01Jan2003, 16:45	9.14
C100B REACH#1	3.23	1572.6	01Jan2003, 18:30	8.71
C100B REACH#2	2.26	1088.1	01Jan2003, 18:00	8.61
C100C	2.84	1419.9	01Jan2003, 17:30	8.70
C100D	2.42	1527.4	01Jan2003, 17:30	9.16
C100D REACH#1	18.31	9032.6	01Jan2003, 19:30	8.96
C100D REACH#2	15.07	7437.2	01Jan2003, 19:30	8.88
C100D REACH#3	7.91	3986.0	01Jan2003, 19:15	8.80
C100E	2.24	1427.8	01Jan2003, 18:15	9.23
C100E REACH#1	23.73	11777.0	01Jan2003, 19:30	8.92
C100E REACH#2	21.75	10843.2	01Jan2003, 19:30	8.95
C100E REACH#3	20.73	10355.7	01Jan2003, 19:30	8.98
C100F	2.58	1684.1	01Jan2003, 17:45	8.47
C100F REACH	28.36	14025.6	01Jan2003, 19:45	8.85
C100G	2.23	1000.0	01Jan2003, 17:45	7.54
C100G REACH	32.50	16192.9	01Jan2003, 19:45	8.80
C100H	1.98	1793.0	01Jan2003, 17:00	8.97
C100H REACH#1	42.97	19778.4	01Jan2003, 20:30	8.51
C100H REACH#2	40.83	18796.6	01Jan2003, 20:30	8.52
C100I	3.79	2731.3	01Jan2003, 17:15	8.94
C100I REACH	44.95	20566.4	01Jan2003, 21:00	8.52
C100J	6.27	1681.0	01Jan2003, 19:30	7.95
C100J REACH	57.28	25388.1	01Jan2003, 21:30	8.37
C100K	1.76	1284.0	01Jan2003, 17:15	8.87
C100K#1	1.76	1284.0	01Jan2003, 17:15	8.87
C100L	3.38	3071.4	01Jan2003, 17:00	9.54
C100L REACH#1	65.31	27355.7	01Jan2003, 22:45	8.32
C100L REACH#2	63.55	26915.2	01Jan2003, 22:00	8.32
C100M	1.76	1080.3	01Jan2003, 18:00	9.81
C100M REACH#1	91.75	37286.0	01Jan2003, 22:30	8.62
C100M REACH#2	87.76	36154.6	01Jan2003, 22:00	8.59
C100M REACH#3	86.15	35904.6	01Jan2003, 21:15	8.58

50-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	28399.0	01Jan2003, 22:30	8.38
C100 REACH	5.07	2686.8	01Jan2003, 19:30	8.85
C102#1	2.90	1036.8	01Jan2003, 18:30	9.36
C102#OULET	3.99	2223.1	01Jan2003, 17:15	9.56
C102A	2.90	1036.8	01Jan2003, 18:30	9.36
C102B	1.09	1554.3	01Jan2003, 16:45	10.19
C102B REACH	2.90	1036.2	01Jan2003, 19:00	9.32
C103	1.61	2068.1	01Jan2003, 16:45	9.89
C106-00#1	14.39	9648.0	01Jan2003, 17:45	9.44
C106-00#2	9.59	7236.2	01Jan2003, 17:15	9.51
C106-00#3	4.84	3350.0	01Jan2003, 17:15	9.45
C106-00#OUTLET	17.46	11634.1	01Jan2003, 18:30	9.39
C106-01#1	2.78	1572.4	01Jan2003, 17:30	9.15
C106-01#OUTLET	4.80	2649.2	01Jan2003, 19:00	9.30
C106-08#OUTLET	1.82	1456.8	01Jan2003, 17:00	9.55
C106A	1.82	1456.8	01Jan2003, 17:00	9.55
C106B	3.02	1910.4	01Jan2003, 17:30	9.40
C106C	1.89	2219.8	01Jan2003, 16:45	9.56
C106C REACH	4.84	3328.7	01Jan2003, 17:30	9.45
C106D	2.86	1924.6	01Jan2003, 17:15	9.57
C106E	2.78	1572.4	01Jan2003, 17:30	9.15
C106F	2.02	1236.7	01Jan2003, 17:30	9.51
C106F REACH	2.78	1536.0	01Jan2003, 19:30	9.14
C106G	3.07	2656.3	01Jan2003, 17:00	9.17
C106G REACH#1	14.39	9454.3	01Jan2003, 18:45	9.44
C106G REACH#2	9.59	7166.0	01Jan2003, 17:45	9.51
C118	3.87	2779.1	01Jan2003, 17:45	9.02
C118_Diversion	3.87	1500.9	01Jan2003, 17:45	4.83
C118_Pond	0.00	441.9	01Jan2003, 22:45	
C1180000_0009_J	3.87	1501.6	01Jan2003, 17:45	6.81
C1180000_0009_R	1.93	1692.0	01Jan2003, 18:15	9.16
C118A	1.93	1787.1	01Jan2003, 17:15	9.16
C118B	1.94	2477.4	01Jan2003, 17:00	8.88

50-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1307.0	01Jan2003, 17:15	8.14
C120 REACH	55.05	24648.3	01Jan2003, 20:45	8.40
C123	2.44	1571.4	01Jan2003, 17:45	8.23
C123 REACH	48.74	22251.9	01Jan2003, 20:45	8.54
C127	2.14	1545.0	01Jan2003, 17:00	8.48
C132	4.07	1251.0	01Jan2003, 18:30	7.59
C134	2.03	623.3	01Jan2003, 19:30	7.30
C134 REACH	34.73	17022.9	01Jan2003, 20:15	8.71
C137	1.56	938.3	01Jan2003, 17:15	8.45
C143	1.98	1115.3	01Jan2003, 17:15	8.58
C144	1.02	594.6	01Jan2003, 17:15	8.41
C145#1	1.86	979.6	01Jan2003, 17:30	9.53
C145#OUTLET	3.24	1803.9	01Jan2003, 17:30	9.34
C145A	1.86	979.6	01Jan2003, 17:30	9.53
C145B	1.38	828.1	01Jan2003, 17:15	9.08
C147#1	1.82	943.2	01Jan2003, 17:30	9.23
C147#2	2.71	1358.6	01Jan2003, 17:45	8.82
C147#OUTLET	7.16	3460.6	01Jan2003, 19:45	8.98
C147A	1.82	943.2	01Jan2003, 17:30	9.23
C147B	2.71	1358.6	01Jan2003, 17:45	8.82
C147C	2.63	2043.8	01Jan2003, 17:15	9.06
C147C REACH	4.53	2038.8	01Jan2003, 20:30	8.93
C147 DETENTION	4.53	2070.2	01Jan2003, 19:45	8.94
C161	2.39	1006.6	01Jan2003, 18:15	7.93
C162	0.97	509.4	01Jan2003, 17:30	8.96
DET#1	4.53	2070.2	01Jan2003, 19:45	8.94
DET#2	4.53	2301.3	01Jan2003, 17:45	8.99
DETENTION REACH#1	5.07	2699.4	01Jan2003, 19:00	8.86
DETENTION REACH#2	3.23	1559.6	01Jan2003, 19:00	8.70
Outlet	93.51	37976.8	01Jan2003, 22:30	8.64

100-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-100

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(1%flood)
 Compute Time: 01Dec2015, 11:01:25 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	43005.0	01Jan2003, 22:00	10.40
C100#10	44.95	24835.5	01Jan2003, 20:30	10.31
C100#11	42.97	23878.3	01Jan2003, 20:30	10.29
C100#12	40.83	22760.2	01Jan2003, 20:15	10.30
C100#13	34.73	20618.8	01Jan2003, 19:45	10.52
C100#14	32.50	19577.7	01Jan2003, 19:45	10.61
C100#15	28.36	17000.6	01Jan2003, 19:30	10.66
C100#16	23.73	14318.3	01Jan2003, 19:30	10.73
C100#17	21.75	13216.6	01Jan2003, 19:30	10.77
C100#18	20.73	12609.2	01Jan2003, 19:30	10.80
C100#19	18.31	11037.7	01Jan2003, 19:30	10.77
C100#2	87.76	41753.0	01Jan2003, 21:30	10.37
C100#20	15.07	9162.5	01Jan2003, 19:30	10.69
C100#21	7.91	4779.7	01Jan2003, 19:15	10.60
C100#22	5.07	3306.4	01Jan2003, 18:15	10.67
C100#23	3.23	1890.7	01Jan2003, 18:00	10.52
C100#24	2.26	1292.4	01Jan2003, 17:45	10.41
C100#3	86.15	41266.2	01Jan2003, 21:30	10.35
C100#4	68.69	32926.7	01Jan2003, 23:15	10.13
C100#5	65.31	32028.2	01Jan2003, 22:45	10.08
C100#6	63.55	31429.2	01Jan2003, 22:15	10.08
C100#7	57.28	29702.6	01Jan2003, 21:30	10.17
C100#8	55.05	28734.2	01Jan2003, 21:30	10.18
C100#9	48.74	26316.6	01Jan2003, 21:15	10.33
C100#D1	5.07	3219.9	01Jan2003, 19:00	10.66
C100#D2	3.23	1868.9	01Jan2003, 18:30	10.51

100-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1292.4	01Jan2003, 17:45	10.41
C100B	1.84	1688.3	01Jan2003, 16:45	10.96
C100B REACH#1	3.23	1868.9	01Jan2003, 18:30	10.51
C100B REACH#2	2.26	1291.1	01Jan2003, 18:00	10.41
C100C	2.84	1681.9	01Jan2003, 17:45	10.51
C100D	2.42	1793.9	01Jan2003, 17:30	10.98
C100D REACH#1	18.31	11035.4	01Jan2003, 19:30	10.77
C100D REACH#2	15.07	9134.6	01Jan2003, 19:45	10.69
C100D REACH#3	7.91	4771.4	01Jan2003, 19:30	10.60
C100E	2.24	1680.6	01Jan2003, 18:15	11.05
C100E REACH#1	23.73	14302.3	01Jan2003, 19:45	10.73
C100E REACH#2	21.75	13178.7	01Jan2003, 19:45	10.76
C100E REACH#3	20.73	12610.1	01Jan2003, 19:30	10.79
C100F	2.58	1987.1	01Jan2003, 17:45	10.27
C100F REACH	28.36	16963.7	01Jan2003, 20:00	10.66
C100G	2.23	1198.8	01Jan2003, 17:45	9.30
C100G REACH	32.50	19551.1	01Jan2003, 20:00	10.60
C100H	1.98	2092.4	01Jan2003, 17:00	10.79
C100H REACH#1	42.97	23787.9	01Jan2003, 20:45	10.29
C100H REACH#2	40.83	22699.7	01Jan2003, 20:30	10.29
C100I	3.79	3204.3	01Jan2003, 17:15	10.75
C100I REACH	44.95	24497.0	01Jan2003, 21:30	10.29
C100J	6.27	2014.1	01Jan2003, 19:45	9.53
C100J REACH	57.28	29545.5	01Jan2003, 22:15	10.14
C100K	1.76	1505.9	01Jan2003, 17:15	10.68
C100K#1	1.76	1505.9	01Jan2003, 17:15	10.68
C100L	3.38	3572.6	01Jan2003, 17:00	11.37
C100L REACH#1	65.31	31868.7	01Jan2003, 23:15	10.07
C100L REACH#2	63.55	31353.0	01Jan2003, 22:45	10.07
C100M	1.76	1265.5	01Jan2003, 18:00	11.65
C100M REACH#1	91.75	42976.2	01Jan2003, 22:30	10.38
C100M REACH#2	87.76	41619.1	01Jan2003, 22:00	10.36
C100M REACH#3	86.15	41247.7	01Jan2003, 21:45	10.34

100-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	32928.6	01Jan2003, 23:15	10.13
C100 REACH	5.07	3206.2	01Jan2003, 19:30	10.66
C102#1	2.90	1228.5	01Jan2003, 19:00	11.10
C102#OULET	3.99	2572.3	01Jan2003, 17:15	11.32
C102A	2.90	1228.5	01Jan2003, 19:00	11.10
C102B	1.09	1785.4	01Jan2003, 16:45	12.05
C102B REACH	2.90	1227.5	01Jan2003, 19:15	11.05
C103	1.61	2384.0	01Jan2003, 16:45	11.73
C106-00#1	14.39	11149.2	01Jan2003, 17:45	11.27
C106-00#2	9.59	8442.8	01Jan2003, 17:15	11.34
C106-00#3	4.84	3918.0	01Jan2003, 17:15	11.29
C106-00#OUTLET	17.46	13574.6	01Jan2003, 18:30	11.22
C106-01#1	2.78	1850.7	01Jan2003, 17:30	10.97
C106-01#OUTLET	4.80	3129.3	01Jan2003, 19:15	11.12
C106-08#OUTLET	1.82	1698.5	01Jan2003, 17:00	11.38
C106A	1.82	1698.5	01Jan2003, 17:00	11.38
C106B	3.02	2240.6	01Jan2003, 17:30	11.23
C106C	1.89	2566.6	01Jan2003, 16:45	11.39
C106C REACH	4.84	3896.6	01Jan2003, 17:45	11.29
C106D	2.86	2250.3	01Jan2003, 17:15	11.40
C106E	2.78	1850.7	01Jan2003, 17:30	10.97
C106F	2.02	1449.7	01Jan2003, 17:30	11.34
C106F REACH	2.78	1813.1	01Jan2003, 19:30	10.96
C106G	3.07	3098.4	01Jan2003, 17:00	10.99
C106G REACH#1	14.39	11001.9	01Jan2003, 18:45	11.27
C106G REACH#2	9.59	8379.4	01Jan2003, 17:45	11.34
C118	3.87	3263.6	01Jan2003, 17:45	10.84
C118_Diversion	3.87	1782.5	01Jan2003, 17:30	5.60
C118_Pond	0.00	524.8	01Jan2003, 23:00	
C1180000_0009_J	3.87	1795.6	01Jan2003, 19:00	8.59
C1180000_0009_R	1.93	1984.1	01Jan2003, 18:15	10.98
C118A	1.93	2083.1	01Jan2003, 17:15	10.98
C118B	1.94	2866.2	01Jan2003, 17:00	10.69

100-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	1548.9	01Jan2003, 17:30	9.92
C120 REACH	55.05	28701.1	01Jan2003, 21:45	10.18
C123	2.44	1857.8	01Jan2003, 17:45	10.02
C123 REACH	48.74	26213.2	01Jan2003, 21:45	10.32
C127	2.14	1815.9	01Jan2003, 17:00	10.28
C132	4.07	1511.3	01Jan2003, 19:00	9.25
C134	2.03	755.1	01Jan2003, 19:45	8.96
C134 REACH	34.73	20554.2	01Jan2003, 20:15	10.51
C137	1.56	1108.1	01Jan2003, 17:15	10.24
C143	1.98	1317.3	01Jan2003, 17:30	10.38
C144	1.02	702.7	01Jan2003, 17:15	10.20
C145#1	1.86	1151.7	01Jan2003, 17:45	11.36
C145#OUTLET	3.24	2122.3	01Jan2003, 17:30	11.17
C145A	1.86	1151.7	01Jan2003, 17:45	11.36
C145B	1.38	973.5	01Jan2003, 17:15	10.91
C147#1	1.82	1112.3	01Jan2003, 17:45	11.05
C147#2	2.71	1606.8	01Jan2003, 17:45	10.63
C147#OUTLET	7.16	4391.1	01Jan2003, 19:30	10.79
C147A	1.82	1112.3	01Jan2003, 17:45	11.05
C147B	2.71	1606.8	01Jan2003, 17:45	10.63
C147C	2.63	2389.8	01Jan2003, 17:15	10.88
C147C REACH	4.53	2558.7	01Jan2003, 20:00	10.73
C147 DETENTION	4.53	2597.3	01Jan2003, 19:15	10.75
C161	2.39	1204.8	01Jan2003, 18:30	9.69
C162	0.97	601.6	01Jan2003, 17:45	10.77
DET#1	4.53	2597.3	01Jan2003, 19:15	10.75
DET#2	4.53	2719.1	01Jan2003, 17:45	10.80
DETENTION REACH#1	5.07	3219.9	01Jan2003, 19:00	10.66
DETENTION REACH#2	3.23	1856.7	01Jan2003, 19:00	10.50
Outlet	93.51	43802.9	01Jan2003, 22:15	10.41

500-YEAR MITIGATED

Project: C100-00-00 Simulation Run: Mitigated-500

Start of Run: 01Jan2003, 00:00 Basin Model: Mitigated
 End of Run: 03Jan2003, 00:00 Meteorologic Model: Region_3(.2%flood)
 Compute Time: 01Dec2015, 11:00:19 Control Specifications: JAN03

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100#1	91.75	56937.6	01Jan2003, 20:45	15.84
C100#10	44.95	32724.3	01Jan2003, 23:30	15.80
C100#11	42.97	32224.7	01Jan2003, 22:45	15.78
C100#12	40.83	31522.5	01Jan2003, 22:00	15.79
C100#13	34.73	28736.2	01Jan2003, 21:00	16.07
C100#14	32.50	27579.1	01Jan2003, 19:45	16.17
C100#15	28.36	23908.4	01Jan2003, 20:15	16.24
C100#16	23.73	20247.6	01Jan2003, 20:30	16.32
C100#17	21.75	19484.0	01Jan2003, 19:45	16.36
C100#18	20.73	18654.0	01Jan2003, 19:30	16.39
C100#19	18.31	16469.5	01Jan2003, 19:15	16.36
C100#2	87.76	55633.1	01Jan2003, 19:45	15.81
C100#20	15.07	13901.1	01Jan2003, 19:00	16.27
C100#21	7.91	6992.1	01Jan2003, 19:15	16.19
C100#22	5.07	4708.6	01Jan2003, 18:30	16.26
C100#23	3.23	2767.8	01Jan2003, 18:15	16.09
C100#24	2.26	1896.8	01Jan2003, 18:00	15.98
C100#3	86.15	54189.5	01Jan2003, 19:45	15.79
C100#4	68.69	38579.9	02Jan2003, 01:30	15.53
C100#5	65.31	38049.5	02Jan2003, 00:45	15.48
C100#6	63.55	37535.3	01Jan2003, 23:45	15.49
C100#7	57.28	35300.3	01Jan2003, 20:30	15.64
C100#8	55.05	34377.7	02Jan2003, 01:15	15.66
C100#9	48.74	32542.1	02Jan2003, 01:30	15.81
C100#D1	5.07	4641.7	01Jan2003, 19:00	16.25
C100#D2	3.23	2677.9	01Jan2003, 19:30	16.08

500-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100A	2.26	1896.8	01Jan2003, 18:00	15.98
C100B	1.84	2381.2	01Jan2003, 17:00	16.60
C100B REACH#1	3.23	2677.9	01Jan2003, 19:30	16.08
C100B REACH#2	2.26	1894.8	01Jan2003, 18:15	15.97
C100C	2.84	2460.9	01Jan2003, 18:00	16.09
C100D	2.42	2573.3	01Jan2003, 17:45	16.62
C100D REACH#1	18.31	16360.2	01Jan2003, 19:45	16.36
C100D REACH#2	15.07	13616.8	01Jan2003, 19:45	16.27
C100D REACH#3	7.91	6982.1	01Jan2003, 19:15	16.18
C100E	2.24	2412.9	01Jan2003, 18:15	16.65
C100E REACH#1	23.73	20210.5	01Jan2003, 21:00	16.31
C100E REACH#2	21.75	18749.0	01Jan2003, 20:45	16.35
C100E REACH#3	20.73	18596.7	01Jan2003, 19:45	16.39
C100F	2.58	2868.0	01Jan2003, 18:00	15.81
C100F REACH	28.36	23888.7	01Jan2003, 20:45	16.23
C100G	2.23	1792.4	01Jan2003, 18:00	14.73
C100G REACH	32.50	27260.4	01Jan2003, 21:15	16.16
C100H	1.98	2928.3	01Jan2003, 17:00	16.37
C100H REACH#1	42.97	31916.5	01Jan2003, 23:45	15.77
C100H REACH#2	40.83	31091.8	01Jan2003, 23:15	15.78
C100I	3.79	4565.8	01Jan2003, 17:15	16.33
C100I REACH	44.95	31347.7	02Jan2003, 01:45	15.77
C100J	6.27	3006.7	01Jan2003, 19:45	14.40
C100J REACH	57.28	35047.1	02Jan2003, 03:00	15.60
C100K	1.76	2144.8	01Jan2003, 17:30	16.26
C100K#1	1.76	2144.8	01Jan2003, 17:30	16.26
C100L	3.38	4970.3	01Jan2003, 17:15	17.00
C100L REACH#1	65.31	37902.3	02Jan2003, 03:00	15.46
C100L REACH#2	63.55	37440.1	02Jan2003, 02:00	15.46
C100M	1.76	1810.8	01Jan2003, 18:15	17.30
C100M REACH#1	91.75	56608.6	01Jan2003, 21:15	15.81
C100M REACH#2	87.76	54566.1	01Jan2003, 20:45	15.79
C100M REACH#3	86.15	54150.1	01Jan2003, 19:45	15.79

