AECOM Water

TBPE Reg. No. F-3580

Prepared for:
Strom Drainage Program Support
City of Houston
Houston, Texas
WBS No. **M-000126-0076-3**

Prepared by:
AECOM
Houston, Texas
60183142
December 2013

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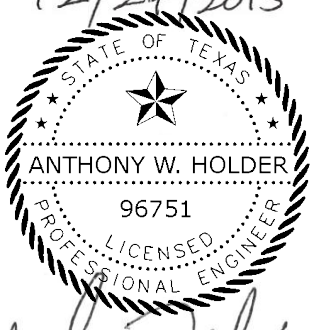

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List of Abbreviations

A	Rational Method and Clark Unit Hydrograph Area
AECOM	AECOM Technical Services, Inc.
ArcHydro	GIS Processing Utilities
b, d, and e	Rational Method Intensity-Duration-Frequency Coefficients
C	Rational Method Runoff Coefficient
CFS	Cubic Feet Per Second
FIS	Flood Insurance Study
FT	Feet
GIMS	Geographic Information & Management System (City of Houston)
GIS	Geographic Information System
HEC-GeoRAS	Geographic Information System Processing Utilities for HEC-RAS
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HCFCD	Harris County Flood Control District
H-GAC	Houston-Galveston Area Council
I	Rational Method Intensity
I_a	Ratio of Impervious Area to Total Area
IN/HR	Inches Per Hour
LiDAR	Light Detection and Ranging
NUSA LiDAR	2001 LiDAR Flown in 2008, with Non-Uniform Spatial Adjustment
PS&E	Plans, Specifications, and Estimates
R	Clark Unit Hydrograph Storage Coefficient
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
t_c	Time of Concentration
TSARP	Tropical Storm Allison Recovery Project
WSE	Water Surface Elevation

Executive Summary

City of Houston, under the Storm Drainage Program Support (WA 310, Work Order #3), authorized the Phase II Design services for this Local Drainage Project. This drainage analysis is for proposed storm drainage improvements and mitigation to the Skyscraper Shadows subdivision in southeast Houston, as shown in **Exhibit 1.** The purpose of the study was to identify existing drainage conditions including problem flooding areas, and to propose alternatives to the drainage design to alleviate existing problems without causing downstream impacts. The improvements will be reflected in the Plans, Specifications, and Estimates for the Skyscraper Shadows Local Drainage Project (WBS No. **M-000126-0076-3, Contract No. C55495**).

The overland flow for Skyscraper Shadows is generally from the southwest to the northeast, as shown in **Exhibit 2**. The subdivision's ditch systems are designed to allow the runoff to outfall to the three surrounding ditches, with the majority of the runoff flowing towards A120-00-00. A large portion of the area drains north to Almeda-Genoa Road during extreme events and then is carried by storm sewer towards A120-00-00. It appears that the Almeda-Genoa Road system does not have capacity to convey the peak flow from these extreme events and is causing runoff to pond in the northern section of the subdivision. Additionally, the roadside ditch system provides relief for the Almeda-Genoa Road system by conveying a portion of the flow east towards A120-00-00. The existing conditions model indicates that the outfall system and roadway cross culverts flowing toward A120-00-00 do not provide sufficient capacity and contribute to the flooding in the central portion of the subdivision. This is especially true for the area south of Gulick Lane between Randolph Street and Wingtip Drive, where greater flooding depths are noted.

The proposed revisions to the Skyscraper Shadows subdivision summarized in **Exhibit 3** include regular maintenance of roadside ditches, improvement of driveway culverts to the minimum 24" diameter standard in the City of Houston, and proposed storm sewer systems along Gulick Lane and Holiday Lane, improvements to the outfalls on Wetherby Lane, and Swiftwater Lane, and new ditch safety end treatments on Lanham Lane, Swiss Lane, and Wayfarer Lane. The proposed revisions are designed to bring the subdivision's drainage capacity up to be adequate for a 2-year event, and to improve the extreme event performance. Based on LiDAR-estimated slab elevations, the design should result in mitigation of structural flooding for storms less than a 10-year to 25-year event. Residual structural flooding during larger storms is likely to continue, but less frequently and at reduced inundation depths.

