VOLUME 2

2023 REGIONAL FLOOD PLAN
REGION 6
SAN JACINTO

January 2023

PREPARED FOR THE **SAN JACINTO REGIONAL FLOOD PLANNING GROUP**

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Supplemental Source Documentation

Appendix 5-4A:
Non-Structural Flood Mitigation

APPENDIX 5-4A NONSTRUCTURAL FLOOD MITIGATION

The referenced report, Natural Hazard Mitigation Saves, can be accessed at the following location.

"Natural Hazard Mitigation Saves." Principal Investigator Porter, K.; Co-Principal Investigators Dash, N., Huyck, C., Santos, J., Scawthorn, C.; Investigators: Eguchi, M., Eguchi, R., Ghosh., S., Isteita, M., Mickey, K., Rashed, T., Reeder, A.; Schneider, P.; and Yuan, J., Directors, MMC. Investigator Intern: Cohen-Porter, A., National Institute of Building Sciences, 2019.https://www.nibs.org/files/pdfs/NIBS_MMC_MitigationSaves_2019.pdf

Appendix 5-4B:
Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan

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LOWER CLEAR CREEK AND DICKINSON BAYOU FLOOD MITIGATION PLAN

Lower Clear Creek Alternatives Evaluation and Recommendation

FINAL REPORT

Prepared for:

City of League City

June 2021

Prepared by:

FREESE AND NICHOLS, INC.
11200 Broadway St. Suite 2320
Pearland, Texas 77584

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1 EXECUTIVE SUMMARY

The purpose of this study was to develop a comprehensive flood mitigation plan for the Lower Clear Creek Watershed with a focus on the riverine impacts along the main channel beginning near Farm to Market Road 1959 through the outlet of Clear Creek/Clear Lake into Galveston Bay. In conjunction with Harris County Flood Control District's MAAPnext effort, Freese and Nichols, Inc. (FNI) developed state-of-the-art hydrologic and hydraulic models leveraging current NOAA Atlas 14 rainfall, 2018 LiDAR data, and a 1D/2D unsteady-state modeling approach. FNI evaluated both existing and future conditions flood risks based on the 24-hour duration 2-, 5-, 10-, 50-, 100-, and 500-year Atlas 14 storm events, as well as Hurricane Harvey rainfall. FNI identified vulnerabilities in the Lower Clear Creek Watershed, including instances of flooding at structures and the resulting damage estimates, as well as impacts to critical infrastructure and transportation systems.

FNI investigated and modeled a total of 16 flood mitigation projects along Clear Creek. These projects consist of detention basins, linear conveyance improvements, channel and tunnel diversions, and crossing improvements. FNI evaluated each project based on four quantitative metrics including instances of flooding, flood damages reduced, constructions costs, and transportation system impacts. FNI also assessed five qualitative (non-cost) metrics in its project evaluation, including operations and maintenance requirements, and impacts to aesthetics and the community. Each concept was modeled individually, and based on the analysis of each discrete project's impacts, FNI developed three combination alternatives that incorporate multiple projects to optimize benefits while preventing adverse impacts. A summary of these flood mitigation alternatives is presented in **Table 1** provided on the next page. Maps presenting these alternatives are provided in **Section 3** of this report as **Figure 8**, **Figure 12**, and **Figure 16**.

Based on discussions with stakeholders, all of the combination alternatives and any of the individual projects greater than $50 million in capital cost are unlikely to be funded by an individual entity. Mitigation will require partnerships and cost sharing agreements between the entities. These agreements could be developed piecemeal on a project by project basis, or by development of a watershed-wide entity focused on flood damage reduction along the main channel of Clear Creek. In addition to local funding opportunities through ad valorem, additional grant and matching programs exist at the Federal and State level that should be further evaluated as this study progresses into future phases.

Table 1: Summary of Flood Mitigation Alternatives

Alternative	Discrete Projects	Cost	Non-Cost Score	Reductions Over the 50-year Design Period		Reductions During Harvey	
				Damages	Flooding Instances	Damages	Flooding Instances
1: Detention + Conveyance	Friendswood Detention Basin	$275 M	4.4	$60 M	1,960	$100 M	930
	Timber Creek Golf Course Detention Basin						
	Clearing and De-snagging - FM 1959 to Bay Area Blvd.						
	SH 3 and UPRR Capacity Improvements						
	FM 270 Auxiliary Opening						
	Clear Lake Outlet Expansion						
2: Detention + Conveyance + FM 2351 Tunnel	Friendswood Detention Basin	$1,250 M	3.6	$95 M	3,110	$155 M	1,490
	Timber Creek Golf Course Detention Basin						
	Clearing and De-snagging - FM 1959 to Bay Area Blvd.						
	40-Foot Diam Tunnel Diversion from FM 2351 to Clear Lake						
	SH 3 and UPRR Capacity Improvements						
	FM 270 Auxiliary Opening						
	Clear Lake Outlet Expansion						
3: Detention + Conveyance + I-45 Tunnel	Friendswood Detention Basin	$1,150 M	3.4	$70 M	2,300	$125 M	1,150
	Timber Creek Golf Course Detention Basin						
	Channel Benching Above OHWM - FM 1959 to Bay Area Blvd.						
	40-Foot Diam Tunnel Diversion from I-45 to Galveston Bay						
	SH 3 and UPRR Capacity Improvements						
	FM 270 Auxiliary Opening						

FNI proposes the following conclusions resulting from this study:

1. The alternatives proposed in this study are targeted toward mitigating the riverine flood risk during large, infrequent storms. For structures at risk of flooding under smaller, more frequent storms such as the 2-year and the 5-year events, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. FNI calculated that 54 structures flood during the 5-year event under future conditions.
2. Improvements should be implemented wholistically – from FM 1959 down to Galveston Bay to prevent adverse impacts.
    a. Large scale vegetative clearing or channel improvements through Friendswood cannot be constructed as stand-alone projects, and upstream or inline detention may not provide sufficient mitigation to prevent increases in discharges and water surface elevations in the downstream sections of the Creek.
    b. Increasing the conveyance upstream of Clear Lake necessitates increasing the conveyance out of the Lake into Galveston Bay. Increasing the capacity of the outlets to Galveston Bay could expose this area to greater storm surge risk and environmental impacts, and should be analyzed further as this study progresses into future phases. A solution should be developed in conjunction with the improvements proposed as part of the Coastal Texas Study at the Clear Lake outlets.
3. Tunnel solutions are less cost efficient than other alternatives, and do not score well based on the 50-year project window used by USACE and FEMA given they are designed to operate during storm events equal to or exceeding the 10-year storm. However, they provide the greatest level of protection during events of catastrophic magnitude such as the 500-yr storm event and Hurricane Harvey, and can be designed to provide additional benefits to local drainage systems.
4. The project benefits captured in this study do not fully account for the benefits the proposed alternatives could provide to the local drainage systems, which could be significant, particularly for the tunnel projects. The output from the alternatives developed in this study's hydraulic models should be integrated into local storm sewer network models to capture additional benefits achieved outside of the riverine floodplain of Clear Creek and its major tributaries.

5. The proposed alternatives mitigate but do not eliminate the flood risk in the study area. Significant residual risk persists due to certain low-lying structures and the compound effect of rainfall and storm surge that will likely become more severe in the future due to rising sea levels.

Based on these conclusions, FNI recommends a feasibility study be conducted to:

- Refine the combination alternatives proposed as part this study,
- Identify supplemental benefits the alternatives could provide to areas located outside of the riverine floodplains, particularly as it relates to the tunnel projects,
- Reduce the uncertainty associated with the compound flooding results by conducting further analyses to improve the understanding of its impacts on the alternatives' benefits,
- Identify efficiencies in the alternatives to reduce cost,
- Develop a project delivery plan, and
- Recommend a distinct alternative for implementation.

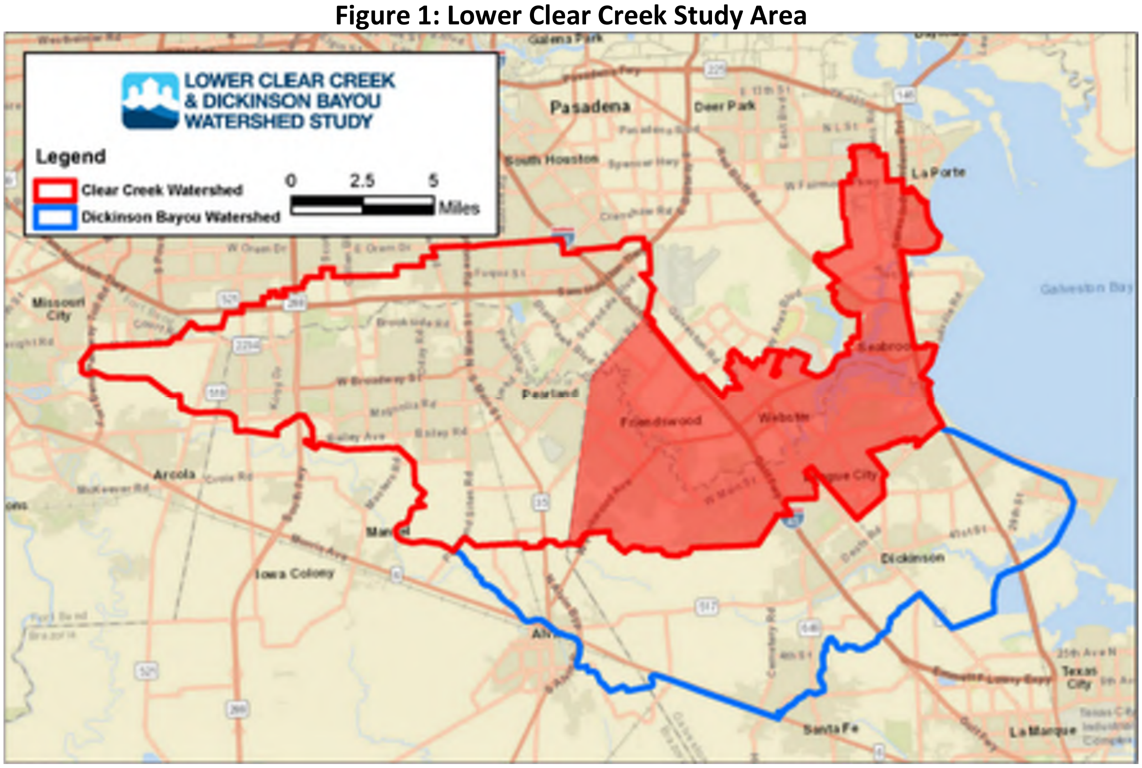
2 BACKGROUND

In August 2017, Hurricane Harvey struck the Texas coast, bringing a historic amount of rainfall to the Houston region. The storm produced never-before-seen precipitation depths in Galveston, Harris, and Brazoria Counties, as well as surrounding counties. As was the case with most of the watersheds in the region, Clear Creek and Dickinson Bayou experienced widespread flooding, which resulted in significant flood damages in the region.

The goal of this study was to develop a comprehensive flood mitigation plan for the Lower Clear Creek and Dickinson Bayou Watersheds with a focus on the riverine impacts along the main channel of each waterway. The flood mitigation plan is focused on mitigating the risk of extreme events similar to Hurricane Harvey, Tropical Storm Allison, and other large tropical storms, as well as flood damages from smaller more frequent storms. The targeted reduction in flood depths was set as multiple feet of reduction at Interstate 45 (I-45) during a 100-year storm.

This evaluation and recommendation report is focused on the Clear Creek Watershed, and more specifically the area defined as Lower Clear Creek (shown in red in **Figure 1** below) which includes the Clear Creek Watershed within Galveston and Harris Counties beginning near Farm to Market Road 1959 (FM 1959) through the outlet of Clear Creek/Clear Lake into Galveston Bay.

Figure 1: Lower Clear Creek Study Area



The flood mitigation projects that FNI developed as part of this study reflect a concept-level analysis. Although this level of detail is adequate to evaluate the general efficacy of the projects in providing flood risk mitigation, the preliminary siting and sizing that was performed will need to be refined in a future phase as part of a feasibility study.

In order to distinguish project improvements along the Creek and to acknowledge the different characteristics of the Creek between FM 1959 and Galveston Bay, the project area was divided into three Planning Areas as shown in **Figure 2** provided on the following page.

1. Reach 1 (CC-1) from FM 1959 to Bay Area Boulevard passes through Friendswood and is characterized by a constrained main creek channel that is joined by multiple major tributaries including Turkey Creek, Mary's Creek, Cowart Creek, and Chigger Creek. Nearly all development is built slab on grade even in close proximity to the channel.

2. Reach 2 (CC-2) from Bay Area Boulevard to Farm to Market Road 270 (FM 270) is a transitory section of the creek between the higher elevation in Friendswood and the tidally influenced section of the Creek. Reach CC-2 crosses major transportation corridors including I-45, Texas State Highway 3 (SH 3), FM 270, and the Union Pacific Railroad (UPRR) tracks. This is the least developed section of the Creek, although additional development is planned for the future. Nearly all development is constructed slab on grade in this reach.

3. Reach 3 (CC-3) from FM 270 to the outlet at Galveston Bay is entirely tidally influenced and includes Clear Lake and its surrounding communities. Reach CC-3 is subject to significant inflows from Armand Bayou and Taylor Lake. Many of the structures in this reach are elevated due to storm surge risks and previous damage from Hurricane Ike and other coastal storm events.

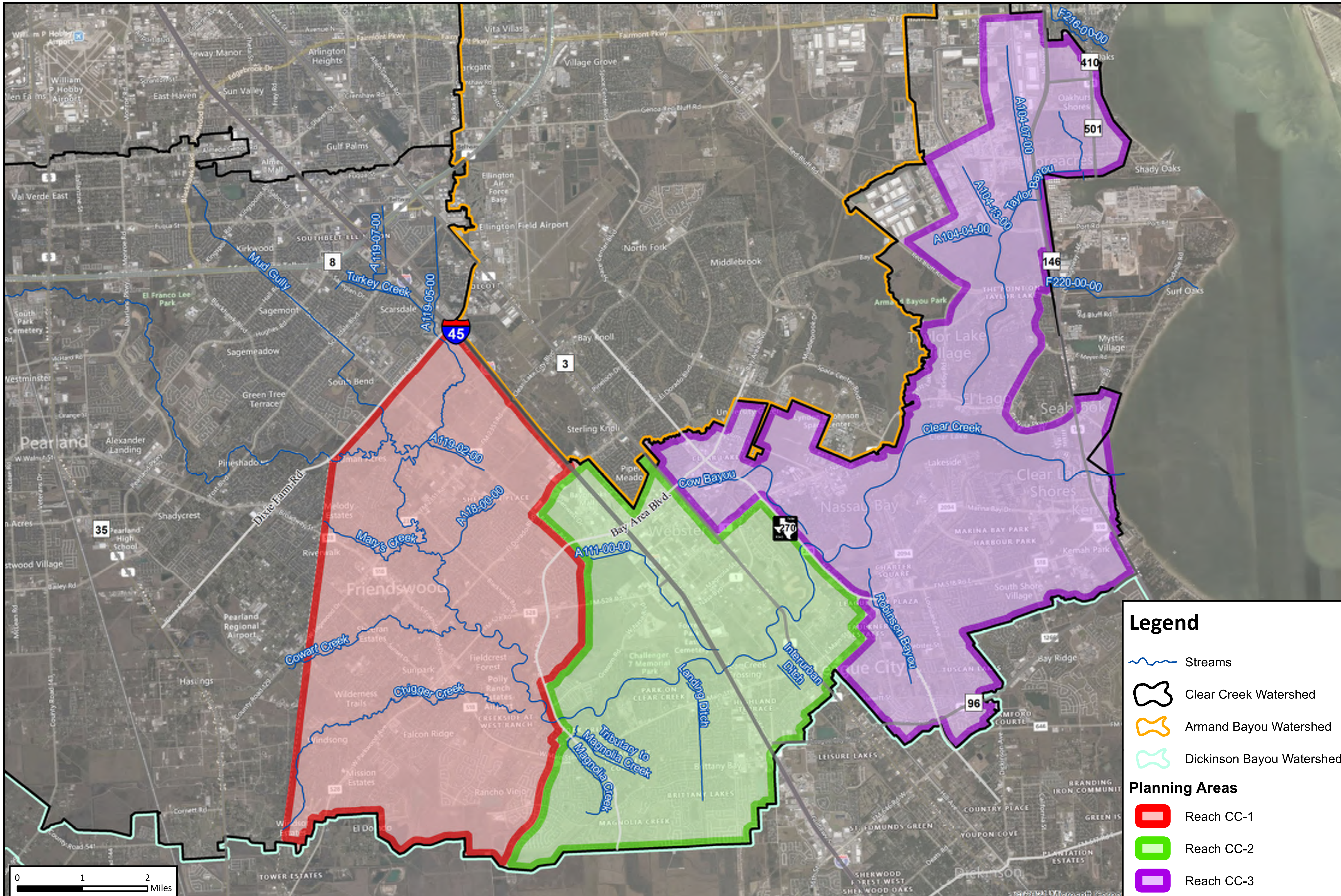


FIGURE 2

FN JOB NO LEA19668
FILE Fig2.LCC_PlanningAreas
DATE 4/19/2021
SCALE 1:8
DRAFTED 90206

Lower Clear Creek

Planning Areas

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2.1 PROJECT PHASING

To maximize the effectiveness of the study, the effort was divided into Phases. This Alternatives Evaluation and Recommendation report represents the culmination of Phase 3: Project(s) Identification. The previous phases completed were:

- Phase 1: Discovery & Baselining
- Phase 2: Watershed Study

The deliverables for the prior two phases are included as **Appendix B**, **Appendix C**, and **Appendix D** to this report for reference. This report includes the alternatives analysis and recommendations that conclude Phases 1 through 3 of the project. Future phases may be authorized and developed by the City of League City and other stakeholders based on the results of this study.

2.2 PLANNING PARTNERS

League City led the engagement of numerous stakeholders along Lower Clear Creek to fund Phases 1 through 3 of this study. League City also entered into an agreement to receive Planning Assistance to States (PAS) funding from the United States Army Corps of Engineers (USACE) under the authority provided by Section 22 of the Water Resources Development Act of 1974 (PL 93-251), as amended. USACE Galveston District provided in-kind services and was engaged in all aspects of the project including technical reviews and a downstream boundary condition analysis accounting for storm surge and future sea level rise.

Key planning partners and contributors included:

- The United States Army Corps of Engineers (USACE)
- Harris County Flood Control District (HCFCD) including MAAPnext consultant Pape-Dawson Engineers, Inc. (Pape-Dawson)
- Galveston County including consultant RPS Group, Inc. (RPS)
- City of Friendswood

Additional planning partners and study contributors included:

- Galveston County Consolidated Drainage District
- LJA Engineering, Inc. (LJA) through their work on the League City Municipal Drainage Plan
- Other members of the Clear Creek Watershed Steering Committee

2.3 HYDROLOGY AND HYDRAULICS

As part of Phase 2 of this project, FNI performed a hydrologic and hydraulic study of the Clear Creek Watershed (refer to **Appendix B** and **Appendix C** for more details). The model development for the main stem of Clear Creek was conducted by Pape-Dawson per the partnership agreement with HCFCD as part of the MAAPnext effort. FNI focused its modeling effort on the main tributaries within Galveston County beginning downstream of FM 1959, and that effort was integrated into the overall Clear Creek Watershed hydrologic and hydraulic models.

2.3.1 Data Sources

The main data sources used in this study included:

- 2018 LiDAR: FNI developed the study's topographic information using Light Detection and Ranging (LiDAR) data obtained from the Texas Natural Resources Information System (TNRIS) and the Houston-Galveston Area Council of Governments (HGAC). This LiDAR data was collected January through March 2018, and uses the vertical datum GEOID12B.
- Atlas 14 Rainfall: Precipitation data was obtained from NOAA's Atlas 14, Volume 11 Version 2.0 (Atlas 14). Atlas 14 is the most up to date precipitation data.
- Effective Models: The effective hydrologic and hydraulic models for the main stem of Clear Creek were downloaded from HCFCD's Model and Map Management (M3) System. A data request was submitted to the Federal Emergency Management Agency (FEMA) in February 2020 to gather all available effective models within the study area.

2.3.2 Hydrology

FNI generated updated hydrologic parameters based on the Basin Development Factor (BDF) methodology. The hydrologic model was developed using the USACE Hydrologic Engineering Center's Hydrology Modeling System (HEC-HMS) version 4.3. FNI executed 24-hour duration storm events in the model including the Annual Exceedance Probabilities (AEP) of 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), and 0.2% (500-year), as well as historical storm events such as Hurricane Harvey. FNI analyzed both existing conditions based on current land use, and future conditions based on predicted future development occurring without detention. The study's results for the 100-year storm event are summarized in **Table 2** provided on the next page.

Table 2: 100-Year Peak Discharges (cfs) at Key Locations

Location	Contributing Drainage Area (Sq M)	FEMA Effective	FNI		
			Existing	Future	% Increase
Watershed Outfall (SH 146)*	256	47,042	86,764	86,890	0.1%
Downstream of Armand Bayou Confluence*	247	47,042	86,715	86,847	0.15%
FM 270 (Upstream of Armand Bayou Confluence)	162	24,535	36,788	37,145	0.97%
I-45	152	23,660	34,983	35,401	1.2%
Chigger Creek Confluence	141	22,891	32,486	32,972	1.5%
Turkey Creek Confluence	78	12,497	18,338	18,738	2.2%
FM 1959	55	5,376	9,614	10,011	4.1%

These 100-year results show significant increases between the effective discharges and the discharges computed as part of this study. These increases can be attributed to multiple factors, including:

- Increases in rainfall depths associated with the latest and improved Atlas 14 precipitation data: For the 24-hour duration 100-year storm event, depths increased from 13.5 inches to 18 inches.
- Differences in the hydrologic modeling methodology including hydrologic routing.
- Increases in resolution of the hydrologic and hydraulic models that were developed.

(*) It is important to note that revised hydrologic and hydraulic modeling is currently under development for the Armand Bayou Watershed as part of the MAAPnext effort. Consequently, the discharges presented in **Table 2** downstream of the Armand Bayou confluence with Clear Creek are not finalized and subject to change.

2.3.3 Hydraulics

The hydraulic model was developed using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 5.0.7. The hydraulic modeling approach consisted in developing detailed combined 1D/2D unsteady-state models for the main stem of Clear Creek and all its major tributaries. The models were then combined into a single hydraulic model that covers the entire Lower Clear Creek Watershed. The model was calibrated using historical storms including Hurricane Harvey. To properly model tidal and storm surge impacts, stages were applied on the downstream end of Clear Creek based on guidance provided by USACE Galveston District.

To capture future conditions, the existing conditions model was adjusted to include:

- Fully-developed discharges,
- Expected future sea level rise (+1.52 feet) over the 50-year project horizon based on the Medium Sea Level Change Scenario analyzed by the USACE,
- Major projects under construction since 2018, which included the Imperial Estates floodplain benching in Friendswood and the I-45 TxDOT bridge improvements.

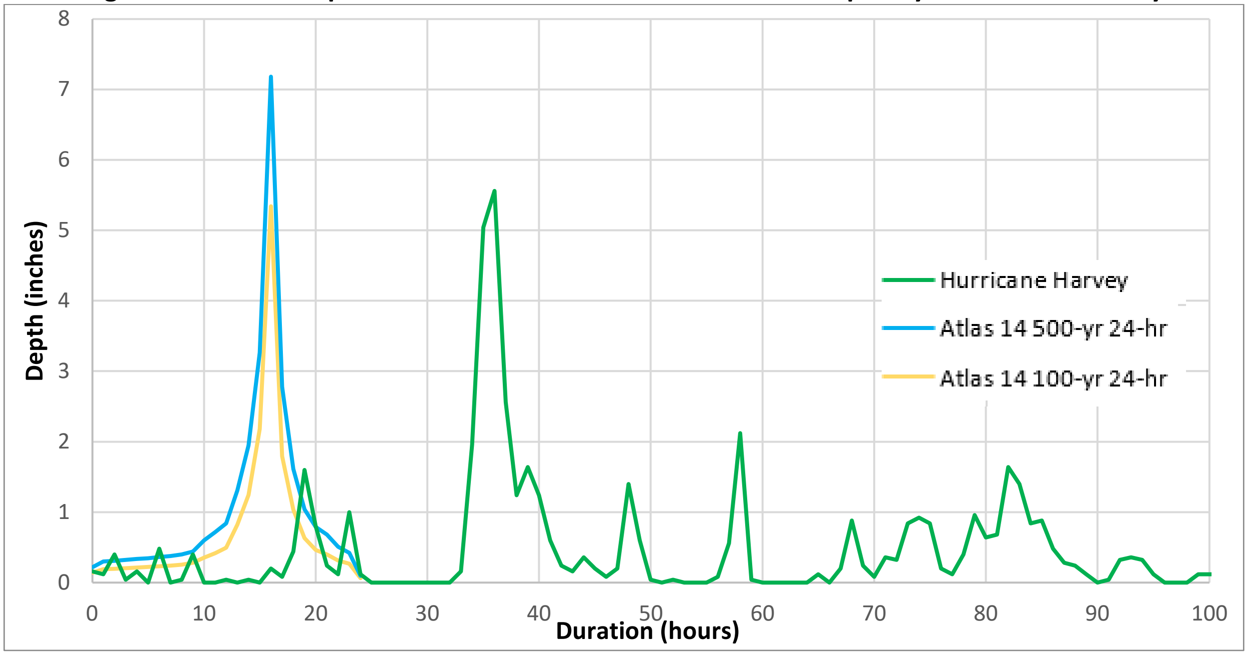
2.3.4 Hurricane Harvey

Because this flood mitigation plan is focused on mitigating the risk of extreme events, it was important to evaluate Hurricane Harvey as it is the most recent catastrophic flood event whose impacts are still felt by stakeholders and the public today. This evaluation included a comparison of rainfall depths and intensity to the new NOAA Atlas 14 events. Rainfall induced flooding is the result of both rainfall intensity and duration. High intensity storms cause flooding when the precipitation rate exceeds the infiltration capacity of soils and the conveyance capacity of the natural channels and stormwater systems. However, total runoff volume is also an important contributor to flooding, particularly in flat, low-lying areas such as Harris and Galveston Counties: Long duration storms of lesser intensity can also result in flooding by filling detention ponds designed to reduce the stress on the conveyance system, as once the design volume is exceeded the detention no longer mitigates the impacts to the conveyance system.

Hurricane Harvey was both a high intensity storm and a long duration storm, and therefore resulted in significant inundation in Clear Creek and other watersheds in the Houston metropolitan area. The data presented in green in **Figure 3** provided on the next page corresponds to rainfall depths measured at the I-45 gage on Clear Creek starting August 25 at 12:00 pm. Rainfall from Harvey lasted over 96 hours (4 days) and exceeded a peak intensity of 5 inches in an hour at approximately hour 37 (August 27 01:00 am). **Figure 3** also shows the Atlas 14 500-year and 100-year 24-hour storm intensities in blue and yellow, respectively, for comparison.

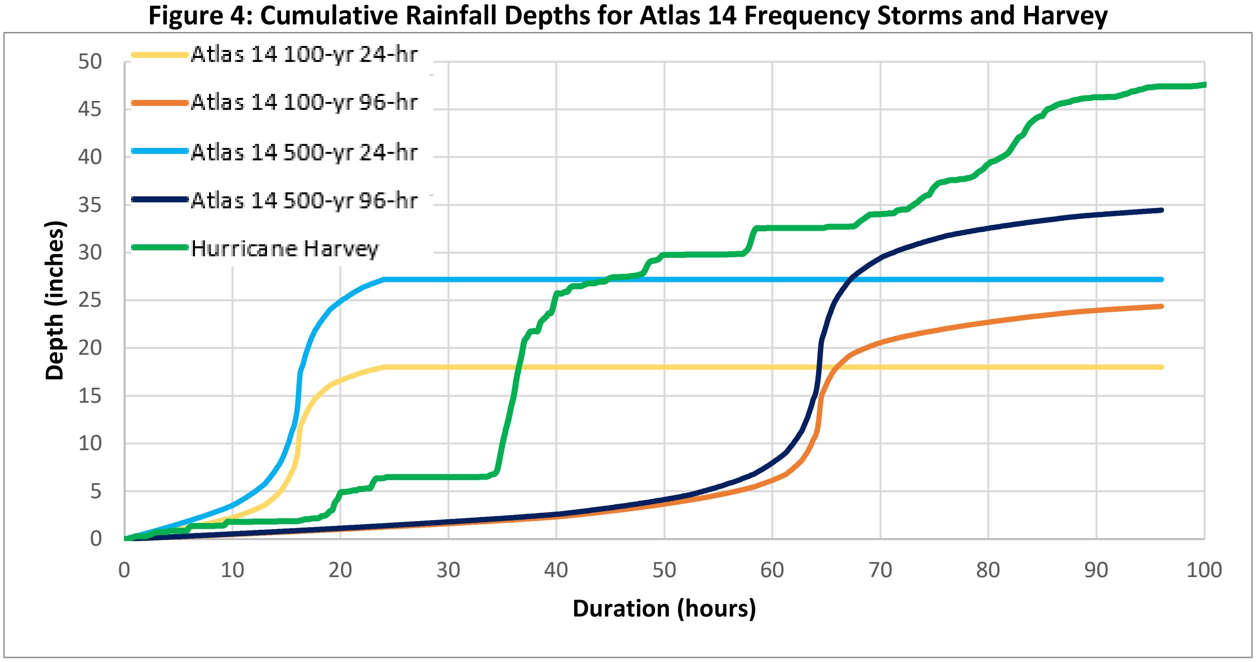
Harvey's maximum intensity was greater than the Atlas 14 100-year 24-hour event but less than the 500-year 24-hour event; however Harvey held that intensity for a long duration and was accompanied by other rainfall exceeding a rate of 1 inch an hour nearly 7 times over the 96 hour period. Prior to the peak intensity beginning at approximately hour 32, over 6 inches of rain had already fallen, saturating the soil and reducing available detention storage. When the maximum intensity occurred, the local storm drainage systems and detention ponds were already stressed, resulting in even greater stress to the conveyance system.

Figure 3: Rainfall Depths at 1-Hour Increments for Atlas 14 Frequency Storms and Harvey



As can be seen in **Figure 4**, rainfall depths from Hurricane Harvey cummulated over the entire storm duration exceeded the Atlas 14 500-year 96-hour duration depths.

Figure 4: Cumulative Rainfall Depths for Atlas 14 Frequency Storms and Harvey



To evaluate project benefits during high-intensity rainfall events, all the combination alternatives were analyzed using the Atlas 14 24-hour storm events to confirm that they were able to convey the maximum storm intensity. To confirm efficacy during long-duration storm events such as tropical storms and hurricanes that produce high volumes of runoff, Hurricane Harvey rainfall was also modeled through the combination alternatives.

2.4 FLOOD RISK

As part of Phase 2 of this study, FNI performed an inundation damages assessment to identify vulnerabilities in the Lower Clear Creek Watershed, including instances of flooding at structures and the resulting damage estimates (refer to **Appendix D** for more details). These two quantitative metrics are detailed in **Section 2.5.1**. A structural inventory was developed in GIS to identify the structures that are located within the floodplains developed as part of the hydraulic modeling effort. Property value information and property type classification were acquired from the Harris County Appraisal District (HCAD) and Galveston Central Appraisal District (GCAD), and associated with the building footprints. Most structures were assigned an assumed finished floor elevation of 0.5 feet above the lowest ground elevation at the structure. As feasible, certain structures were identified as elevated (not built on at-grade slab) and assigned a separate depth-damage curve to compute the flood risk. The elevated structures that were identified are primarily located in Reach CC-3.

FNI evaluated both existing and future conditions flood risks based on the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what those risks could amount to over the 50-year project design period. A discount rate of 7% was used to calculate the net present value of the damages. This report focuses on future conditions instances of flooding and structural damages, as those factors served as the relevant baseline against which the flood mitigation projects proposed as part of Phase 3 were evaluated. FNI also evaluated the impacts that Hurricane Harvey produced in the riverine model (see **Section 2.5.3** for the limitations of the riverine model). These results are shown in **Table 3** and **Table 4**.

Table 3: Structural Damages ($M) for Future Conditions and Hurricane Harvey

Planning Area	Frequency Storms – Future Conditions							Harvey
	500-Yr	100-Yr	50-Yr	10-Yr	5-Yr	2-Yr	50-Yr Period	
CC-1	519.2	124.9	59.5	9.3	3.3	0.8	106.3	163.4
CC-2	153.5	44.7	19.0	6.5	1.8	0.8	43.2	66.0
CC-3	247.6	133.1	99.0	57.5	7.2	5.9	215.6	127.0
Totals	**920.4**	**302.7**	**177.4**	**73.2**	**12.3**	**7.5**	**365.1**	**356.5**

Table 4: Instances of Flooding for Future Conditions and Hurricane Harvey

Planning Area	Frequency Storms – Future Conditions							Harvey
	500-Yr	100-Yr	50-Yr	10-Yr	5-Yr	2-Yr	50-Yr Period	
CC-1	4,840	1,128	584	90	26	7	3,595	1,442
CC-2	1,353	364	154	37	6	3	1,067	635
CC-3	2,322	1,153	832	452	22	12	5,349	1,117
Totals	**8,515**	**2,645**	**1,570**	**579**	**54**	**22**	**10,011**	**3,194**

2.5 EVALUATION FACTORS

2.5.1 Quantitative Metrics

Four quantitative metrics were used in this study to identify the concepts that provide the greatest flood risk mitigation:

1. Instances of Flooding: Number of structures flooded in a given storm event (e.g. 100-year), as well as the number of times a given structure is predicted to flood over a 50-year period. This was analyzed for each of the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what the instances could amount to over the 50-year project design period. An instance of flooding reports whether a given structure is inundated or not. See **Appendix D** for more information.

2. Structural Damages: Monetary value resulting from the damages caused by floodwaters at a given structure. This was analyzed for each of the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what the damages could amount to over the 50-year project design period. Structural damages are a function of floodwater depths at a given structure, and are computed based on depth-damage relationships developed by USACE. See **Appendix D** for more information.

3. Transportation System Impacts: Frequency and risk of pedestrian, roadway, and railroad crossings being overtopped by floodwaters. These impacts are representative of public safety hazards, mobility constraints, and impacts to emergency responders. The level of service and hazard was calculated for all main channel and tributary crossings located in the study area. See **Appendix D** for more information.

4. Capital Cost: Cost to construct the improvement in 2021 dollars. Operations and maintenance (O&M) costs were not calculated at this time, but O&M requirements were taken into account as one of the non-cost factors. Capital cost was developed on a rough order of magnitude (ROM) basis for comparative purposes between projects. FNI performed cost estimation in a matter that is consistent with an AACE Level 5 estimate based on a project maturity level of 0 to 2% using parametric methods and unit price quantity take-offs. An estimate of this class carries an accuracy that ranges between -20% to -30% on the low end to +30% to +50% on the high end.

2.5.2 Qualitative Metrics

Quantitative metrics alone do not fully describe the benefits or challenges of the projects analyzed. In order to better capture the full impact of the projects, non-cost factors were also developed in coordination with the key stakeholder group. The group determined that the following non-cost factors, in conjunction with the quantitative factors, would best capture the project impacts:

1. Land Acquisition: Ease of property acquisition. Property already owned by public entities will receive highest scoring. Projects requiring acquisition of numerous parcels, particularly residential and commercial acquisition, will receive the lowest scoring. Subterranean easements required for tunnel projects are seen as less difficult to acquire even through residential and commercial areas.

2. Community Impact/Aesthetics: How easily will the project gain public support by minimizing disruption during construction and providing a long-term amenity with aesthetic and recreational benefits during operation? What is the scale of the disturbance during construction, is the disturbance isolated to a single area or does it cover a large area? What are its transportation impacts to bridges and roads?

3. O&M/Resiliency: How simple is the system to operate, how much energy and manpower is required to operate it, and how resilient is it to natural disaster (loss of power)? Projects that include only routine operation and maintenance already performed by the sponsors will score the highest. Projects that operate passively without the need to operate control structures and pumps will also score the highest. Projects that have ongoing operational cost (pump stations) will score the lowest.

4. Other Agency Coordination: How much coordination is required outside of the project sponsor group with entities including but not limited to TXDOT, railroad and environmental groups?

5. Speed of Implementation: How quickly can the project be planned, designed and constructed including all necessary land acquisition and permitting? Projects that are the fastest at delivering benefits will score the highest.

A pair-wise analysis was conducted to develop a weighting of these non-cost factors in a May 2020 meeting with the key stakeholders. The results and weighting of this effort is shown below in **Table 5**. A score of 1 means the row category is less important than the column category, 2 means it is equally important, and 3 means it is more important.

Table 5: Non-Cost Factors Pair-Wise Matrix

Factor	Land Acquisition	Community Impact/Aesthetics	O&M/Resiliency	Other Agency Coordination	Speed of Implementation	Total	Weight
Land Acquisition	-	3	2	3	1	**9**	**22.5%**
Community Impact/Aesthetics	1	-	2	3	2	**8**	**20.0%**
O&M/Resiliency	2	2	-	3	3	**10**	**25.0%**
Other Agency Coordination	1	1	1	-	1	**4**	**10.0%**
Speed of Implementation	3	2	1	3	-	**9**	**22.5%**

2.5.3 Limitations

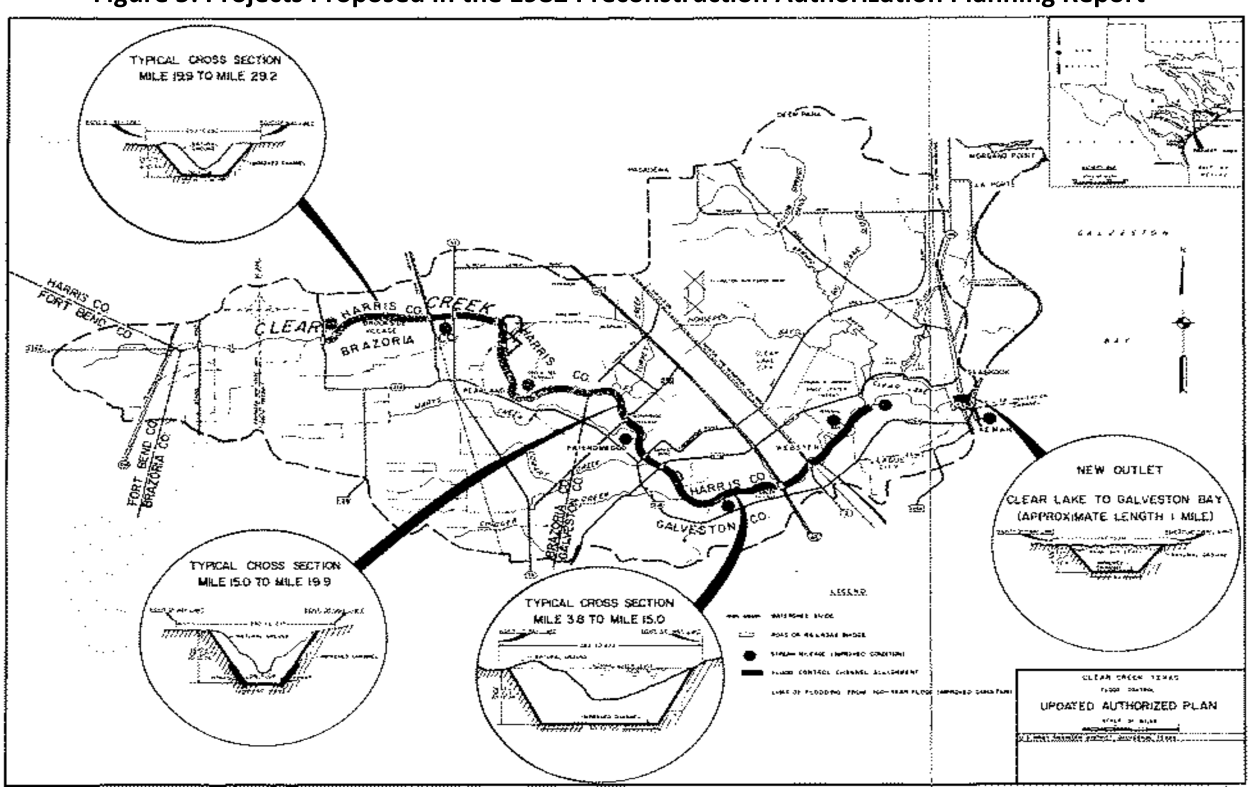
This study is focused on mitigating riverine flooding along Clear Creek. The model that was developed was calibrated to historical storms and water level measurements along the Creek, as discussed in **Appendix C**. The model incorporates the main stem of Clear Creek and all its major tributaries, and was developed to accurately capture the flooding risks associated with the swelling of the creeks. The model is not meant to accurately depict the propagation of floodwaters within neighborhoods and on roadways located outside of the riverine floodplains. It was beyond the scope of this study to fully capture the instances of flooding and structural damages that are caused by ponding water that cannot be conveyed effectively to the streams through the local storm sewer/culvert network. This is evidenced by flood damages and rescues that occurred during Hurricane Harvey in Friendswood and League City outside of the riverine floodplains. To fully capture the instances of flooding and structural damages occurring away from the main stem of Clear Creek and its major tributaries, the output from this study's hydraulic models should be integrated into local storm sewer network models. The results presented herein do not account for local drainage system benefits and therefore likely underpredict the actual reductions in instances of flooding and structural damages provided by the solutions.

The flood mitigation projects that FNI developed as part of this study reflect a concept-level analysis. Although this level of detail is adequate to evaluate the general efficacy of the projects in providing flood risk mitigation, the preliminary siting and sizing that was performed will need to be refined in a future phase as part of a feasibility study.

2.6 PREVIOUS STUDIES AND PROJECT CONSTRAINTS

Flood risk management efforts on Clear Creek have been discussed for decades, dating back at least to the 1960s. A major Federal civil works project has been planned for Clear Creek for nearly as long, dating back to the USACE 1982 Preconstruction Authorization Planning Report. The improvements proposed in the 1982 report included improvements to the outlet of Clear Lake into Galveston Bay, and channel widening of Clear Creek from the Lake all the way upstream to Mykawa Road in Pearland, Texas. The Clear Lake outlet structure improvements were constructed in 1997 including a new outlet channel and gated structure, but the remaining proposed improvements were met with environmental and community roadblocks that delayed and eventually prevented their construction.

Figure 5: Projects Proposed in the 1982 Preconstruction Authorization Planning Report



Hurricane Harvey and the never-before-seen flood damages in the watershed prompted a review of previous efforts, and galvanized additional project funding for the completion of studies and the construction of mitigation improvements. The largest of these projects is the Clear Creek Federal Project being advanced by USACE and HCFCD. Currently, a design-build package is underway for construction of conveyance improvements and detention along the main channel of Clear Creek and its tributaries from State Highway 288 to FM 1959. The funds for this project were appropriated by Congress in 2018.

The section of Clear Creek from FM 1959 to the outlet at Clear Lake was not included as part of the Federal project in part due to the environmental and community concerns raised in this section of the creek in the early 1980s. Previous project recommendations for major channel modifications such as widening did not receive local stakeholder support at that time. These community and environmental concerns led to the development of the following conceptual design constraints which informed our approach in this study:

1. <u>No channel widening on Clear Creek downstream of Bay Area Blvd:</u> Environmental concerns exist in this tidally-influenced section due to the prevalence of wetlands, which increase both cost and permitting schedule.

2. <u>No new open cut crossings of Interstate 45:</u> I-45 is a major transportation corridor, thus an open cut crossing would result in major traffic disruptions that would impact not only the local stakeholders but also regional and national stakeholders.

3. <u>No additional conveyance to Clear Lake without additional conveyance out of the lake:</u> The current outlet capacity from Clear Lake to Galveston Bay is finite. Conveyance improvements made upstream of Clear Lake will affect the timing and rate of floodwaters discharging into the Lake. Providing additional conveyance out of the Lake is necessary to prevent an increase in flooding instances and damages in the Lake communities.

4. <u>No clearing/de-snagging downstream of Bay Area Blvd. on Clear Creek:</u> Similarly to constraint 1, significant vegetative clearing along the banks of Clear Creek downstream of Bay Area Blvd. is likely to impact wetland habitats and would be difficult and time consuming to permit. Furthermore, this section of the creek is not as densely vegetated as other parts upstream, and therefore the opportunity to increase conveyance through vegetative clearing is more limited.

Considering these constraints, FNI evaluated numerous flood risk mitigation concepts. These concepts included one or a combination of the following:

- Detention basins,
- Channel modifications including benching, widening and deepening,
- Vegetative clearing and de-snagging of channel banks,
- Diversions including bypass channels and tunnels,
- Capacity improvements at key structures such as roadway and railroad crossings,
- Structural elevations and voluntary property buyouts

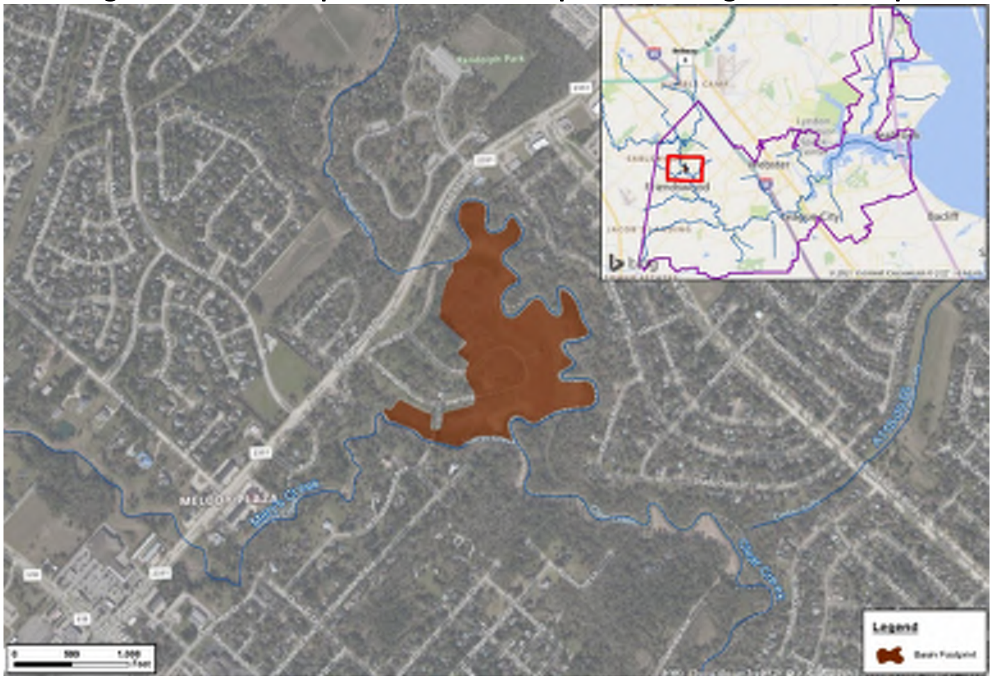
The performance of these concepts has been evaluated based on the quantitative and qualitative factors presented above. The results are presented collectively as combination alternatives in **Section 3**, and individually in **Appendix A**.

2.7 IMPROVEMENTS MADE SINCE HURRICANE HARVEY

In addition to the multiple study efforts that began following Hurricane Harvey, there have been improvements completed along Clear Creek by the Galveston County Consolidated Drainage District (GCCDD) and HCFCD, particularly in Reach CC-1. Minor improvements have been made including localized vegetative clearing, but the following improvements represent major modifications to the behavior of Clear Creek:

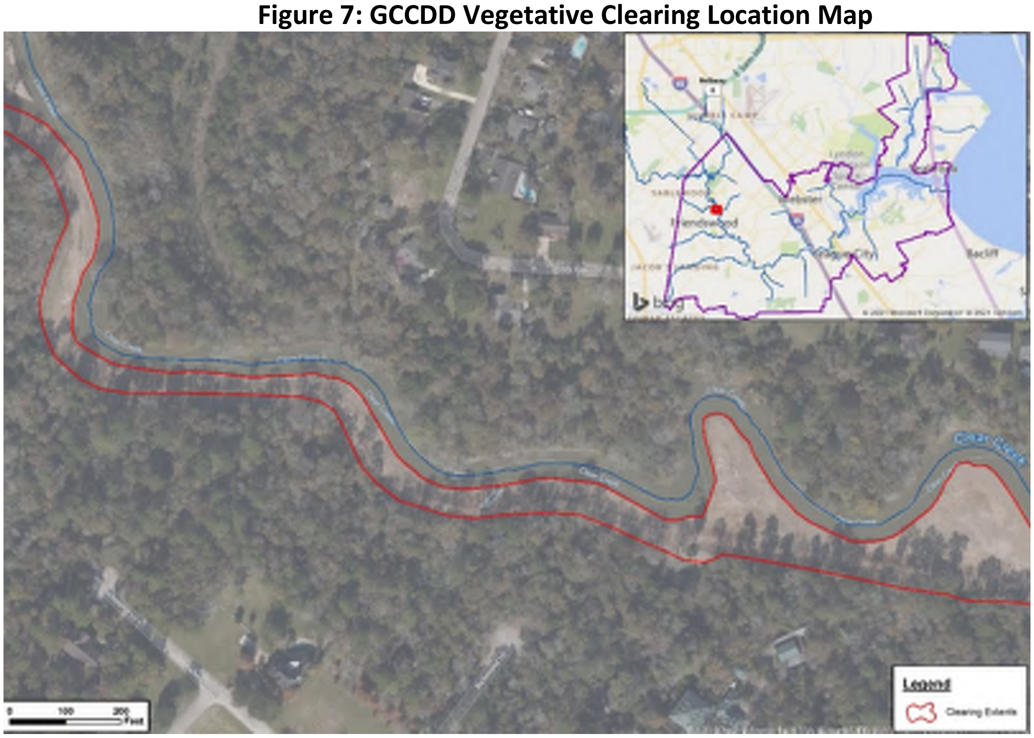
- Imperial Estates Floodplain Benching: The GCCDD has completed a floodplain benching project along the west side of Clear Creek in the Imperial Estates neighborhood just downstream of FM 2351. The grading starts at the ordinary high water mark elevation, slopes upward at a 1% slope, and then transitions to existing grade at the interior limits with a 4:1 slope. 880 acre-feet of material has been removed from the site. A location map for this project is shown in **Figure 6** provided on the next page.

Figure 6: GCCDD Imperial Estates Floodplain Benching Location Map



- Clearing of West Bank of Clear Creek from FM 2351 to FM 528: As part of a bond project completed in May 2019, GCCDD has performed vegetative clearing on the west bank of Clear Creek between FM2351 and FM 528. The clearing extends about 60 feet up the bank, and corresponds to a complete clearing of all vegetation, as can be seen in **Figure 7**.

Figure 7: GCCDD Vegetative Clearing Location Map



2.8 COASTAL TEXAS STUDY – CLEAR LAKE GATE SYSTEM

The Coastal Texas Protection and Restoration Feasibility Study Draft Report published in October 2020 presents a *Multiple Lines of Defense* strategy used to design cost-effective, environmentally friendly solutions that will reduce risks of storms impacting the coastal communities and restore important wildlife habitat at the same time. For Clear Creek, the draft plan proposes the following:

- In the southernmost of the two Clear Lake outlets, a 75-foot floating sector gate would be constructed to accommodate boat traffic into and out of the Lake. The sector gate would have a sill elevation of -10 feet (NAVD88) to match the authorized depth of the existing channel. To the right and left of the sector gate, circulation gates would be added to address potential water quality concerns and assure tidal flow between the outlet and Clear Lake.
- In the northernmost outlet, a pumping station would be needed so that, when the gates are closed, water coming down from the watershed (due to rainfall) would be pumped out to the Bay. The pumping station would have a designed capacity of 20,000 cubic feet per second.
- To tie the gates and the pumping station together, and to connect to the land on both sides, a floodwall system at an elevation of 17 feet would be constructed. The floodwall and closure structure would start on the west side of State Highway 146, near NASA Road 1, and end on the south side of the outlet, near Marina Bay Drive west of State Highway 146.

The primary objective of the FNI study presented in this report is to analyze and mitigate the risks associated with riverine flooding. Although this objective differs from the Coastal Texas Study's objective, the two studies' objective interconnect in the downstream reach of Clear Creek near its outlet to Galveston Bay. As these two studies are refined in the years to come, solutions should be jointly designed to mitigate risks associated with both riverine and coastal flooding along this downstream section of Clear Creek.

3 COMBINATION ALTERNATIVES

FNI investigated and modeled a total of 16 flood mitigation projects along Clear Creek. These projects consist of detention basins, linear conveyance improvements, channel and tunnel diversions, and crossing improvements, and are presented individually in detail in **Appendix A**. Based on the analysis of each discrete project's impacts, FNI developed three combination alternatives that incorporate multiple projects to optimize benefits while preventing adverse impacts. These alternatives were analyzed based on the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, and their benefits were calculated over the 50-year design period. To confirm efficacy during long-duration storm events, Hurricane Harvey rainfall was also modeled through the combination alternatives.

3.1 ALTERNATIVE 1: DETENTION + CONVEYANCE IMPROVEMENTS

Alternative 1 corresponds to the combination of the following projects, as shown in **Figure 8**:

1. Friendswood Detention Basin
2. Timber Creek Golf Course Detention Basin
3. Clearing and De-snagging – FM 1959 to Bay Area Blvd.
4. SH 3 and UPRR Capacity Improvements
5. FM 270 Auxiliary Opening
6. Clear Lake Outlet Expansion

The estimated capital cost for Alternative 1 is $275 million. The 100-year Inundation Depth Changes Map is shown in **Figure 8**. **Figure 9** shows the 100-year future conditions and Alternative 1 water surface profiles plotted with the estimated finished floor elevations of structures along the Clear Creek.

Alternative 1 provides the greatest benefits in Reach CC-1 through the City of Friendswood, with water surface elevation reductions of about 1.5 feet in the 100-year storm event. Reach CC-2 sees notable benefits in the vicinity of I-45, with maximum reductions in 100-year water surface elevations of about 0.9 feet. Reach CC-3 through Clear Lake benefits from the expansion of the Lake's outlet, with reductions in 100-year water surface elevations of about 0.5 feet.

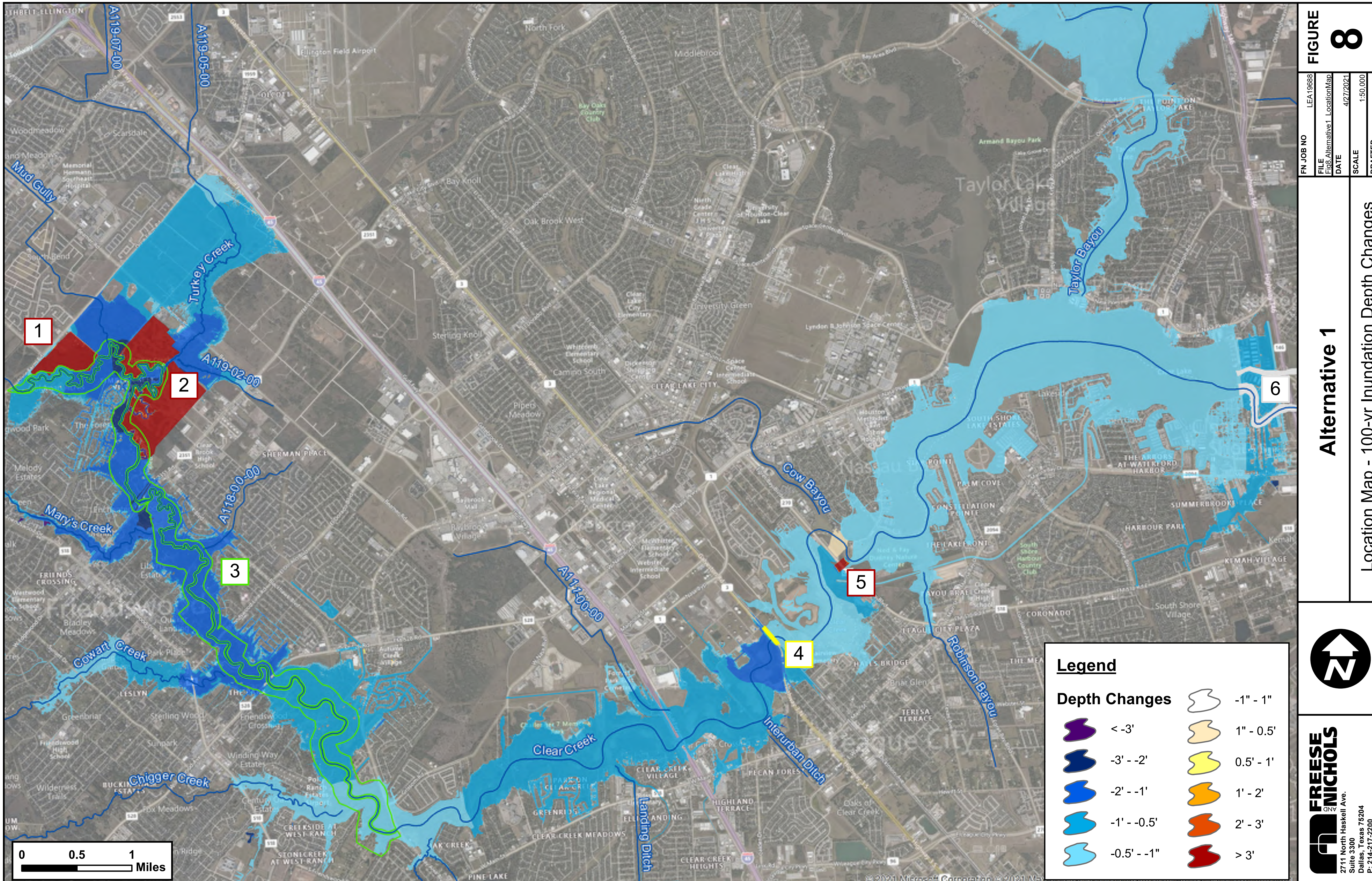
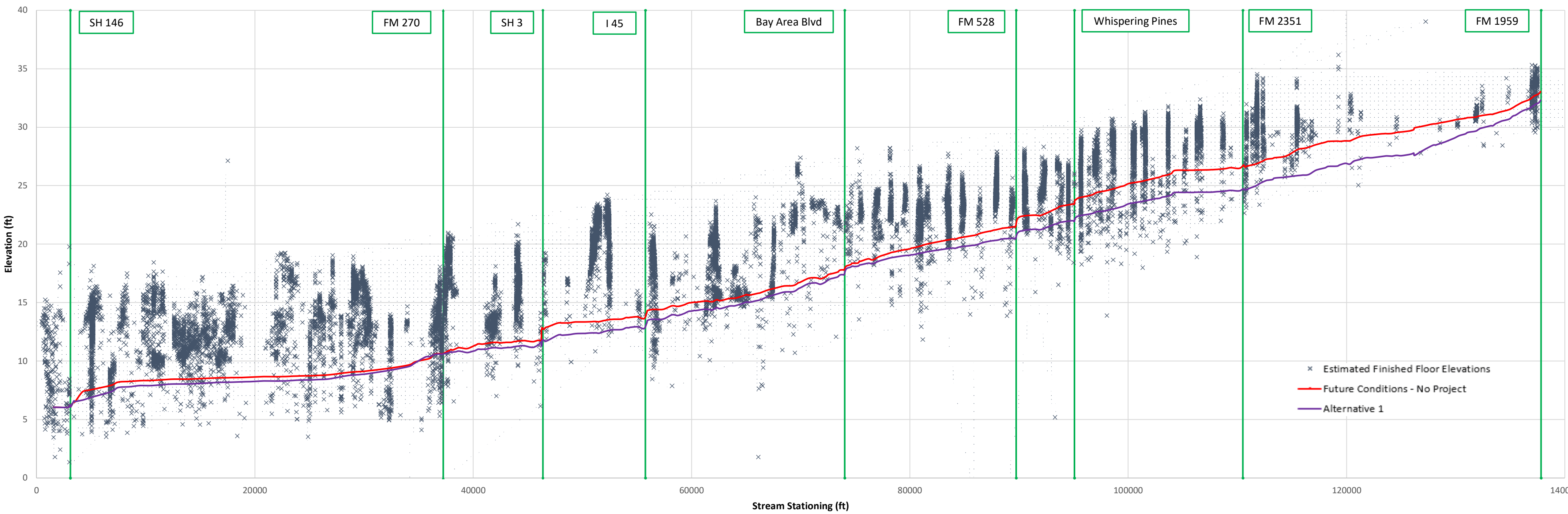


FIGURE 8
FN JOB NO LEA19688
FILE Fig8.Alternative1_LocationMap
DATE 4/27/2021
SCALE 1:50,000
DRAFTED 90206
Alternative 1
Location Map - 100-yr Inundation Depth Changes
FREESE NICHOLS
2711 North Haskell Ave.
Suite 3300
Dallas, Texas 75204
P: 214-217-2200
Legend
Depth Changes
< -3'
-3' - -2'
-2' - -1'
-1' - -0.5'
-0.5' - -1"
-1" - 1"
1" - 0.5'
0.5' - 1'
1' - 2'
2' - 3'
> 3'
0 0.5 1 Miles
1
2
3
4
5
6
Turkey Creek
A119-02-00
A119-07-00
A119-05-00
A118-00-00
A111-00-00
Mud Gully
Mary's Creek
Cowart Creek
Chigger Creek
Clear Creek
Landing Ditch
Interurban Ditch
Cow Bayou
Robinson Bayou
Taylor Bayou
Taylor Lake Village
Nassau Bay
League City
Friendswood
Webster

Figure 9: Alternative 1 100-Year Water Surface Profile



The increased conveyance through Reach CC-1 associated with the clearing and de-snagging occurs without causing adverse impacts downstream of Bay Area Blvd. thanks to:

- The decrease in peak discharges upstream associated with the detention at the Friendswood and Timber Creek Golf Course basins.
- The increase in conveyance capacity associated with the improvements of the SH 3, UPRR, and FM 270 crossings, as well as the expansion of the Clear Lake outlet.

The implementation sequencing for Alternative 1 is as follows:

No mitigation required, can be completed at any time	Mitigation required, must be completed in the following order
Friendswood Detention Basin	1. Clear Lake Outlet Expansion
Timber Creek Golf Course Detention Basin	2. FM 270 Auxiliary Opening
Clear Lake Outlet Expansion	3. SH 3 and UPRR Capacity Improvements
Structural Elevations and Voluntary Buyouts	4. Clearing and De-snagging – FM 1959 to Bay Area Blvd.

The non-cost factors associated with this combination alternative are presented in **Table 6**.

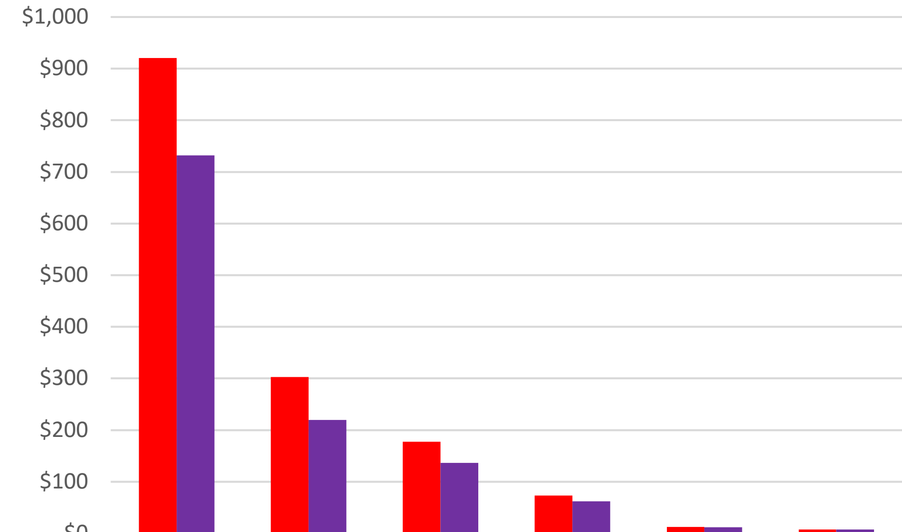
Table 6: Alternative 1 Non-Cost Factors

Factor	Score
Land Acquisition	4
Community Impact/Aesthetics	5
O&M/Resiliency	5
Other Agency Coordination	3
Speed of Implementation	4
Non-Cost Factor Weighted Score	**4.4**

The structural damages and flooding instances for future conditions (no project) and Alternative 1 are presented in **Figure 10** and **Figure 11**, respectively. Over the 50-year design period, Alternative 1 leads to a decrease in flood damages of $60 million, and 1,960 reductions in flooding instances. This translates to 7.1 instances of flooding reduced for every $ million spent in construction costs, and a benfit/cost ratio of 0.23. Additionally, Alternative 1 leads to 45 reductions in roadway overtopping over the 50-year design period.

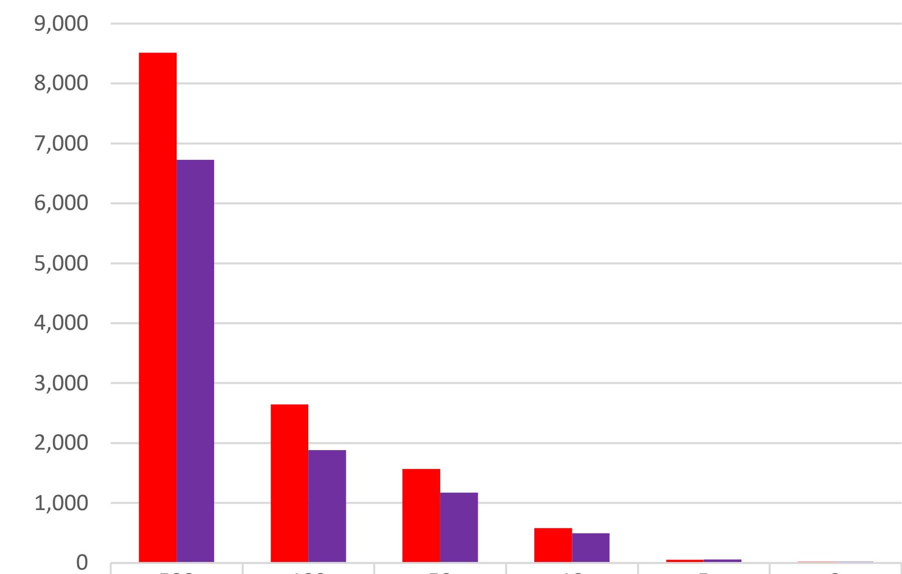
FNI also ran a Hurricane Harvey simulation to assess Alternative 1's performance during tropical storms and hurricanes that can produce large amounts of rainfall over multiple days. Alternative 1 would have reduced structural damages by $100 million and flooding instances by 930, without creating adverse impacts.

Figure 10: Structural Damages ($M) by Event – Alternative 1



	500	100	50	10	5	2
Future Conditions	920.3	302.7	177.4	73.2	12.3	7.5
Alternative 1	731.7	219.5	136.5	62.3	11.9	7.2

Figure 11: Flood Instances by Event – Alternative 1



	500	100	50	10	5	2
Future Conditions	8,515	2,645	1,570	579	54	22
Alternative 1	6,728	1,883	1,172	497	57	21

Key Take-Aways:

1. Clearing and de-snagging significantly increase conveyance through Reach CC-1 (Friendswood).
2. The downstream impacts associated with the clearing and de-snagging from FM 1959 to Bay Area Blvd. are partially offset by the Friendswood and Timber Creek Golf Course Detention Basins.
3. Improving the capacity of the SH 3 and UPRR bridge crossings provides greater benefit than improving the capacity of the bridge opening at I-45.
4. Increasing the conveyance out of Clear Lake is necessary to increase conveyance through the SH 3, UPRR, and FM 270 crossings.
5. Storm surge and the predicted future sea level rise limit the efficacy of projects to mitigate the flood risk in the Clear Lake communities.
6. Dredging of Clear Lake is not anticipated to improve conveyance during large storm events due to elevated water levels in Galveston Bay and Clear Lake.
7. Significant residual risk remains with the construction of Alternative 1.

3.2 ALTERNATIVE 2: DETENTION + CONVEYANCE + FM 2351 TUNNEL

Alternative 2 corresponds to the combination of the following projects, as shown in **Figure 12:**

1. Friendswood Detention Basin
2. Timber Creek Golf Course Detention Basin
3. Clearing and De-snagging – FM 1959 to Bay Area Blvd.
4. 40-Foot Diameter Tunnel Diversion from FM 2351 to Clear Lake
5. SH 3 and UPRR Capacity Improvements
6. FM 270 Auxiliary Opening
7. Clear Lake Outlet Expansion

The estimated capital cost for Alternative 2 is $1,250 million. The 100-year Inundation Depth Changes Map is shown in **Figure 12**. **Figure 13** shows the 100-year future conditions and Alternative 2 water surface profiles plotted with the estimated finished floor elevations of structures along the Clear Creek.

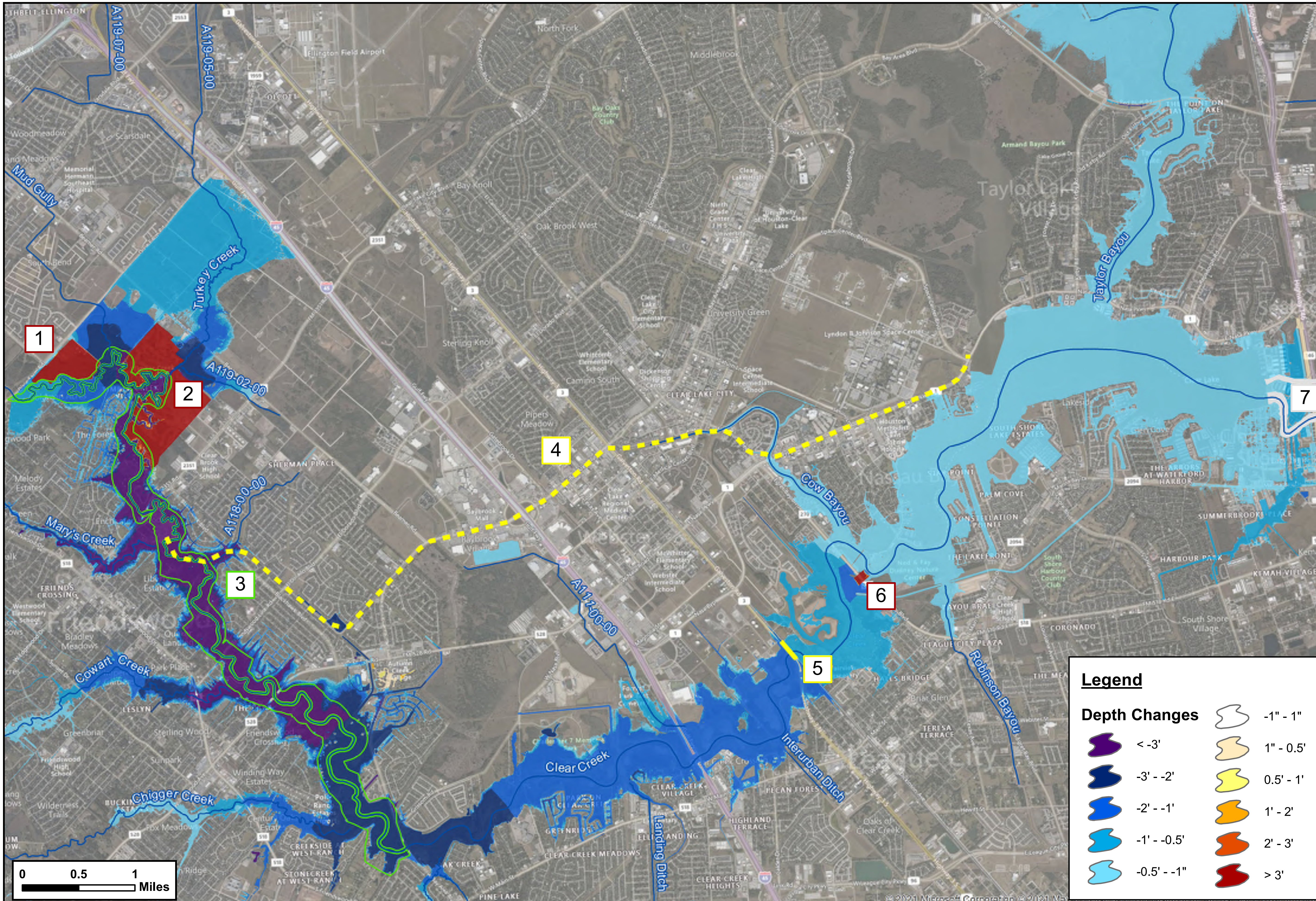


FIGURE 12

FN JOB NO	LEA19688
FILE	Fig12.Alternative2_LocationMap
DATE	5/12/2021
SCALE	1:50,000
DRAFTED	90206

Alternative 2

Location Map - 100-yr Inundation Depth Changes

FREESE AND NICHOLS
2711 North Haskell Ave.
Suite 3300
Dallas, Texas 75204
P: 214-217-2200

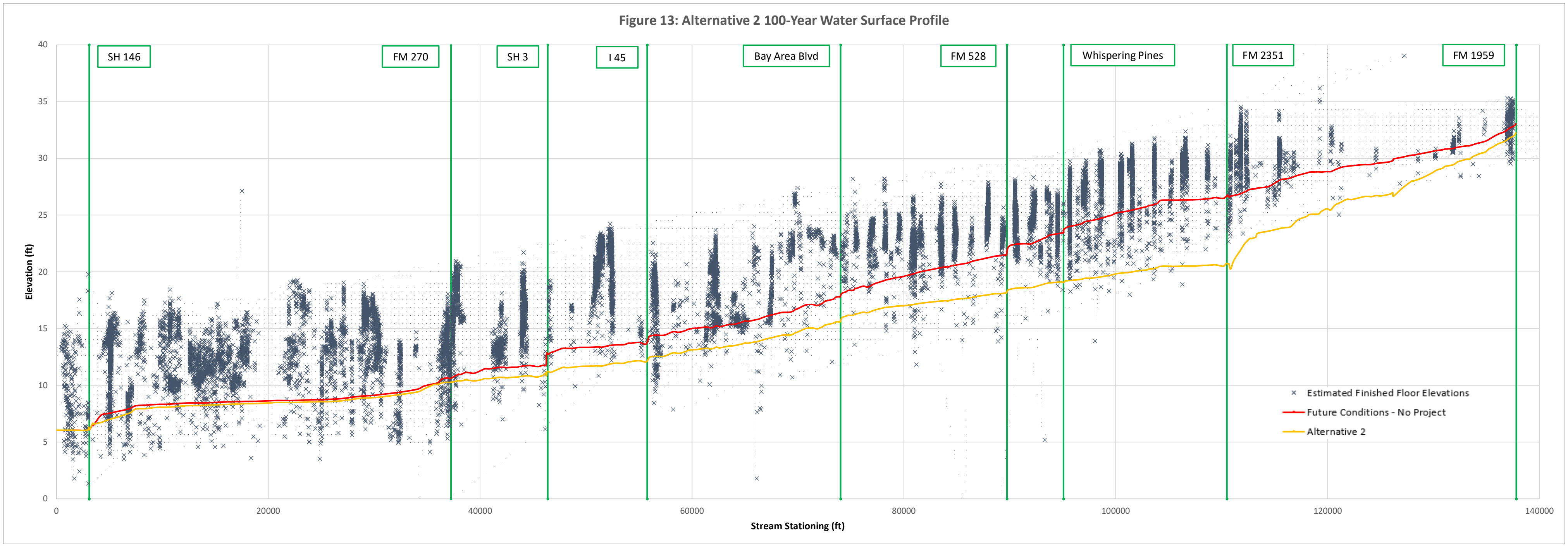


Figure 13: Alternative 2 100-Year Water Surface Profile
SH 146
FM 270
SH 3
I 45
Bay Area Blvd
FM 528
Whispering Pines
FM 2351
FM 1959
Elevation (ft)
Stream Stationing (ft)
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 2

As described in detail in **Appendix A**, the 40-foot FM 2351 to Clear Lake tunnel was retained based on an efficiency analysis of various tunnel configurations. This alternative provides the greatest benefits in Reach CC-1 through the City of Friendswood, with water surface elevation reductions of over 6 feet in the 100-year storm event at FM 2351. Water surface elevation reductions and benefits lessen moving downstream away from the tunnel intake. In Reach CC-2, I-45 sees a reduction in 100-year water surface elevations of 1.8 feet. Reach CC-3 through Clear Lake benefits from the expansion of the Lake's outlet, with reductions in 100-year water surface elevations of about 0.5 feet.