500-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C100M REACH#4	68.69	38579.1	02Jan2003, 01:30	15.53
C100 REACH	5.07	4630.1	01Jan2003, 19:30	16.24
C102#1	2.90	1802.6	01Jan2003, 19:15	16.42
C102#OULET	3.99	3584.9	01Jan2003, 17:15	16.73
C102A	2.90	1802.6	01Jan2003, 19:15	16.42
C102B	1.09	2400.3	01Jan2003, 16:45	17.73
C102B REACH	2.90	1798.9	01Jan2003, 19:45	16.36
C103	1.61	3230.8	01Jan2003, 16:45	17.39
C106-00#1	14.39	15757.6	01Jan2003, 18:15	16.89
C106-00#2	9.59	11907.0	01Jan2003, 17:30	16.98
C106-00#3	4.84	5566.8	01Jan2003, 17:30	16.92
C106-00#OUTLET	17.46	18806.0	01Jan2003, 19:15	16.84
C106-01#1	2.78	2677.2	01Jan2003, 17:45	16.56
C106-01#OUTLET	4.80	4549.1	01Jan2003, 19:15	16.72
C106-08#OUTLET	1.82	2383.7	01Jan2003, 17:15	17.02
C106A	1.82	2383.7	01Jan2003, 17:15	17.02
C106B	3.02	3208.9	01Jan2003, 17:45	16.85
C106C	1.89	3497.2	01Jan2003, 16:45	17.03
C106C REACH	4.84	5544.1	01Jan2003, 17:45	16.92
C106D	2.86	3205.1	01Jan2003, 17:30	17.04
C106E	2.78	2677.2	01Jan2003, 17:45	16.56
C106F	2.02	2079.0	01Jan2003, 17:45	16.97
C106F REACH	2.78	2637.2	01Jan2003, 19:45	16.55
C106G	3.07	4348.7	01Jan2003, 17:15	16.59
C106G REACH#1	14.39	15405.7	01Jan2003, 19:45	16.89
C106G REACH#2	9.59	11807.1	01Jan2003, 17:45	16.98
C118	3.87	4658.7	01Jan2003, 17:45	16.43
C118_Diversion	3.87	2842.2	01Jan2003, 17:30	8.26
C118_Pond	0.00	722.2	01Jan2003, 23:30	
C1180000_0009_J	3.87	3213.7	01Jan2003, 17:45	14.02
C1180000_0009_R	1.93	2822.1	01Jan2003, 18:00	16.58
C118A	1.93	2909.8	01Jan2003, 17:15	16.58
C118B	1.94	3916.1	01Jan2003, 17:00	16.27

500-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI ²)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
C120	2.23	2258.8	01Jan2003, 17:45	15.44
C120 REACH	55.05	34327.5	02Jan2003, 02:00	15.65
C123	2.44	2689.3	01Jan2003, 18:00	15.54
C123 REACH	48.74	32358.1	02Jan2003, 02:15	15.80
C127	2.14	2595.0	01Jan2003, 17:15	15.82
C132	4.07	2294.7	01Jan2003, 19:15	14.39
C134	2.03	1149.1	01Jan2003, 20:00	14.08
C134 REACH	34.73	28429.8	01Jan2003, 22:15	16.05
C137	1.56	1608.0	01Jan2003, 17:30	15.78
C143	1.98	1918.1	01Jan2003, 17:30	15.93
C144	1.02	1022.7	01Jan2003, 17:30	15.74
C145#1	1.86	1664.3	01Jan2003, 18:00	17.00
C145#OUTLET	3.24	3062.5	01Jan2003, 17:45	16.80
C145A	1.86	1664.3	01Jan2003, 18:00	17.00
C145B	1.38	1403.0	01Jan2003, 17:30	16.54
C147#1	1.82	1614.2	01Jan2003, 18:00	16.67
C147#2	2.71	2347.9	01Jan2003, 18:15	16.22
C147#OUTLET	7.16	7018.3	01Jan2003, 18:45	16.38
C147A	1.82	1614.2	01Jan2003, 18:00	16.67
C147B	2.71	2347.9	01Jan2003, 18:15	16.22
C147C	2.63	3379.6	01Jan2003, 17:30	16.51
C147C REACH	4.53	3936.0	01Jan2003, 19:00	16.30
C147 DETENTION	4.53	3948.9	01Jan2003, 18:30	16.32
C161	2.39	1800.1	01Jan2003, 18:45	15.11
C162	0.97	875.2	01Jan2003, 18:00	16.38
DET#1	4.53	3948.9	01Jan2003, 18:30	16.32
DET#2	4.53	3962.0	01Jan2003, 18:00	16.40
DETENTION REACH#1	5.07	4641.7	01Jan2003, 19:00	16.25
DETENTION REACH#2	3.23	2668.6	01Jan2003, 19:45	16.07
Outlet	93.51	58039.9	01Jan2003, 21:15	15.84

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: C11
Project: Salt Water Ditch
Project #: 325912
Date: 8/27/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	10-year Peak Flows (cfs)					50-year Peak Flows (cfs)				
	Revised Existing	Proposed	Mitigated	ΔQ (Proposed - Revised Existing)	ΔQ (Mitigated - Revised Existing)	Revised Existing	Proposed	Mitigated	ΔQ (Proposed - Revised Existing)	ΔQ (Mitigated - Revised Existing)
Outlet	22659	22968	22355	309	-304	38129	38732	37977	603	-152
C100#1	22275	22578	21978	303	-297	37454	38046	37322	592	-132
C100#2	21690	21971	21388	281	-302	36516	37058	36392	542	-124
C100#3	21518	21784	21211	266	-307	36066	36561	35962	495	-104
C100#4	17352	17517	17031	165	-321	28471	28933	28402	462	-69
C100#5	16912	17055	16588	143	-324	27617	28087	27560	471	-57
C100#6	16624	16776	16298	151	-326	27056	27525	27000	469	-56
C100#7	15785	15934	15456	148	-329	25631	26171	25582	540	-49
C100#8	15287	15419	14961	132	-326	24741	25248	24691	507	-50
C118 outfall	1343	2371	1078	1028	-265	2005	3628	1502	1623	-503
C118A	540	1223	1223	683	683	829	1787	1787	958	958
C118B	1195	1732	1732	537	537	1753	2477	2477	725	725

COMPUTED SIMS BAYOU C100-00-00 PEAK FLOW RATES AND IMPACTS

Table ID: C12
Project: Salt Water Ditch
Project #: 325912
Date: 8/27/2015
Prepared By: PH
Checked By: CM

HEC-HMS Node	100-year Peak Flows (cfs)					500-year Peak Flows (cfs)				
	Revised Existing	Proposed	Mitigated	ΔQ (Proposed - Revised Existing)	ΔQ (Mitigated - Revised Existing)	Revised Existing	Proposed	Mitigated	ΔQ (Proposed - Revised Existing)	ΔQ (Mitigated - Revised Existing)
Outlet	43940	44997	43803	1058	-137	58175	59054	58040	879	-135
C100#1	43125	44185	43005	1060	-120	57116	57871	56938	754	-179
C100#2	41870	42938	41753	1068	-117	55646	56217	55633	572	-12
C100#3	41373	42435	41266	1062	-107	54234	54623	54190	389	-45
C100#4	32957	33346	32927	388	-31	38602	40375	38580	1773	-22
C100#5	32050	32390	32028	340	-22	38078	39435	38050	1358	-28
C100#6	31450	31898	31429	448	-21	37568	38835	37535	1267	-32
C100#7	29718	30119	29703	402	-15	35373	37130	35300	1758	-72
C100#8	28744	29113	28734	369	-10	34422	35902	34378	1480	-44
C118 outfall	2328	4274	1796	1946	-532	3189	6117	3214	2928	25
C118A	983	2083	2083	1100	1100	1445	2910	2910	1465	1465
C118B	2046	2866	2866	821	821	2858	3916	3916	1058	1058

APPENDIX D

COSTS

- **COSTS FOR PROPOSED ALTERNATIVE 1**
- **COSTS FOR PROPOSED ALTERNATIVE 2**

COSTS FOR PROPOSED ALTERNATIVE 1

Table ID: D1
Project: Salt Water Ditch
Project #: 325912
Date: 12/1/2015
Prepared By: PH
Checked By: CM

Description	Unit	Unit Price	Units	Total Cost
Channel Items				
Clearing and Grubbing	AC	\$4,500	70	\$315,000
Channel Excavation - Offsite Disposal	CY	\$12	622140	\$7,465,680
Channel Excavation - Use as Fill	CY	\$8	44875	\$359,000
Relocate Centerpoint Energy Utilities	LS	Further Coordination Required		
Bridge Replacement	SF	\$100	70210	\$7,021,000
Backslope Swale Interceptor	LF	\$3	21615	\$64,845
Riprap	SY	\$31	3200	\$99,200
Anchored Sodding	LF	\$4.30	15000	\$64,500
Dry Seeding	AC	\$1,500	70	\$105,000
Sheetpile Drop Structure	LS	\$150,000	1	\$150,000
12' x 8' RCB	LF	\$1,150	0	\$0
12' x 10' RCB	LF	\$1,200	0	\$0
Land Acquisition - Drainage Easements	AC	\$80,700	0.31	\$25,017
Land Acquisition - Full Parcel Acquisitions	3x Market Value			\$32,835,147
Detention Items				
Clearing and Grubbing	AC	\$4,500	40	\$180,000
Detention Pond Excavation	AC-FT	\$22,875	70	\$1,601,250
Dry Seeding	AC	\$1,500	40	\$60,000
Control Structure	LS	\$300,000	1	\$300,000
Land Acquisition - Detention	AC	\$80,700	40	\$3,228,000
Contingency	20% of TOTAL			\$9,700,878
TOTAL				\$63,574,517

COSTS FOR PROPOSED ALTERNATIVE 2

Table ID: D2
Project: Salt Water Ditch
Project #: 325912
Date: 12/1/2015
Prepared By: PH
Checked By: CM

Description	Unit	Unit Price	Units	Total Cost
Channel Items				
Clearing and Grubbing	AC	\$4,500	70	\$315,000
Channel Excavation - Offsite Disposal	CY	\$12	426025	\$5,112,300
Channel Excavation - Use as Fill	CY	\$8	40080	\$320,640
Relocate Centerpoint Energy Utilities	LS	Further Coordination Required		
Bridge Replacement	SF	\$100	41110	\$4,111,000
Backslope Swale Interceptor	LF	\$3	15960	\$47,880
Riprap	SY	\$31	1970	\$61,070
Anchored Sodding	LF	\$4.30	9000	\$38,700
Dry Seeding	AC	\$1,500	44	\$66,000
Sheetpile Drop Structure	LS	\$150,000	1	\$150,000
12' x 8' RCB	LF	\$1,150	12948	\$14,890,200
12' x 10' RCB	LF	\$1,200	5850	\$7,020,000
Land Acquisition - Drainage Easements	AC	\$80,700	2.28	\$183,996
Land Acquisition - Full Parcel Acquisitions	3x Market Value			\$22,320,987
Detention Items				
Clearing and Grubbing	AC	\$4,500	40	\$180,000
Detention Pond Excavation	AC-FT	\$22,875	70	\$1,601,250
Dry Seeding	AC	\$1,500	40	\$60,000
Control Structure	LS	\$300,000	1	\$300,000
Land Acquisition - Detention	AC	\$80,700	40	\$3,228,000
Contingency	20% of TOTAL			\$10,927,555
TOTAL				\$70,934,578

ADDENDUM TO
FEASIBILITY STUDY FOR
FLOOD DAMAGE REDUCTION
TO SALT WATER DITCH,
HCFC D UNIT C118-00-00

CITY OF HOUSTON
WBS NO. M-000100-0012-3



April 6, 2018

CEI Project No. 325912.00
April 2018

Submitted By:
CivilTech
Engineering, Inc.
Firm Registration No. F-382

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EXHIBITS

- Exhibit 1 – Alternative 3 Layout
- Exhibit 2 – Alternative 3 Water Surface Profile
- Exhibit 3 – Alternative 3 Typical Cross Section
- Exhibit 4 – Alternative 4 Layout
- Exhibit 5 – Alternative 4 Water Surface Profile
- Exhibit 6 – Alternative 4 Typical Cross Section
- Exhibit 7 – Alternative 3 Residual 100-Year Floodplain
- Exhibit 8 – Alternative 4 Residual 100-Year Floodplain
- Exhibit 9 – Flooded Structures

APPENDICIES

- Appendix A: Alternative Analysis

Introduction

CivilTech Engineering, Inc. (CivilTech) was contracted by the City of Houston to perform additional services in Work Order No. 12, under the “Feasibility Study for Flood Damage Reduction on Salt Water Ditch (HCFCU Unit No. C118-00-00) including Alternate Level of Service Analysis”, WBS No. M-000100-0012-3, Ordinance No. 2013-11179, Contract No. 4600011469. The additional services include an alternate level of service analysis to the previously approved report prepared by CivilTech:

- Feasibility Study for Flood Damage Reduction to Salt Water Ditch, HCFCU Unit C118-00-00, City of Houston, WBS No. M-000100-0012-3, dated February 22, 2016, prepared by CivilTech Engineering, Inc.

The original study analyzed flood reduction options within the Salt Water Ditch Watershed in conjunction with Pre-Engineering Need Area M-2014-034. Alternatives included: 1) channel improvements to Salt Water Ditch to contain the 100-year storm event within channel banks and 2) channel improvements utilizing a closed storm sewer system to convey the 100-year storm event for a portion of Salt Water Ditch. The second alternative reduced proposed right-of-way (ROW) versus the first alternative; however, this alternative proved costly and therefore, limited the storm sewer to Martin Luther King Blvd. to keep costs comparable to the first alternative.

In order to minimize parcel acquisitions and costs, the City of Houston requested two additional alternatives as part of the Feasibility Study for Flood Damage Reduction to Salt Water Ditch. Alternative 3 will be a closed storm sewer system providing a 5-year level of service and Alternative 4 will be a closed storm sewer system providing a 10-year level of service. The purpose of this addendum report analyzes these two additional alternatives to improve Salt Water Ditch.

Enclosing Channel with Box Storm Sewer – Alternative 3

Alternative 3 is a closed storm sewer system providing a 5-year level of service. The storm sewers were sized using the Manning’s equation with the HGL below existing channel banks as done in the original analysis. A tailwater was interpolated from the Revised Existing HEC-RAS model developed for Salt Water Ditch from the original analysis. In order for proposed storm sewers from Need Area M-2014-034 to discharge into Salt Water Ditch at Calhoun Rd., the flowline for the storm sewer system was set at 27 ft. at Calhoun Rd. A constant slope of 0.05% was used and maintained throughout the entire system until it daylighted into the existing channel flowline, occurring approximately 1313 feet downstream of Vasser Rd. Revised Existing hydrology was used as the assumptions of a fully developed sub-basin and 100% channel conveyance used to develop the proposed conditions peak flows did not apply for this alternative.

A swale with 6 ft. bottom width and 4H:1V side slopes was designed to lie on top of the storm sewer system. To provide a minimum cover for the storm sewers, the swale was placed 2 ft. above the storm sewer at the downstream end and maintained a 0.05% slope.

Table 1 shows the proposed storm sewer sizes, with the calculations provided in **Appendix A**. A plan view of the Alternative 3 layout is shown on **Exhibit 1** and a plot of the water surface profile is provided as **Exhibit 2**. Three typical channel cross sections were developed to show the storm sewers with the swale. The proposed typical channel cross sections are shown on **Exhibit 3** with their locations shown on **Exhibit 2**.

Existing Salt Water Ditch drainage easements are owned by HCFCD and vary between 30 and 70 ft. These existing drainage easements are presented in Appendix A of the original report. A minimum storm sewer easement width requirement for this alternative was calculated based on City of Houston criteria found in the Infrastructure Design Manual, Chapter 5 which states: "Maintenance operations require an easement width equal to the storm sewer width plus the depth rounded up to the nearest multiple of 5-feet." **Table 1** presents the minimum storm sewer easement width required for each storm sewer segment. The existing drainage easements have sufficient width to accommodate the minimum storm sewer easement width required. Minimum storm sewer easement calculations are provided in **Appendix A**.

Table 1: Alternative 3 Storm Sewer Design Summary

Road From	Road To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Minimum Storm Sewer Easement Width (ft)	Existing HCFCDD Drainage Easement (ft)	Additional Easement Needed (ft)
Calhoun	Jutland	2	6	6	27	30	0
Jutland	St Lo	2	6	6	27	35	0
St Lo	Van Fleet	2	8	6	31	35	0
Van Fleet	Martin Luther King	2	8	6	31	50/70	0
Martin Luther King	Southbank	2	8	6	31	50	0
Southbank	Crestmont	2	8	8	36	70	0
Crestmont	Doulton	2	8	8	36	70	0
Doulton	Belfort	2	8	8	36	70	0
Belfort	Vasser	2	10	8	40	70	0
Vasser	End of Culvert	2	10	8	40	70	0

Enclosing Channel with Box Storm Sewer – Alternative 4

Alternative 4 is a closed storm sewer system providing a 10-year level of service. The storm sewers were sized using the Manning's equation with the HGL below existing channel banks as done in the original analysis. A tailwater was interpolated from the Revised Existing HEC-RAS model developed for Salt Water Ditch from the original analysis. In order for proposed storm sewers from Need Area M-2014-034 to discharge into Salt Water Ditch at Calhoun Rd., the flowline for the storm sewer system was set at 27 ft. at Calhoun Rd. A constant slope of 0.05% was used and maintained throughout the entire system until it daylighted into the existing channel flowline, occurring approximately 1313 feet downstream of Vasser Rd. Revised Existing hydrology was used as the assumptions of a fully developed sub-basin and 100% channel conveyance used to develop the proposed conditions peak flows did not apply for this alternative.

A swale with 6 ft. bottom width and 4H:1V side slopes was designed to lie on top of the storm sewer system. To provide a minimum cover for the storm sewers, the swale was placed 2 ft. above the storm sewer at the downstream end and maintained a 0.05% slope.

Table 2 shows the proposed storm sewer sizes, with the calculations provided in **Appendix A**. A plan view of the Alternative 3 layout is shown on **Exhibit 4** and a plot of the water surface profile is provided as **Exhibit 5**. Three typical channel cross sections were developed to show the storm sewers with the swale. The proposed typical channel cross sections are shown on **Exhibit 6** with their locations shown on **Exhibit 4**.

Existing Salt Water Ditch drainage easements are owned by HCFCD and vary between 30 and 70 ft. These existing drainage easements are presented in Appendix A of the original report. A minimum storm sewer easement width requirement for this alternative was calculated based on City of Houston criteria found in the Infrastructure Design Manual, Chapter 5 which states: "Maintenance operations require an easement width equal to the storm sewer width plus the depth rounded up to the nearest multiple of 5-feet." **Table 1** presents the minimum storm sewer easement width required for each storm sewer segment. The existing drainage easements have sufficient width to accommodate the minimum storm sewer easement width required. Minimum storm sewer easement calculations are provided in **Appendix A**.

Table 2: Alternative 4 Storm Sewer Design Summary.

Road From	Road To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Minimum Storm Sewer Easement Width (ft)	Existing HCFCROW (ft)	Additional Easement Needed (ft)
Calhoun	Jutland	2	6	6	27	30	0
Jutland	St Lo	2	8	6	31	35	0
St Lo	Van Fleet	2	8	6	31	35	0
Van Fleet	Martin Luther King	2	8	8	31	50/70	0
Martin Luther King	Southbank	2	8	8	31	50	0
Southbank	Crestmont	2	8	8	36	70	0
Crestmont	Doulton	2	10	8	40	70	0
Doulton	Belfort	2	10	8	40	70	0
Belfort	Vasser	2	10	10	40	70	0
Vasser	End of Culvert	2	10	10	40	70	0

Cost Estimate

Unit costs were taken from the original study and applicable unit costs for Alternatives 3 and 4 are provided in **Table 3**. A few additional unit costs were needed and include storm sewer sizes, manholes, and inlets. These additional unit costs are based from the FY18 Pre-Engineering Unit Prices provided by the City of Houston. The cost estimates are shown in **Table 4** and the calculations are provided in **Appendix A**.

Table 3: Project Unit Costs

Description	Unit	Unit Price
Inlets	EA	\$2,910
Manhole for Larger than 78" Storm Sewer	EA	\$16,500
Riprap	SY	\$31
6' x 6' RCB	LF	\$480
8' x 6' RCB	AC	\$770
8' x 8' RCB	LS	\$920
10' x 8' RCB	LF	\$960
10' x 10' RCB	LF	\$1,300
Bridge Replacement	SF	\$100
Trench Safety System	LF	\$2
Land Acquisition - Drainage Easements	AC	\$80,700
Land Acquisition - Full Parcel Acquisitions	--	3x Market Value
Environmental Study	--	Further Analysis Required

Table 4: Alternative Cost Comparison

Alternative	Channel Cost	Contingency	Total Cost
3	\$31,932,959	\$6,386,592	\$38,319,551
4	\$36,200,539	\$7,240,108	\$43,440,647

Estimated Flooded Structures

In order to estimate the number of flooded structures for each storm event, new HEC-RAS models were developed for Alternatives 3 and 4. The Revised Existing HEC-RAS model from the original study was used as the base model. Changes to the Revised Existing model include altering peak flows and the channel. Changes to the channel include replacing the existing Salt Water Ditch with the swale section described earlier. Peak flow changes assume the storm sewer systems will receive the entirety of flow from their designed storm event and a residual peak flow was created by subtracting out the design peak flow from each storm event analyzed.

The 100-yr residual floodplains for Alternatives 3 and 4 were mapped based on the new HEC-RAS models and are shown in **Exhibits 7** and **8**. The number of flooded structures were also estimated from the new HEC-RAS model and are provided in **Tables 5** and **6**. **Exhibit 9** shows the location of the flooded structures.

Table 5: Overview of Flood-Affected Structures - Alternative 3

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	25	138	268	613
B	0	0	4	291	719	970	1143
C	0	0	59	271	460	733	1406
Total	0	0	63	587	1317	1971	3162
Fraction of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0.00	0.00	0.00	0.03	0.16	0.31	0.70
B	0.00	0.00	0.00	0.24	0.60	0.82	0.96
C	0.00	0.00	0.03	0.14	0.23	0.37	0.70
Total	0.00	0.00	0.02	0.14	0.32	0.49	0.78

Table 6: Overview of Flood-Affected Structures - Alternative 4

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	1	45	171	550
B	0	0	0	23	381	819	1121
C	0	0	0	126	302	546	1288
Total	0	0	0	150	728	1536	2959
Fraction of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0.00	0.00	0.00	0.00	0.05	0.20	0.63
B	0.00	0.00	0.00	0.02	0.32	0.69	0.94
C	0.00	0.00	0.00	0.06	0.15	0.27	0.64
Total	0.00	0.00	0.00	0.04	0.18	0.38	0.73

Detention

Improvements to Salt Water Ditch will decrease time of concentration and storage within the sub-basin; therefore, peak flows into Sims Bayou will increase. This increase in peak flow into Sims Bayou will require detention to mitigate impacts. Detention mitigation was calculated and three potential sites for detention ponds were given in the original analysis. Detention for alternatives 3 and 4 was not part of the scope for this addendum but will be required and should be provided during the design phase.