Based on the analysis performed by AECOM and described in this report, the proposed drainage improvements, along with the proposed revisions to the detention basin, will result in no adverse impact to either A120-00-00 or A125-00-00 for rainfall events up to and including the 100-year storm.

1.0 Introduction

1.1 Project Name and Purpose

This study includes hydrologic and hydraulic analysis for proposed revisions to the Skyscraper Shadows subdivision in southeast Houston. **Exhibit 1** shows the general project vicinity. The purpose of the study was to identify existing drainage conditions including problem flooding areas, and to propose alternatives to the drainage design to alleviate existing problems without causing downstream impacts.

This drainage analysis represents the storm drainage improvements and mitigation that will be reflected in the construction plans for the Skyscraper Shadows Local Drainage Project (WBS No. **M-000126-0076-3, Contract No. C55495**). The improvements will be reflected in the Plans, Specifications, and Estimates (PS&E).

1.2 Project Limits

The Skyscraper Shadows subdivision is located in the southeast portion of Houston as shown on **Exhibit 1**.The project limits are from Almeda Genoa Road on the north side of the subdivision and Wayfarer Lane on the south, and between Ballantine Street on the west and Monroe Road on the east. The proposed project includes drainage improvements along Swiss Lane, Gulick Lane, Lanham Lane, Holiday Lane, Wetherby Lane, Swiftwater Lane, and Wayfarer Lane.

1.3 Project Objectives

The work to be performed by the Engineer is the preparation of a drainage study to determine existing flooding characteristics, determine proposed improvements to reduce flooding in the project area, evaluate hydrologic and hydraulic impacts associated with the proposed project, determine mitigation measures necessary to offset any downstream impacts from the project, and develop hydrologic and hydraulic data for use in PS&E for the proposed Skyscraper Shadows drainage improvements.

1.4 Assumptions and Constraints

As a part of this study the following assumptions and constraints should be noted:

1. The drainage system within the area of the subdivision is a complex system of roadside ditches, overland flow paths, and roadways served by storm sewers. General overland flow directions differ from ditch and subsurface flow directions. There are man-made obstructions to flow due to raised roadways and berms and man-made flow paths due to depressed roadways, storm sewers, and open channels.

2. City of Houston owns the drainage channel immediately adjacent to the subdivision; however, farther downstream, this channel is owned by Harris County Flood Control District (HCFCD). The ditch downstream has silted up over time, limiting outfall depths in the project area.

1.5 Prior Studies

No prior hydrologic and hydraulic studies have been located for this project area.

1.6 Coordination

AECOM and the City of Houston met with HCFCD on **September 26, 2013** to discuss possible downstream channel desilting and HCFCD's requirements. After that meeting, City of Houston decided to pursue a wet-bottom detention facility, which would avoid the necessity to pursue channel desilting and the geotechnical issues with the downstream channel's side slope stability that would be associated with the desilting process.

2.0 Site Conditions

2.1 Location and Topography

The Skyscraper Shadows subdivision is located in the southeast portion of Houston, Texas, just south of Almeda Genoa Road and west of Monroe Road, as shown on **Exhibit 1**. The project area is primarily served by roadside ditches; however, the two major roads bordering the subdivision (Almeda Genoa and Monroe) are curb-and-gutter roadways served by storm sewer systems. In general, the roadside ditches are silted up, reducing the flow capacity in the ditches and through the culverts under driveways and under roadways. In many areas, the ditch flow lines do not smoothly proceed from upstream to downstream, and many of the culverts are at reverse grade. These conditions exacerbate the silting of the ditches, which further reduces flow capacity. In addition, many of the driveway culverts and roadway culverts are smaller than the current City of Houston minimum culvert size of 24" diameter.

The topographic conditions in the subdivision, as shown on **Exhibit 2**, generally result in flow toward the center of the subdivision. The lowest points within the subdivision are in the north half of the project area, along Gulick Lane and Lanham Lane, between Randolph Street and Wingtip Drive. A summary of the proposed improvements is shown in **Exhibit 3**.