The tunnel diverts flow from FM 2351 down to Clear Lake thus bypassing most of Reach CC-1, and all of Reach CC-2. This not only provides significant water surface elevation reductions in these reaches, but also allows for the clearing and de-snagging to occur without causing adverse impacts. However, the tunnel diversion provides a more efficient pathway for water get to Clear Lake than the winding densely vegetated creek, and therefore increasing the conveyance out of the Lake is necessary to offset the increase in peak discharges that occurs at the tunnel outlet. The implementation sequencing for Alternative 2 is as follows:

No mitigation required, can be completed at any time	Mitigation required, must be completed in the following order
Friendswood Detention Basin	1. Clear Lake Outlet Expansion
Timber Creek Golf Course Detention Basin	2. FM 270 Auxiliary Opening
Clear Lake Outlet Expansion	3. SH 3 and UPRR Capacity Improvements
Structural Elevations and Voluntary Buyouts	4. 40-Foot Diameter Tunnel Diversion from FM 2351 to Clear Lake
	5. Clearing and De-snagging – FM 1959 to Bay Area Blvd.

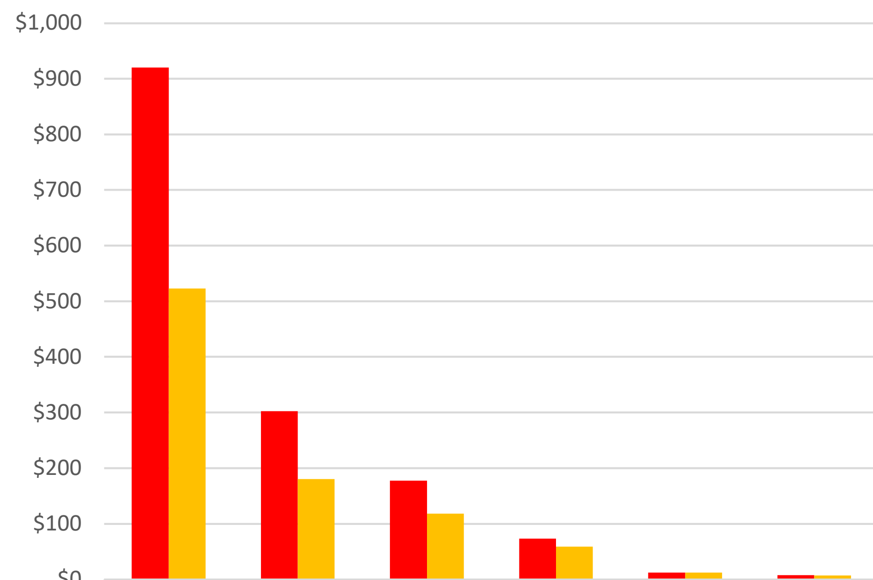
The non-cost factors associated with this project are presented in **Table 7**.

Table 7: Alternative 2 Non-Cost Factors

Factor	Score
Land Acquisition	4
Community Impact/Aesthetics	4
O&M/Resiliency	3
Other Agency Coordination	2
Speed of Implementation	4
Non-Cost Factor Weighted Score	**3.6**

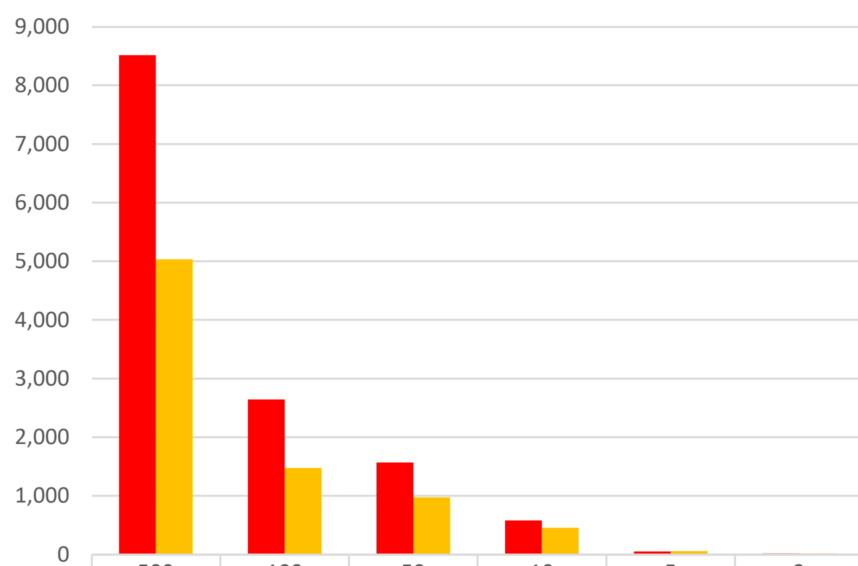
The structural damages and flooding instances for future conditions (no project) and Alternative 2 are presented **Figure 14** and **Figure 15**, respectively.

Figure 14: Structural Damages ($M) by Event – Alternative 2



	500	100	50	10	5	2
Future Conditions	920.3	302.7	177.4	73.2	12.3	7.5
Alternative 2	523.1	180.4	118.0	59.0	11.9	7.2

Figure 15: Flood Instances by Event – Alternative 2



	500	100	50	10	5	2
Future Conditions	8,515	2,645	1,570	579	54	22
Alternative 2	5,031	1,477	975	455	57	21

Over the 50-year design period, Alternative 2 leads to a decrease in flood damages of $95 million, and 3,110 reductions in flooding instances. This translates to 2.5 instances of flooding reduced for every $M spent in construction costs, and a benfit/cost ratio of 0.08. Additionally, Alternative 2 leads to 50 reductions in roadway overtopping over the 50-year design period.

Alternative 2 is shown to provide significant flood mitigation benefits in events of catastrophic magnitude such as the 500-year storm event: Alterative 2 reduces structural damages by $400 million, and flooding instances by 3,480.

FNI also ran a Hurricane Harvey simulation to assess Alternative 2's performance during tropical storms and hurricanes that can produce large amounts of rainfall over multiple days. Alternative 2 would have reduced structural damages by $155 million and flooding instances by 1,490, and not create adverse impacts.

Key Take-Aways:

1. The FM 2351 tunnel diversion, in combination with the clearing and de-snagging, significantly reduces water surface elevations through Reach CC-1 (Friendswood).
2. Having the tunnel discharge into Clear Lake requires an expansion of the Lake's outlet capacity.
3. The tunnel could be supplemented with a pump station that would increase its maximum conveyance capacity by pulling more water through the syphon. This could provide either increased benefits or a decrease in construction costs by reducing the tunnel diameter.
4. The tunnel presents opportunity for local drainage connections along its alignment in Friendswood, Webster, and Houston that could provide additional flood risk mitigation not captured in this study.
5. Because the tunnel is designed to only operate during storm events equal to or exceeding the 10-year storm, Alternative 2 provides limited benefits in frequent storm events such as the 2-year and 5-year events, and therefore does not score well on a 50-year basis. However, Alternative 2 provides significant flood risk mitigation during storm events of catastrophic magnitude such as the 500-year storm.
6. Improving the capacity of the SH 3 and UPRR bridge crossings provides greater benefit than improving I-45.

7. Storm surge and the predicted future sea level rise limit the efficacy of projects to mitigate the flood risk in the Clear Lake communities.
8. Dredging of Clear Lake is not anticipated to improve conveyance during large storm events due to elevated water levels in Galveston Bay and Clear Lake.
9. Significant residual risk remains with the construction of Alternative 2.

3.3 ALTERNATIVE 3: DETENTION + CONVEYANCE + I-45 TUNNEL

Alternative 3 corresponds to the combination of the following projects, as shown **Figure 16**:

1. Friendswood Detention Basin
2. Timber Creek Golf Course Detention Basin
3. Channel Benching Above OHWM – FM 1959 to Bay Area Blvd.
4. 40-Foot Diameter Tunnel Diversion from I-45 to Galveston Bay
5. SH 3 and UPRR Capacity Improvements
6. FM 270 Auxiliary Opening

The estimated capital cost for Alternative 3 is $ 1,150 million. The 100-year Inundation Depth Changes Map is shown in **Figure 16**. **Figure 17** shows the 100-year future conditions and Alternative 3 water surface profiles plotted with the estimated finished floor elevations of structures along the Clear Creek.

As described in detail in **Appendix A**, the 40-foot I-45 to Galveston Bay tunnel was retained based on an efficiency analysis of various tunnel configurations. This alternative provides significant benefits in Reach CC-1 through the City of Friendswood, with water surface elevation reductions of over 7 feet in the 100-year storm event immediately downstream of FM 1959. Alternative 3 also provides notable water surface elevation reductions in Reach CC-2 in the vicinity of I-45, with reductions exceeding 2 feet in the 100-year storm event. Reach CC-3 through Clear Lake benefits from water being diverted by the tunnel out of Clear Creek and bypassing the Lake down to Galveston Bay. Unlike for Alternatives 1 and 2 that necessitate an improvement of the Lake's outlet capacity, the information presented in **Figure 16** and **Figure 17** reflect the Lake's primary and second outlets being left in their existing state.

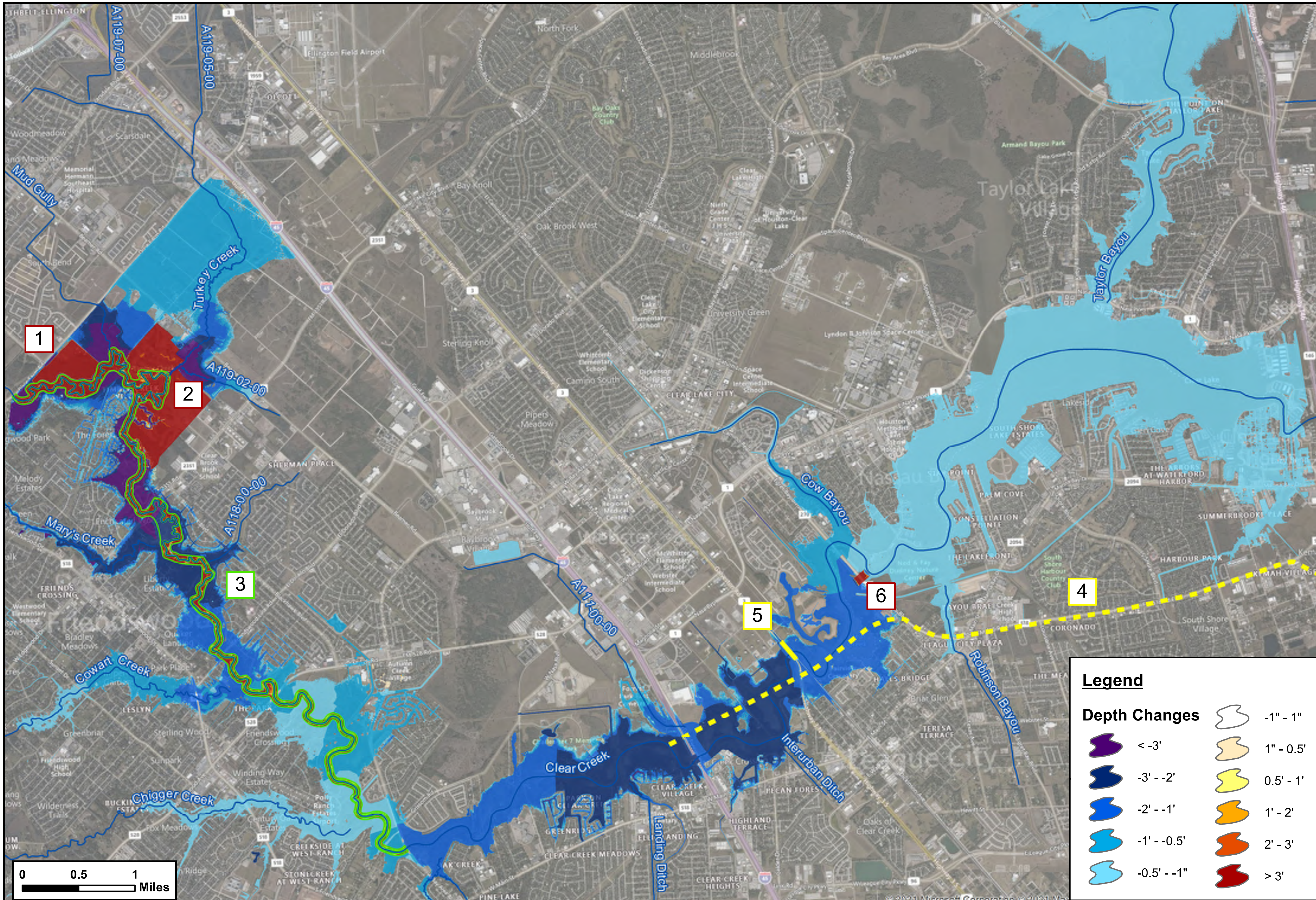


FIGURE 16

FN JOB NO LEA19688
FILE Fig16.Alternative3_LocationMap
DATE 5/12/2021
SCALE 1:50,000
DRAFTED 90206

Alternative 3

Location Map - 100-yr Inundation Depth Changes

FREESE AND NICHOLS
2711 North Haskell Ave.
Suite 3300
Dallas, Texas 75204
P: 214-217-2200

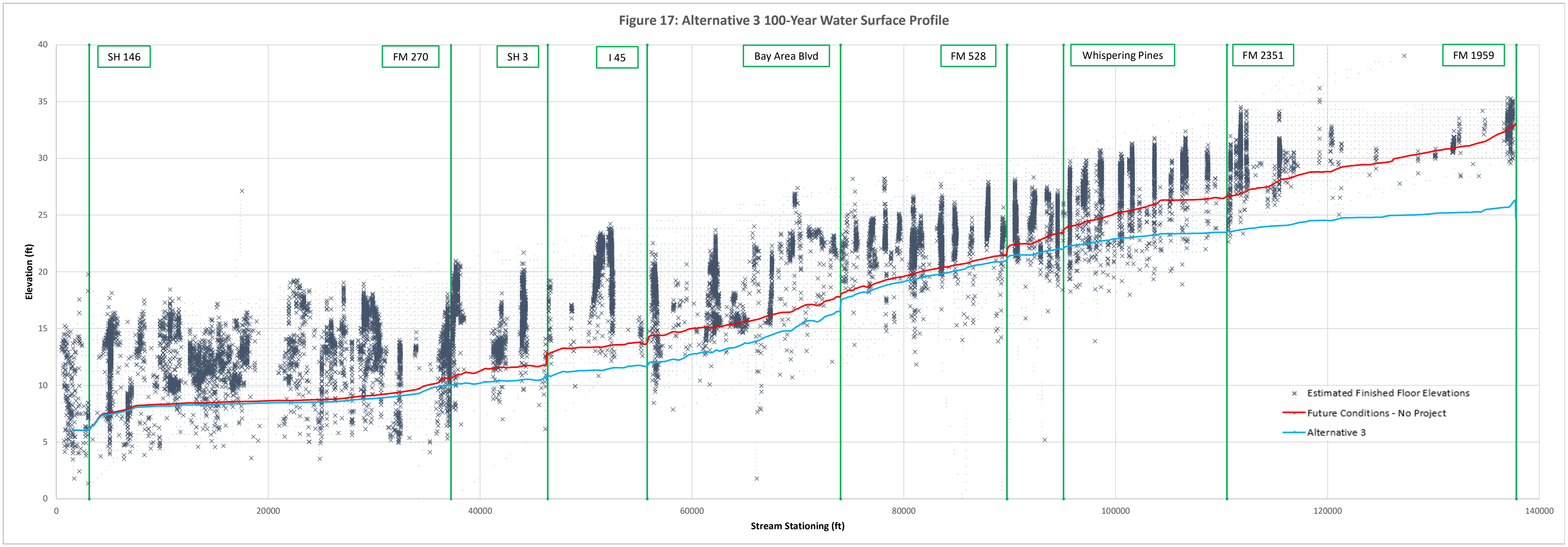


Figure 17: Alternative 3 100-Year Water Surface Profile
SH 146
FM 270
SH 3
I 45
Bay Area Blvd
FM 528
Whispering Pines
FM 2351
FM 1959
Elevation (ft)
Stream Stationing (ft)
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 3
0
5
10
15
20
25
30
35
40
0
20000
40000
60000
80000
100000
120000
140000

Placing the tunnel intake on the upstream side of I-45 downstream of the proposed channel benching allows this alternative to include major channel improvements in Friendswood (OHWM benching) to achieve a significant increase in conveyance without causing adverse impacts downstream. Additionally, placing the intake at I-45 maximizes the water surface elevation reductions in that section of the reach, notably at the Clear Creek Village neighborhood that is shown to include multiple structures at risk of flooding during the 100-year storm event. This alignment also follows FM 518 through League City, presenting an opportunity to benefit the local drainage system with various connections along the alignment. Finally, this tunnel alignment bypasses Clear Lake and outfalls to Galveston Bay directly, which removes the need to expand the Lake's outlet capacity.

The implementation sequencing for Alternative 3 is as follows:

No mitigation required, can be completed at any time	Mitigation required, must be completed in the following order
Friendswood Detention Basin	1. 40-Foot Diameter Tunnel Diversion from I 45 to Galveston Bay
Timber Creek Golf Course Detention Basin	2. FM 270 Auxiliary Opening
40-Foot Diameter Tunnel Diversion from I 45 to Galveston Bay	3. SH 3 and UPRR Capacity Improvements
Structural Elevations and Voluntary Buyouts	4. Channel Benching Above OHWM

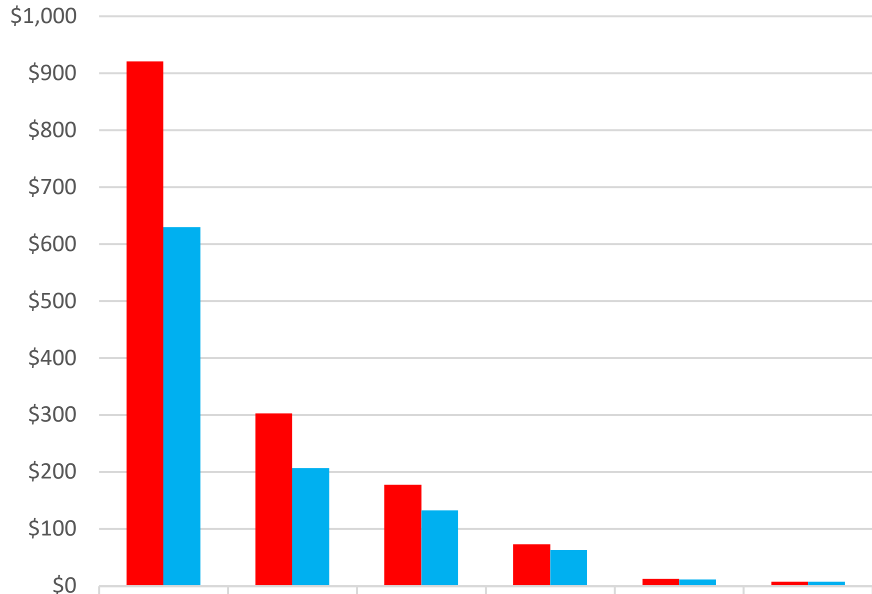
The non-cost factors associated with this project are presented in **Table 8**.

Table 8: Alternative 3 Non-Cost Factors

Factor	Score
Land Acquisition	3
Community Impact/Aesthetics	4
O&M/Resiliency	3
Other Agency Coordination	3
Speed of Implementation	4
Non-Cost Factor Weighted Score	**3.4**

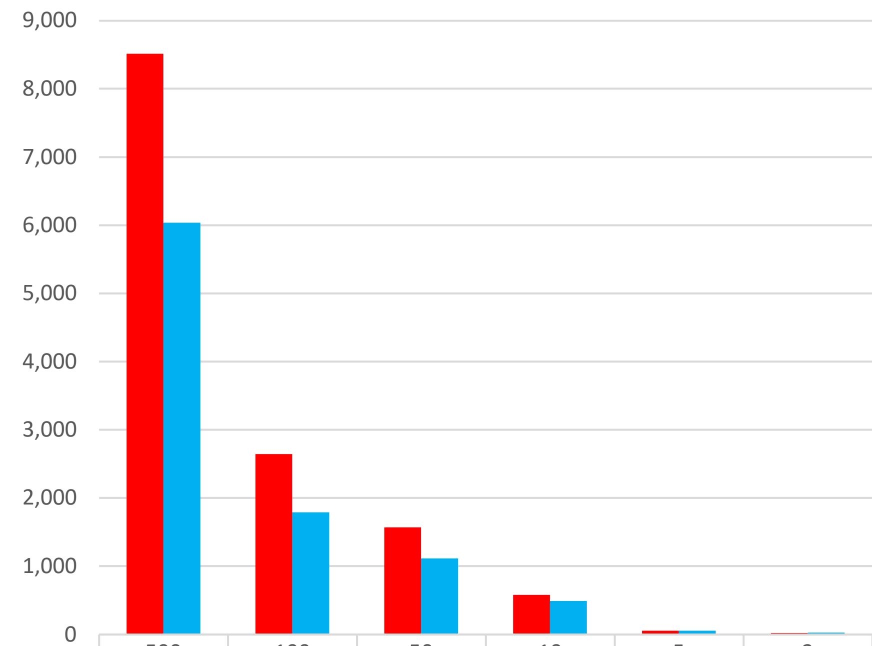
The structural damages and flooding instances for future conditions (no project) and Alternative 3 are presented in **Figure 18** and **Figure 19,** respectively.

Figure 18: Structural Damages ($M) by Event – Alternative 3



	500	100	50	10	5	2
Future Conditions	920.3	302.7	177.4	73.2	12.3	7.5
Alternative 3	629.4	206.8	132.9	63.0	11.4	7.5

Figure 19: Flood Instances by Event – Alternative 3



	500	100	50	10	5	2
Future Conditions	8,515	2,645	1,570	579	54	22
Alternative 3	6,035	1,792	1,113	488	52	24

Over the 50-year design period, Alternative 3 leads to a decrease in flood damages of $70 million, and 2,300 reductions in flooding instances. This translates to 2 instances of flooding reduced for every $M spent in construction costs, and a benfit/cost ratio of 0.06. Additionally, Alternative 3 leads to 82 reductions in roadway overtopping over the 50-year design period.

Alternative 3 is shown to provide significant flood mitigation benefits in events of catastrophic magnitude such as the 500-year storm event: Alterative 3 reduces structural damages by $290 million, and flooding instances by 2,480.

FNI also ran a Hurricane Harvey simulation to assess Alternative 3's performance during tropical storms and hurricanes that can produce large amounts of rainfall over multiple days. Alternative 3 would have reduced damages by $125 million and flooding instances by 1,150, and not create adverse impacts.

<u>Key takeaways:</u>

1. This alternative does not require expanding Clear Lake's outlet capacity.
2. The tunnel could be supplemented with a pump station that would increase its maximum conveyance capacity by pulling more water through the syphon. This could provide either increased benefits or a decrease in construction costs by reducing the tunnel diameter.
3. The tunnel presents a major opportunity for local drainage connections along its alignment in League City that could provide additional flood risk mitigation not captured in this study.
4. Because the tunnel is designed to only operate during storm events equal to or exceeding the 10-year storm, Alternative 3 provides limited benefits in frequent storm events such as the 2-year and 5-year events, and therefore does not score well on a 50-year basis. However, Alternative 3 provides significant flood risk mitigation during storm events of catastrophic magnitude such as the 500-year storm.
5. Improving the capacity of the SH 3 and UPRR bridge crossings provides greater benefit than improving I-45.
6. Storm surge and the predicted future sea level rise limit the efficacy of projects to mitigate the flood risk in the Clear Lake communities.
7. Dredging of Clear Lake is not anticipated to improve conveyance during large storm events due to elevated water levels in Galveston Bay and Clear Lake.
8. Significant residual risk remains with the construction of Alternative 3.

4 CONCLUSIONS

Table 9 shows the 100-year peak water surface elevation reductions at FM 2351 and I-45 between Alternatives 1, 2, and 3, and future conditions (no project). A comparison of the complete 100-year water surface profiles is presented in **Figure 20** provided on the next page.

Table 9: 100-Year Peak Water Surface Elevation Reductions at FM 2351 and I-45

Alternative	FM 2351	I-45
1: Detention + Conveyance Improvements	2.04 feet	0.88 feet
2: Detention + Conveyance + FM 2351 Tunnel	6.06 feet	1.82 feet
3: Detention + Conveyance + I-45 Tunnel	2.83 feet	2.28 feet

As presented in **Section 3**, Alternative 1 Detention + Conveyance Improvements is the lowest capital cost alternative and provides significant flood risk mitigation compared to pre-project conditions. Alternative 1 provides the highest 50-year design period benefit/cost ratio, but does not provide the greatest reductions in water surface elevations.

Alternatives 2 and 3 provide greater flood risk mitigation than Alternative 1, but this increase in benefits is not linearly correlated with their increase in construction costs. To better evaluate the benefits of all three alternatives, and particularly Alternatives 2 and 3, the riverine analysis prepared for this study needs to be integrated with local storm drainage networks to capture both riverine and localized storm drain benefits to better define the true benefit/cost ratios.

In addition to integrating localized benefits, Alternatives 2 and 3 can also be further refined: The analysis presented was based on a 40-foot diameter gravity flow tunnel. Opportunities exist for the tunnels to supplement gravity conveyance with stormwater pump stations, potentially reducing construction costs and increasing benefits.

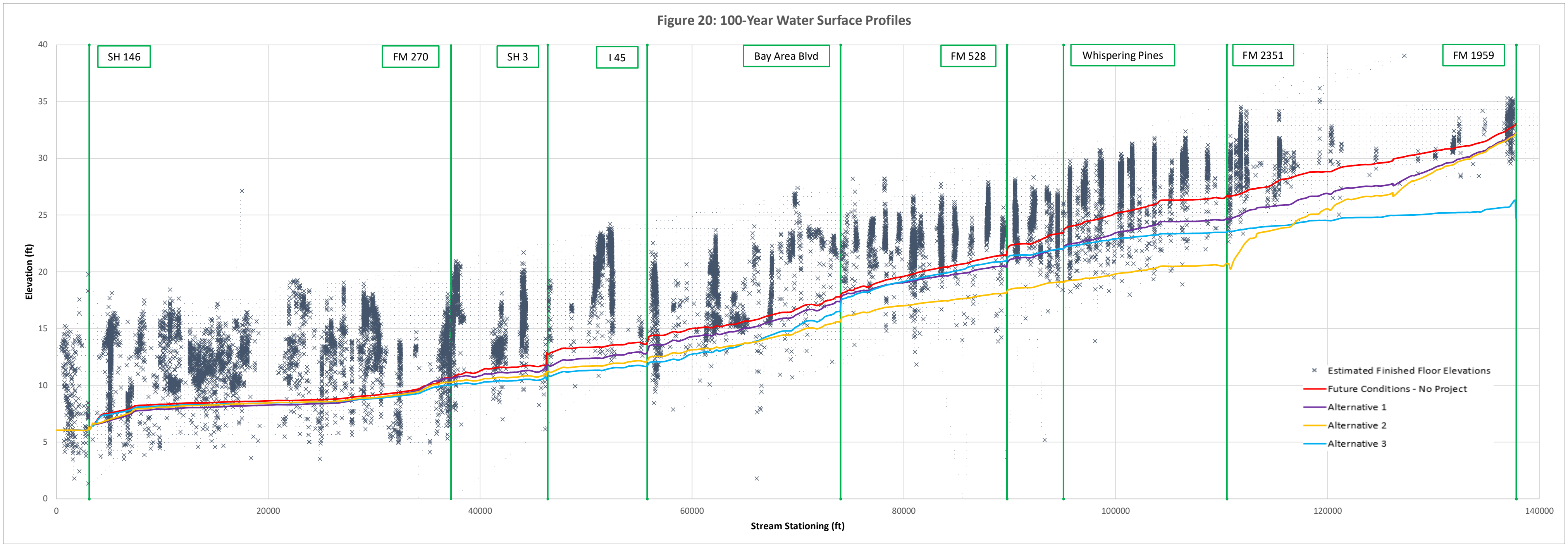
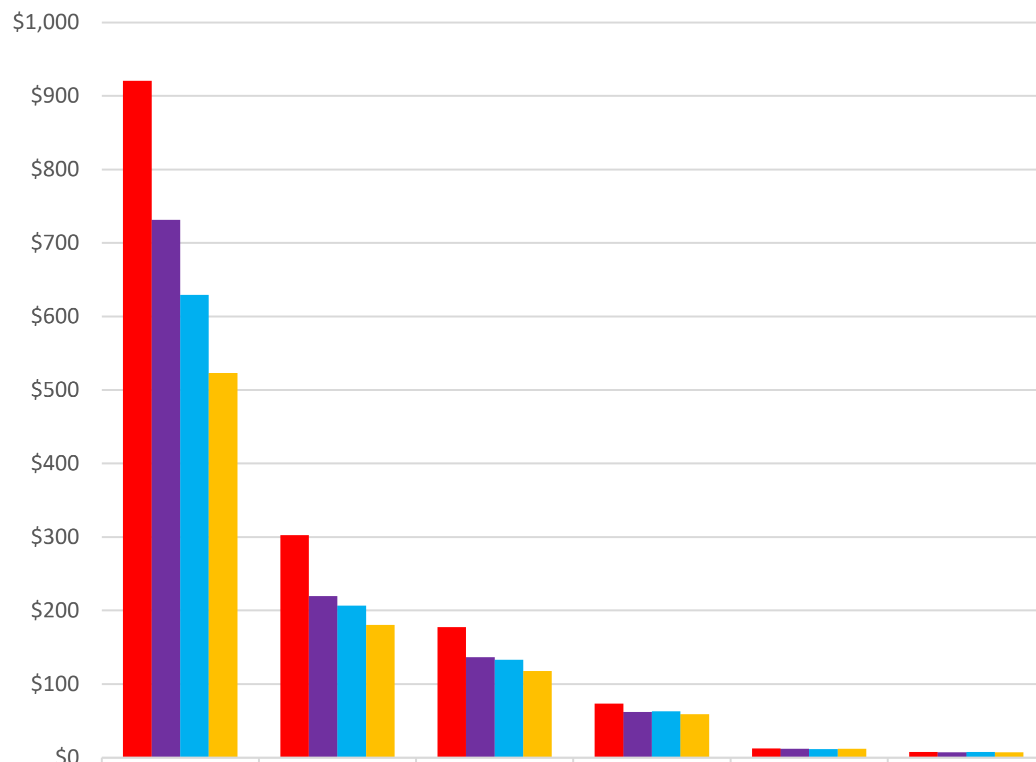


Figure 20: 100-Year Water Surface Profiles
SH 146
FM 270
SH 3
I 45
Bay Area Blvd
FM 528
Whispering Pines
FM 2351
FM 1959
Elevation (ft)
Stream Stationing (ft)
0
5
10
15
20
25
30
35
40
0
20000
40000
60000
80000
100000
120000
140000
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 1
Alternative 2
Alternative 3

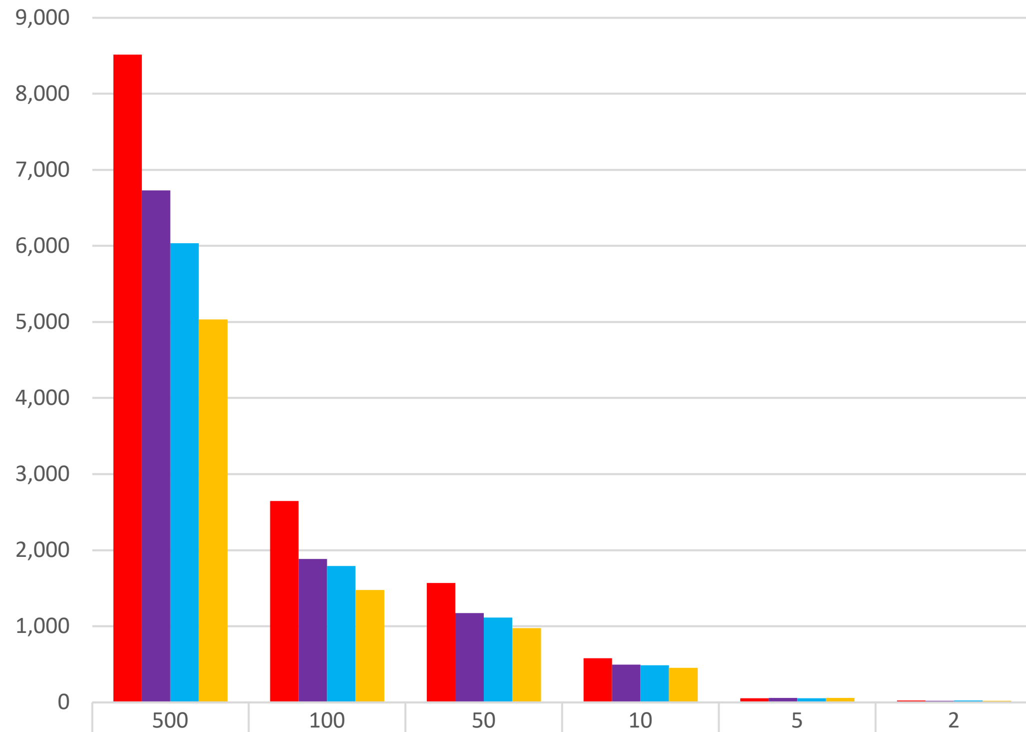
Flood risk mitigation in Reach CC-3 is very difficult. Implementing projects that reduce water levels downstream of FM 270 during large storm events is very challenging due to the high flows discharged by Armand Bayou, elevated Bay and Lake elevations generated by tropical storms and hurricanes such as Harvey, and future predicted sea level rise. It may be possible to increase the outlet capacity of Clear Lake into Galveston Bay, but increasing the size of the opening to Galveston Bay could also expose this area to greater storm surge risk and environmental impacts. Furthermore, the outlet at Clear Lake is being considered for a surge gate as part of the Texas Coastal study. Recommendations for any increase or change to the outlet from Clear Lake into Galveston Bay will require coordination with a number of entities including USACE, HCFCD, GLO, and environmental and community interests. Alternative 3 discharges directly into Galveston Bay thus mitigating this conflict, and could provide even greater benefits if coordinated with the improvements proposed at the existing outlet by the Texas Coastal Study. **Figure 21** and **Figure 22** summarize the structural damages and instances of flooding associated with each Alternative compared to future conditions (no project).

Figure 21: Summary of Structural Damages ($M) by Event for All Alternatives



	500	100	50	10	5	2
Future Conditions	920.3	302.7	177.4	73.2	12.3	7.5
Alternative 1	731.7	219.5	136.5	62.3	11.9	7.2
Alternative 3	629.4	206.8	132.9	63.0	11.4	7.5
Alternative 2	523.1	180.4	118.0	59.0	11.9	7.2

Figure 22: Summary of Flood Instances by Event for All Alternatives



	500	100	50	10	5	2
Future Conditions	8,515	2,645	1,570	579	54	22
Alternative 1	6,728	1,883	1,172	497	57	21
Alternative 3	6,035	1,792	1,113	488	52	24
Alternative 2	5,031	1,477	975	455	57	21

FNI proposes the following conclusions:

1. The alternatives proposed in this study are targeted toward mitigating the riverine flood risk during large, infrequent storms. For structures at risk of flooding under smaller, more frequent storms such as the 2-year and the 5-year events, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. FNI calculated that 54 structures flood during the 5-year event under future conditions.

2. Improvements should be implemented wholistically – from FM 1959 down to Galveston Bay to prevent adverse impacts.

    a. Large scale vegetative clearing or channel improvements through Friendswood cannot be constructed as stand-alone projects, and upstream or inline detention may not provide sufficient mitigation to prevent increases in discharges and water surface elevations in the downstream sections of the Creek.

b. Increasing the conveyance upstream of Clear Lake necessitates increasing the conveyance out of the Lake into Galveston Bay. Increasing the capacity of the outlets to Galveston Bay could expose this area to greater storm surge risk and environmental impacts, and should be analyzed further as this study progresses into future phases. A solution should be developed in conjunction with the improvements proposed as part of the Coastal Texas Study at the Clear Lake outlets.

3. Tunnel solutions are less cost efficient than other alternatives, and do not score well based on the 50-year project window used by USACE and FEMA given they are designed to operate during storm events equal to or exceeding the 10-year storm. However, they provide the greatest level of protection during events of catastrophic magnitude such as the 500-yr storm event and Hurricane Harvey, and can be designed to provide additional benefits to local drainage systems.

4. The project benefits captured in this study do not fully account for the benefits the proposed alternatives could provide to the local drainage systems, which could be significant, particularly for the tunnel projects. The output from the alternatives developed in this study's hydraulic models should be integrated into local storm sewer network models to capture additional benefits achieved outside of the riverine floodplain of Clear Creek and its major tributaries.

5. The proposed alternatives mitigate but do not eliminate the flood risk in the study area. Significant residual risk persists due to certain low-lying structures and the compound effect of rainfall and storm surge that will likely become more severe in the future due to rising sea levels.

5 RECOMMENDATIONS

Since the combination alternatives analyzed do not have a benefit/cost ratio greater than 1.0, project recommendations are closely tied to project funding potential with a focus on local funding for a significant share of the project.

5.1 PROJECT FUNDING

5.1.1 Local Funding

All of the combination alternatives and any of the individual projects greater than $50 million in capital cost are unlikely to be funded by an individual entity such as the City of League City or the City of Friendswood. These improvements will require partnerships and cost sharing agreements between the entities. These agreements could be developed piecemeal on a project by project basis, but would be better accomplished through the development of a watershed-wide entity focused on flood risk mitigation along the main channel of Clear Creek such as the Clear Creek Flood Control District originally proposed in 1995 and offered for consideration again at the State level in 2019.

Such an entity would have a clear mission of flood protection for Clear Creek and provide a single clear partner for larger entities such as USACE, the Texas General Land Office, and the Texas Water Development Board. This entity would not conflict or restrict Harris County Flood Control District, Brazoria County Drainage District 4, Galveston County Consolidated Drainage District, and other entities along the Creek from their responsibilities. Instead, the newly formed Clear Creek Flood Control District would allow other entities to focus their efforts on tributary drainage to Clear Creek thus maximizing the benefit of their existing ad valorem taxes. The Clear Creek Flood Control District would need to be created by the Texas State Legislature and then voted upon by the Watershed's residents to grant it taxing authority. The tax rate for the District would be a function of the projects recommended following the next phase of this study. Discussions with state and local officials as well as the Clear Creek Watershed Steering Committee to gain traction for this concept should proceed immediately.

5.1.2 External Funding

In addition to local funding opportunities through ad valorem, additional grant and matching programs exist at the Federal and State level that should be evaluated once clear cost benefit metrics are prepared including local benefits. These funding entities and their programs are discussed in greater detail in **Appendix E** and include:

- United States Army Corps of Engineers
- Texas General Land Office
- Federal Emergency Management Agency
- Texas Water Development Board
- United States Department of Housing and Urban Development
- United States Department of Agriculture

There are many different financial partnership opportunities, but external sources come with their own objectives. Even if a project may qualify and be selected for a program, most programs require a local match that is a significant percentage, and many programs have strings attached. Each partner will have distinct eligibility and accountability criteria by which they are legally obligated to, often including benefit/cost ratios.

Many of these requirements include:

- Additional Protections for Cultural Resources and the Environment
- Restrictions on what actions are reimbursable
- Additional reporting requirements on how money is spent
- Transparency and fairness in how contracts are advertised and awarded
- Special contract provisions regarding how work will be recorded and conducted

As these programs are pursued, it is important to understand the implications that each program's requirements may impose on the project. Because of the makeup of the communities along Clear Creek, these projects will not perform well for programs that put a heavy emphasis on low to moderate income and socially vulnerable populations.

For structures at risk of flooding under frequent storms, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. This can be specifically undertaken with the help of the following programs:

- NRCS-EWP Pilot Program
- FEMA-HMGP
- FEMA-BRIC
- TWDB-FIF

5.2 NEXT STEPS

The first recommendation and next step is to integrate the outputs from the alternatives developed as part of this study into local storm sewer network models for Friendswood, League City, Webster, Houston, and other municipalities to capture additional benefits achieved outside of the riverine floodplain of Clear Creek and its major tributaries. This should be completed for all three alternatives, but especially for Alternatives 2 and 3 which provide opportunities to route the tunnels in a way that allows the tunnel to improve local drainage system performance with additional shafts.

The only individual project with a capital cost less than $50 million that can be pursued independently is the Friendswood Detention Basin which, if not being included as part of the Clear Creek Federal Project to mitigate upstream impacts, should be prioritized for design and construction as the land is already owned by Harris County Flood Control District and a conceptual design of the basin exists.

The other project elements are all contingent on either one of the large tunnels and/or improvements to the Clear Lake outlet into Galveston Bay. Further analysis of the Clear Lake outlet into Galveston Bay in coordination with the potential surge gate from the Texas Coastal Study should proceed immediately. Improvements to the outlet would allow other smaller capital cost improvements including the FM 270 Bypass and SH 3/UPRR bridge replacement to be initiated, as well as larger improvements such as the FM 2351 Tunnel or clearing and de-snagging of the Creek from FM 1959 to Bay Area Boulevard.

Appendix A

Evaluation of Discrete Projects

Appendix B

Hydrologic Technical Memorandum

Appendix C

Hydraulic Technical Memorandum

Appendix D

Inundation Damages Assessment

Technical Memorandum

Appendix E

Preliminary Funding Memorandum



LOWER CLEAR CREEK AND DICKINSON BAYOU FLOOD MITIGATION PLAN

Dickinson Bayou Alternatives Evaluation and Recommendation

FINAL REPORT

Prepared for:

City of League City

June 2021

Prepared by:

FREESE AND NICHOLS, INC.
11200 Broadway St. Suite 2320
Pearland, Texas 77584

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LOWER CLEAR CREEK AND DICKINSON BAYOU FLOOD MITIGATION PLAN

Dickinson Bayou Alternatives Evaluation and Recommendation

FINAL REPORT

Prepared for:

City of League City

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1 EXECUTIVE SUMMARY

The purpose of this study was to develop a comprehensive flood mitigation plan for Dickinson Bayou with a focus on the riverine impacts along the main channel beginning near Farm to Market Road 528 through the outlet into Dickinson Bay. In conjunction with RPS Group, Inc. (RPS), Freese and Nichols, Inc. (FNI) developed state-of-the-art hydrologic and hydraulic models leveraging current NOAA Atlas 14 rainfall, 2018 LiDAR data, and a 1D/2D unsteady-state modeling approach. FNI evaluated both existing and future conditions flood risks based on the 24-hour duration 2-, 5-, 10-, 50-, 100-, and 500-year Atlas 14 storm events, as well as Hurricane Harvey rainfall. FNI identified vulnerabilities in the Dickinson Bayou Watershed, including instances of flooding at structures and the resulting damage estimates, as well as impacts to critical infrastructure and transportation systems.

FNI investigated and modeled a total of 10 flood mitigation projects along Dickinson Bayou. These projects consist of detention basins and channel diversions. FNI evaluated each project based on four quantitative metrics including instances of flooding, flood damages reduced, constructions costs, and transportation system impacts. FNI also assessed five qualitative (non-cost) metrics in its project evaluation, including operations and maintenance requirements, and impacts to aesthetics and the community. Each concept was modeled individually, and based on the analysis of each discrete project's impacts, FNI developed two combination alternatives that incorporate multiple projects to optimize benefits while preventing adverse impacts. A summary of these flood mitigation alternatives is presented in **Table 1** provided on the next page. Maps presenting these alternatives are provided in **Section 3** of this report as **Figure 7** and **Figure 11**.

Based on discussions with stakeholders, the combination alternatives and any of the individual projects greater than $50 million in capital cost are unlikely to be funded by an individual entity. Mitigation will require partnerships and cost sharing agreements between the entities. These agreements could be developed piecemeal on a project-by-project basis, or by development of a watershed-wide entity focused on flood damage reduction along the main channel of Dickinson Bayou. In addition to local funding opportunities through ad valorem, additional grant and matching programs exist at the Federal and State level that should be further evaluated as this study progresses into future phases. For improvements in and around the City of Dickinson, population metrics may qualify for grants through the Texas General Land Office (Community Development Block Grants (CDBG)).

Table 1: Summary of Flood Mitigation Alternatives

Alternative	Discrete Projects	Cost	Non-Cost Score	Reductions Over the 50-year Design Period		Reductions During Harvey	
				Damages	Flooding Instances	Damages	Flooding Instances
1: Detention	Mc Farland Rd. Detention Basin W Cemetery Rd. Detention Basin Hilton Ln. Detention Basin Magnolia Bayou and Borden Gully Detention Basins	$220 M	3.7	$40 M	2,490	$35 M	420
2: Detention + Bypass Channel	Mc Farland Rd. Detention Basin W Cemetery Rd. Detention Basin Hilton Ln. Detention Basin Magnolia Bayou and Borden Gully Detention Basins Desel Dr. 11,000 cfs Channel Diversion	$500 M	2.9	$245 M	15,100	$180 M	1,940

FNI proposes the following conclusions resulting from this study:

1. The alternatives proposed in this study are targeted toward mitigating the riverine flood risk during large, infrequent storms. For structures at risk of flooding under smaller, more frequent storms such as the 2-year and the 5-year events, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. FNI calculated that over 1,300 structures flood during the 5-year event under future conditions. A significant number of these structures are located in the Dickinson "Bowl" in the vicinity of I-45.
2. Placing detention in the upstream portion of the watershed where undeveloped land is currently available will prove critical as the area develops in the future, but offers limited benefits in the Dickinson "Bowl" where most of the structures at risk of flooding are located.
3. Constructing a diversion channel from downstream of I-45 to the Bayou's outlet provides significant flood risk mitigation in the population centers located around I-45 that are at the highest risk of riverine flooding.
4. The project benefits captured in this study do not fully account for the benefits the proposed alternatives could provide to the local drainage systems, which could be significant. The output from the alternatives developed in this study's hydraulic models should be integrated into local storm sewer network models to capture additional benefits achieved outside of the riverine floodplain of Dickinson Bayou and its major tributaries.
5. The proposed alternatives mitigate but do not eliminate the flood risk in the study area. Significant residual risk persists east of I-45 due to an abundance of low-lying structures in the Dickinson "Bowl". Flooding risks will likely increase in the future as the upstream portion of the watershed develops, and the compound effect of rainfall and storm surge becomes more severe due to rising sea levels.

Based on these conclusions, FNI recommends a feasibility study be conducted to:

- Refine the combination alternatives proposed as part this study,
- Identify supplemental benefits the alternatives could provide to areas located outside of the riverine floodplains,
- Reduce the uncertainty associated with the compound flooding results by conducting further analyses to improve the understanding of its impacts on the alternatives' benefits,
- Identify efficiencies in the alternatives to reduce cost,
- Develop a project delivery plan, and
- Recommend a distinct alternative for implementation.

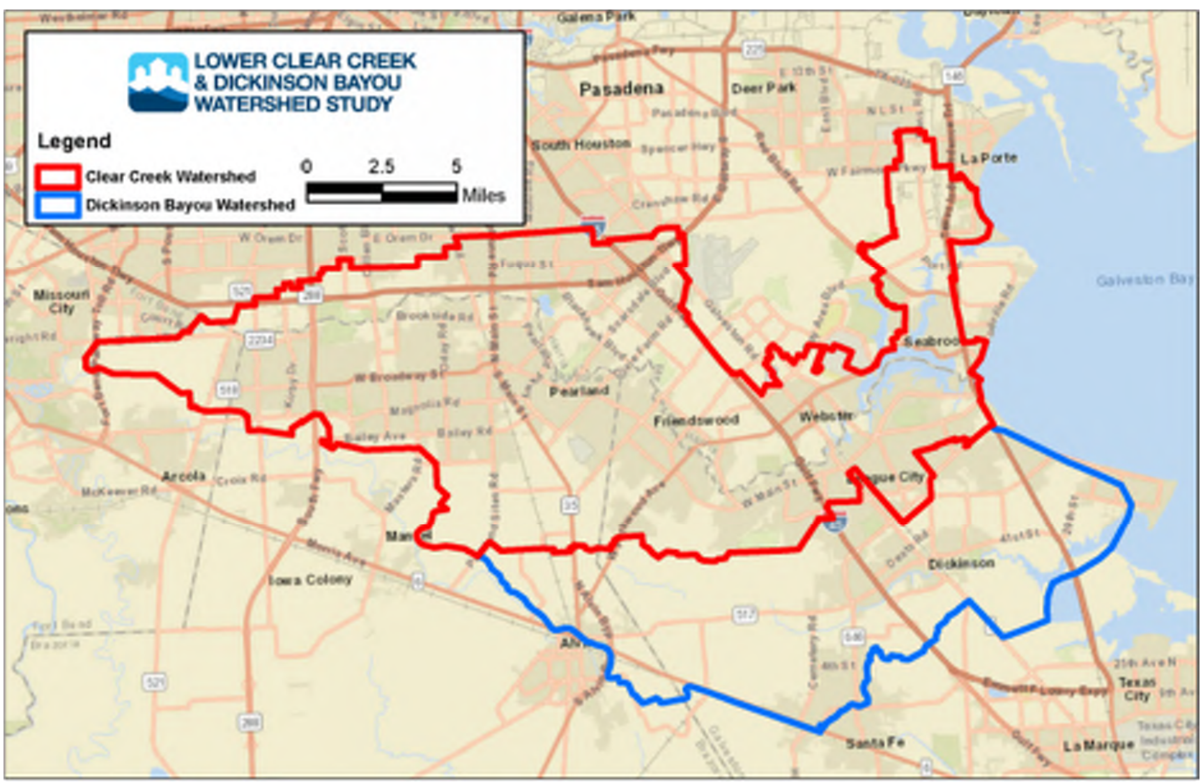
2 BACKGROUND

In August 2017, Hurricane Harvey struck the Texas coast, bringing a historic amount of rainfall to the Houston region. The storm produced never-before-seen precipitation depths in Galveston, Harris, and Brazoria Counties, as well as surrounding counties. As was the case with most of the watersheds in the region, Clear Creek and Dickinson Bayou experienced widespread flooding, which resulted in significant flood damages in the region.

The goal of this study was to develop a comprehensive flood mitigation plan for the Lower Clear Creek and Dickinson Bayou Watersheds with a focus on the riverine impacts along the main channel of each waterway. The flood mitigation plan is focused on mitigating the risk of extreme events similar to Hurricane Harvey, Tropical Storm Allison, and other large tropical storms, as well as flood damages from smaller more frequent storms. The targeted reduction in flood depths was set as multiple feet of reduction at Interstate 45 (I-45) during a 100-year storm.

This report is focused on the Dickinson Bayou Watershed shown in blue in **Figure 1** below. The detailed planning area extends from the American Canal downstream of FM 528 down to the outlet on the upstream side of State Highway 146.

Figure 1: Dickinson Bayou Study Area



The flood mitigation projects that FNI developed as part of this study reflect a concept-level analysis. Although this level of detail is adequate to evaluate the general efficacy of the projects in providing flood risk mitigation, the preliminary siting and sizing that was performed will need to be refined in a future phase as part of a feasibility study.

In order to distinguish project improvements along the Bayou and to acknowledge the different characteristics of the Bayou between FM 528 and SH 146, the project area was divided into three Planning Areas as shown in **Figure 2** provided on the following page.

1. Reach 1 (DB-1) from the American Canal downstream of FM 528 to FM 517 passes through mostly undeveloped land in the western part of League City. Nearly all existing development is built slab on grade, even in close proximity to the main channel and an existing channel bypass in this reach, but there are very few structures. This area is slated for large residential developments which are already being constructed.

2. Reach 2 (DB-2) from FM 517 to I-45 is a more populated section of the watershed. Beginning at Cemetery Road, low density residential properties begin to line the Bayou on both banks. The Bayou is easily navigable up to Cemetery Road for recreational watercraft. Approaching I-45, higher density suburban residential developments abut the bayou. Nearly all development is constructed slab on grade in this reach.

3. Reach 3 (DB-3) from I-45 to SH 146 is the most densely populated section of the watershed, particularly the section between I-45 and SH 3 referred to as the Dickinson "Bowl" due to its low-lying elevation. Within the "Bowl", there are many structures at low elevation at risk of riverine and storm surge flooding. Most of the structures located in the "Bowl" are slab on grade, while further east towards SH 146 structures begin to be mostly elevated. Water levels are controlled by Galveston Bay throughout this reach.

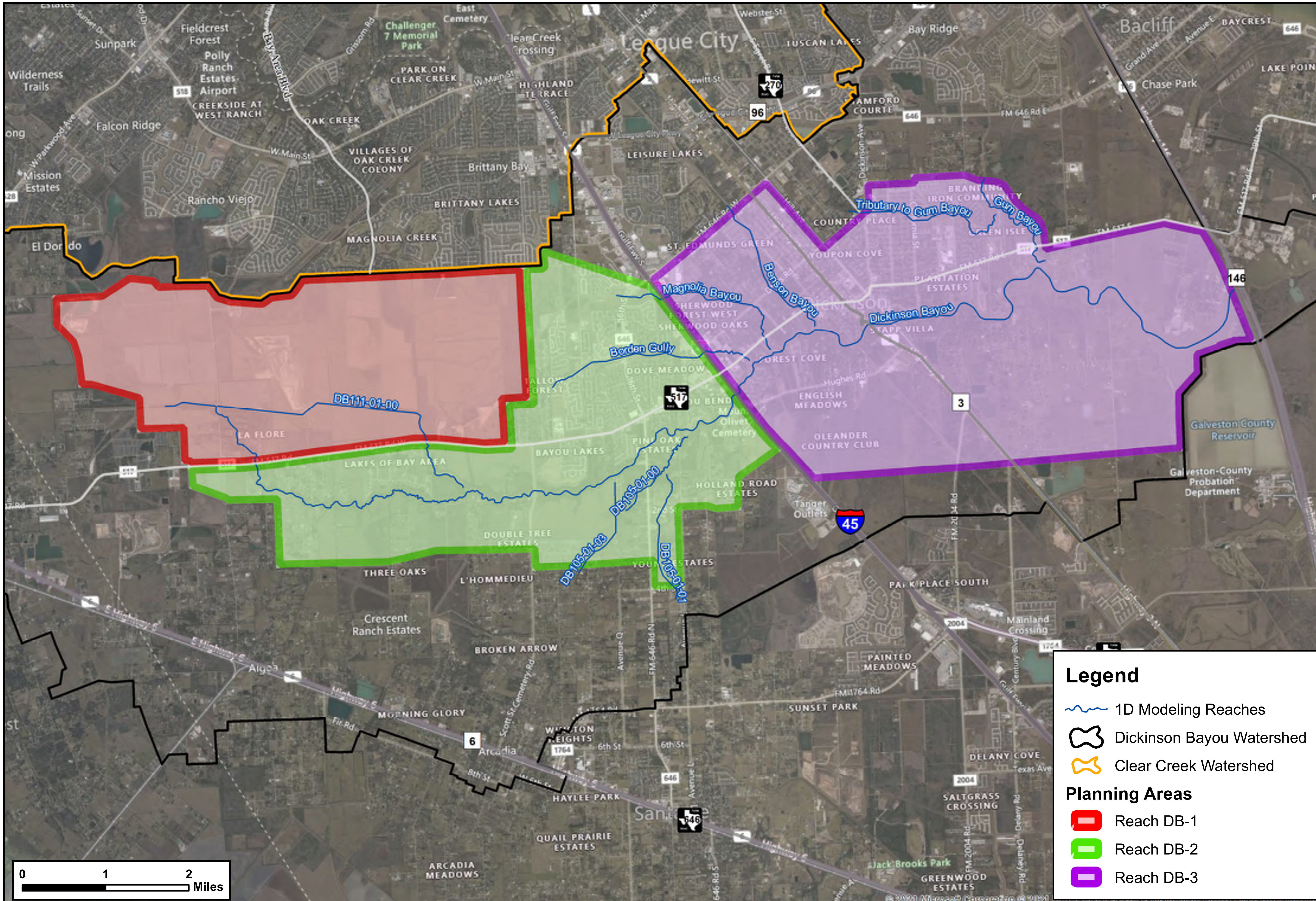


FIGURE 2

Dickinson Bayou
Planning Areas

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FILE Fig3_DB_PlanningAreas
DATE 4/13/2021
SCALE 1:67,645
DRAFTED 90206

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Document Path: H:\STORMWATER\Final Exhibits\2021_04_30 Final Report\Dickinson Bayou\Fig3_DB_PlanningAreas.mxd

2.1 PROJECT PHASING

To maximize the effectiveness of the study, the effort was divided into Phases. This Alternatives Evaluation and Recommendation report represents the culmination of Phase 3: Project(s) Identification. The previous phases completed were:

- Phase 1: Discovery & Baselining
- Phase 2: Watershed Study

The deliverables for the prior two phases are included as **Appendix B**, **Appendix C**, and **Appendix D** to this report for reference. This report includes the alternatives analysis and recommendations that conclude Phases 1 through 3 of the project. Future phases may be authorized and developed by the City of League City and other stakeholders based on the results of this study.

2.2 PLANNING PARTNERS

League City led the engagement of numerous stakeholders along Dickinson Bayou to fund Phases 1 through 3 of this study. League City also entered into an agreement to receive Planning Assistance to States (PAS) funding from the United States Army Corps of Engineers (USACE) under the authority provided by Section 22 of the Water Resources Development Act of 1974 (PL 93-251), as amended. USACE Galveston District provided in-kind services and was engaged in all aspects of the project including technical reviews and a downstream boundary condition analysis accounting for storm surge and future sea level rise.

Key planning partners and contributors included:

- The United States Army Corps of Engineers (USACE)
- Harris County Flood Control District (HCFCD) including MAAPnext consultant Pape-Dawson Engineers, Inc. (Pape-Dawson) for the work on Lower Clear Creek.
- Galveston County including consultant RPS
- City of Friendswood

Additional planning partners and study contributors included:

- Galveston County Consolidated Drainage District
- LJA Engineering, Inc. (LJA) through their work on the League City Municipal Drainage Plan

2.3 HYDROLOGY AND HYDRAULICS

During Phase 2 of this project, FNI performed a hydrologic and hydraulic study of the Dickinson Bayou Watershed (refer to **Appendix B** and **Appendix C** for more details). The model development was conducted by RPS per the partnership agreement with Galveston County as part of the Mainland Galveston County Master Drainage Plan Update.

2.3.1 Data Sources

Some of the main data sources used in this study were:

- 2018 LiDAR: The study's topographic information was developed using Light Detection and Ranging (LiDAR) data obtained from the Texas Natural Resources Information System (TNRIS) and the Houston-Galveston Area Council of Governments (HGAC). This LiDAR data was collected January through March 2018, and uses the vertical datum GEOID12B.
- Atlas 14 Rainfall: Precipitation data was obtained from NOAA's Atlas 14, Volume 11 Version 2.0 (Atlas 14). Atlas 14 is the most up to date precipitation data.
- Effective Models: A data request was submitted to the Federal Emergency Management Agency (FEMA) in February 2020 to gather all available effective models within the study area.
- Previous Studies: Models developed by JKC Engineering in a previous study were obtained and reviewed.

2.3.2 Hydrology

FNI generated updated hydrologic parameters based on the Basin Development Factor (BDF) methodology. The hydrologic model was developed using the USACE Hydrologic Engineering Center's Hydrology Modeling System (HEC-HMS) version 4.3. FNI executed 24-hour duration storm events in the model including the Annual Exceedance Probabilities (AEP) of 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), and 0.2% (500-year), as well as historical storm events such as Hurricane Harvey. FNI analyzed both existing conditions based on current land use, and future conditions based on predicted future development occurring without detention. The study's results for the 100-year storm event are summarized in **Table 2** provided on the next page.

Table 2: 100-Year Peak Discharges (cfs) at Key Locations

Location	Contributing Drainage Area (Sq M)	FEMA Effective	RPS/FNI		
			Existing	Future	% Increase
Watershed Outfall (SH 146)	98.9	22,000	22,495	23,855	6.0%
Gum Bayou Confluence	86.4	17,100	20,965	22,409	6.9%
Benson Bayou Confluence	69.1	12,000	15,948	17,202	7.9%
I-45	52.5	5,920	11,936	12,629	5.8%
FM 517	24.6	N/A	3,893	4,179	7.3%

These 100-year results show increases between the effective discharges and the discharges computed as part of this study, especially in the upstream sections of the reach. These increases can be attributed to multiple factors, including:

- Increases in rainfall depths associated with the latest and improved Atlas 14 precipitation data. For the 24-hour duration 100-year storm event, depths increased from 13.5 inches to 18 inches.
- Differences in the hydrologic modeling methodology including hydrologic routing.
- Increases in resolution of the hydrologic and hydraulic models that were developed.

2.3.3 Hydraulics

The hydraulic model was developed using the U.S. Army Corps of Engineers Hydrologic (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 5.0.7. A detailed 1D/2D unsteady-state model was developed for the main stem of Dickinson Bayou and its major tributaries. To properly model tidal and storm surge impacts, stages were applied on the downstream end of Dickinson Bayou based on guidance provided by USACE Galveston District. To capture future conditions, the existing conditions model was adjusted to include:

- Fully-developed discharges,
- Expected future sea level rise (+1.52 feet) over the 50-year project horizon, based on the Medium Sea Level Change Scenario analyzed by the USACE,
- Major projects under construction along the Bayou since 2018, which included the I-45 TxDOT bridge improvements on Dickinson Bayou, Borden Gully, and Magnolia Bayou.

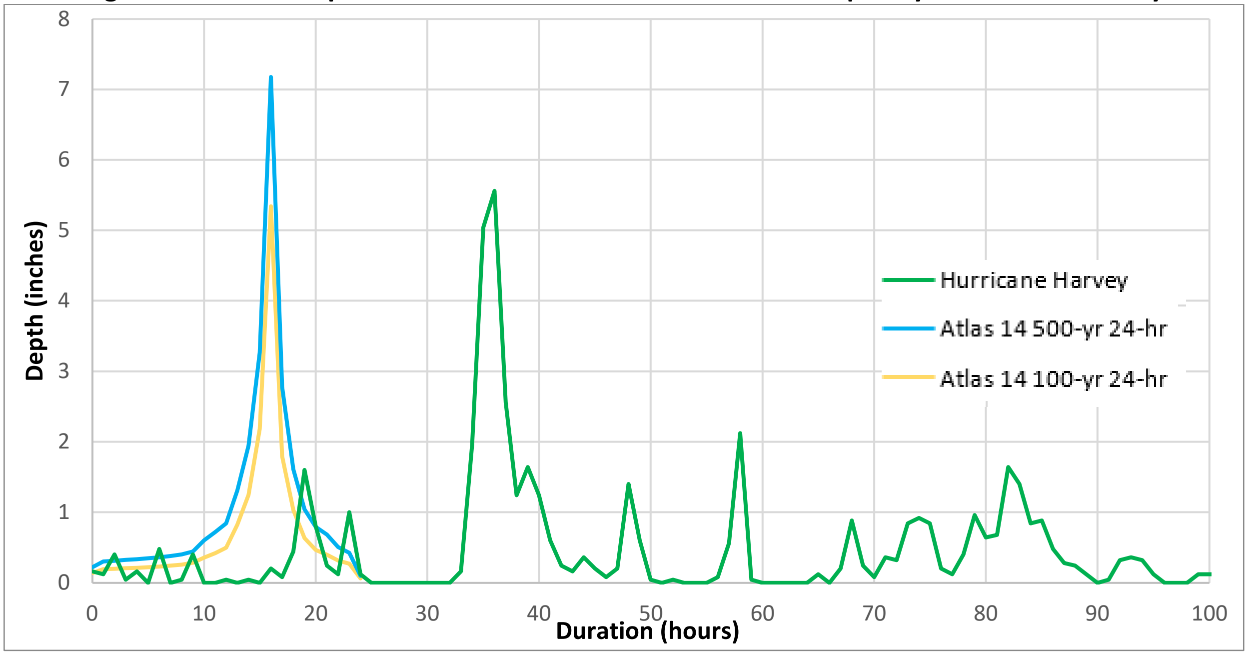
2.3.4 Hurricane Harvey

Because this flood mitigation plan is focused on mitigating the risk of extreme events, it was important to evaluate Hurricane Harvey as it is the most recent catastrophic flood event whose impacts are still felt by stakeholders and the public today. This evaluation included a comparison of rainfall depths and intensity to the new NOAA Atlas 14 events. Rainfall induced flooding is the result of both rainfall intensity and duration. High intensity storms cause flooding when the precipitation rate exceeds the infiltration capacity of soils and the conveyance capacity of the natural channels and stormwater systems. However, total runoff volume is also an important contributor to flooding, particularly in flat, low-lying areas such as Harris and Galveston Counties: Long duration storms of lesser intensity can also result in flooding by filling detention ponds designed to reduce the stress on the conveyance system, as once the design volume is exceeded the detention no longer mitigates the impacts to the conveyance system.

Hurricane Harvey was both a high intensity storm and a long duration storm, and therefore resulted in significant flooding in Dickinson Bayou and other watersheds in the Houston metropolitan area. The data presented in green in **Figure 3** provided on the next page corresponds to rainfall depths measured at the I-45 gage on Clear Creek starting August 25 at 12:00 pm. Rainfall from Harvey lasted over 96 hours (4 days) and exceeded a peak intensity of 5 inches in an hour at approximately hour 37 (August 27 01:00 am). **Figure 3** also shows the Atlas 14 500-year and 100-year 24-hour storm intensities in blue and yellow, respectively, for comparison.

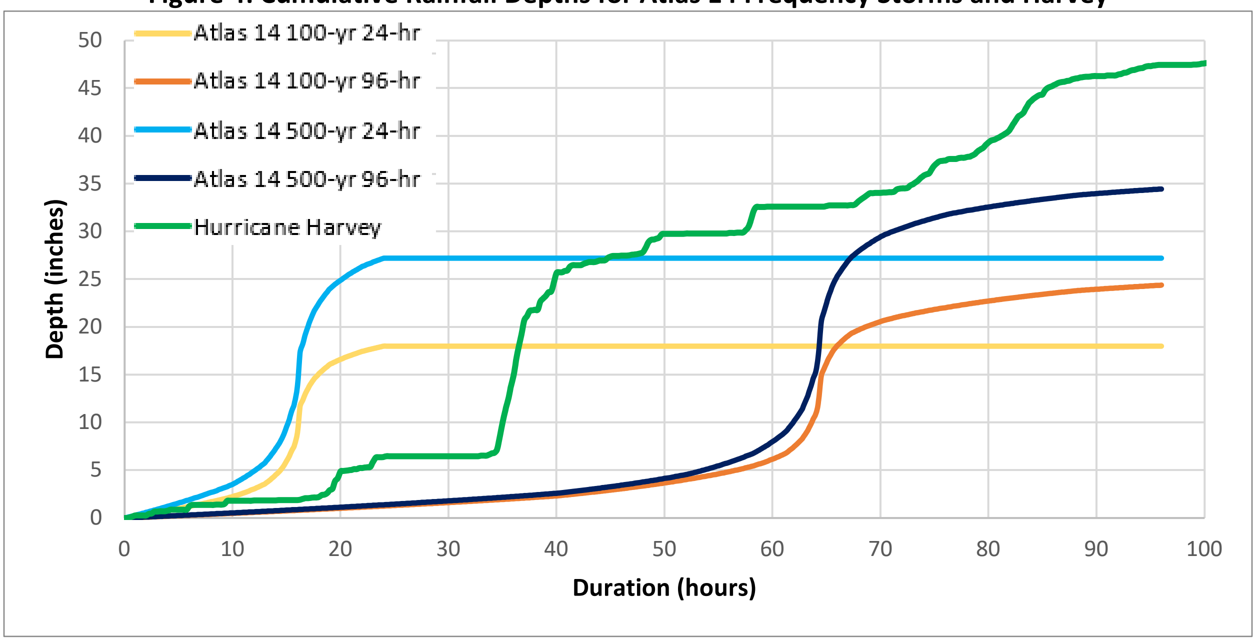
Harvey's maximum intensity was greater than the Atlas 14 100-year 24-hour event but less than the 500-year 24-hour event; however Harvey held that intensity for a long duration and was accompanied by other rainfall exceeding a rate of 1 inch an hour nearly 7 times over the 96 hour period. Prior to the peak intensity beginning at approximately hour 32, over 6 inches of rain had already fallen, saturating the soil and reducing available detention storage. When the maximum intensity occurred, the local storm drainage systems and detention ponds were already stressed, resulting in even greater stress to the conveyance system.

Figure 3: Rainfall Depths at 1-Hour Increments for Atlas 14 Frequency Storms and Harvey



As can be seen in **Figure 4**, rainfall depths from Hurricane Harvey cummulated over the entire storm duration exceeded the Atlas 14 500-year 96-hour duration depths.

Figure 4: Cumulative Rainfall Depths for Atlas 14 Frequency Storms and Harvey



To evaluate project benefits during high-intensity rainfall events, all the combination alternatives were analyzed using the Atlas 14 24-hour storm events to confirm that they were able to convey the maximum storm intensity. To confirm efficacy during long-duration storm events such as tropical storms and hurricanes that produce high volumes of runoff, Hurricane Harvey rainfall was also modeled through the combination alternatives.

2.4 FLOOD RISK

As part of Phase 2 of this study, FNI performed an inundation damages assessment to identify vulnerabilities in the Dickinson Bayou Watershed, including instances of flooding at structures and the resulting damage estimates (refer to **Appendix D** for more details). These two quantitative metrics are detailed in **Section 2.5.1**. A structural inventory was developed in GIS to identify the structures that are located within the floodplains developed as part of the hydraulic modeling effort. Property value information and property type classification were acquired from the Harris County Appraisal District (HCAD) and Galveston Central Appraisal District (GCAD), and associated with the building footprints. Structures were assigned an assumed finished floor elevation of 0.5 feet above the lowest ground elevation at the structure.

FNI evaluated both existing and future conditions flood risks based on the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what those risks could amount to over the 50-year project design period. A discount rate of 7% was used to calculate the net present value of the damages. This report focuses on future conditions instances of flooding and structural damages, as those factors served as the relevant baseline against which the flood mitigation projects proposed as part of Phase 3 were evaluated. FNI also evaluated the impacts that Hurricane Harvey produced in the riverine model (see **Section 2.5.3** for the limitations of the riverine model). These results are shown in **Table 3** and **Table 4**.

Table 3: Structural Damages ($M) for Future Conditions and Hurricane Harvey

Planning Area	Frequency Storms – Future Conditions							Harvey
	500-Yr	100-Yr	50-Yr	10-Yr	5-Yr	2-Yr	50-Yr Period	
DB-1	0.9	0.6	0.5	0.2	0.1	0.0	1.3	0.4
DB-2	398.5	164.2	100.7	28.5	15.5	8.0	227.2	227.2
DB-3	419.1	240.6	182.4	79.0	38.7	20.3	483.5	325.7
Totals	**818.5**	**405.5**	**283.6**	**107.7**	**54.4**	**28.4**	**712.0**	**553.3**

Table 4: Instances of Flooding for Future Conditions and Hurricane Harvey

Planning Area	Frequency Storms – Future Conditions							Harvey
	500-Yr	100-Yr	50-Yr	10-Yr	5-Yr	2-Yr	50-Yr Period	
DB-1	62	54	45	15	3	2	62	34
DB-2	6,421	3,153	1,995	566	304	136	6,421	4,111
DB-3	8,147	5,789	4,784	2,044	1,018	444	8,147	7,030
Totals	**14,630**	**8,996**	**6,824**	**2,625**	**1,325**	**582**	**14,630**	**11,175**

2.5 EVALUATION FACTORS

2.5.1 Quantitative Metrics

Four quantitative metrics were used in this study to identify the concepts that provide the greatest flood risk mitigation:

1. Instances of Flooding: Number of structures flooded in a given storm event (e.g. 100-year), as well as the number of times a given structure is predicted to flood over a 50-year period. This was analyzed for each of the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what the instances could amount to over the 50-year project design period. An instance of flooding reports whether a given structure is inundated or not. See **Appendix D** for more information.

2. Structural Damages: Monetary value resulting from the damages caused by floodwaters at a given structure. This was analyzed for each of the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, as well as a statistical prediction of what the damages could amount to over the 50-year project design period. Structural damages are a function of floodwater depths at a given structure, and are computed based on depth-damage relationships developed by USACE. See **Appendix D** for more information.

3. Transportation System Impacts: Frequency and risk of pedestrian, roadway, and railroad crossings being overtopped by floodwaters. These impacts are representative of public safety hazards, mobility constraints, and impacts to emergency responders. The level of service and hazard was calculated for all main channel and tributary crossings located in the study area. See **Appendix D** for more information.

4. Capital Cost: Cost to construct the improvement in 2021 dollars. Operations and maintenance (O&M) costs were not calculated at this time, but O&M requirements were taken into account as one of the non-cost factors. Capital cost was developed on a rough order of magnitude (ROM) basis for comparative purposes between projects. FNI performed cost estimation in a manner that is consistent with an AACE Level 5 estimate based on a project maturity level of 0 to 2% using parametric methods and unit price quantity take-offs. An estimate of this class carries an accuracy that ranges between -20% to -30% on the low end to +30% to +50% on the high end.