EXHIBITS

EXHIBIT 1: ALTERNATIVE 3 LAYOUT

EXHIBIT 2: ALTERNATIVE 3 WATER SURFACE PROFILE

EXHIBIT 3: ALTERNATIVE 3 TYPICAL CROSS SECTION

EXHIBIT 4: ALTERNATIVE 4 LAYOUT

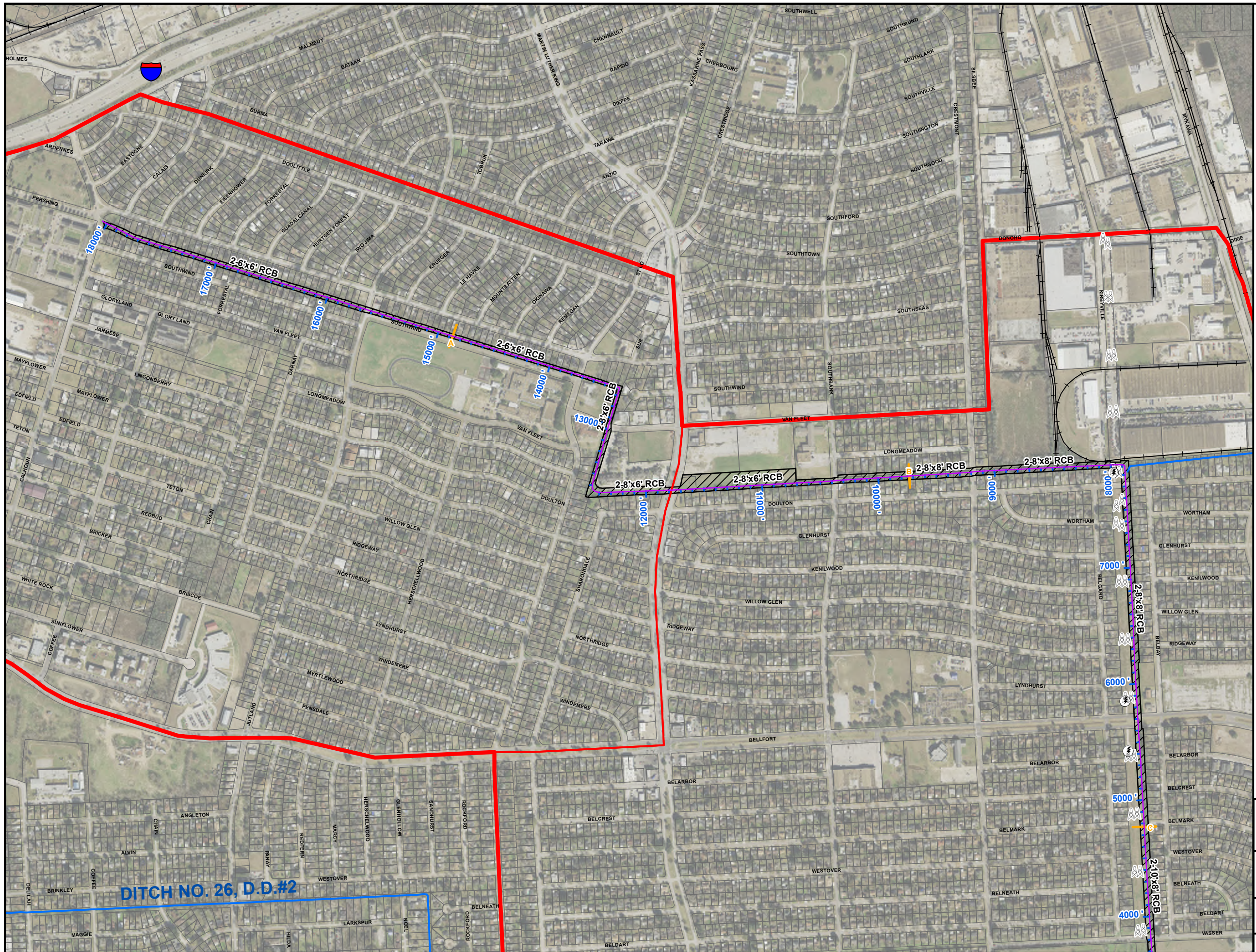
EXHIBIT 5: ALTERNATIVE 4 WATER SURFACE PROFILE

EXHIBIT 6: ALTERNATIVE 4 TYPICAL CROSS SECTION

EXHIBIT 7: ALTERNATIVE 3 RESIDUAL 100-YEAR FLOODPLAIN

EXHIBIT 8: ALTERNATIVE 4: RESIDUAL 100-YEAR FLOODPLAIN

EXHIBIT 9: FLOODED STRUCTURES



0 400 800 ft

1 inch = 800 feet

Legend

- Proposed Storm Sewer
 - Streams
 - Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC D UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 LAYOUT



0 400 800 ft

1 inch = 800 feet

Legend

- Proposed Storm Sewer
 - Streams
 - Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

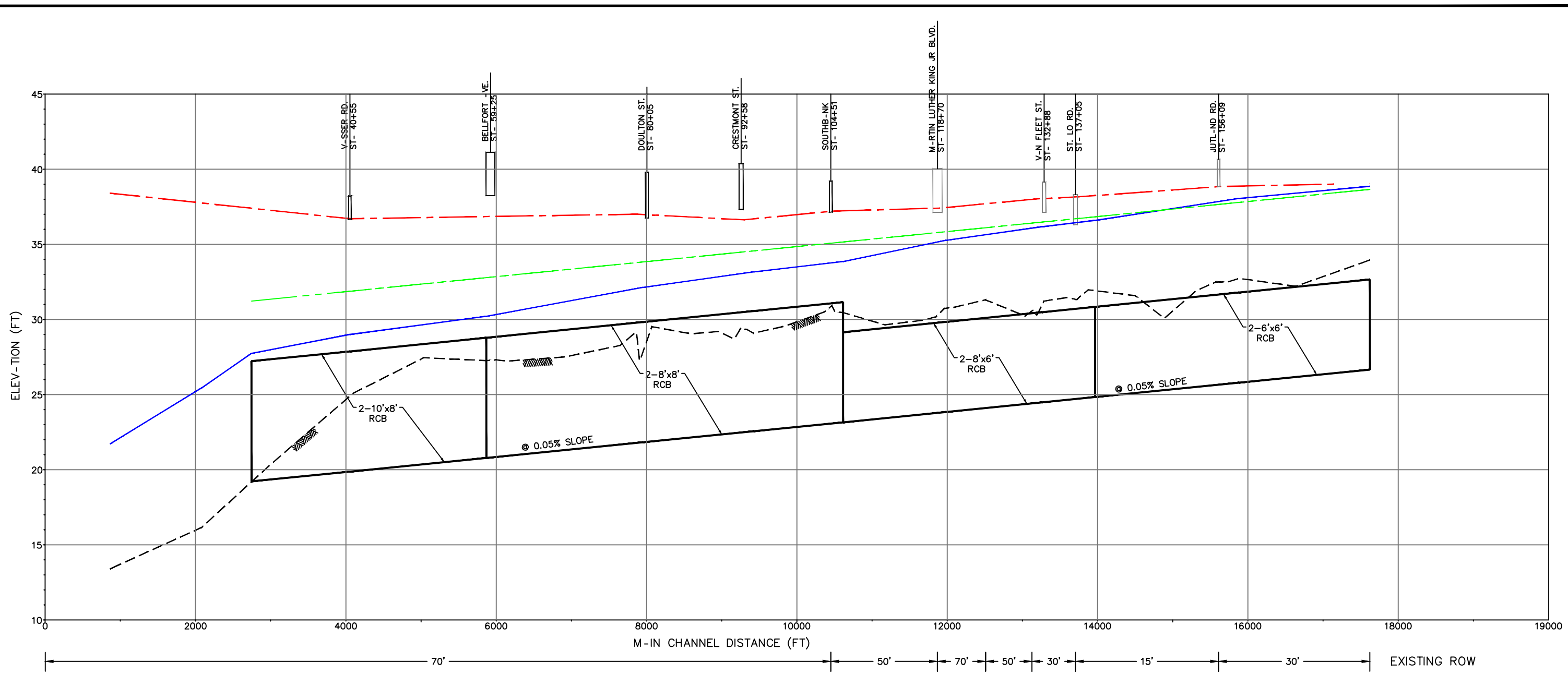
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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 LAYOUT



LEGEND

—	PROPOSED 5-YR WSEL
—	PROPOSED STORM SEWER FLOW LINE
- - -	EXISTING FLOW LINE
- . - . -	CRITICAL ELEVATION
- - -	PROPOSED CHANNEL FLOW LINE

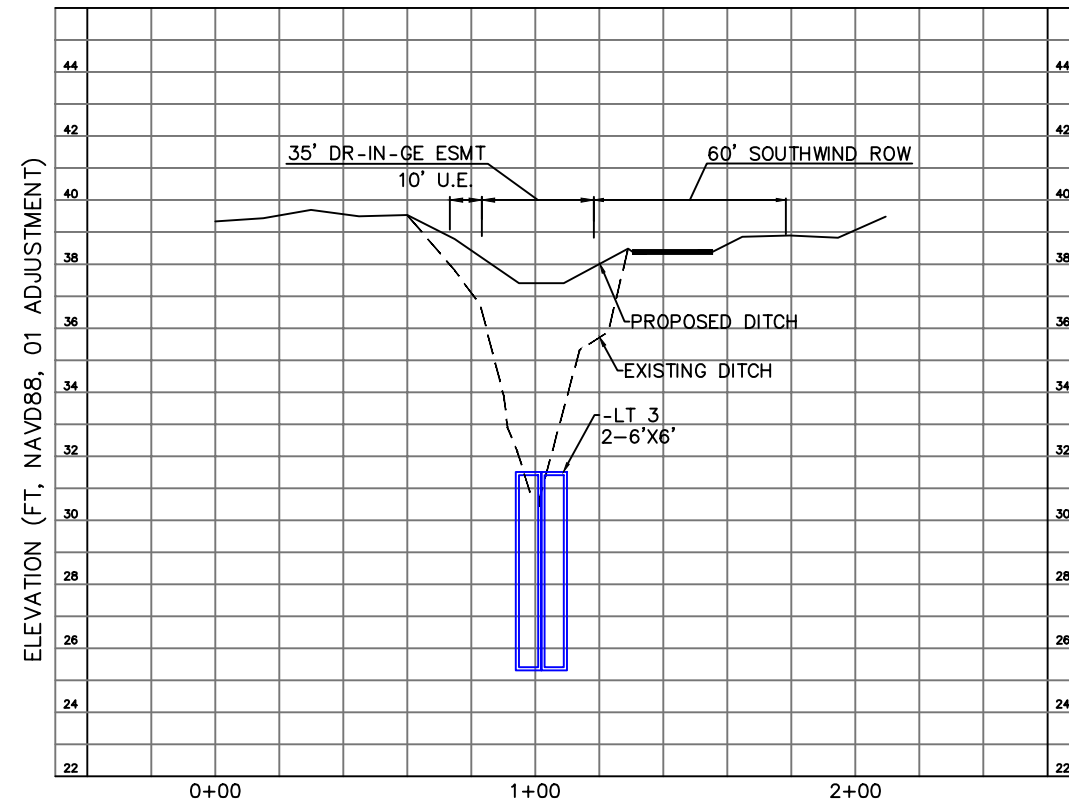
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 COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 3 WATER SURFACE PROFILE
 Date: MARCH 2018
 Exhibit No: 2

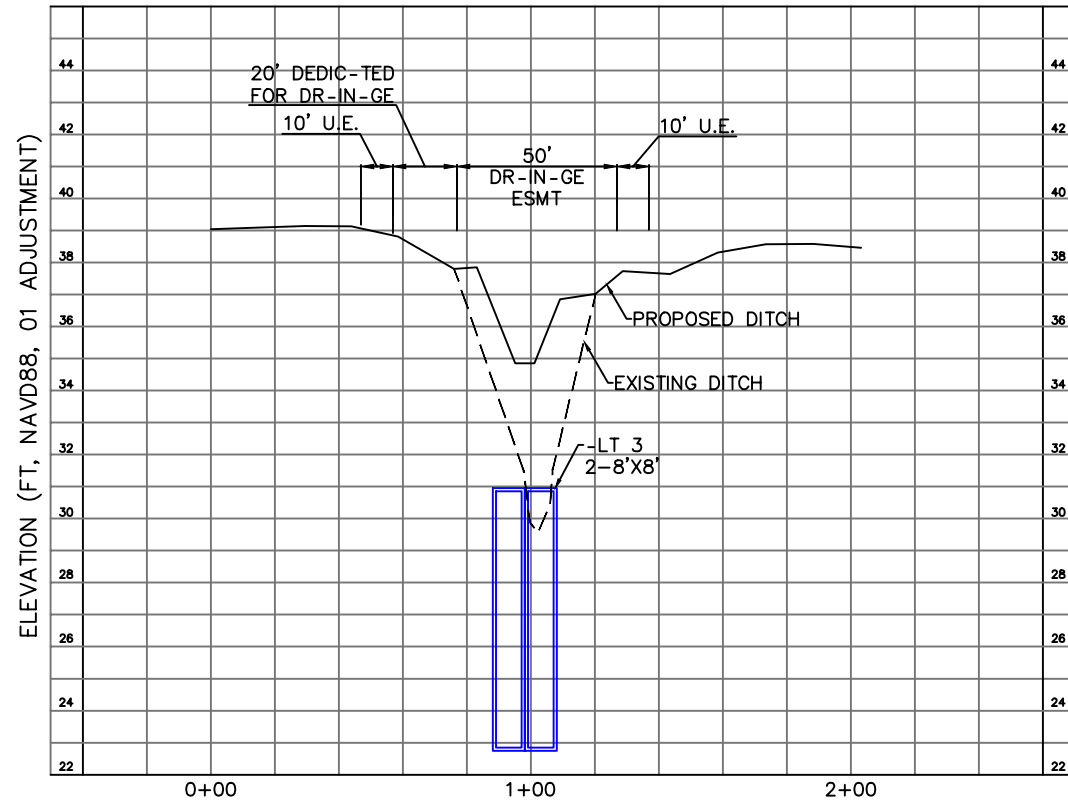
TYPICAL CROSS SECTION A



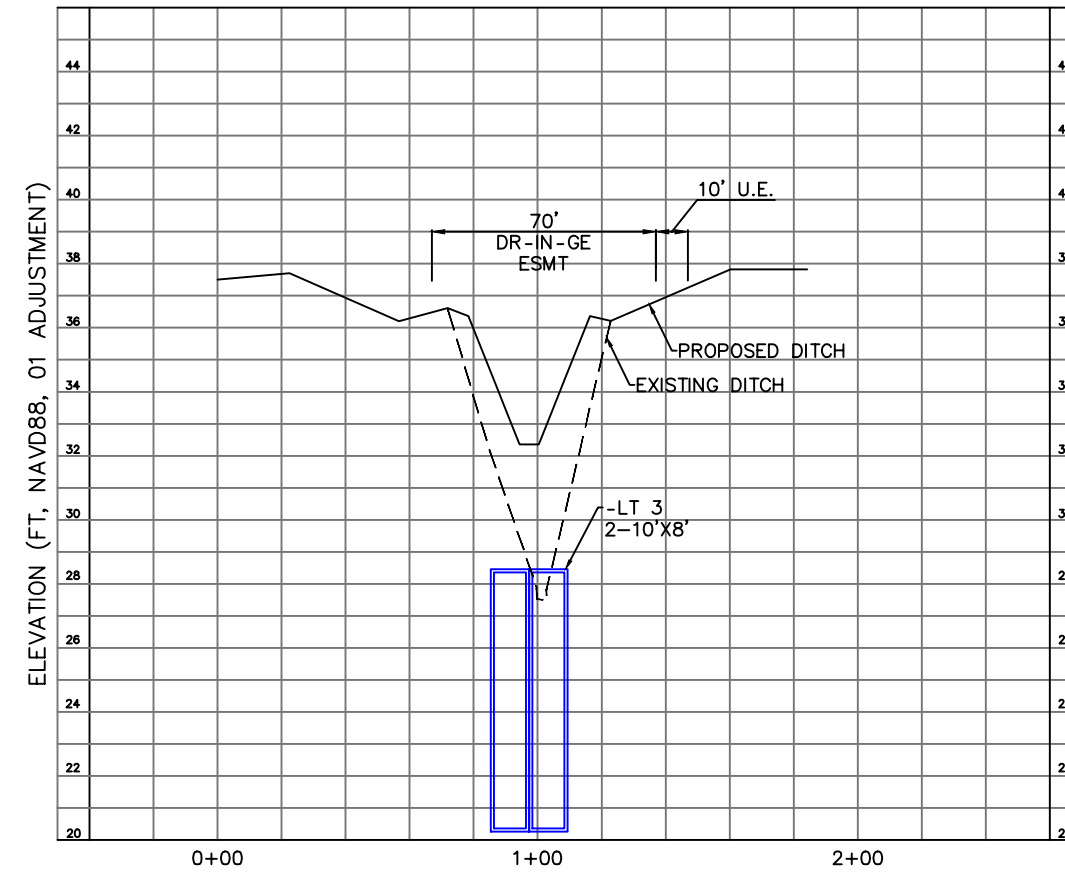
LEGEND

- EXISTING DITCH
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING PAVEMENT

TYPICAL CROSS SECTION B

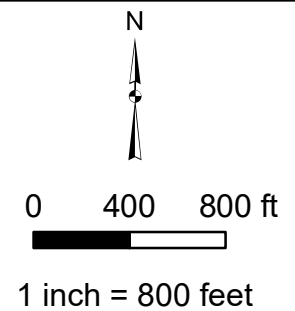
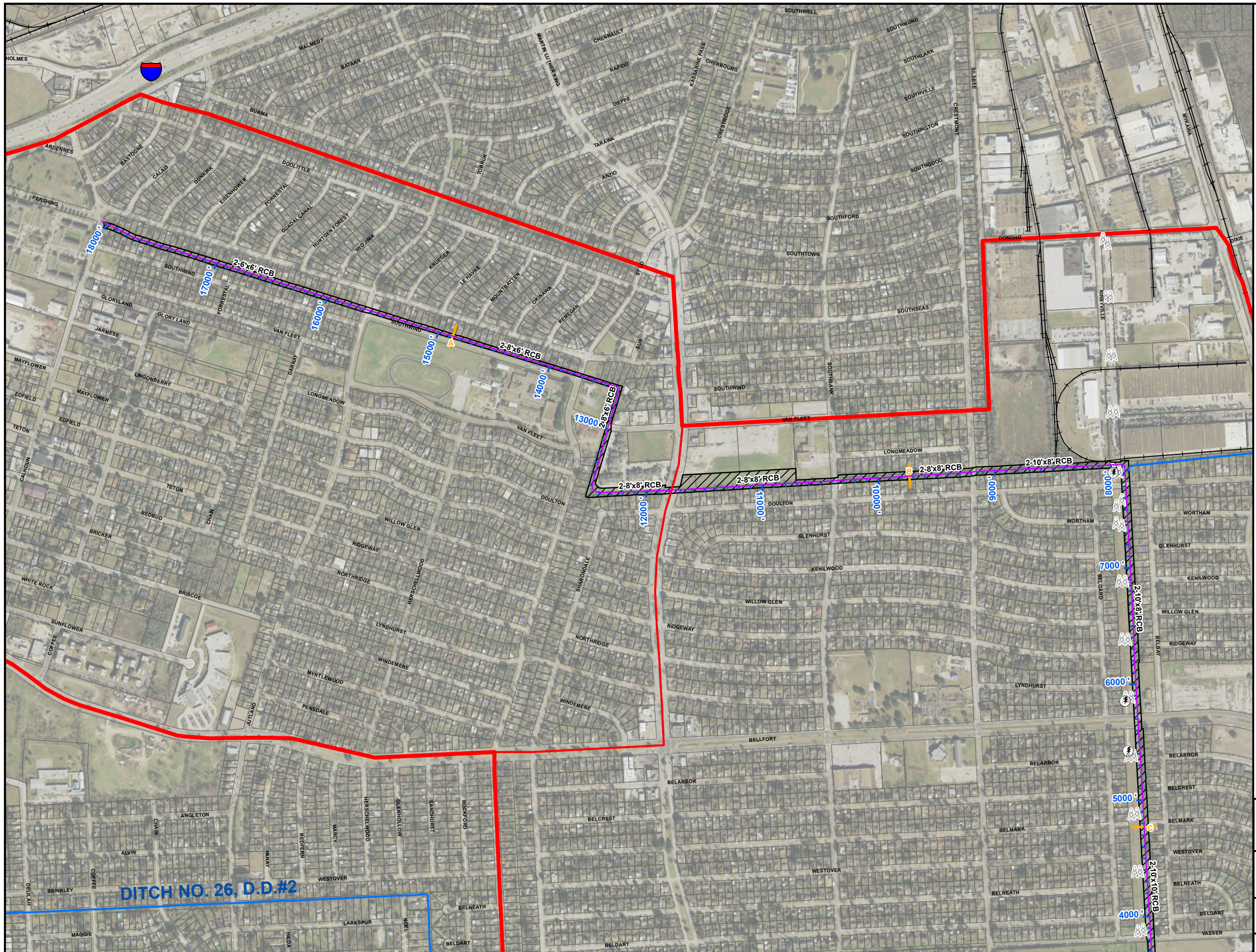