2.2 HCFCD Facilities and Unit Numbers

Three channels with HCFCD designations drain the project area (A125-00-00, its tributary A125-03-00, and A120-00-00). A125-00-00 runs along the western edge of the project area, A125-03-00 runs along the south edge of the subdivision, and A120-00-00 runs along Monroe on the eastern edge of the project area from Almeda Genoa Road to Swiftwater Lane, where it turns 90 degrees east. An existing detention facility is located adjacent to the channel where it turns to the east. **Exhibit 1** shows the three channels and the limits of the drainage area included in this analysis.

2.3 Right-of-Way

Roadside ditch modifications are being undertaken within City of Houston right-of-way throughout the project. HCFCD's A125-00-00 is not being modified. City of Houston owns the tract where the existing detention facility and the proposed expanded detention facility will be located. HCFCD owns and maintains the portion of ditch A120-00-00 adjacent to Monroe Road and the area adjacent to the proposed detention facility. East of Moers Road, ditch A120-00-00 is owned by HCFCD. All the channel modifications and detention excavation are being performed within City of Houston right-of-way.

2.4 Pipelines and Utilities

Within the project area, typical subdivision utilities have been located and are noted on the PS&E, but there are no known pipelines or utilities affecting the channel modifications or detention excavation. Several "critical locate" situations have been called out on the PS&E sheets.

3.0 Methodology

3.1 General Hydrologic and Hydraulic Analysis

The US Army Corps of Engineers' HEC-HMS and HEC-RAS drainage models were utilized for this analysis of the design and mitigation. The model versions used on this project are HEC-HMS 3.4 and HEC-RAS 4.1.0.

The hydrologic and hydraulic methodologies used in this analysis are described below. The hydrology was a combination of the Rational Method and the Clark Unit Hydrograph method, with hydrographs developed within HEC-HMS to match Rational Method peak flows. Hydraulic computations were performed within HEC-RAS using the unsteady flow option.

3.2 Available Data

Project related data were collected and used in the study. The following is a list of data collected and/or used:

- 2008 Light Detection and Ranging (LiDAR) data
- 2001 LiDAR Flown in 2008 Non-Uniform Spatial Adjustment
- 2012 aerial maps from Houston-Galveston Area Council (H-GAC)
- Effective Flood Insurance Study (FIS) watershed/sub-watershed boundaries
- HCFCD Right-of-Way
- HCFCD channel network
- Surveyed driveway culvert locations, sizes, and elevations

3.3 Hydrologic Methodology

The storms used in this analysis include the following five annual exceedance probabilities: 50%, 10%, 4%, 2%, and 1% (i.e., recurrence interval of 2-year, 10-year, 25-year, 50-year and 100-year storm event, respectively). While the annual exceedance probability is a more accurate term, as two 100-year storms could occur in back-to-back years, this report will refer to the more commonly used recurrence interval to describe the storms.

Because the proposed improvements do not significantly change the drainage area characteristics (aside from the increased impervious cover due to expansion of the detention basin), the hydrologic calculations are identical in all conditions and for all models. The hydrologic parameter collection will be described only within this section.

3.3.1 Drainage Area Delineation

LiDAR topographic data was used to delineate subbasins and offsite drainage areas. City of Houston Geographic Information & Management System (GIMS) storm sewer data was used in developing offsite drainage areas.

Drainage area delineation was performed in support of the hydraulic analysis methodology. A description of how the hydraulic methodology affects the drainage area delineation is included with

the description of the hydraulic analysis methodology. In areas served by roadside ditches, the drainage area boundaries are generally along the road centerlines and the back lot lines, while in areas served by curb-and-gutter roads with storm sewer systems, the drainage area boundaries are generally only at the back lot line. The drainage areas were delineated to support a 'trunkline-level' analysis that does not include all inlets and leads. **Exhibit 4** shows the delineated drainage areas for existing and proposed conditions.

3.3.2 Peak Flow Estimation

The peak flow from each drainage area was estimated using the Rational Method with the City of Houston's Time-of-Concentration (t_c) equation for the five storm events. A HEC-HMS basin model was then created for each storm event that included a subbasin for each drainage area. Peak flows were computed based on the t_c derived by City of Houston's equation and adjustments were made to the Clark Unit Hydrograph Method R-value to produce peak flows equal to that computed using the Rational Method. Loss rates used were those specified by HCFCD that encompassed the study area.