2.5.2 Qualitative Metrics

Quantitative metrics alone do not fully describe the benefits or challenges of the projects analyzed. In order to better capture the full impact of the projects, non-cost factors were also developed in coordination with the key stakeholder group. The group determined that the following non-cost factors, in conjunction with the quantitative factors, would best capture the project impacts:

1. Land Acquisition: Ease of property acquisition. Property already owned by public entities will receive highest scoring. Projects requiring acquisition of numerous parcels, particularly residential and commercial acquisition, will receive the lowest scoring. Subterranean easements required for tunnel projects are seen as less difficult to acquire even through residential and commercial areas.

2. Community Impact/Aesthetics: How easily will the project gain public support by minimizing disruption during construction and providing a long-term amenity with aesthetic and recreational benefits during operation? What is the scale of the disturbance during construction, is the disturbance isolated to a single area or does it cover a large area? What are its transportation impacts to bridges and roads?

3. O&M/Resiliency: How simple is the system to operate, how much energy and manpower is required to operate it, and how resilient is it to natural disaster (loss of power)? Projects that include only routine operation and maintenance already performed by the sponsors will score the highest. Projects that operate passively without the need to operate control structures and pumps will also score the highest. Projects that have ongoing operational cost (pump stations) will score the lowest.

4. Other Agency Coordination: How much coordination is required outside of the project sponsor group with entities including but not limited to TXDOT, railroads and environmental groups?

5. Speed of Implementation: How quickly can the project be planned, designed and constructed including all necessary land acquisition and permitting? Projects that are the fastest at delivering benefits will score the highest.

A pair-wise analysis was conducted to develop a weighting of these non-cost factors in a May 2020 meeting with the key stakeholders. The results and weighting of this effort is shown below in **Table 5**. A score of 1 means the row category is less important than the column category, 2 means it is equally important, and 3 means it is more important.

Table 5: Non-Cost Factors Pair-Wise Matrix

Factor	Land Acquisition	Community Impact/Aesthetics	O&M/Resiliency	Other Agency Coordination	Speed of Implementation	Total	Weight
Land Acquisition	-	3	2	3	1	**9**	**22.5%**
Community Impact/Aesthetics	1	-	2	3	2	**8**	**20.0%**
O&M/Resiliency	2	2	-	3	3	**10**	**25.0%**
Other Agency Coordination	1	1	1	-	1	**4**	**10.0%**
Speed of Implementation	3	2	1	3	-	**9**	**22.5%**

2.5.3 Study Limitations

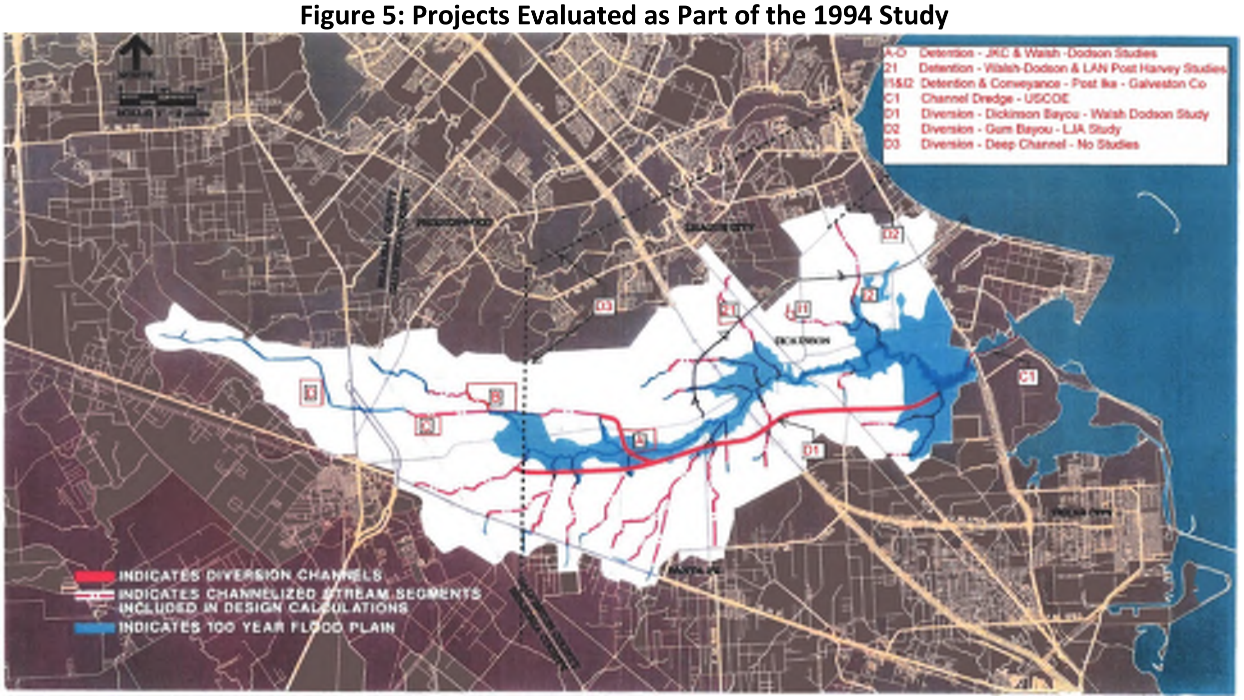
This study is focused on mitigating riverine flooding along Dickinson Bayou. The model incorporates the main stem of Dickinson Bayou and all its major tributaries, and was developed to accurately capture the flooding risks associated with the swelling of the streams. The model is not meant to accurately depict the propagation of floodwaters within neighborhoods and on roadways located outside of the riverine floodplains. It was beyond the scope of this study to fully capture the instances of flooding and structural damages that are caused by ponding water that cannot be conveyed effectively to the streams through the local storm sewer/culvert network. This is evidenced by flood damages and rescues that occurred during Hurricane Harvey in League City and Dickinson outside of the riverine floodplains. To fully capture the instances of flooding and structural damages occurring away from the main stem of Dickinson Bayou and its major tributaries, the output from this study's hydraulic models should be integrated into local storm sewer network models. The results presented herein do not account for local drainage system benefits and therefore likely underpredict the actual reductions in instances of flooding and structural damages provided by the solutions.

The flood mitigation projects that FNI developed as part of this study reflect a concept-level analysis. Although this level of detail is adequate to evaluate the general efficacy of the projects in providing flood risk mitigation, the preliminary siting and sizing that was performed will need to be refined in a future phase as part of a feasibility study.

2.6 PREVIOUS STUDIES AND PROJECT CONSTRAINTS

A watershed wide flood study of Dickinson Bayou had not been completed since the mid 1990s. Walsh Engineering Inc. and Dodson & Associates completed a study in 1994 that recommended construction of a major bypass channel and other flood improvements including detention, channel dredging, and tributary improvements as shown in **Figure 5**.

Figure 5: Projects Evaluated as Part of the 1994 Study



Previous project recommendations for major channel modifications such as widening did not receive local stakeholder support at that time. FNI developed the following conceptual design constraints which guided concept development towards solutions with higher probability of implementation. Those constraints included:

1. No channel widening: Downstream of Cemetery Road, a project that would significantly impact aesthetics and the community in that section of the Bayou is not seen as a favorable alternative. Upstream of Cemetery Road, the low number of structures at risk does not justify a major conveyance improvement.

2. No significant benefits achievable through vegetative clearing and de-snagging: Dickinson Bayou, unlike other natural streams in the region such as Clear Creek, is not densely vegetated in the areas most at risk of riverine flooding. The more densely vegetated sections of the Bayou are located upstream of FM 646, and a clearing project in this low population density area would not produce significant benefits while potentially creating adverse impacts downstream.

3. No new open cut crossings of Interstate 45: I-45 is a major transportation corridor, thus an open cut crossing would result in major traffic disruptions that would impact not only the local stakeholders but also regional and national stakeholders.

4. Infeasible to eliminate flood risk in Dickinson "Bowl": As shown in **Figure 6** provided on the next page, a topographic depression exists between I-45 and SH 3. This topographic "Bowl" coincides with the confluence of Borden Gully, Magnolia Bayou, and Benson Bayou, three major flow contributors in the watershed. This area has a significant number of low-lying structures at risk of flooding during frequent storm events like the 2-year and 5-year events. While significant reductions in the flood risk can be achieved in this area, removal of all structures from the floodplain is not feasible.

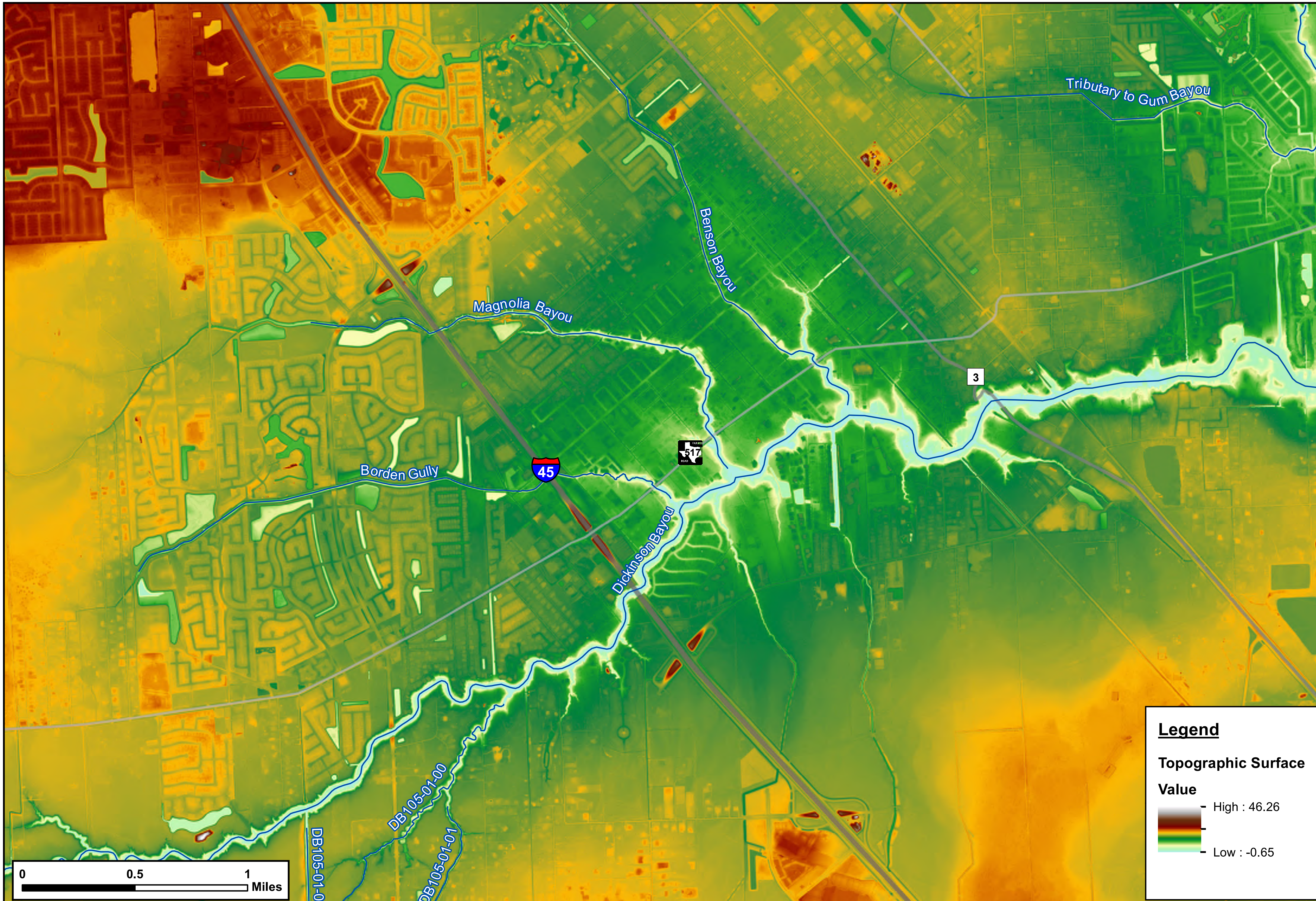


FIGURE 6

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Dickinson Topographic "Bowl"

Dickinson Bayou Watershed

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2.7 COASTAL TEXAS STUDY – DICKINSON BAY GATE SYSTEM

The Coastal Texas Protection and Restoration Feasibility Study Draft Report published in October 2020 presents a *Multiple Lines of Defense* strategy used to design cost-effective, environmentally friendly solutions that will reduce risks of storms impacting the coastal communities and restore important wildlife habitat at the same time. For Dickinson Bayou, the draft plan proposes the following:

- There is only one outlet from Dickinson Bayou into Galveston Bay. At the entrance into Dickinson Bay, the plan calls for a 100-foot-wide floating sector gate with a sill depth of -9 feet (NAVD88) to match the authorized depth of the existing channel. To allow for additional tidal flow through the system, the gate width would be 40 feet wider than the authorized channel (which is 60 feet).
- A pumping station would be constructed, that, when the gates are closed, would pump water coming from the watershed (due to rainfall) out to the bay. The pumping station would have a designed capacity of 19,500 cubic feet per second.
- To the north and south of the sector gate-pumping station complex, a tie into the land with an 18-foot-high floodwall would be required. The entire structure would start on the west side of State Highway 146, near Avenue T, and end on the south side of the bayou, near Waterman's Harbor west of State Highway 146.

The primary objective of the FNI study presented in this report is to analyze and mitigate the risks associated with riverine flooding. Although this objective differs from the Coastal Texas Study's objective, the two studies' objectives interconnect in the downstream reach of Dickinson Bayou near its outlet to Galveston Bay. Additionally, due to the compound flooding risk in Reach 3 east of I-45, implementation of the Dickinson Bayou Gate may allow additional flood mitigation measures to be implemented once the surge barrier is constructed to address riverine impacts. As these two studies are refined in the years to come, solutions should be jointly designed to mitigate risks associated with both riverine and coastal flooding along this downstream reach of Dickinson Bayou.

3 COMBINATION ALTERNATIVES

FNI investigated and modeled a total of 10 flood mitigation projects along Dickinson Bayou. These projects consist of detention basins and channel diversions, and are presented individually in detail in **Appendix A**. Based on the analysis of each discrete project's impacts, FNI developed two combination alternatives that incorporate multiple projects to optimize benefits while preventing adverse impacts. These alternatives were analyzed based on the 2-, 5-, 10-, 50-, 100-, and 500-year storm events, and their benefits were calculated over the 50-year design period. To confirm efficacy during long-duration storm events, Hurricane Harvey rainfall was also modeled through the combination alternatives.

3.1 ALTERNATIVE 1: DETENTION

Alternative 1 focuses solely on mitigation by detention and includes the following projects, as shown in **Figure 7**:

1. Mc Farland Rd. Detention Basin
2. W Cemetery Rd. Detention Basin
3. Hilton Ln. Detention Basin
4. Magnolia Bayou and Borden Gully Detention Basins

The estimated capital cost for Alternative 1 is $220 million. The 100-year Inundation Depth Changes Map is shown in **Figure 7**. **Figure 8** shows 100-year future conditions and Alternative 1 water surface profiles plotted with the estimated finished floor elevations of structures along Dickinson Bayou.

Reach DB-1 sees maximum reductions in 100-year water surface elevations of about 0.5 feet. Alternative 1 provides the greatest benefits in Reach DB-2 upstream of FM 646, with water surface elevation reductions of over 0.6 feet in the 100-year storm event. Reach DB-3 downstream of I-45 sees limited benefits from this alternative, with reductions in 100-year water surface elevations of up to about 0.25 feet.

Since Alternative 1 consists of detention basins only, all of its individual projects can be completed independently without adverse impacts. The minor increases in depths in the immediate vicinity of the Mc Farland Rd. basin are caused by ponding overland drainage, and can be mitigated as the project is refined in future phases. The non-cost factors associated with this combination alternative are presented in **Table 6**.

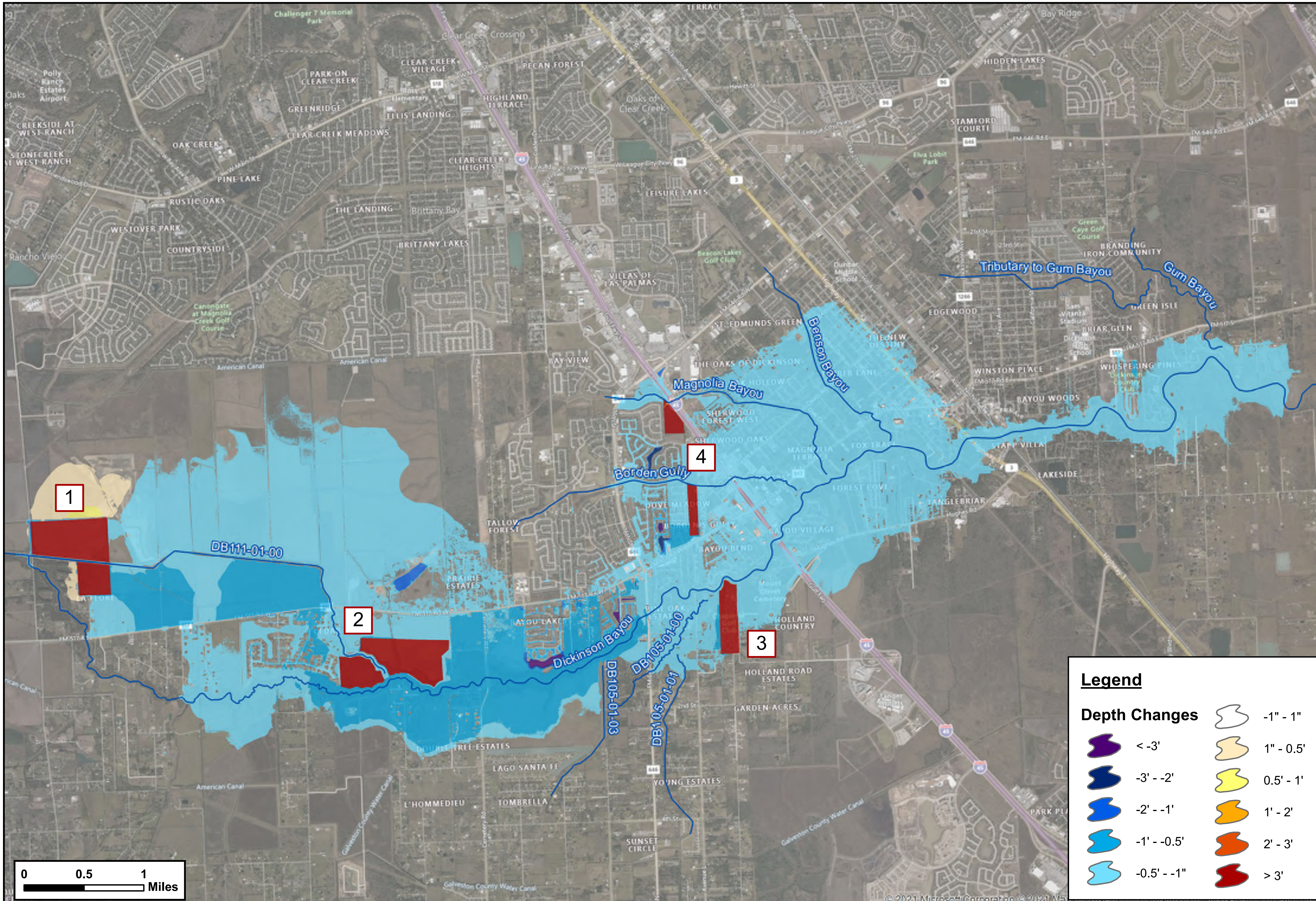

FIGURE 7

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Alternative 1

Location Map - 100-yr Inundation Depth Changes

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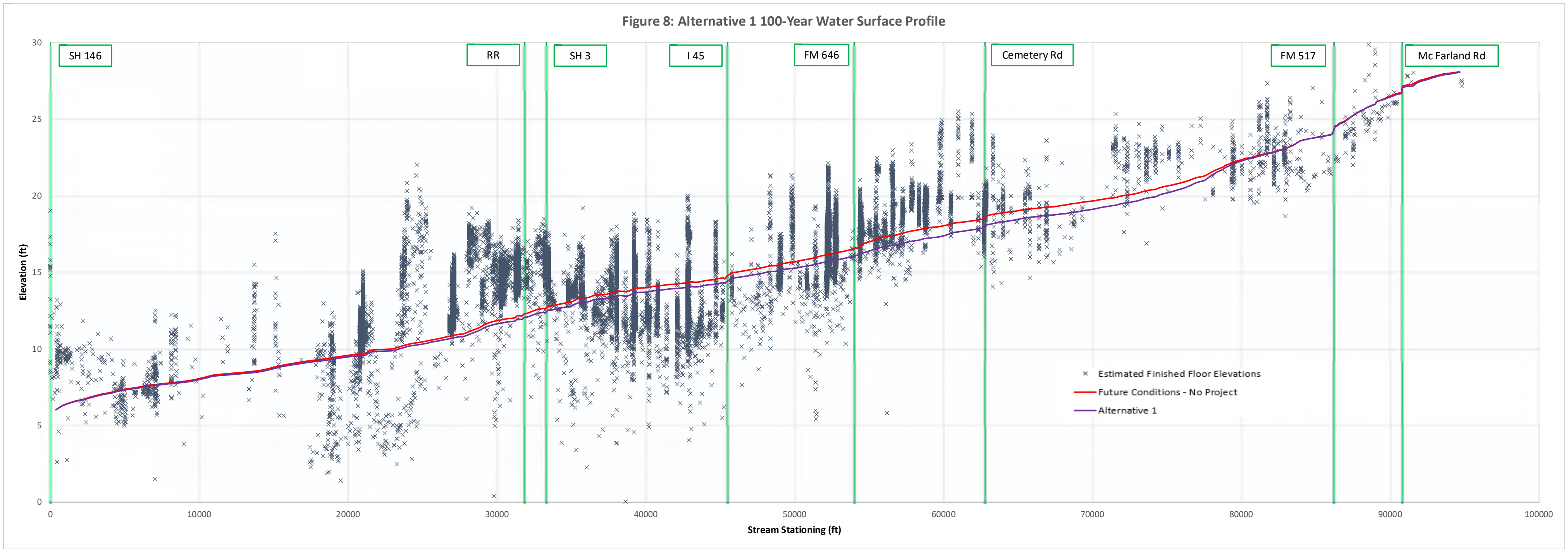


Figure 8: Alternative 1 100-Year Water Surface Profile
SH 146
RR
SH 3
I 45
FM 646
Cemetery Rd
FM 517
Mc Farland Rd
Elevation (ft)
Stream Stationing (ft)
0
5
10
15
20
25
30
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 1

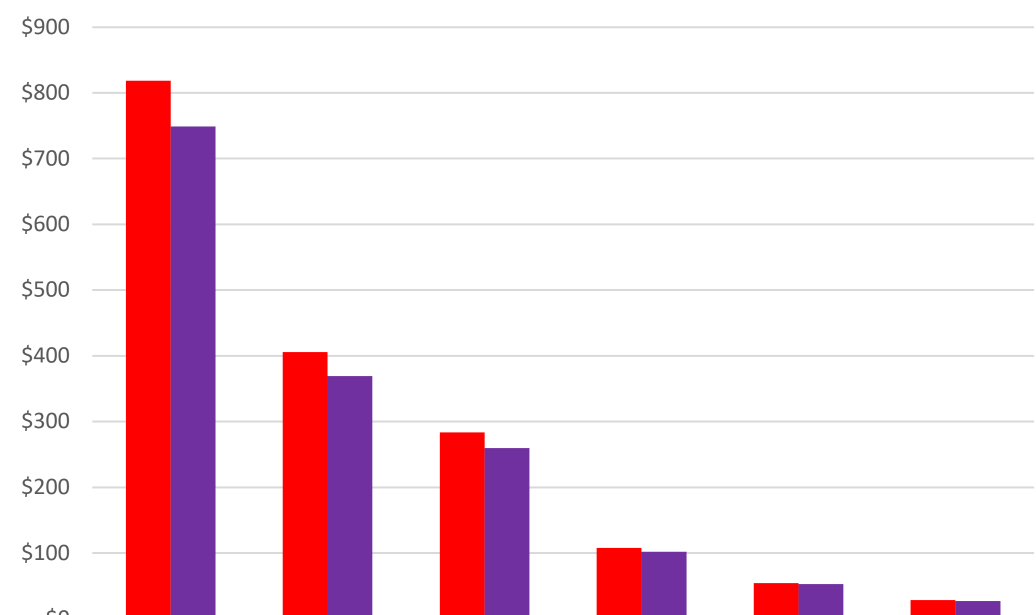
Table 6: Alternative 1 Non-Cost Factors

Factor	Score
Land Acquisition	2
Community Impact/Aesthetics	4
O&M/Resiliency	4
Other Agency Coordination	5
Speed of Implementation	4
Non-Cost Factor Weighted Score	**3.7**

The flood damages and instances for future conditions (no project) and Alternative 1 are presented in **Figure 9** and **Figure 10,** respectively. Over the 50-year design period, Alternative 1 leads to a decrease in flood damages of $40 million, and 2,490 reductions in flooding instances. This translates to 11.3 instances of flooding reduced for every $ million spent in construction costs, and a benefit-cost ratio of 0.19. Additionally, Alternative 1 leads to 40 reductions in roadway overtopping over the 50-year design period.

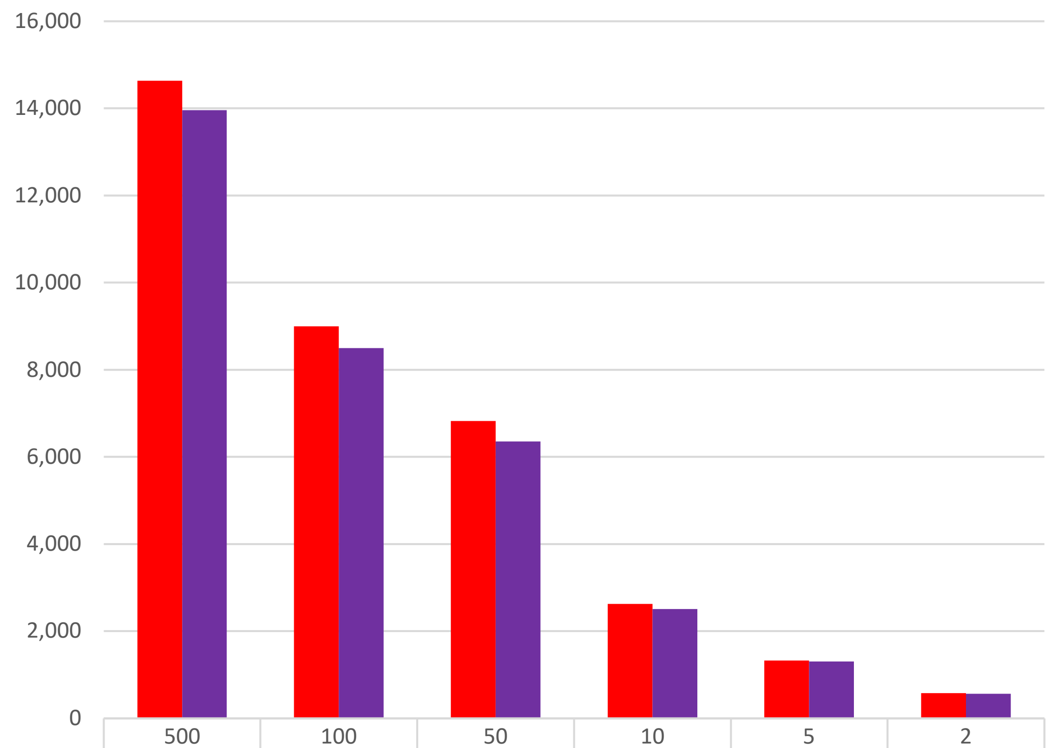
FNI also ran a Hurricane Harvey simulation to assess Alternative 1's performance during tropical storms and hurricanes that can produce large amounts of rainfall over multiple days. Alternative 1 would have reduced structural damages by $35 million, and flooding instances by 420.

Figure 9: Flood Damages ($M) by Event – Alternative 1



	500	100	50	10	5	2
Future Conditions	$818.5	$405.5	$283.6	$107.7	$54.4	$28.4
Alternative 1	$748.8	$369.3	$259.5	$102.1	$52.9	$27.1

Figure 10: Flood Instances by Event – Alternative 1



	500	100	50	10	5	2
Future Conditions	14,630	8,996	6,824	2,625	1,325	582
Alternative 1	13,960	8,499	6,355	2,506	1,305	565

Key Take-Aways:

1. The Dickinson Bayou Watershed upstream of Cemetery Rd. is mostly undeveloped, and therefore the quantifiable benefits associated with the inundation depth reductions provided by Alternative 1 are limited. New development should be built with slab elevations above flood risk levels.
2. A portion of the land in Reach DB-1 and DB-2 that is undeveloped today should be set aside for regional detention to allow for future development to occur without generating adverse impacts downstream.
3. Placing detention in the upstream portion of the watershed where undeveloped land is currently available has limited benefits in the Dickinson "Bowl" where most of the structures at risk of flooding are located.
4. Significant residual risk remains with the construction of Alternative 1.

3.2 ALTERNATIVE 2: DETENTION + BYPASS CHANNEL

Alternative 2 corresponds to the combination of the following projects, as shown in **Figure 11**.

1. Mc Farland Rd. Detention Basin
2. W Cemetery Rd. Detention Basin
3. Hilton Ln. Detention Basin
4. Magnolia Bayou and Borden Gully Detention Basins
5. Desel Dr. 11,000 cfs Channel Diversion

The estimated capital cost for Alternative 2 is $500 million. The 100-year Inundation Depth Changes Map is shown in **Figure 11**. **Figure 12** shows 100-year future conditions and Alternative 2 water surface profiles plotted with the estimated finished floor elevations of structures along Dickinson Bayou.

Reach DB-1 sees maximum reductions in 100-year water surface elevations of about 0.5 feet. The benefits of Alternative 2 become progressively greater moving downstream towards the bypass channel's intake. Reach DB-2 sees water surface elevation reductions of up to 2 feet in the 100-year storm event just upstream of I-45. Alternative 2 provides the greatest water surface elevation reduction in reach DB-3 where the bypass channel's intake is located, with reductions in 100-year water surface elevations of up to 3 feet.

The detention basins proposed as part of Alternative 2 can be completed independently without adverse impacts. The minor increases in depths in the immediate vicinity of the Mc Farland Rd. basin are caused by ponding overland drainage, and can be mitigated as the project is refined in future phases. The bypass channel is shown to cause a rise in water surface elevations at its downstream confluence with Dickinson Bayou. Although this increase occurs in an area of low population density, further property-specific evaluations should be conducted to determine what measures are required to mitigate the flooding impacts at these properties. The non-cost factors associated with this combination alternative are presented in **Table 7**.

Table 7: Alternative 2 Non-Cost Factors

Factor	Score
Land Acquisition	1
Community Impact/Aesthetics	2
O&M/Resiliency	5
Other Agency Coordination	3
Speed of Implementation	3
Non-Cost Factor Weighted Score	**2.9**

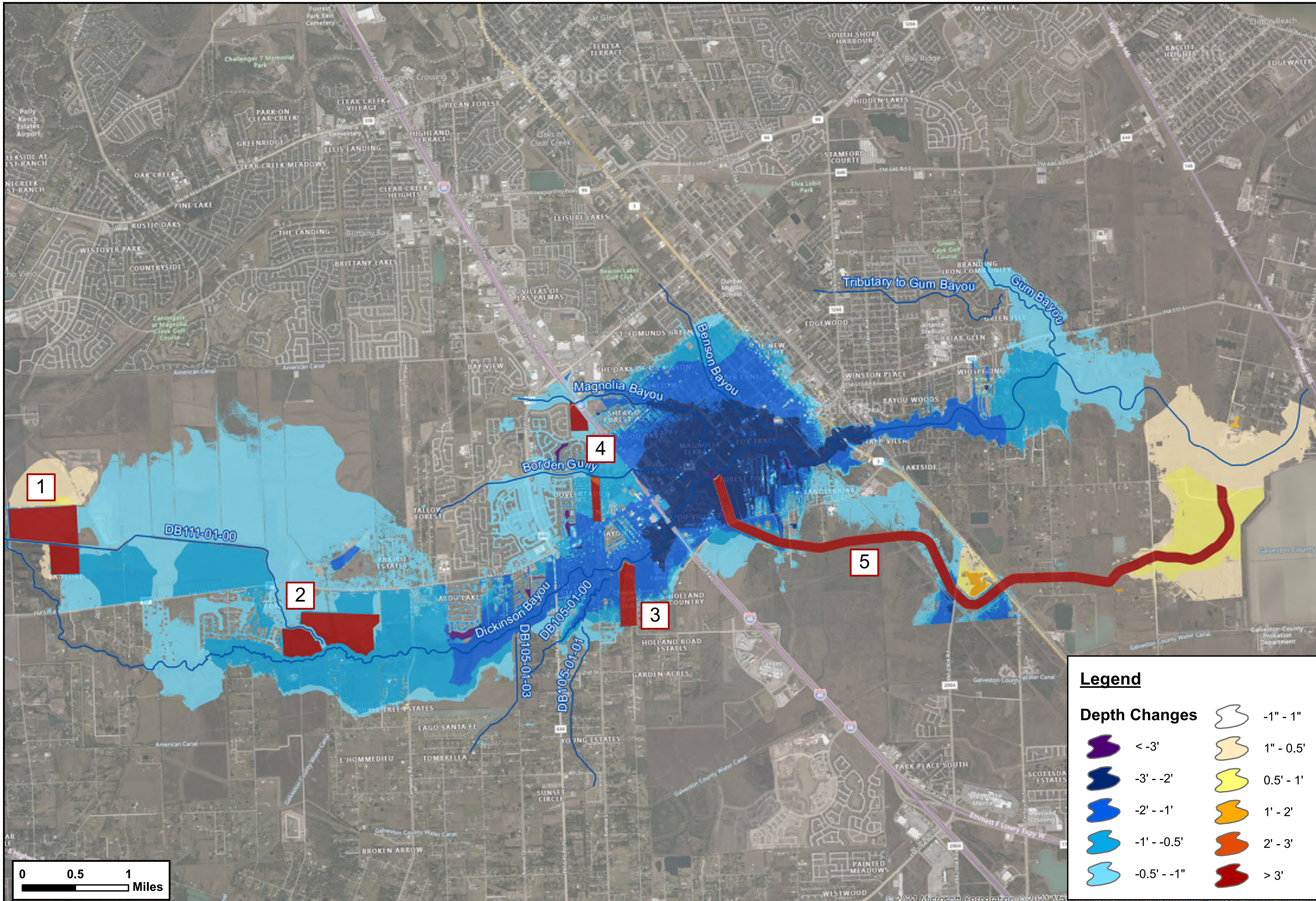


FIGURE 11

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SCALE	1:53,000
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Alternative 2

Location Map - 100-yr Inundation Depth Changes

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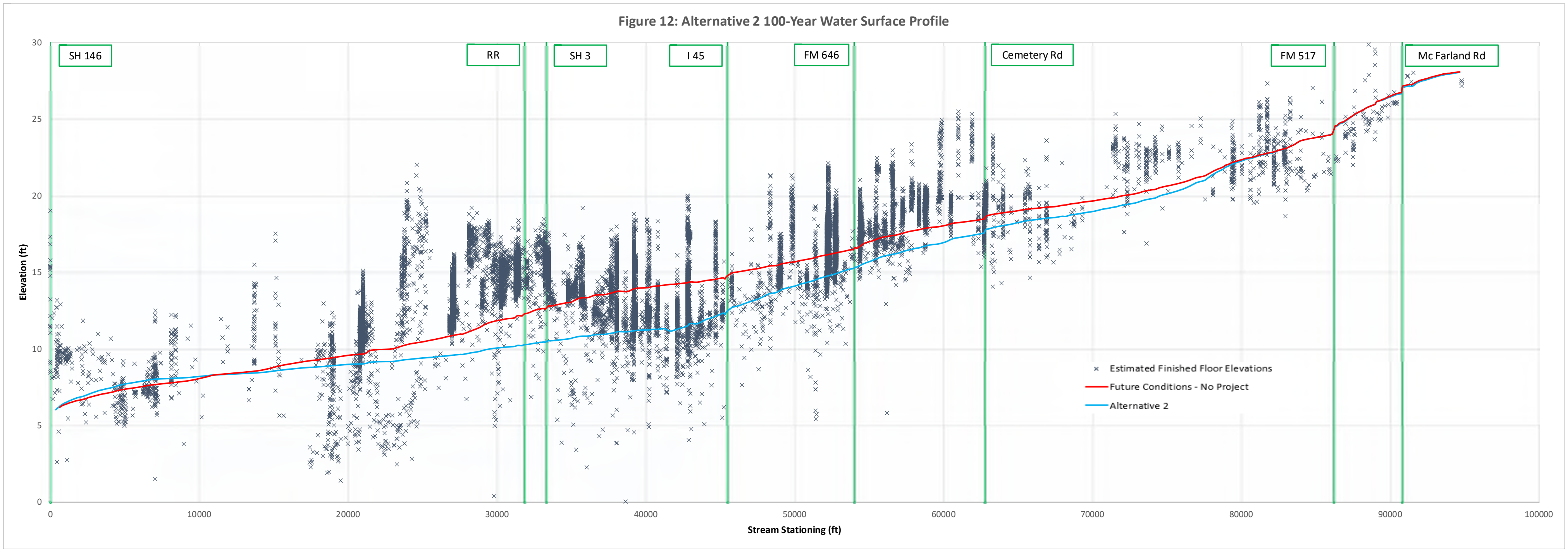


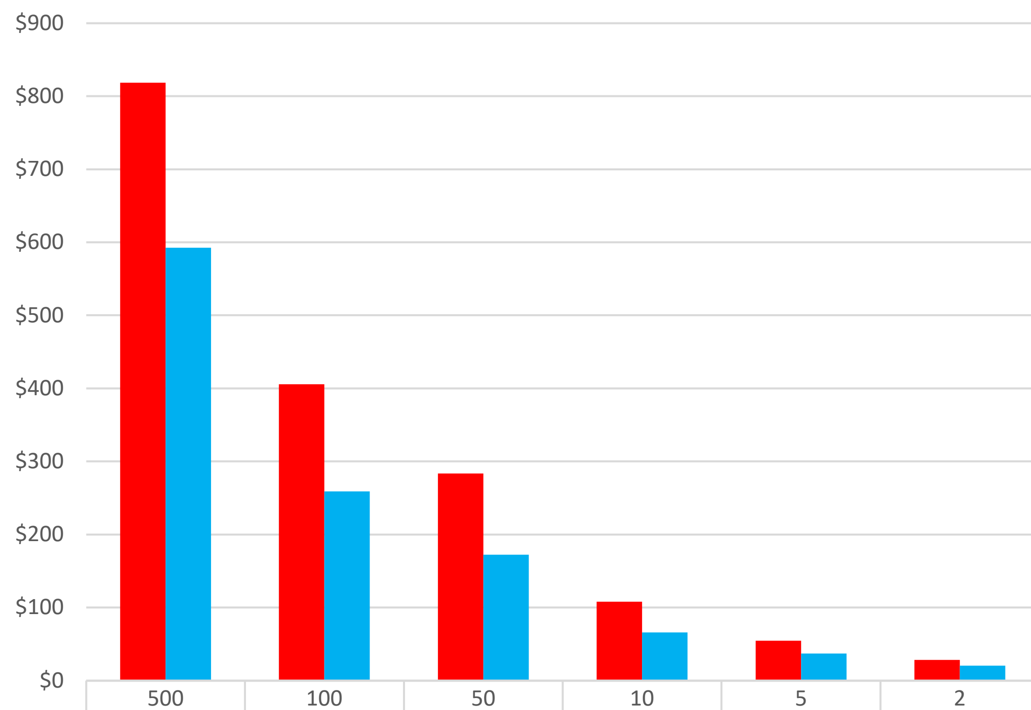
Figure 12: Alternative 2 100-Year Water Surface Profile
SH 146
RR
SH 3
I 45
FM 646
Cemetery Rd
FM 517
Mc Farland Rd
Elevation (ft)
Stream Stationing (ft)
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 2
0
5
10
15
20
25
30
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000

The flood damages and instances for future conditions (no project) and Alternative 2 are presented in **Figure 13** and **Figure 14**, respectively. Over the 50-year design period, Alternative 2 leads to a decrease in flood damages of $245 million, and 15,100 reductions in flooding instances. This translates to 30.2 instances of flooding reduced for every $ million spent in construction costs, and a benefit-cost ratio of 0.49. Additionally, Alternative 2 leads to 111 reductions in roadway overtopping over the 50-year design period.

Alternative 2 is shown to provide significant flood mitigation benefits in events of catastrophic magnitude such as the 500-year storm event: Alternative 2 reduces structural damages by $225 million, and flooding instances by 1,900.

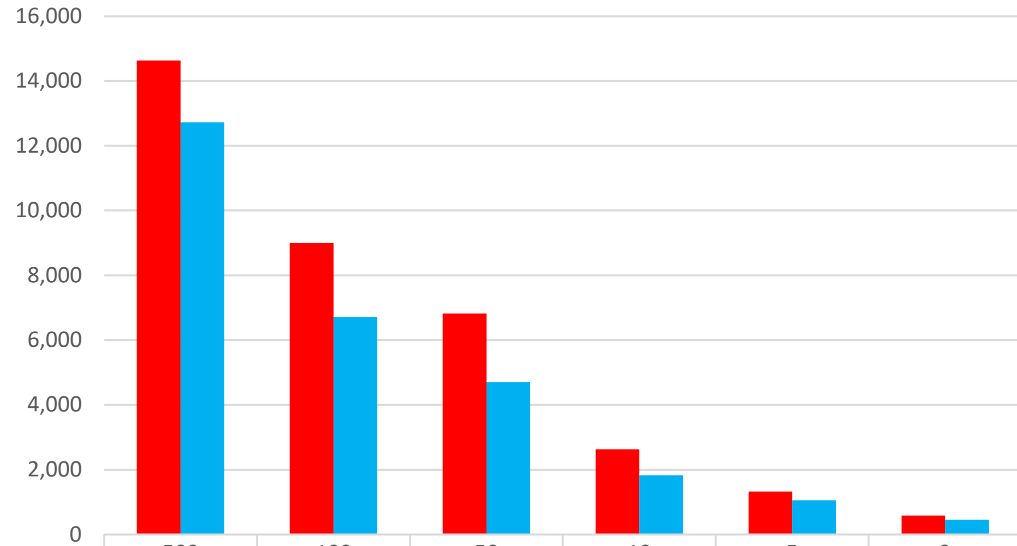
FNI also ran a Hurricane Harvey simulation to assess Alternative 2's performance during tropical storms and hurricanes that can produce large amounts of rainfall over multiple days. Alternative 2 is shown to reduce structural damages by $180 million, and flooding instances by 1,940.

Figure 13: Flood Damages ($M) by Event – Alternative 2



	500	100	50	10	5	2
Future Conditions	$818.5	$405.5	$283.6	$107.7	$54.4	$28.4
Alternative 2	$592.4	$258.8	$172.3	$65.8	$36.9	$20.1

Figure 14: Flood Instances by Event – Alternative 2



	500	100	50	10	5	2
Future Conditions	14,630	8,996	6,824	2,625	1,325	582
Alternative 2	12,727	6,711	4,700	1,830	1,054	452

<u>Key Take-Aways:</u>

1. The Dickinson Bayou Watershed upstream of Cemetery Rd. is mostly undeveloped, and therefore the quantifiable benefits associated with the inundation depth reductions provided by Alternative 2 are limited. New development should be built with slab elevations above flood risk levels.
2. A portion of the land in Reach DB-1 and DB-2 that is undeveloped today should be set aside for regional detention to allow for future development to occur without generating adverse impacts downstream.
3. Constructing a diversion channel from downstream of I-45 to the Bayou's outlet provides significant flood risk mitigation in the population centers located around I-45, particularly in the Dickinson "Bowl" east of I-45. It also eliminates the need to build a channel across I-45. Alternative 2 has a benefit/cost ratio of 0.5 which is the highest of any alternative evaluated as part of the Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan.
4. The Dickinson "Bowl" contains a vast number of low-lying structures at risk of flooding during frequent storm events like the 2-year and 5-year events. Alternative 2 cannot adequately mitigate the flood risk at these structures. Voluntary buyouts and elevation of the finished floors is recommended for these structures.
5. Significant residual risk remains with the construction of Alternative 2.

4 CONCLUSIONS

Table 8 shows the 100-year peak water surface elevation reductions at Cemetery Rd. and I-45 between Alternative 1, Alternative 2, and future conditions (no project). A comparison of the complete 100-year water surface profiles is presented in **Figure 15** provided on the next page.

Table 8: 100-Year Peak Water Surface Elevation Reductions at Cemetery Rd. and I-45

Alternative	Cemetery Rd.	I-45
1: Detention	0.59 feet	0.37 feet
2: Detention + Diversion Channel	0.88 feet	2.29 feet

Alternative 1 is about half the cost of Alternative 2 but provides significantly less flood risk mitigation. Alternative 2 has a benefit/cost ratio of 0.5 which is the highest of any alternative evaluated as part of the Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan. The proposed diversion channel provides significant flood risk mitigation in the population centers located around I-45 that are subject to an elevated risk of riverine flooding. As presented in **Appendix A**, increasing the channel capacity increases constructions costs but also the benefits obtained from the project. As this study progresses into future phases, the design of the diversion channel can optimized based on available funds and flood risk mitigation objectives.

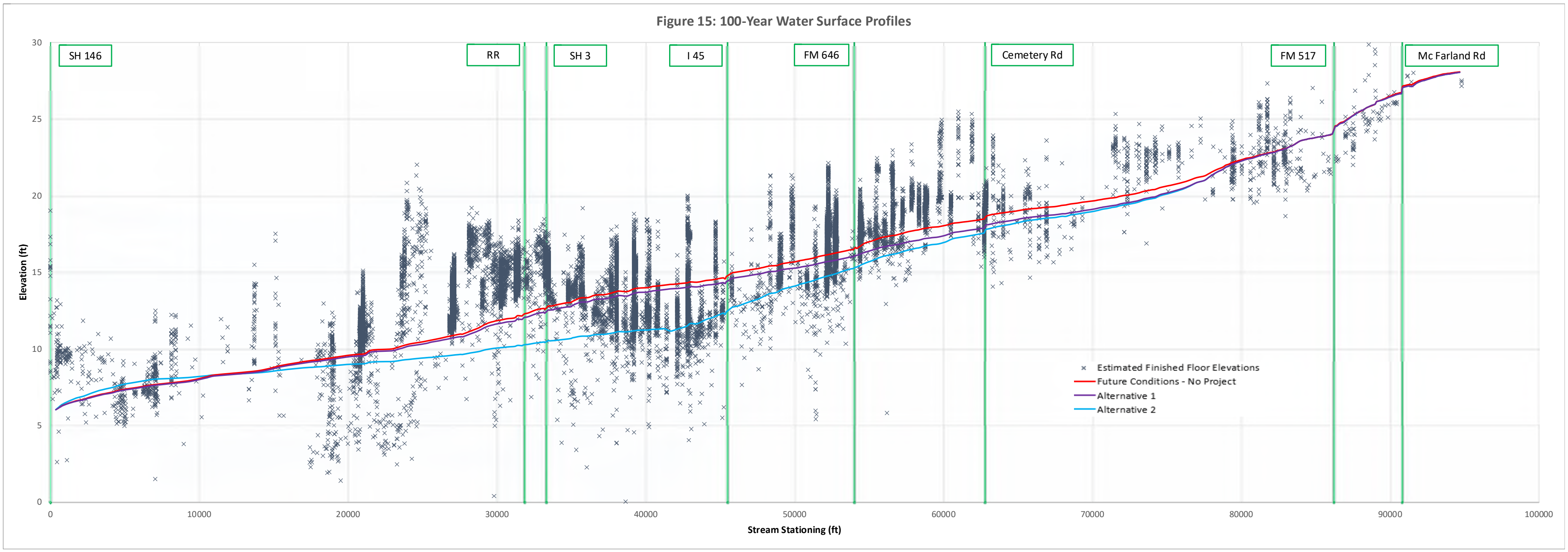
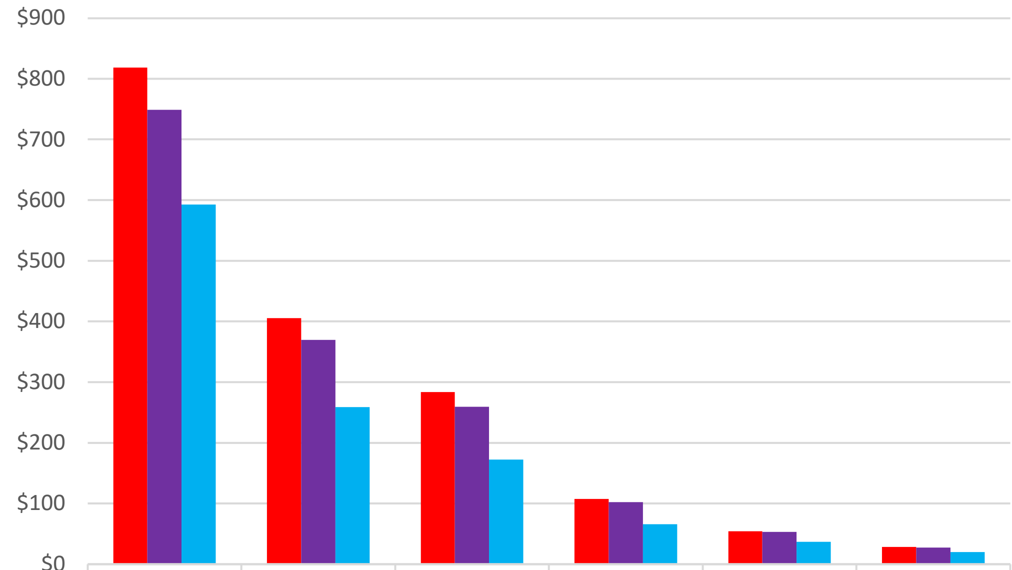


Figure 15: 100-Year Water Surface Profiles
SH 146
RR
SH 3
I 45
FM 646
Cemetery Rd
FM 517
Mc Farland Rd
Elevation (ft)
Stream Stationing (ft)
0
5
10
15
20
25
30
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Estimated Finished Floor Elevations
Future Conditions - No Project
Alternative 1
Alternative 2

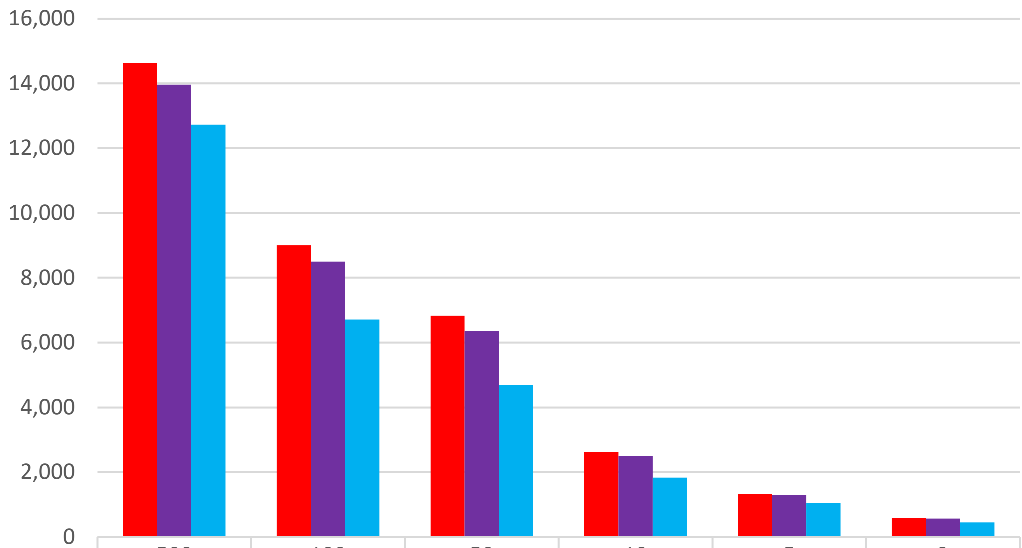
Figure 16 and **Figure 17** summarize the structural damages and instances of flooding associated with each alternative compared to future conditions (no project).

Figure 16: Summary of Structural Damages ($M) by Event for All Alternatives



	500	100	50	10	5	2
Future Conditions	818.5	405.5	283.6	107.7	54.4	28.4
Alternative 1	748.8	369.3	259.5	102.1	52.9	27.1
Alternative 2	592.4	258.8	172.3	65.8	36.9	20.1

Figure 17: Summary of Flood Instances by Event for All Alternatives



	500	100	50	10	5	2
Future Conditions	14,630	8,996	6,824	2,625	1,325	582
Alternative 1	13,960	8,499	6,355	2,506	1,305	565
Alternative 2	12,727	6,711	4,700	1,830	1,054	452

FNI proposes the following conclusions resulting from this study:

1. The alternatives proposed in this study are targeted toward mitigating the riverine flood risk during large, infrequent storms. For structures at risk of flooding under smaller, more frequent storms such as the 2-year and the 5-year events, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. FNI calculated that over 1,300 structures flood during the 5-year event under future conditions. A significant number of these structures are located in the Dickinson "Bowl" in the vicinity of I-45.
2. Placing detention in the upstream portion of the watershed where undeveloped land is currently available will prove critical as the area develops in the future, but offers limited benefits in the Dickinson "Bowl" where most of the structures at risk of flooding are located.
3. Constructing a diversion channel from downstream of I-45 to the Bayou's outlet provides significant flood risk mitigation in the population centers located around I-45 that are at the highest risk of riverine flooding.
4. The project benefits captured in this study do not fully account for the benefits the proposed alternatives could provide to the local drainage systems, which could be significant. The output from the alternatives developed in this study's hydraulic models should be integrated into local storm sewer network models to capture additional benefits achieved outside of the riverine floodplain of Dickinson Bayou and its major tributaries.
5. The proposed alternatives mitigate but do not eliminate the flood risk in the study area. Significant residual risk persists east of I-45 due to an abundance of low-lying structures in the Dickinson "Bowl". Flooding risks will likely increase in the future as the upstream portion of the watershed develops, and the compound effect of rainfall and storm surge becomes more severe due to rising sea levels.

5 RECOMMENDATIONS

Since the combination alternatives analyzed do not have a benefit-cost ratio greater than 1.0, project recommendations are closely tied to project funding potential with a focus on local funding for a significant share of the project.

5.1 PROJECT FUNDING

5.1.1 Local Funding

All of the combination alternatives and any of the individual projects greater than $50 million in capital cost are unlikely to be funded by an individual entity such as the City of League City or the City of Dickinson. These improvements will require partnerships and cost sharing agreements between the entities. These agreements could be developed piecemeal on a project-by-project basis, but would be better accomplished through development of a watershed-wide entity focused on flood damage reduction along the main channel of Dickinson Bayou such as the Clear Creek Flood Control District originally proposed in 1995 and offered for consideration again at the State level in 2019.

Such an entity would have a clear mission of flood protection for Dickinson Bayou and provide a single clear partner for larger entities such as USACE, Texas General Land Office, and the Texas Water Development Board. This entity would not conflict or restrict Galveston County Consolidated Drainage District and other entities along the Bayou from their responsibilities. Instead, the newly formed Dickinson Bayou Flood Control District would allow other entities to focus their efforts on tributary drainage to Dickinson Bayou thus maximizing the benefit of their existing ad valorem taxes. The Dickinson Bayou Flood Control District would need to be created by the Texas State Legislature and then voted upon by the Watershed's residents to grant it taxing authority. The tax rate for the District would be a function of the projects recommended following the next phase of this study. Discussions with state and local officials to gain traction for this concept should proceed immediately.

5.1.2 External Funding

In addition to local funding opportunities through ad valorem, additional grant and matching programs exist at the Federal and State level that should be evaluated once clear cost/benefit metrics are prepared that include potential local benefits. These funding entities and their programs are discussed in greater detail in **Appendix E** and include:

- United States Army Corps of Engineers
- Texas General Land Office
- Federal Emergency Management Agency
- Texas Water Development Board
- United States Department of Housing and Urban Development
- United States Department of Agriculture

There are many different financial partnership opportunities, but external sources come with their own objectives. Even if a project may qualify and be selected for a program, most programs require a local match that is a significant percentage and many programs have strings attached. Each partner will have distinct eligibility and accountability criteria by which they are legally obligated to, often including benefit cost ratio.

Many of these requirements include:

- Additional Protections for Cultural Resources and the Environment
- Restrictions on what actions are reimbursable
- Additional reporting requirements on how money is spent
- Transparency and fairness in how contracts are advertised and awarded
- Special contract provisions regarding how work will be recorded and conducted

As these programs are pursued it is important to understand the implications that each program's requirements may impose on the project; these projects will not perform well for programs that put a heavy emphasis on low to moderate income and socially vulnerable populations.

For structures at risk of flooding under frequent storms, elevating the structure or acquiring the property and removing it from the floodplain is likely the most cost-effective approach. This can be specifically undertaken with the help of the following programs:

- NRCS-EWP Pilot Program
- FEMA-HMGP
- FEMA-BRIC
- TWDB-FIF

5.2 NEXT STEPS

FNI recommends that this concepts analysis study be followed by a feasibility study to:

- Refine the combination alternatives proposed as part this study,
- Identify supplemental benefits the alternatives could provide to areas located outside of the riverine floodplains. The outputs from the alternatives developed as part of this study should be integrated into local storm sewer network models for League City, Dickinson, and other municipalities,
- Reduce the uncertainty associated with the compound flooding results to improve the understanding of its impacts on the alternatives' benefits,
- Identify efficiencies in the alternatives to reduce cost,
- Develop a project delivery plan, and
- Recommend a distinct alternative for implementation.

Appendix A

Evaluation of Discrete Projects

Appendix B

Hydrologic Technical Memorandum

Appendix C

Hydraulic Technical Memorandum

Appendix D

Inundation Damages Assessment

Technical Memorandum

Appendix E

Preliminary Funding Memorandum

Appendix 5-4C:
Brays Bayou CDBG-MIT

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 that 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 HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD 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 Bintlff 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 6.6% Local — 5 points

Resiliency Measures: Yes — 5 points

TOTAL — **80.68 points**

Poverty Rate: 16.2%

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

Innovative approaches
Practical results
Outstanding service

BENEFIT-COST ANALYSIS

BRAYS 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

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-94[1]. (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-94[3].
    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 6.0[4] (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 of 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-year[5] 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 (CSVR) 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 assessments[8]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

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

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*).

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

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*).

$$Capital\ Recovery\ Factor\ (\frac{A}{P}) = \frac{Annual\ Value}{Present\ Value} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Equation 3

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

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*.

$$BCR = \frac{(Expected\ Annual\ Benefits * \ Uniform\ Series\ Present\ Worth\ Factor) + Present\ Worth\ Social\ Benefits}{Project\ Capital\ Cost}$$ ***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 inventory[9].

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 Manual[10]. 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 methodology[11], 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."

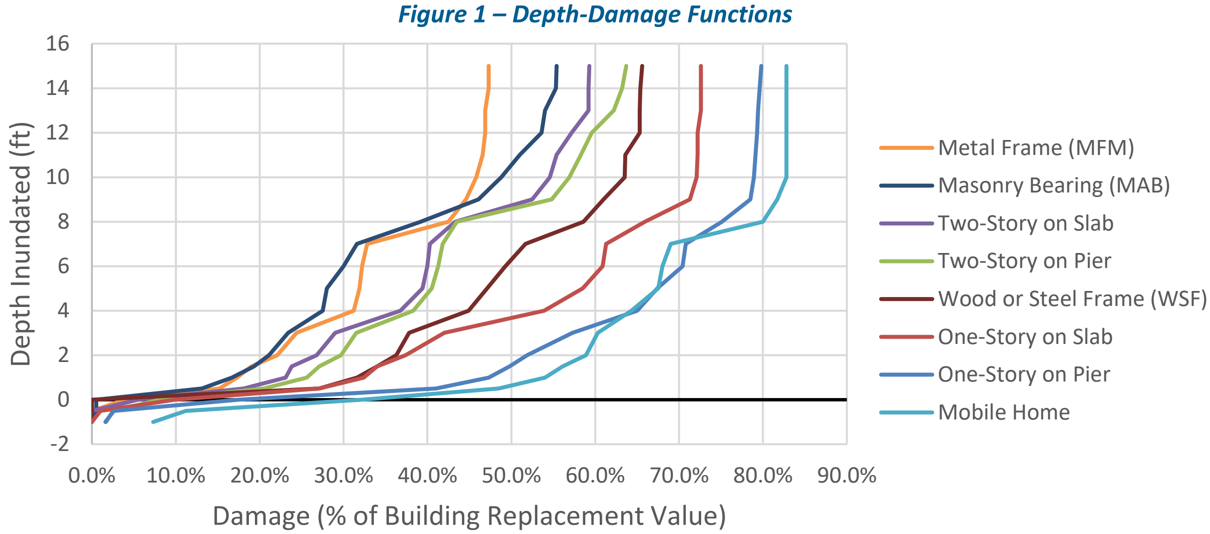
median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size (*Equation 6*). This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

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf)$$ ***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 RSMeans 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 District[13] 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.

Figure 1 – Depth-Damage Functions



[12] R.S. Means, 2005.
[13] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) 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 District[13], 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 disaster[14]. 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-burdened[17]. 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 subscription[18]. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

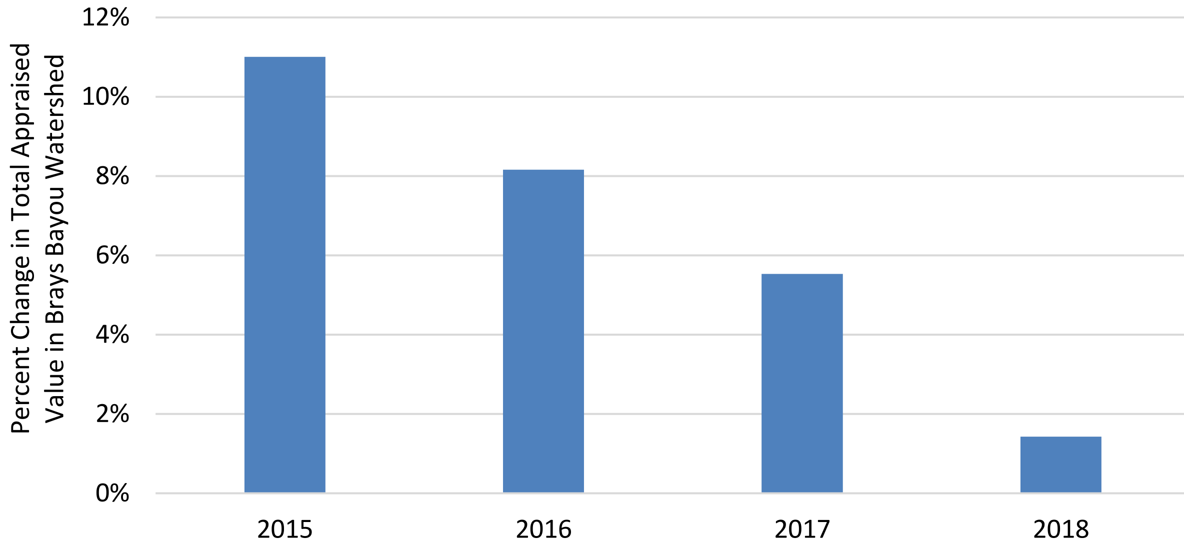
3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

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 <= r < 1.25	1.25 <= 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)

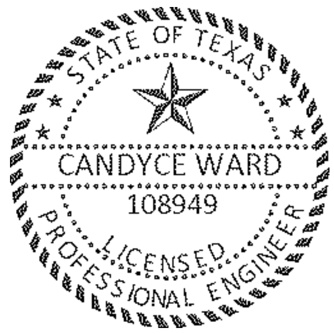
Cost Verification Controls must be in place to assure that construction costs are reasonable and consistent with market costs at the time and place of construction.