TYPICAL CROSS SECTION C



SCALE
H: 1"=60' V: 1"=6'

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- Legend**
- Proposed Storm Sewer
 - Streams
 - +— Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

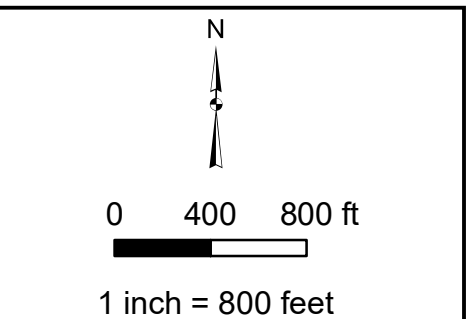
Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 LAYOUT



- Legend**
- Proposed Storm Sewer
 - Streams
 - +— Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- ⚡ Sub Station
 - 🏠 Transmission Tower

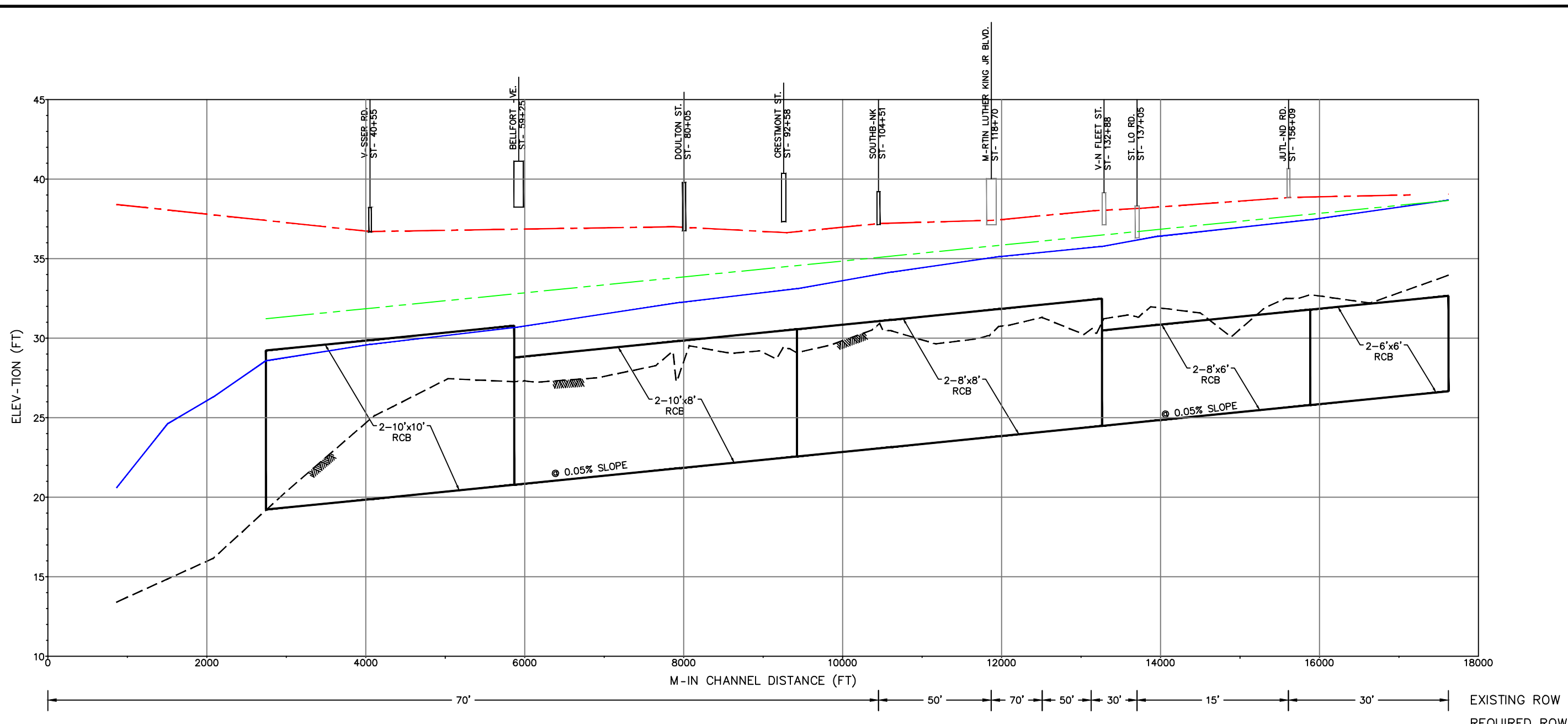
Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 LAYOUT



- LEGEND**
- PROPOSED 10-YR WSEL
 - PROPOSED STORM SEWER FLOW LINE
 - - - EXISTING FLOW LINE
 - - - CRITICAL ELEVATION
 - - - PROPOSED CHANNEL FLOW LINE

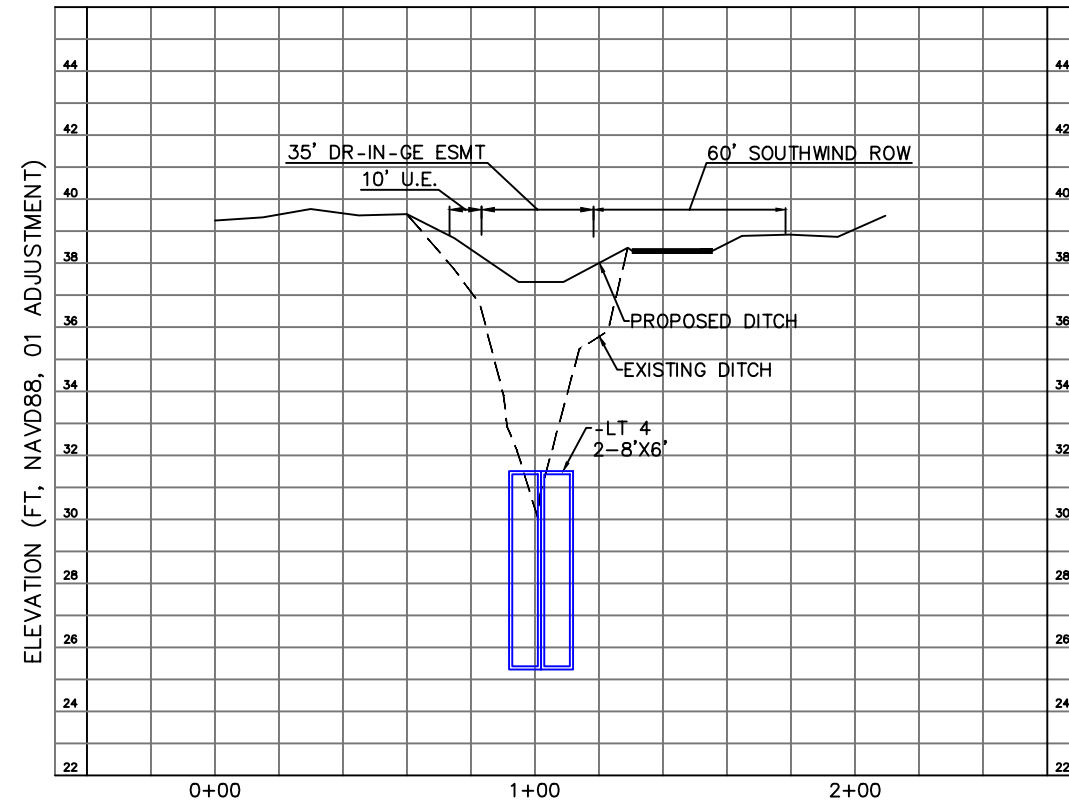
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ALTERNATIVE 4 WATER SURFACE PROFILE
 Date: MARCH 2018
 Exhibit No: 5

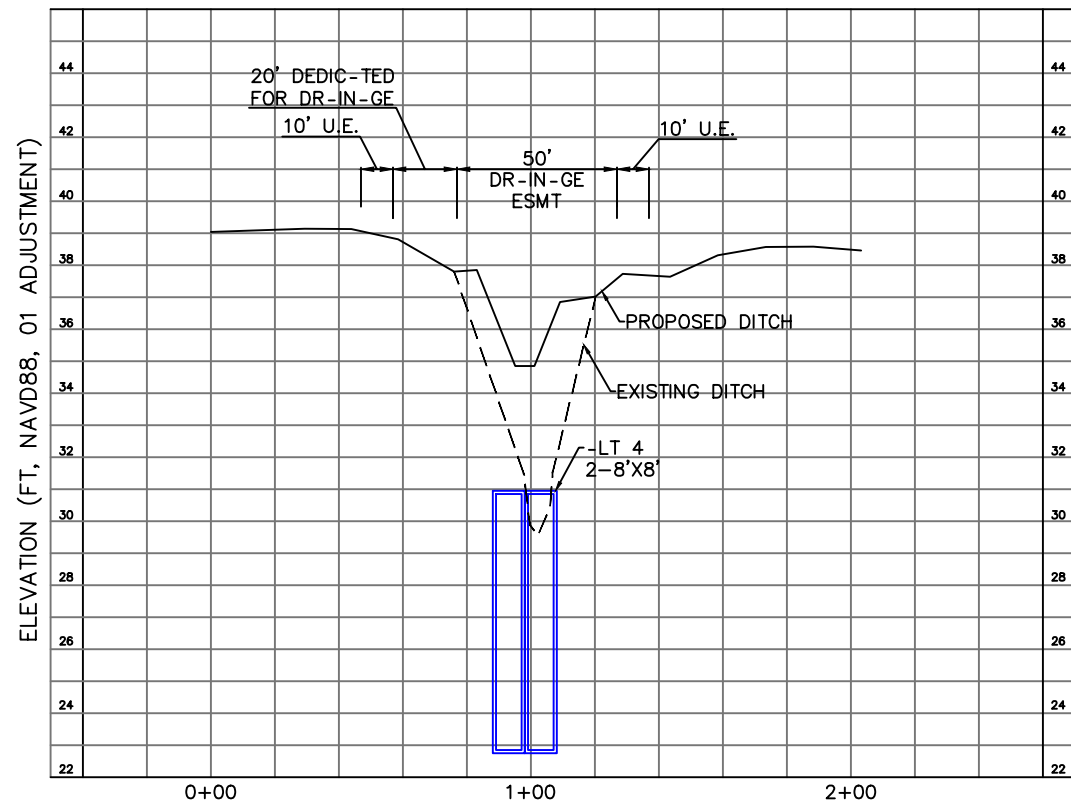
TYPICAL CROSS SECTION A



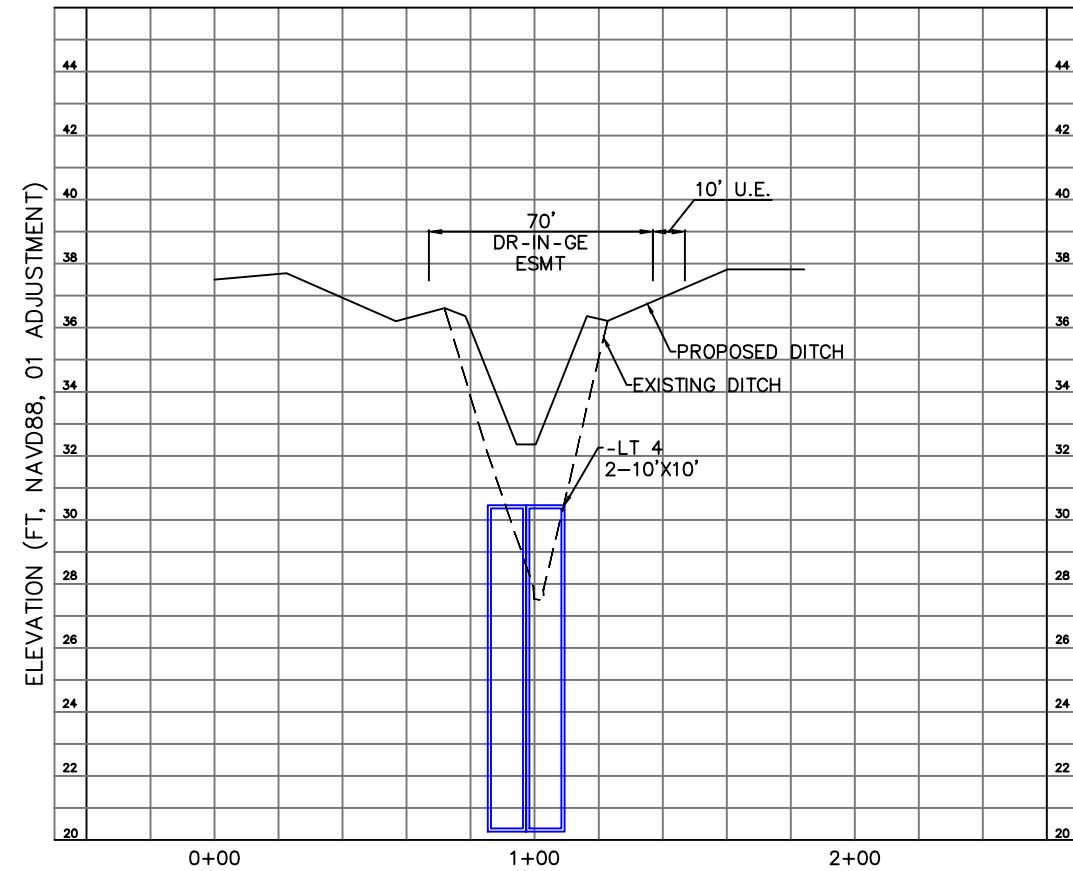
LEGEND

- EXISTING DITCH
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING PAVEMENT

TYPICAL CROSS SECTION B

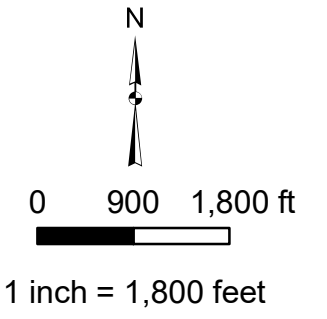
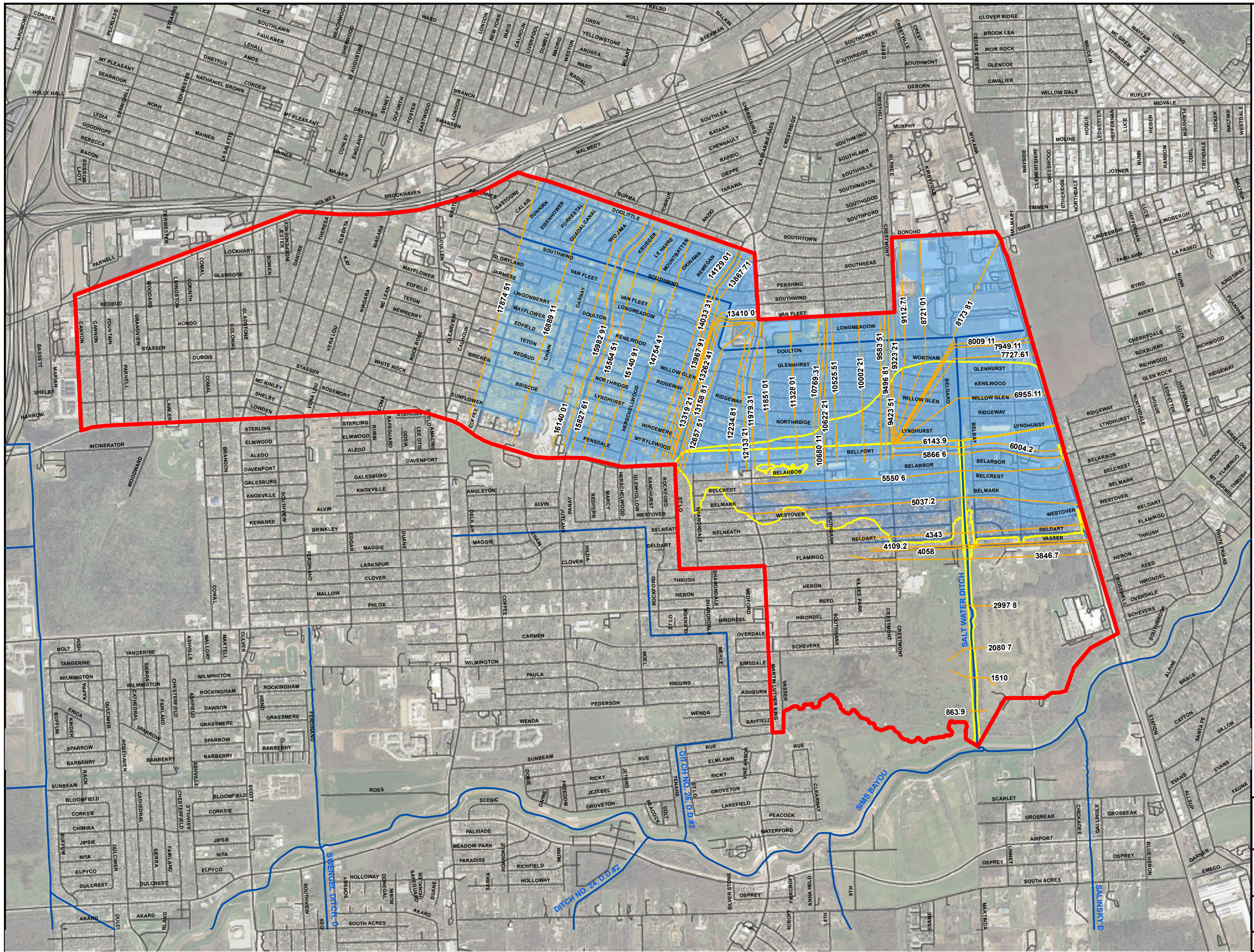


TYPICAL CROSS SECTION C



SCALE
H: 1"=60' V: 1"=6'

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- Legend**
- HEC-RAS Cross Sections
 - Streams
 - FEMA Effective Floodplain
 - Residual 100-Year Floodplain
 - Revised Existing 100-Year Floodplain
 - Salt Water Ditch Subwatershed

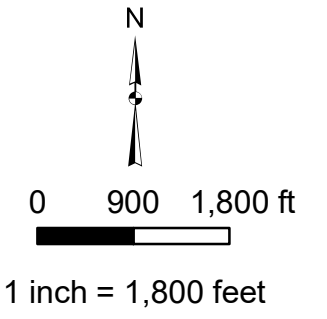
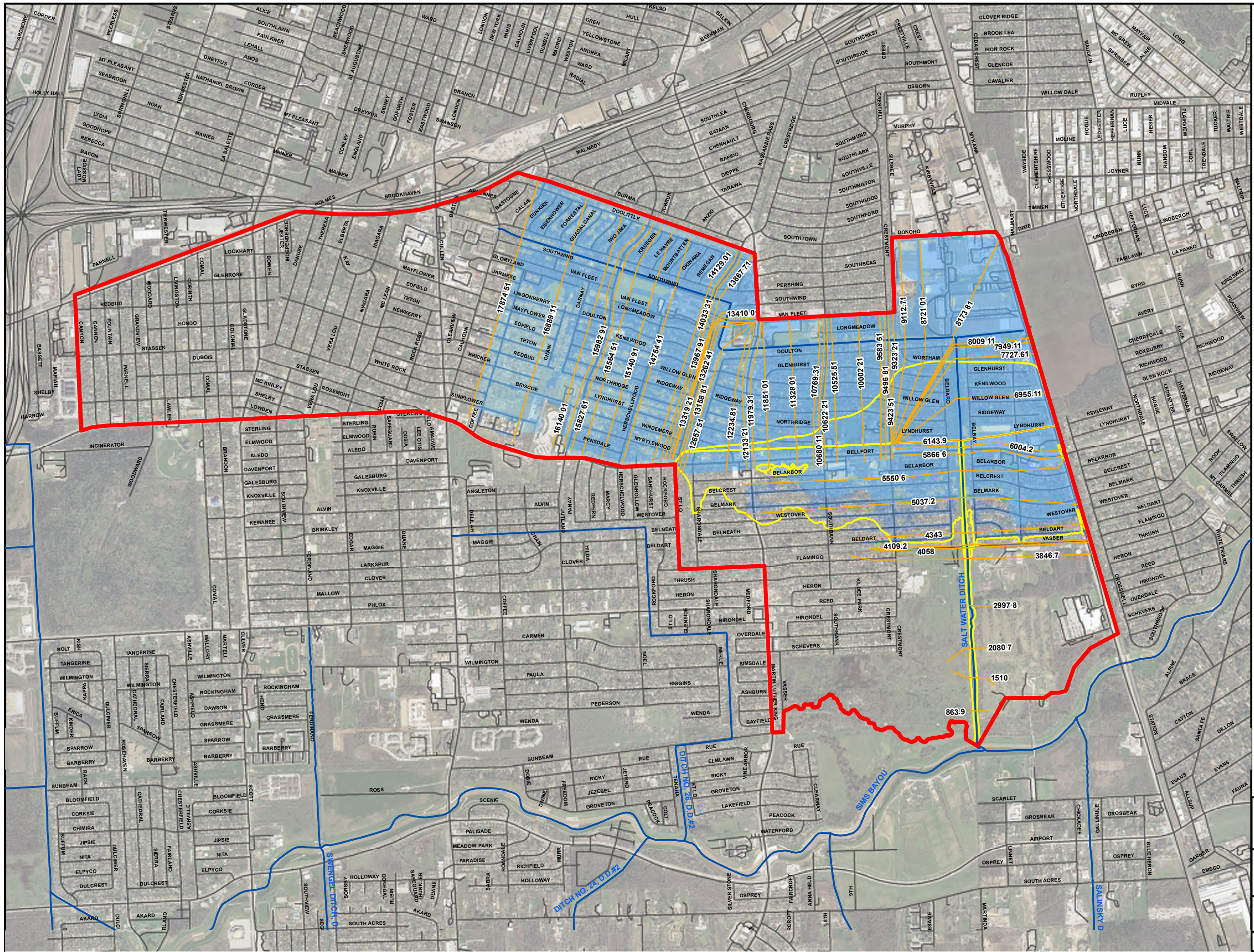
Aerials: 2012 HGAC