3.3.2.1 Rational Method

The Rational Method was used to estimate peak flows for all drainage areas. The utilization of the Rational Method follows the guidelines described in *Chapter 9,* of the City of Houston's *Infrastructure Design Manual* (IDM), July 2012 revision*.* The Rational Method equation is expressed as

$$Q = CIA,$$

where

Q = maximum rate of runoff (cfs),

C = runoff coefficient,

I = average rainfall intensity (in/hr), and

A = drainage area (ac).

A runoff coefficient (C) was assigned to each land-use type in this study. For the details on the determination of C-values, please refer to **Section 3.3.4, Land-Use***.*

The rainfall intensity was determined using the equation

$$I = \frac{b}{(t_c + d)^e},$$

where

I = rainfall intensity (in/hr), and

t_c = time of concentration (min).

b, d, e = coefficients for specific frequencies listed in Chapter 9 of the IDM.

Once runoff coefficient (*C*), average rainfall intensity (*I*) and drainage area acreage (*A*) were determined, they were substituted into the Rational Method equation to calculate peak flows.

3.3.3 Time of Concentration (t_c)

The t_c was estimated using the formula in Chapter 9 of the IDM,

$$t_c = 10A^{0.1761} + 15,$$

where A is the drainage area in acres.

3.3.4 Land-Use

Peak flow estimations were calculated using a runoff coefficient value (*C-value*), which is a function of land-use. For each drainage area, H-GAC 2012 aerial photography was used to estimate impervious cover. Impervious cover values selected were 0.2 to 0.25 for mostly undeveloped drainage areas, 0.4 for residential areas, 0.45 for denser residential areas and mixed-use offsite areas, 0.55 to 0.65 for industrial/commercial areas, and 0.9 for portions of the A120-00-00 channel. Roadway right-of way was assumed to be part of the adjacent drainage area.

The drainage area (ID 1753) that contains the existing detention basin and proposed detention basin expansion was assigned a 0.50 impervious cover value for existing conditions and 0.85 for proposed conditions. This is the only change in land use between existing and proposed conditions.

The *C-value* for each drainage area were calculated from the assigned impervious cover using the equation found in Section 9.05.B.3.a.2 of the City of Houston IDM,

$$C = 0.6I_a + 0.2,$$

where I_a is the ratio of impervious area to total area.

The *C*-value for each drainage area were used to calculate existing and proposed peak flow estimates for the Rational Method and the percentage of impervious cover was used within HEC-HMS to develop hydrographs from the drainage areas.

3.3.5 Hydrograph Development

Once the area, existing/proposed weighted *C*-value, weighted percent impervious cover, and time of concentration were developed for each drainage area, peak flows for the existing/proposed storms were calculated using the Rational Method. The subbasin parameters were entered into HEC-HMS, which was then utilized to calculate hydrographs for the impact analysis. A runoff node was created for each drainage area, and assigned the appropriate area, t_c, and percent impervious cover. For the detention basin's drainage area, two subbasins were created, one with each percent impervious cover.

The Green and Ampt Loss Method was used to account for precipitation loss, while the Clark Unit Hydrograph was selected for transforming the direct runoff response. Watershed-specific parameters, including drainage area, percent imperviousness, t_c, and storage coefficient (*R)* were inserted into the HEC-HMS model. The general hydrologic parameters, including initial loss, moisture deficit, suction, and conductivity used in loss method were taken from the TSARP technical white paper for the Clear Creek watershed. These parameters are summarized in **Table 3-1**.