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 HCFCD 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 HCFCD 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 refected 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 Hawiian 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 Hawiian 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 Hawiian/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)

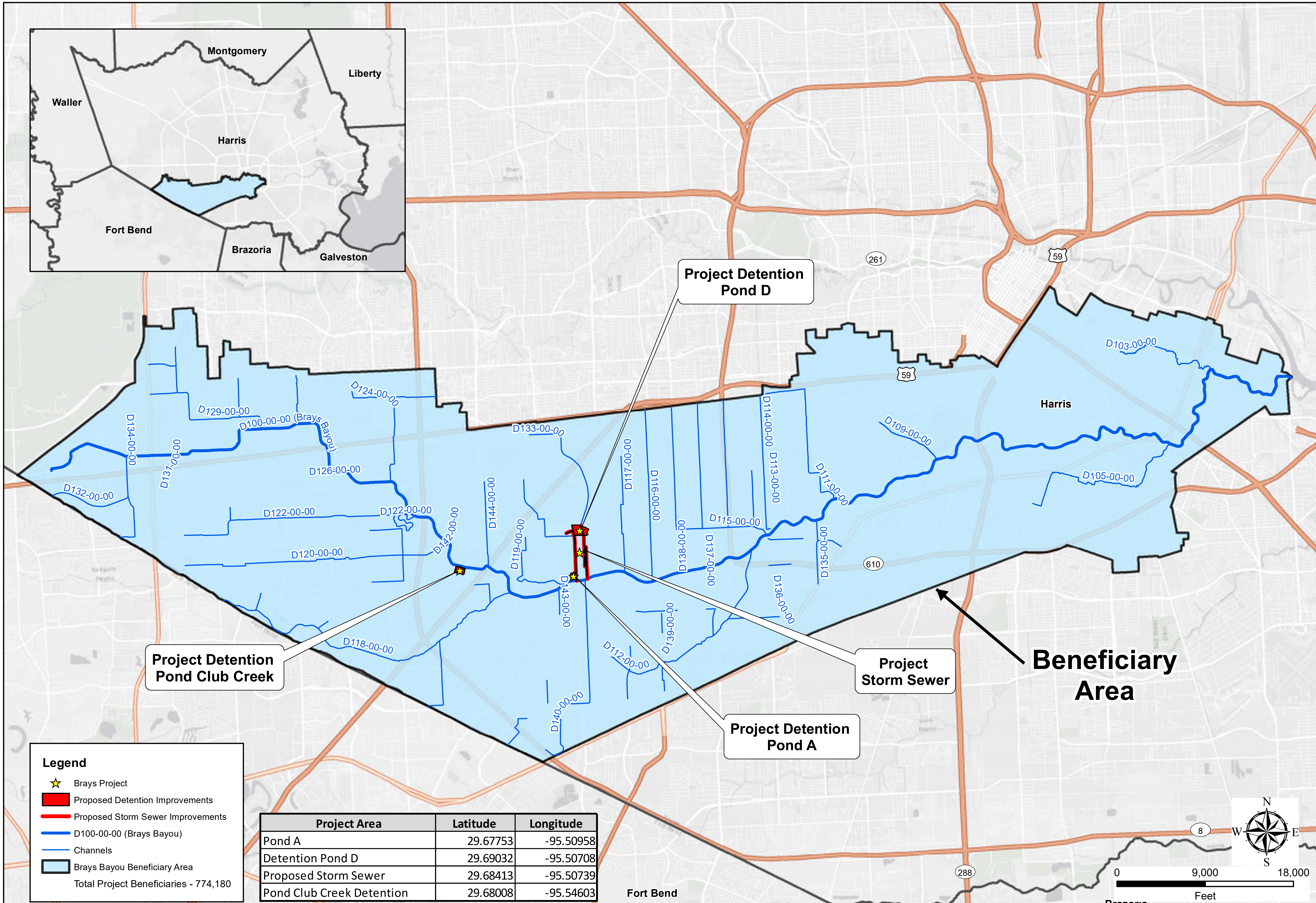
LMI Evaluation

Number of LMI Persons *(numerator for LMI %)*	**413,675**
Persons with the potential for being deemed Low-, Moderate- and Middle-income *(denominator for LMI %)*	**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 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

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CDBG-MIT

Brays Bayou Watershed - Project Area Map

FN PROJECT NO. SCG17357

DATE CREATED 9/28/2020

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

FILE NAME Brays_Project_Area_Map

PREPARED BY AMJ

FREESE NICHOLS

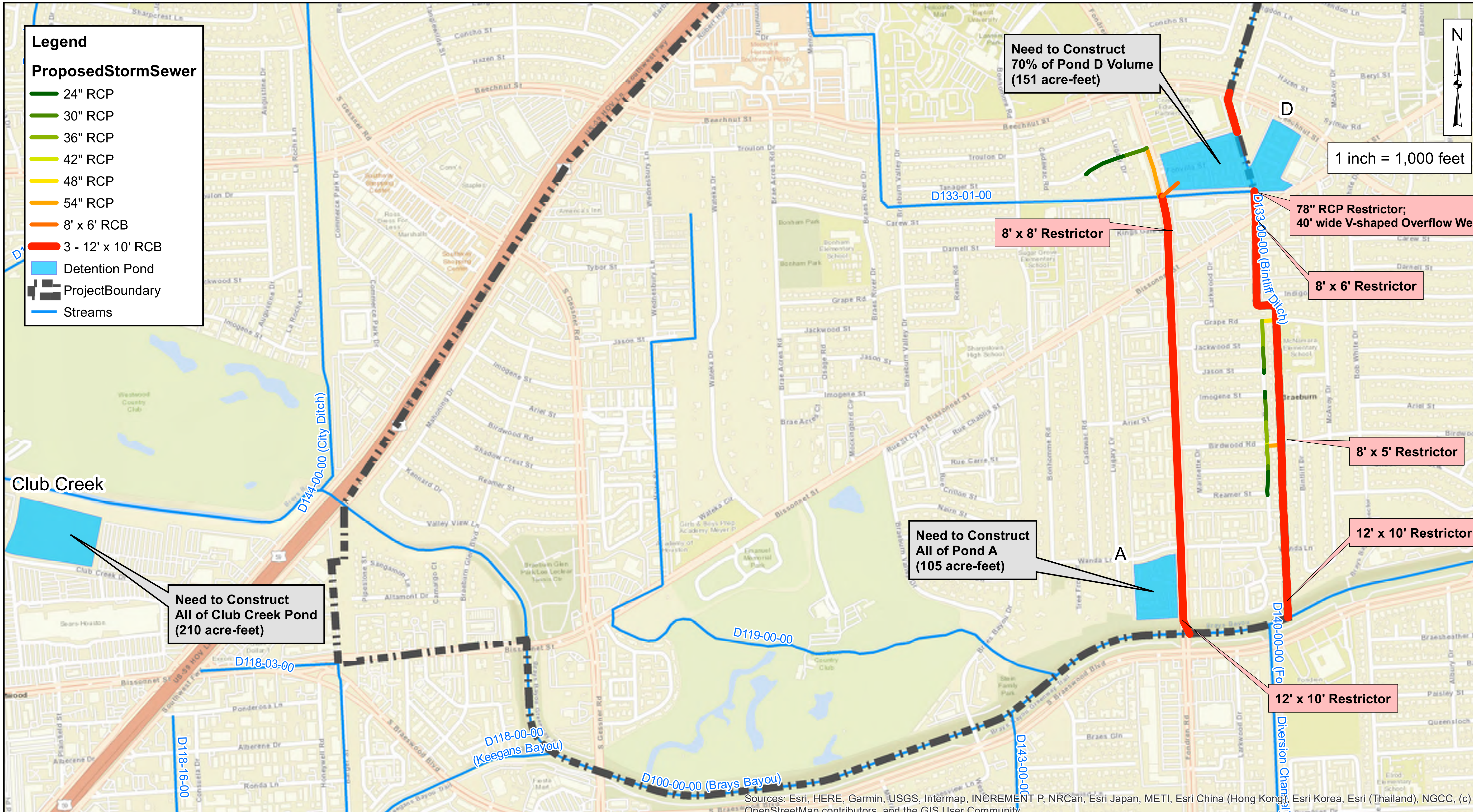
STUART CONSULTING GROUP

EXHIBIT

1

Date Saved: 9/28/2020 8:35:49 PM

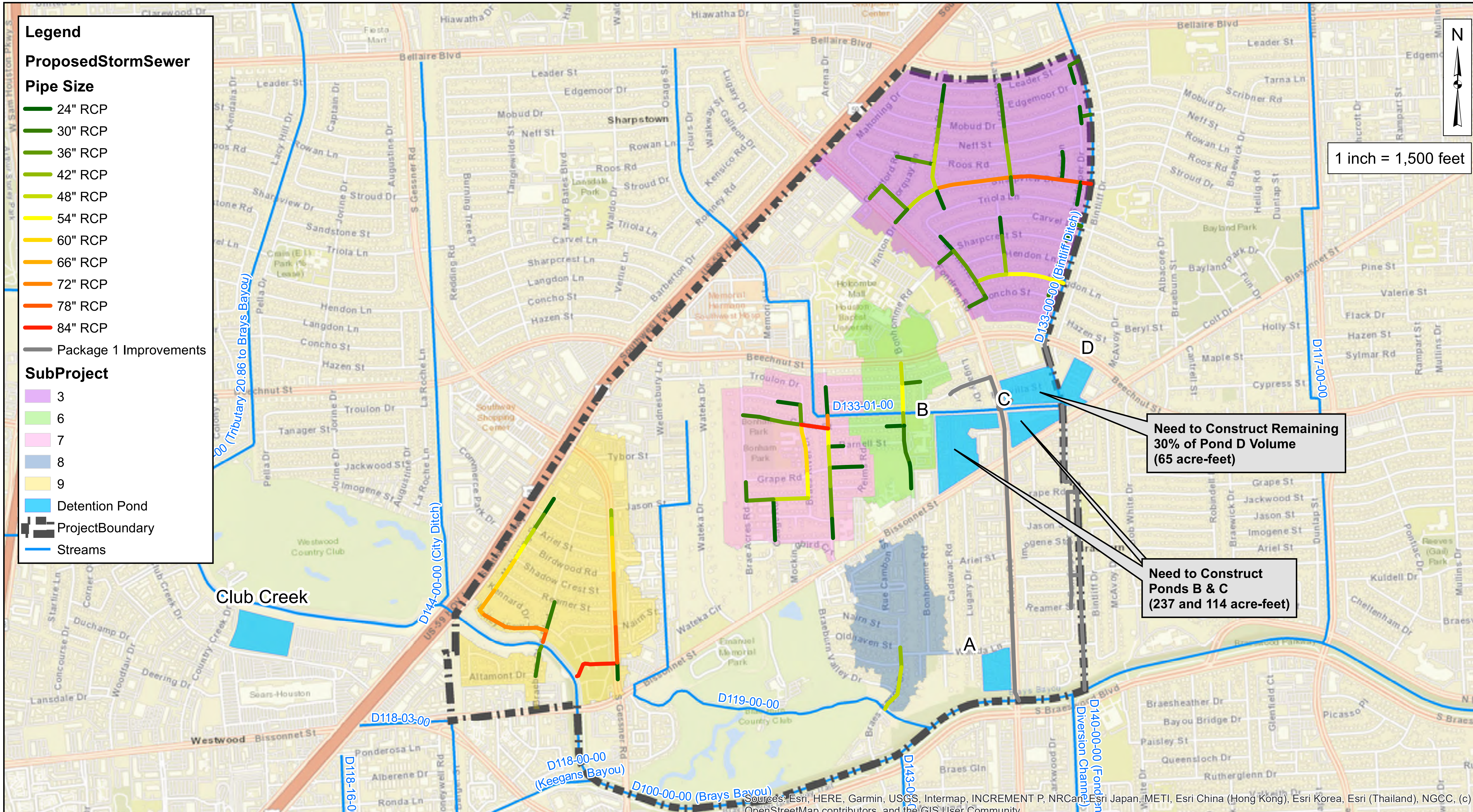
Path: H:\STORMWATER\CDBG_MIT_Projects\Working\D100_Brays_Bayou\Brays Application Exhibits\Project_Area\Brays_Project_Area_Map.mxd



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**



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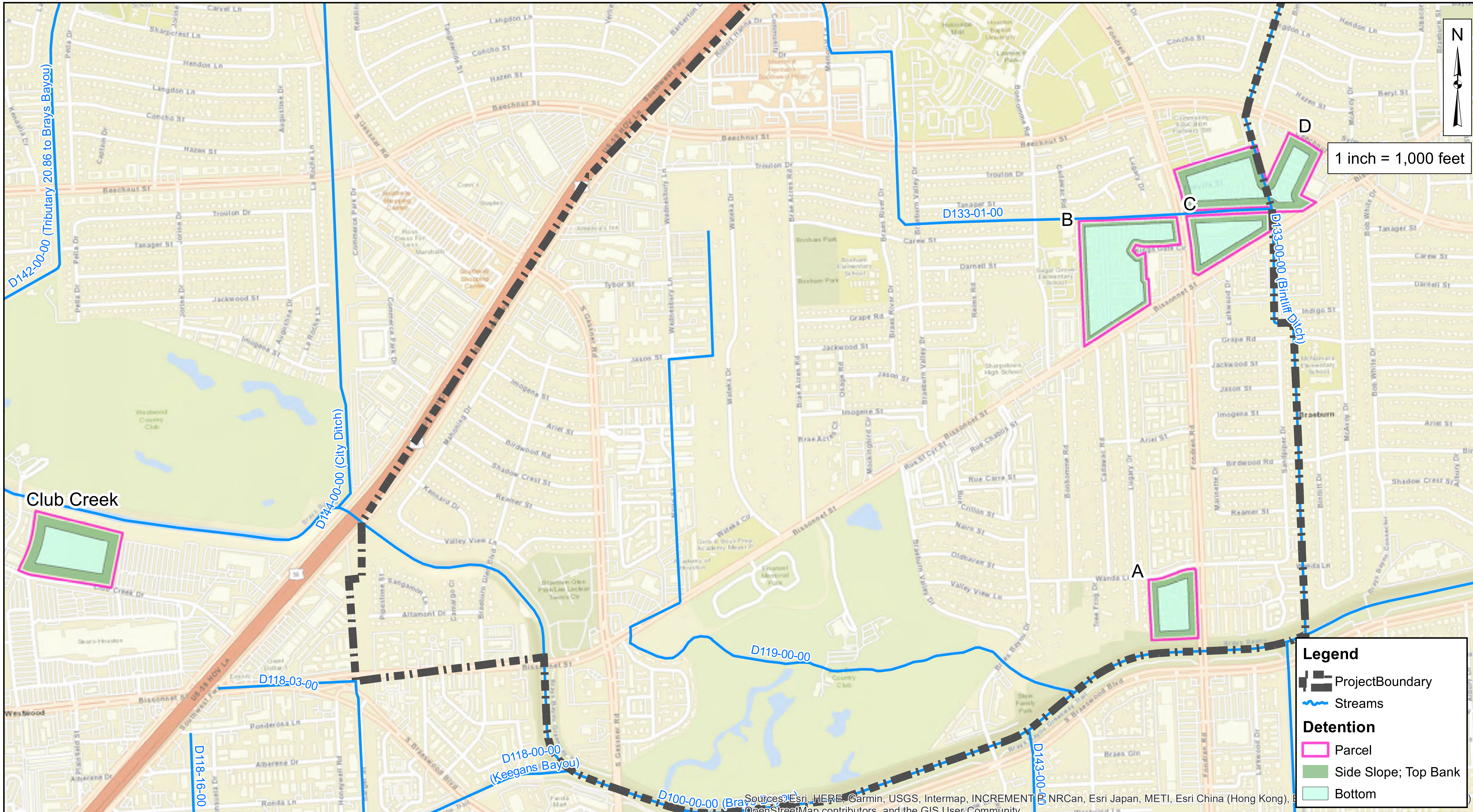
13430 Northwest Freeway, Suite 1100
Houston, Texas 77040
713.462.3242 | fax 713.462.3262
www.cobbfendley.com

Sharpstown Drainage Masterplan
Additional Sub-Project Proposed Improvements

Date: July 2020	**EXHIBIT 2**



CobbFendley
Texas Registration No. 274

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Sharpstown Drainage Masterplan
Proposed Detention Facilities

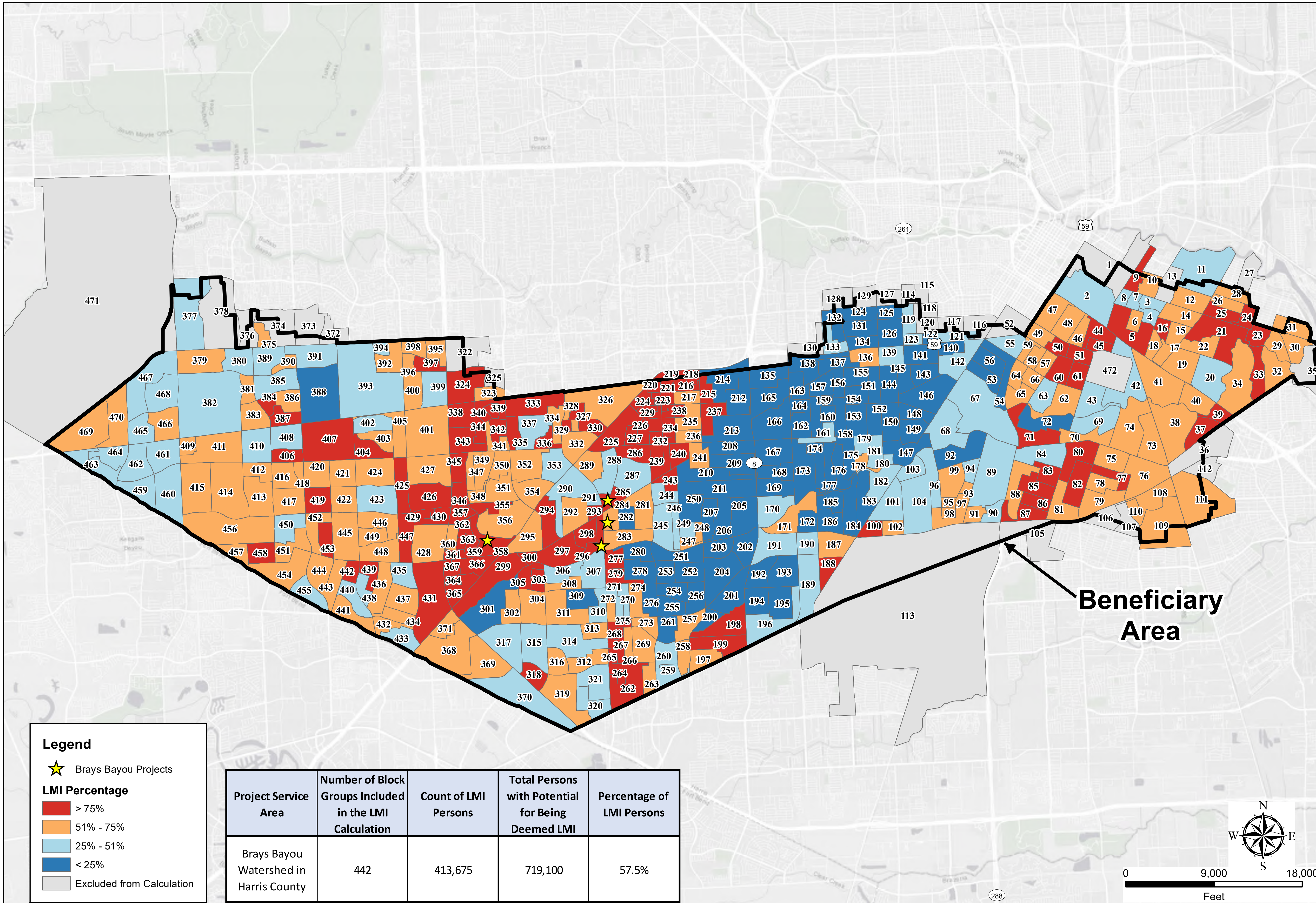
Date: July 2020	**EXHIBIT 3**

ATTACHMENT 3

PROJECT BENEFICIARY MAP

Brays Bayou Watershed Beneficiary Area Map

STUART CONSULTING GROUP
CDBG-MIT



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%

FN PROJECT NO. SCG17357
DATE CREATED 9/28/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Brays_Project_Area_Map_LMI_1
PREPARED BY AMJ

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
2
(1 of 2)

Brays Bayou Watershed Beneficiary Area Table

STUART CONSULTING GROUP

CDBG-MIT

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	482013101002	937	2,283	41%	No	39.6%
2	482013102001	1,692	1,830	92%	Yes	28.2%
3	482013103001	671	671	100%	Yes	48.4%
4	482013103002	678	678	100%	Yes	41.5%
5	482013103003	1,190	1,190	100%	Yes	81.1%
6	482013103004	890	890	100%	Yes	56.7%
7	482013103005	632	632	100%	Yes	30.9%
8	482013103006	798	798	100%	Yes	36.1%
9	482013104002	547	862	63%	Yes	81.2%
10	482013104003	654	802	82%	Yes	72.0%
11	482013105001	727	885	82%	Yes	49.4%
12	482013105002	1,850	1,850	100%	Yes	74.4%
13	482013105003	479	1,772	27%	No	69.7%
14	482013106001	1,065	1,068	100%	Yes	56.3%
15	482013106002	2,034	2,037	100%	Yes	65.4%
16	482013106003	671	671	100%	Yes	77.4%
17	482013106004	595	595	100%	Yes	61.3%
18	482013106005	1,503	1,503	100%	Yes	69.4%
19	482013107001	2,050	2,053	100%	Yes	67.8%
20	482013107002	2,249	2,249	100%	Yes	43.4%
21	482013108001	1,186	1,186	100%	Yes	87.5%
22	482013108002	1,418	1,418	100%	Yes	71.3%
23	482013109002	1,139	1,139	100%	Yes	79.8%
24	482013109003	1,234	1,237	100%	Yes	90.8%
25	482013109004	484	484	100%	Yes	91.2%
26	482013109005	1,558	1,558	100%	Yes	68.6%
27	482013110002	5	925	1%	No	94.7%
28	482013110005	1,437	1,656	87%	Yes	68.7%
29	482013111002	1,179	1,179	100%	Yes	73.2%
30	482013111003	1,620	1,626	100%	Yes	69.9%
31	482013111004	1,250	1,668	75%	Yes	69.3%
32	482013112001	1,790	1,790	100%	Yes	65.1%
33	482013112002	1,909	1,909	100%	Yes	81.3%
34	482013112003	1,176	1,176	100%	Yes	73.4%
35	482013114001	725	1,541	47%	No	55.8%
36	482013117002	0	2,425	0%	No	68.6%
37	482013118001	1,473	1,473	100%	Yes	77.3%
38	482013118002	1,651	1,651	100%	Yes	57.8%
39	482013118003	1,341	1,341	100%	Yes	93.5%
40	482013119001	1,228	1,228	100%	Yes	72.7%
41	482013119002	1,372	1,372	100%	Yes	67.8%
42	482013120001	1,037	1,040	100%	Yes	45.1%
43	482013120002	2,556	2,556	100%	Yes	49.8%
44	482013122001	582	588	99%	Yes	93.3%
45	482013122002	933	933	100%	Yes	91.5%
46	482013122003	481	481	100%	Yes	67.5%
47	482013123001	1,065	1,065	100%	Yes	75.0%
48	482013123002	829	829	100%	Yes	72.8%
49	482013124001	1,040	1,047	99%	Yes	55.1%
50	482013124002	544	544	100%	Yes	85.5%
51	482013124003	621	621	100%	Yes	81.9%
52	482013125002	749	1,269	59%	No	39.1%
53	482013126001	3,456	3,456	100%	Yes	23.5%
54	482013126002	1,841	1,841	100%	Yes	9.2%
55	482013126003	586	586	100%	Yes	47.5%
56	482013126004	1,482	1,482	100%	Yes	21.2%
57	482013127001	880	880	100%	Yes	70.1%
58	482013127002	1,100	1,100	100%	Yes	58.2%
59	482013127003	406	406	100%	Yes	57.0%
60	482013128001	1,499	1,499	100%	Yes	98.5%
61	482013128002	1,015	1,015	100%	Yes	84.3%
62	482013129001	2,655	2,655	100%	Yes	66.5%
63	482013129002	1,367	1,367	100%	Yes	47.0%
64	482013130001	801	801	100%	Yes	63.2%
65	482013130002	1,016	1,016	100%	Yes	56.1%
66	482013130003	786	786	100%	Yes	66.7%
67	482013131001	2,887	2,887	100%	Yes	28.7%
68	482013131002	674	674	100%	Yes	35.6%
69	482013132001	1,032	1,034	100%	Yes	43.9%
70	482013132002	648	648	100%	Yes	60.6%
71	482013132003	1,641	1,643	100%	Yes	83.9%
72	482013132004	677	677	100%	Yes	15.7%
73	482013133001	898	898	100%	Yes	65.1%
74	482013133002	1,544	1,546	100%	Yes	54.2%
75	482013134001	875	875	100%	Yes	54.7%
76	482013134002	2,277	2,277	100%	Yes	69.4%
77	482013135001	872	872	100%	Yes	83.3%
78	482013135002	1,021	1,021	100%	Yes	74.9%
79	482013135003	969	969	100%	Yes	73.1%
80	482013136001	1,081	1,081	100%	Yes	76.0%
81	482013136002	1,587	1,587	100%	Yes	64.9%
82	482013136003	1,943	1,952	100%	Yes	83.8%
83	482013137001	876	876	100%	Yes	80.6%
84	482013137002	1,389	1,389	100%	Yes	45.6%
85	482013138001	1,040	1,040	100%	Yes	85.5%
86	482013138002	725	725	100%	Yes	93.0%
87	482013138003	715	715	100%	Yes	91.2%
88	482013138004	2,283	2,283	100%	Yes	73.2%
89	482013139001	2,617	2,617	100%	Yes	46.1%
90	482013139002	1,135	1,135	100%	Yes	33.8%
91	482013139003	802	802	100%	Yes	57.8%
92	482013140011	83	83	100%	Yes	0.0%
93	482013140012	614	614	100%	Yes	72.1%
94	482013140013	2,108	2,108	100%	Yes	37.6%
95	482013140021	1,537	1,537	100%	Yes	72.9%
96	482013140022	839	839	100%	Yes	40.7%
97	482013140023	1,096	1,096	100%	Yes	51.5%
98	482013140024	981	981	100%	Yes	58.3%
99	482013140025	2,164	2,164	100%	Yes	50.3%
100	482013143001	769	769	100%	Yes	96.3%
101	482013143002	984	984	100%	Yes	47.8%
102	482013143003	2,510	2,510	100%	Yes	59.5%
103	482013144001	1,004	1,004	100%	Yes	48.4%
104	482013144002	2,258	2,258	100%	Yes	39.2%
105	482013311004	0	1,538	0%	No	75.6%
106	482013321001	761	1,728	44%	No	77.9%
107	482013321002	968	1,696	57%	No	83.8%
108	482013322001	1,403	1,403	100%	Yes	69.9%
109	482013322002	2,657	3,145	84%	Yes	72.9%
110	482013322003	681	681	100%	Yes	61.7%
111	482013327002	1,236	1,701	73%	Yes	74.3%
112	482013328001	807	1,398	58%	No	85.5%
113	482013341002	5,622	10,021	56%	No	50.7%
114	482014104012	51	1,059	5%	No	25.1%
115	482014104013	31	1,113	3%	No	18.3%
116	482014107021	228	1,801	13%	No	50.6%
117	482014107022	361	1,007	36%	No	67.4%
118	482014108001	252	1,455	17%	No	30.5%
119	482014108002	1,363	1,363	100%	Yes	38.1%
120	482014108003	768	1,397	55%	No	53.6%
121	482014109001	970	1,171	83%	Yes	47.1%
122	482014109002	1,082	1,082	100%	Yes	16.5%
123	482014109003	616	616	100%	Yes	32.6%
124	482014110001	1,427	1,596	89%	Yes	20.7%
125	482014110002	2,197	2,232	98%	Yes	17.0%
126	482014110003	1,470	1,470	100%	Yes	23.5%
127	482014111003	718	1,218	59%	No	20.8%
128	482014114002	197	853	23%	No	0.0%
129	482014114003	357	624	57%	No	1.3%
130	482014115011	725	2,532	29%	No	26.9%
131	482014115021	991	991	100%	Yes	7.7%
132	482014115022	724	760	95%	Yes	12.3%
133	482014115023	393	621	63%	Yes	36.3%
134	482014115024	1,639	1,639	100%	Yes	17.5%
135	482014117002	2,104	2,104	100%	Yes	23.5%
136	482014118001	1,078	1,078	100%	Yes	67.7%
137	482014118002	1,499	1,499	100%	Yes	12.4%
138	482014118003	1,556	1,556	100%	Yes	18.6%
139	482014118004	956	956	100%	Yes	25.0%
140	482014119001	904	904	100%	Yes	20.9%
141	482014119002	967	967	100%	Yes	7.5%
142	482014119003	1,302	1,302	100%	Yes	36.0%
143	482014120001	1,520	1,520	100%	Yes	22.2%
144	482014120002	1,436	1,436	100%	Yes	10.8%
145	482014120003	1,102	1,102	100%	Yes	3.7%
146	482014121001	2,768	2,768	100%	Yes	0.0%
147	482014122001	688	688	100%	Yes	15.4%
148	482014122002	916	916	100%	Yes	3.5%
149	482014122003	2,016	2,016	100%	Yes	13.3%
150	482014122004	2,289	2,294	100%	Yes	20.2%
151	482014123001	1,453	1,453	100%	Yes	9.1%
152	482014123002	1,520	1,520	100%	Yes	5.7%
153	482014123003	1,215	1,217	100%	Yes	14.6%
154	482014123004	1,665	1,665	100%	Yes	0.0%
155	482014123005	1,166	1,166	100%	Yes	4.3%
156	482014124001	700	700	100%	Yes	6.6%
157	482014124002	1,485	1,485	100%	Yes	1.9%
158	482014124003	891	891	100%	Yes	9.8%
159	482014124004	1,661	1,661	100%	Yes	3.8%
160	482014125001	916	916	100%	Yes	2.2%
161	482014125002	680	680	100%	Yes	40.2%
162	482014126001	1,551	1,551	100%	Yes	9.4%
163	482014126002	1,621	1,621	100%	Yes	8.4%
164	482014126003	769	769	100%	Yes	10.7%
165	482014127001	1,233	1,233	100%	Yes	18.1%
166	482014127002	2,314	2,314	100%	Yes	16.6%
167	482014128001	2,466	2,473	100%	Yes	6.4%
168	482014128002	1,347	1,347	100%	Yes	3.2%
169	482014128003	1,441	1,441	100%	Yes	9.7%
170	482014129001	1,420	1,420	100%	Yes	36.2%
171	482014129002	1,647	1,647	100%	Yes	50.6%
172	482014129003	1,011	1,011	100%	Yes	16.4%
173	482014130001	1,725	1,725	100%	Yes	3.0%
174	482014130002	2,193	2,196	100%	Yes	22.9%
175	482014131001	992	1,079	92%	Yes	9.0%
176	482014131002	1,036	1,036	100%	Yes	6.9%
177	482014131003	1,049	1,049	100%	Yes	10.4%
178	482014132011	1,183	1,183	100%	Yes	57.3%
179	482014132012	1,518	1,518	100%	Yes	37.5%
180	482014132021	915	915	100%	Yes	37.4%
181	482014132022	3,068	3,068	100%	Yes	33.9%
182	482014133001	1,901	1,901	100%	Yes	35.0%
183	482014133002	2,835	2,835	100%	Yes	24.3%
184	482014133003	1,526	1,528	100%	Yes	7.9%
185	482014133004	836	836	100%	Yes	17.5%
186	482014133005	679	679	100%	Yes	0.0%
187	482014201001	1,855	1,855	100%	Yes	55.5%
188	482014201002	1,079	1,079	100%	Yes	81.8%
189	482014202001	1,104	1,106	100%	Yes	41.9%
190	482014202002	1,630	1,630	100%	Yes	41.6%
191	482014203001	1,605	1,605	100%	Yes	35.8%
192	482014203002	832	832	100%	Yes	9.9%
193	482014203003	1,357	1,357	100%	Yes	9.0%
194	482014204001	1,097	1,097	100%	Yes	22.9%
195	482014204002	1,588	1,588	100%	Yes	24.7%
196	482014204003	962	962	100%	Yes	42.6%
197	482014205001	1,183	1,183	100%	Yes	70.9%
198	482014205002	1,114	1,114	100%	Yes	100.0%
199	482014205003	1,628	1,628	100%	Yes	99.6%
200	482014206001	701	701	100%	Yes	23.3%
201	482014206002	1,582	1,582	100%	Yes	22.4%
202	482014207001	626	626	100%	Yes	6.9%
203	482014207002	481	481	100%	Yes	2.7%
204	482014207003	1,891	1,891	100%	Yes	10.5%
205	482014208001	599	599	100%	Yes	12.0%
206	482014208002	1,042	1,042	100%	Yes	6.9%
207	482014208003	707	707	100%	Yes	11.0%
208	482014209001	1,071	1,071	100%	Yes	9.4%
209	482014209002	2,046	2,046	100%	Yes	10.0%
210	482014209003	1,843	1,846	100%	Yes	3.0%
211	482014209004	2,098	2,098	100%	Yes	4.3%
212	482014210001	1,101	1,101	100%	Yes	9.1%
213	482014210002	1,821	1,824	100%	Yes	13.2%
214	482014211011	831	831	100%	Yes	21.8%
215	482014211012	2,397	2,397	100%	Yes	80.6%
216	482014211021	3,427	3,427	100%	Yes	88.6%
217	482014211022	1,500	1,500	100%	Yes	70.7%
218	482014211023	821	821	100%	Yes	90.5%
219	482014212011	2,202	2,202	100%	Yes	76.3%
220	482014212012	2,542	2,542	100%	Yes	81.4%
221	482014212013	689	689	100%	Yes	79.1%
222	482014212021	2,524	2,524	100%	Yes	98.8%
223	482014212022	2,266	2,266	100%	Yes	97.8%
224	482014212023	221	221	100%	Yes	76.7%
225	482014213001	2,687	2,687	100%	Yes	83.3%
226	482014213002	2,930	3,021	97%	Yes	95.4%
227	482014213003	1,509	1,509	100%	Yes	89.0%
228	482014214011	1,544	1,544	100%	Yes	92.0%
229	482014214012	2,398	2,398	100%	Yes	91.5%
230	482014214021	1,999	1,999	100%	Yes	90.0%
231	482014214022	1,802	1,802	100%	Yes	97.1%
232	482014214031	1,420	1,420	100%	Yes	78.8%
233	482014214032	1,998	1,998	100%	Yes	91.1%
234	482014214033	713	713	100%	Yes	78.4%
235	482014215001	483	483	100%	Yes	54.1%
236	482014215002	3,560	3,560	100%	Yes	72.1%
237	482014215003	1,314	1,314	100%	Yes	81.2%
238	482014215004	2,518	2,518	100%	Yes	80.6%
239	482014216001	1,441	1,441	100%	Yes	93.3%
240	482014216002	2,514	2,514	100%	Yes	96.7%
241	482014216003	1,807	1,807	100%	Yes	51.5%
242	482014216004	1,740	1,740	100%	Yes	97.3%
243	482014217001	1,726	1,726	100%	Yes	76.3%
244	482014217002	833	833	100%	Yes	30.6%
245	482014217003	1,239	1,239	100%	Yes	36.1%
246	482014217004	953	953	100%	Yes	48.4%
247	482014218001	1,203	1,203	100%	Yes	61.5%
248	482014218002	850	850	100%	Yes	69.1%
249	482014218003	1,164	1,164	100%	Yes	33.1%
250	482014218004	1,782	1,782	100%	Yes	6.9%
251	482014219001	849	849	100%	Yes	16.4%
252	482014219002	941	941	100%	Yes	22.4%
253	482014219003	741	741	100%	Yes	15.6%
254	482014220001	723	723	100%	Yes	4.9%
255	482014220002	948	948	100%	Yes	12.6%
256	482014220003	867	867	100%	Yes	24.6%
257	482014221001	1,178	1,178	100%	Yes	53.8%
258	482014221002	1,109	1,109	100%	Yes	54.4%
259	482014221003	1,397	1,397	100%	Yes	46.2%
260	482014221004	968	968	100%	Yes	35.4%
261	482014221005	748	748	100%	Yes	14.4%
262	482014222001	2,590	2,590	100%	Yes	81.1%
263	482014222002	1,909	1,909	100%	Yes	70.0%
264	482014222003	407	407	100%	Yes	77.3%
265	482014223011	2,047	2,047	100%	Yes	83.3%
266	482014223012	1,830	1,835	100%	Yes	51.6%
267	482014223013	960	960	100%	Yes	89.7%
268	482014223014	3,351	3,351	100%	Yes	87.2%
269	482014223021	1,881	1,881	100%	Yes	63.7%
270	482014224011	887	887	100%	Yes	42.9%
271	482014224012	992	992	100%	Yes	46.2%
272	482014224013	1,318	1,318	100%	Yes	71.2%
273	482014224021	1,859	1,859	100%	Yes	68.4%
274	482014224022	2,114	2,114	100%	Yes	62.8%
275	482014224023	1,831	1,831	100%	Yes	100.0%
276	482014224024	808	808	100%	Yes	14.1%
277	482014225001	2,870	2,870	100%	Yes	80.7%
278	482014225002	1,034	1,034	100%	Yes	12.0%
279	482014225003	2,459	2,459	100%	Yes	91.7%
280	482014225004	755	755	100%	Yes	24.5%
281	482014226001	1,926	1,926	100%	Yes	55.0%
282	482014226002	1,251	1,251	100%	Yes	3.0%
283	482014226003	3,400	3,400	100%	Yes	60.7%
284	482014226004	1,352	1,352	100%	Yes	51.9%
285	482014227011	2,089	2,089	100%	Yes	83.8%
286	482014227012	1,239	1,239	100%	Yes	85.0%
287	482014227013	2,389	2,389	100%	Yes	48.7%
288	482014227021	1,872	1,872	100%	Yes	41.8%
289	482014227022	1,210	1,210	100%	Yes	66.7%
290	482014228001	678	678	100%	Yes	33.3%
291	482014228002	435	435	100%	Yes	26.2%
292	482014228003	2,042	2,042	100%	Yes	58.9%
293	482014228004	1,640	1,640	100%	Yes	100.0%
294	482014229001	2,162	2,162	100%	Yes	83.3%
295	482014229002	2,173	2,173	100%	Yes	68.2%
296	482014230001	3,278	3,278	100%	Yes	88.8%
297	482014230002	659	659	100%	Yes	97.0%
298	482014230003	2,179	2,179	100%	Yes	75.4%
299	482014231001	1,139	1,139	100%	Yes	96.1%
300	482014231002	1,384	1,384	100%	Yes	91.6%
301	482014232011	1,564	1,564	100%	Yes	24.2%
302	482014232012	2,088	2,088	100%	Yes	50.4%
303	482014232021	2,708	2,708	100%	Yes	96.9%
304	482014232022	3,631	3,631	100%	Yes	61.0%
305	482014232023	1,925	1,925	100%	Yes	89.5%
306	482014233011	1,385	1,385	100%	Yes	26.7%
307	482014233012	2,181	2,181	100%	Yes	47.8%
308	482014233013	1,065	1,065	100%	Yes	69.2%
309	482014233021	1,024	1,024	100%	Yes	15.1%
310	482014233022	1,711	1,711	100%	Yes	46.0%
311	482014233023	2,510	2,510	100%	Yes	61.1%
312	482014234011	2,279	2,279	100%	Yes	74.5%
313	482014234012	1,903	1,903	100%	Yes	67.0%
314	482014234013	1,542	1,542	100%	Yes	36.8%
315	482014234021	3,221	3,221	100%	Yes	25.1%
316	482014234022	1,468	1,468	100%	Yes	52.1%
317	482014235001	1,993	1,993	100%	Yes	36.7%
318	482014236001	1,312	1,312	100%	Yes	81.7%
319	482014236002	1,558	1,558	100%	Yes	50.9%
320	482014236003	1,847	1,847	100%	Yes	48.1%
321	482014236004	2,603	2,603	100%	Yes	38.3%
322	482014323004	750	1,998	38%	No	56.3%
323	482014324001	832	1,115	75%	Yes	66.0%
324	482014324002	1,615	2,131	76%	Yes	79.1%
325	482014324003	730	2,132	34%	No	81.1%
326	482014328011	1,490	1,490	100%	Yes	68.3%
327	482014328012	2,072	2,072	100%	Yes	95.3%
328	482014328013	1,497	1,497	100%	Yes	74.7%
329	482014328021	2,326	2,326	100%	Yes	97.8%
330	482014328022	2,445	2,445	100%	Yes	91.0%
331	482014328023	1,200	1,200	100%	Yes	70.2%
332	482014328024	43	43	100%	Yes	57.1%
333	482014329011	1,869	1,869	100%	Yes	79.6%
334	482014329012	833	833	100%	Yes	58.3%
335	482014329021	2,329	2,329	100%	Yes	95.1%
336	482014329022	2,556	2,556	100%	Yes	86.9%
337	482014329023	1,468	1,468	100%	Yes	49.3%
338	482014330011	1,160	1,160	100%	Yes	100.0%
339	482014330012	2,038	2,038	100%	Yes	100.0%
340	482014330013	2,889	2,889	100%	Yes	89.5%
341	482014330021	1,636	1,636	100%	Yes	73.3%
342	482014330022	2,136	2,136	100%	Yes	94.6%
343	482014330031	1,867	1,867	100%	Yes	92.1%
344	482014330032	4,174	4,174	100%	Yes	94.9%
345	482014331001	1,859	1,859	100%	Yes	86.0%
346	482014331002	2,157	2,174	99%	Yes	80.7%
347	482014332011	2,497	2,497	100%	Yes	66.7%
348	482014332012	1,630	1,630	100%	Yes	67.9%
349	482014332013	1,125	1,125	100%	Yes	72.9%
350	482014332021	1,835	1,835	100%	Yes	54.5%
351	482014332022	2,953	2,953	100%	Yes	65.1%
352	482014333001	1,512	1,512	100%	Yes	67.8%
353	482014333002	1,607	1,607	100%	Yes	41.8%
354	482014333003	1,950	1,950	100%	Yes	58.1%
355	482014334001	3,096	3,096	100%	Yes	77.8%
356	482014334002	1,689	1,689	100%	Yes	57.8%
357	482014335011	1,867	1,867	100%	Yes	87.7%
358	482014335012	2,478	2,478	100%	Yes	95.6%
359	482014335013	1,147	1,147	100%	Yes	95.6%
360	482014335021	2,263	2,263	100%	Yes	71.4%
361	482014335022	1,077	1,077	100%	Yes	90.4%
362	482014335023	3,134	3,134	100%	Yes	80.2%
363	482014335024	2,114	2,114	100%	Yes	98.0%
364	482014336001	1,712	1,712	100%	Yes	86.2%
365	482014336002	614	614	100%	Yes	98.8%
366	482014336003	1,466	1,466	100%	Yes	94.4%
367	482014336004	2,674	2,674	100%	Yes	85.3%
368	482014401001	1,980	1,980	100%	Yes	70.7%
369	482014401002	2,280	2,280	100%	Yes	61.7%
370	482014401003	2,588	2,588	100%	Yes	26.4%
371	482014401004	267	267	100%	Yes	64.6%
372	482014513002	0	1,394	0%	No	50.2%
373	482014513003	69	2,273	3%	No	27.1%
374	482014514021	1,149	2,933	39%	No	53.8%
375	482014514022	1,815	1,815	100%	Yes	62.1%
376	482014514032	547	1,227	45%	No	27.9%
377	482014516021	3,234	3,937	82%	Yes	27.1%
378	482014516022	2,965	5,916	50%	No	29.0%
379	482014517001	2,969	2,969	100%	Yes	51.6%
380	482014517002	704	704	100%	Yes	48.2%
381	482014518001	889	889	100%	Yes	73.7%
382	482014518002	3,013	3,017	100%	Yes	41.8%
383	482014518003	1,886	1,886	100%	Yes	51.2%
384	482014519011	668	668	100%	Yes	78.5%
385	482014519012	2,270	2,270	100%	Yes	27.2%
386	482014519013	2,490	2,490	100%	Yes	69.4%
387	482014519014	2,099	2,099	100%	Yes	88.4%
388	482014519021	2,484	2,484	100%	Yes	14.5%
389	482014520001	3,733	3,733	100%	Yes	36.1%
390	482014520002	1,358	1,358	100%	Yes	69.9%
391	482014520003	3,269	3,269	100%	Yes	49.8%
392	482014521001	3,003	3,003	100%	Yes	71.8%
393	482014521002	5,379	5,379	100%	Yes	35.1%
394	482014521003	2,213	2,213	100%	Yes	35.2%
395	482014522011	1,807	1,807	100%	Yes	60.1%
396	482014522012	597	597	100%	Yes	65.7%
397	482014522013	1,304	1,304	100%	Yes	75.1%
398	482014522014	1,805	1,805	100%	Yes	74.8%
399	482014522021	914	914	100%	Yes	44.8%
400	482014522022	2,825	2,825	100%	Yes	60.3%
401	482014523001	2,405	2,405	100%	Yes	66.9%
402	482014524001	2,481	2,481	100%	Yes	43.1%
403	482014524002	2,858	2,858	100%	Yes	60.0%
404	482014524003	1,644	1,644	100%	Yes	79.9%
405	482014524004	1,136	1,136	100%	Yes	72.3%
406	482014525001	2,895	2,895	100%	Yes	82.7%
407	482014525002	2,352	2,352	100%	Yes	90.5%
408	482014525003	2,680	2,680	100%	Yes	46.1%
409	482014526001	2,670	2,670	100%	Yes	74.0%
410	482014526002	2,812	2,812	100%	Yes	27.6%
411	482014526003	3,425	3,425	100%	Yes	69.3%
412	482014527001	1,642	1,642	100%	Yes	65.5%
413	482014527002	3,704	3,704	100%	Yes	52.5%
414	482014527003	5,255	5,255	100%	Yes	60.0%
415	482014527004	2,523	2,523	100%	Yes	68.7%
416	482014528011	2,348	2,348	100%	Yes	66.8%
417	482014528012	2,024	2,024	100%	Yes	52.7%
418	482014528013	1,454	1,454	100%	Yes	67.0%
419	482014528021	4,384	4,384	100%	Yes	86.7%
420	482014528022	2,629	2,629	100%	Yes	69.4%
421	482014529001	1,749	1,749	100%	Yes	69.6%
422	482014529002	2,310	2,310	100%	Yes	62.6%
423	482014530001	3,045	3,045	100%	Yes	37.6%
424	482014530002	2,668	2,668	100%	Yes	73.2%
425	482014530003	2,487	2,487	100%	Yes	84.1%
426	482014531001	3,247	3,247	100%	Yes	81.7%
427	482014531002	1,303	1,303	100%	Yes	56.2%
428	482014532001	3,056	3,056	100%	Yes	62.1%
429	482014532002	2,309	2,309	100%	Yes	93.9%
430	482014532003	3,355	3,355	100%	Yes	82.6%
431	482014533001	3,471	3,471	100%	Yes	84.9%
432	482014534011	1,652	1,658	100%	Yes	66.7%
433	482014534012	1,524	1,524	100%	Yes	27.5%
434	482014534021	860	860	100%	Yes	55.1%
435	482014534022	1,619	1,619	100%	Yes	48.1%
436	482014534023	3,878	3,878	100%	Yes	70.3%
437	482014534024	1,959	1,959	100%	Yes	70.4%
438	482014534031	1,677	1,677	100%	Yes	37.6%
439	482014534032	3,003	3,003	100%	Yes	87.9%
440	482014535011	2,565	2,565	100%	Yes	49.2%
441	482014535012	2,462	2,462	100%	Yes	60.2%
442	482014535013	1,657	1,657	100%	Yes	76.5%
443	482014535021	2,091	2,091	100%	Yes	63.5%
444	482014535022	1,668	1,668	100%	Yes	54.3%
445	482014536011	2,463	2,466	100%	Yes	61.0%
446	482014536021	1,990	1,990	100%	Yes	72.4%
447	482014536022	2,392	2,392	100%	Yes	92.8%
448	482014536023	2,810	2,810	100%	Yes	66.7%
449	482014536024	1,148	1,148	100%	Yes	50.5%
450	482014537001	3,198	3,198	100%	Yes	48.6%
451	482014537002	1,967	1,967	100%	Yes	55.6%
452	482014537003	2,310	2,310	100%	Yes	66.6%
453	482014537004	2,329	2,329	100%	Yes	81.2%
454	482014538001	2,676	2,676	100%	Yes	51.5%
455	482014538002	1,636	1,636	100%	Yes	48.4%
456	482014539001	6,881	6,881	100%	Yes	52.2%
457	482014539002	1,627	1,627	100%	Yes	69.9%
458	482014539003	2,708	2,708	100%	Yes	79.4%
459	482014540001	2,293	2,293	100%	Yes	39.6%
460	482014540002	3,140	3,140	100%	Yes	40.0%
461	482014541001	662	662	100%	Yes	48.4%
462	482014541002	3,332	3,332	100%	Yes	39.9%
463	482014542001	3,131	3,131	100%	Yes	28.2%
464	482014542002	1,411	1,411	100%	Yes	31.6%
465	482014543011	2,137	2,137	100%	Yes	29.9%
466	482014543012	1,229	1,229	100%	Yes	74.2%
467	482014543013	5,329	5,329	100%	Yes	47.0%
468	482014543014	3,364	3,364	100%	Yes	48.2%
469	482014543021	2,454	2,454	100%	Yes	54.0%
470	482014543022	4,074	4,074	100%	Yes	54.9%
471	482014544001	0	0	0%	No	33.9%
472	482013121001	0	0	0%	No	0.0%

FN PROJECT NO. SCG17357

DATE CREATED 9/28/2020

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

FILE NAME Brays_Project_Area_Map_LMI_2

PREPARED BY AMJ

EXHIBIT

2

(2 of 2)

Appendix 5-4D:
Sims Bayou CDBG-MIT

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 ¾ 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'

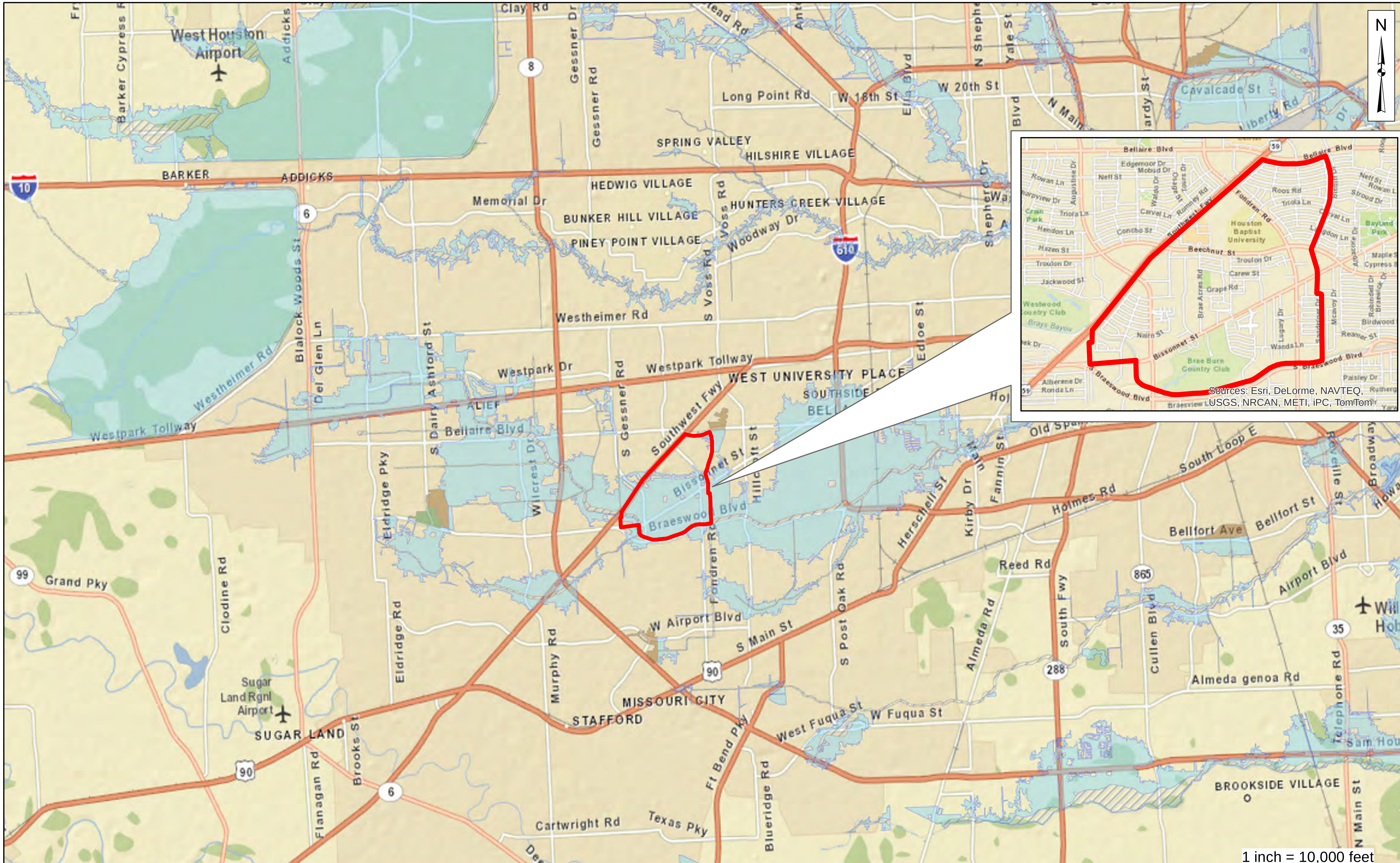
500-Year Pond WSE	62.98’	63.02’	62.64’	60.47’	67.66’
Detention Volume (does not include volume above existing ground elevation)	105 ac-ft	237 ac-ft	114 ac-ft	216 ac-ft	210 ac-ft

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.



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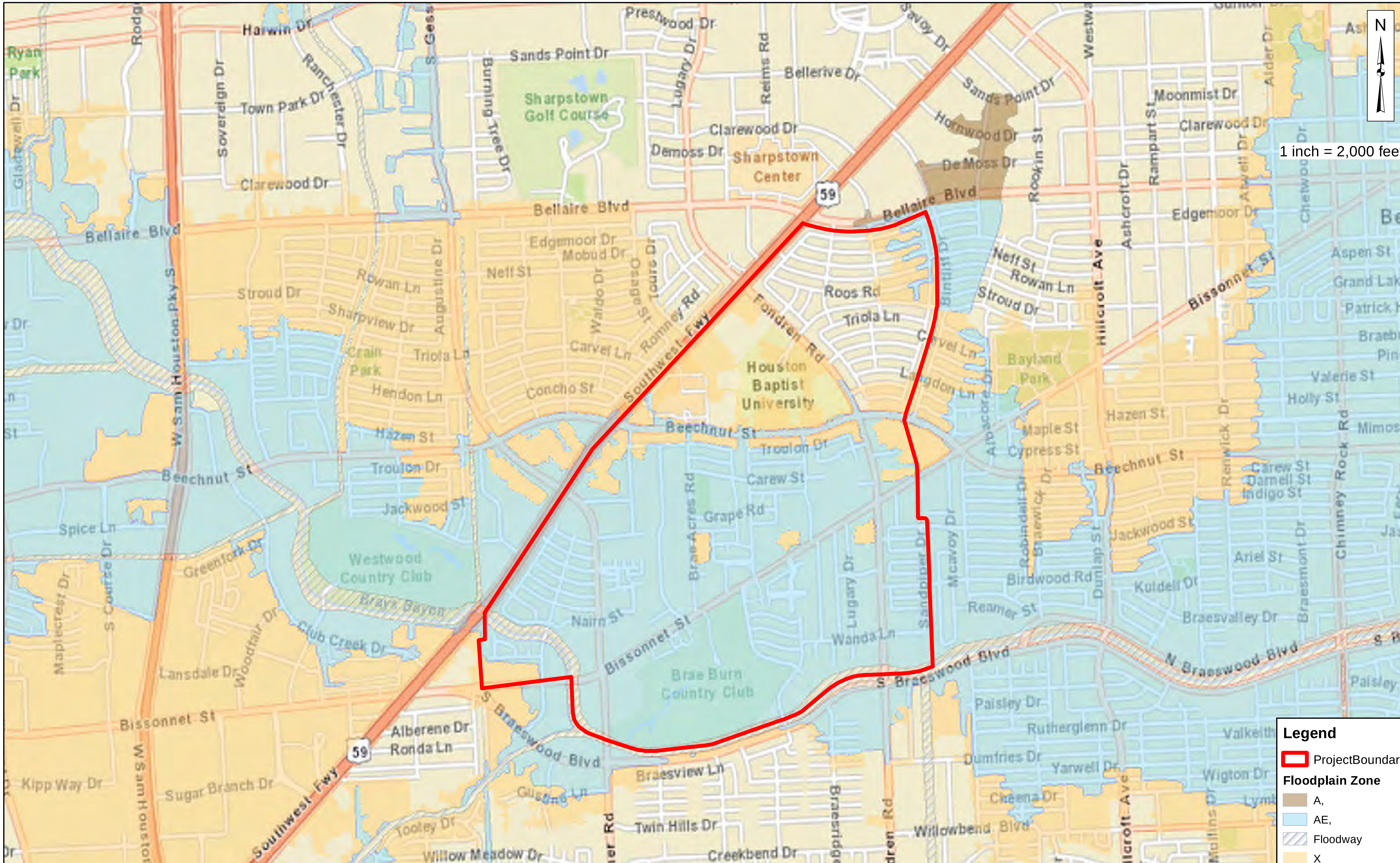
Sharpstown Master Drainage Plan
Project Location Map

Date: April 2020	EXHIBIT 1



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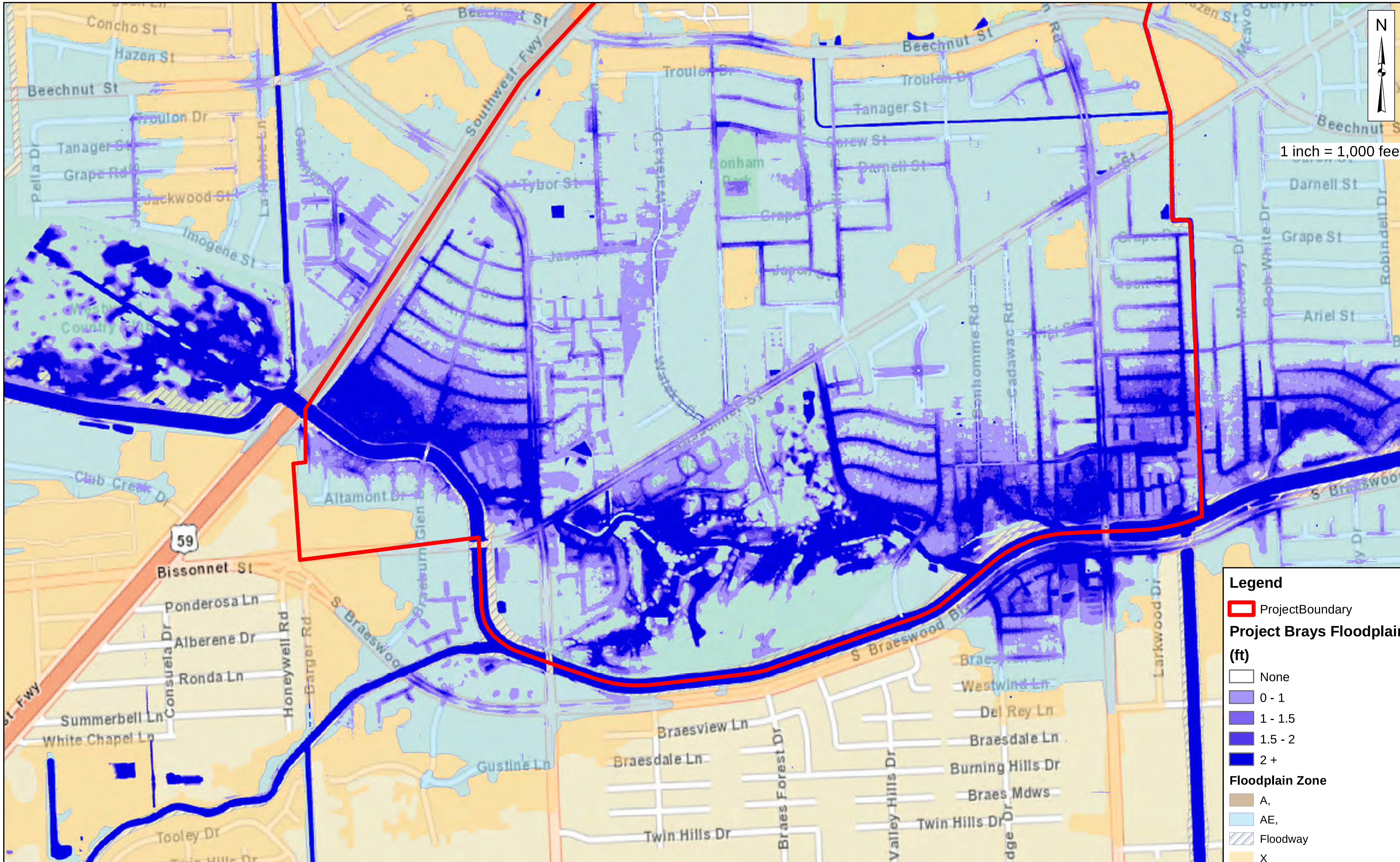
Sharpstown Master Drainage Plan
Effective FEMA Floodplain Boundaries Map

Date: August 2020 | **EXHIBIT 2**



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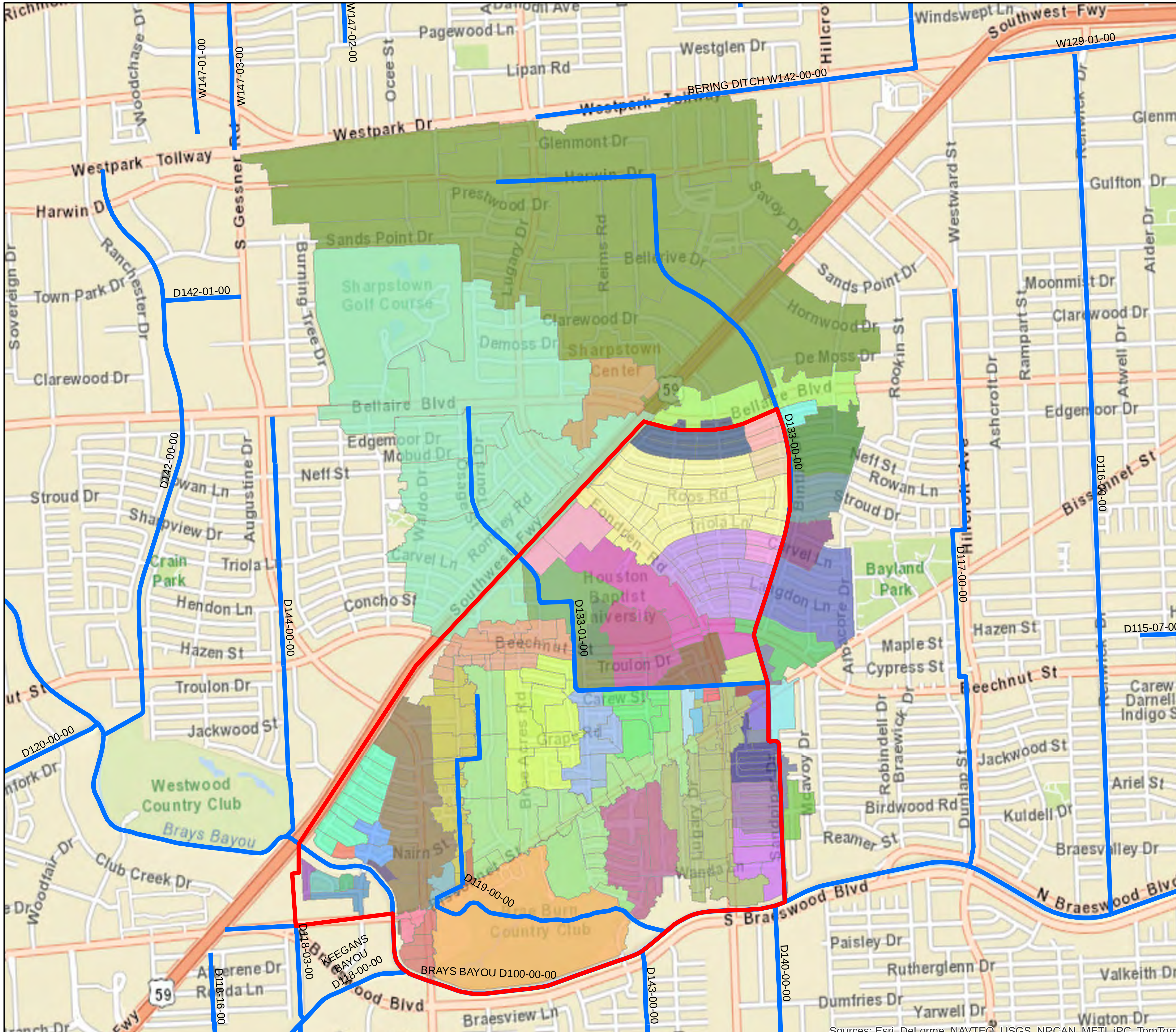
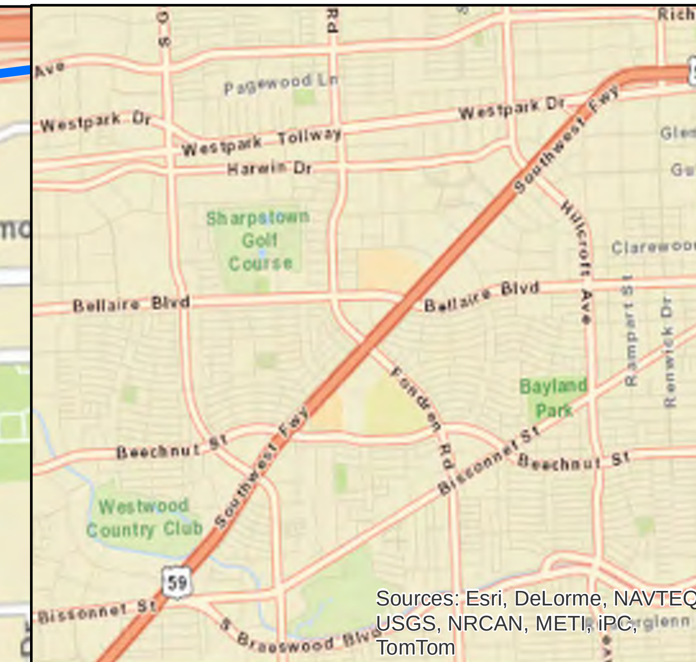
Sharpstown Master Drainage Plan
Project Brays Floodplain Map

Date: August 2020

EXHIBIT 3





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Sharpstown Master Drainage Plan
Drainage Area Map

Date: August 2020

EXHIBIT 4 -

1 inch = 2,000 feet

N

Legend

- DA_Grid3
- ProjectBoundary
- Streams

Outfall

- 00405-00-OUT
- 00406-00-OUT
- 00407-00-OUT
- 00538-00-OUT
- 00539-00-OUT
- 00545-00-OUT
- 00546-00-OUT
- 00547-00-OUT
- 00567-00-OUT
- 00755-00-OUT
- 00756-00-OUT
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- 05385-00-OUT
- 05386-00-OUT
- 05419-00-OUT
- 05450-00-OUT
- 06691-00-OUT
- 06692-00-OUT
- 06693-00-OUT
- 06694-00-OUT
- 11900-00-GLF
- 13300-00-OUT
- 13300-00-STR
- 13301-00-OUT
- 13301-00-STR

EXHIBIT 5 - Existing Condition Hydrologic Calculations																	
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	C	%IMP	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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

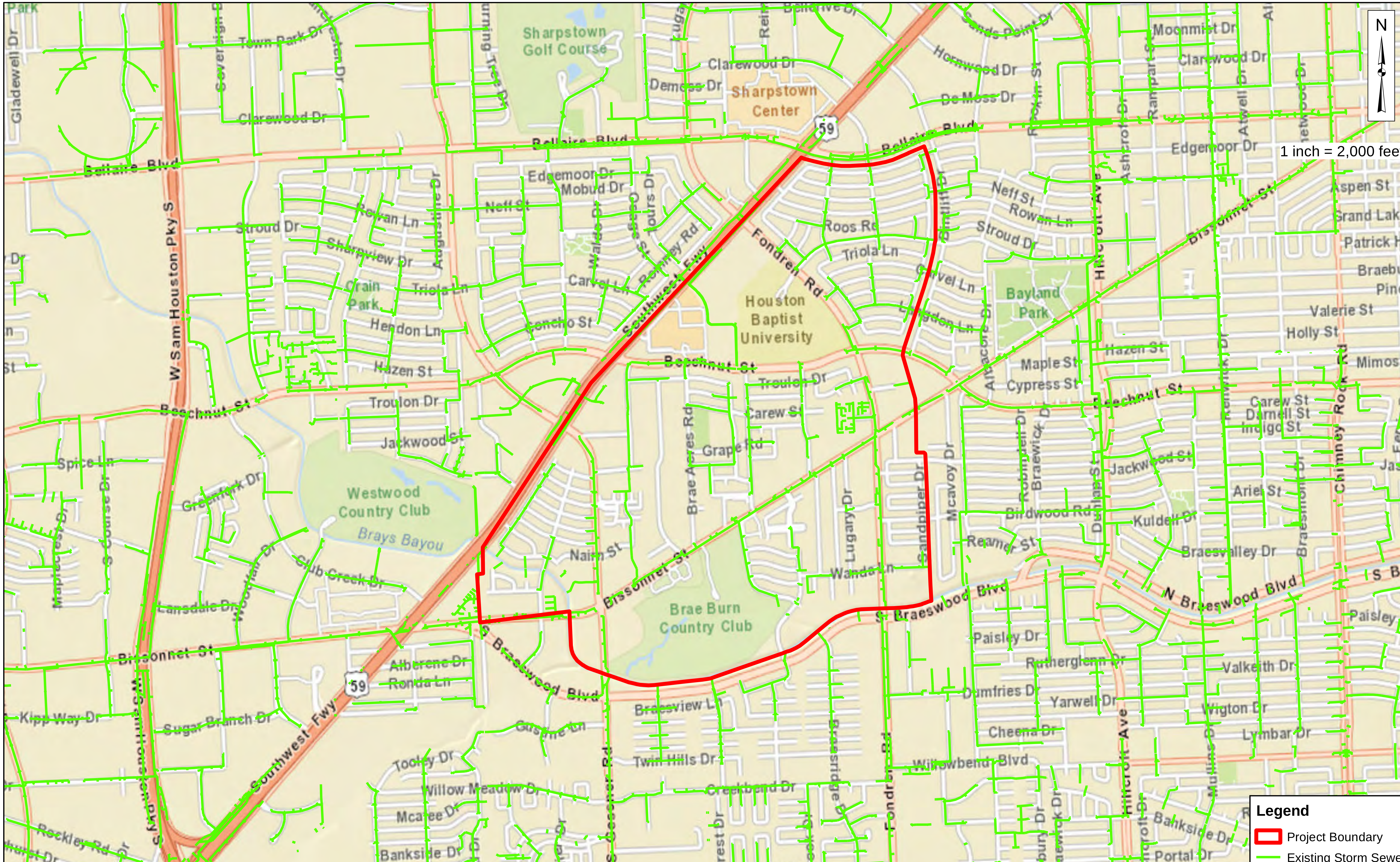
EXHIBIT 5 - Existing Condition Hydrologic Calculations

					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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																
					2 year		5 year		10 year		25 year		50 year		100 year	
Drainage Area	Area (acre)	Tc (min)	**C**	**%IMP**	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



Sharpstown Master Drainage Plan
Existing Condition Storm Sewer Layout Map

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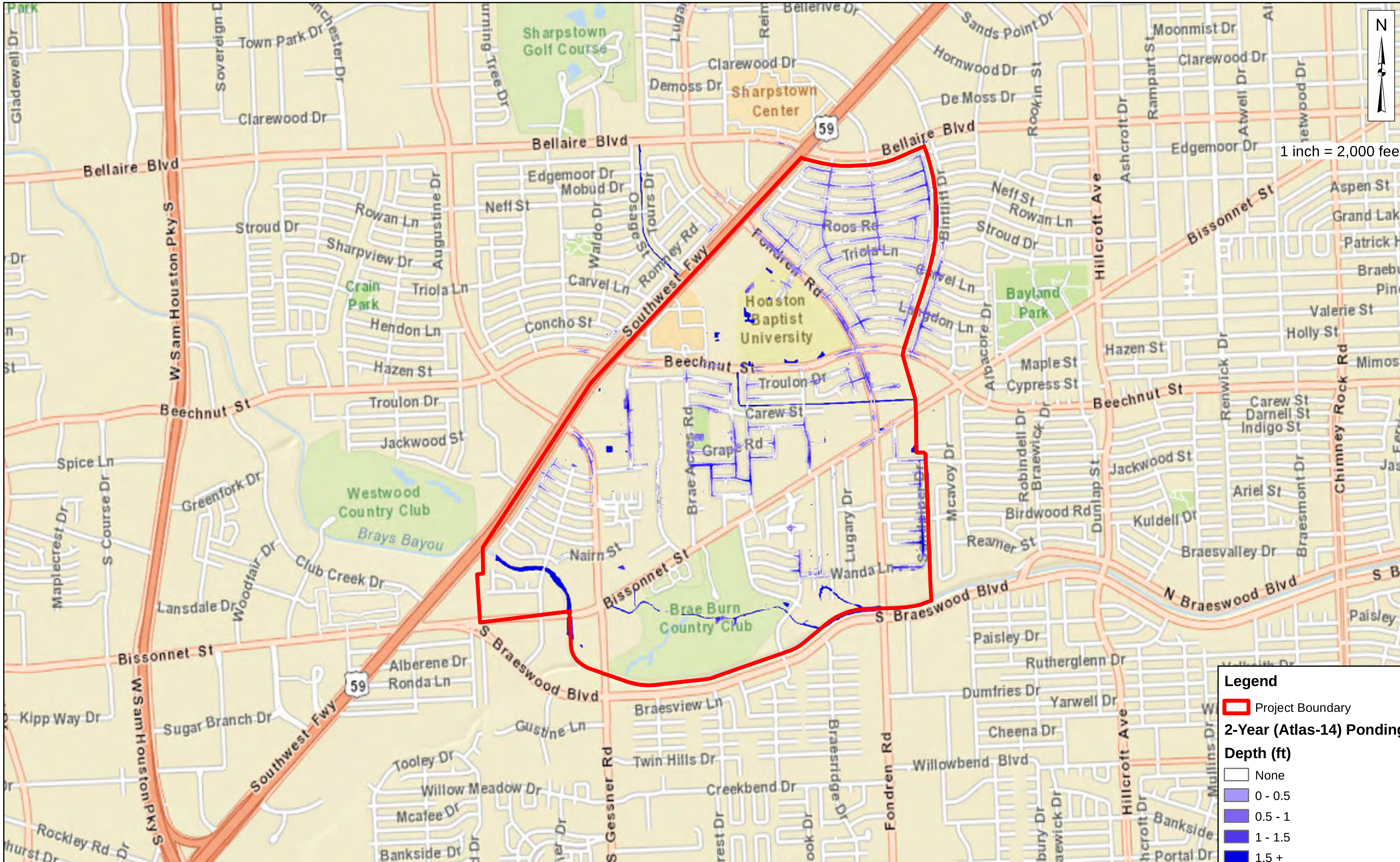
Date: August 2020	EXHIBIT 6



Sharpstown Master Drainage Plan
Existing Condition 2-Year (Atlas-14) Ponding Map

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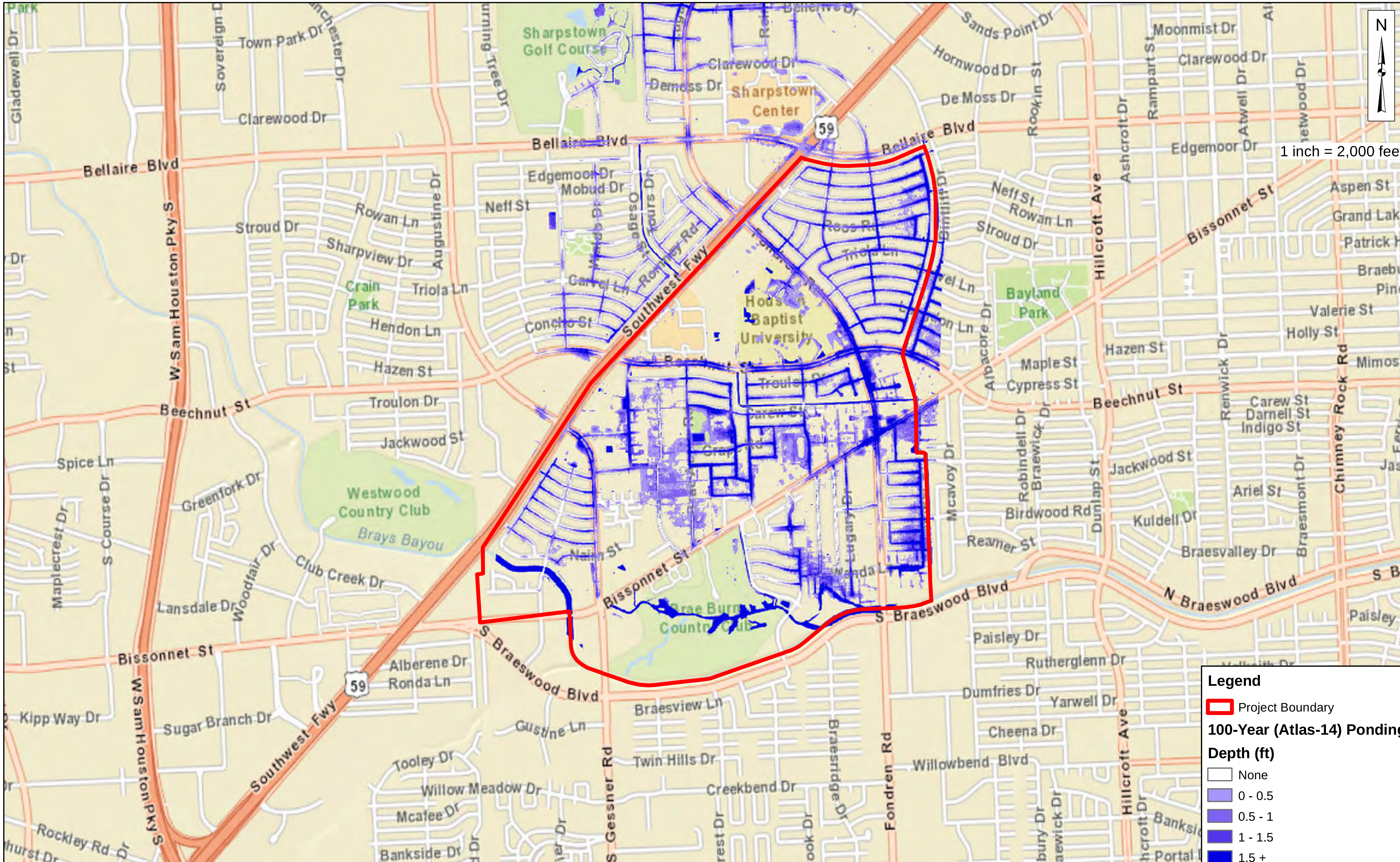
Date: August 2020	EXHIBIT 7



Sharpstown Master Drainage Plan
Existing Condition 100-Year (Atlas-14) Ponding Map

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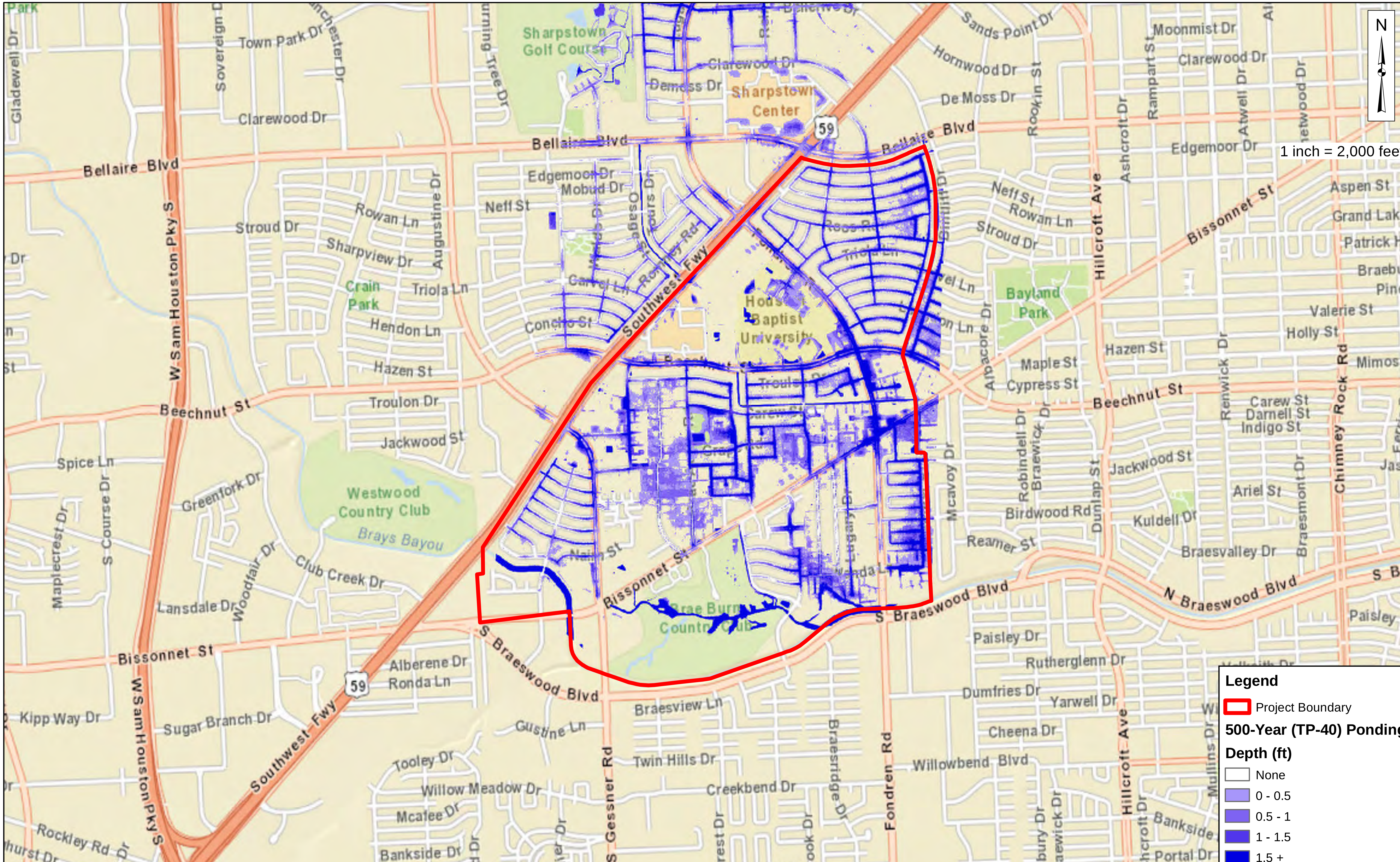
Date: August 2020	EXHIBIT 8



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Sharpstown Master Drainage Plan
Existing Condition 500-Year (TP-40) Ponding Map