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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 RESIDUAL FLOODPLAIN



- Legend**
- HEC-RAS Cross Sections
 - Streams
 - FEMA Effective Floodplain
 - Residual 100-Year Floodplain
 - Revised Existing 100-Year Floodplain
 - Salt Water Ditch Subwatershed

Aerials: 2012 HGAC

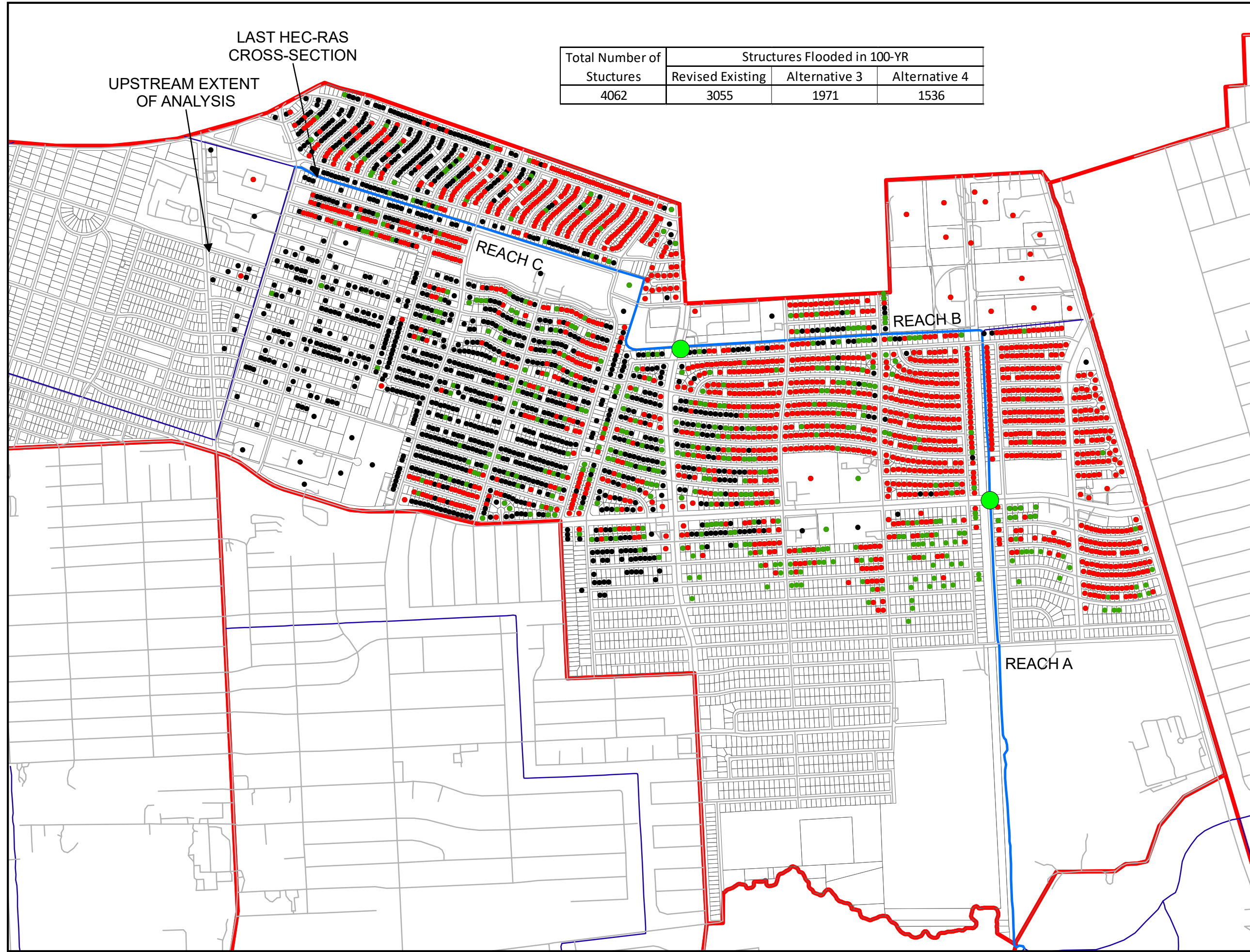
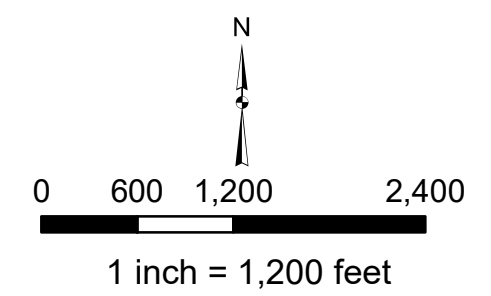
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FEASIBILITY STUDY FOR SALT WATER DITCH
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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 RESIDUAL FLOODPLAIN

Total Number of Structures	Structures Flooded in 100-YR		
	Revised Existing	Alternative 3	Alternative 4
4062	3055	1971	1536



- Legend**
- Flooded Structures in 100-YR Event Alternative 4
 - Flooded Structures in 100-YR Event Alternative 3
 - Flooded Structures in 100-YR Event
 - Reach Breaks
 - Salt Water Ditch
 - Stream Centerline
 - Parcels in Salt Water Ditch Subwatershed
 - Subwatershed Boundary

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FEASIBILITY STUDY FOR SALT WATER DITCH
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 COH WORK AUTHORIZATION NO. 12

FLOODED STRUCTURES

APPENDIX A
ALTERNATIVE ANALYSIS

APPENDIX A.1 - STORM SEWER CALCULATIONS

APPENDIX A.2 – MINIMUM STORM SEWER EASEMENT CALCULATIONS

APPENDIX A.3 – QUANTITY AND COST ESTIMATE CALCULATIONS

APPENDIX A.1

STORM SEWER CALCULATIONS

- **STORM SEWER CALCULATIONS FOR PROPOSED ALTERNATIVE 3**
- **STORM SEWER CALCULATIONS FOR PROPOSED ALTERNATIVE 4**

Storm Sewer - Alternative 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCU Unit C118-00-00)
Project No: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Soffit Elevation		Natural Ground	
From Road	To Road										Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)
Calhoun	Jutland	202.00	2429	2	6	6	0.05	0.015	209.00	2.90	27.00	25.79	2.81	0.05	1.13	39.18	38.05	33.00	31.79	39.5	38.9
Jutland	St Lo	258.00	1915	2	6	6	0.05	0.015	209.00	2.90	25.79	24.83	3.58	0.08	1.46	38.05	36.59	31.79	30.83	38.9	38.1
St Lo	Van Fleet	331.00	706	2	8	6	0.05	0.015	304.61	3.17	24.83	24.48	3.45	0.06	0.42	36.59	36.17	30.83	30.48	38.1	38.6
Van Fleet	Martin Luther King	363.00	1281	2	8	6	0.05	0.015	304.61	3.17	24.48	23.83	3.78	0.07	0.91	36.17	35.26	30.48	29.83	38.6	38.0
Martin Luther King	Southbank	438.30	1367	2	8	6	0.05	0.015	304.61	3.17	23.83	23.15	4.57	0.10	1.42	35.26	33.85	29.83	29.15	38.0	37.4
Southbank	Crestmont	483.00	1189	2	8	8	0.05	0.015	450.11	3.52	23.15	22.56	3.77	0.06	0.68	33.85	33.16	31.15	30.56	37.4	37.6
Crestmont	Doulton	533.00	1474	2	8	8	0.05	0.015	450.11	3.52	22.56	21.82	4.16	0.07	1.03	33.16	32.13	30.56	29.82	37.6	36.8
Doulton	Belfort	603.00	2082	2	8	8	0.05	0.015	450.11	3.52	21.82	20.78	4.71	0.09	1.87	32.13	30.26	29.82	28.78	36.8	36.3
Belfort	Vasser	713.00	1811	2	10	8	0.05	0.015	603.58	3.77	20.78	19.87	4.46	0.07	1.26	30.26	29.00	28.78	27.87	36.3	35.7
Vasser	End of Culvert	834.00	1313	2	10	8	0.05	0.015	603.58	3.77	19.87	19.22	5.21	0.10	1.25	29.00	27.74	27.87	27.22	35.7	35.0

Storm Sewer - Alternative 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCU Unit C118-00-00)
Project No: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Grade Line		Soffit Elevation		Natural Ground	
From Road	To Road										Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)
Calhoun	Jutland	249	2429	2	6	6	0.05	0.015	209.00	2.90	27.00	25.79	3.46	0.07	1.72	39.16	37.44	33.00	31.79	39.5	38.9
Jutland	St Lo	318	1915	2	8	6	0.05	0.015	304.61	3.17	25.79	24.83	3.31	0.05	1.04	37.44	36.40	31.79	30.83	38.9	38.1
St Lo	Van Fleet	408	706	2	8	6	0.05	0.015	304.61	3.17	24.83	24.48	4.25	0.09	0.63	36.40	35.76	30.83	30.48	38.1	38.6
Van Fleet	Martin Luther King	447	1281	2	8	8	0.05	0.015	450.11	3.52	24.48	23.83	3.49	0.05	0.63	35.76	35.13	32.48	31.83	38.6	38.0
Martin Luther King	Southbank	540	1367	2	8	8	0.05	0.015	450.11	3.52	23.83	23.15	4.22	0.07	0.98	35.13	34.15	31.83	31.15	38.0	37.4
Southbank	Crestmont	595	1189	2	8	8	0.05	0.015	450.11	3.52	23.15	22.56	4.65	0.09	1.04	34.15	33.11	31.15	30.56	37.4	37.7
Crestmont	Doulton	657	1474	2	10	8	0.05	0.015	603.58	3.77	22.56	21.82	4.11	0.06	0.87	33.11	32.24	30.56	29.82	37.7	37.7
Doulton	Bellfort	743	2082	2	10	8	0.05	0.015	603.58	3.77	21.82	20.78	4.64	0.08	1.58	32.24	30.66	29.82	28.78	37.7	37.5
Bellfort	Vasser	877	1811	2	10	10	0.05	0.015	816.11	4.08	20.78	19.87	4.39	0.06	1.05	30.66	29.61	30.78	29.87	37.5	36.6
Vasser	End of Culvert	1026	1313	2	10	10	0.05	0.015	816.11	4.08	19.87	19.22	5.13	0.08	1.04	29.61	28.58	29.87	29.22	36.6	37.0

APPENDIX A.2

MINIMUM STORM SEWER EASEMENT CALCULATIONS

- **MINIMUM STORM SEWER EASEMENT CALCULATIONS FOR PROPOSED ALTERNATIVE 3**
- **MINIMUM STORM SEWER EASEMENT CALCULATIONS FOR PROPOSED ALTERNATIVE 4**

MINIMUM STORM SEWER EASEMENT CALCULATIONS ALTERNATIVE 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCD Unit C118-00-00)
Project #: 325912
Date: 3/30/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Pipe Sizes			Natural Ground (ft)	Flowline (ft)	Total Depth (ft)	Required Easement (ft)
From Road	To Road	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)				
Calhoun	Jutland	2	6	6	38.9	25.8	13.1	27
Jutland	St Lo	2	6	6	38.1	24.8	13.3	27
St Lo	Van Fleet	2	8	6	38.6	24.5	14.1	31
Van Fleet	Martin Luther King	2	8	6	38.0	23.8	14.2	31
Martin Luther King	Southbank	2	8	6	37.4	23.2	14.2	31
Southbank	Crestmont	2	8	8	37.7	22.6	15.2	36
Crestmont	Doulton	2	8	8	37.7	21.8	15.9	36
Doulton	Bellfort	2	8	8	37.5	20.8	16.7	36
Bellfort	Vasser	2	10	8	36.6	19.9	16.7	40
Vasser	End of Culvert	2	10	8	37.0	19.2	17.8	40

MINIMUM STORM SEWER EASEMENT CALCULATIONS ALTRERNATIVE 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/30/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Pipe Sizes			Natural Ground (ft)	Flowline (ft)	Total Depth (ft)	Required Easement (ft)
From Road	To Road	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)				
Calhoun	Jutland	2	6	6	38.9	25.8	13.1	27
Jutland	St Lo	2	8	6	38.1	24.8	13.3	31
St Lo	Van Fleet	2	8	6	38.6	24.5	14.1	31
Van Fleet	Martin Luther King	2	8	8	38.0	23.8	14.2	31
Martin Luther King	Southbank	2	8	8	37.4	23.2	14.2	31
Southbank	Crestmont	2	8	8	37.7	22.6	15.2	36
Crestmont	Doulton	2	10	8	37.7	21.8	15.9	40
Doulton	Belfort	2	10	8	37.5	20.8	16.7	40
Belfort	Vasser	2	10	10	36.6	19.9	16.7	40
Vasser	End of Culvert	2	10	10	37.0	19.2	17.8	40

APPENDIX A.3

COSTS

- **COSTS FOR PROPOSED ALTERNATIVE 3**
- **COSTS FOR PROPOSED ALTERNATIVE 4**

COSTS FOR PROPOSED ALTERNATIVE 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Description	Unit	Unit Price	Units	Total Cost
Inlets	EA	\$2,910	36	\$104,760
Manhole for Larger than 78" Storm Sewer	EA	\$16,500	36	\$594,000
Riprap	SY	\$31	1301	\$40,331
6' x 6' RCB	LF	\$480	8688	\$4,170,240
8' x 6' RCB	AC	\$770	6768	\$5,211,360
8' x 8' RCB	LS	\$920	9490	\$8,730,800
10' x 8' RCB	LF	\$960	6248	\$5,998,080
Bridge Replacement	SF	\$100	70210	\$7,021,000
Trench Safety System	LF	\$2	31194	\$62,388
Land Acquisition - Drainage Easements	AC	\$80,700	0	\$0
Land Acquisition - Full Parcel Acquisitions	3x Market Value		0	\$0
Contingency	20% of TOTAL			\$6,386,592
TOTAL				\$38,319,551

Note: Storm Sewer cost estimates based on FY 18 Pre-Engineering Unit Prices

COSTS FOR PROPOSED ALTERNATIVE 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Description	Unit	Unit Price	Units	Total Cost	
Inlets	EA	\$2,910	36	\$104,760	
Manhole for Larger than 78" Storm Sewer	EA	\$16,500	36	\$594,000	
Riprap	SY	\$31	1301	\$40,331	
6' x 6' RCB	LF	\$480	4858	\$2,331,840	
8' x 6' RCB	AC	\$770	5242	\$4,036,340	
8' x 8' RCB	LS	\$920	7674	\$7,060,080	
10' x 8' RCB	LF	\$960	7112	\$6,827,520	
10' x 10' RCB	LF	\$1,300	6248	\$8,122,400	
Bridge Replacement	SF	\$100	70210	\$7,021,000	
Trench Safety System	LF	\$2	31134	\$62,268	
Land Acquisition - Drainage Easements	AC	\$80,700	0	\$0	
Land Acquisition - Full Parcel Acquisitions	3x Market Value		0	\$0	
Contingency				20% of TOTAL	\$7,240,108
TOTAL					\$43,440,647

Note: Storm Sewer cost estimates based on FY 18 Pre-Engineering Unit Prices

ADDENDUM TO
FEASIBILITY STUDY FOR
FLOOD DAMAGE REDUCTION
TO SALT WATER DITCH,
HCFC D UNIT C118-00-00

CITY OF HOUSTON
WBS NO. M-000100-0012-3



April 6, 2018

CEI Project No. 325912.00
April 2018

Submitted By:
CivilTech
Engineering, Inc.
Firm Registration No. F-382

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EXHIBITS

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- Exhibit 2 – Alternative 3 Water Surface Profile
- Exhibit 3 – Alternative 3 Typical Cross Section
- Exhibit 4 – Alternative 4 Layout
- Exhibit 5 – Alternative 4 Water Surface Profile
- Exhibit 6 – Alternative 4 Typical Cross Section
- Exhibit 7 – Alternative 3 Residual 100-Year Floodplain
- Exhibit 8 – Alternative 4 Residual 100-Year Floodplain
- Exhibit 9 – Flooded Structures

APPENDICIES

- Appendix A: Alternative Analysis

Introduction

CivilTech Engineering, Inc. (CivilTech) was contracted by the City of Houston to perform additional services in Work Order No. 12, under the “Feasibility Study for Flood Damage Reduction on Salt Water Ditch (HCFC Unit No. C118-00-00) including Alternate Level of Service Analysis”, WBS No. M-000100-0012-3, Ordinance No. 2013-11179, Contract No. 4600011469. The additional services include an alternate level of service analysis to the previously approved report prepared by CivilTech:

- Feasibility Study for Flood Damage Reduction to Salt Water Ditch, HCFC Unit C118-00-00, City of Houston, WBS No. M-000100-0012-3, dated February 22, 2016, prepared by CivilTech Engineering, Inc.

The original study analyzed flood reduction options within the Salt Water Ditch Watershed in conjunction with Pre-Engineering Need Area M-2014-034. Alternatives included: 1) channel improvements to Salt Water Ditch to contain the 100-year storm event within channel banks and 2) channel improvements utilizing a closed storm sewer system to convey the 100-year storm event for a portion of Salt Water Ditch. The second alternative reduced proposed right-of-way (ROW) versus the first alternative; however, this alternative proved costly and therefore, limited the storm sewer to Martin Luther King Blvd. to keep costs comparable to the first alternative.

In order to minimize parcel acquisitions and costs, the City of Houston requested two additional alternatives as part of the Feasibility Study for Flood Damage Reduction to Salt Water Ditch. Alternative 3 will be a closed storm sewer system providing a 5-year level of service and Alternative 4 will be a closed storm sewer system providing a 10-year level of service. The purpose of this addendum report analyzes these two additional alternatives to improve Salt Water Ditch.

Enclosing Channel with Box Storm Sewer – Alternative 3

Alternative 3 is a closed storm sewer system providing a 5-year level of service. The storm sewers were sized using the Manning’s equation with the HGL below existing channel banks as done in the original analysis. A tailwater was interpolated from the Revised Existing HEC-RAS model developed for Salt Water Ditch from the original analysis. In order for proposed storm sewers from Need Area M-2014-034 to discharge into Salt Water Ditch at Calhoun Rd., the flowline for the storm sewer system was set at 27 ft. at Calhoun Rd. A constant slope of 0.05% was used and maintained throughout the entire system until it daylighted into the existing channel flowline, occurring approximately 1313 feet downstream of Vasser Rd. Revised Existing hydrology was used as the assumptions of a fully developed sub-basin and 100% channel conveyance used to develop the proposed conditions peak flows did not apply for this alternative.

A swale with 6 ft. bottom width and 4H:1V side slopes was designed to lie on top of the storm sewer system. To provide a minimum cover for the storm sewers, the swale was placed 2 ft. above the storm sewer at the downstream end and maintained a 0.05% slope.

Table 1 shows the proposed storm sewer sizes, with the calculations provided in **Appendix A**. A plan view of the Alternative 3 layout is shown on **Exhibit 1** and a plot of the water surface profile is provided as **Exhibit 2**. Three typical channel cross sections were developed to show the storm sewers with the swale. The proposed typical channel cross sections are shown on **Exhibit 3** with their locations shown on **Exhibit 2**.

Existing Salt Water Ditch drainage easements are owned by HCFCD and vary between 30 and 70 ft. These existing drainage easements are presented in Appendix A of the original report. A minimum storm sewer easement width requirement for this alternative was calculated based on City of Houston criteria found in the Infrastructure Design Manual, Chapter 5 which states: "Maintenance operations require an easement width equal to the storm sewer width plus the depth rounded up to the nearest multiple of 5-feet." **Table 1** presents the minimum storm sewer easement width required for each storm sewer segment. The existing drainage easements have sufficient width to accommodate the minimum storm sewer easement width required. Minimum storm sewer easement calculations are provided in **Appendix A**.

Table 1: Alternative 3 Storm Sewer Design Summary

Road From	Road To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Minimum Storm Sewer Easement Width (ft)	Existing HCFCDD Drainage Easement (ft)	Additional Easement Needed (ft)
Calhoun	Jutland	2	6	6	27	30	0
Jutland	St Lo	2	6	6	27	35	0
St Lo	Van Fleet	2	8	6	31	35	0
Van Fleet	Martin Luther King	2	8	6	31	50/70	0
Martin Luther King	Southbank	2	8	6	31	50	0
Southbank	Crestmont	2	8	8	36	70	0
Crestmont	Doulton	2	8	8	36	70	0
Doulton	Belfort	2	8	8	36	70	0
Belfort	Vasser	2	10	8	40	70	0
Vasser	End of Culvert	2	10	8	40	70	0

Enclosing Channel with Box Storm Sewer – Alternative 4

Alternative 4 is a closed storm sewer system providing a 10-year level of service. The storm sewers were sized using the Manning's equation with the HGL below existing channel banks as done in the original analysis. A tailwater was interpolated from the Revised Existing HEC-RAS model developed for Salt Water Ditch from the original analysis. In order for proposed storm sewers from Need Area M-2014-034 to discharge into Salt Water Ditch at Calhoun Rd., the flowline for the storm sewer system was set at 27 ft. at Calhoun Rd. A constant slope of 0.05% was used and maintained throughout the entire system until it daylighted into the existing channel flowline, occurring approximately 1313 feet downstream of Vasser Rd. Revised Existing hydrology was used as the assumptions of a fully developed sub-basin and 100% channel conveyance used to develop the proposed conditions peak flows did not apply for this alternative.

A swale with 6 ft. bottom width and 4H:1V side slopes was designed to lie on top of the storm sewer system. To provide a minimum cover for the storm sewers, the swale was placed 2 ft. above the storm sewer at the downstream end and maintained a 0.05% slope.