Table 3-1: Green and Ampt Loss Parameters for All Drainage Areas

Parameter	Initial Loss (in)	Moisture Deficit	Suction (in)	Conductivity (in/hr)
Value Used	0.1	0.385	12.45	0.024

Along with the subbasin parameters described above, a spreadsheet was used to vary the Clark Unit Hydrograph's *R* until the peak flow from the subbasin matched the calculated value within 0.5% of the Rational Method calculation, where possible, using a one minute time step. A unique storage coefficient was developed for each drainage area for each storm. Once the R values were entered into HEC-HMS, the peak flows from the HEC-HMS engine may not exactly match the spreadsheet's values, as the HEC-HMS model uses a 5-minute time step. As a result, the peak flows within the HEC-HMS model will not exactly match the Rational Method peak flows calculated for every drainage area. This issue will not significantly affect the design or impact analysis, as the timing of the hydrograph peak and the placement of the proper volume near the peak are the driving factors for the analysis, especially for the larger storms. **Table 3-2** and **3** summarize the hydrologic parameters and peak flows for each of the drainage areas.

The City of Houston does not provide rational method intensity duration frequency coefficients (b, d, and e) for the 50-year storm. To estimate the 50-year peak flow, an *R* value interpolated from the 25-year and 100-year calibrations was used in HEC-HMS along with the 50-year rainfall distribution. The interpolation was linear in R and used a normal probability distribution for the storm frequency.

Table 3-2: Summary of Hydrologic Parameters for All Drainage Areas

Drainage Area ID	Area (ac)	t_c (hr)	Impervious Cover (%)	C	Storage Coefficient, R (hr)				
					2-yr	10-yr	25-yr	50-yr*	100-yr
100	47.44	0.579	45	0.47	1.026	1.051	1.087	1.161	1.229
101	41.76	0.572	45	0.47	1.018	1.042	1.077	1.151	1.218
102	28.65	0.551	45	0.47	0.989	1.010	1.047	1.118	1.183
103	165.04	0.660	45	0.47	1.139	1.164	1.205	1.288	1.362
104	4.98	0.471	65	0.59	0.601	0.590	0.598	0.636	0.670
105	7.10	0.485	40	0.44	0.993	1.027	1.066	1.146	1.217
106	7.35	0.487	40	0.44	0.986	1.030	1.067	1.143	1.211
107	7.47	0.487	40	0.44	0.996	1.034	1.076	1.149	1.215
108	7.53	0.488	40	0.44	0.993	1.037	1.070	1.145	1.213
109	6.90	0.484	40	0.44	0.982	1.027	1.070	1.144	1.211
110	6.22	0.480	40	0.44	0.974	1.026	1.053	1.131	1.201
111	6.01	0.479	40	0.44	0.975	1.021	1.052	1.129	1.199
112	6.05	0.479	40	0.44	0.985	1.019	1.052	1.130	1.201
113	5.95	0.478	40	0.44	0.978	1.018	1.060	1.135	1.203
114	6.19	0.480	40	0.44	0.984	1.018	1.057	1.133	1.202
115	7.39	0.487	40	0.44	0.994	1.027	1.066	1.142	1.211
116	5.94	0.478	40	0.44	0.977	1.017	1.058	1.133	1.201
117	8.78	0.494	40	0.44	1.008	1.041	1.086	1.162	1.231
118	13.53	0.514	65	0.59	0.644	0.629	0.640	0.682	0.719
119	7.82	0.489	65	0.59	0.618	0.605	0.617	0.655	0.690

Table 3-2 continued.