Date: August 2020	EXHIBIT 9

Exhibit 10

Effective vs Duplicate Effective HEC-RAS Profile

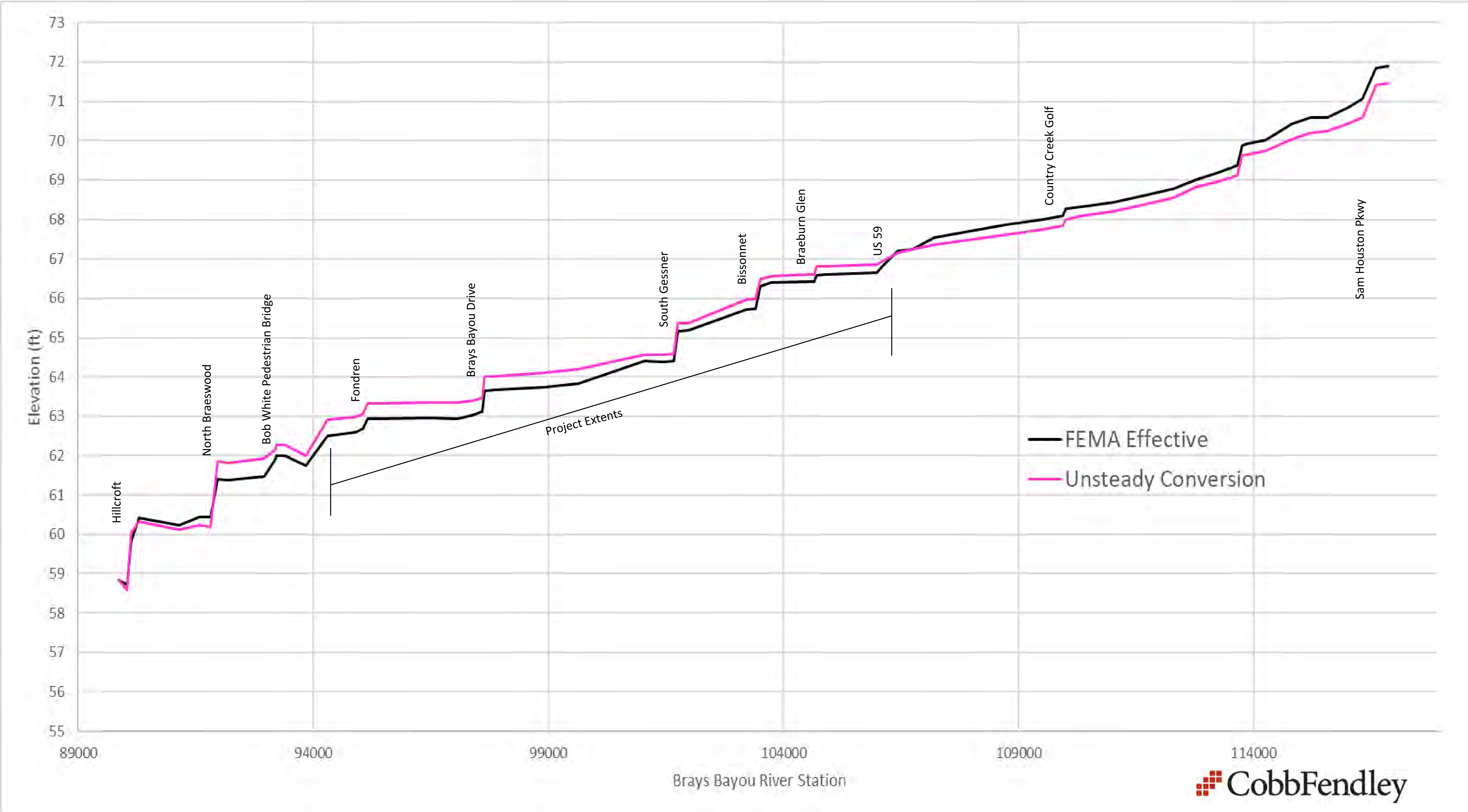
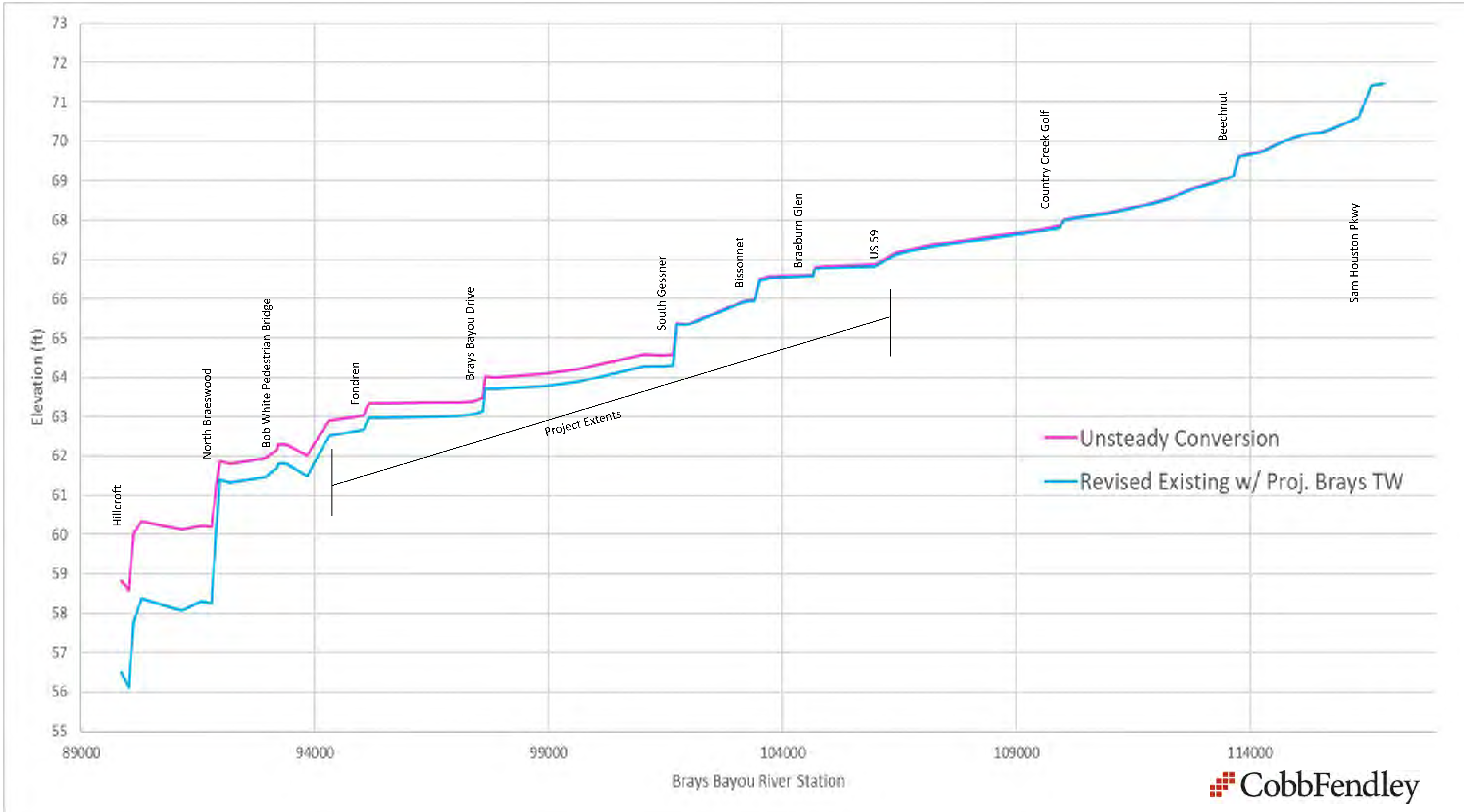
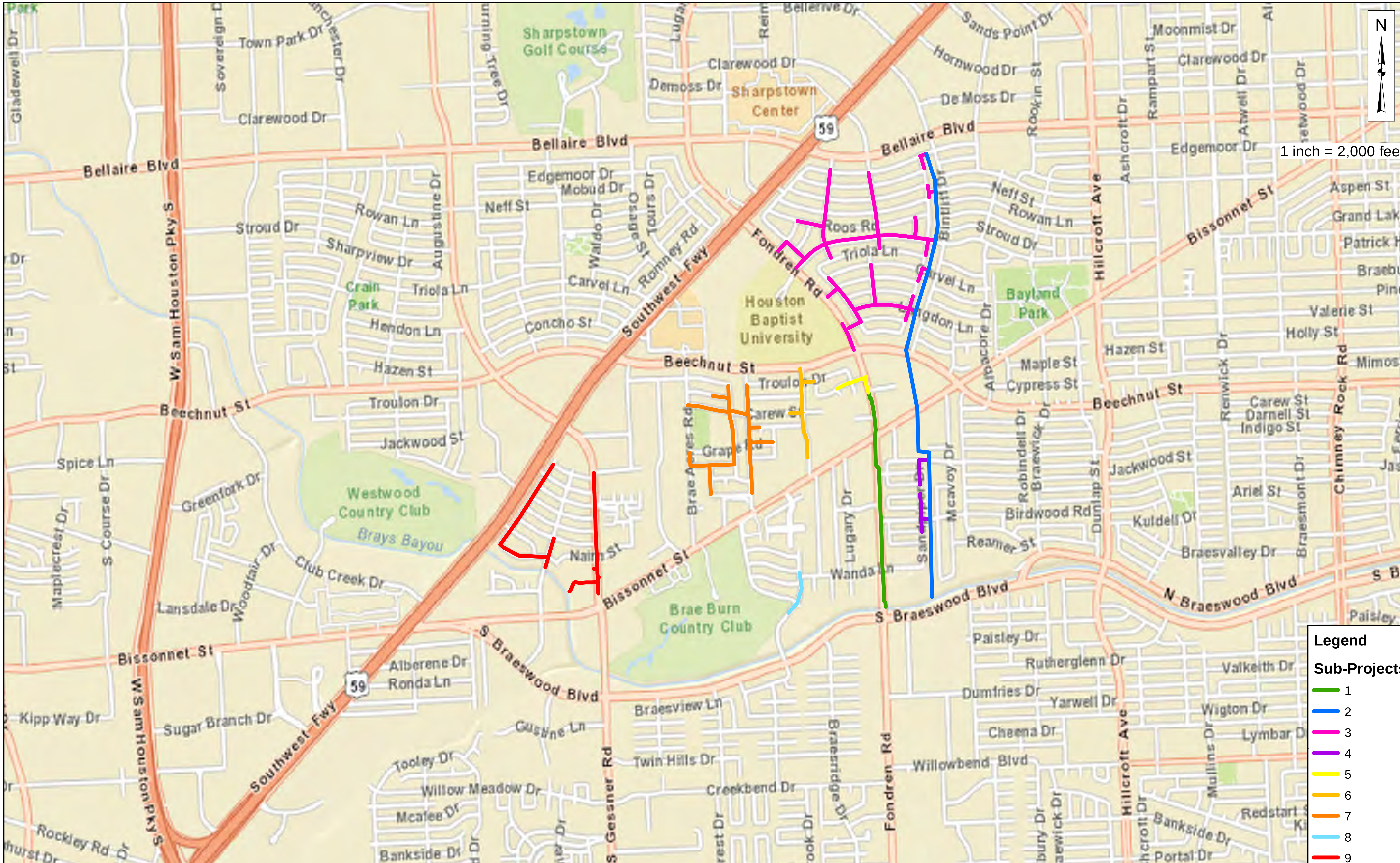


Exhibit 11

Duplicate Effective vs Revised Existing HEC-RAS Profile





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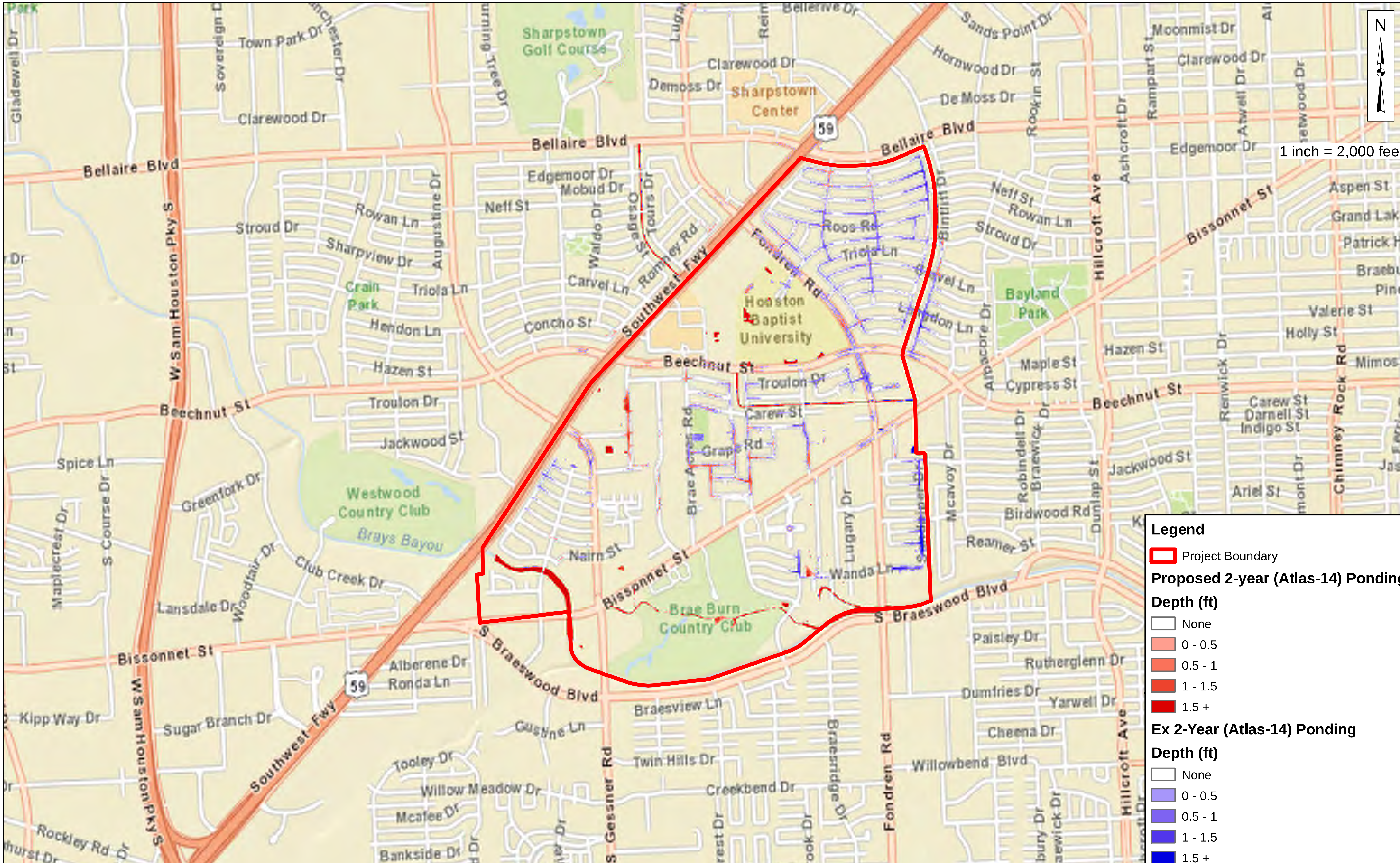
Sharpstown Master Drainage Plan
Proposed Sub-Project Map

Date: August 2020

EXHIBIT 12



Sharpstown Master Drainage Plan
Proposed Condition 2-Year (Atlas-14) Ponding Map

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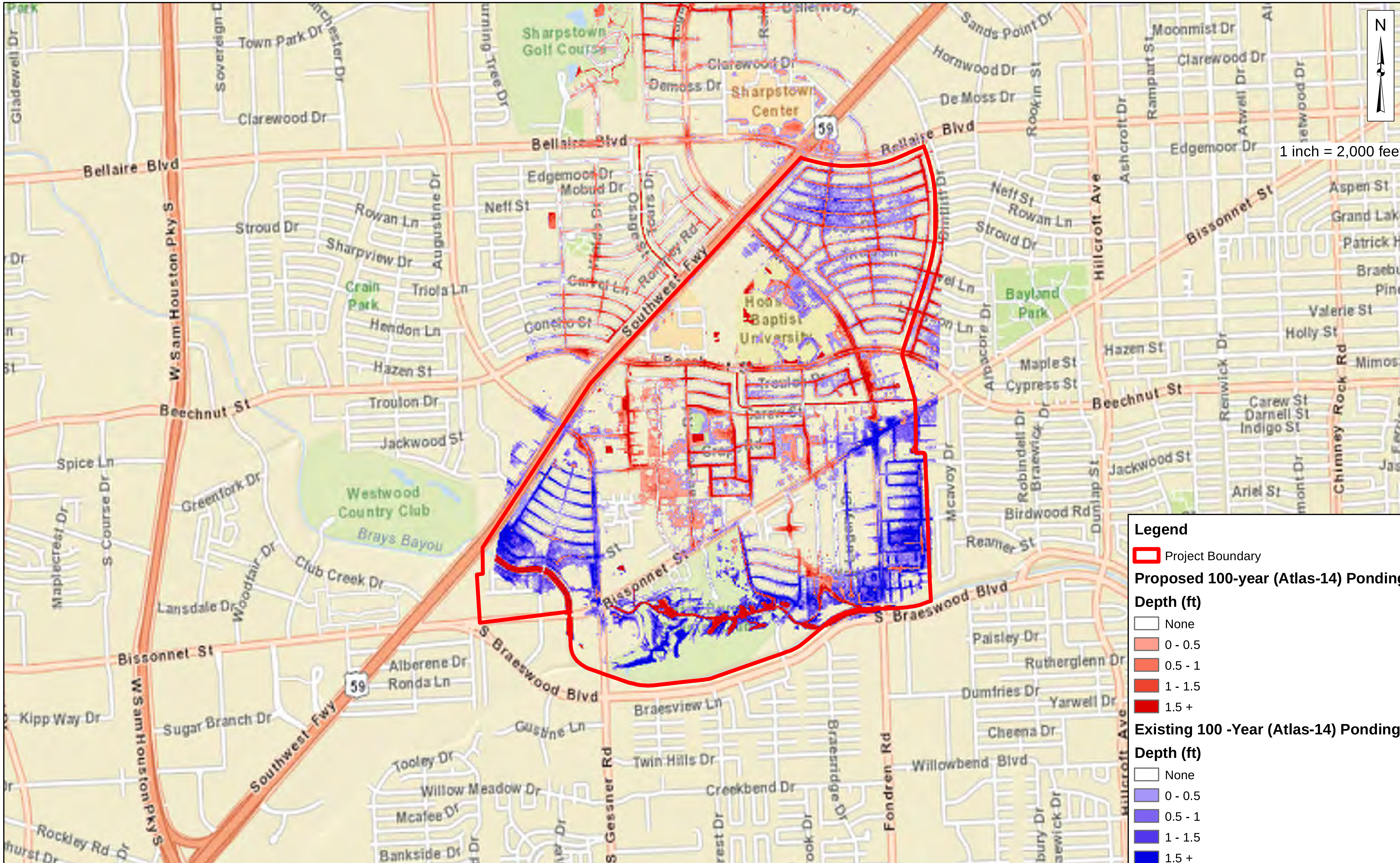
Date: August 2020

EXHIBIT 13



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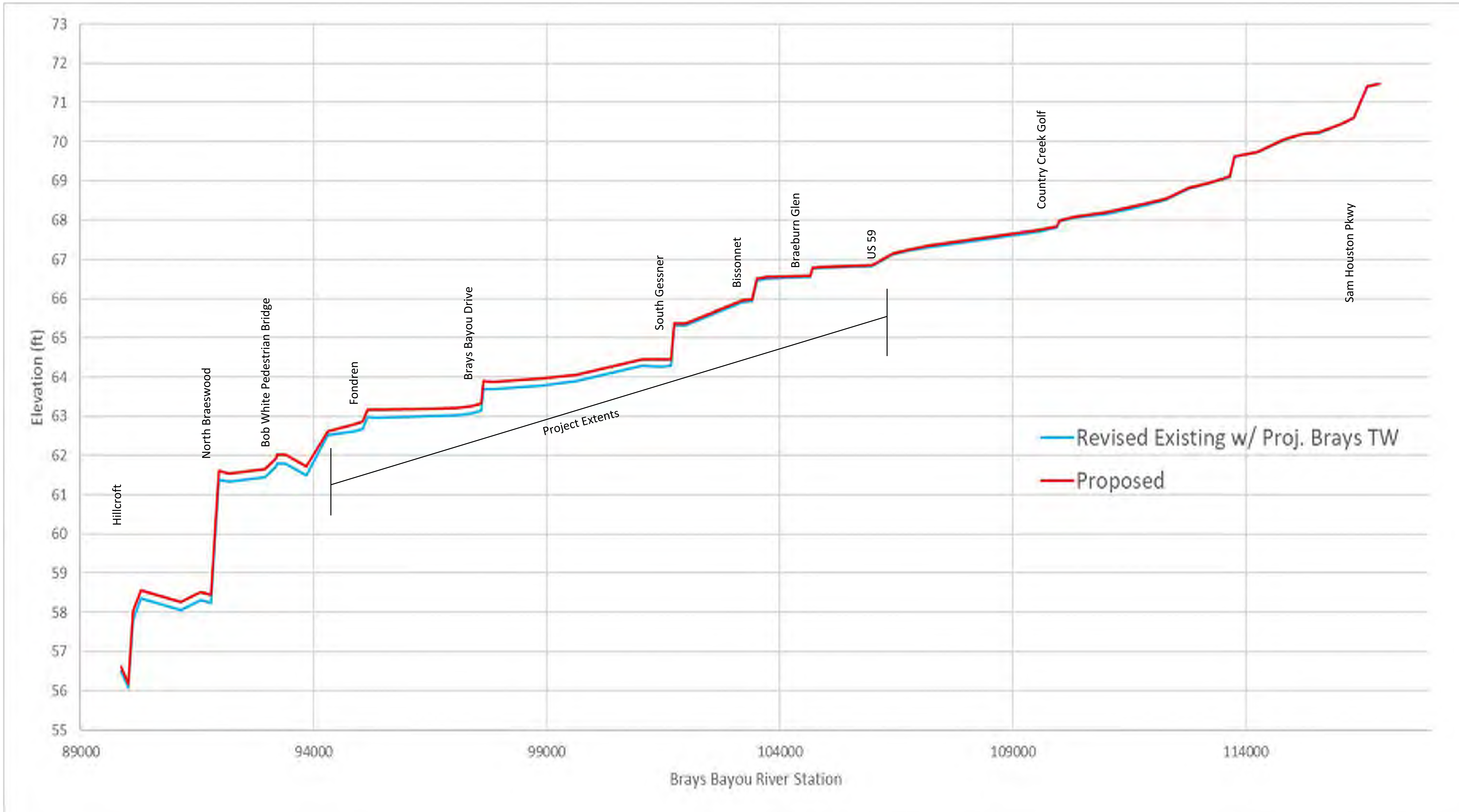
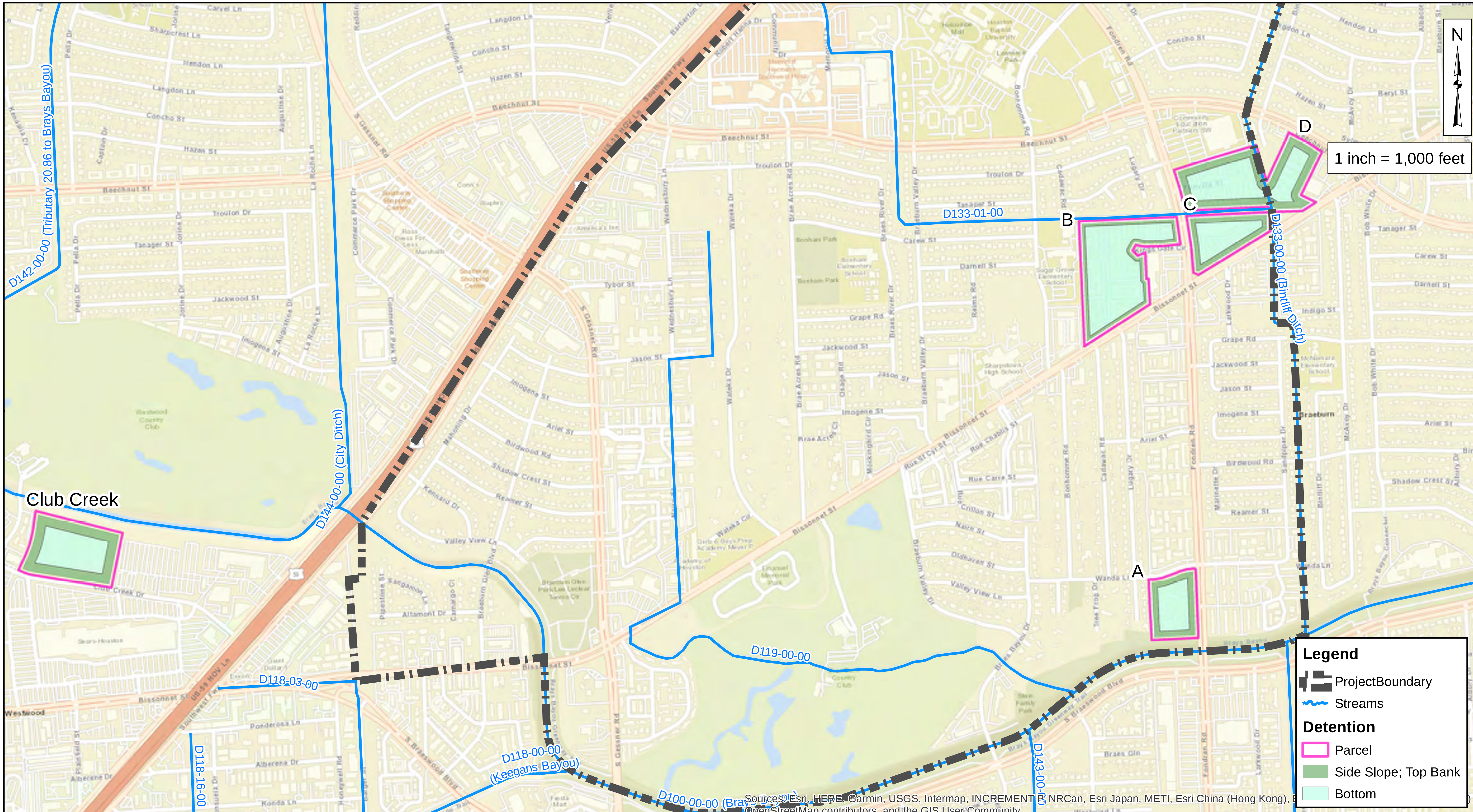
Sharpstown Master Drainage Plan
Proposed Condition 100-Year (Atlas-14) Ponding Map

Date: August 2020	EXHIBIT 14

Exhibit 15

Proposed vs Revised Existing HEC-RAS Profiles





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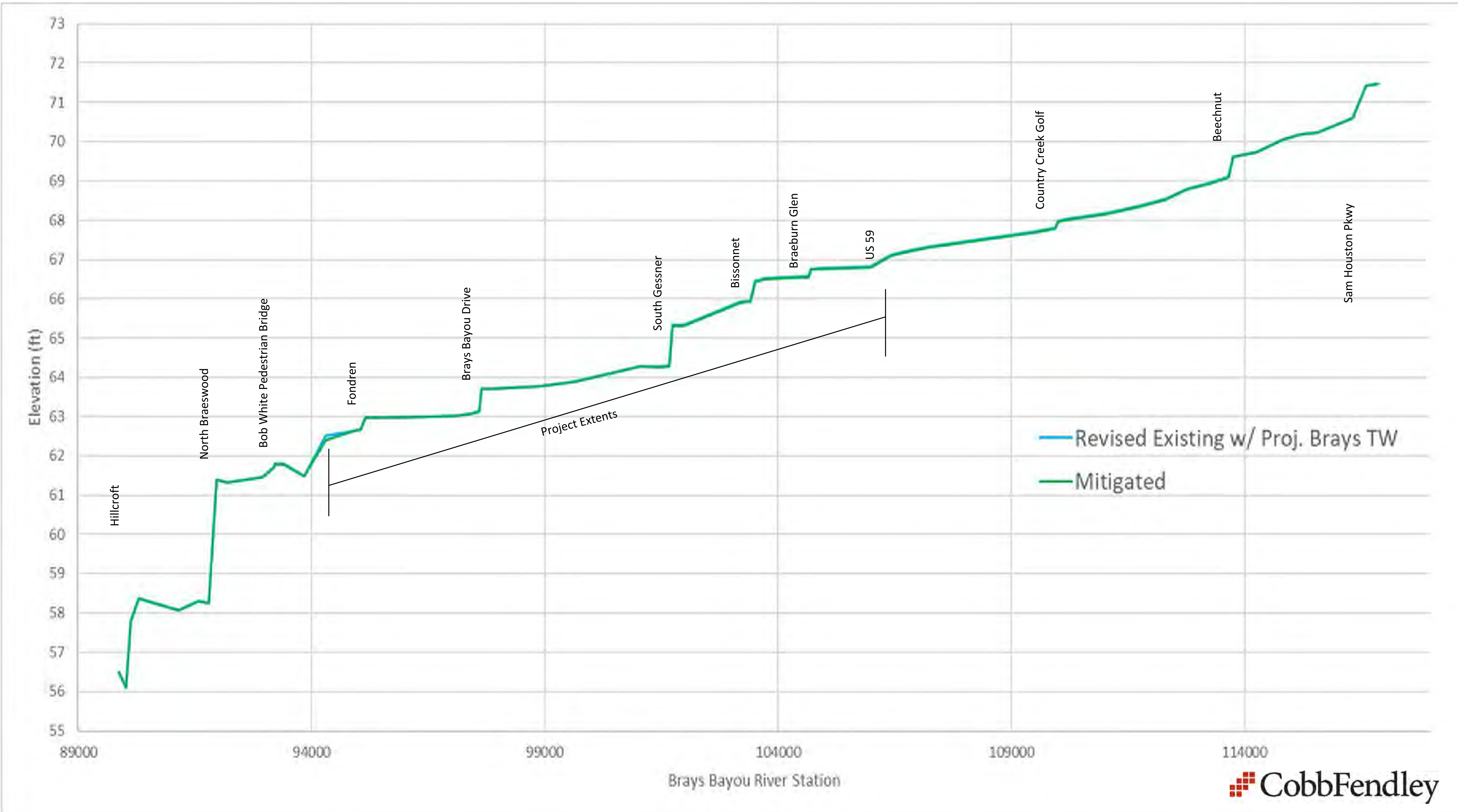
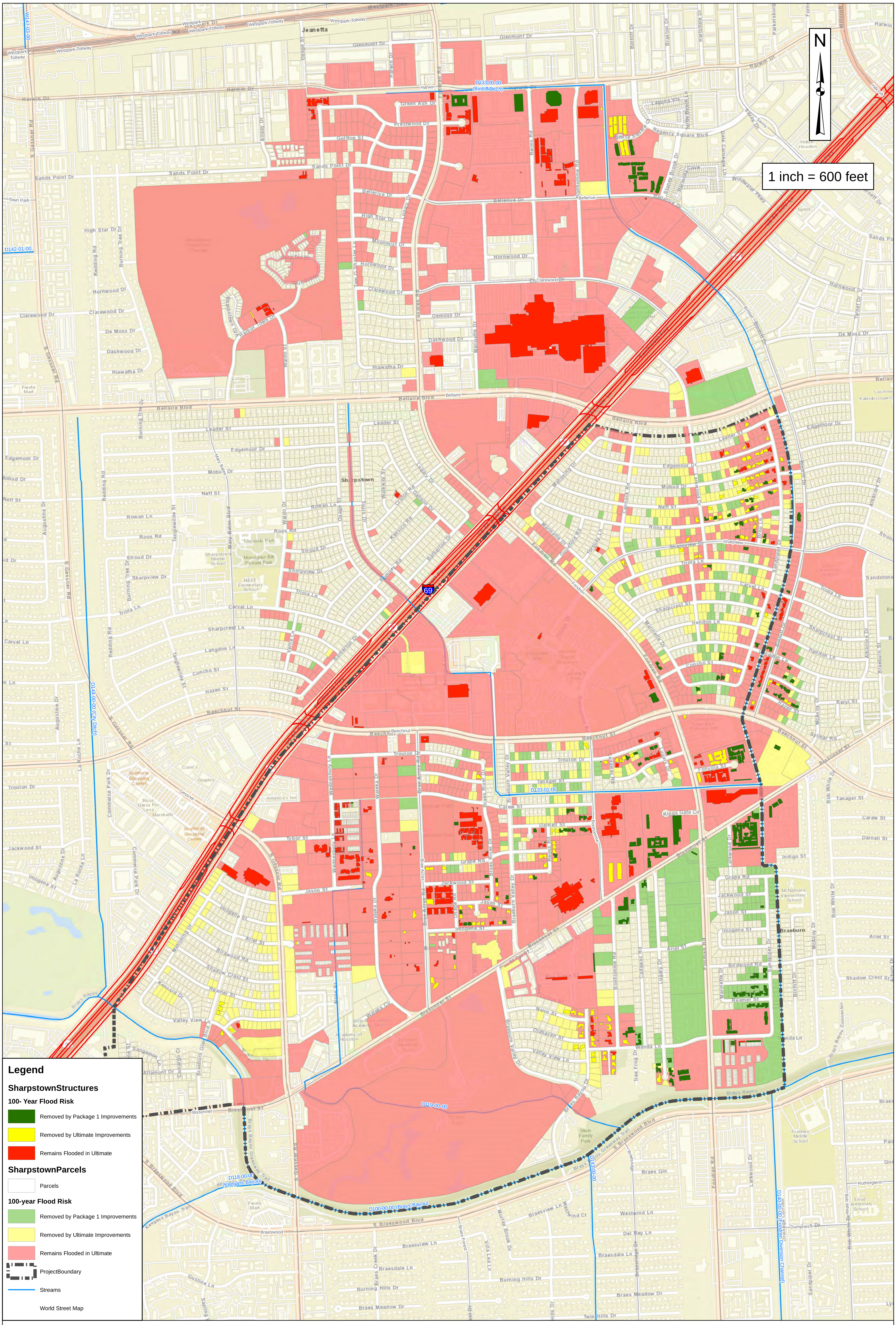
Sharpstown Drainage Masterplan
Proposed Detention Facilities

Date: July 2020	EXHIBIT 16

Exhibit 17

Mitigated vs Revised Existing HEC-RAS Profile





Sharpstown

Exhibit 18 Benefitted Parcels and Structures

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

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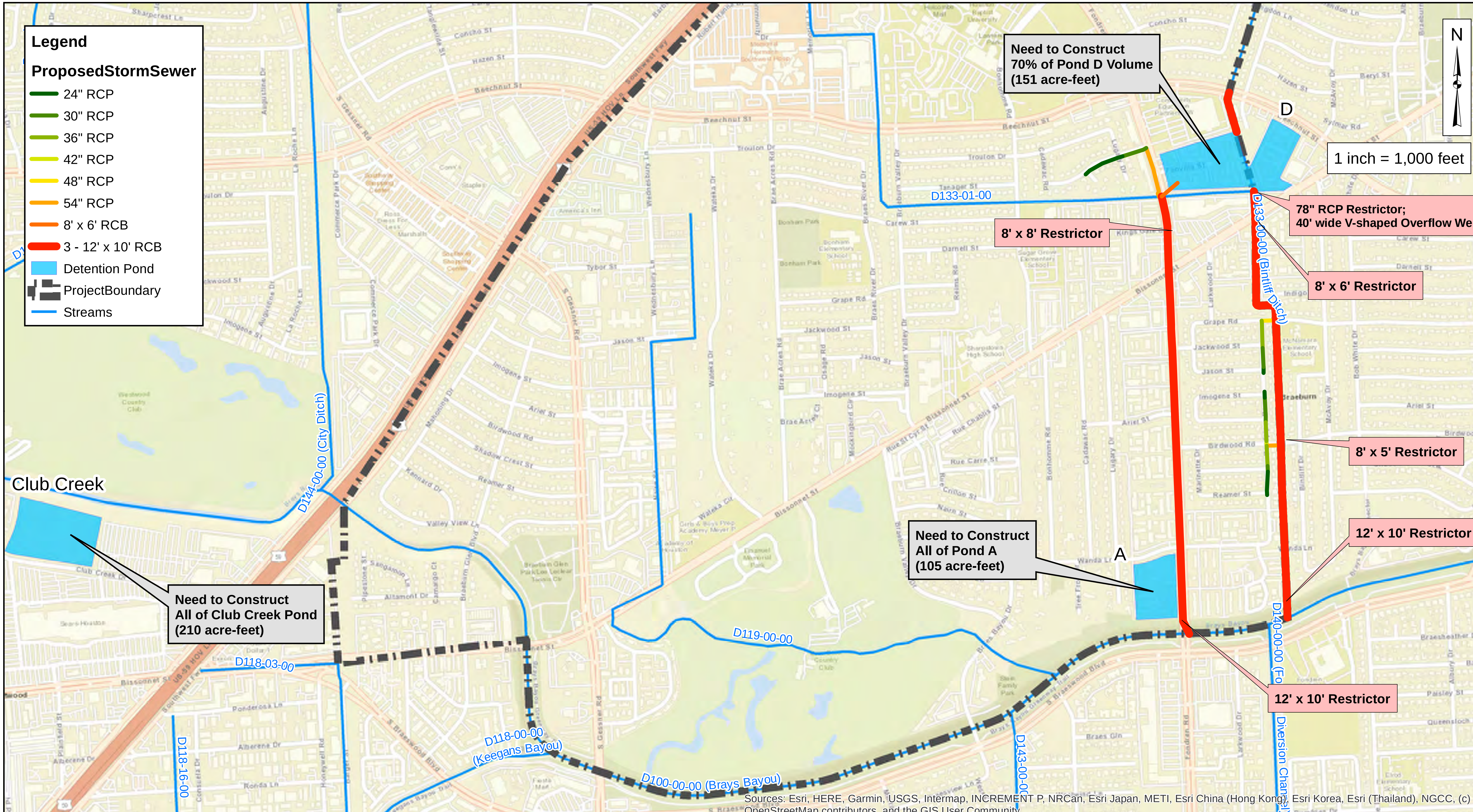

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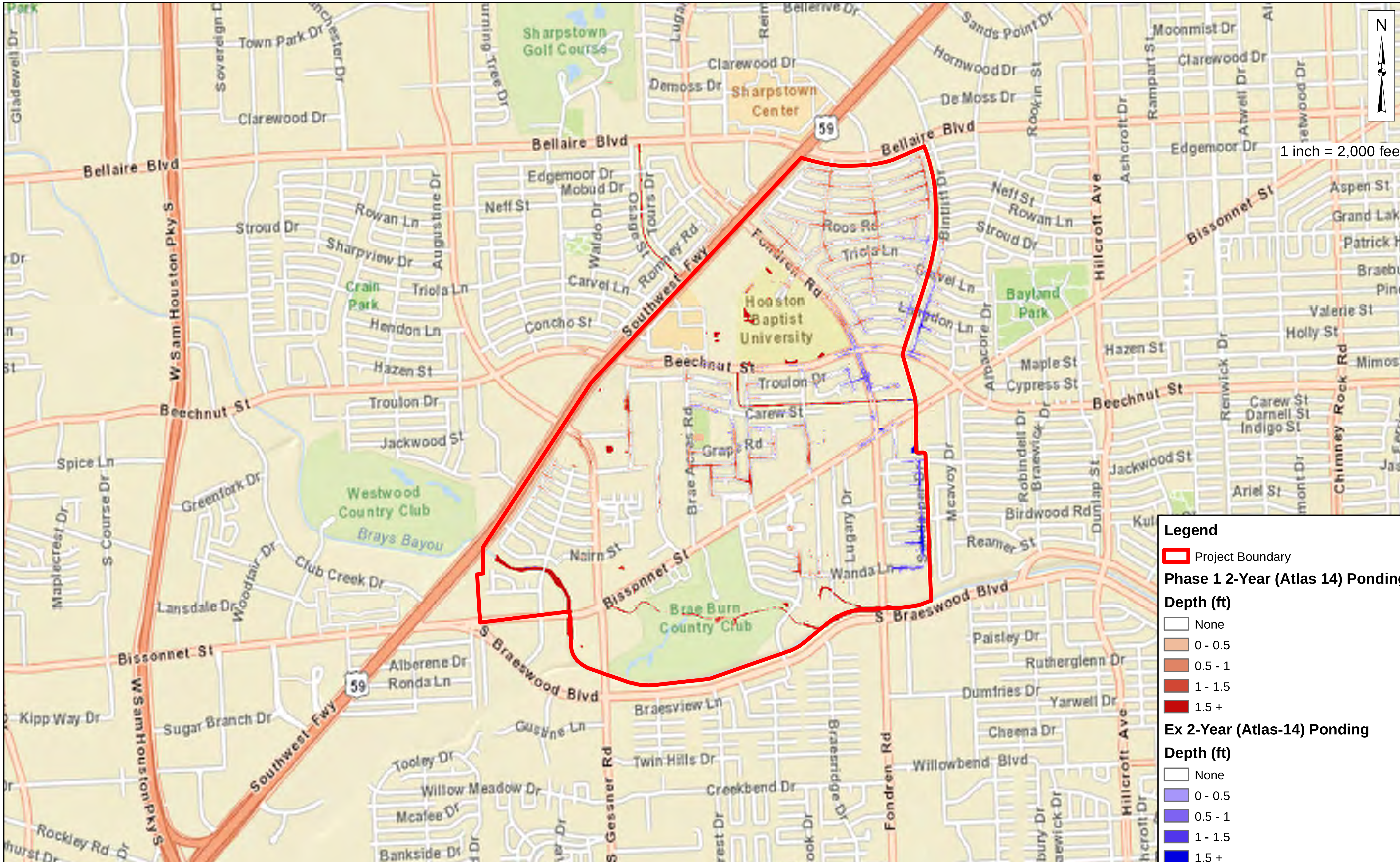
Sharpstown Drainage Masterplan
Package 1 Proposed Improvements

Date: July 2020	**EXHIBIT 19**

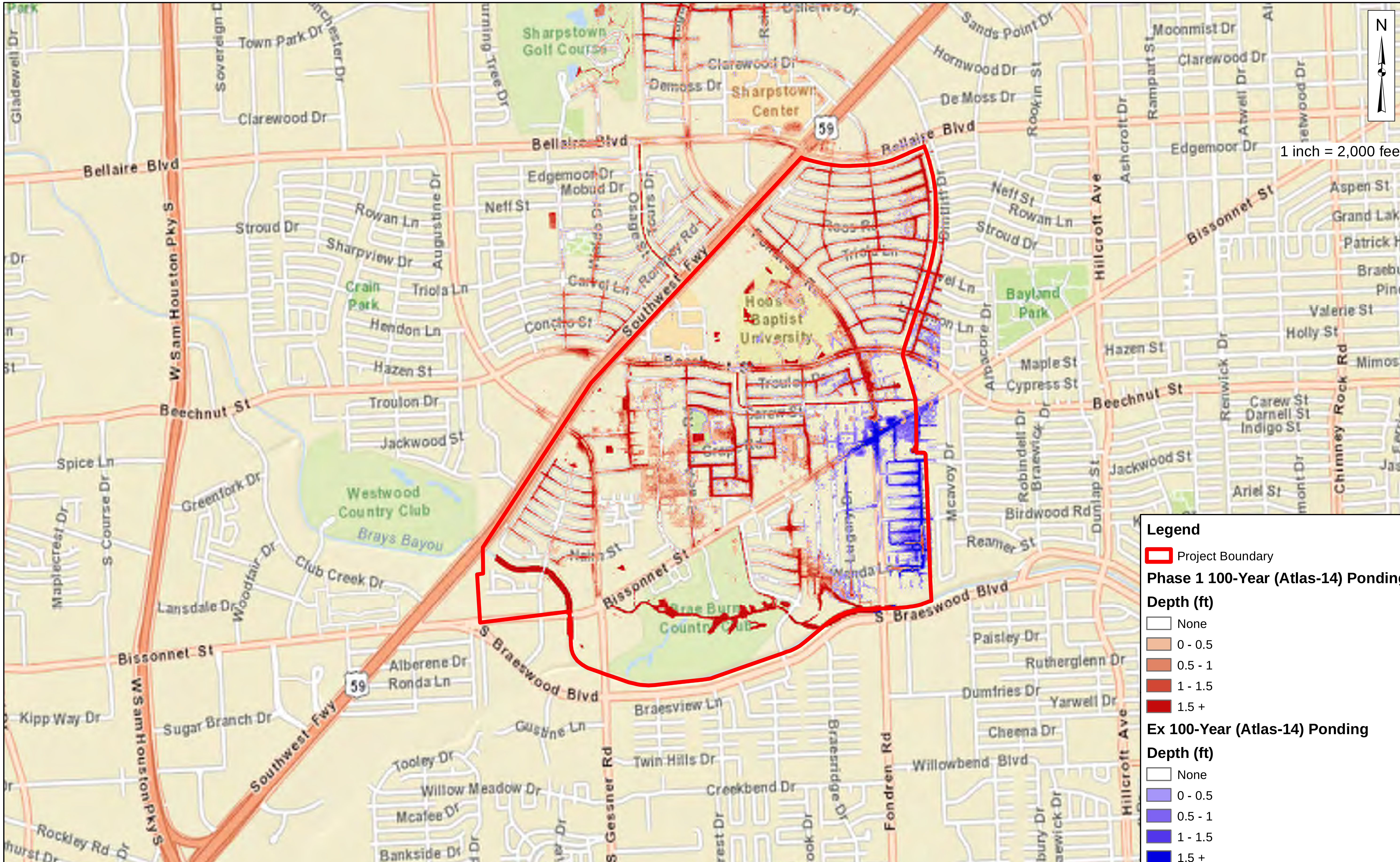


Sharpstown Master Drainage Plan
Proposed Phase 1 Condition 2-Year (Atlas-14) Ponding Map

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

Date: August 2020

EXHIBIT 20

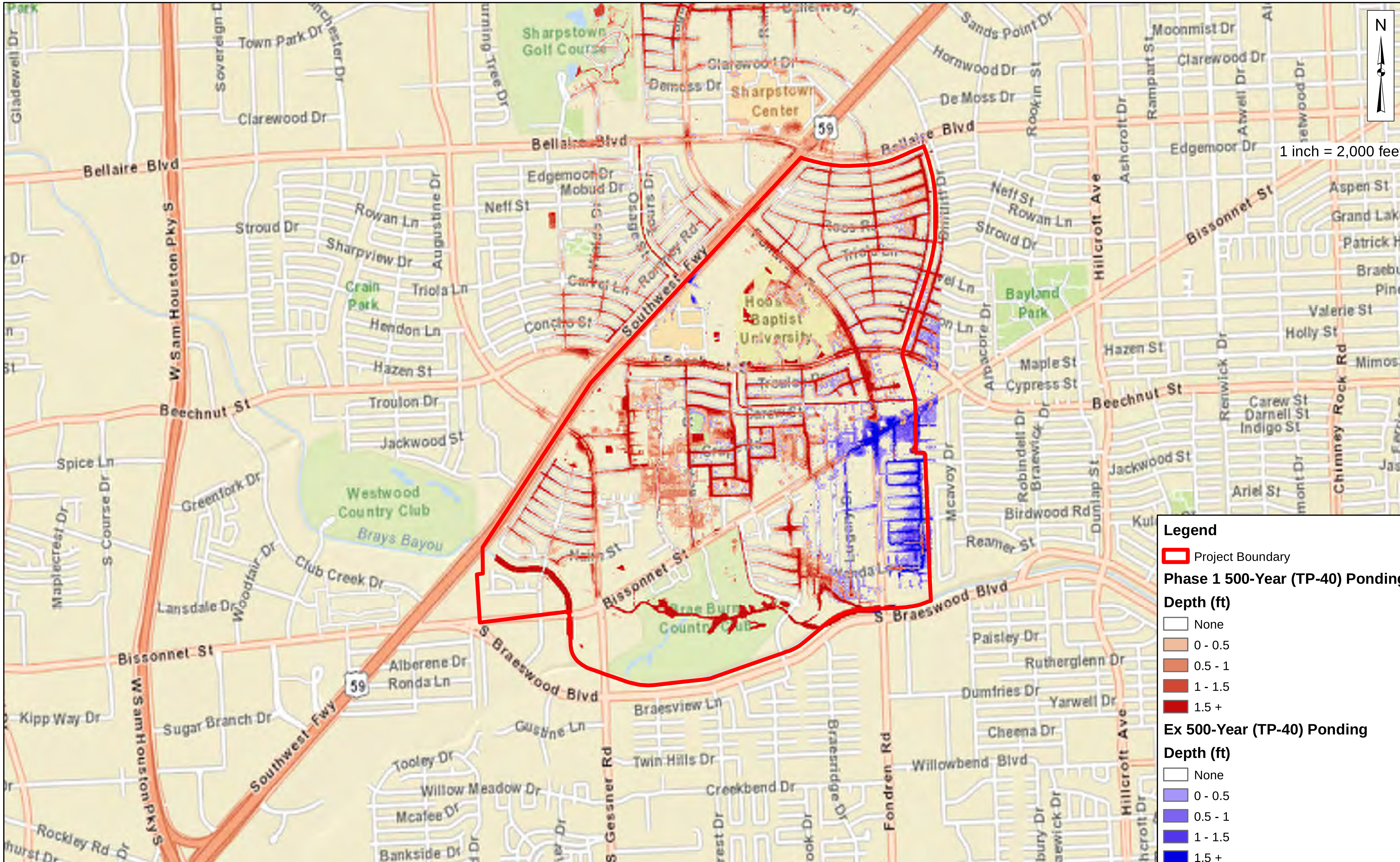


CobbFendley
Texas Registration No. 274
13430 Northwest Freeway, Suite 1100
Houston, Texas 77040
713.462.3242 | fax 713.462.3262
www.cobbfendley.com

Sharpstown Master Drainage Plan
Proposed Phase 1 Condition 100-Year (Atlas-14) Ponding Map

Date: August 2020

EXHIBIT 21



CobbFendley Texas Registration No. 274 13430 Northwest Freeway, Suite 1100 Houston, Texas 77040 713.462.3242 | fax 713.462.3262 www.cobbfendley.com	**Sharpstown Master Drainage Plan** **Proposed Phase 1 Condition 500-Year (TP-40) Ponding Map**	
	Date: August 2020	**EXHIBIT 22**

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, HCFCD 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 (HCFCD 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, HCFCD prepared a HCFCD 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 HCFCD 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
    - ***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: 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 (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.

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:	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:	$344.94	12 points
% of Beneficiaries per Population:	0.067	0.67 points
% Non-CDBG Funds:	6.4% from HCFCD	5 points
Resiliency Measures:	yes	N/A
TOTAL		**74.67 points**
Poverty Rate:	16.8%	

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
  - ***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: 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 HCFCD placed projects like this one on the bond table since it was property the HCFCD already owned and would allow HCFCD 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 HCFCD. 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 HCFCD. 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 HCFCD 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-feet 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***

- 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: 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 it 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

Innovative approaches
Practical results
Outstanding service

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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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-94[1]. (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-94[3].
    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 6.0[4] (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 of 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-year[5] 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 (CSVR) 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 assessments[8]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

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

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*).

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

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*).

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

Equation 3

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

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*.

$$BCR = \frac{(Expected\ Annual\ Benefits * \ Uniform\ Series\ Present\ Worth\ Factor) + Present\ Worth\ Social\ Benefits}{Project\ Capital\ Cost}$$ ***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 inventory[9].

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 Manual[10]. 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 methodology[11], 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."

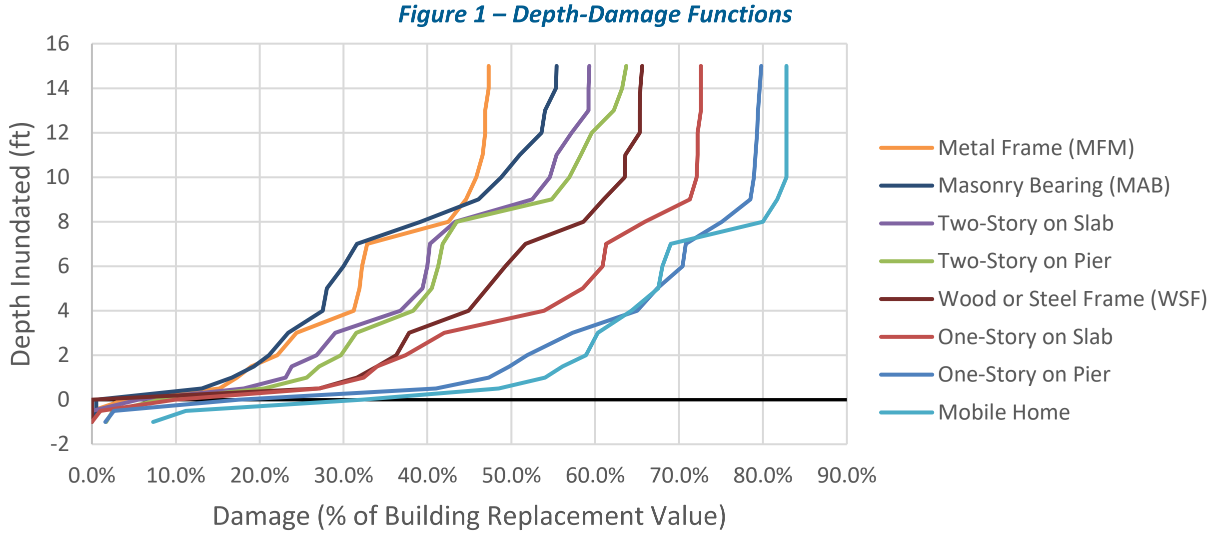
median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size (*Equation 6*). This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

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf)$$ **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 RSMeans 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 District[13] 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.

Figure 1 – Depth-Damage Functions



[12] R.S. Means, 2005.
[13] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) 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 District[13], 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 disaster[14]. 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 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-burdened[17]. 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 subscription[18]. 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

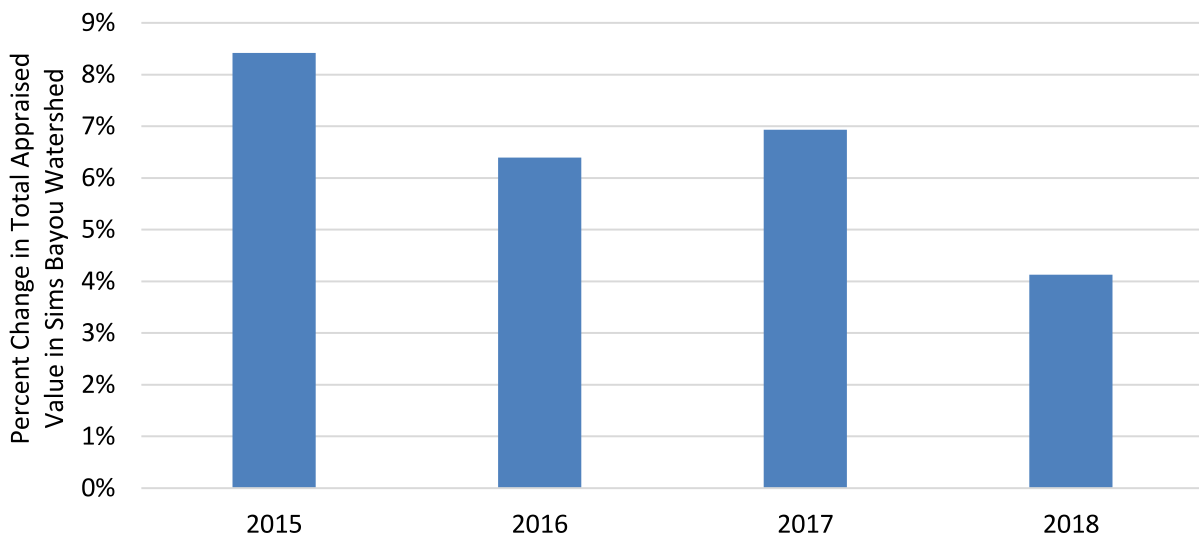
[16] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

[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 work[19]. 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 <= r < 1.25	1.25 <= 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. HCFCD will maintain the detention ponds.

2. Identify and explain any special engineering activities.

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

STATE OF TEXAS
BRANDON NGUYEN
94972
LICENSED
PROFESSIONAL ENGINEER

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 ABUTTMENT 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
HCFCD 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
	$ -		0	$ -	$ -	$ -
	$ -		0	$ -	$ -	$ -
	$ -		0	$ -	$ -	$ -
	$ -		0	$ -	$ -	$ -
	$ -		0	$ -	$ -	$ -
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 HCFCD CDBG-MIT projects will be included in the Annual Operational and Maintenance Budget prepared and funded by the HCFCD. All cost associated with the successful maintenance and operation of this project as well as all other projects under the responsibility of HCFCD are included in this budget.

2. Identify and explain any special engineering activities.

STATE OF TEXAS
TIMOTHY E. BUSCHA
82600
LICENSED
PROFESSIONAL ENGINEER

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

2. Identify and explain any special engineering activities.

N/A

STATE OF TEXAS
JEFFREY J. EBERSOLE
105972
LICENSED PROFESSIONAL ENGINEER

Seal

Date:	9-23-20
Phone Number:	713-783-7788

Signature of Registered Engineer/Architect Responsible For Budget Justification:

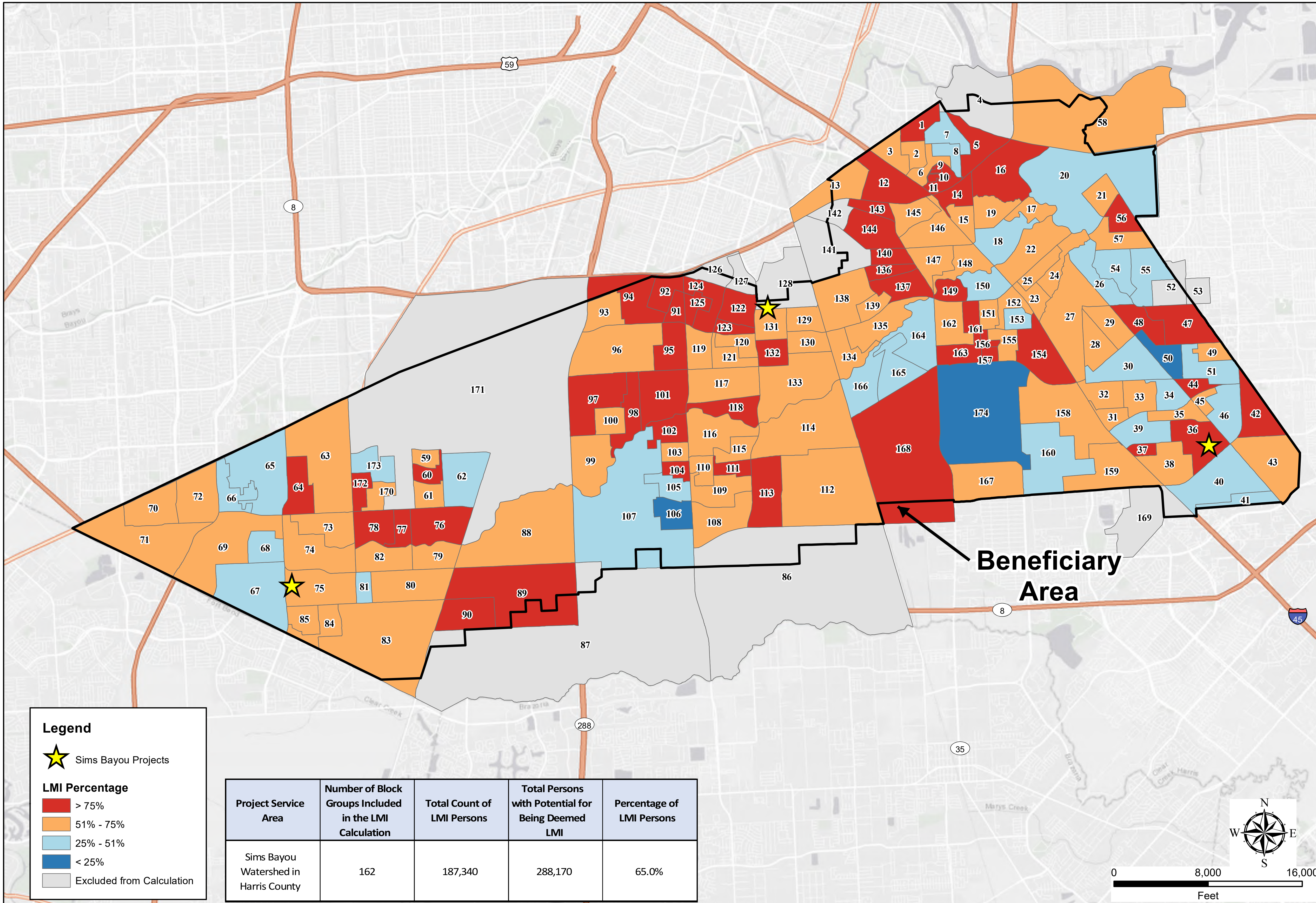
9-23-20

Costello, Inc.
TBPE No. 280

Sims Bayou Watershed Beneficary Area Map

CDBG-MIT

STUART CONSULTING GROUP



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%

FN PROJECT NO. SCG17357

DATE CREATED 10/2/2020

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

FILE NAME Sims_Project_Area_Map_LMI_1

PREPARED BY AMJ

FREESE NICHOLS

STUART CONSULTING GROUP

EXHIBIT

2

(1 of 2)

Sims Bayou Watershed Beneficiary Area Table

STUART CONSULTING GROUP

CDBG-MIT

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%

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
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%

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
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%

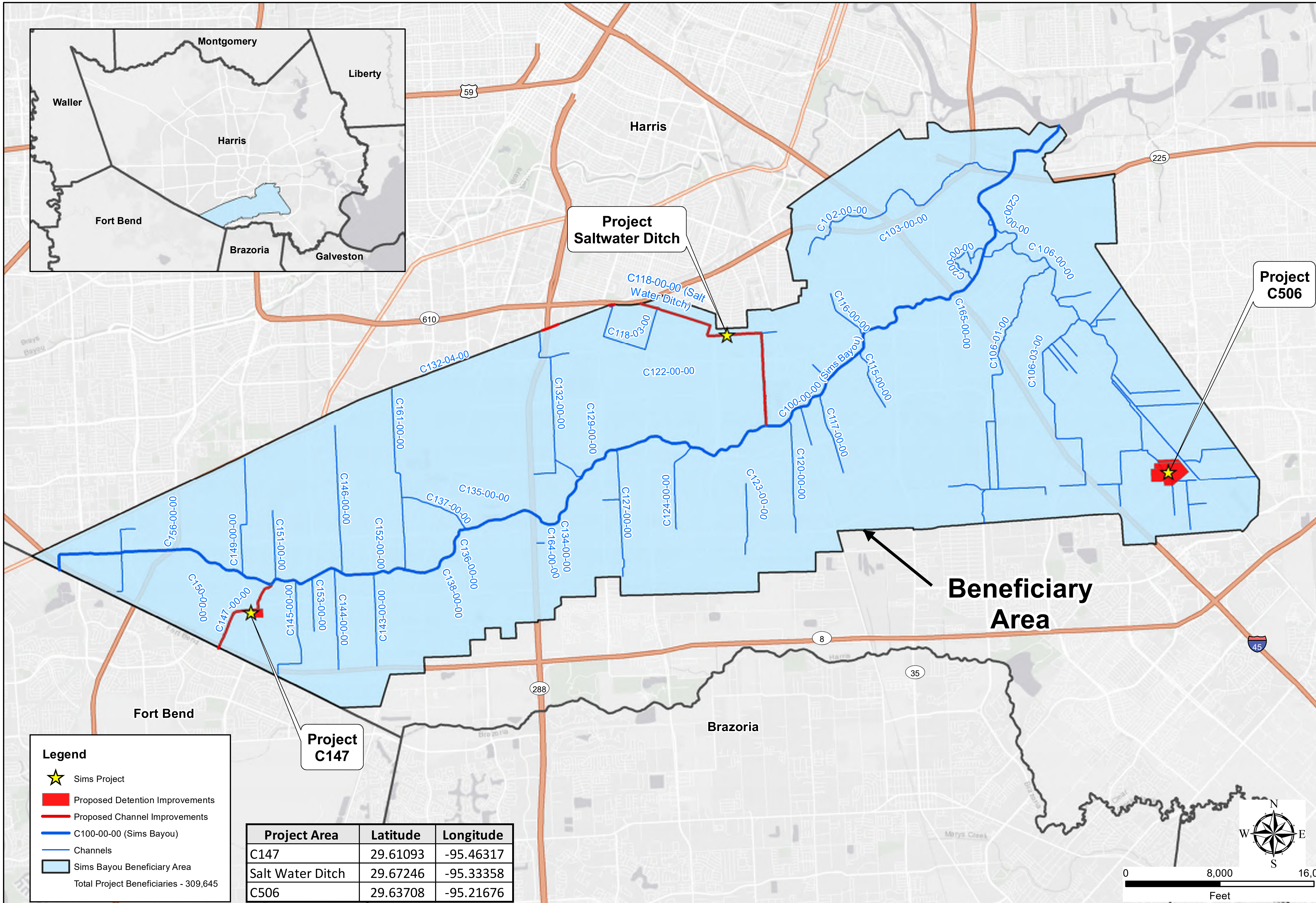
Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
135	482013325002	1,297	1,297	100%	Yes	63.6%
136	482013326001	1,061	1,061	100%	Yes	88.1%
137	482013326002	2,617	2,617	100%	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	482013341003	743	743	100%	Yes	82.7%
173	482013341004	2,177	2,177	100%	Yes	26.1%
174	482019800001	32	32	100%	Yes	0.0%

FN PROJECT NO. SCG17357
DATE CREATED 9/28/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Sims_Project_Area_Map_LMI_2
PREPARED BY AMJ

FREESE NICHOLS

STUART CONSULTING GROUP

EXHIBIT
2
(2 of 2)



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

FN PROJECT NO. SCG17357
DATE CREATED 10/2/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Sims_Project_Area_Map
PREPARED BY AMJ

STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed - Project Area Map

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
1

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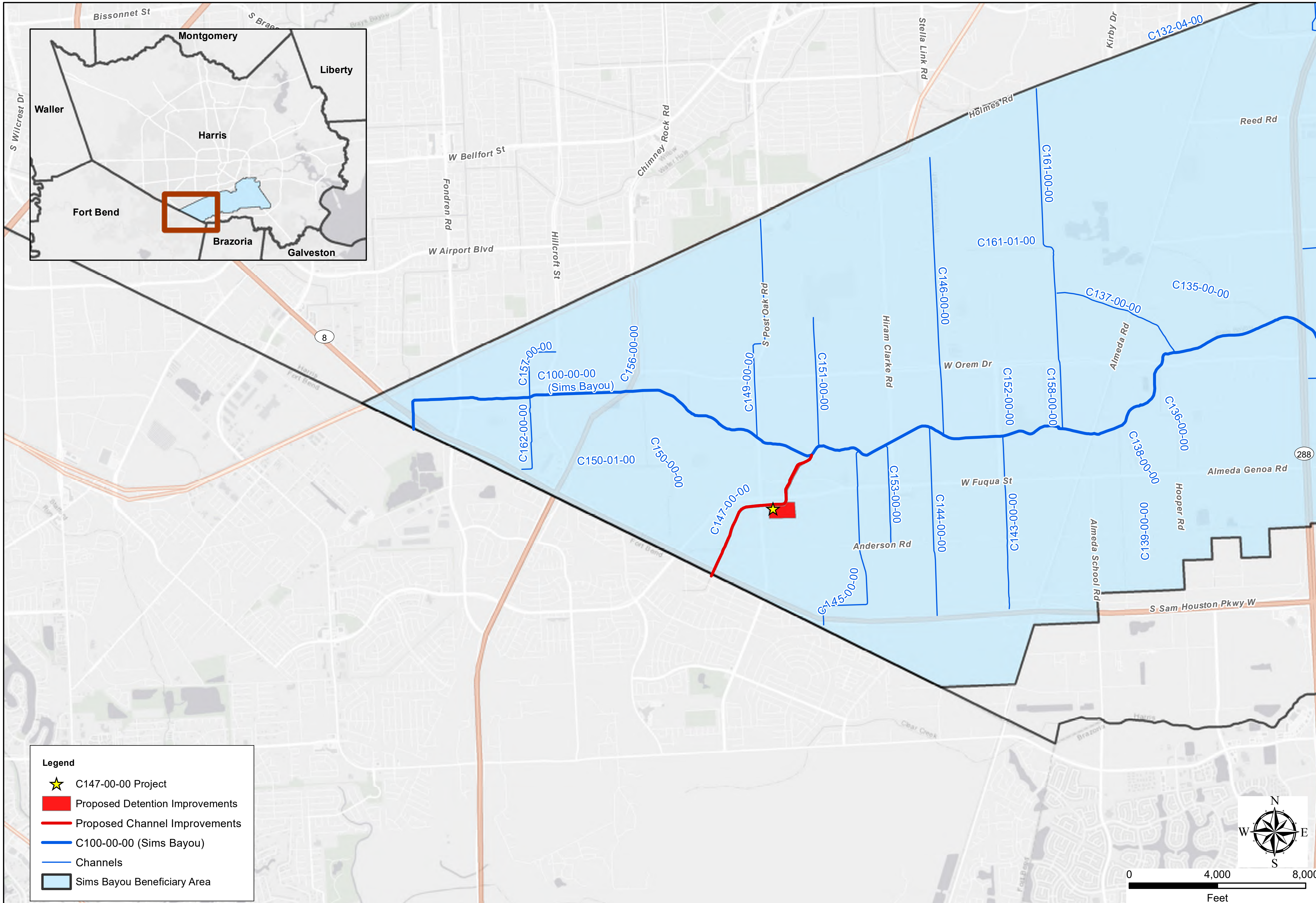
ATTACHMENT 2A

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



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DATE CREATED	9/27/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Sims_C147_Project_Benefit
PREPARED BY	AMJ

STUART CONSULTING GROUP
CDBG-MIT

Sims Bayou Watershed - Project C147-00-00

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
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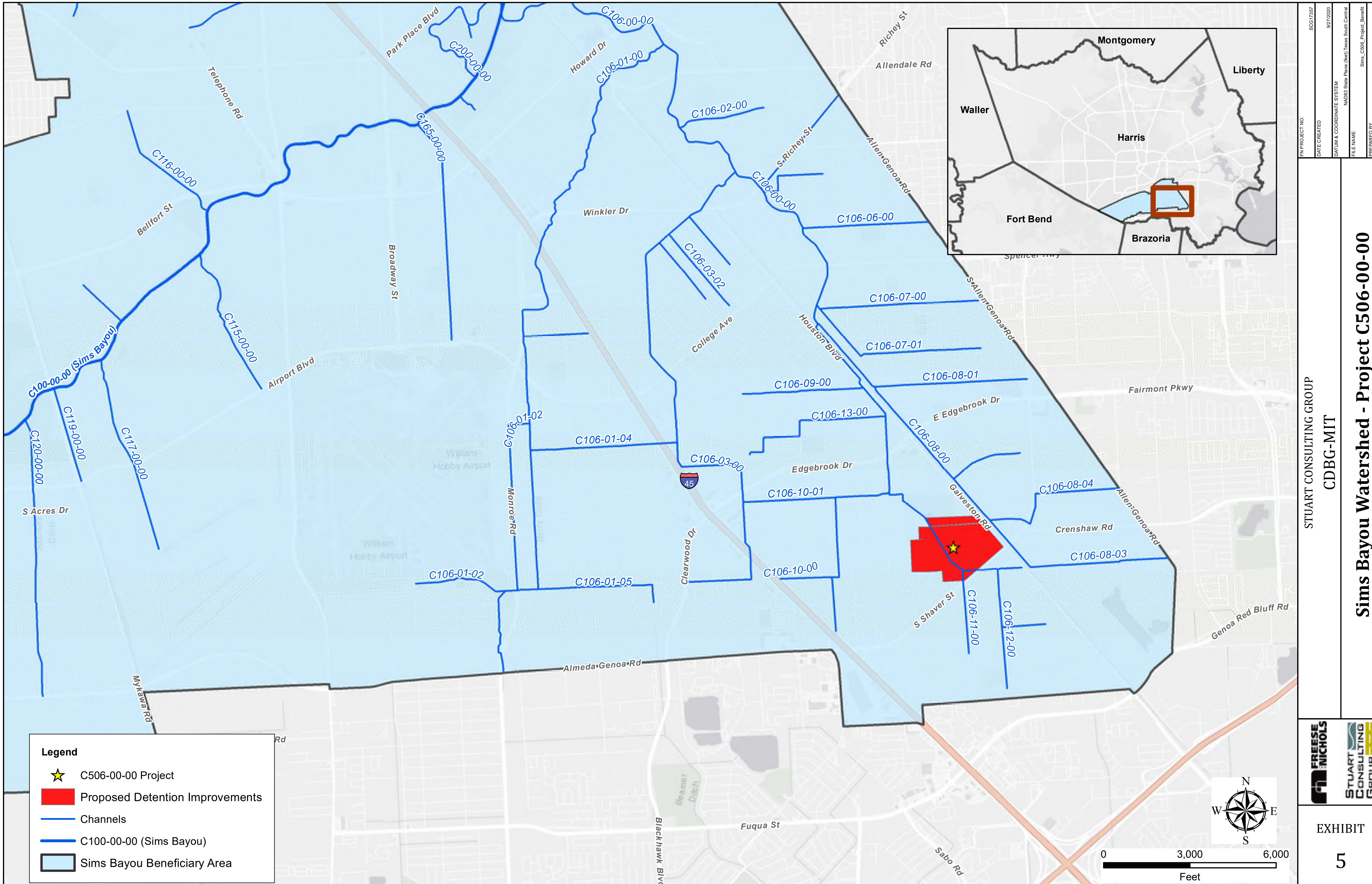
ATTACHMENT 2B

PROJECT AREA MAP

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

PROJECT:
SIMS BAYOU WATERSHED
MITIGATION PROJECT



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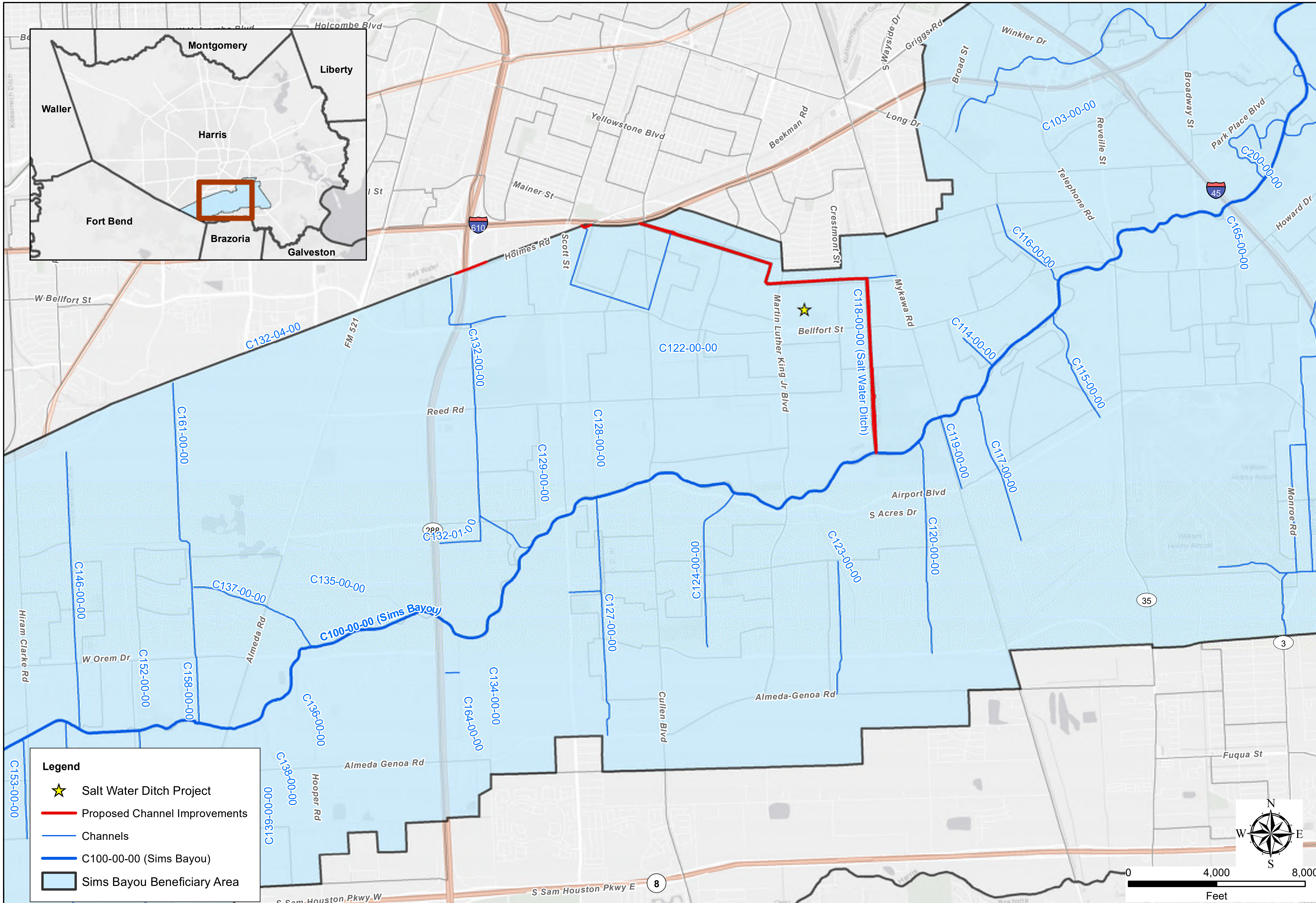
ATTACHMENT 2C

PROJECT AREA MAP

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

PROJECT:
SIMS BAYOU WATERSHED MITIGATION PROJECT



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DATE CREATED 9/28/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Sims_SWD_Project_Benefit
PREPARED BY AMJ

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Sims Bayou Watershed- Project Salt Water Ditch

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
4

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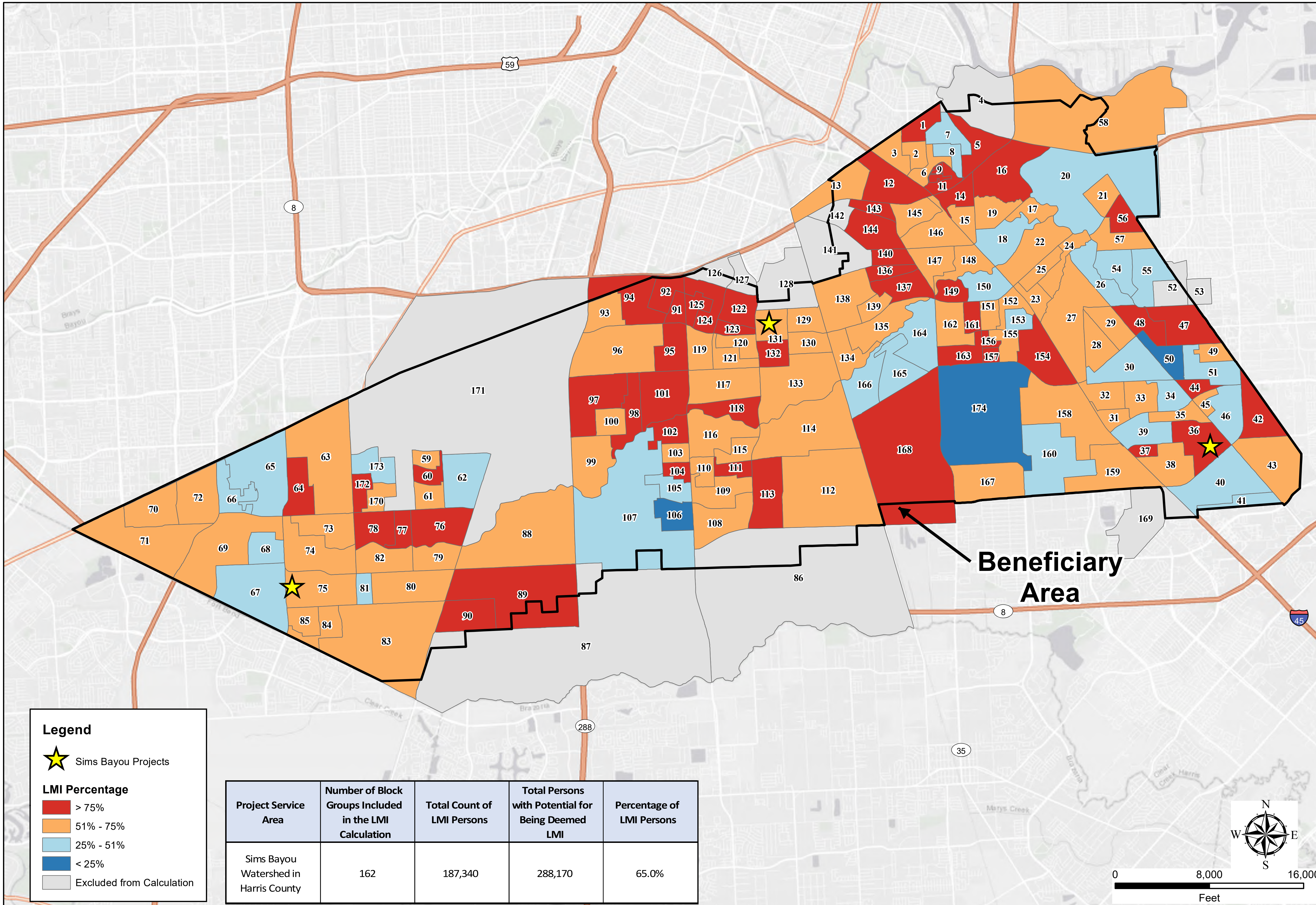
ATTACHMENT 3

PROJECT BENEFICIARY MAP



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%

Sims Bayou Watershed Beneficary Area Map

CDBG-MIT

STUART CONSULTING GROUP

FN PROJECT NO. SCG17357
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

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT
2
(1 of 2)

Sims Bayou Watershed Beneficiary Area Table

STUART CONSULTING GROUP

CDBG-MIT

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	482013341003	743	743	100%	Yes	82.7%
173	482013341004	2,177	2,177	100%	Yes	26.1%
174	482019800001	32	32	100%	Yes	0.0%

FN PROJECT NO. SCG17357
DATE CREATED 9/28/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME Sims_Project_Area_Map_LMI_2
PREPARED BY AMJ

EXHIBIT

2

(2 of 2)

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 refected 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 Hawiian 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 Hawiian 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 Hawiian/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.