Table 2 shows the proposed storm sewer sizes, with the calculations provided in **Appendix A**. A plan view of the Alternative 3 layout is shown on **Exhibit 4** and a plot of the water surface profile is provided as **Exhibit 5**. Three typical channel cross sections were developed to show the storm sewers with the swale. The proposed typical channel cross sections are shown on **Exhibit 6** with their locations shown on **Exhibit 4**.

Existing Salt Water Ditch drainage easements are owned by HCFCD and vary between 30 and 70 ft. These existing drainage easements are presented in Appendix A of the original report. A minimum storm sewer easement width requirement for this alternative was calculated based on City of Houston criteria found in the Infrastructure Design Manual, Chapter 5 which states: "Maintenance operations require an easement width equal to the storm sewer width plus the depth rounded up to the nearest multiple of 5-feet." **Table 1** presents the minimum storm sewer easement width required for each storm sewer segment. The existing drainage easements have sufficient width to accommodate the minimum storm sewer easement width required. Minimum storm sewer easement calculations are provided in **Appendix A**.

Table 2: Alternative 4 Storm Sewer Design Summary.

Road From	Road To	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Minimum Storm Sewer Easement Width (ft)	Existing HCFCROW (ft)	Additional Easement Needed (ft)
Calhoun	Jutland	2	6	6	27	30	0
Jutland	St Lo	2	8	6	31	35	0
St Lo	Van Fleet	2	8	6	31	35	0
Van Fleet	Martin Luther King	2	8	8	31	50/70	0
Martin Luther King	Southbank	2	8	8	31	50	0
Southbank	Crestmont	2	8	8	36	70	0
Crestmont	Doulton	2	10	8	40	70	0
Doulton	Belfort	2	10	8	40	70	0
Belfort	Vasser	2	10	10	40	70	0
Vasser	End of Culvert	2	10	10	40	70	0

Cost Estimate

Unit costs were taken from the original study and applicable unit costs for Alternatives 3 and 4 are provided in **Table 3**. A few additional unit costs were needed and include storm sewer sizes, manholes, and inlets. These additional unit costs are based from the FY18 Pre-Engineering Unit Prices provided by the City of Houston. The cost estimates are shown in **Table 4** and the calculations are provided in **Appendix A**.

Table 3: Project Unit Costs

Description	Unit	Unit Price
Inlets	EA	\$2,910
Manhole for Larger than 78" Storm Sewer	EA	\$16,500
Riprap	SY	\$31
6' x 6' RCB	LF	\$480
8' x 6' RCB	AC	\$770
8' x 8' RCB	LS	\$920
10' x 8' RCB	LF	\$960
10' x 10' RCB	LF	\$1,300
Bridge Replacement	SF	\$100
Trench Safety System	LF	\$2
Land Acquisition - Drainage Easements	AC	\$80,700
Land Acquisition - Full Parcel Acquisitions	--	3x Market Value
Environmental Study	--	Further Analysis Required

Table 4: Alternative Cost Comparison

Alternative	Channel Cost	Contingency	Total Cost
3	\$31,932,959	\$6,386,592	\$38,319,551
4	\$36,200,539	\$7,240,108	\$43,440,647

Estimated Flooded Structures

In order to estimate the number of flooded structures for each storm event, new HEC-RAS models were developed for Alternatives 3 and 4. The Revised Existing HEC-RAS model from the original study was used as the base model. Changes to the Revised Existing model include altering peak flows and the channel. Changes to the channel include replacing the existing Salt Water Ditch with the swale section described earlier. Peak flow changes assume the storm sewer systems will receive the entirety of flow from their designed storm event and a residual peak flow was created by subtracting out the design peak flow from each storm event analyzed.

The 100-yr residual floodplains for Alternatives 3 and 4 were mapped based on the new HEC-RAS models and are shown in **Exhibits 7** and **8**. The number of flooded structures were also estimated from the new HEC-RAS model and are provided in **Tables 5** and **6**. **Exhibit 9** shows the location of the flooded structures.

Table 5: Overview of Flood-Affected Structures - Alternative 3

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	25	138	268	613
B	0	0	4	291	719	970	1143
C	0	0	59	271	460	733	1406
Total	0	0	63	587	1317	1971	3162
Fraction of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0.00	0.00	0.00	0.03	0.16	0.31	0.70
B	0.00	0.00	0.00	0.24	0.60	0.82	0.96
C	0.00	0.00	0.03	0.14	0.23	0.37	0.70
Total	0.00	0.00	0.02	0.14	0.32	0.49	0.78

Table 6: Overview of Flood-Affected Structures - Alternative 4

Number of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0	0	0	1	45	171	550
B	0	0	0	23	381	819	1121
C	0	0	0	126	302	546	1288
Total	0	0	0	150	728	1536	2959
Fraction of Flooded Structures							
Reach	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
A	0.00	0.00	0.00	0.00	0.05	0.20	0.63
B	0.00	0.00	0.00	0.02	0.32	0.69	0.94
C	0.00	0.00	0.00	0.06	0.15	0.27	0.64
Total	0.00	0.00	0.00	0.04	0.18	0.38	0.73

Detention

Improvements to Salt Water Ditch will decrease time of concentration and storage within the sub-basin; therefore, peak flows into Sims Bayou will increase. This increase in peak flow into Sims Bayou will require detention to mitigate impacts. Detention mitigation was calculated and three potential sites for detention ponds were given in the original analysis. Detention for alternatives 3 and 4 was not part of the scope for this addendum but will be required and should be provided during the design phase.

EXHIBITS

EXHIBIT 1: ALTERNATIVE 3 LAYOUT

EXHIBIT 2: ALTERNATIVE 3 WATER SURFACE PROFILE

EXHIBIT 3: ALTERNATIVE 3 TYPICAL CROSS SECTION

EXHIBIT 4: ALTERNATIVE 4 LAYOUT

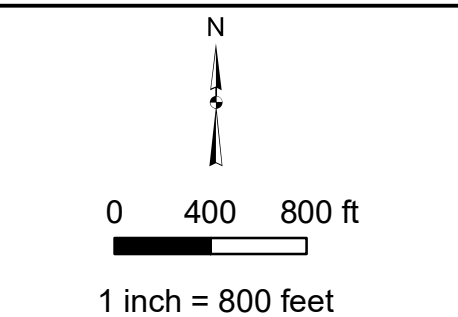
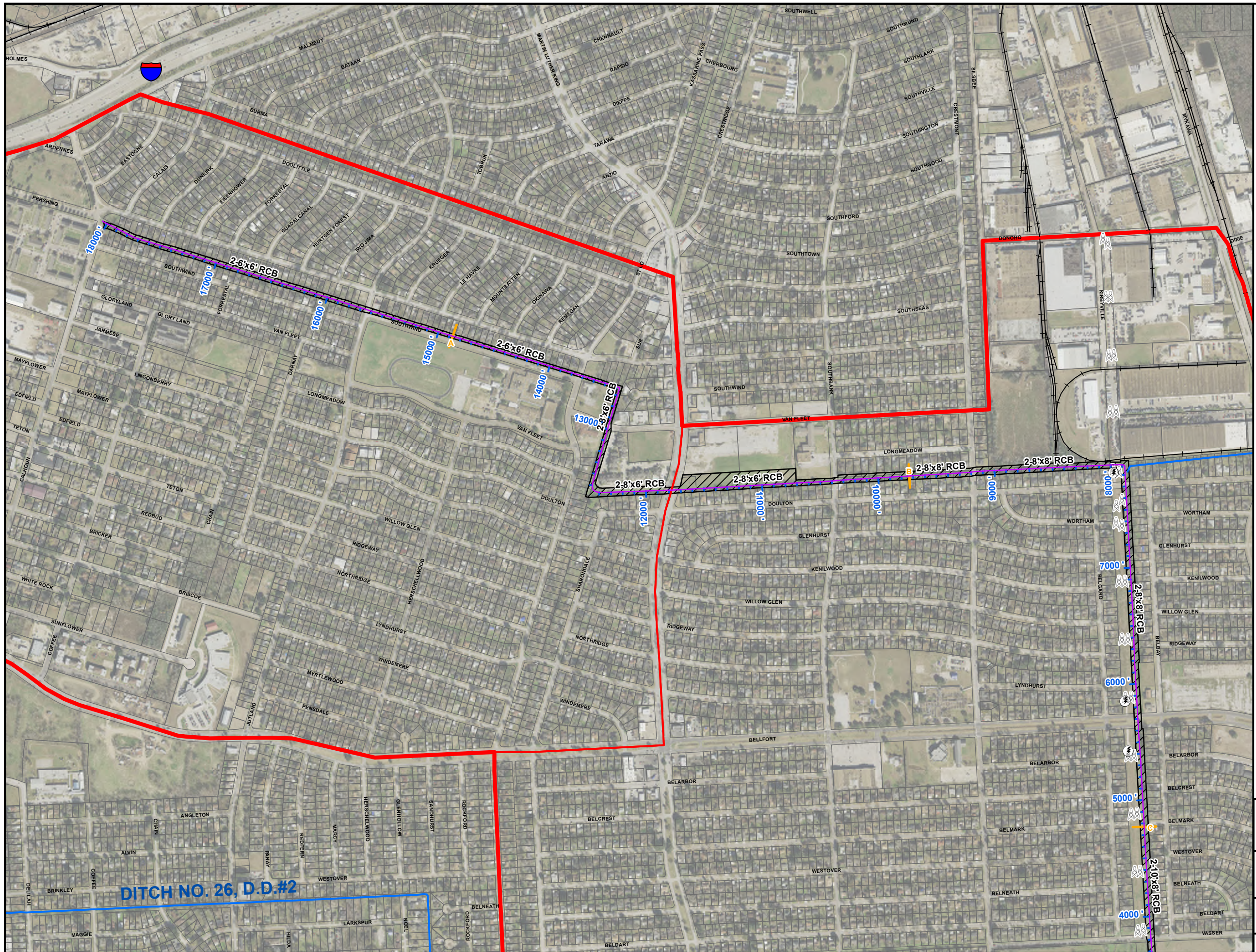
EXHIBIT 5: ALTERNATIVE 4 WATER SURFACE PROFILE

EXHIBIT 6: ALTERNATIVE 4 TYPICAL CROSS SECTION

EXHIBIT 7: ALTERNATIVE 3 RESIDUAL 100-YEAR FLOODPLAIN

EXHIBIT 8: ALTERNATIVE 4: RESIDUAL 100-YEAR FLOODPLAIN

EXHIBIT 9: FLOODED STRUCTURES



- Legend**
- Proposed Storm Sewer
 - Streams
 - Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 LAYOUT



0 400 800 ft

1 inch = 800 feet

Legend

- Proposed Storm Sewer
 - Streams
 - Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

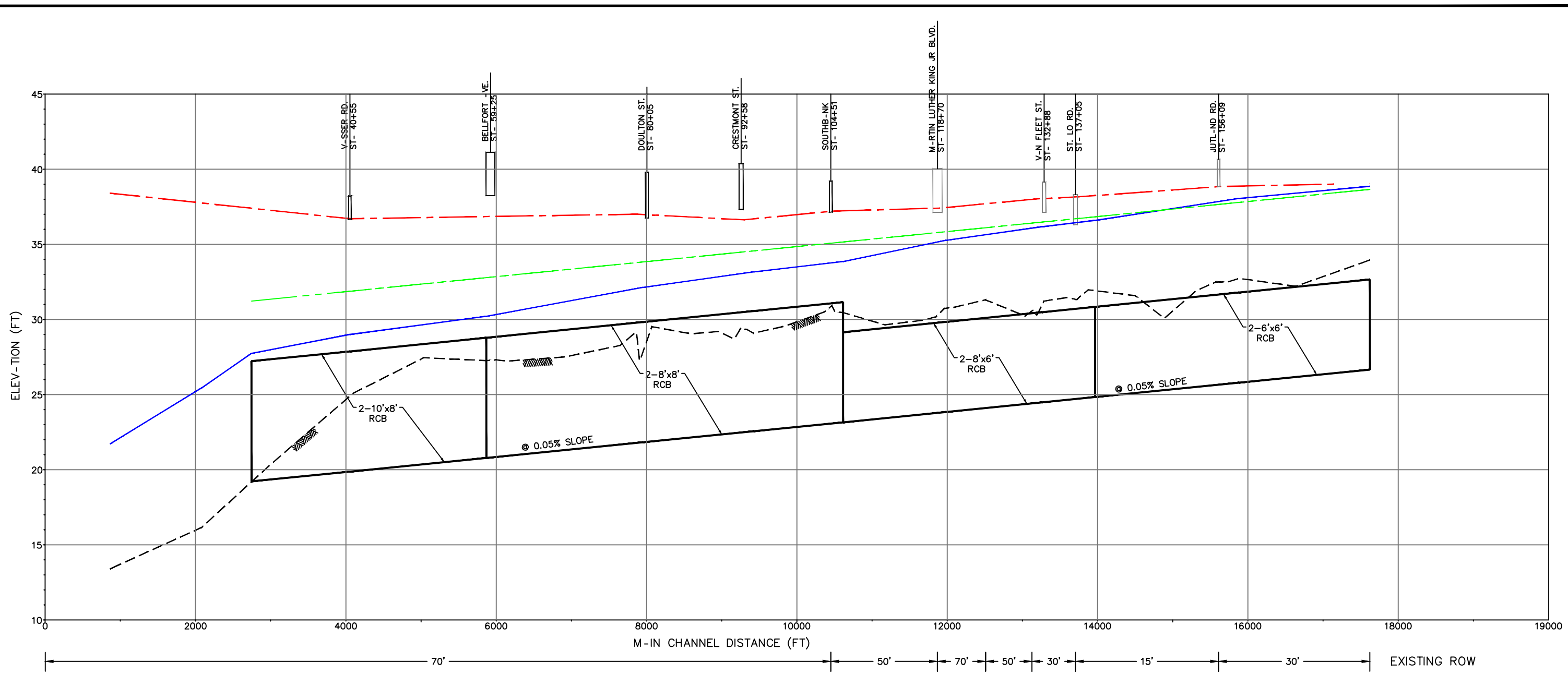
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FEASIBILITY STUDY FOR SALT WATER DITCH
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ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 LAYOUT



LEGEND

—	PROPOSED 5-YR WSEL
—	PROPOSED STORM SEWER FLOW LINE
- - -	EXISTING FLOW LINE
- - -	CRITICAL ELEVATION
- - -	PROPOSED CHANNEL FLOW LINE

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Engineering, Inc.

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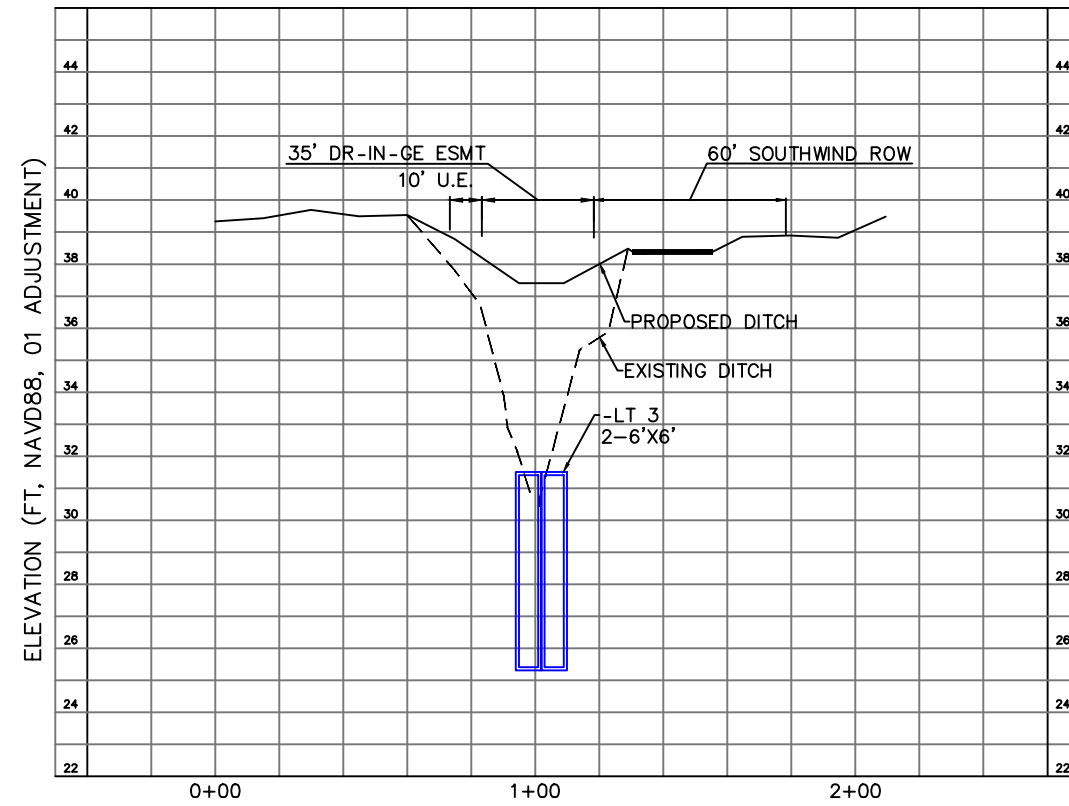
ADDENDUM TO FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 3 WATER SURFACE PROFILE

Date: MARCH 2018

Exhibit No: 2

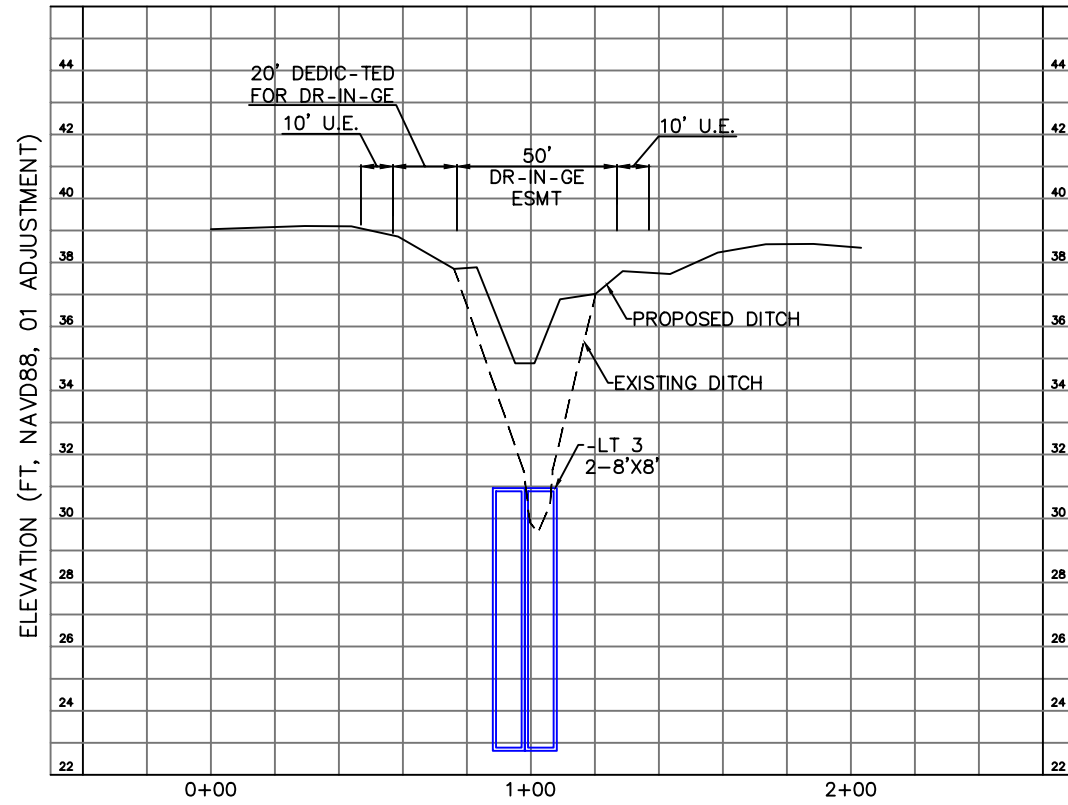
TYPICAL CROSS SECTION A



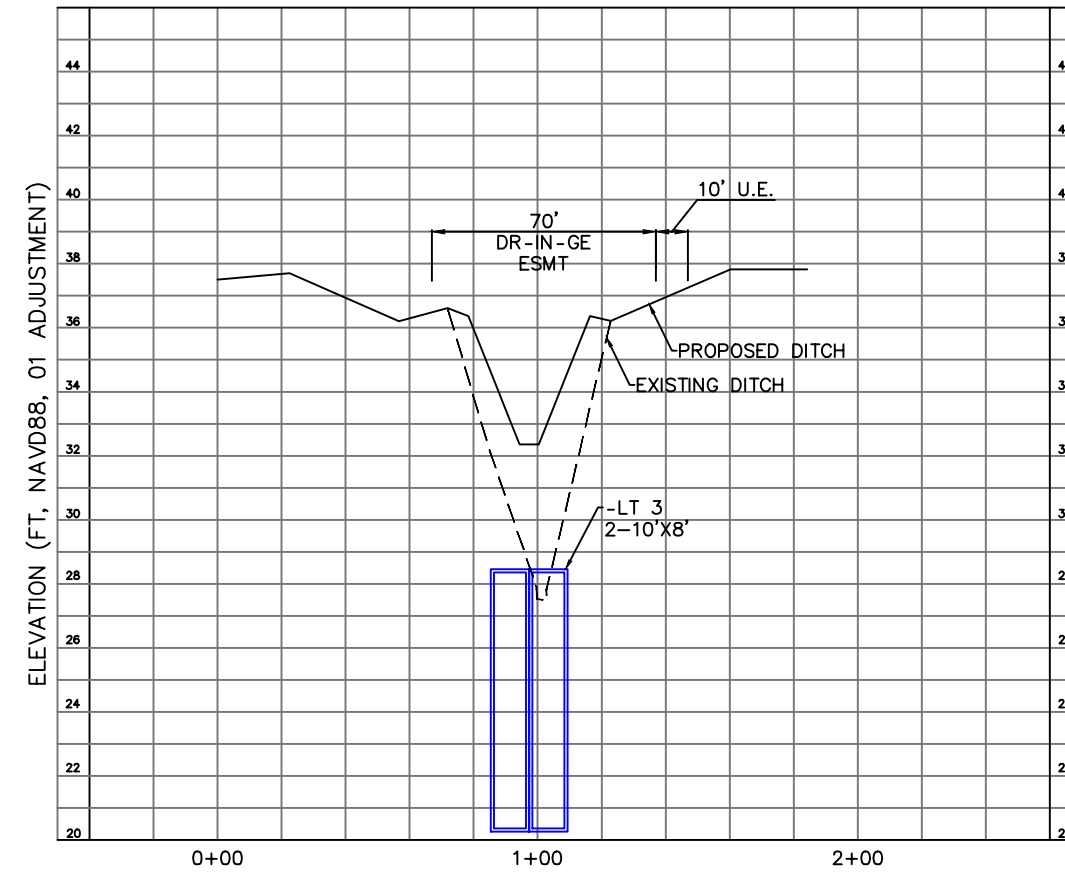
LEGEND

- EXISTING DITCH
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING PAVEMENT