Drainage Area ID	Area (ac)	t_c (hr)	Impervious Cover (%)	C	Storage Coefficient, R (hr)				
					2-yr	10-yr	25-yr	50-yr*	100-yr
120	13.18	0.512	40	0.44	1.033	1.070	1.109	1.189	1.260
121	12.24	0.509	40	0.44	1.027	1.064	1.103	1.183	1.256
122	12.55	0.510	40	0.44	1.029	1.066	1.104	1.183	1.254
123	12.50	0.510	40	0.44	1.023	1.066	1.111	1.189	1.259
124	12.41	0.510	40	0.44	1.030	1.067	1.109	1.186	1.255
125	12.63	0.510	40	0.44	1.029	1.069	1.109	1.186	1.255
126	12.60	0.510	40	0.44	1.025	1.065	1.105	1.184	1.256
127	12.68	0.511	40	0.44	1.026	1.070	1.112	1.189	1.259
128	12.61	0.510	40	0.44	1.027	1.067	1.107	1.187	1.259
129	12.65	0.511	40	0.44	1.032	1.065	1.106	1.187	1.259
130	15.40	0.520	40	0.44	1.046	1.084	1.124	1.203	1.274
131	12.51	0.510	40	0.44	1.024	1.068	1.105	1.184	1.254
132	18.27	0.528	40	0.44	1.052	1.097	1.139	1.217	1.288
133	13.08	0.512	40	0.44	1.029	1.069	1.113	1.190	1.260
134	6.15	0.479	65	0.59	0.610	0.600	0.609	0.647	0.680
135	14.52	0.517	40	0.44	1.040	1.081	1.122	1.200	1.270
136	12.10	0.509	40	0.44	1.028	1.066	1.108	1.186	1.256
137	12.24	0.509	40	0.44	1.028	1.065	1.103	1.184	1.257
138	12.24	0.509	40	0.44	1.026	1.064	1.109	1.186	1.255
139	12.08	0.508	40	0.44	1.026	1.063	1.105	1.183	1.253
140	12.25	0.509	40	0.44	1.028	1.066	1.104	1.185	1.258
141	12.28	0.509	40	0.44	1.023	1.064	1.103	1.184	1.258
142	12.34	0.509	40	0.44	1.020	1.064	1.105	1.183	1.254
143	12.24	0.509	40	0.44	1.027	1.064	1.109	1.186	1.255
144	12.25	0.509	40	0.44	1.028	1.066	1.104	1.185	1.258
145	15.03	0.519	40	0.44	1.038	1.081	1.120	1.200	1.271
146	12.18	0.509	40	0.44	1.029	1.063	1.107	1.187	1.258
147	17.70	0.526	40	0.44	1.049	1.092	1.134	1.214	1.285
148	11.39	0.506	20	0.32	1.583	1.738	1.853	1.997	2.126
149	7.88	0.490	90	0.74	0.395	0.364	0.361	0.384	0.406
150	76.82	0.608	55	0.53	0.885	0.883	0.906	0.965	1.018
151	26.68	0.547	55	0.53	0.813	0.813	0.834	0.889	0.938
152	30.93	0.555	55	0.53	0.825	0.823	0.842	0.897	0.947
153	163.65	0.659	45	0.47	1.137	1.163	1.204	1.287	1.361
1203	3.88	0.462	40	0.44	0.956	1.003	1.027	1.098	1.163
1204	5.65	0.476	40	0.44	0.977	1.018	1.059	1.131	1.196
1205	5.82	0.477	40	0.44	0.982	1.023	1.059	1.129	1.193
1206	36.34	0.564	25	0.35	1.518	1.647	1.735	1.871	1.994
1207	42.17	0.572	25	0.35	1.538	1.664	1.754	1.891	2.014
1208	23.14	0.540	25	0.35	1.468	1.597	1.683	1.816	1.936
1229	20.16	0.533	45	0.47	0.965	0.987	1.022	1.092	1.155

Table 3-2 continued.

Drainage Area ID	Area (ac)	t_c (hr)	Impervious Cover (%)	C	Storage Coefficient, R (hr)				
					2-yr	10-yr	25-yr	50-yr*	100-yr
1230	20.08	0.533	45	0.47	0.964	0.988	1.022	1.091	1.153
1543	4.43	0.467	20	0.32	1.473	1.663	1.764	1.896	2.015
1544	6.03	0.479	60	0.56	0.670	0.661	0.674	0.717	0.756
1753	9.15	0.496	50	0.5	0.830	0.842	0.864	0.922	0.974
1753_Prop	9.15	0.496	85	0.71	0.439	0.407	0.406	0.432	0.456

*Storage coefficient for the 50-year storm event was interpolated based on the 25- and 100-year storm events