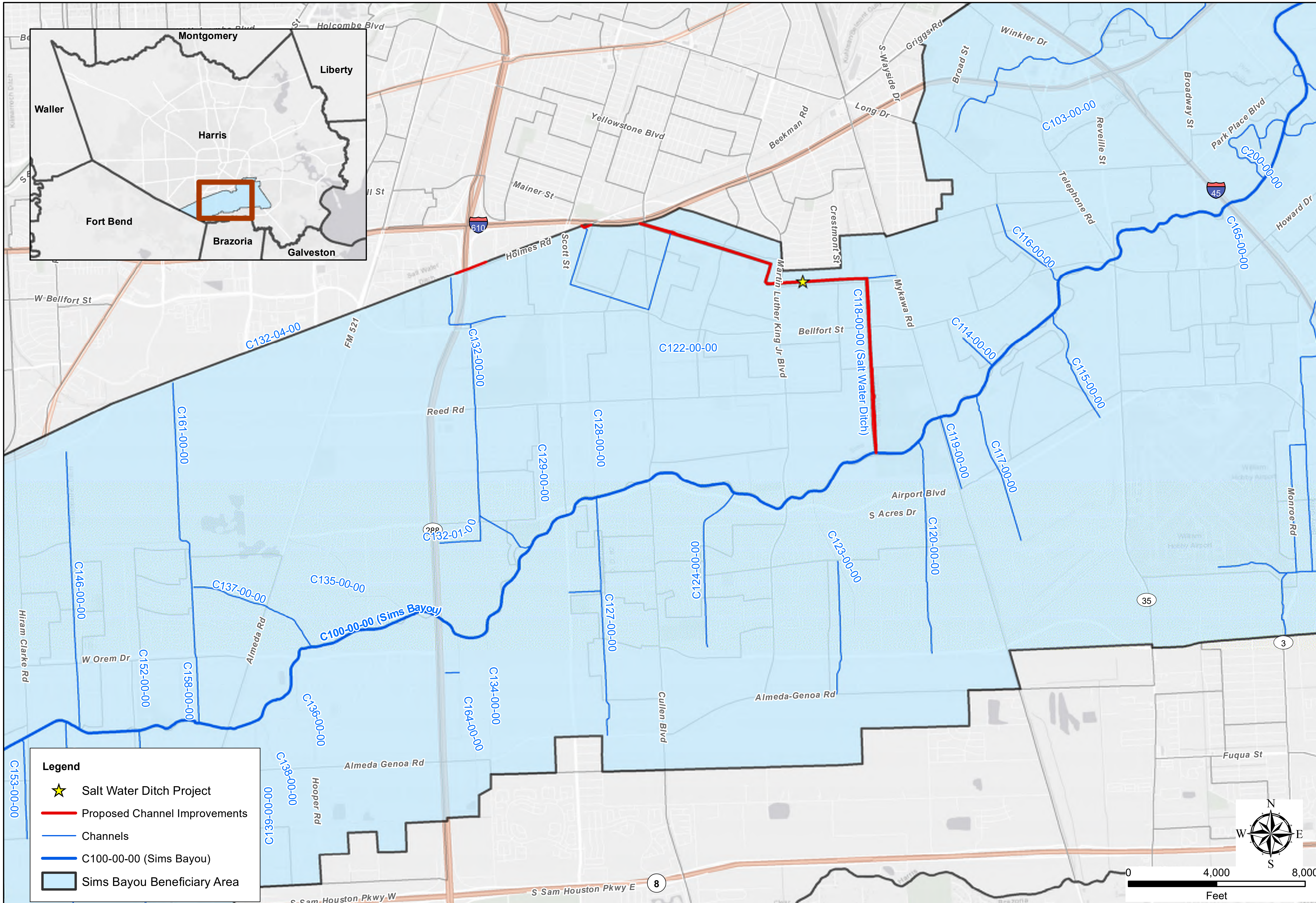
Total Population Within a Jurisdiction:
Population of Harris County, based on ACS 2014-2018 5-year estimate

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 *(numerator for LMI %)*	**187,340**
Persons with the potential for being deemed Low-, Moderate- and Middle-income *(denominator for LMI %)*	**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**.



FN PROJECT NO. SCG17357
DATE CREATED 10/2/2020
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

FREESE NICHOLS
STUART CONSULTING GROUP

EXHIBIT

4

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

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:

Harris County Flood Control District

CITY OF HOUSTON TEXAS

STATE OF TEXAS
CONNOR McCOLLOCH
120523
LICENSED PROFESSIONAL ENGINEER
February 22, 2016

Submitted By:

CivilTech Engineering, Inc.

Firm Registration No. F-382

CEI Project No. 325912.00

February 2016

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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 Bellfort 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 (CSVRs) 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 Bellfort 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 (Tc) 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 *HCFCD 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, HCFCD 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**.

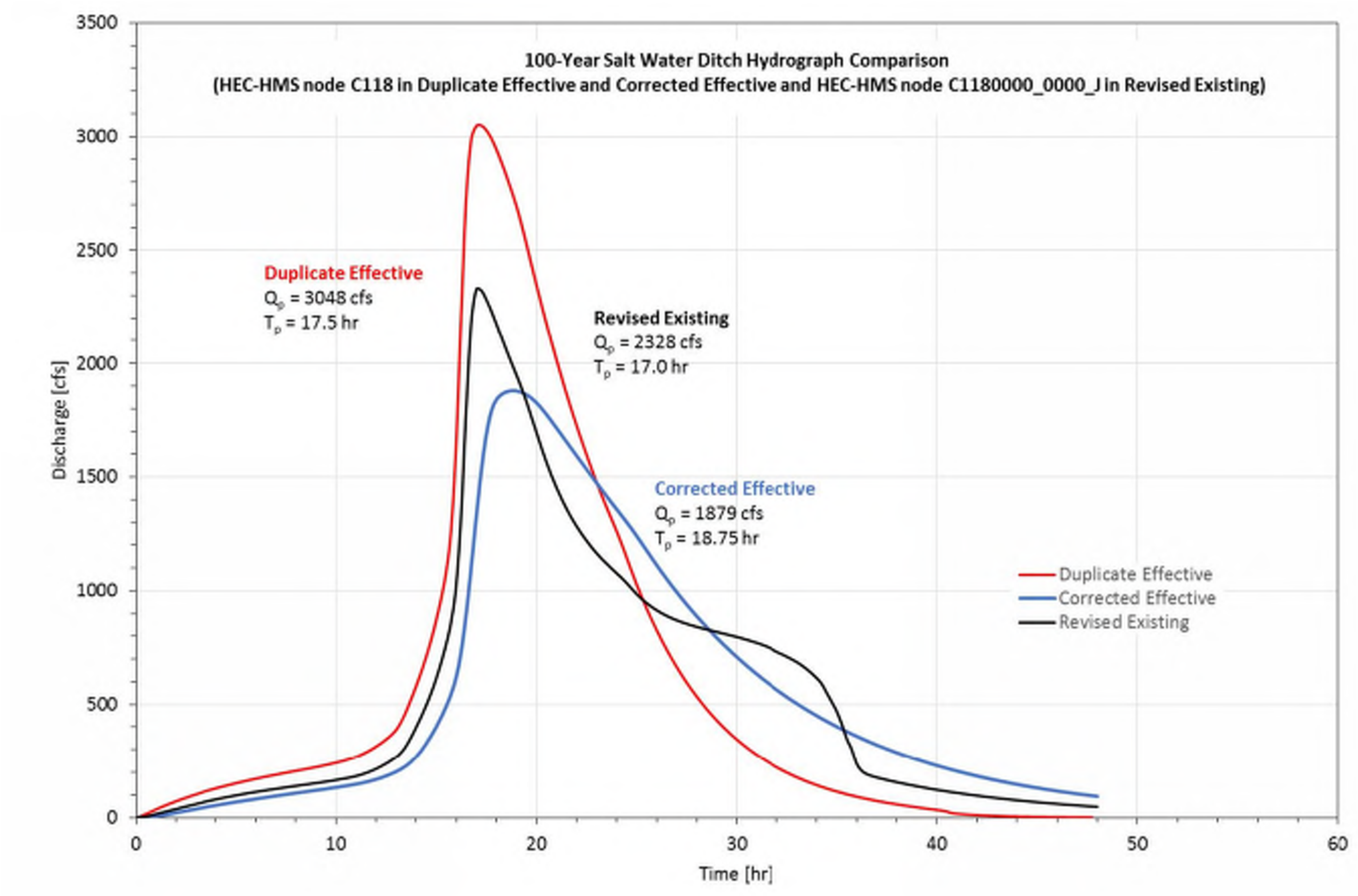


Figure 1: 100-Year Salt Water Ditch Hydrograph Comparison

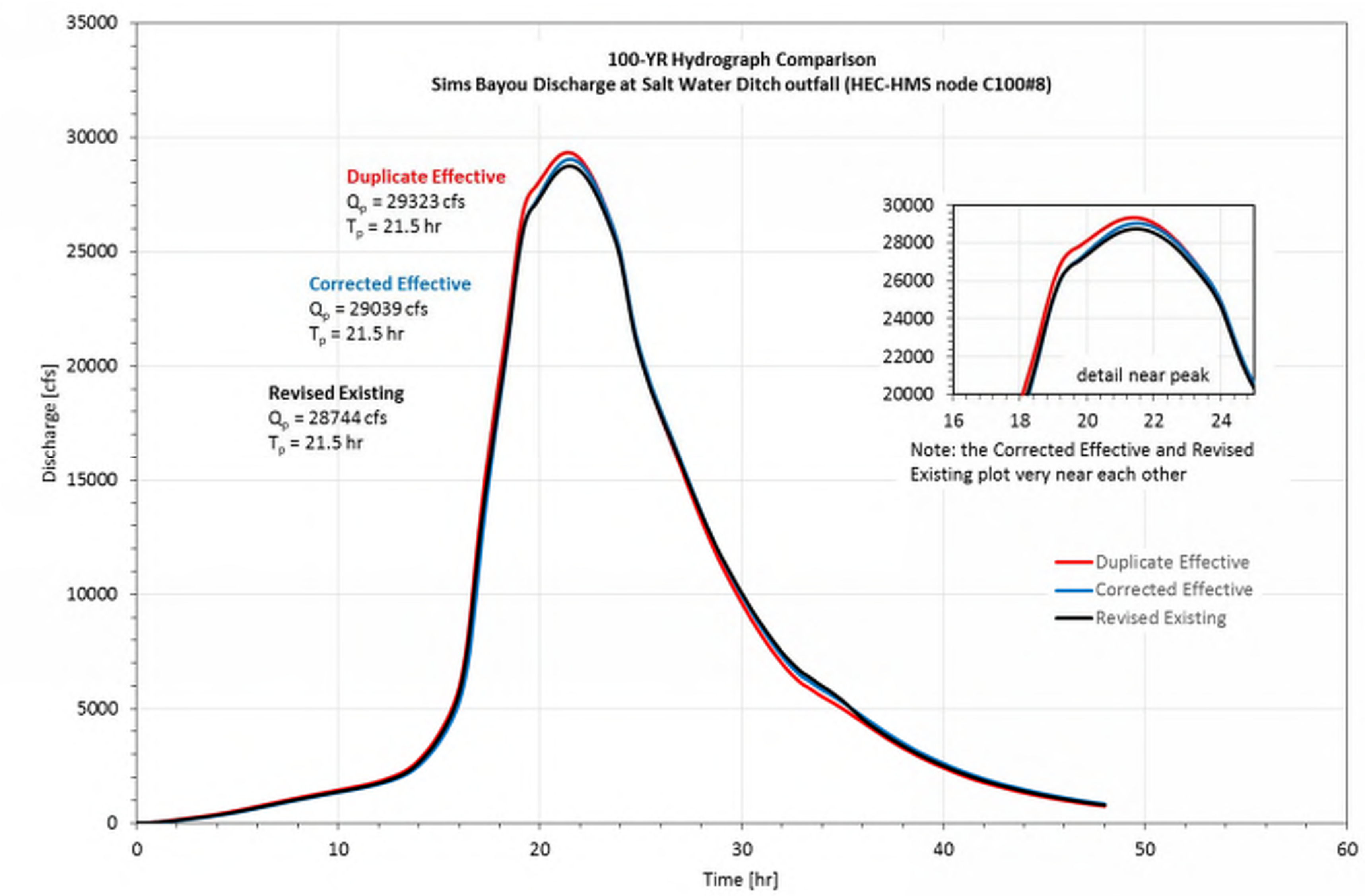


Figure 2: 100-Year Sims Bayou Hydrograph Comparison

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, HCFCD 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 Bellfort 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 Bellfort 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 (CSVRs) 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

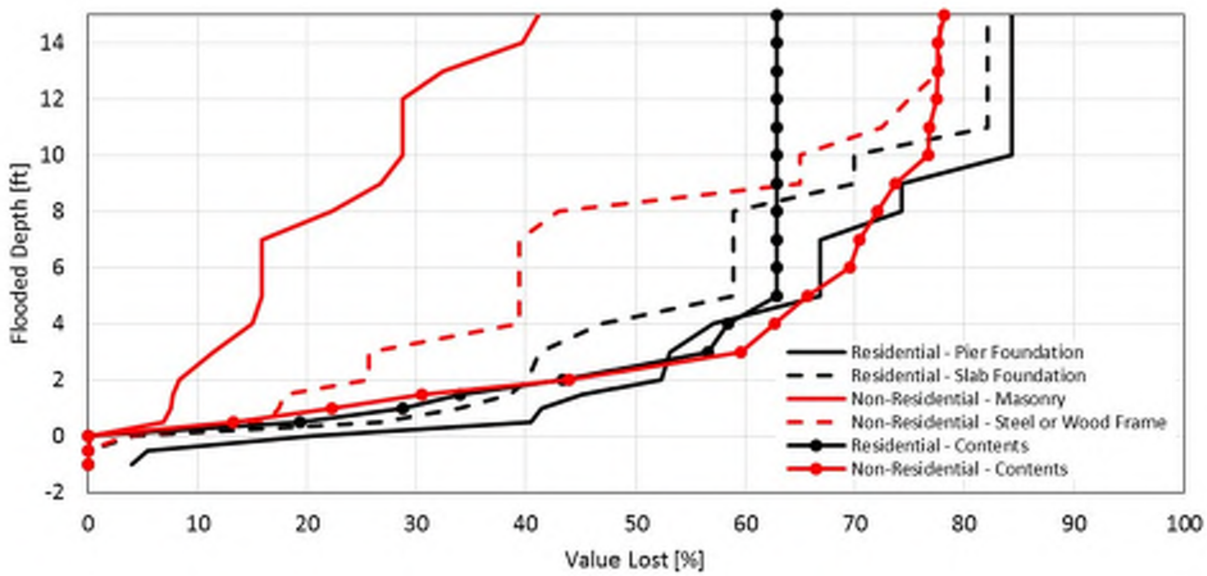


Figure 3: Overview of Depth-Damage Relationships

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 Bellfort 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%.

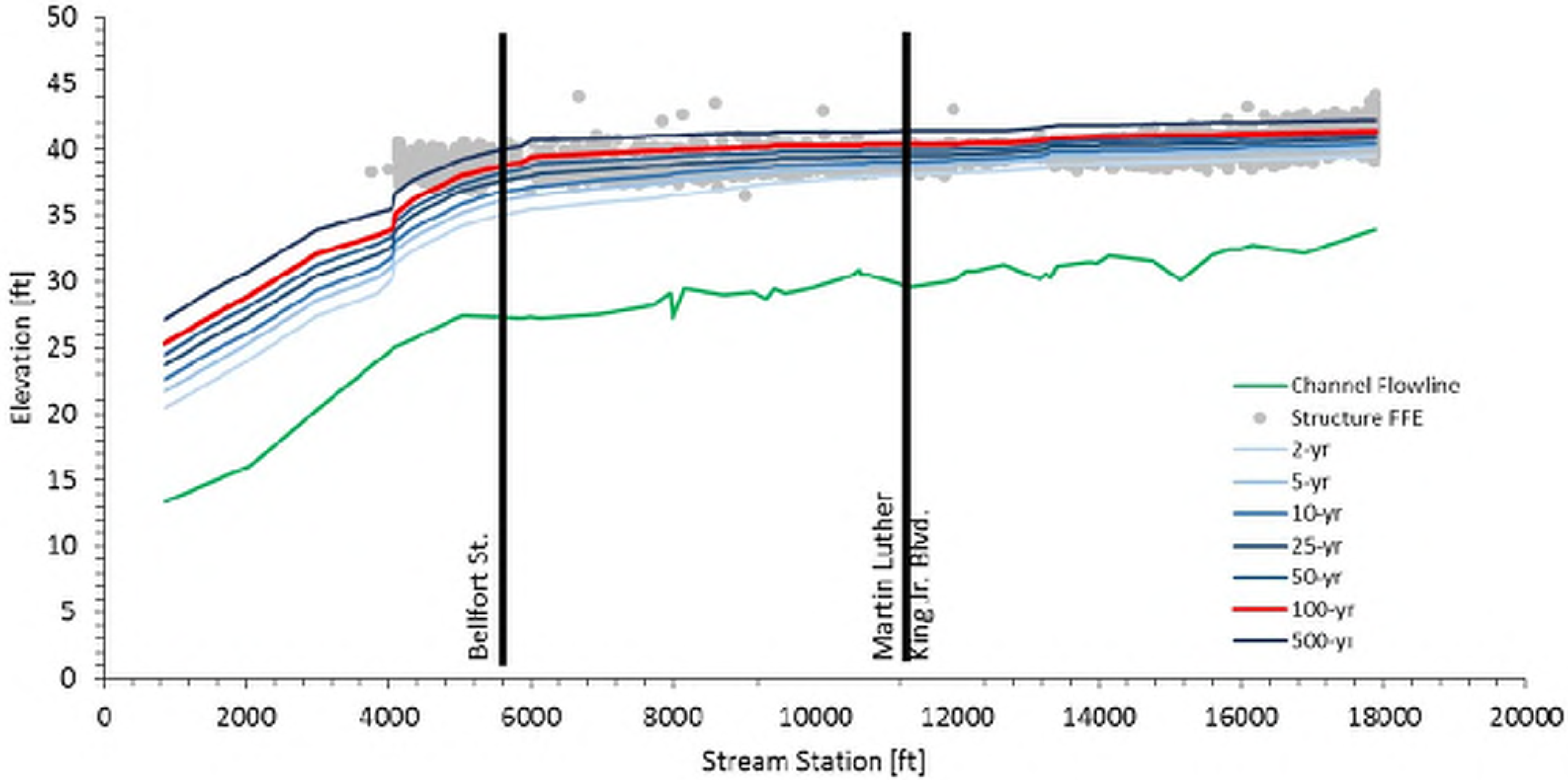


Figure 4: Water Surface Profile for Various Flood Frequencies Relative to the Finished Floor Elevation of Structures along Salt Water Ditch

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) HCFCD 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 HCFCD 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. HCFCD rain gage 360 (C100 Sims Bayou @ Martin Luther King Road) was used in conjunction with the HCFCD 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		

[1]These sources only report homes; no non-residential structures included
[2]Numbers from FEMA repetitive loss claims
[3]Numbers from City of Houston field survey data
[4]Numbers 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 HCFCD immediate flood report estimated more than 2,200 flooded homes in the upper reach of the Salt Water Ditch subwatershed (C118). The HCFCD 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 HCFCD, 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 HCFCD 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: [1]Channel 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

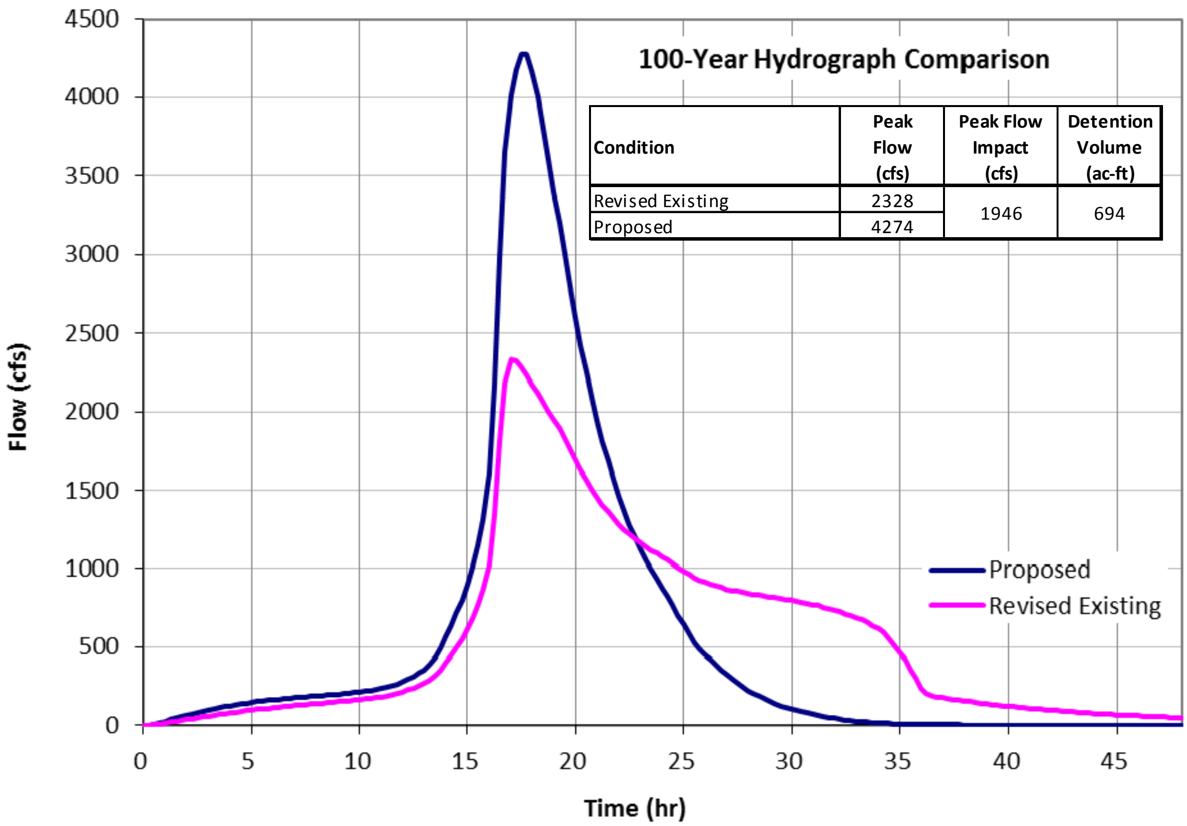
As noted, one of the objectives for proposed improvements was the minimization of parcel acquisitions. However, the existing ROW is limited such that acquisition is inevitable. One potential alternative to limit the number of acquisitions is to use a closed conduit drainage system in lieu of channel 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.



Condition	Peak Flow (cfs)	Peak Flow Impact (cfs)	Detention Volume (ac-ft)
Revised Existing	2328	1946	694
Proposed	4274		

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**.

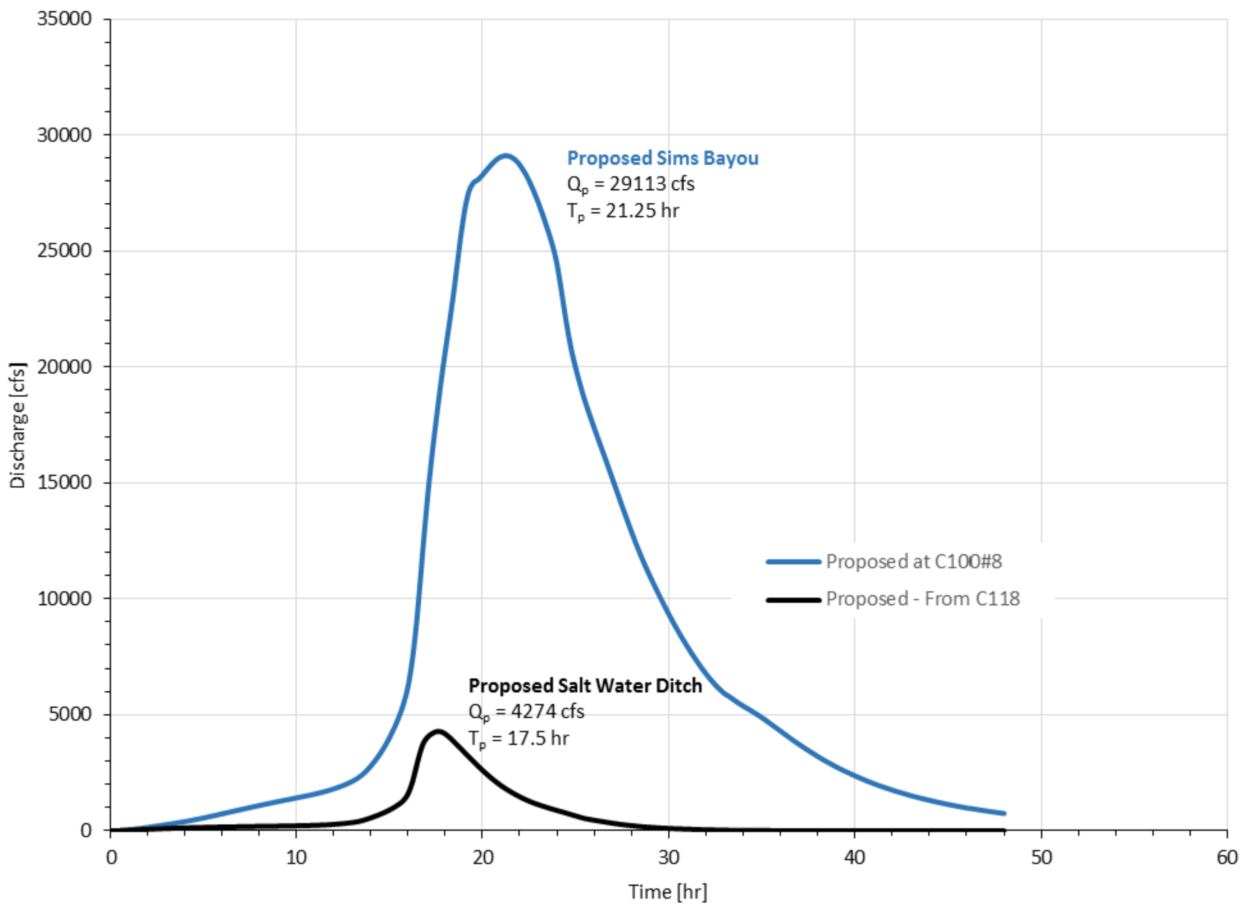


Figure 7: Comparison of Sims Bayou 100-Year Hydrograph

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

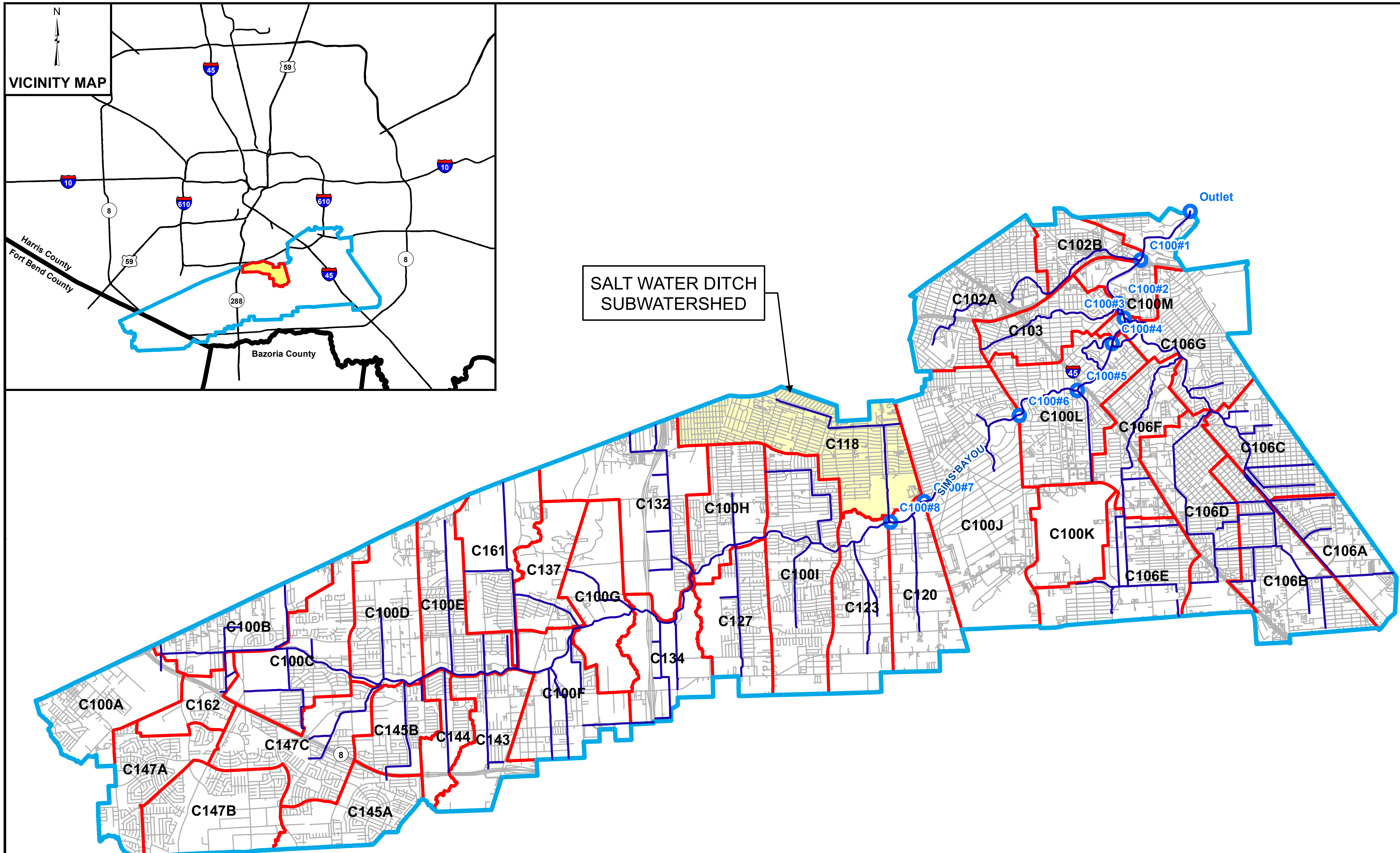
5.10 Project Funding Options

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



N

0 1 2 mi

1 inch = 2 miles

Legend

- Streams
- HEC-HMS Node
- Sims Bayou Watershed Boundary
- Subwatershed Boundary
- Salt Water Ditch Subwatershed

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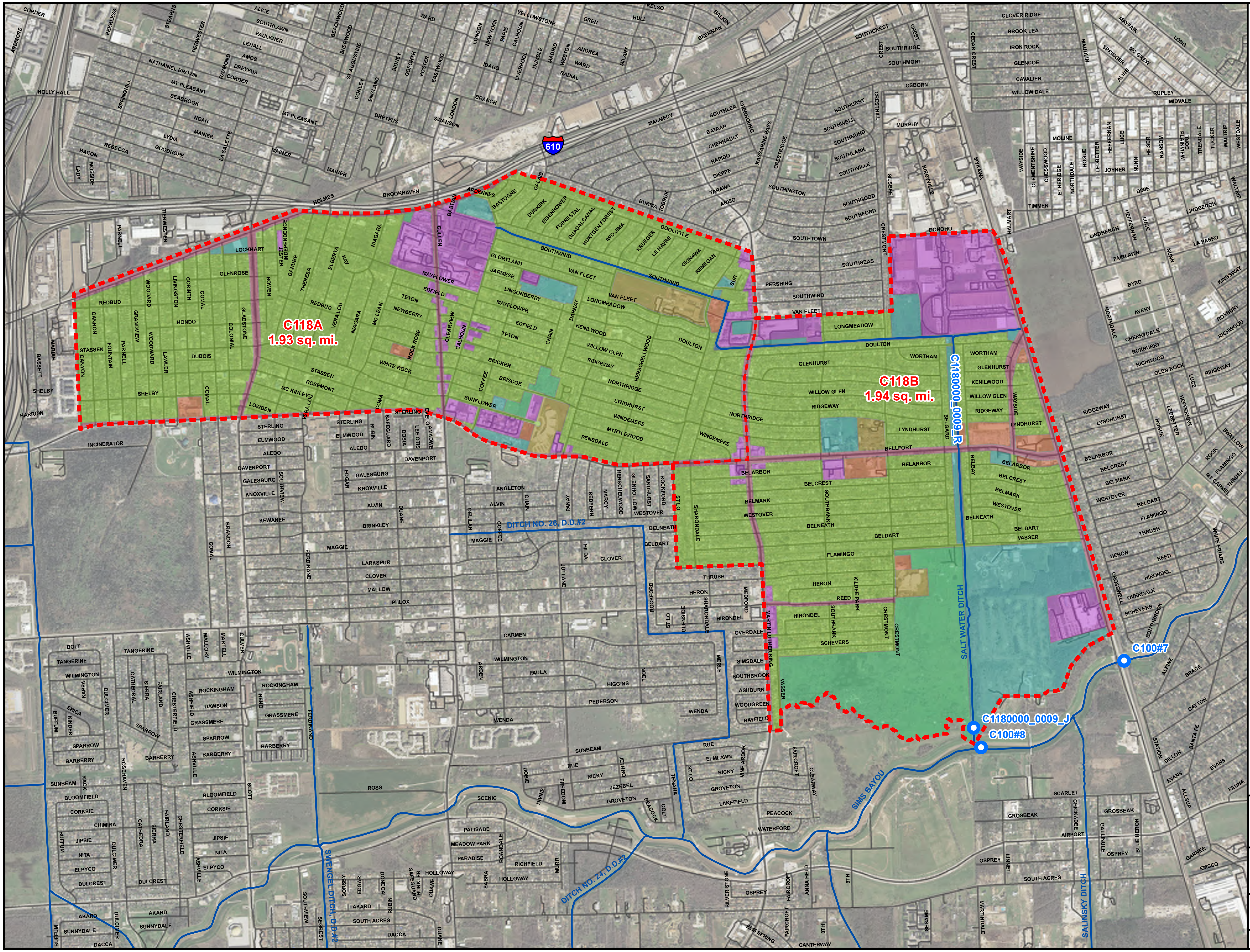
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

SIMS BAYOU WATERSHED

NOVEMBER 2015	Job No: 325912	EXHIBIT 1



N

0 900 1,800 ft

1 inch = 1,800 feet

Legend

- HEC-HMS Node
- Streams
- Salt Water Ditch Subareas

HCFCD 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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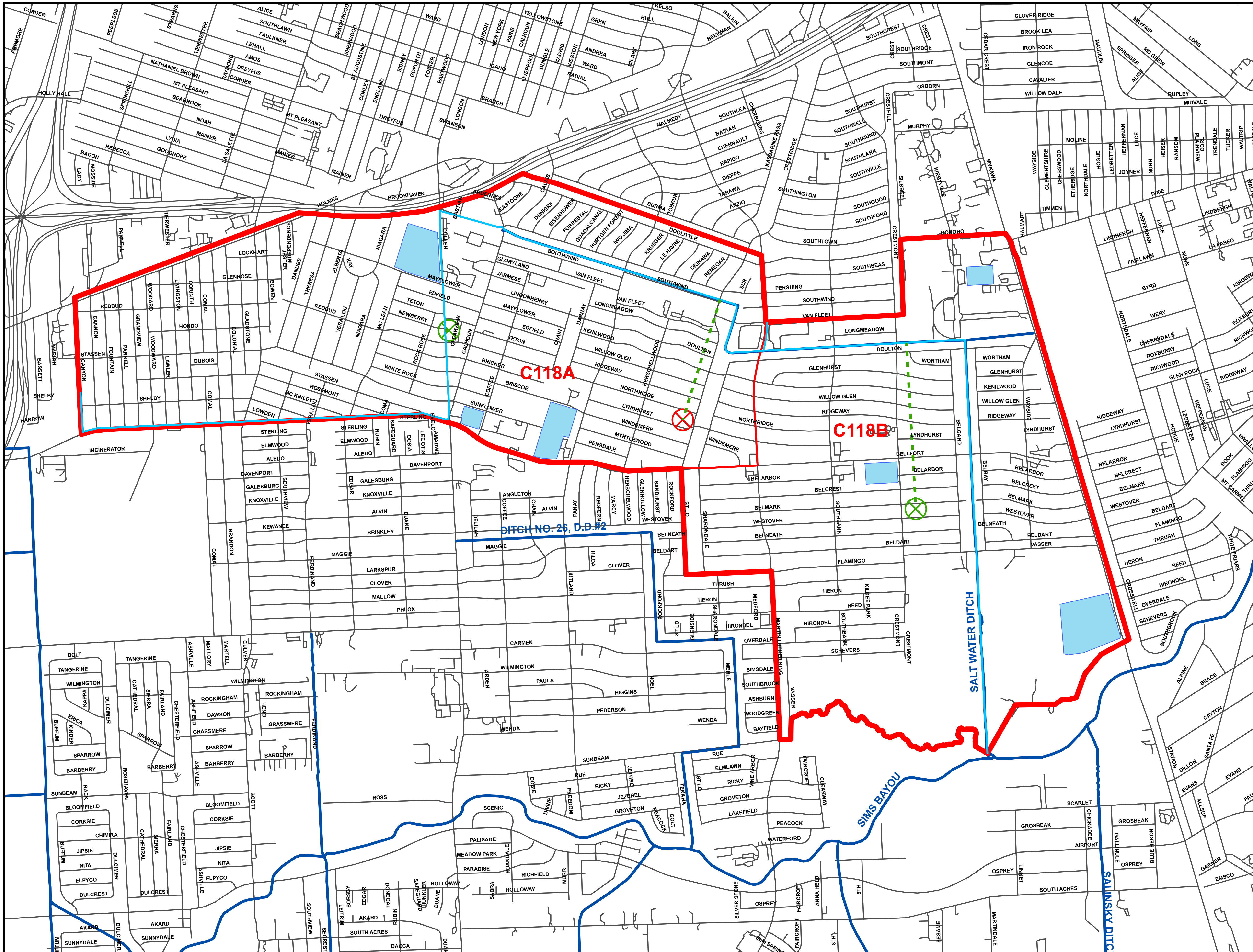
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

SALT WATER DITCH SUBWATERSHED & LAND USE

NOVEMBER 2015 | Job No: 325912 | EXHIBIT 2



N

0 900 1,800 ft

1 inch = 1,800 feet

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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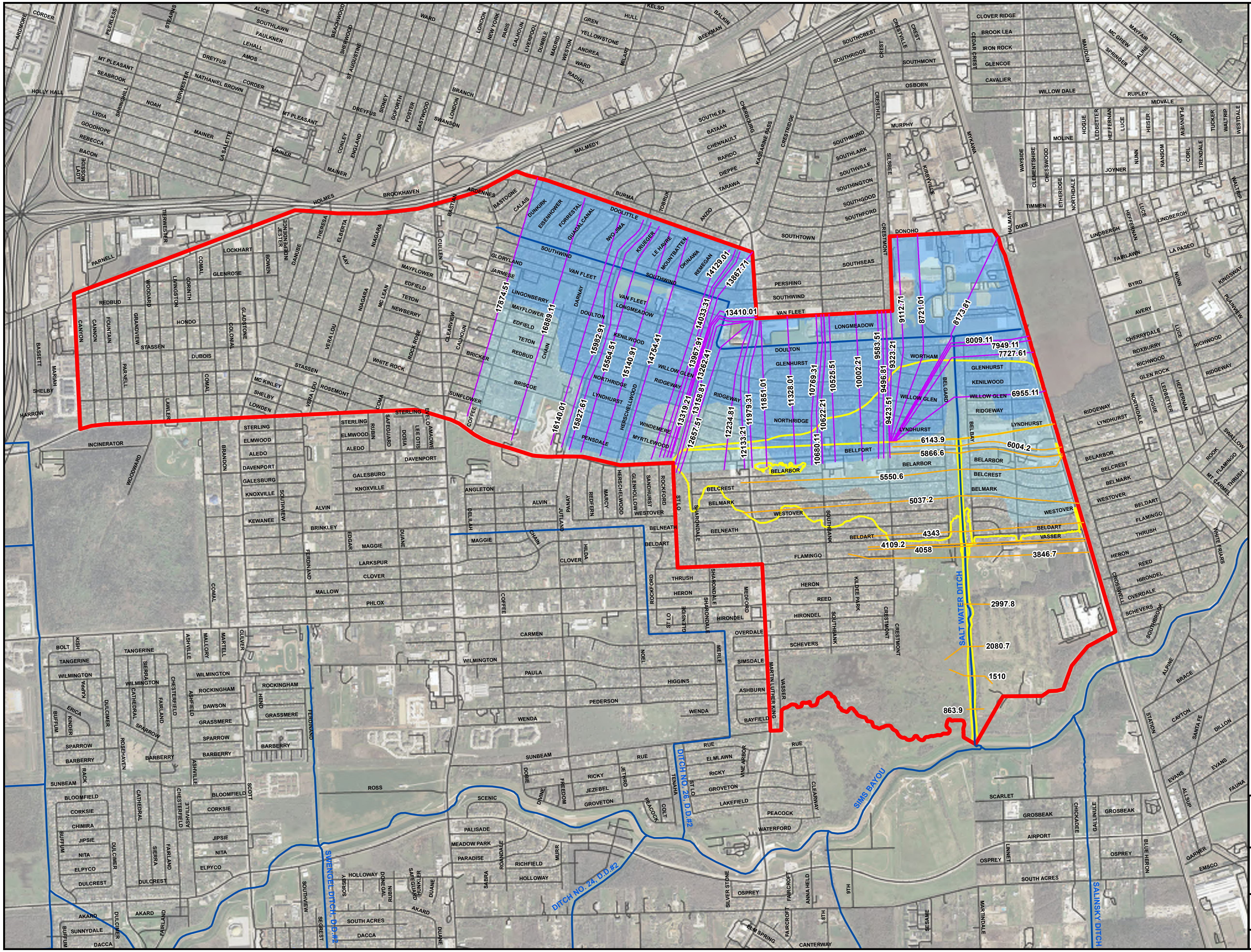
PHYSICAL WATERSHED CHARACTERISTICS

NOVEMBER 2015 | Job No: 325912 | EXHIBIT 3



N

0 900 1,800 ft

1 inch = 1,800 feet

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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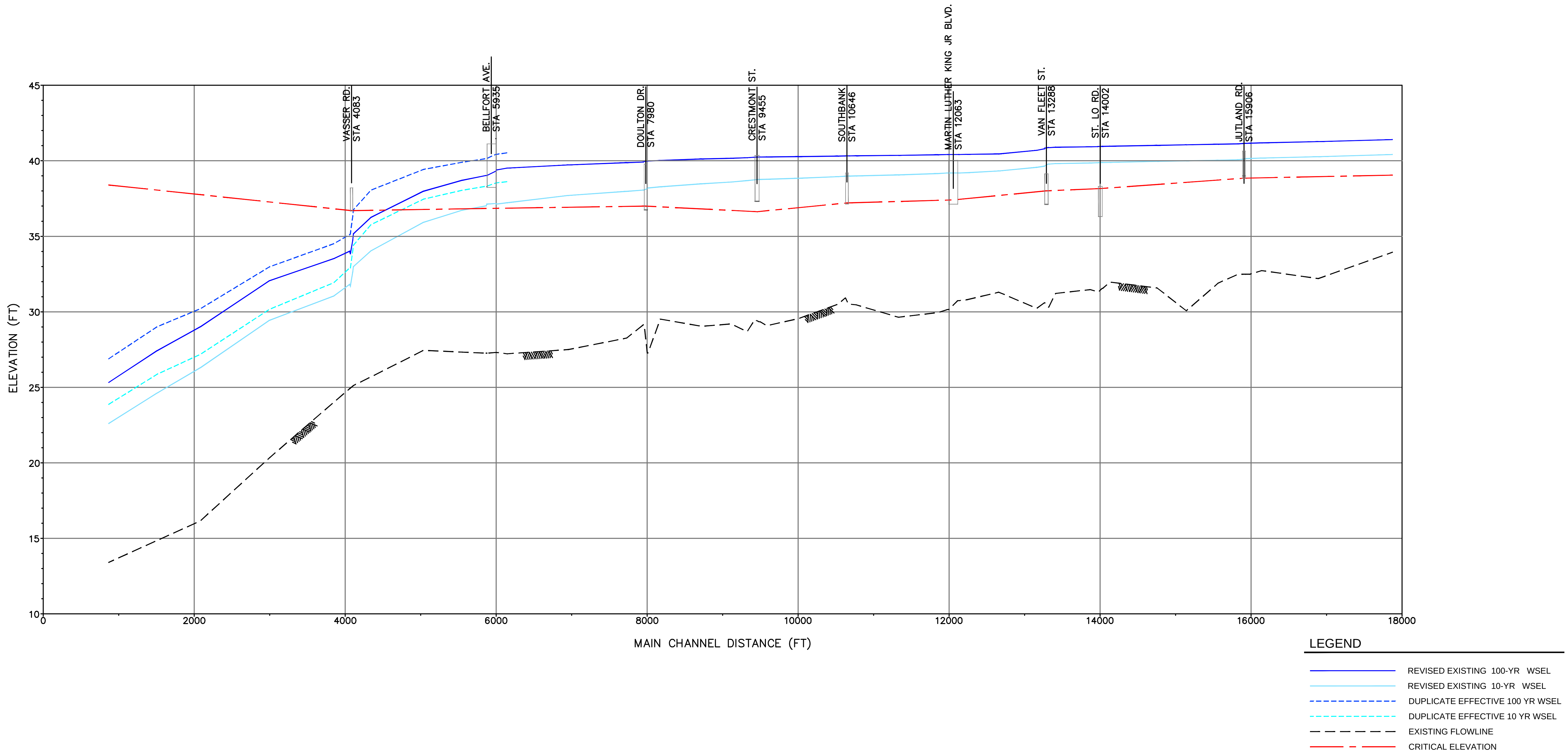
HEC-RAS CROSS SECTIONS & REVISED FLOODPLAIN

NOVEMBER 2015	Job No: 325912	EXHIBIT 4



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FEASIBILITY STUDY FOR SALT WATER DITCH
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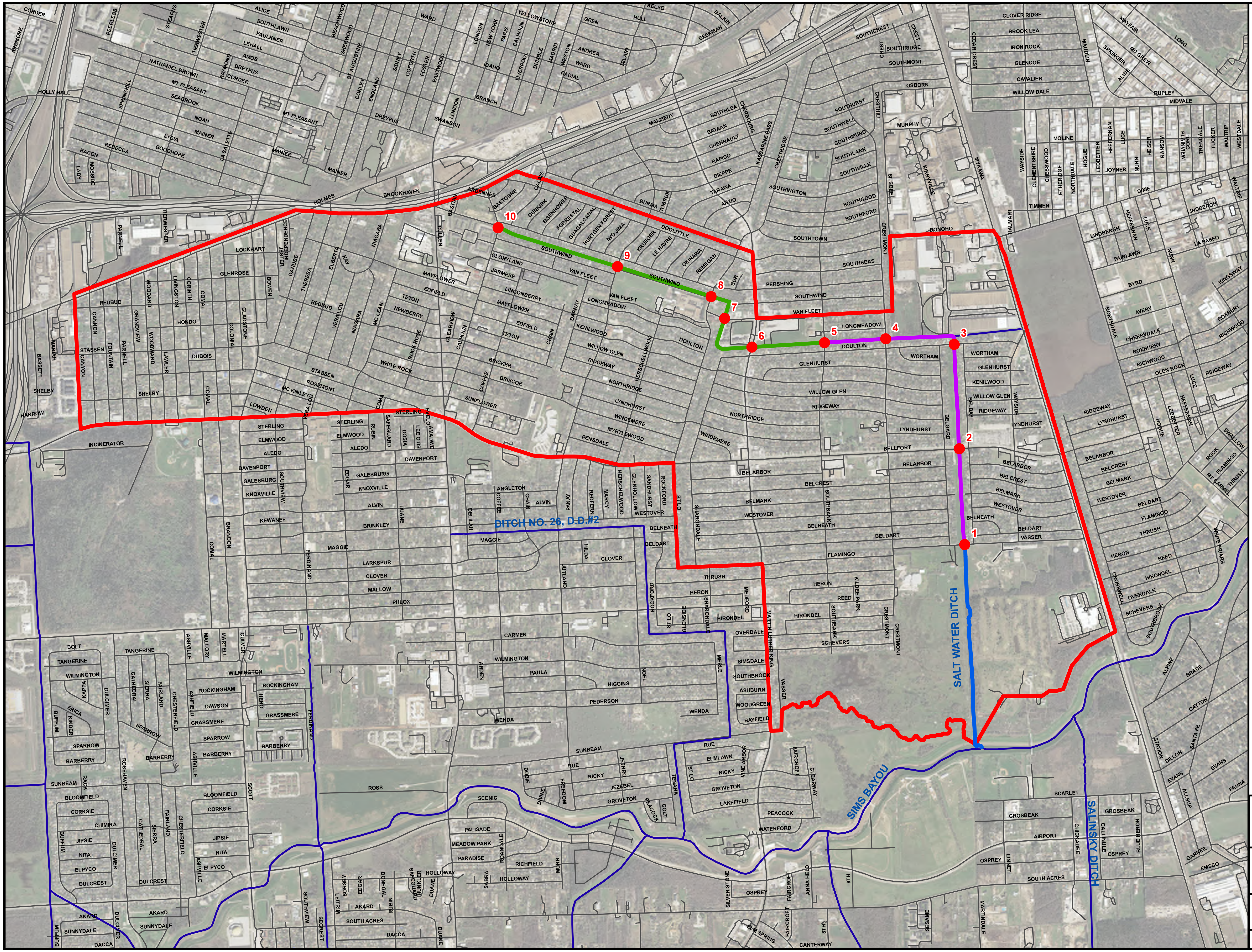
EXISTING WATER SURFACE PROFILE

Date: NOV. 2015

Exhibit No: 5



N

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	Bellfort
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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FEASIBILITY STUDY FOR SALT WATER DITCH
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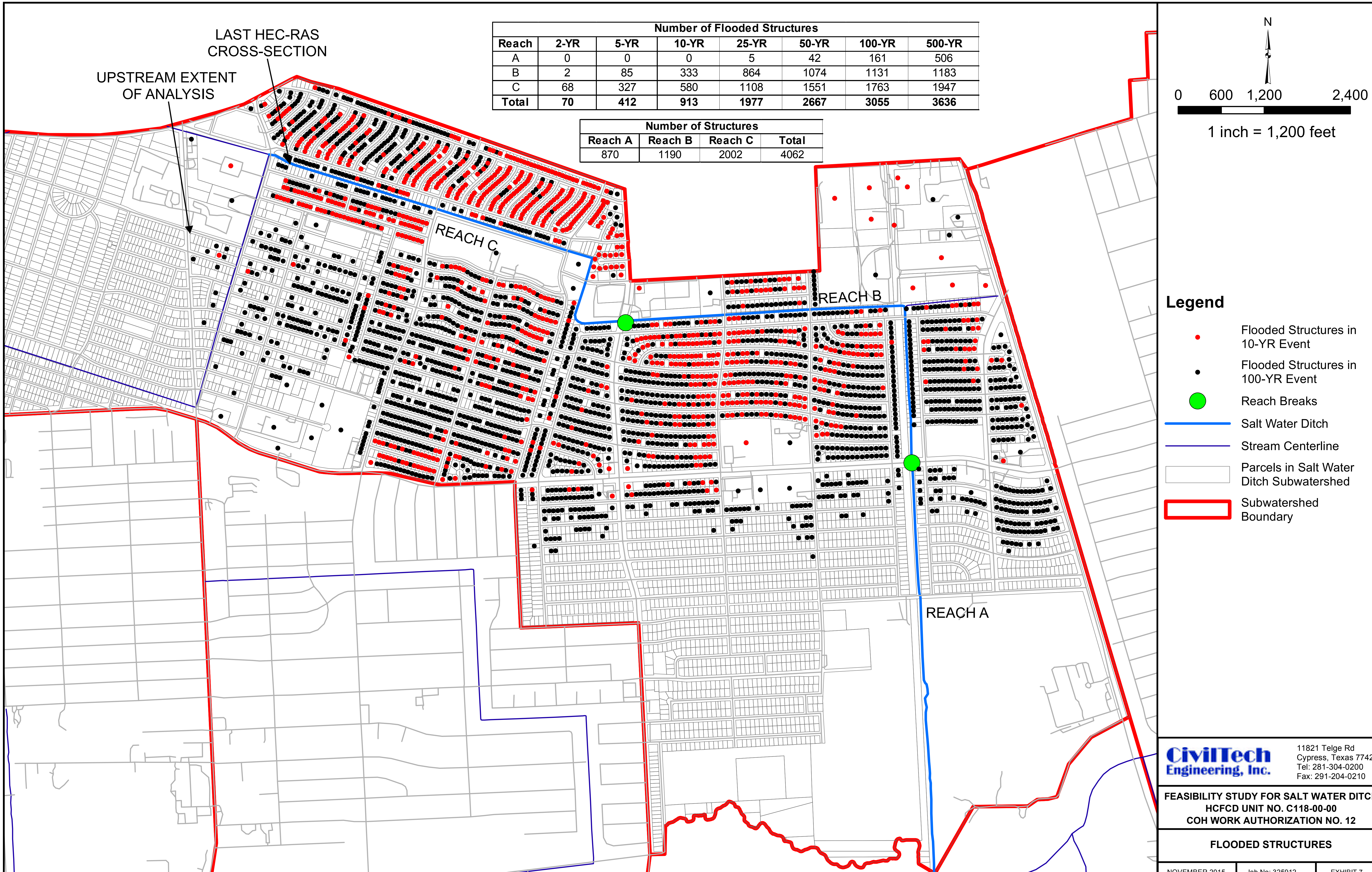
SALT WATER DITCH
CHANNEL CAPACITY

NOVEMBER 2015 | Job No: 325912 | EXHIBIT 6

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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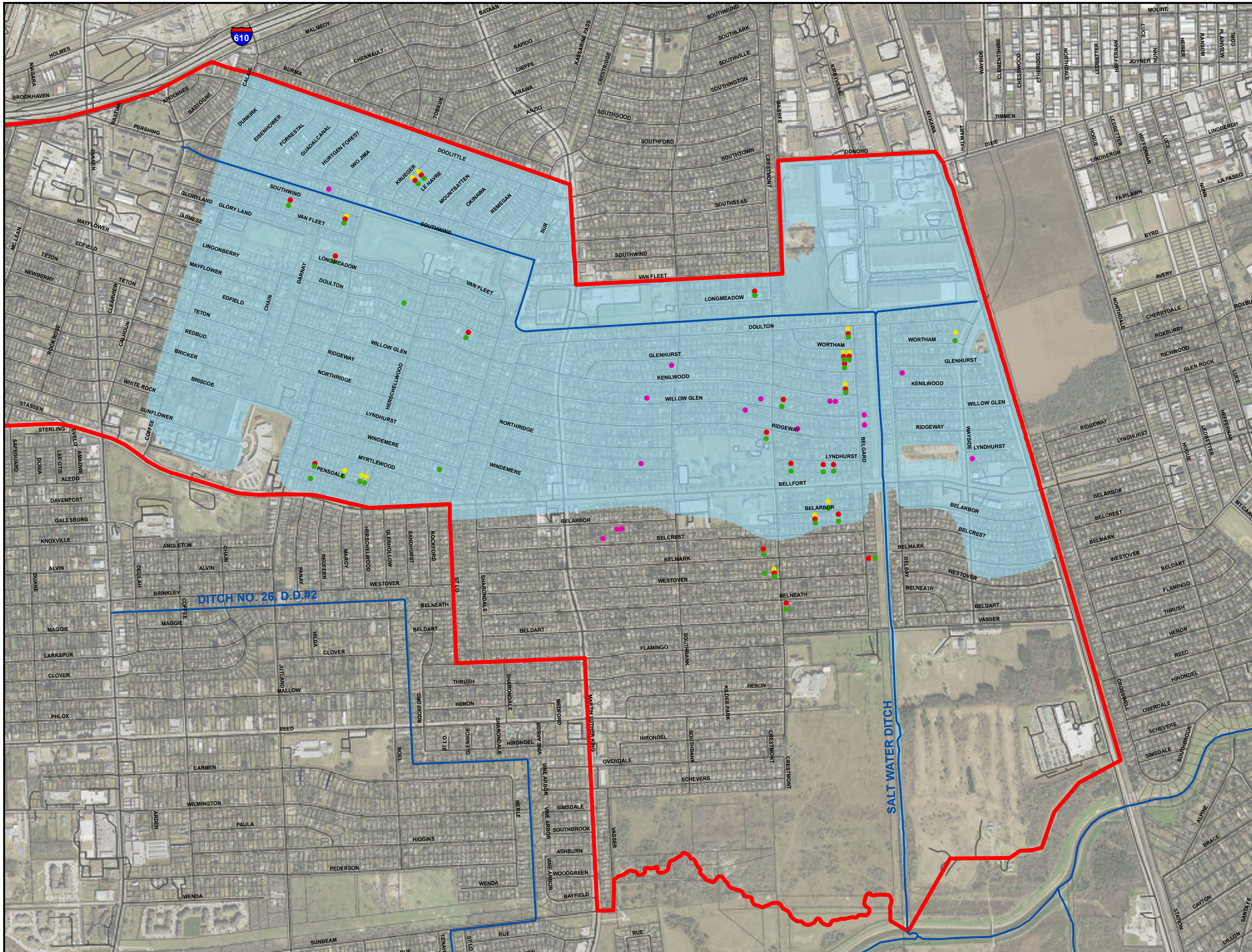
FLOODED STRUCTURES

NOVEMBER 2015	Job No: 325912	EXHIBIT 7



N

0 600 1,200 ft

1 inch = 1,200 feet

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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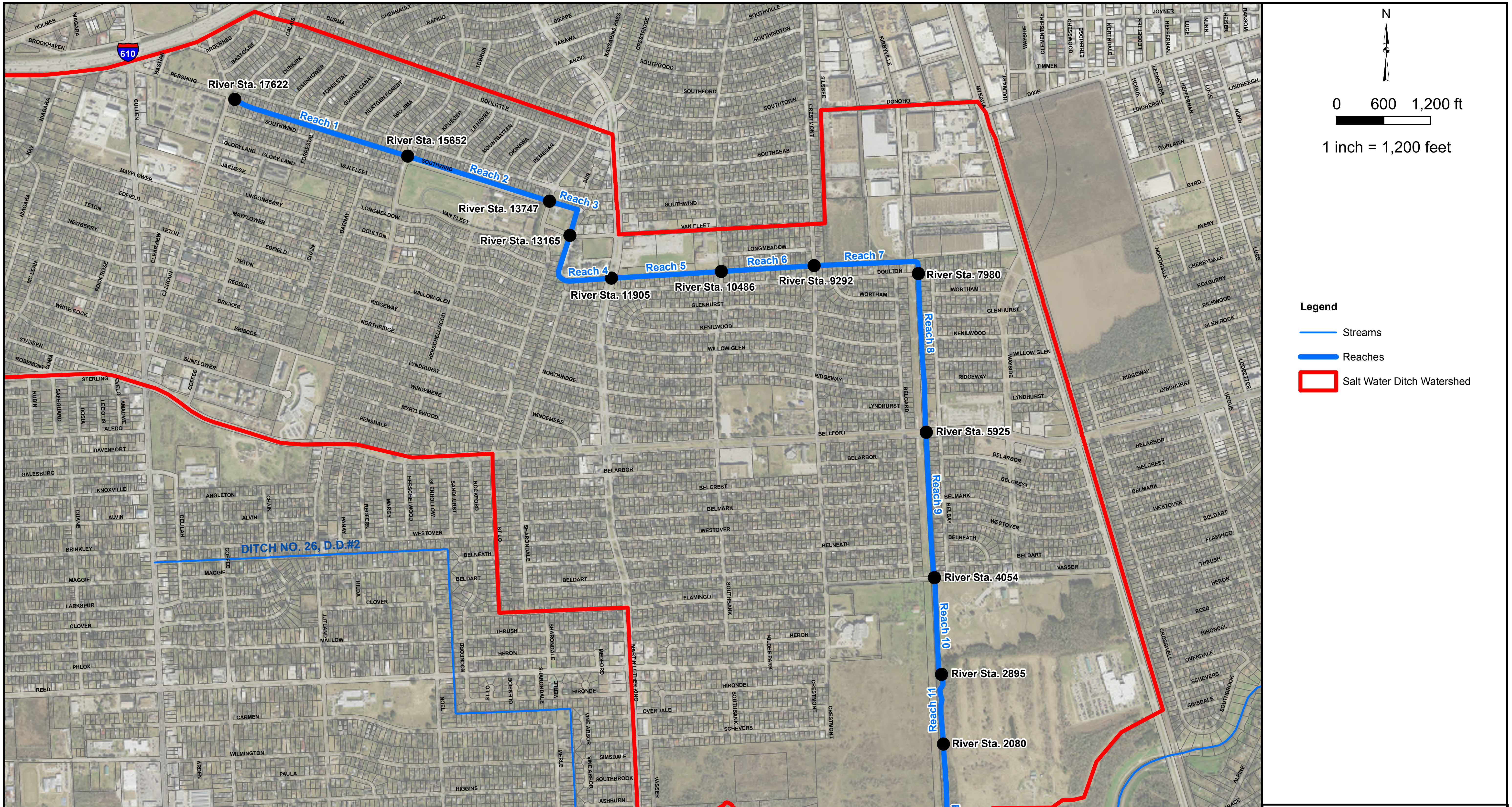
DOCUMENTED FLOOD LOSSES

NOVEMBER 2015	Job No: 325912	EXHIBIT 8



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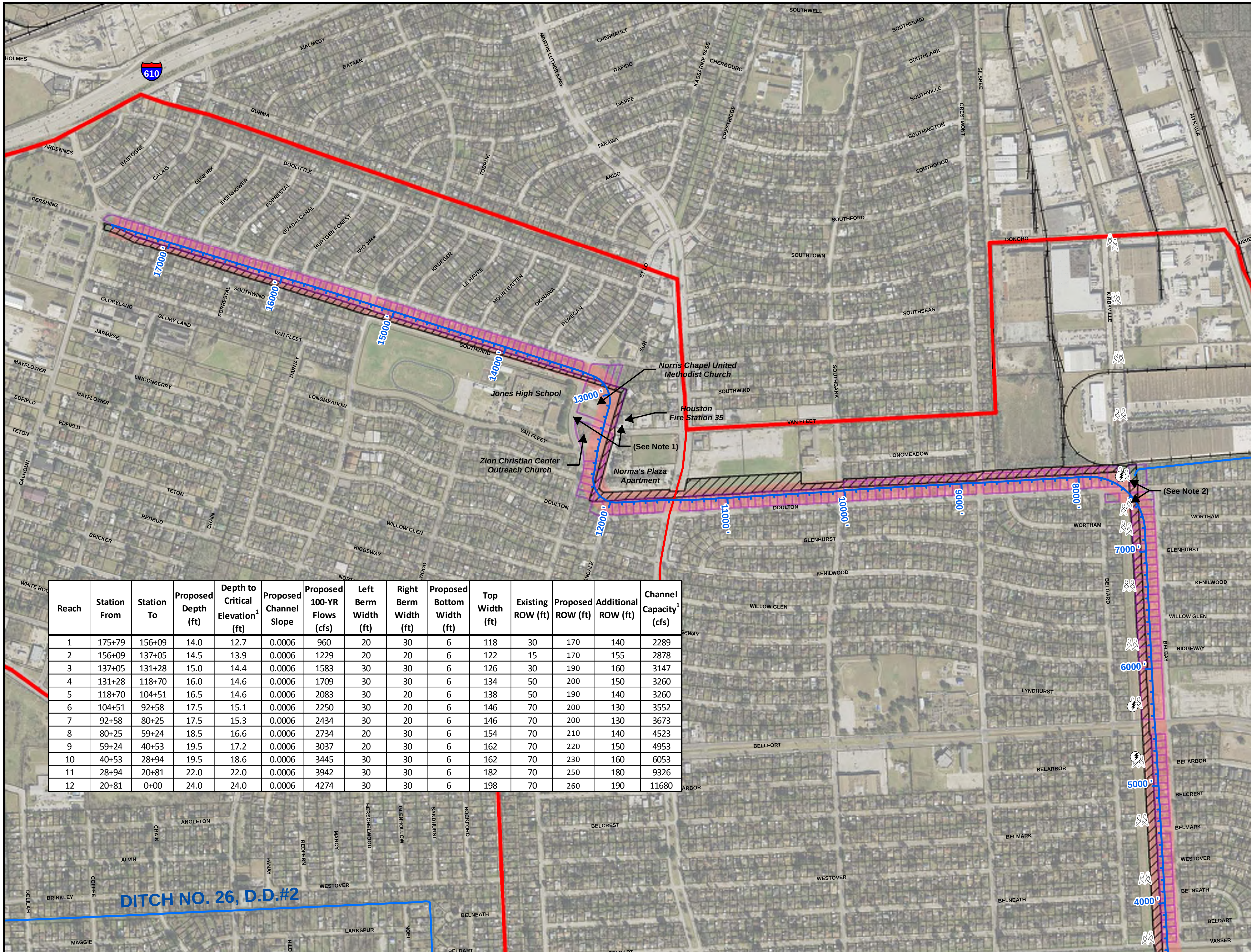
SALT WATER DITCH REACH SEGMENTS

NOVEMBER 2015	Job No: 325912	EXHIBIT 9



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

N

0 400 800 ft

1 inch = 800 feet

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

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.

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FEASIBILITY STUDY FOR SALT WATER DITCH
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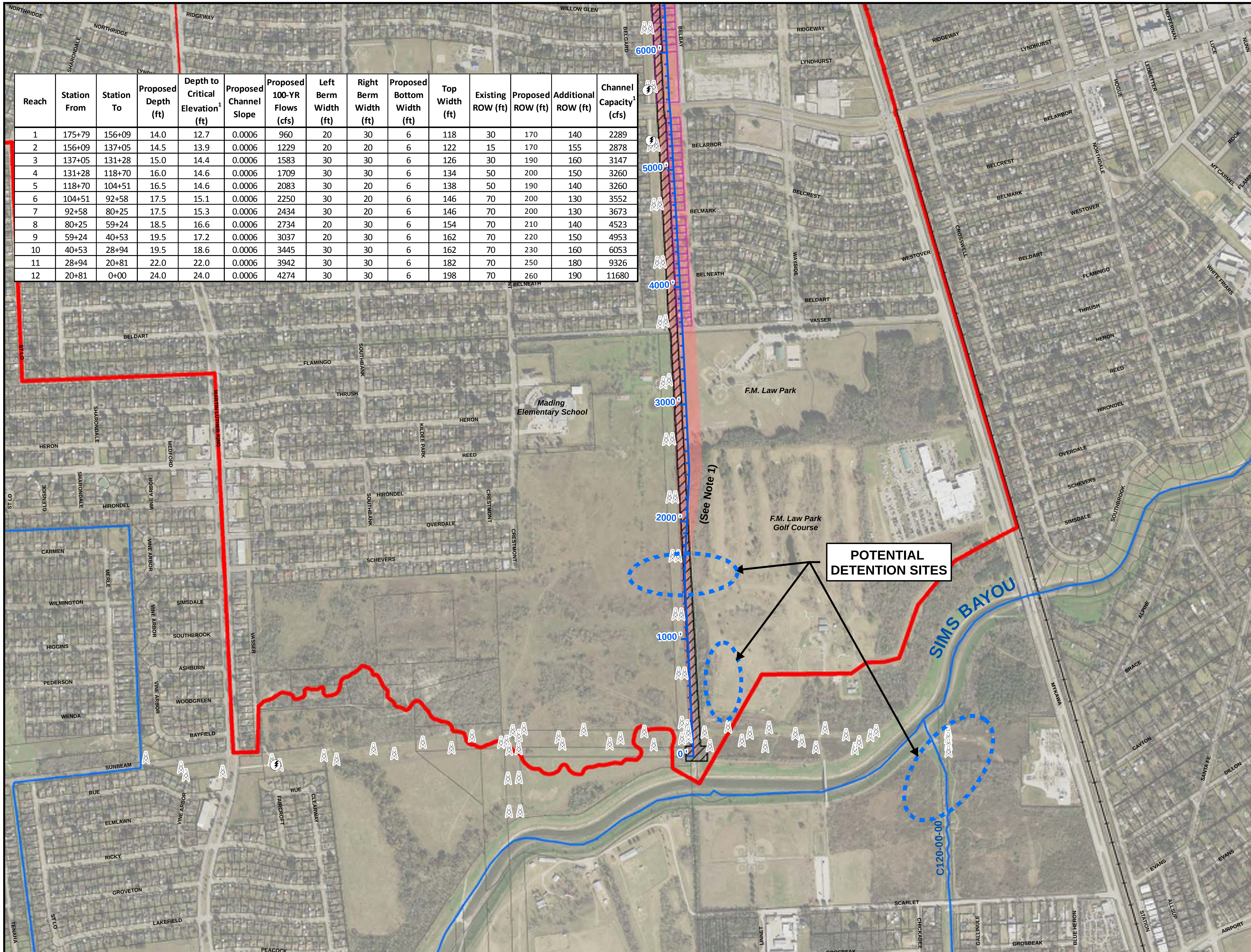
ALTERNATIVE 1 LAYOUT

NOVEMBER 2015	Job No: 325912	EXHIBIT 10a

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



N

0 400 800 ft

1 inch = 800 feet

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.