TYPICAL CROSS SECTION B

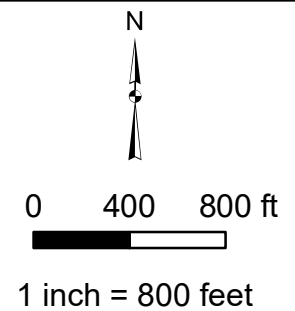
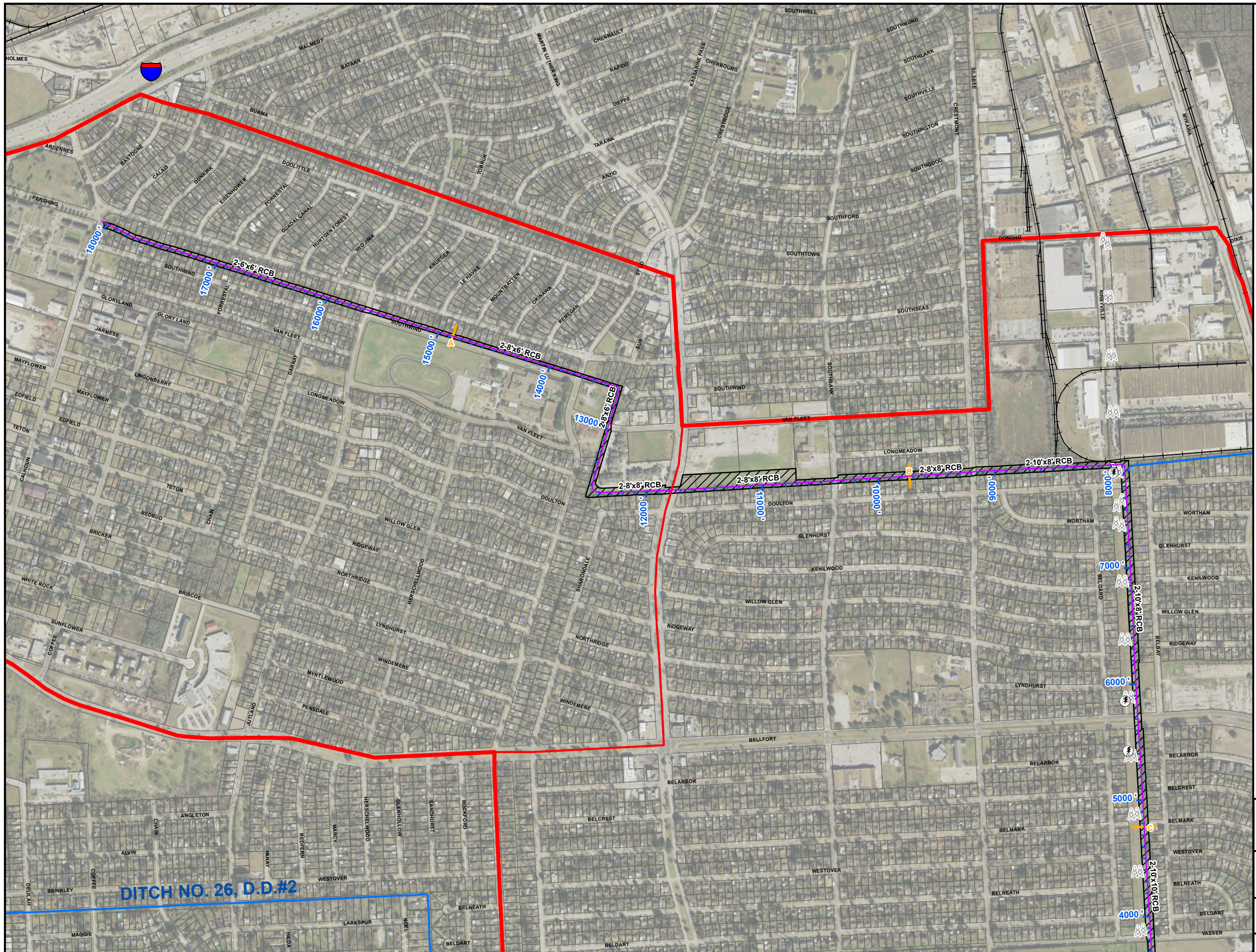


TYPICAL CROSS SECTION C



SCALE
H: 1"=60' V: 1"=6'

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- Legend**
- Proposed Storm Sewer
 - Streams
 - Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- Sub Station
 - Transmission Tower

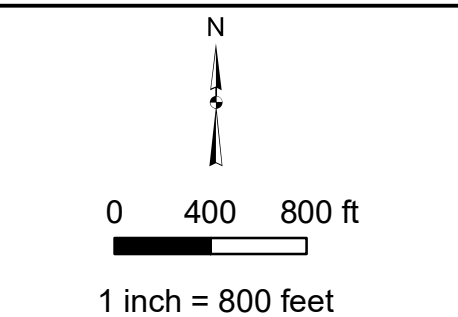
Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 LAYOUT



- Legend**
- Proposed Storm Sewer
 - Streams
 - +— Railroads
 - Typical Channel Cross Section Location
 - Existing Channel Right-Of-Way
 - Salt Water Ditch Watershed
 - Salt Water Ditch Subbasin
- Centerpoint Electric Utilities**
- ⚡ Sub Station
 - 🏠 Transmission Tower

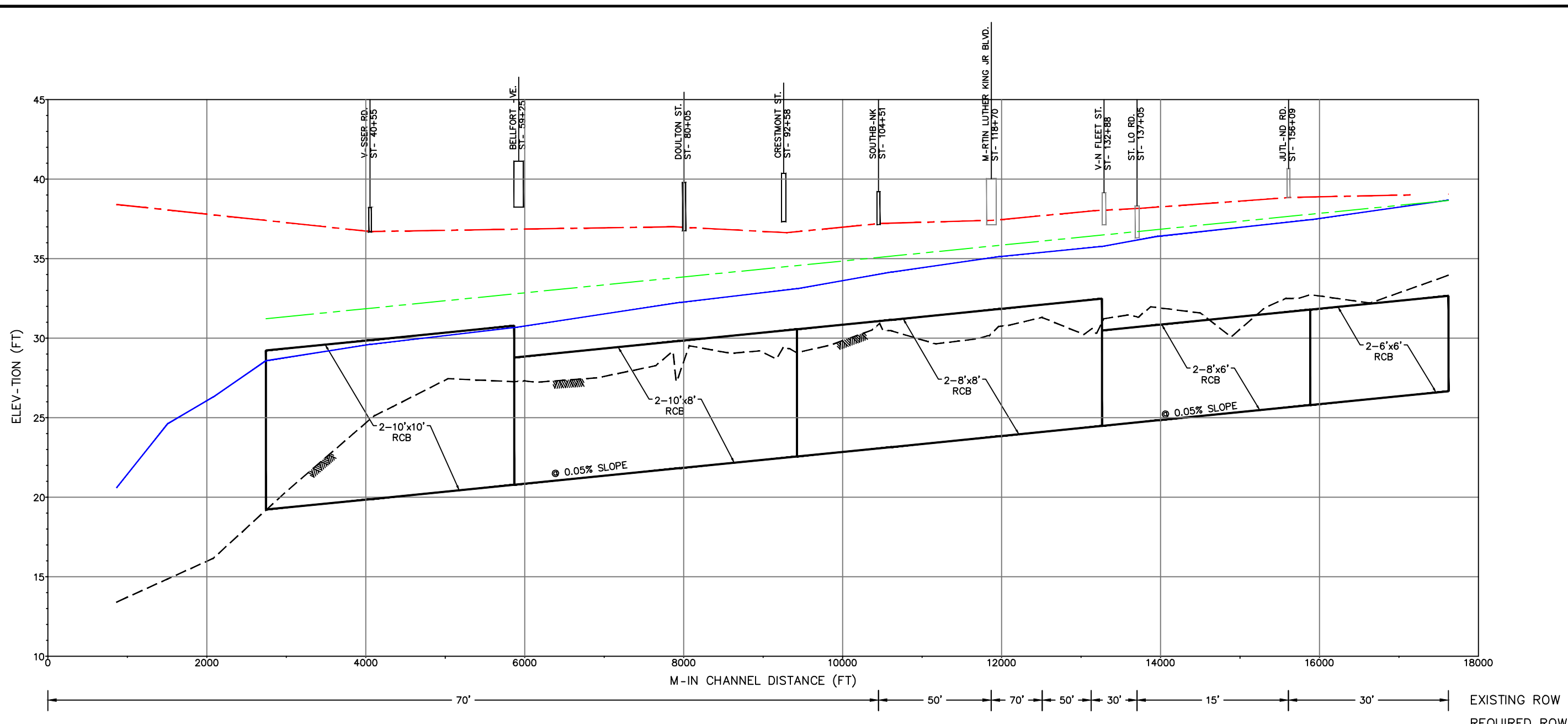
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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 LAYOUT



LEGEND

—	PROPOSED 10-YR WSEL
—	PROPOSED STORM SEWER FLOW LINE
- - -	EXISTING FLOW LINE
- . - .	CRITICAL ELEVATION
- - -	PROPOSED CHANNEL FLOW LINE

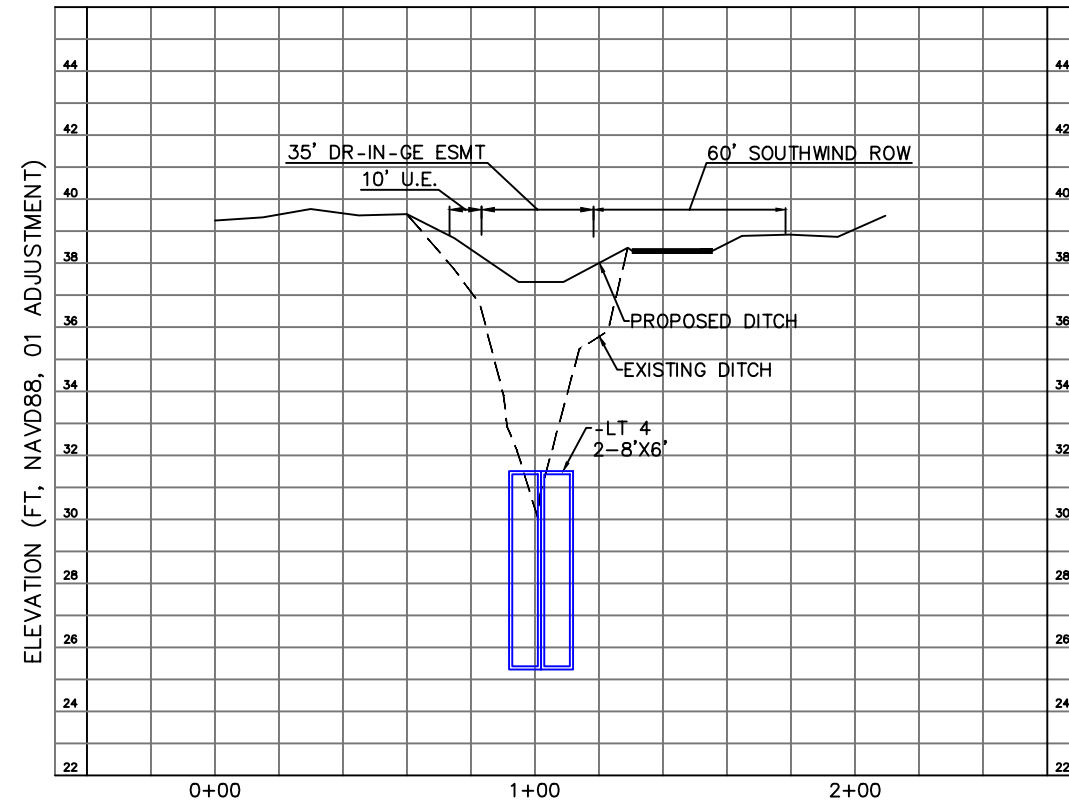
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ADDENDUM TO FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFCU UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 4 WATER SURFACE PROFILE
 Date: MARCH 2018
 Exhibit No: 5

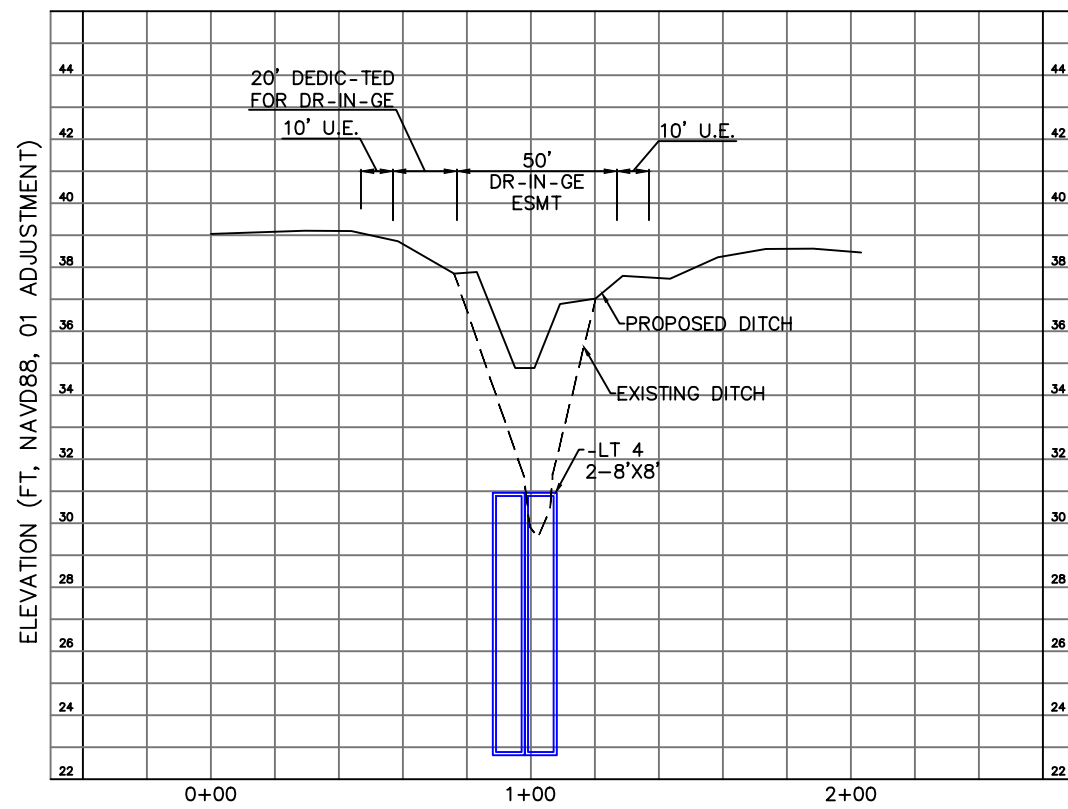
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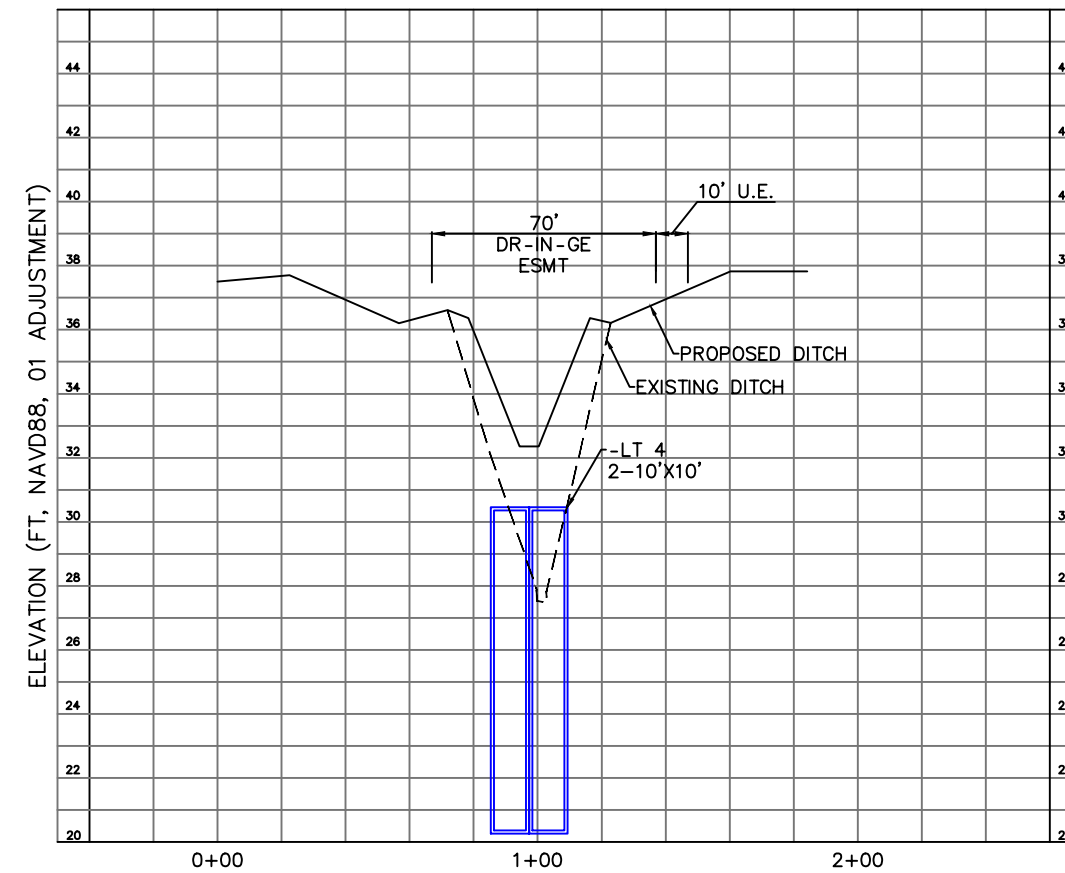
LEGEND

- - - - - EXISTING DITCH
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING PAVEMENT

TYPICAL CROSS SECTION B

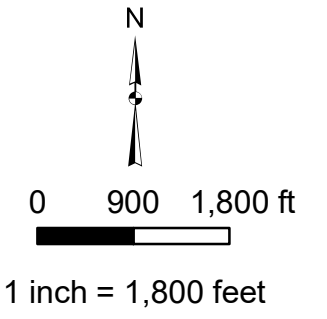
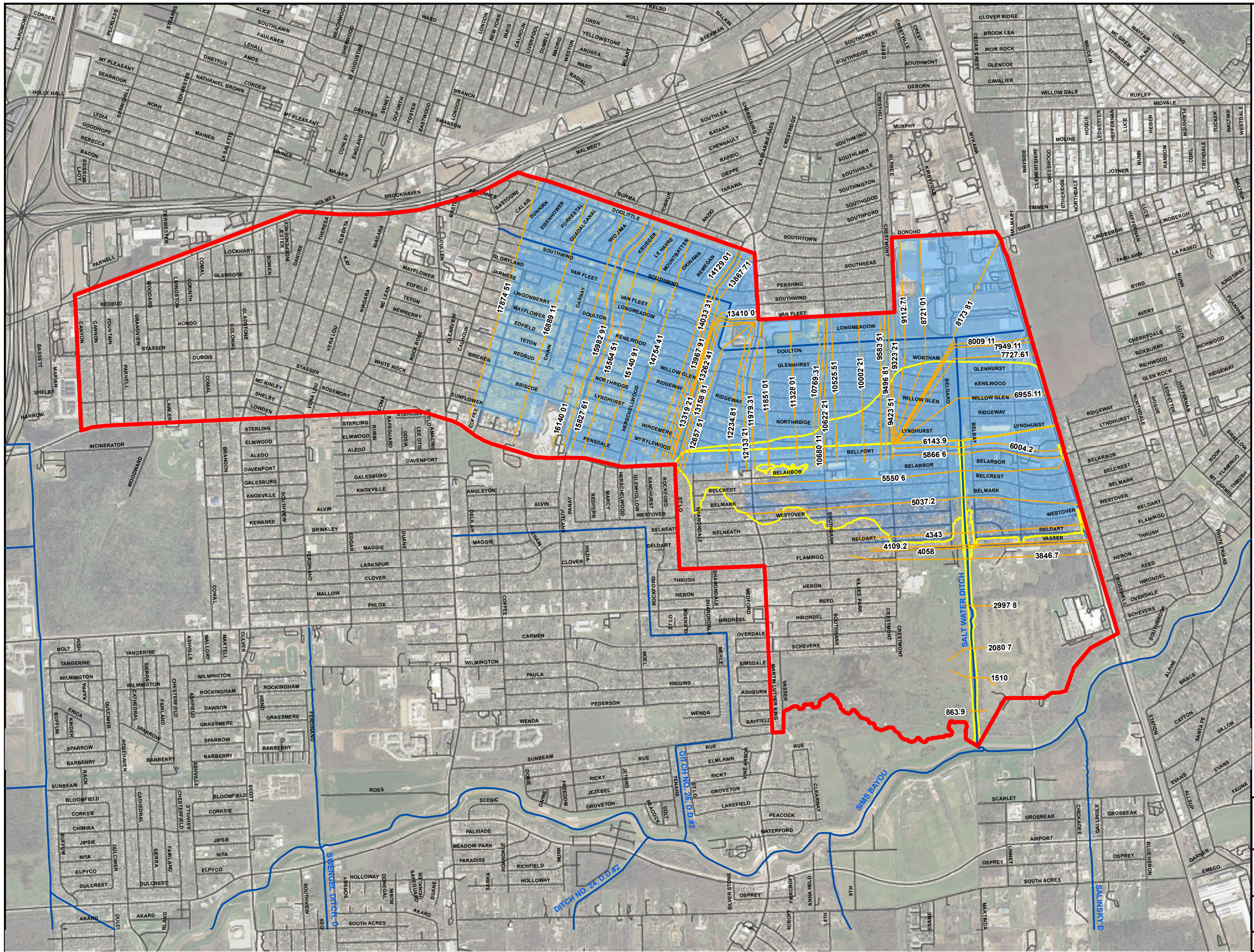