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FEASIBILITY STUDY FOR SALT WATER DITCH
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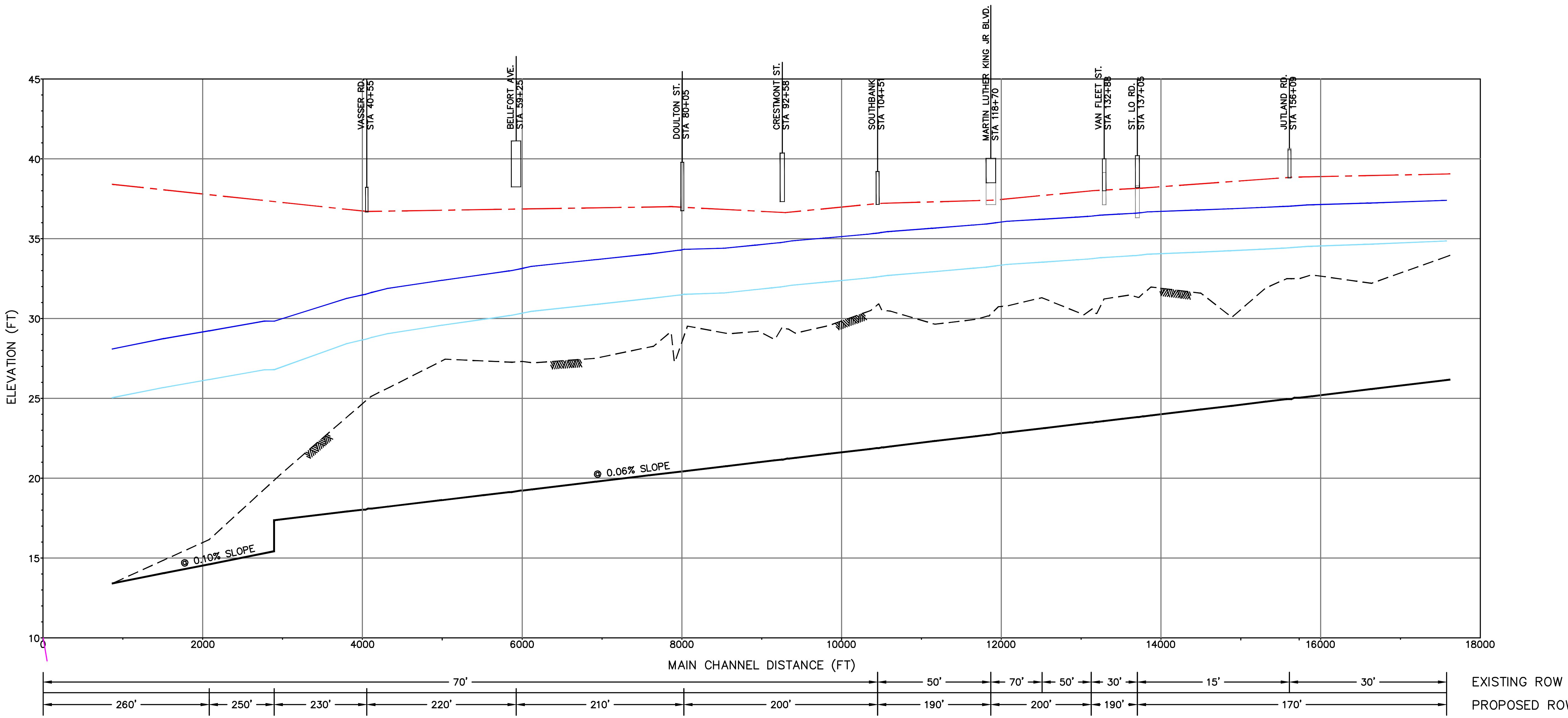
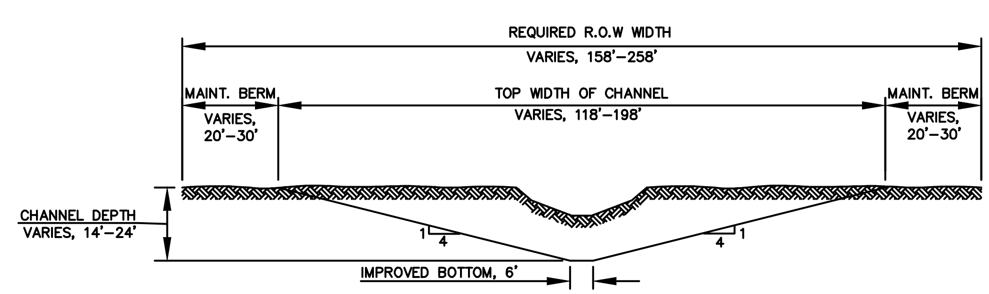
ALTERNATIVE 1 LAYOUT

NOVEMBER 2015	Job No: 325912	EXHIBIT 10b



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	40.65	40.65	38.90	38.90
St Lo Street	137+05	1	130	34	36.59	38.22	39.50	36.31	38.20
Van Fleet Street	131+28	1	130	34	36.40	39.14	39.14	37.12	38.00
Martin Luther King Jr. Blvd.	118+70	1	140	210	35.97	40.03*	40.03	37.10*	38.50
Southbank Street	104+51	1	140	34	35.30	39.20	39.20	37.14	37.14
Crestmont Street	92+58	1	150	34	34.75	40.36	40.36	37.32	37.32
Doulton Drive	80+25	1	240	34	34.31	39.78	39.78	36.75	36.75
Bellfort Avenue	59+24	2	160	42	33.15	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 - 7' x7' RCBs



LEGEND

- PROPOSED 100-YR WSEL
- PROPOSED 10-YR WSEL
- PROPOSED FLOW LINE
- EXISTING FLOW LINE
- CRITICAL ELEVATION

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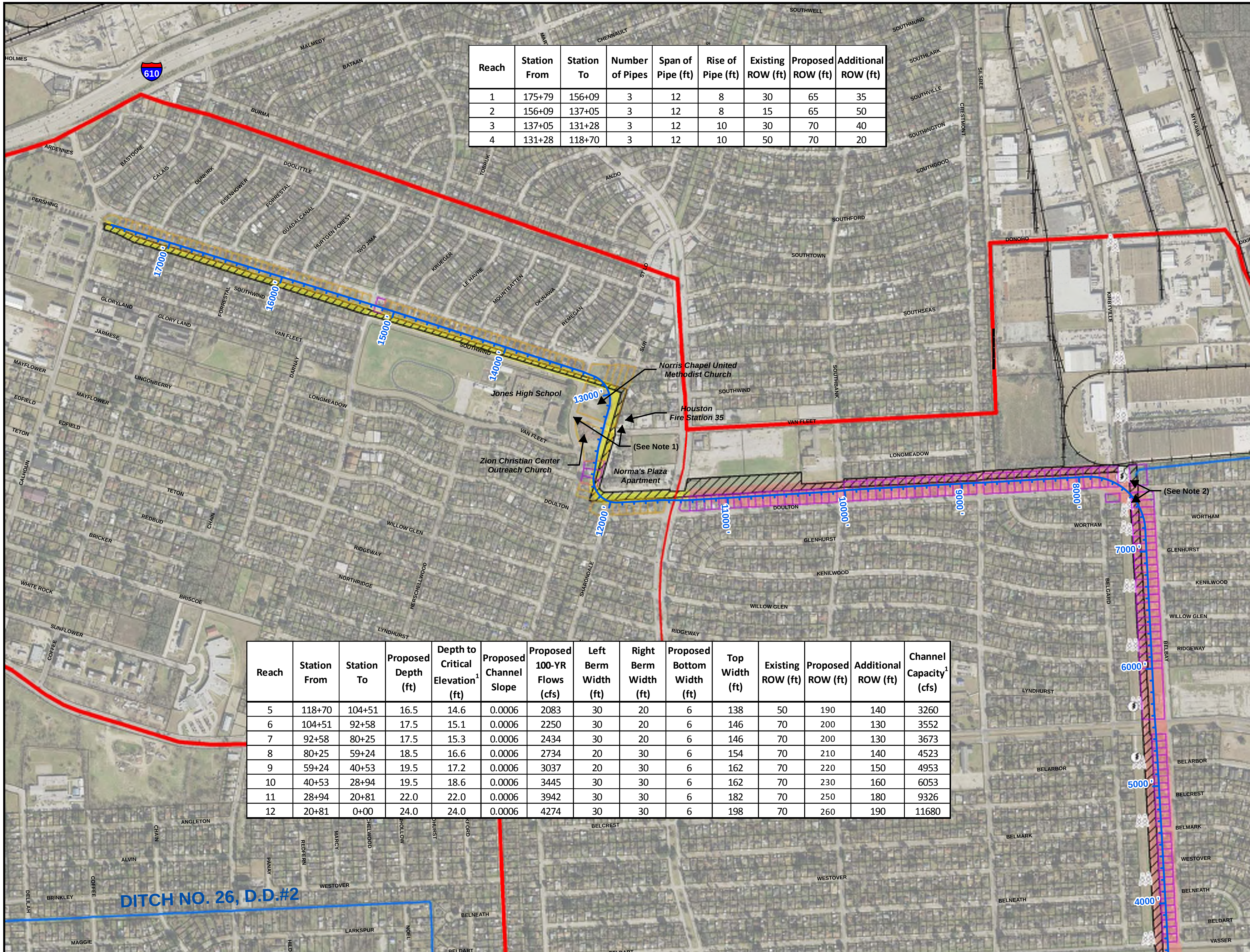
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 1 WATER SURFACE PROFILE

Date: NOV. 2015

Exhibit No: 11



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
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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

N

0 400 800 ft

1 inch = 800 feet

Legend

- Streams
- Railroads
- Proposed Storm Sewer
- Proposed Channel
- Existing Channel Right-Of-Way
- Partial Parcel Acquistions
- 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.

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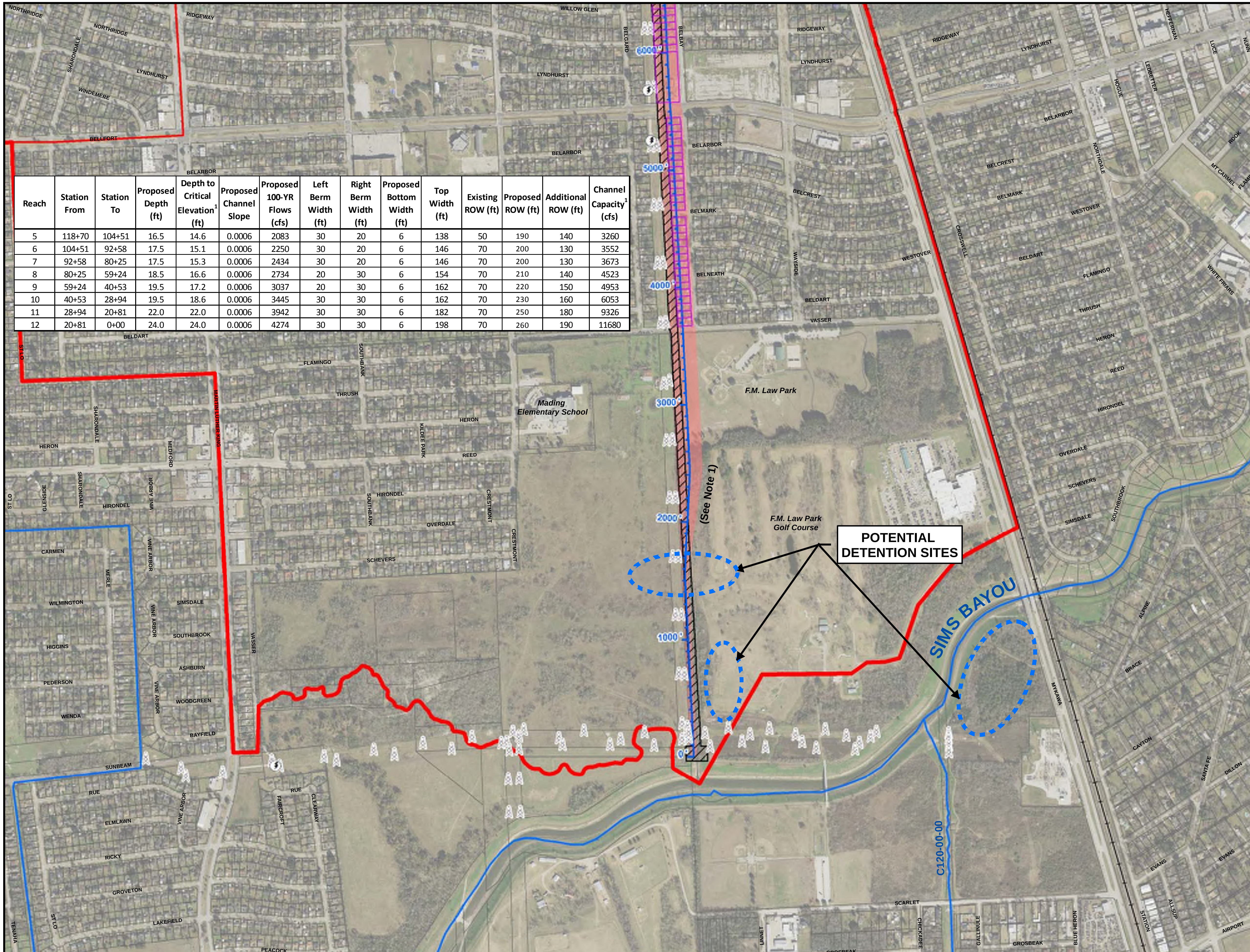
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 2 LAYOUT

NOVEMBER 2015 | Job No: 325912 | EXHIBIT 12a

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 Acquistions
- 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.

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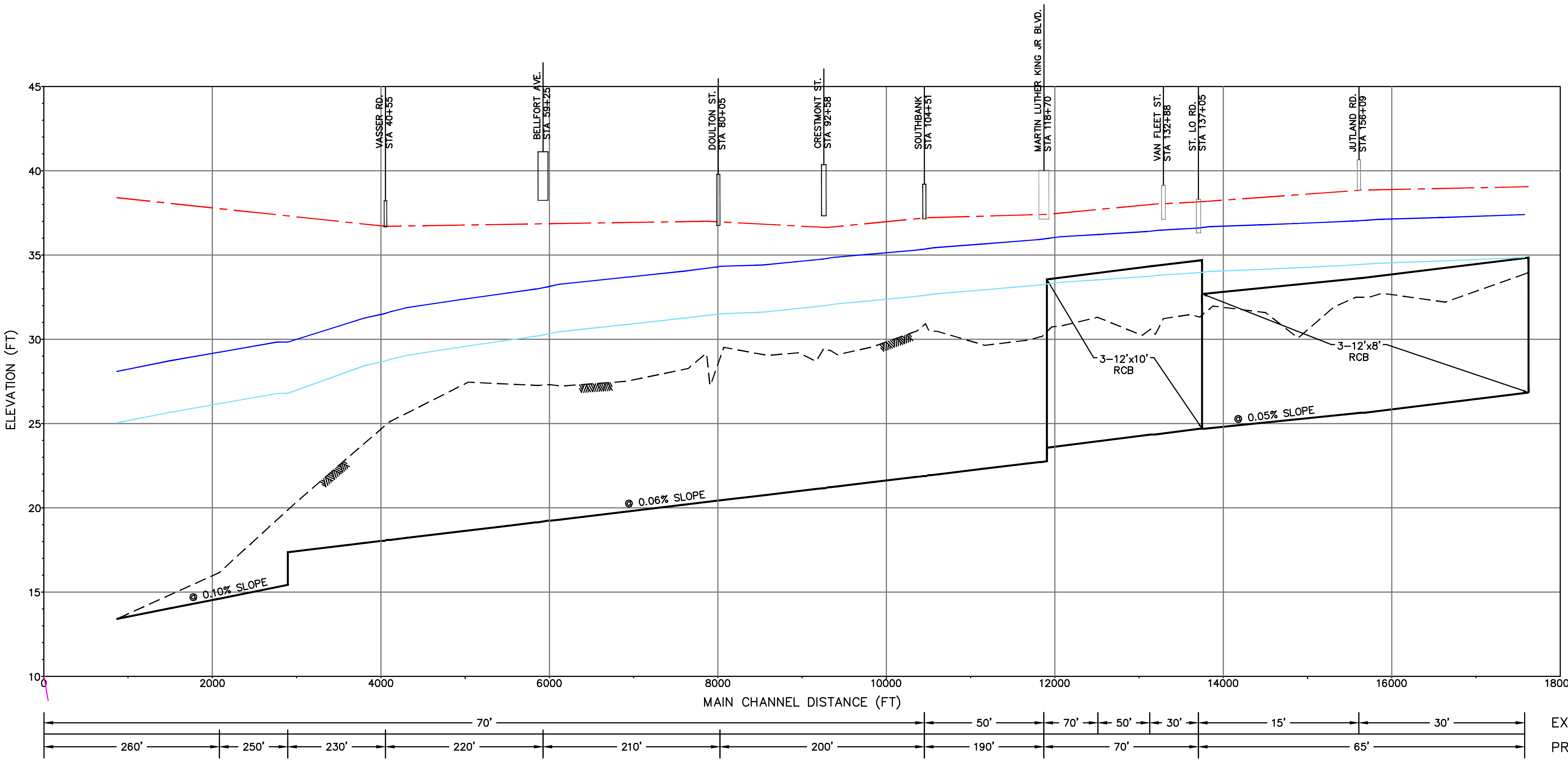
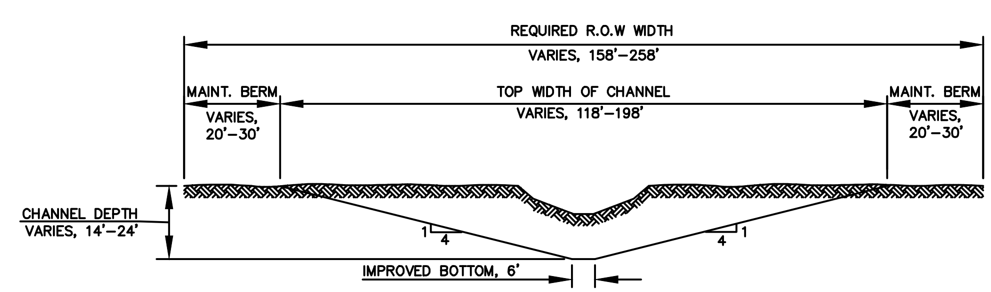
FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

ALTERNATIVE 2 LAYOUT

NOVEMBER 2015 | Job No: 325912 | EXHIBIT 12b



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)
Southbank Street	104+51	1	140	34	35.33	39.20	39.20	37.14	37.14
Crestmont Street	92+58	1	150	34	34.75	40.36	40.36	37.32	37.32
Doulton Drive	80+25	1	240	34	34.31	39.78	39.78	36.75	36.75
Bellfort Avenue	59+24	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



LEGEND

- PROPOSED 100-YR WSEL
- PROPOSED 10-YR WSEL
- PROPOSED FLOW LINE
- EXISTING FLOW LINE
- CRITICAL ELEVATION

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HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

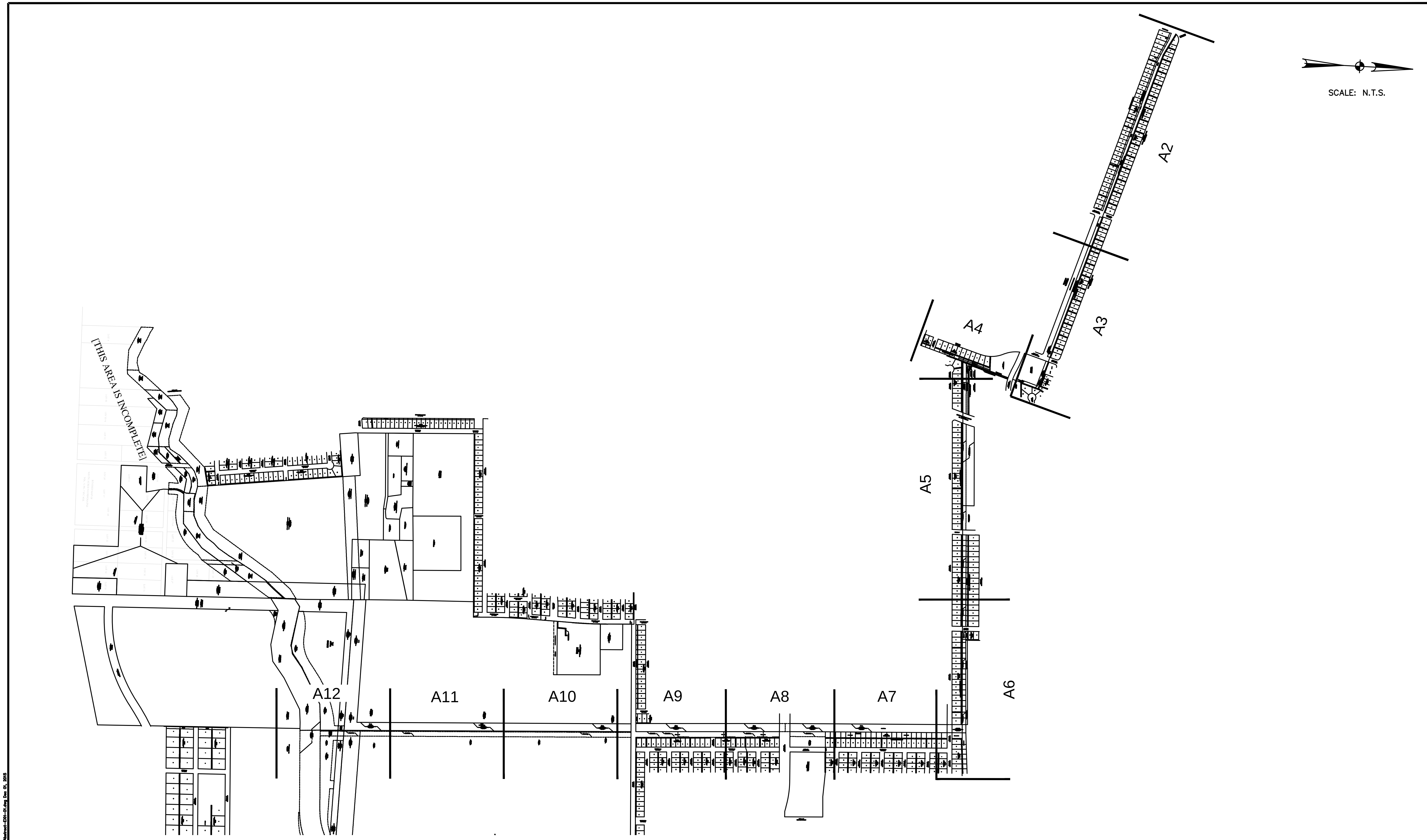
ALTERNATIVE 2 WATER SURFACE PROFILE

Date: NOV. 2015

Exhibit No: 13

APPENDIX A

EXISTING RIGHT-OF-WAY AND EASEMENTS



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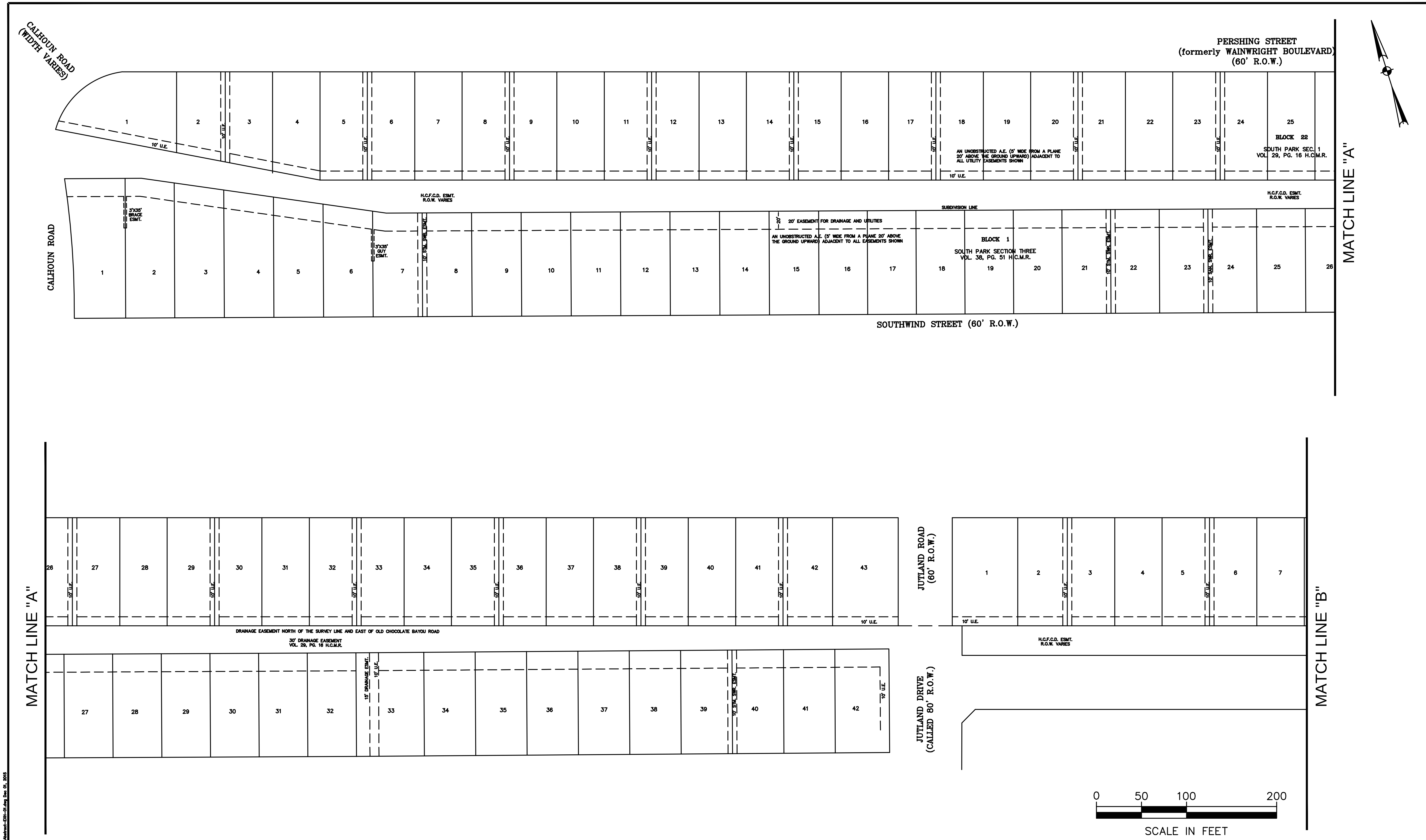
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A1



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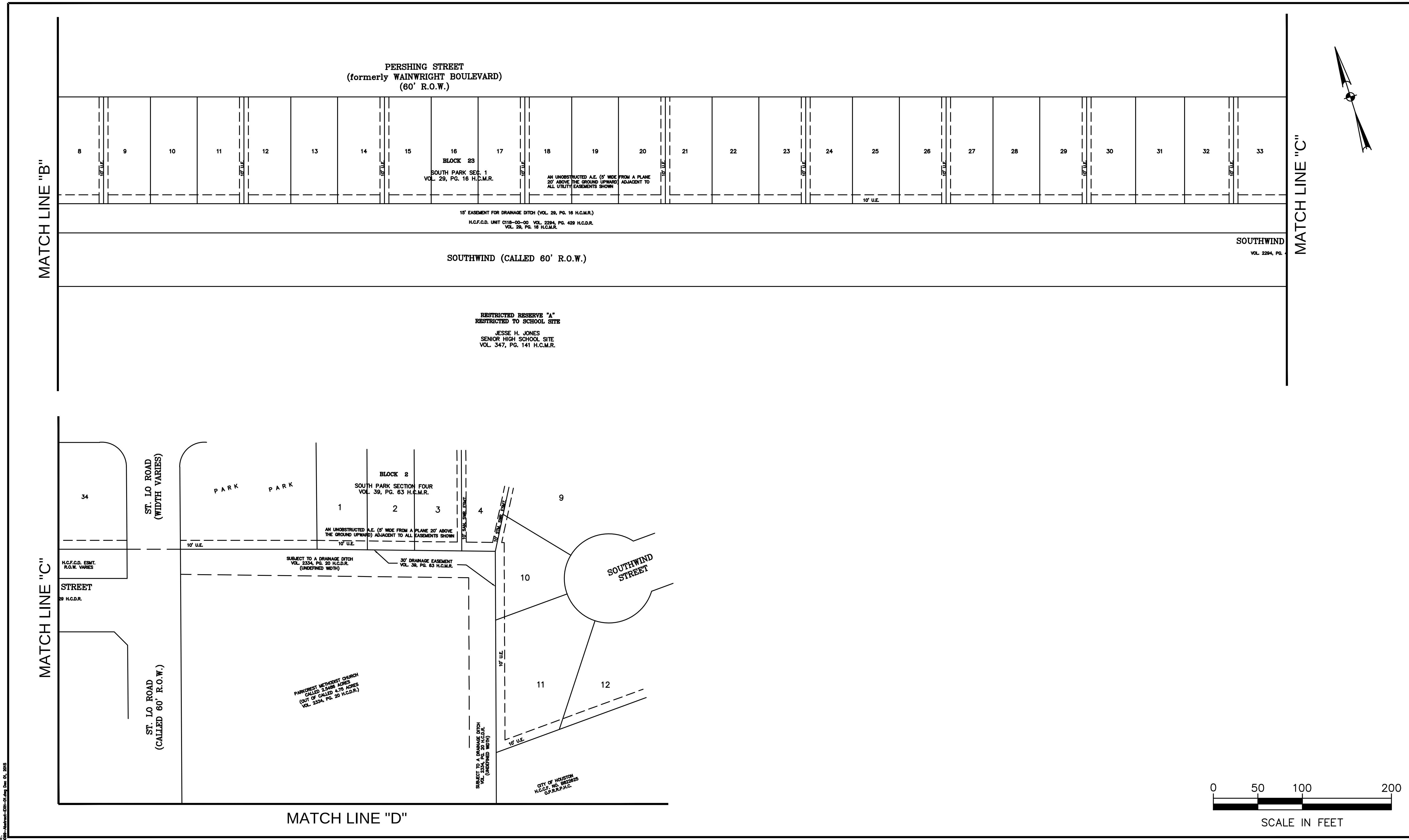
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A2



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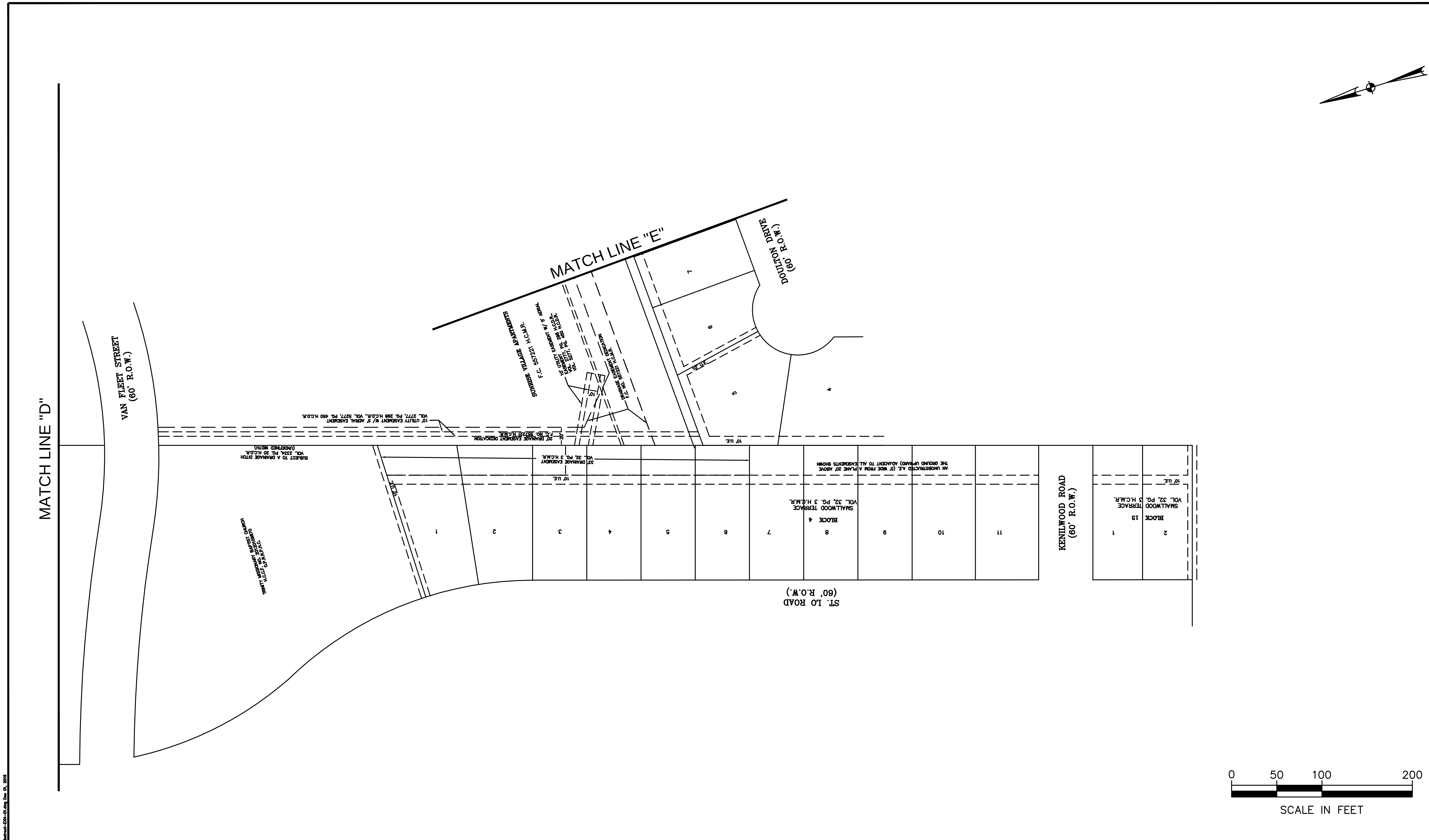
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A3



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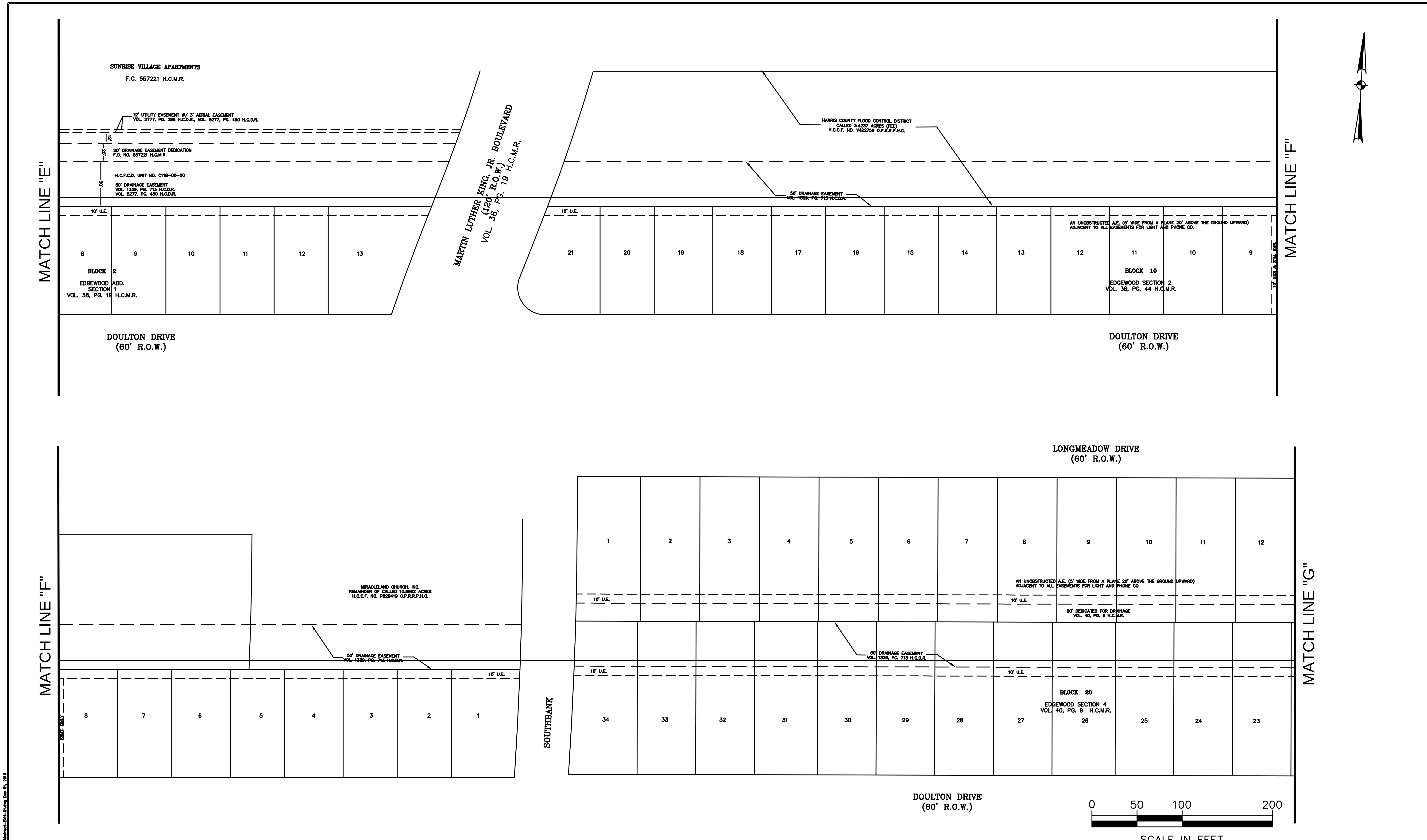
HCFCD UNIT NO. C118-00-00
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A4



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FEASIBILITY STUDY FOR SALT WATER DITCH
HCFCD UNIT NO. C118-00-00
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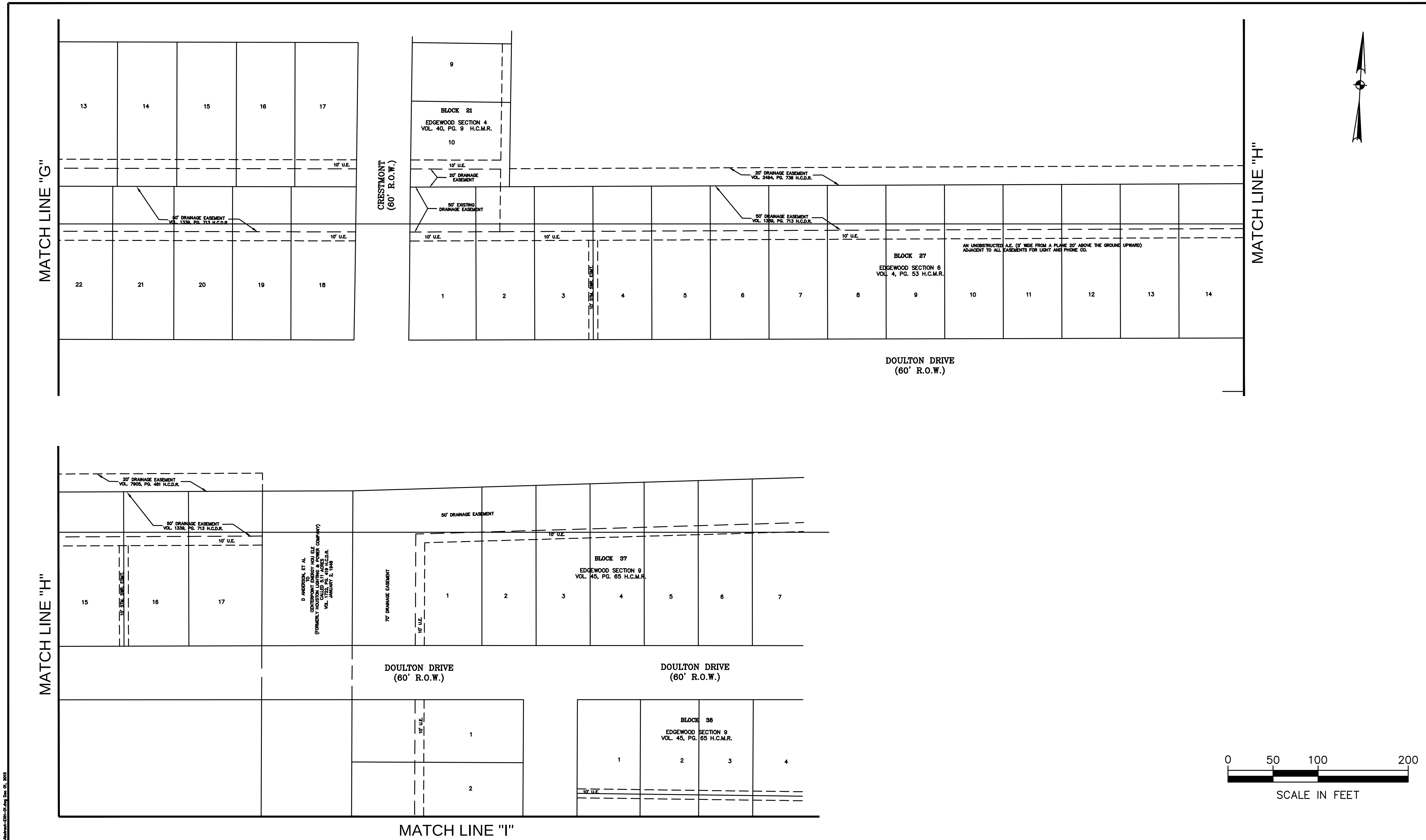
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A5



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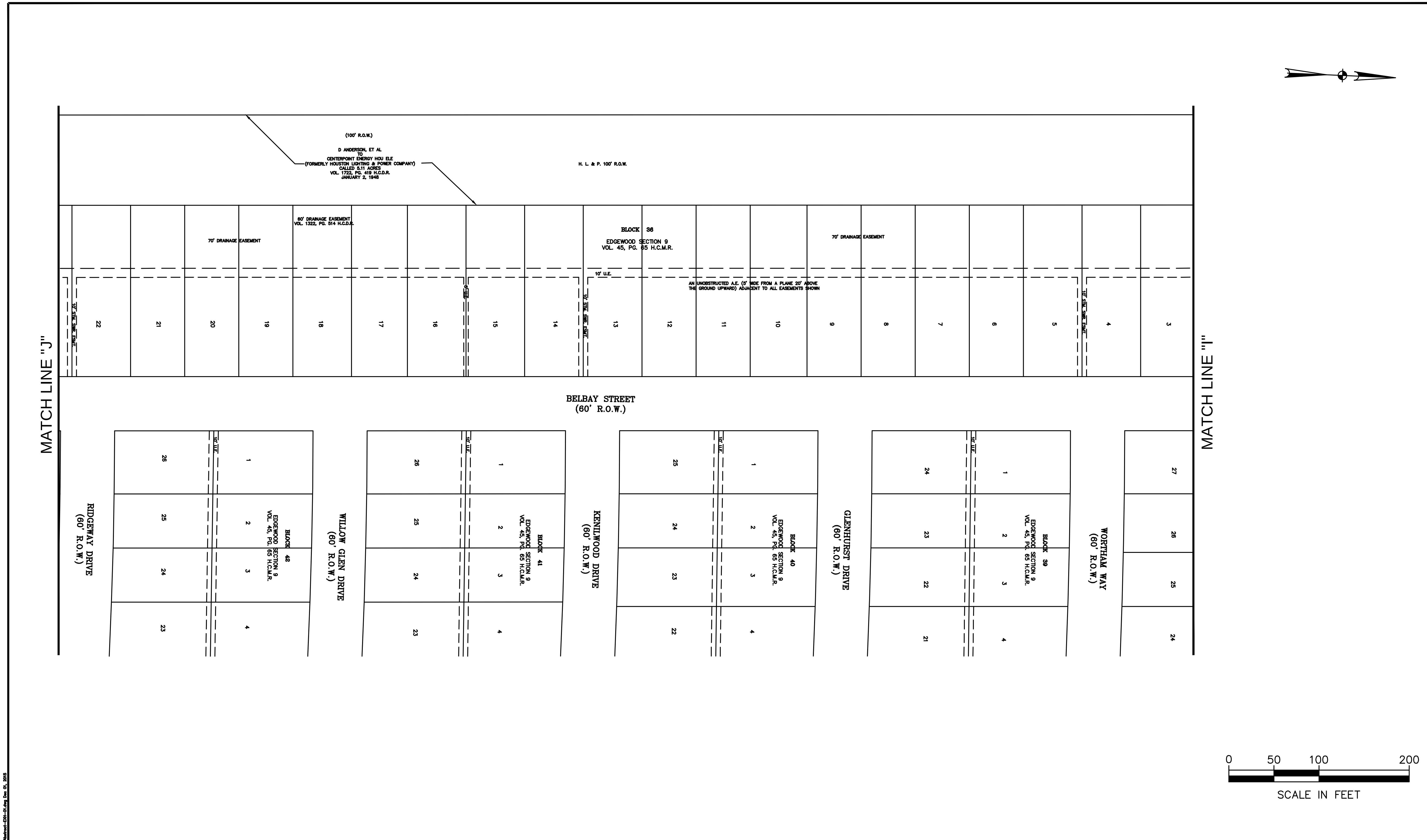
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A6



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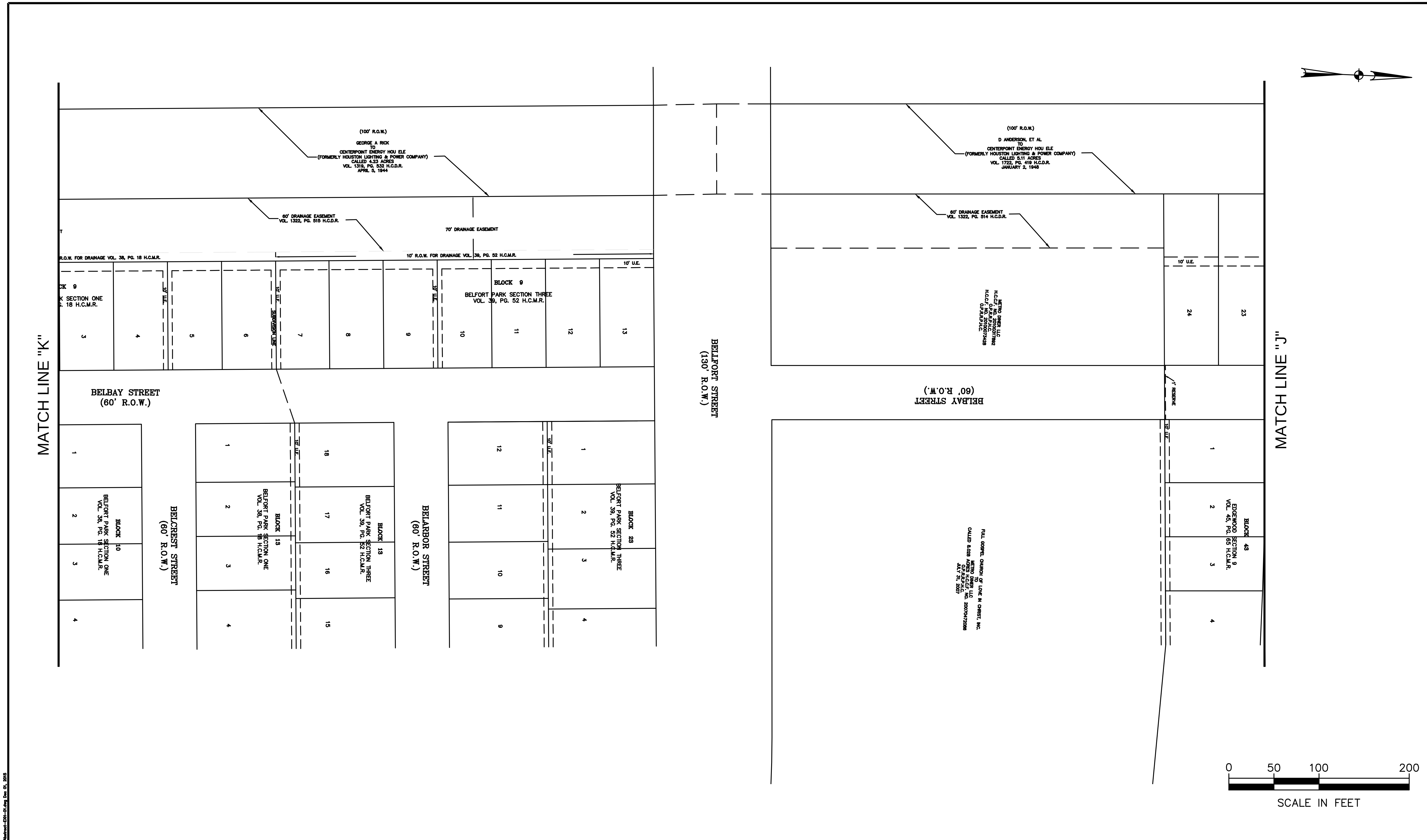
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A7



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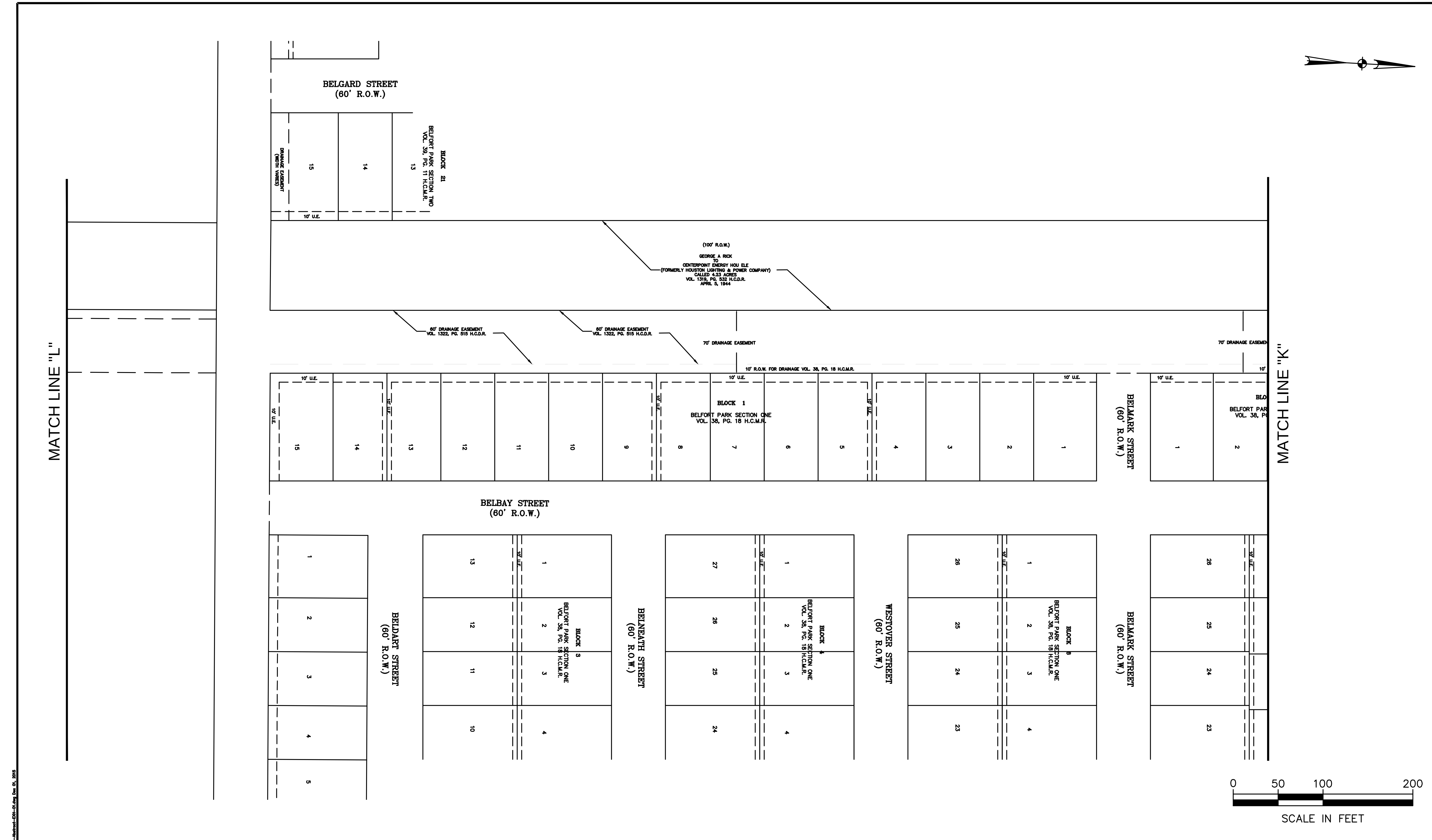
COH WORK AUTHORIZATION NO. 12

EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A8



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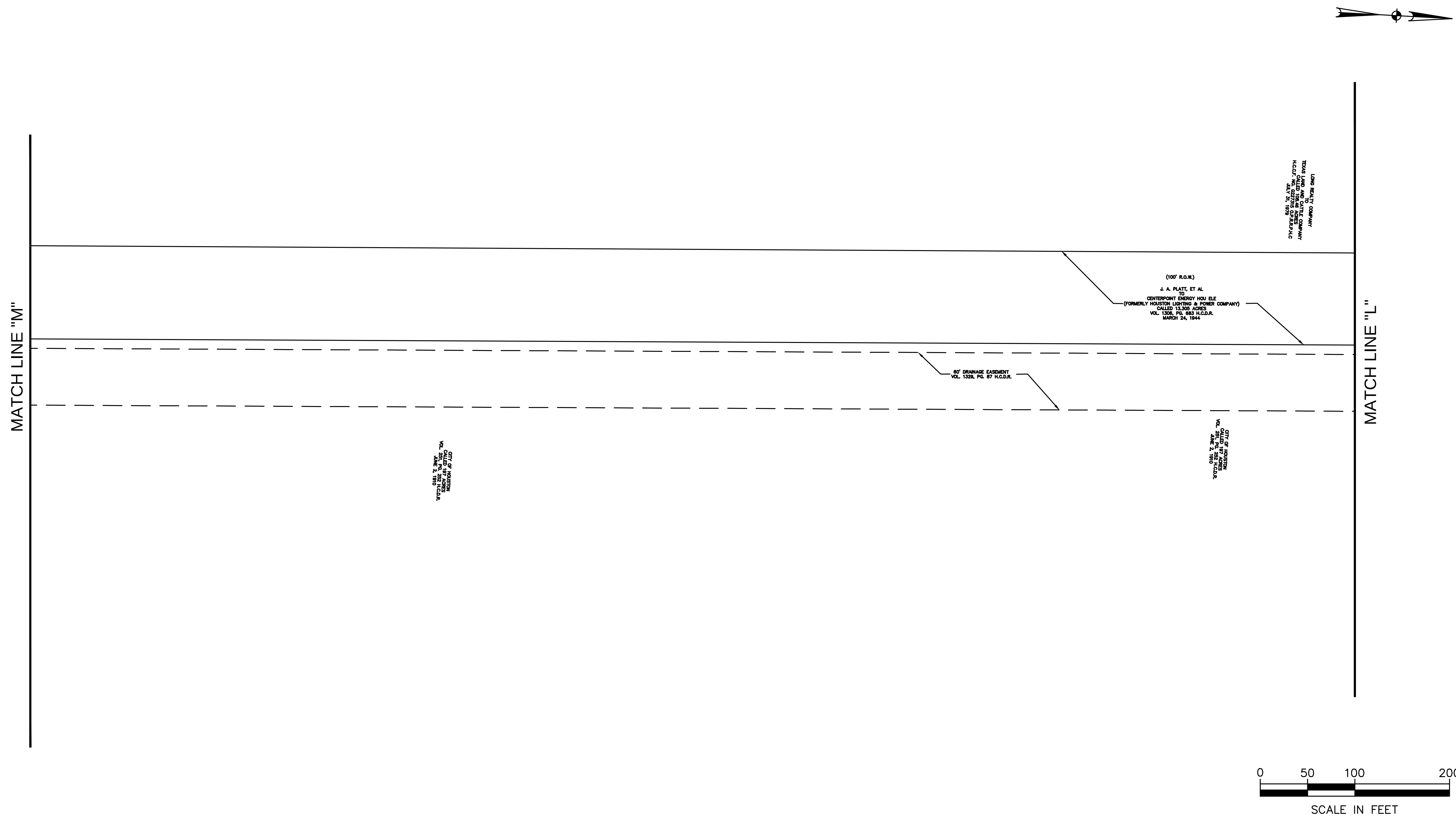

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HCFCD UNIT NO. C118-00-00
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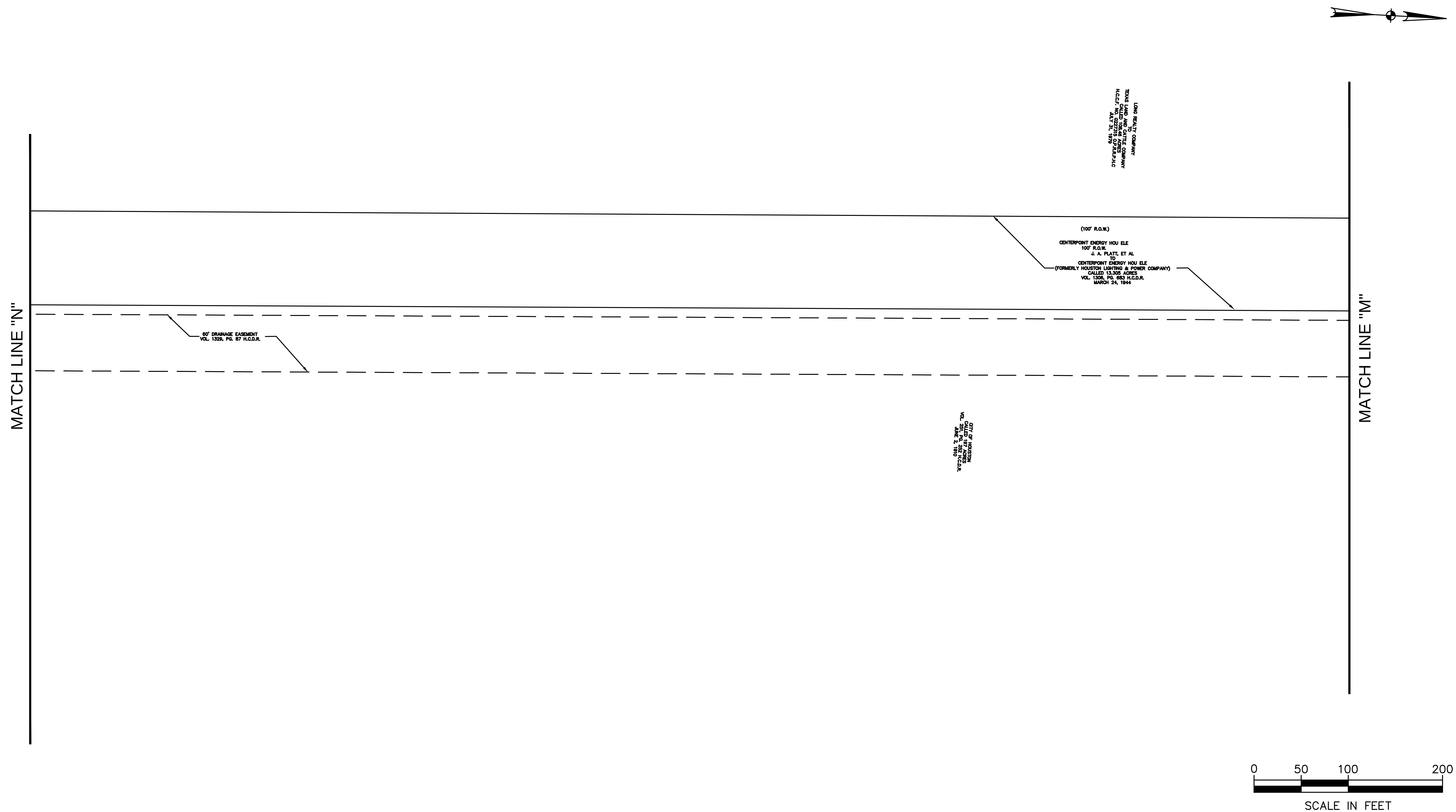
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A10



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HCFCD UNIT NO. C118-00-00
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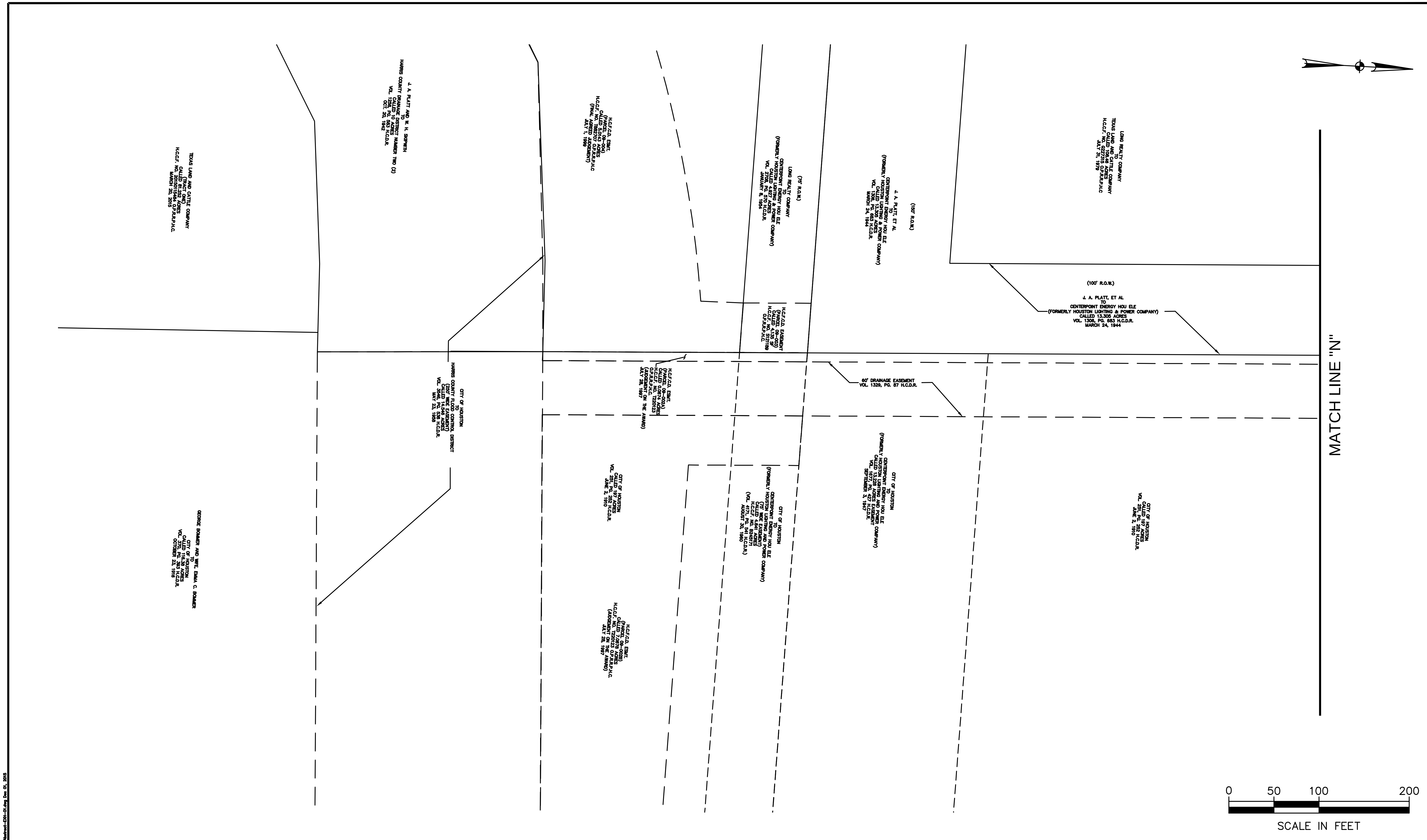
EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A11



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EXISTING ROW & EASEMENTS

Date: NOV. 2015

Exhibit No: A12

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

HCFCD 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

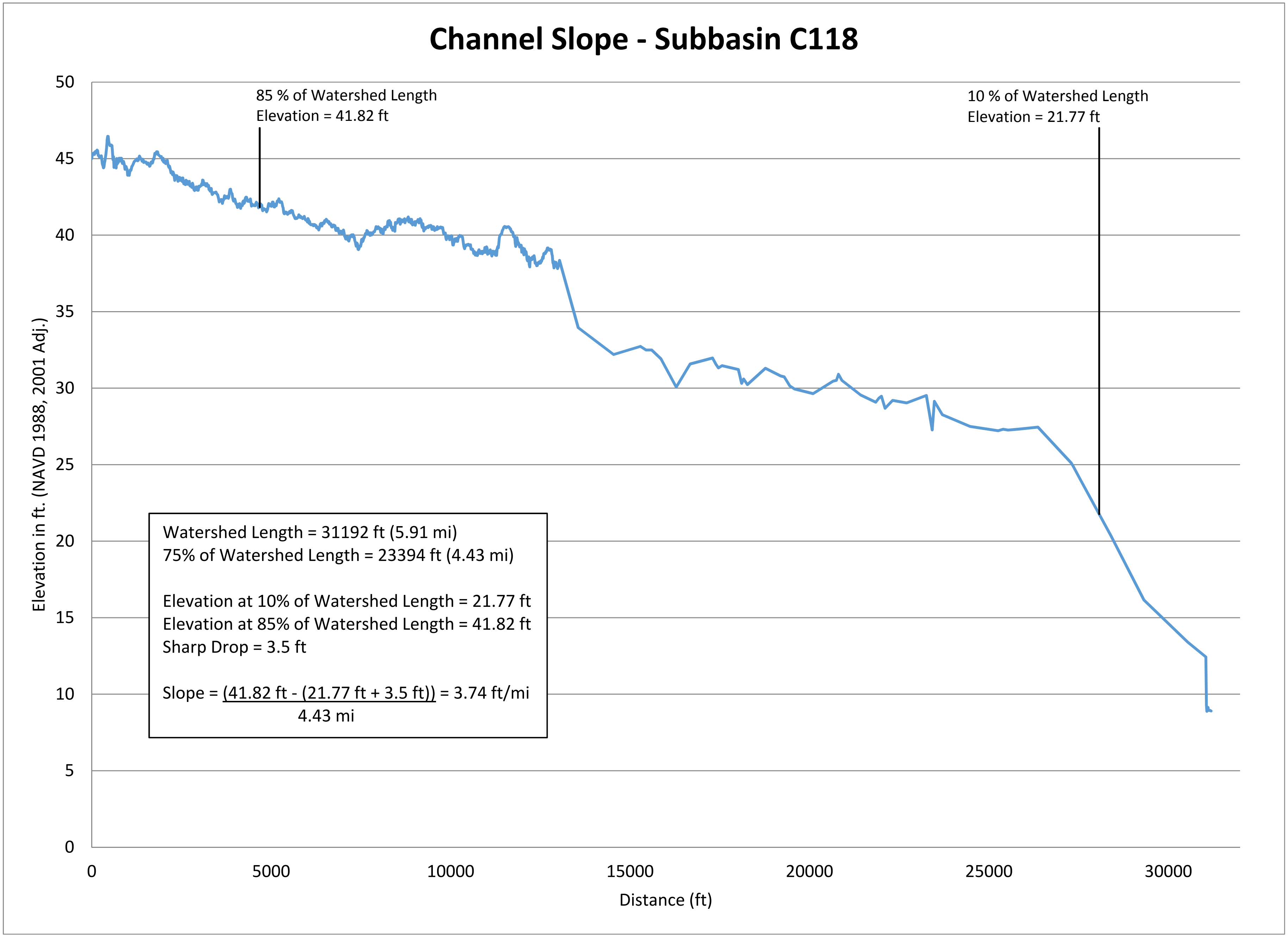
Salt Water Ditch

Existing Land Use and Impervious Percentage Calculations

Table ID: B2
Project #: 325912
Date: 7/8/2015
Prepared By: DJ
Checked By: CM

HCFCD LAND USE TYPES

Drainage Node ID	Drainage Area	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



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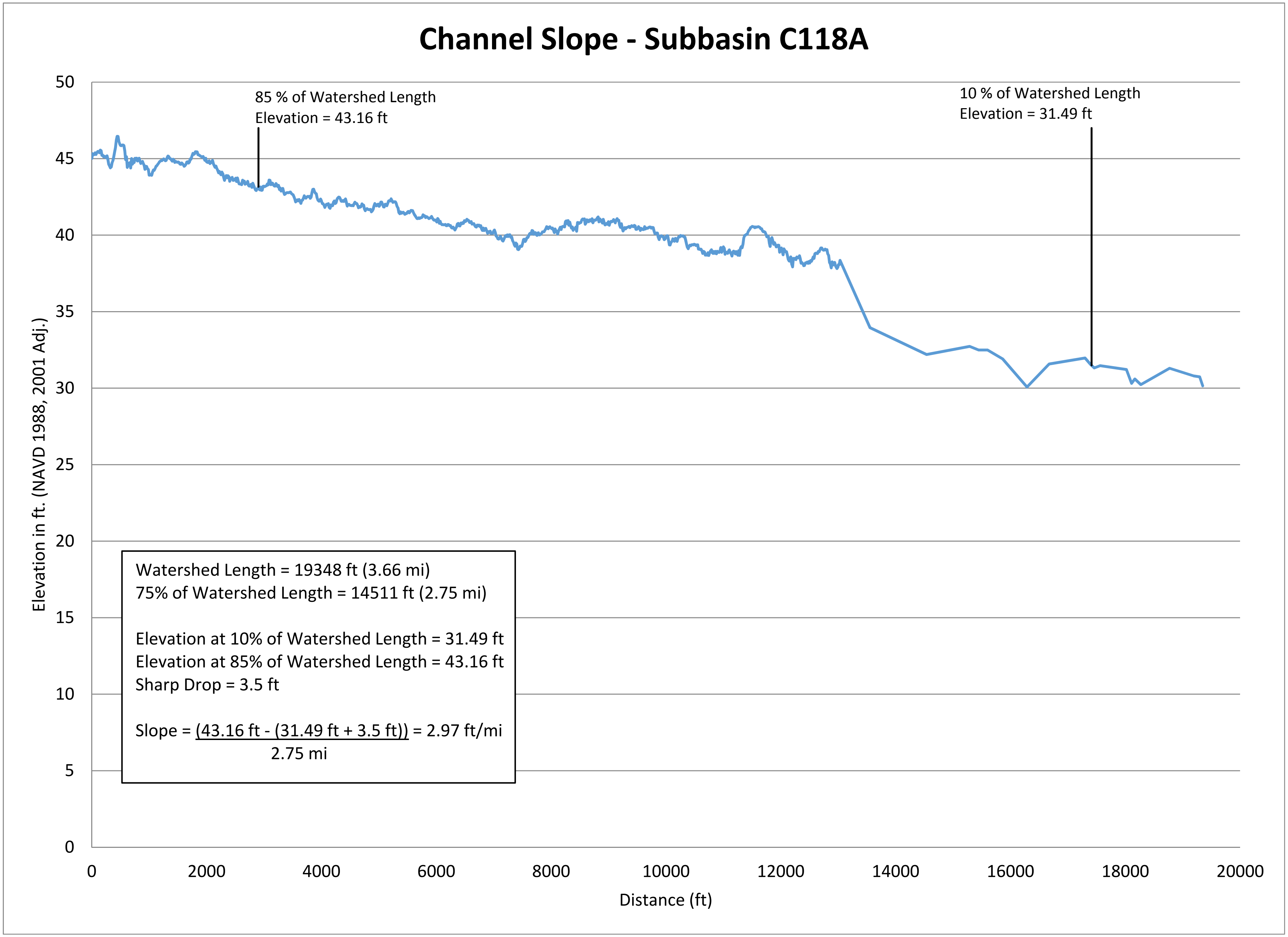

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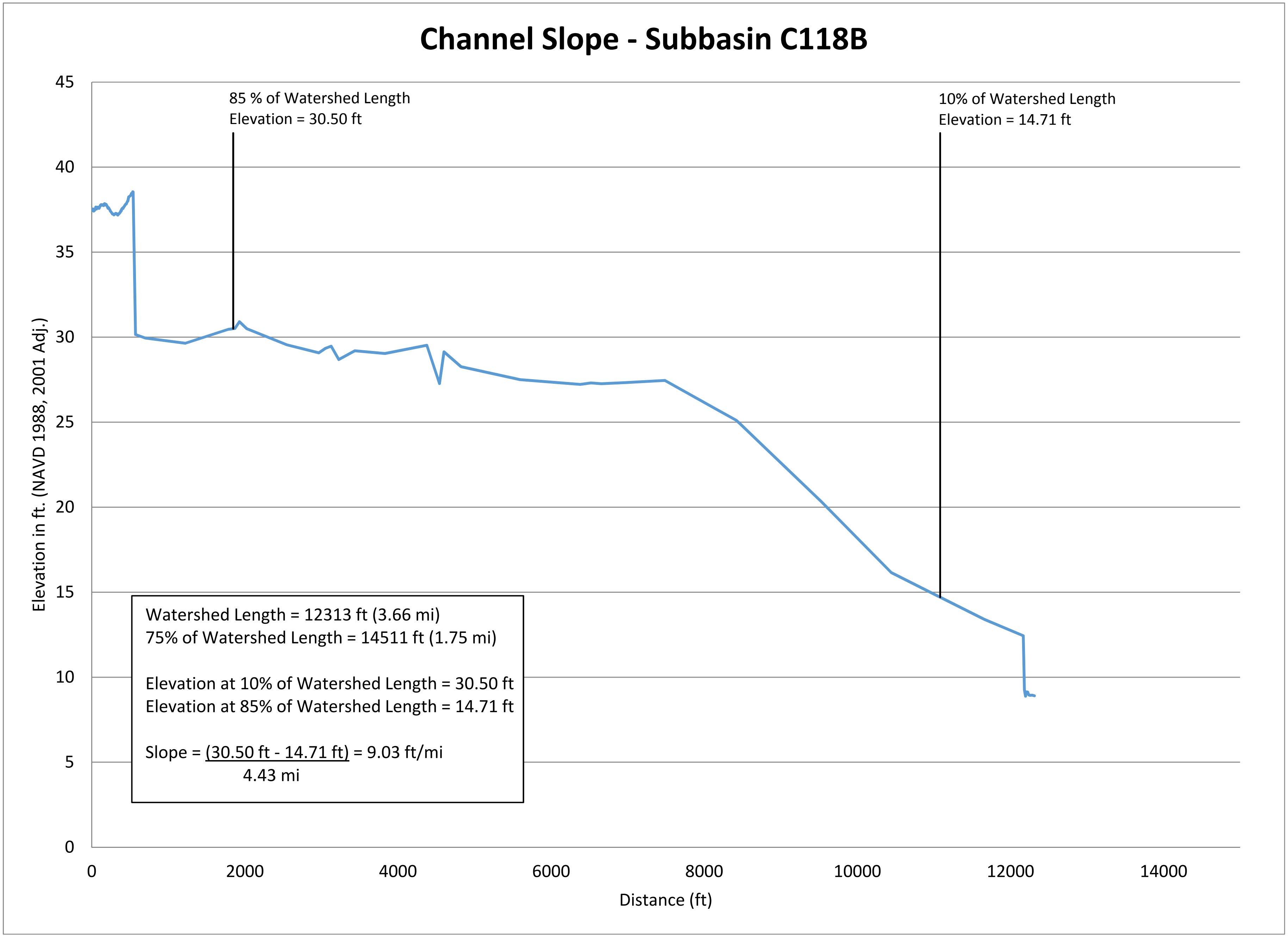

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SALT WATER DITCH DCC CALCULATION

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	Q Perc Chan	Length Chnl	Corrected Effective	Revised Existing
			(cfs)		(ft)	Weighted Average DCC	
C118-00-00_0009	863.9	DCC_100YR	3600	100		50	60
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		40
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)

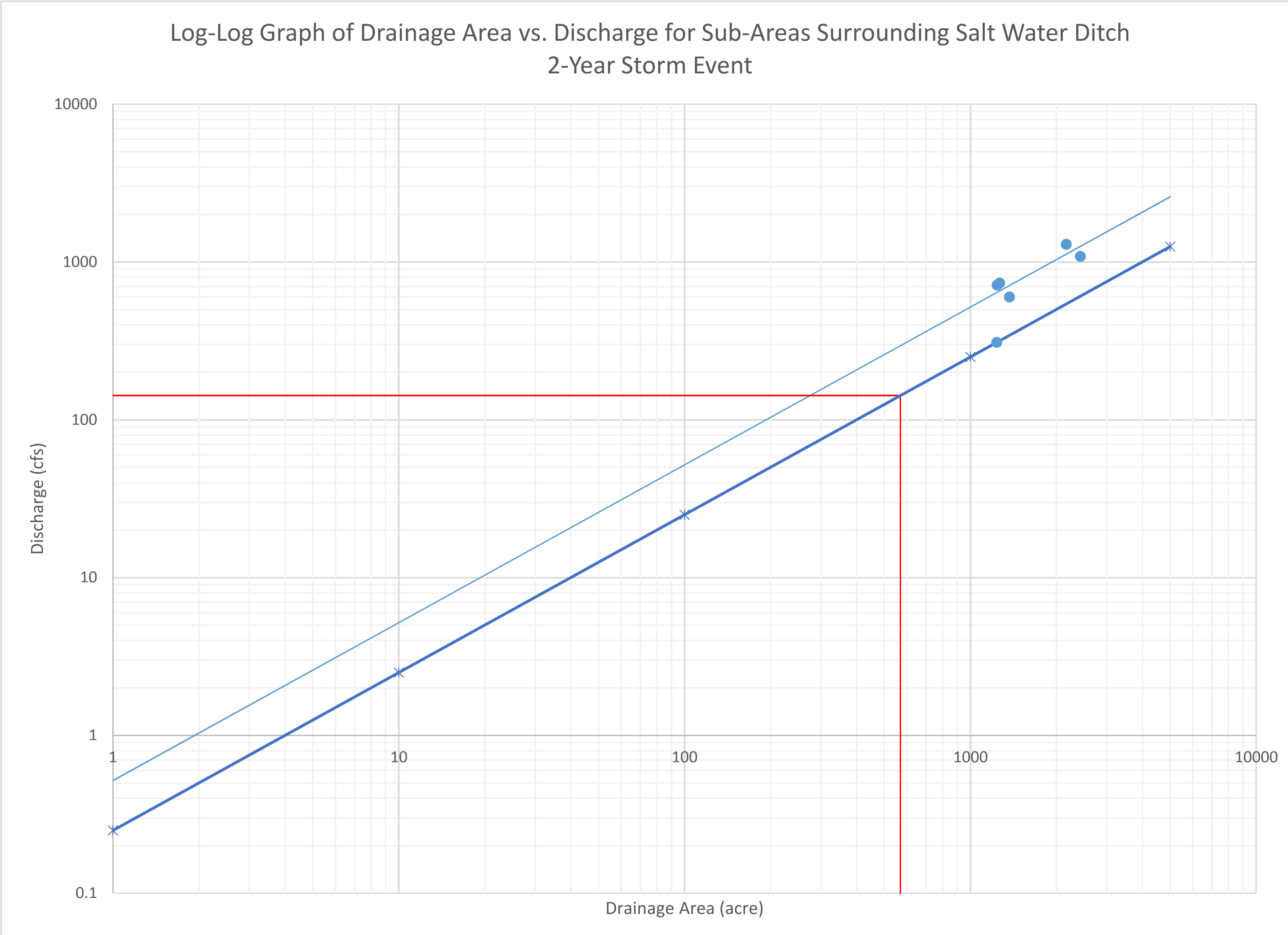
TC&R values for FEMA Effective Model, Corrected Effective Model, and Revised Existing Model

Sims Bayou Watershed

HCFCD TC&R Excel Template

Subwatershed	Drainage Area (acres)	Drainage Area (sq.mi.)	Watershed Length (mi.) L	Length to Centroid(mi.) Lca	Channel Slope(ft./mi) S	Overland Slope(ft./mi.) So	D	Percent Urban Development 2002 DLU	Percent Channel Improvement DCI	Percent Channel Conveyance DCC	Percent Ponding DPP	DLU affected by Detention DET	Percent Impervious 2002	(TC+R)''	TC''	R''	DLU Minimum	DLU (Detention)
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



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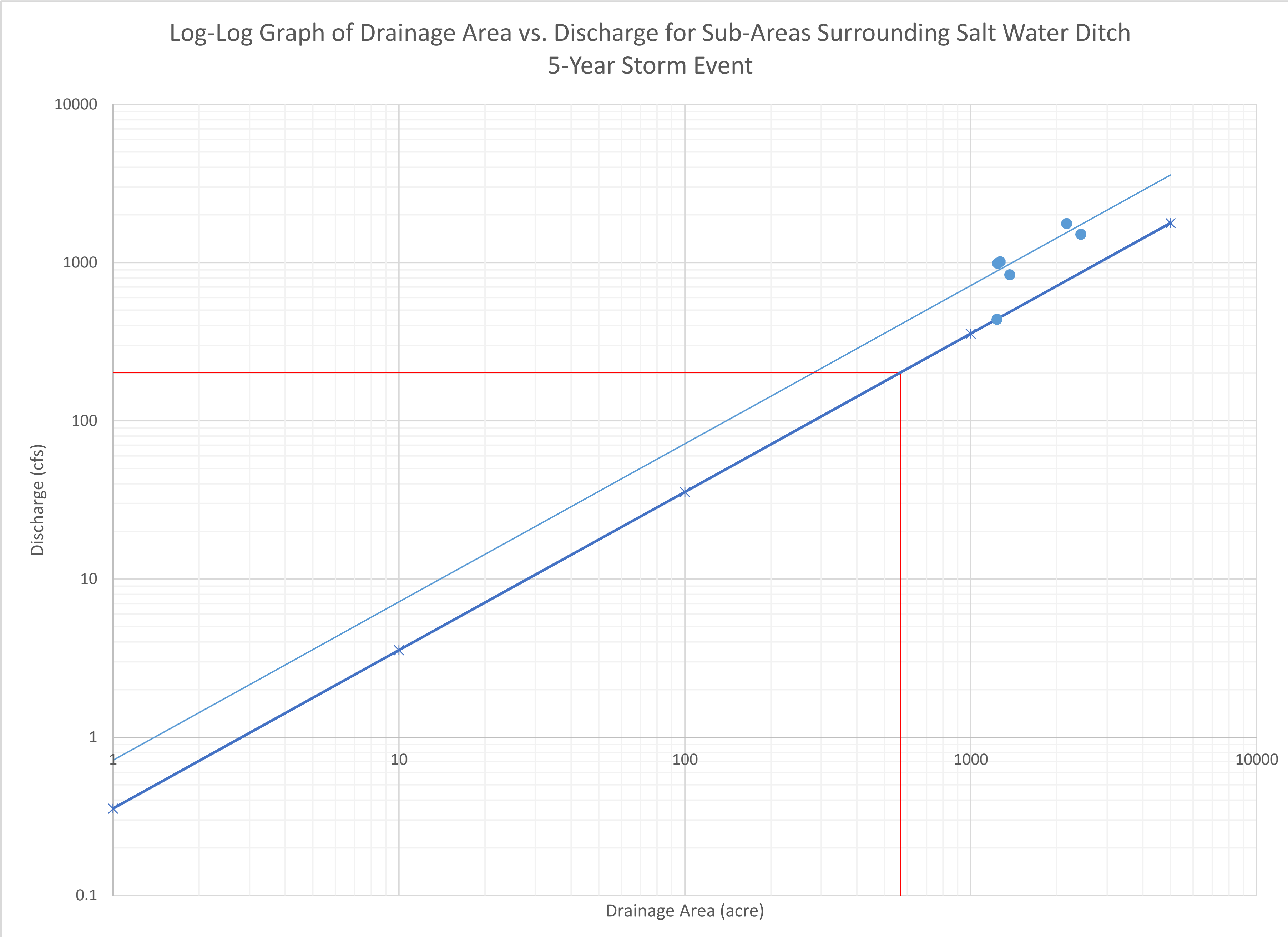

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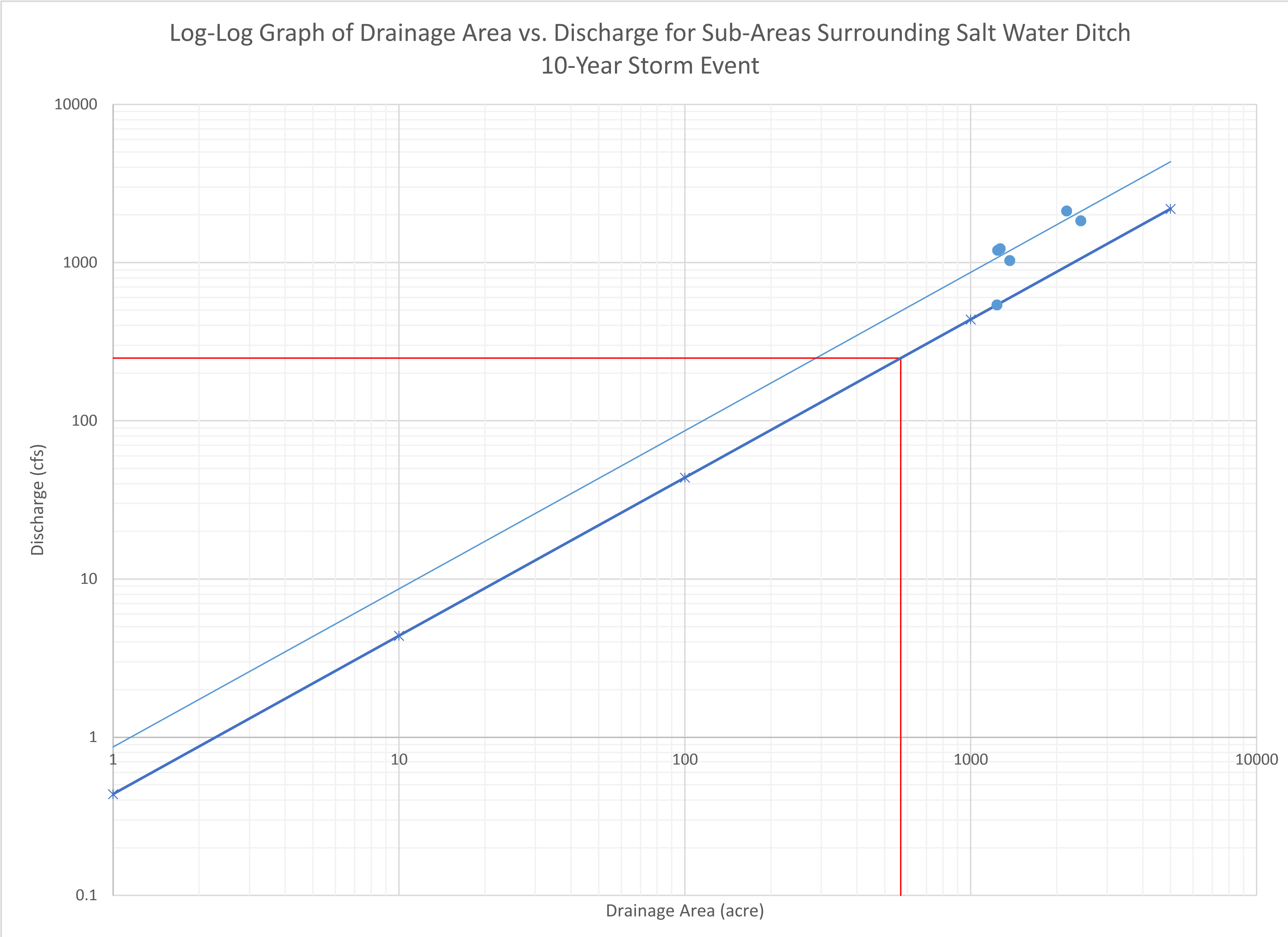

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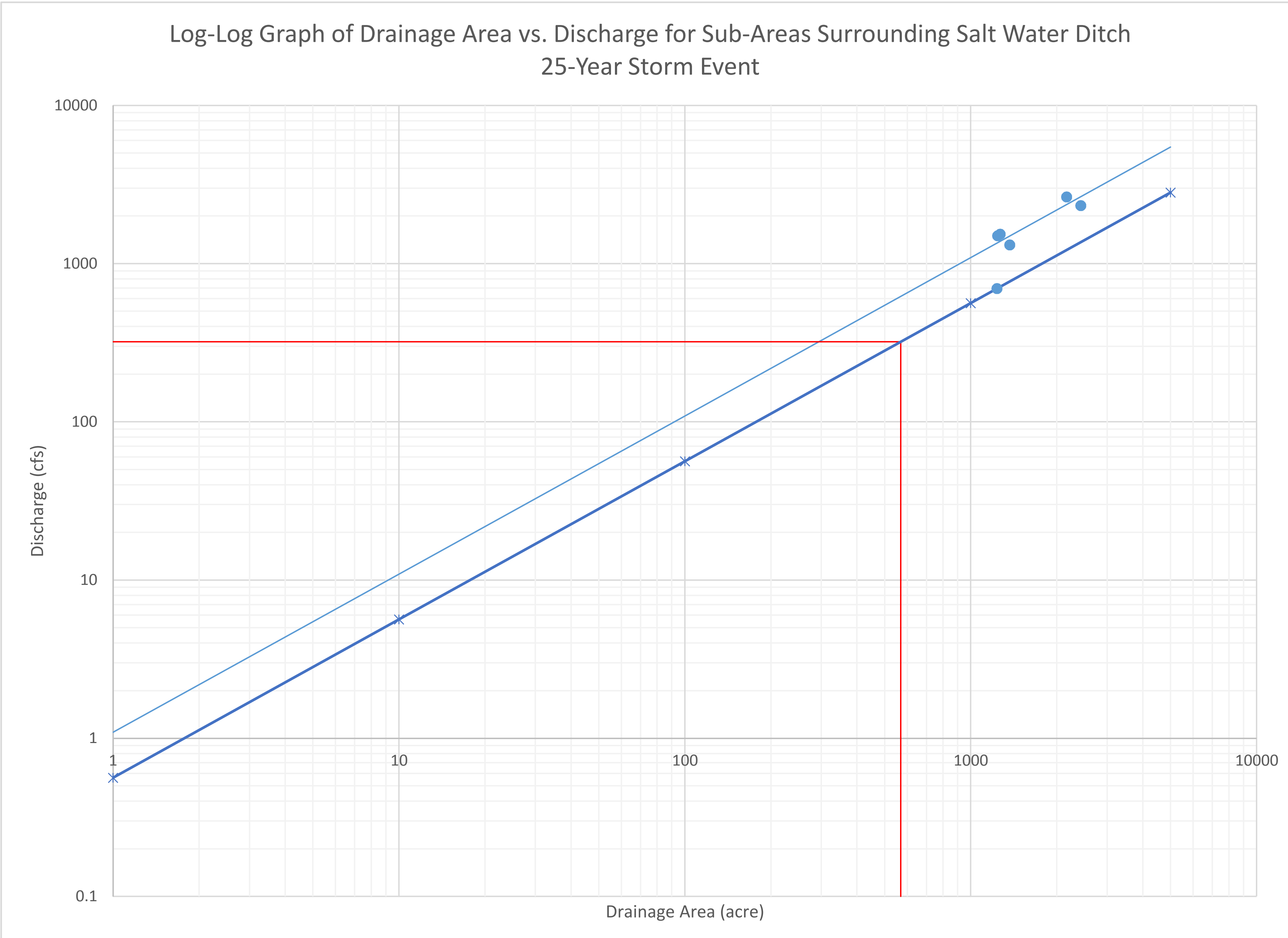
Engineering, Inc.



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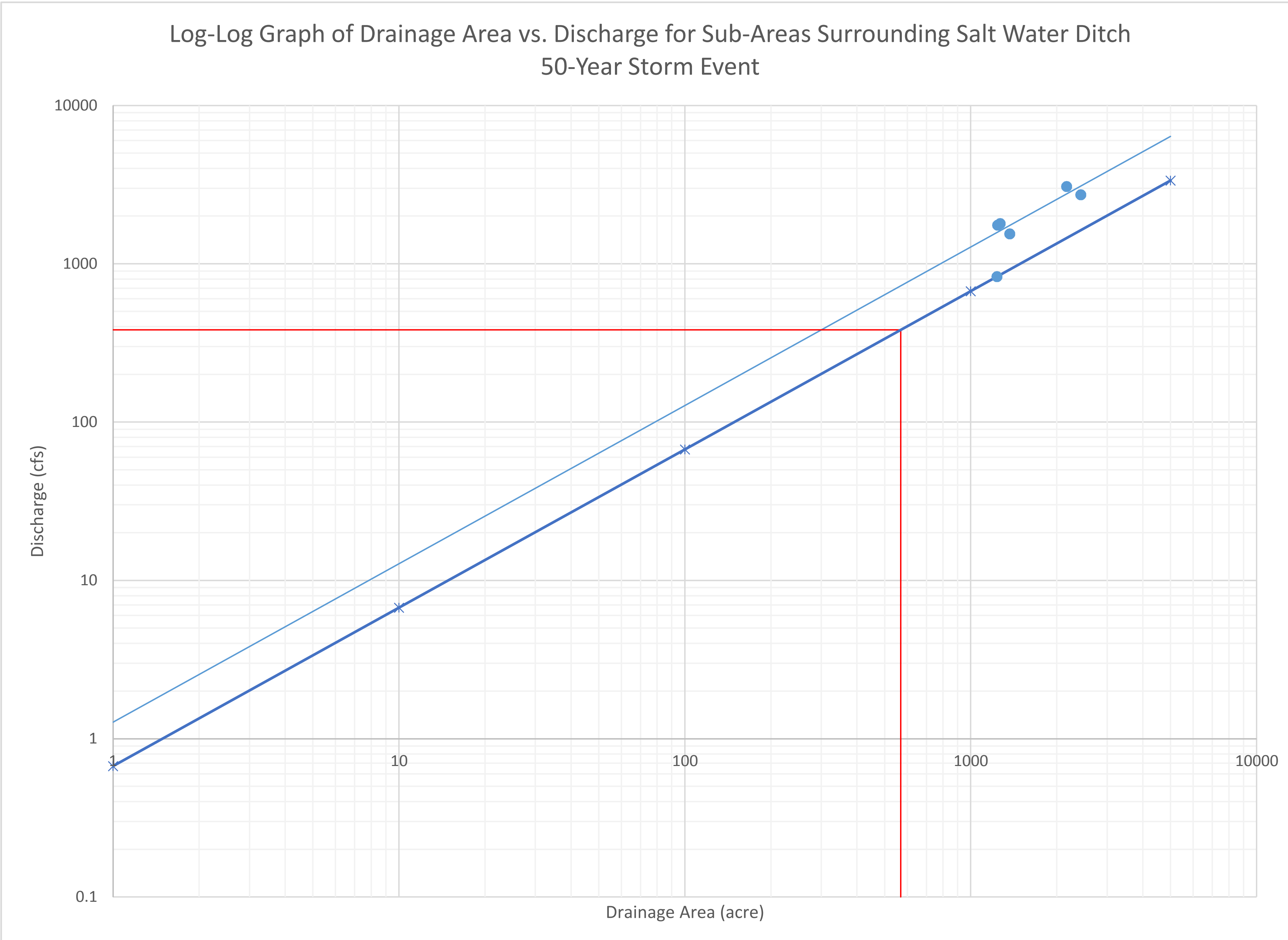

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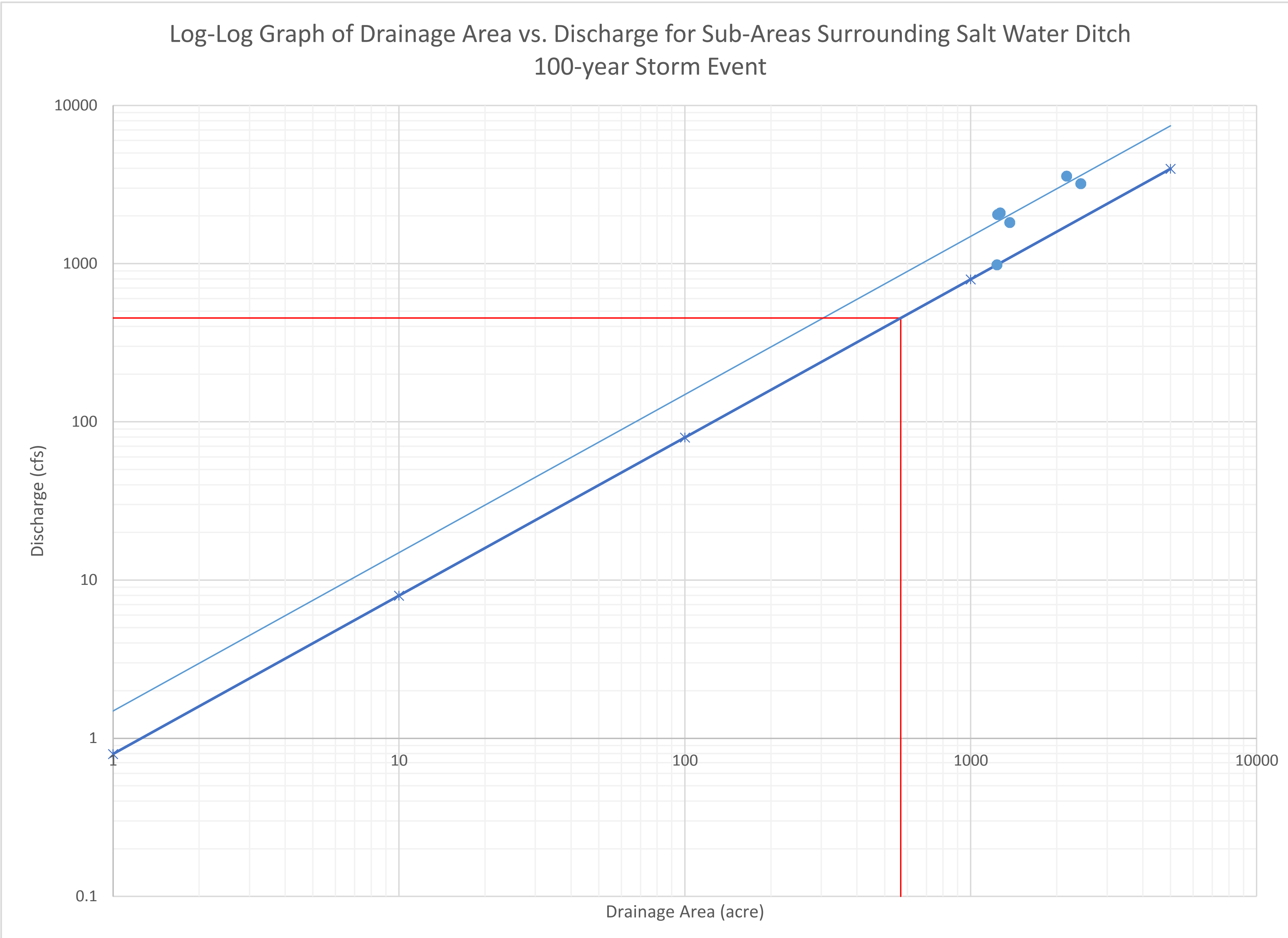

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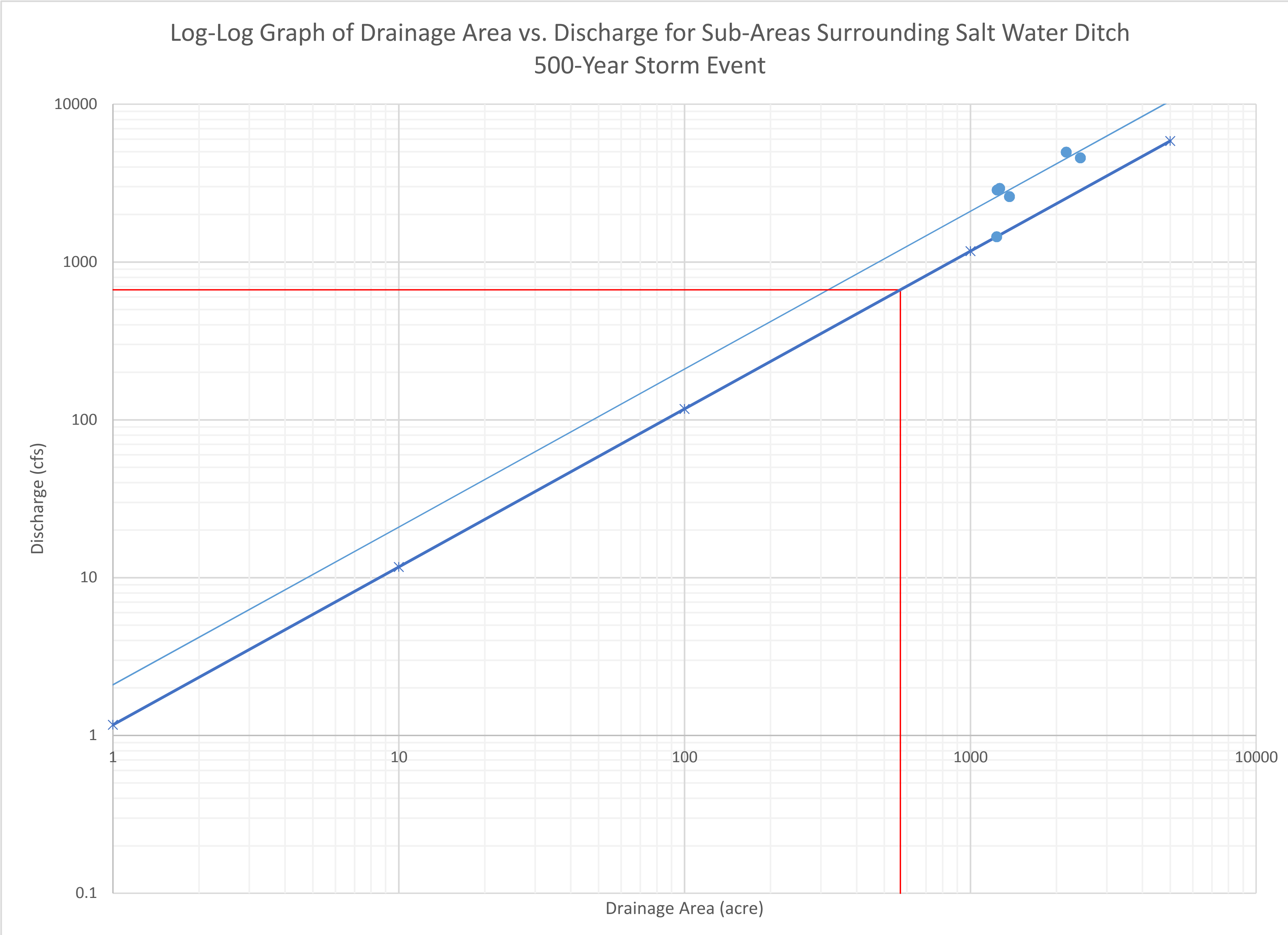

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Salt Water Ditch Flow Distributions

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	50% (2-yr)	25% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)	0.2% (500-yr)	100-yr % Diff.
C1180000_0009_J	U/S of conlufence with C100-00-00	**863.9**	**777**	**1093**	**1343**	**1709**	**2005**	**2328**	**3189**	
	interploated flow	**2080.7**	**702**	**988**	**1214**	**1547**	**1818**	**2116**	**2921**	**10.02%**
	interploated flow	**2997.8**	**650**	**915**	**1125**	**1435**	**1689**	**1969**	**2735**	**7.47%**
	interploated flow	**4109.2**	**592**	**834**	**1026**	**1310**	**1545**	**1805**	**2524**	**9.09%**
	interploated flow	**6004.2**	**506**	**713**	**877**	**1122**	**1326**	**1555**	**2202**	**16.08%**
	interploated flow	**8009.1**	**427**	**603**	**743**	**952**	**1129**	**1329**	**1906**	**17.01%**
	interploated flow	**9496.8**	**377**	**533**	**657**	**843**	**1002**	**1182**	**1712**	**12.44%**
	interploated 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%**
	interploated flow	**13319.2**	**257**	**363**	**447**	**575**	**686**	**814**	**1196**	**20.76%**
	interploated flow	**14033.3**	**234**	**331**	**408**	**525**	**626**	**742**	**1091**	**9.70%**
	interploated 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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	455.68	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	105.02	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	331.86	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	752.49	2606.14	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	158.90	0.35
C118-00-00_0009	5037.2	10PCT_10yr	877.00	27.45	35.93	32.94	36.19	0.001879	4.13	242.42	748.62	0.35
C118-00-00_0009	5037.2	4PCT_25yr	1122.00	27.45	36.83	33.53	37.11	0.001709	4.32	397.53	1517.76	0.34
C118-00-00_0009	5037.2	2PCT_50yr	1326.00	27.45	37.41	33.95	37.72	0.001608	4.51	550.56	2179.18	0.33
C118-00-00_0009	5037.2	1PCT_100yr	1555.00	27.45	37.99	34.39	38.32	0.001543	4.71	816.88	2977.95	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	2056.65	6460.07	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	257.60	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	472.64	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	1278.20	0.26
C118-00-00_0009	5550.6	2PCT_50yr	1326.00	27.33	38.14	33.83	38.37	0.000990	3.88	845.54	3875.88	0.27
C118-00-00_0009	5550.6	1PCT_100yr	1555.00	27.33	38.71	34.27	38.93	0.000909	3.93	1413.61	5197.98	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	2585.89	6346.40	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	431.19	0.19
C118-00-00_0009	5866.6	10PCT_10yr	877.00	27.26	37.02	31.49	37.14	0.000533	2.82	500.26	1680.44	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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		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		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		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		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		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		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		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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	1525.90	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	0.000154	1.23	1290.51	4353.08	0.10
C118-00-00_0009	17874.51	0.2PCT_500yr	666.00	33.95	42.22	38.85	42.23	0.000135	1.29	1814.31	4682.85	0.10

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

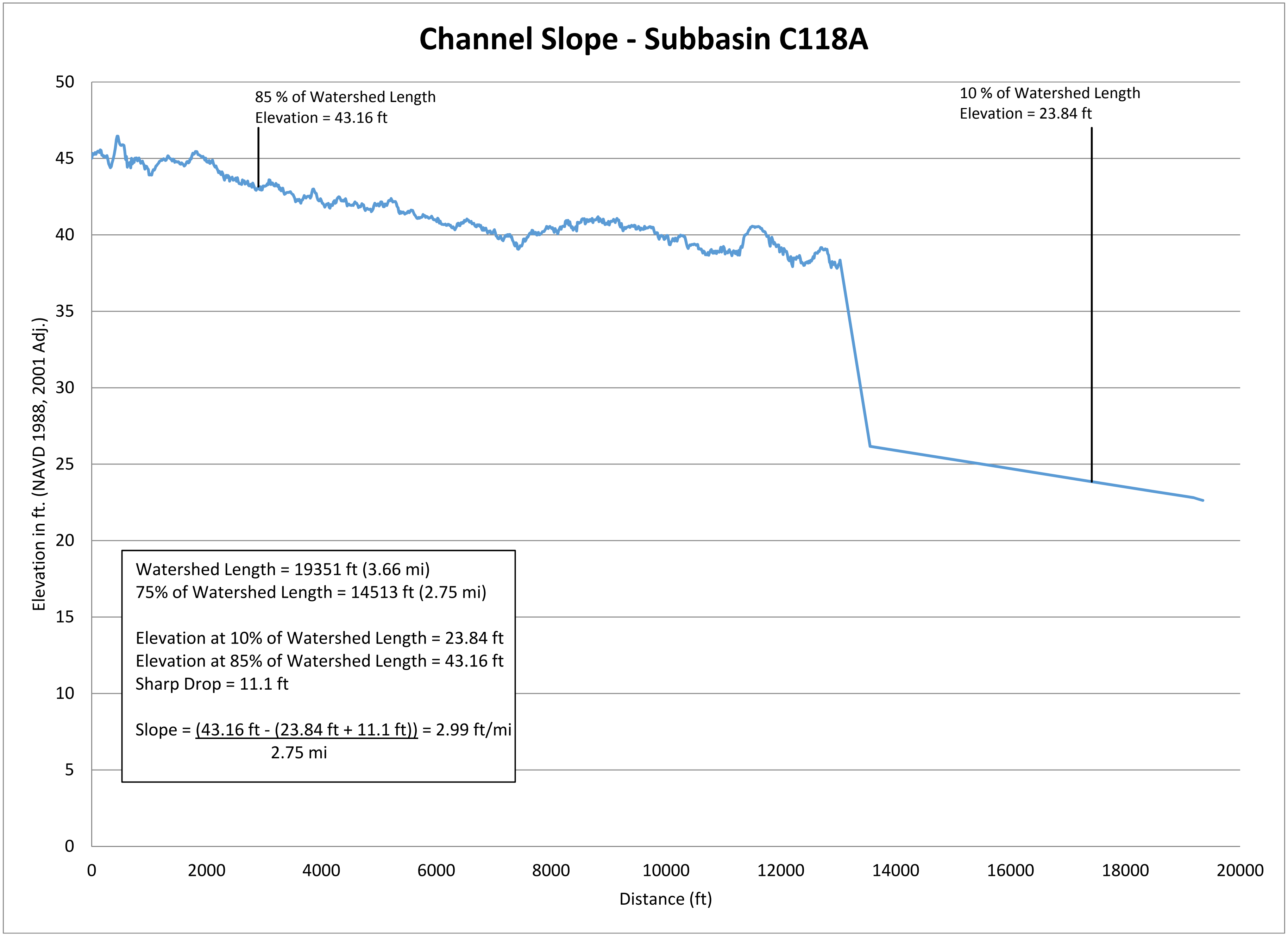
APPENDIX C.5 – PEAK FLOW IMPACTS

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**



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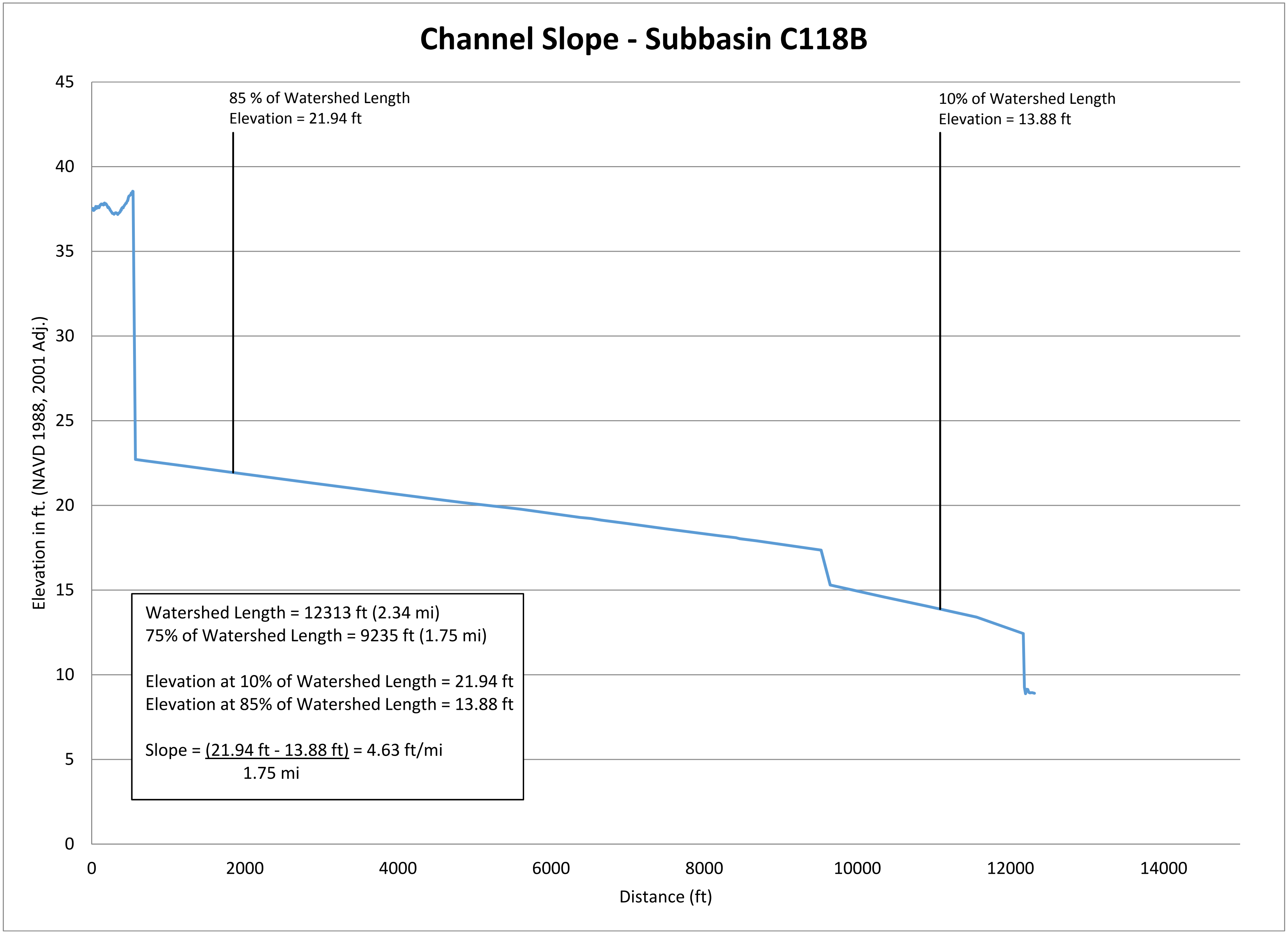
Engineering, Inc.



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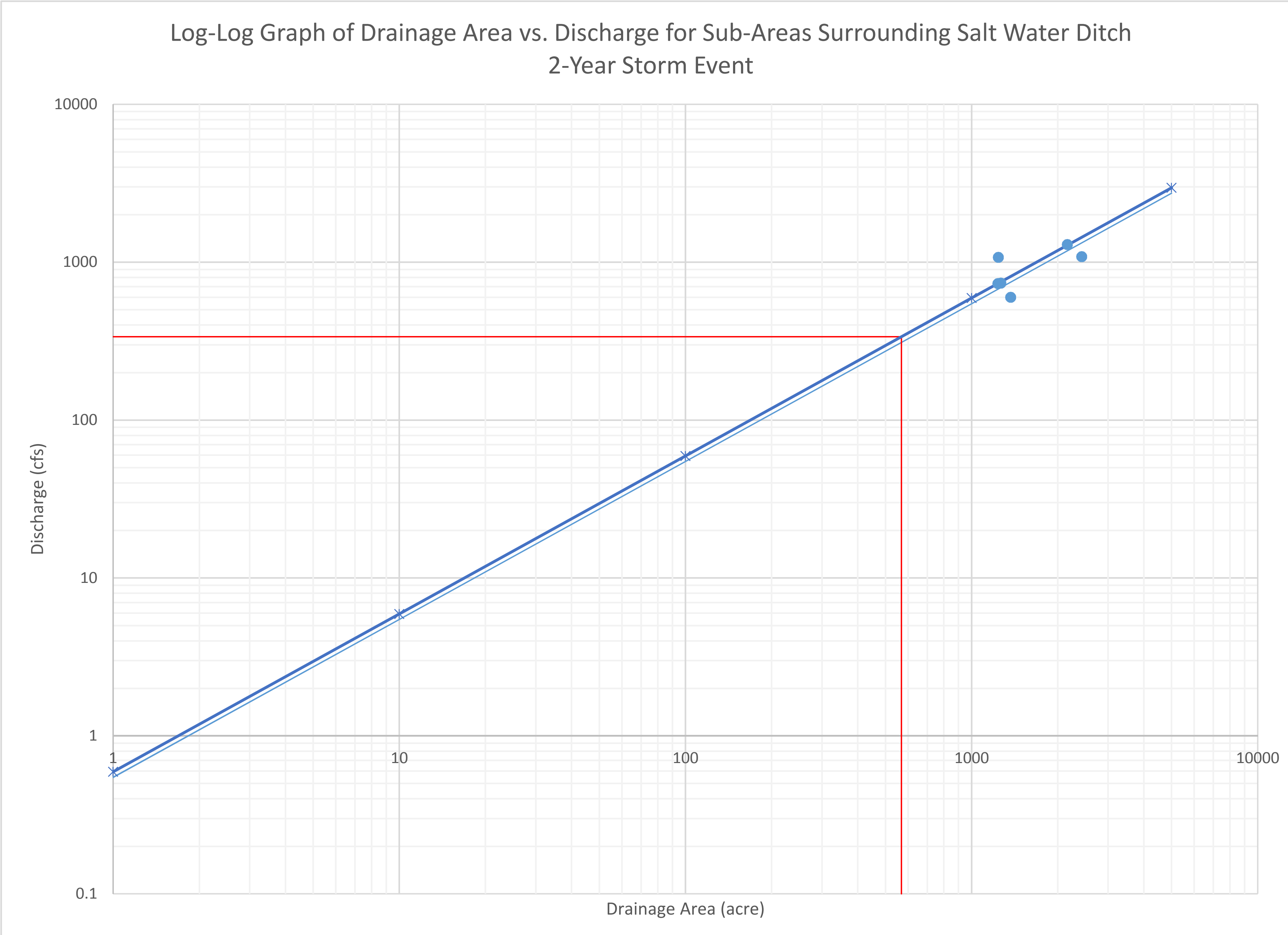
FEMA Effective Model as of June 18, 2007

TC&R values for FEMA Effective Model

Sims Bayou Watershed

HCFCD TC&R Excel Template

Subwatershed	Drainage Area (acres)	Drainage Area (sq.mi.)	Watershed Length (mi.) L	Length to Centroid(mi.) Lca	Channel Slope(ft./mi) S	Overland Slope(ft./mi.) So	D	Percent Urban Development 2002 DLU	Percent Channel Improvement DCI	Percent Channel Conveyance DCC	Percent Ponding DPP	DLU affected by Detention DET	Percent Impervious 2002	(TC+R)''	TC''	R''	DLU Minimum	DLU *(Detention)*
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



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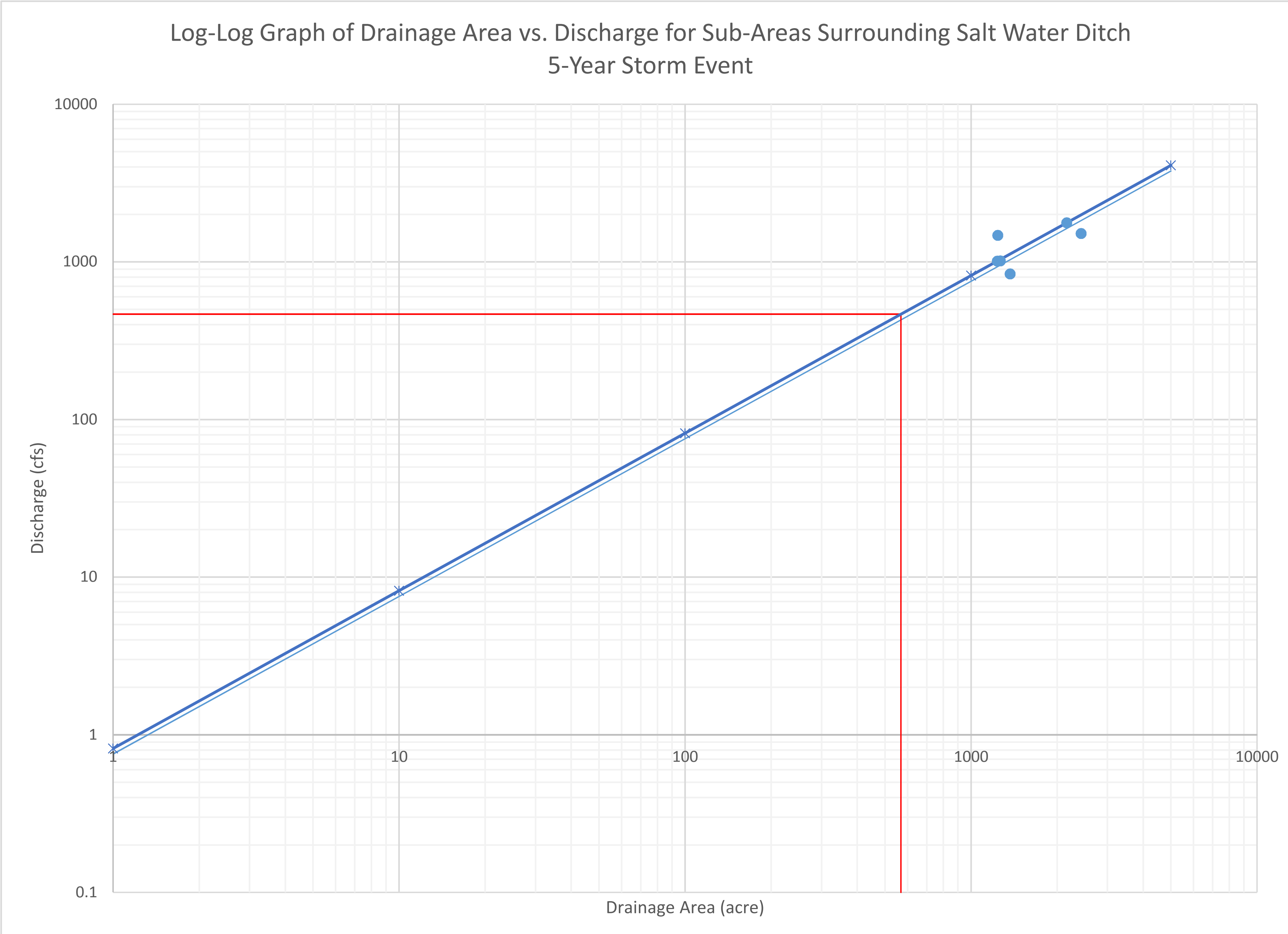

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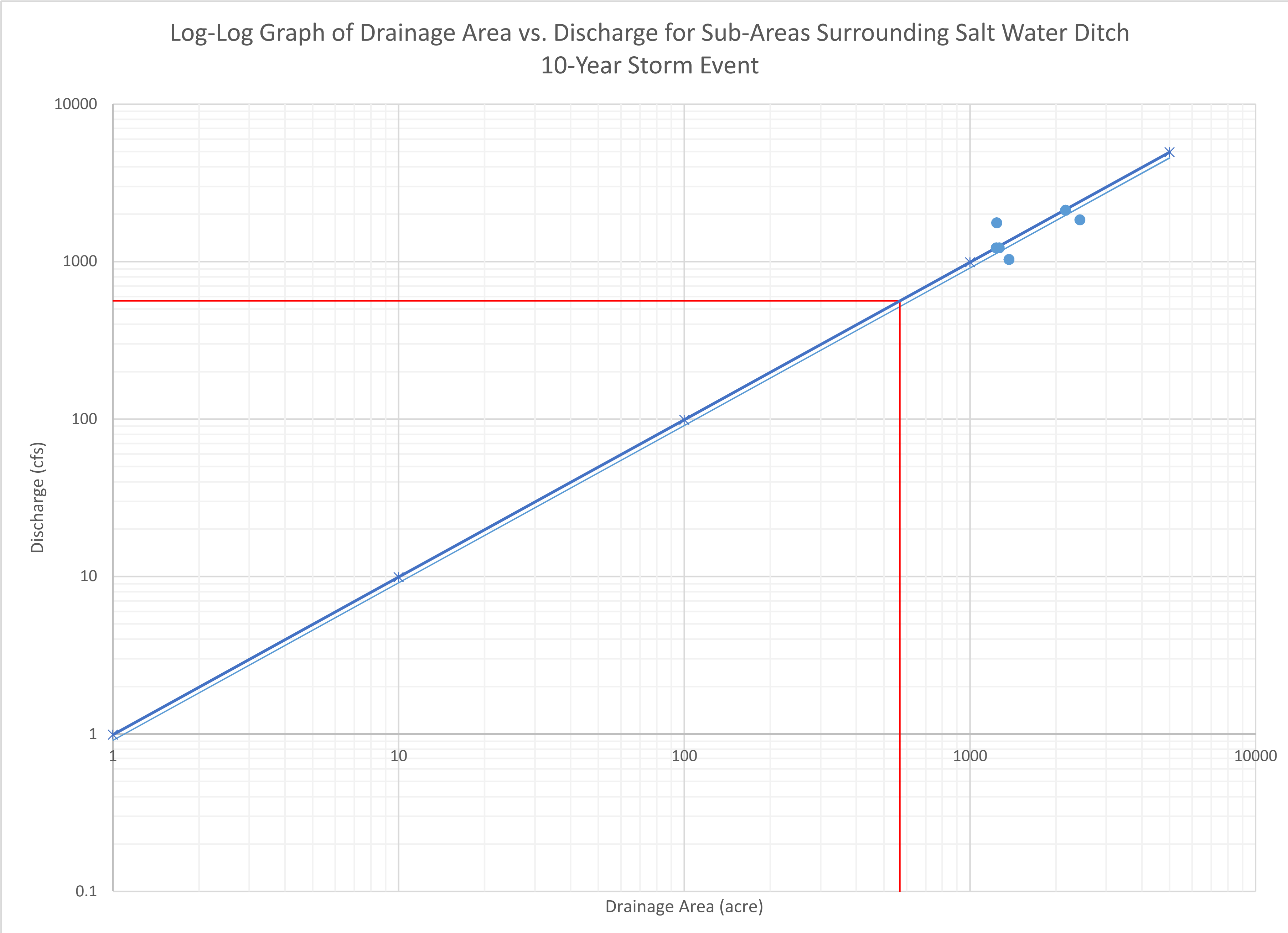

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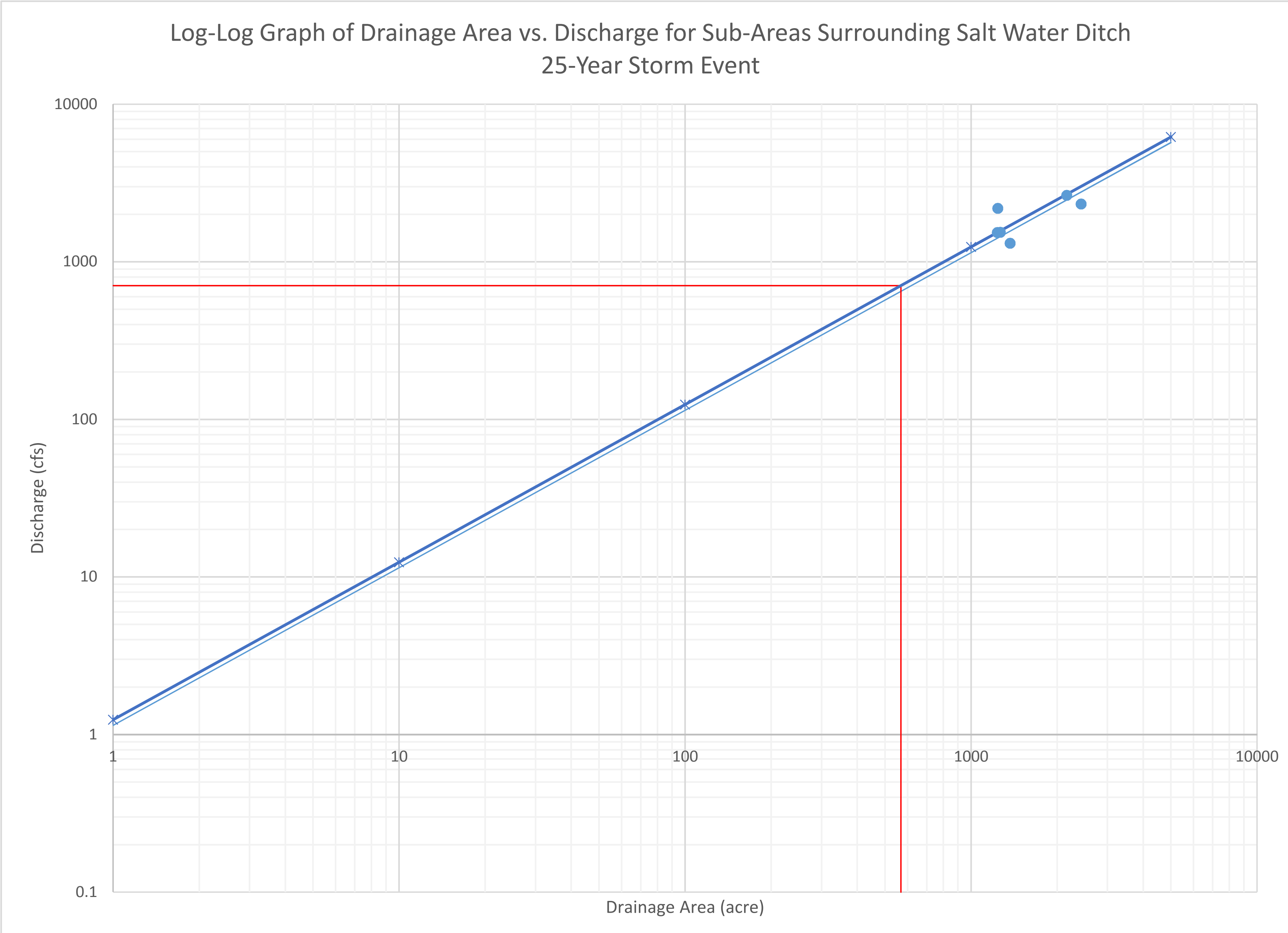

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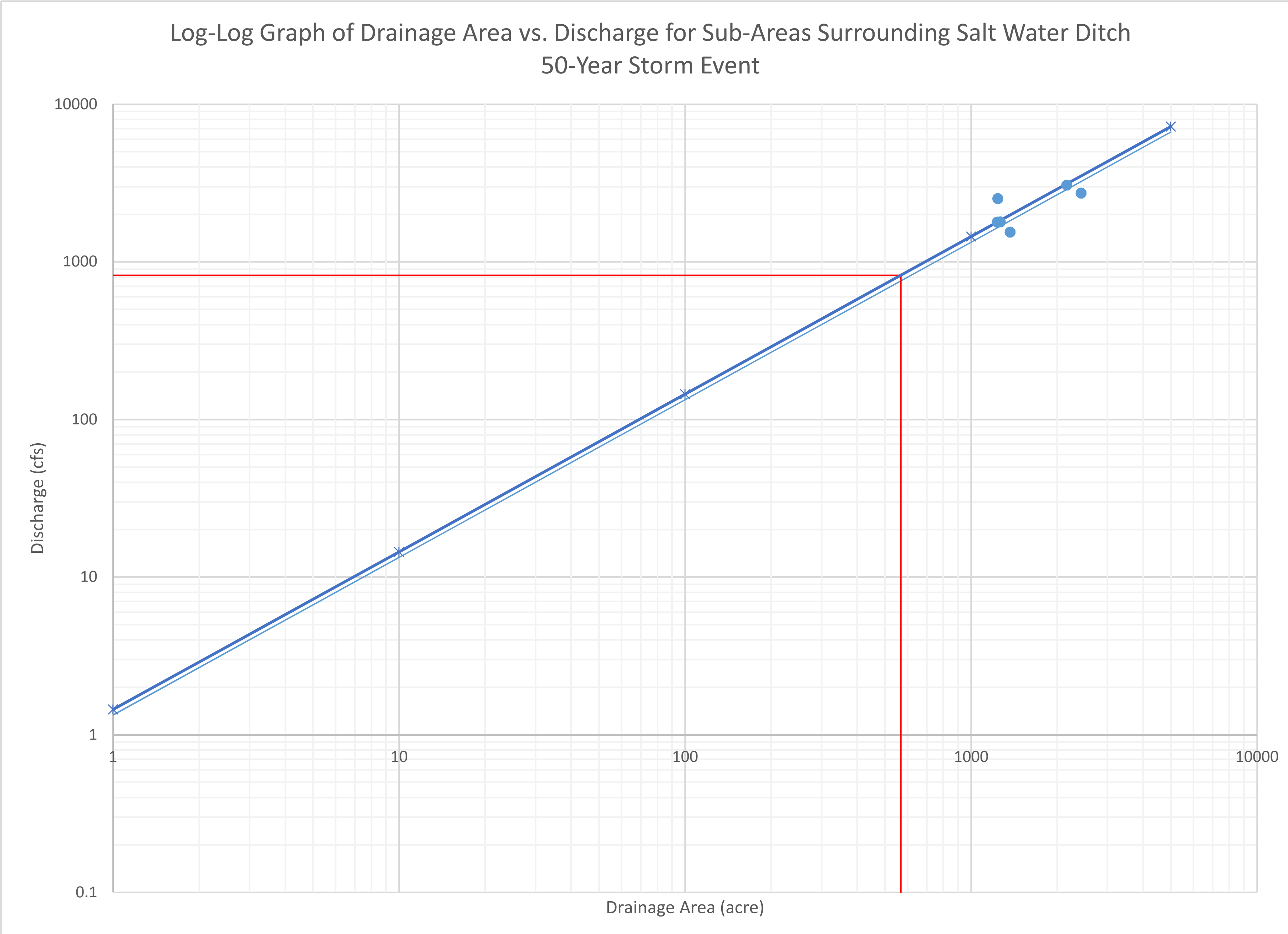

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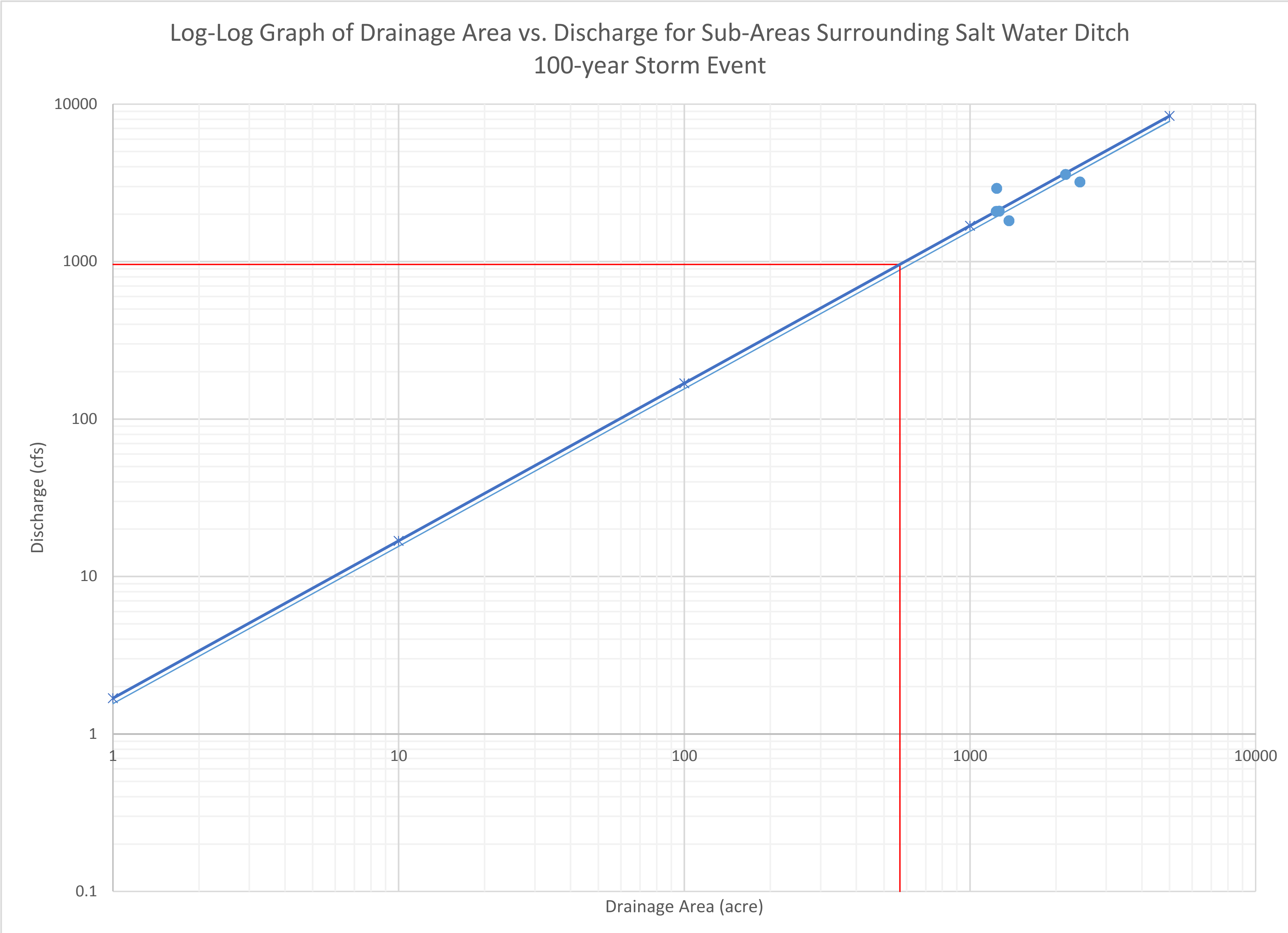

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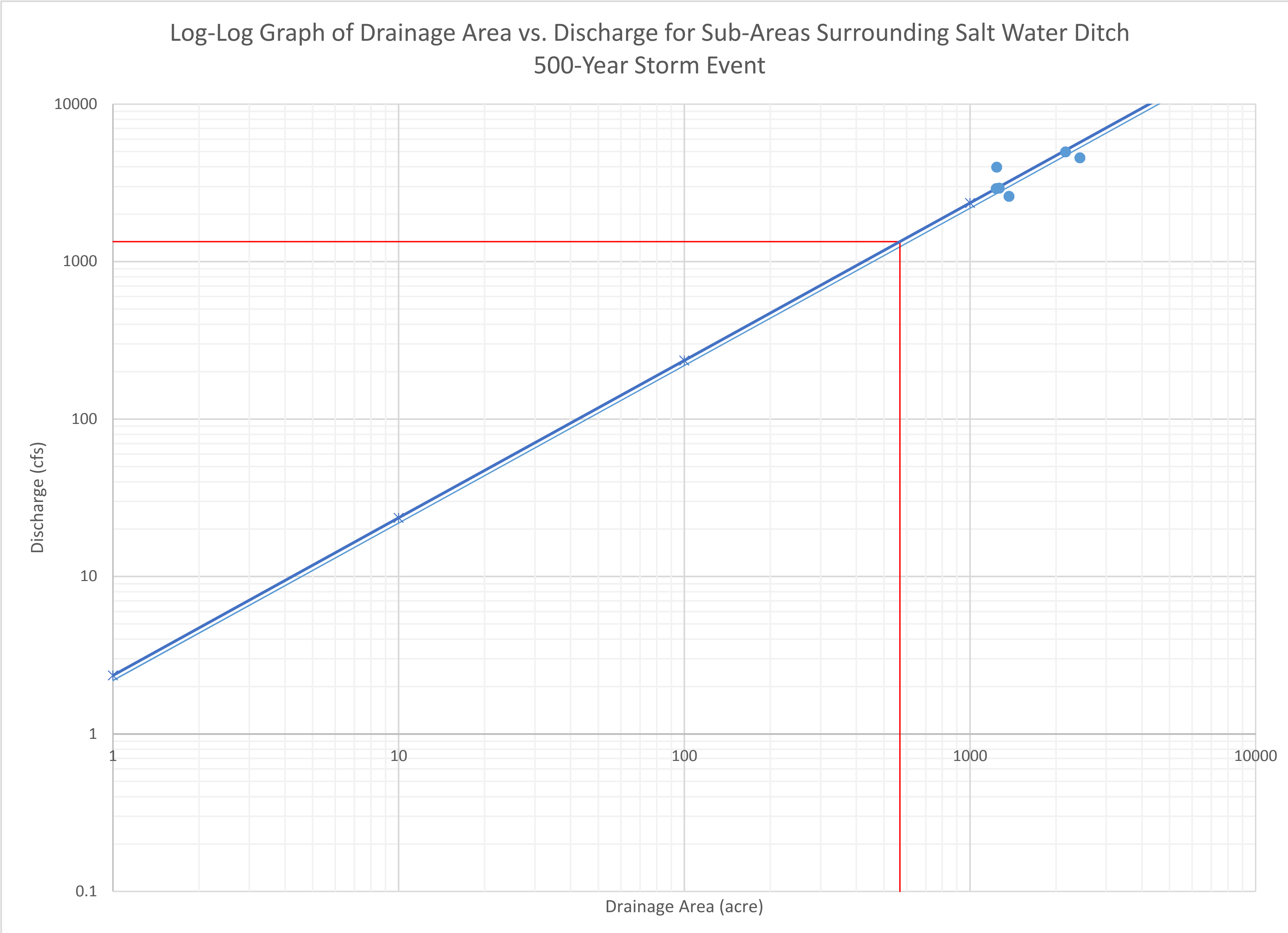

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Salt Water Ditch Flow Distributions

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	50% (2-yr)	25% (5-yr)	10% (10-yr)	4% (25-yr)	2% (50-yr)	1% (100-yr)	0.2% (500-yr)	100-yr % Diff.
C1180000_0009_J	U/S of conlufence 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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	26.65	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	28.04	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	28.97	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	30.12	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	30.97	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	31.85	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	33.99	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	28.11	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	29.50	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	30.41	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	31.55	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	32.38	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	33.25	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	35.36	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	28.66	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	30.04	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	30.94	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	32.07	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	32.90	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	33.76	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	35.86	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	29.05	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	30.43	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	31.32	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	32.45	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	33.28	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	34.14	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	36.23	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	29.28	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	30.65	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	31.55	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	32.67	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	33.49	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	34.35	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	36.44	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	29.55	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	30.91	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	31.80	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	32.92	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	33.74	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	34.60	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	36.67	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	29.76	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	31.12	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	32.00	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	33.12	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	33.93	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	34.79	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	36.86	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	29.87	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	31.22	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	26.72	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	27.31	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	27.68	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	28.17	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	28.53	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	28.91	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	29.83	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	27.06	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	27.65	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	28.02	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	28.51	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	28.87	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	29.25	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	30.17	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	27.12	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	27.69	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	28.07	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	28.56	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	28.92	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	29.30	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	30.22	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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
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	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From	To	Flows	Length	of Pipes	of Pipe	of Pipe	Slope	"n"	Capacity	Velocity		Drop	Upstream	Downstream	Velocity	Gradient	in Head	Upstream	Downstream	Upstrm	Dnstrm	
Road	Road	(cfs)	(ft)		(ft)	(ft)	(%)	(cfs)	(cfs)	(fps)	(ft)	(ft)	(ft)	(ft)	(fps)	(%)	(ft)	(ft)	(ft)	(ft)	(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	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road	Flows (cfs)	Length (ft)	of Pipes	of Pipe (ft)	of Pipe (ft)	Slope (%)	"n" (cfs)	Capacity (cfs)	Velocity (fps)	(ft)	Drop (ft)	Upstream (ft)	Downstream (ft)	Velocity (fps)	Gradient (%)	in Head (ft)	Upstream (ft)	Downstream (ft)	Upstrm (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	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road	Flows (cfs)	Length (ft)	of Pipes	of Pipe (ft)	of Pipe (ft)	Slope (%)	"n" (cfs)	Capacity (cfs)	Velocity (fps)	(ft)	Drop (ft)	Upstream (ft)	Downstream (ft)	Velocity (fps)	Gradient (%)	in Head (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: C5
Project: Salt Water Ditch
Project No: 325912
Date: 9/9/2015
Prepared By: DJ
Checked By:

Pipe Run		Proposed	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From	To	Flows	Length	of Pipes	of Pipe	of Pipe	Slope	"n"	Capacity	Velocity		Drop	Upstream	Downstream	Velocity	Gradient	in Head	Upstream	Downstream	Upstrm	Dnstrm	
Road	Road	(cfs)	(ft)		(ft)	(ft)	(%)	(cfs)	(cfs)	(fps)	(ft)	(ft)	(ft)	(ft)	(fps)	(%)	(ft)	(ft)	(ft)	(ft)	(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: C6
Project: Salt Water Ditch
Project No: 325912
Date: 9/9/2015
Prepared By: DJ
Checked By:

Pipe Run		Proposed	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From	To	Flows	Length	of Pipes	of Pipe	of Pipe	Slope	"n"	Capacity	Velocity		Drop	Upstream	Downstream	Velocity	Gradient	in Head	Upstream	Downstream	Upstrm	Dnstrm	
Road	Road	(cfs)	(ft)		(ft)	(ft)	(%)	(cfs)	(cfs)	(fps)	(ft)	(ft)	(ft)	(ft)	(fps)	(%)	(ft)	(ft)	(ft)	(ft)	(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	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road	Flows (cfs)	Length (ft)	of Pipes	of Pipe (ft)	of Pipe (ft)	Slope (%)	"n" (cfs)	Capacity (cfs)	Velocity (fps)	(ft)	Drop (ft)	Upstream (ft)	Downstream (ft)	Velocity (fps)	Gradient (%)	in Head (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	Reach	Number	Span	Rise		Manning's	Design	Design	Fall	Manhole	Flow Line		Actual	Hydraulic	Change	Hydraulic Gradient		Natural Ground		Notes
From Road	To Road	Flows (cfs)	Length (ft)	of Pipes	of Pipe (ft)	of Pipe (ft)	Slope (%)	"n" (cfs)	Capacity (cfs)	Velocity (fps)	(ft)	Drop (ft)	Upstream (ft)	Downstream (ft)	Velocity (fps)	Gradient (%)	in Head (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

	100-year Peak Flows (cfs)			500-year Peak Flows (cfs)		
HEC-HMS Node	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

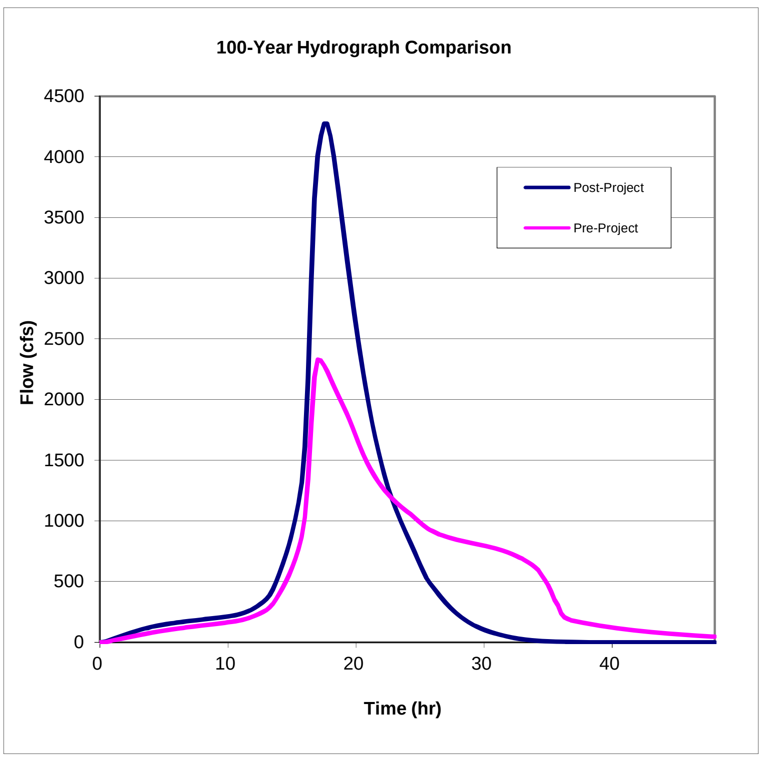
Project Name: Salt Water Ditch
Project No.: 325912
Location: Houston, Texas
Date: 11/20/15
Performed By: CM
Checked By: DJ

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		



CivilTech
Engineering, Inc.

Project Name: Salt Water Ditch
Project No.: 325912
Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

		Runoff Hydrographs			Runoff Volumes	
Time (minutes)	Time (hours)	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

CivilTech
Engineering, Inc.

Project Name: Salt Water Ditch
Project No.: 325912
Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

		Runoff Hydrographs			Runoff Volumes	
Time (minutes)	Time (hours)	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

CivilTech
Engineering, Inc.

Project Name: Salt Water Ditch
Project No.: 325912
Date: 11/20/15

100-YEAR HYDROGRAPH AND VOLUME COMPUTATIONS

Time Interval (min) = 15

		Runoff Hydrographs			Runoff Volumes	
Time (minutes)	Time (hours)	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: Proposed Runoff Q (cfs)	Runoff Hydrographs: Existing Runoff Q (cfs)	Flow Difference Qp-Qe (cfs)	Runoff Volumes: Incremental Volume (ac-ft)	Runoff Volumes: 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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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

5-YEAR MITIGATED

Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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 (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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 (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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

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Hydrologic Element	Drainage Area (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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 (MI2)	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