TYPICAL CROSS SECTION C



SCALE
H: 1"=60' V: 1"=6'

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- Legend**
- HEC-RAS Cross Sections
 - Streams
 - FEMA Effective Floodplain
 - Residual 100-Year Floodplain
 - Revised Existing 100-Year Floodplain
 - Salt Water Ditch Subwatershed

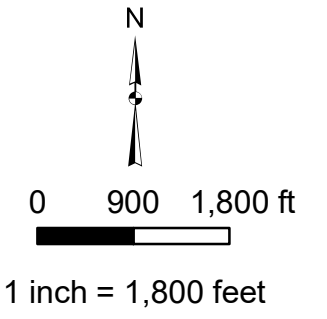
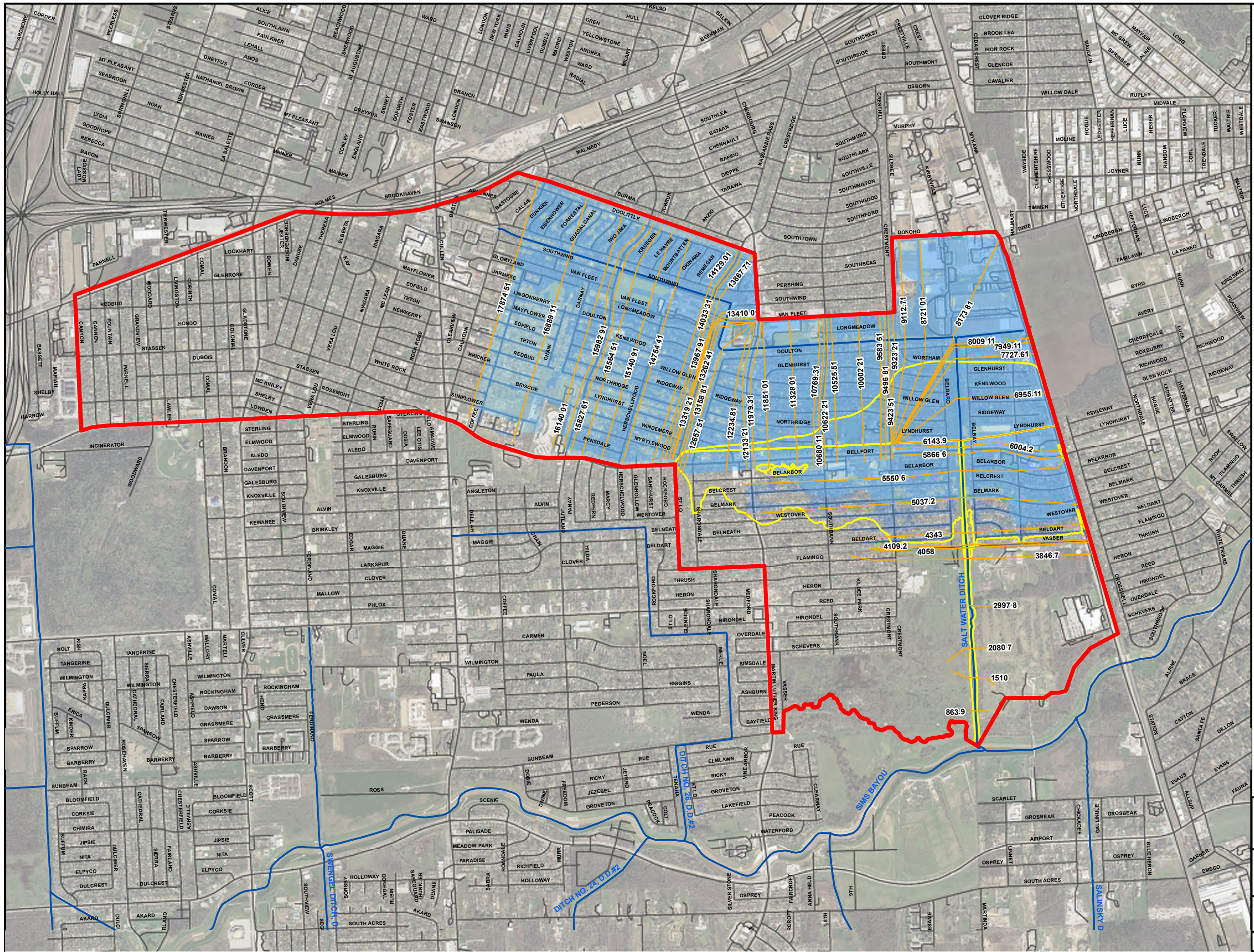
Aerials: 2012 HGAC

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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 3 RESIDUAL FLOODPLAIN



- Legend**
- HEC-RAS Cross Sections
 - Streams
 - FEMA Effective Floodplain
 - Residual 100-Year Floodplain
 - Revised Existing 100-Year Floodplain
 - Salt Water Ditch Subwatershed

Aerials: 2012 HGAC

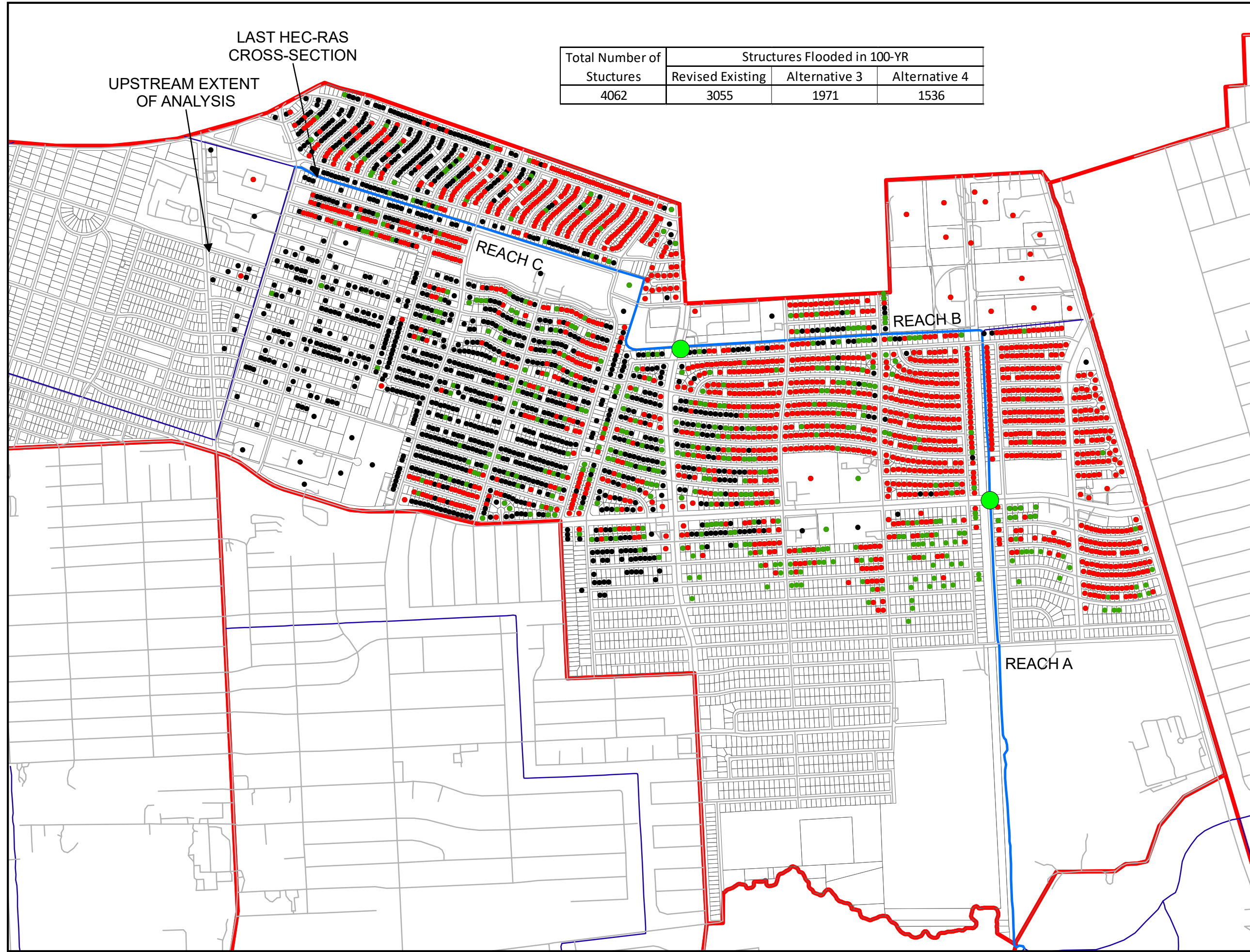
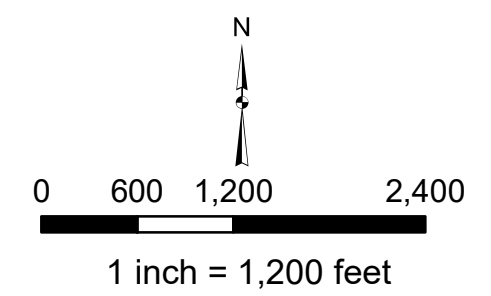
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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFC D UNIT NO. C118-00-00
ALTERNATE LEVEL OF SERVICE ANALYSIS

ALTERNATIVE 4 RESIDUAL FLOODPLAIN

Total Number of Structures	Structures Flooded in 100-YR		
	Revised Existing	Alternative 3	Alternative 4
4062	3055	1971	1536



- Legend**
- Flooded Structures in 100-YR Event Alternative 4
 - Flooded Structures in 100-YR Event Alternative 3
 - Flooded Structures in 100-YR Event
 - Reach Breaks
 - Salt Water Ditch
 - Stream Centerline
 - Parcels in Salt Water Ditch Subwatershed
 - Subwatershed Boundary

CivilTech Engineering, Inc.
 11821 Telge Rd
 Cypress, Texas 77429
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FEASIBILITY STUDY FOR SALT WATER DITCH
 HCFCU UNIT NO. C118-00-00
 COH WORK AUTHORIZATION NO. 12

FLOODED STRUCTURES

APPENDIX A
ALTERNATIVE ANALYSIS

APPENDIX A.1 - STORM SEWER CALCULATIONS

APPENDIX A.2 – MINIMUM STORM SEWER EASEMENT CALCULATIONS

APPENDIX A.3 – QUANTITY AND COST ESTIMATE CALCULATIONS

APPENDIX A.1

STORM SEWER CALCULATIONS

- **STORM SEWER CALCULATIONS FOR PROPOSED ALTERNATIVE 3**
- **STORM SEWER CALCULATIONS FOR PROPOSED ALTERNATIVE 4**

Storm Sewer - Alternative 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCU Unit C118-00-00)
Project No: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Gradient		Soffit Elevation		Natural Ground	
From Road	To Road										Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)
Calhoun	Jutland	202.00	2429	2	6	6	0.05	0.015	209.00	2.90	27.00	25.79	2.81	0.05	1.13	39.18	38.05	33.00	31.79	39.5	38.9
Jutland	St Lo	258.00	1915	2	6	6	0.05	0.015	209.00	2.90	25.79	24.83	3.58	0.08	1.46	38.05	36.59	31.79	30.83	38.9	38.1
St Lo	Van Fleet	331.00	706	2	8	6	0.05	0.015	304.61	3.17	24.83	24.48	3.45	0.06	0.42	36.59	36.17	30.83	30.48	38.1	38.6
Van Fleet	Martin Luther King	363.00	1281	2	8	6	0.05	0.015	304.61	3.17	24.48	23.83	3.78	0.07	0.91	36.17	35.26	30.48	29.83	38.6	38.0
Martin Luther King	Southbank	438.30	1367	2	8	6	0.05	0.015	304.61	3.17	23.83	23.15	4.57	0.10	1.42	35.26	33.85	29.83	29.15	38.0	37.4
Southbank	Crestmont	483.00	1189	2	8	8	0.05	0.015	450.11	3.52	23.15	22.56	3.77	0.06	0.68	33.85	33.16	31.15	30.56	37.4	37.6
Crestmont	Doulton	533.00	1474	2	8	8	0.05	0.015	450.11	3.52	22.56	21.82	4.16	0.07	1.03	33.16	32.13	30.56	29.82	37.6	36.8
Doulton	Belfort	603.00	2082	2	8	8	0.05	0.015	450.11	3.52	21.82	20.78	4.71	0.09	1.87	32.13	30.26	29.82	28.78	36.8	36.3
Belfort	Vasser	713.00	1811	2	10	8	0.05	0.015	603.58	3.77	20.78	19.87	4.46	0.07	1.26	30.26	29.00	28.78	27.87	36.3	35.7
Vasser	End of Culvert	834.00	1313	2	10	8	0.05	0.015	603.58	3.77	19.87	19.22	5.21	0.10	1.25	29.00	27.74	27.87	27.22	35.7	35.0

Storm Sewer - Alternative 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCU Unit C118-00-00)
Project No: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Flows (cfs)	Reach Length (ft)	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)	Slope (%)	Manning's "n" (cfs)	Design Capacity (cfs)	Design Velocity (fps)	Flow Line		Actual Velocity (fps)	Hydraulic Gradient (%)	Change in Head (ft)	Hydraulic Grade Line		Soffit Elevation		Natural Ground	
From Road	To Road										Upstream (ft)	Downstream (ft)				Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)	Upstream (ft)	Downstream (ft)
Calhoun	Jutland	249	2429	2	6	6	0.05	0.015	209.00	2.90	27.00	25.79	3.46	0.07	1.72	39.16	37.44	33.00	31.79	39.5	38.9
Jutland	St Lo	318	1915	2	8	6	0.05	0.015	304.61	3.17	25.79	24.83	3.31	0.05	1.04	37.44	36.40	31.79	30.83	38.9	38.1
St Lo	Van Fleet	408	706	2	8	6	0.05	0.015	304.61	3.17	24.83	24.48	4.25	0.09	0.63	36.40	35.76	30.83	30.48	38.1	38.6
Van Fleet	Martin Luther King	447	1281	2	8	8	0.05	0.015	450.11	3.52	24.48	23.83	3.49	0.05	0.63	35.76	35.13	32.48	31.83	38.6	38.0
Martin Luther King	Southbank	540	1367	2	8	8	0.05	0.015	450.11	3.52	23.83	23.15	4.22	0.07	0.98	35.13	34.15	31.83	31.15	38.0	37.4
Southbank	Crestmont	595	1189	2	8	8	0.05	0.015	450.11	3.52	23.15	22.56	4.65	0.09	1.04	34.15	33.11	31.15	30.56	37.4	37.7
Crestmont	Doulton	657	1474	2	10	8	0.05	0.015	603.58	3.77	22.56	21.82	4.11	0.06	0.87	33.11	32.24	30.56	29.82	37.7	37.7
Doulton	Bellfort	743	2082	2	10	8	0.05	0.015	603.58	3.77	21.82	20.78	4.64	0.08	1.58	32.24	30.66	29.82	28.78	37.7	37.5
Bellfort	Vasser	877	1811	2	10	10	0.05	0.015	816.11	4.08	20.78	19.87	4.39	0.06	1.05	30.66	29.61	30.78	29.87	37.5	36.6
Vasser	End of Culvert	1026	1313	2	10	10	0.05	0.015	816.11	4.08	19.87	19.22	5.13	0.08	1.04	29.61	28.58	29.87	29.22	36.6	37.0

APPENDIX A.2

MINIMUM STORM SEWER EASEMENT CALCULATIONS

- **MINIMUM STORM SEWER EASEMENT CALCULATIONS FOR PROPOSED ALTERNATIVE 3**
- **MINIMUM STORM SEWER EASEMENT CALCULATIONS FOR PROPOSED ALTERNATIVE 4**

MINIMUM STORM SEWER EASEMENT CALCULATIONS ALTERNATIVE 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFCD Unit C118-00-00)
Project #: 325912
Date: 3/30/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Pipe Sizes			Natural Ground (ft)	Flowline (ft)	Total Depth (ft)	Required Easement (ft)
From Road	To Road	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)				
Calhoun	Jutland	2	6	6	38.9	25.8	13.1	27
Jutland	St Lo	2	6	6	38.1	24.8	13.3	27
St Lo	Van Fleet	2	8	6	38.6	24.5	14.1	31
Van Fleet	Martin Luther King	2	8	6	38.0	23.8	14.2	31
Martin Luther King	Southbank	2	8	6	37.4	23.2	14.2	31
Southbank	Crestmont	2	8	8	37.7	22.6	15.2	36
Crestmont	Doulton	2	8	8	37.7	21.8	15.9	36
Doulton	Bellfort	2	8	8	37.5	20.8	16.7	36
Bellfort	Vasser	2	10	8	36.6	19.9	16.7	40
Vasser	End of Culvert	2	10	8	37.0	19.2	17.8	40

MINIMUM STORM SEWER EASEMENT CALCULATIONS ALTRERNATIVE 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/30/2018
Prepared By: ML
Checked By:

Pipe Run		Proposed Pipe Sizes			Natural Ground (ft)	Flowline (ft)	Total Depth (ft)	Required Easement (ft)
From Road	To Road	Number of Pipes	Span of Pipe (ft)	Rise of Pipe (ft)				
Calhoun	Jutland	2	6	6	38.9	25.8	13.1	27
Jutland	St Lo	2	8	6	38.1	24.8	13.3	31
St Lo	Van Fleet	2	8	6	38.6	24.5	14.1	31
Van Fleet	Martin Luther King	2	8	8	38.0	23.8	14.2	31
Martin Luther King	Southbank	2	8	8	37.4	23.2	14.2	31
Southbank	Crestmont	2	8	8	37.7	22.6	15.2	36
Crestmont	Doulton	2	10	8	37.7	21.8	15.9	40
Doulton	Belfort	2	10	8	37.5	20.8	16.7	40
Belfort	Vasser	2	10	10	36.6	19.9	16.7	40
Vasser	End of Culvert	2	10	10	37.0	19.2	17.8	40

APPENDIX A.3

COSTS

- **COSTS FOR PROPOSED ALTERNATIVE 3**
- **COSTS FOR PROPOSED ALTERNATIVE 4**

COSTS FOR PROPOSED ALTERNATIVE 3

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Description	Unit	Unit Price	Units	Total Cost
Inlets	EA	\$2,910	36	\$104,760
Manhole for Larger than 78" Storm Sewer	EA	\$16,500	36	\$594,000
Riprap	SY	\$31	1301	\$40,331
6' x 6' RCB	LF	\$480	8688	\$4,170,240
8' x 6' RCB	AC	\$770	6768	\$5,211,360
8' x 8' RCB	LS	\$920	9490	\$8,730,800
10' x 8' RCB	LF	\$960	6248	\$5,998,080
Bridge Replacement	SF	\$100	70210	\$7,021,000
Trench Safety System	LF	\$2	31194	\$62,388
Land Acquisition - Drainage Easements	AC	\$80,700	0	\$0
Land Acquisition - Full Parcel Acquisitions	3x Market Value		0	\$0
Contingency	20% of TOTAL			\$6,386,592
TOTAL				\$38,319,551

Note: Storm Sewer cost estimates based on FY 18 Pre-Engineering Unit Prices

COSTS FOR PROPOSED ALTERNATIVE 4

Project: Addendum to Feasibility Study for Flood Damage Reduction to Salt Water Ditch (HCFC Unit C118-00-00)
Project #: 325912
Date: 3/2/2018
Prepared By: ML
Checked By:

Description	Unit	Unit Price	Units	Total Cost
Inlets	EA	\$2,910	36	\$104,760
Manhole for Larger than 78" Storm Sewer	EA	\$16,500	36	\$594,000
Riprap	SY	\$31	1301	\$40,331
6' x 6' RCB	LF	\$480	4858	\$2,331,840
8' x 6' RCB	AC	\$770	5242	\$4,036,340
8' x 8' RCB	LS	\$920	7674	\$7,060,080
10' x 8' RCB	LF	\$960	7112	\$6,827,520
10' x 10' RCB	LF	\$1,300	6248	\$8,122,400
Bridge Replacement	SF	\$100	70210	\$7,021,000
Trench Safety System	LF	\$2	31134	\$62,268
Land Acquisition - Drainage Easements	AC	\$80,700	0	\$0
Land Acquisition - Full Parcel Acquisitions	3x Market Value		0	\$0
Contingency		20% of TOTAL		\$7,240,108
TOTAL				\$43,440,647

Note: Storm Sewer cost estimates based on FY 18 Pre-Engineering Unit Prices