Table 3-3: Summary of Peak Flows for All Drainage Areas

Drainage Area ID	Rational Peak Flow (cfs)					HMS Peak Flow (cfs)				
	2-yr	10-yr	25-yr	50-yr*	100-yr	2-yr	10-yr	25-yr	50-yr*	100-yr
100	63.7	95.5	111.6	122.1	135.6	63.3	95.1	111.3	122.1	135.5
101	56.4	84.6	98.8	108.0	120	56.1	84.1	98.4	108.0	119.8
102	39.5	59.2	69	75.3	83.8	39.4	59.0	68.8	75.3	83.5
103	205.3	310.8	363.8	398.5	443.5	204.5	309.4	362.7	398.5	443.0
104	9.4	13.9	16.2	17.7	19.6	9.4	13.8	16.1	17.7	19.5
105	9.8	14.6	17	18.5	20.5	9.8	14.6	17.0	18.5	20.5
106	10.2	15.1	17.6	19.2	21.3	10.2	15.1	17.6	19.2	21.3
107	10.3	15.3	17.8	19.5	21.6	10.2	15.3	17.8	19.5	21.6
108	10.4	15.4	18	19.7	21.8	10.4	15.4	18.0	19.7	21.8
109	9.6	14.2	16.5	18.0	20	9.5	14.2	16.5	18.0	20.0
110	8.7	12.8	15	16.4	18.1	8.6	12.8	15.0	16.4	18.1
111	8.4	12.4	14.5	15.8	17.5	8.3	12.4	14.5	15.8	17.5
112	8.4	12.5	14.6	15.9	17.6	8.3	12.5	14.6	15.9	17.6
113	8.3	12.3	14.3	15.6	17.3	8.2	12.3	14.3	15.6	17.3
114	8.6	12.8	14.9	16.3	18	8.5	12.8	14.9	16.3	18.0
115	10.2	15.2	17.7	19.3	21.4	10.1	15.2	17.7	19.3	21.4
116	8.3	12.3	14.3	15.6	17.3	8.2	12.2	14.3	15.6	17.3
117	12	17.9	20.8	22.8	25.2	12.0	17.9	20.8	22.8	25.2
118	24.4	36.3	42.3	46.1	51.2	24.3	36.1	42.1	46.1	50.9
119	14.5	21.5	25	27.3	30.3	14.4	21.4	24.9	27.3	30.2
120	17.7	26.4	30.8	33.7	37.3	17.7	26.4	30.8	33.7	37.3
121	16.5	24.6	28.7	31.4	34.7	16.5	24.6	28.7	31.4	34.7
122	16.9	25.2	29.4	32.2	35.6	16.9	25.2	29.4	32.2	35.6
123	16.9	25.1	29.2	32.0	35.4	16.9	25.1	29.2	32.0	35.4
124	16.7	24.9	29	31.8	35.2	16.7	24.9	29.0	31.8	35.2
125	17	25.3	29.5	32.3	35.8	17.0	25.3	29.5	32.3	35.8
126	17	25.3	29.5	32.3	35.7	17.0	25.3	29.5	32.3	35.7
127	17.1	25.4	29.6	32.4	35.9	17.1	25.4	29.6	32.4	35.9
128	17	25.3	29.5	32.3	35.7	17.0	25.3	29.5	32.3	35.7
129	17	25.4	29.6	32.3	35.8	17.0	25.4	29.6	32.3	35.8
130	20.5	30.6	35.7	39.0	43.3	20.5	30.6	35.7	39.0	43.2

Table 3-3 continued.

Drainage Area ID	Rational Peak Flow (cfs)					HMS Peak Flow (cfs)				
	2-yr	10-yr	25-yr	50-yr*	100-yr	2-yr	10-yr	25-yr	50-yr*	100-yr
131	16.9	25.1	29.3	32.0	35.5	16.9	25.1	29.3	32.0	35.5
132	24.2	36	42	45.9	51	24.2	36.0	41.9	45.9	50.9
133	17.6	26.2	30.5	33.4	37	17.6	26.2	30.5	33.4	37.0
134	11.5	17	19.8	21.6	24	11.5	16.9	19.7	21.6	23.9
135	19.4	28.9	33.7	36.9	40.9	19.4	28.9	33.7	36.9	40.9
136	16.3	24.3	28.3	31.0	34.3	16.3	24.3	28.3	31.0	34.3
137	16.5	24.6	28.7	31.4	34.7	16.5	24.6	28.7	31.4	34.7
138	16.5	24.6	28.6	31.3	34.7	16.5	24.6	28.6	31.3	34.7
139	16.3	24.3	28.3	31.0	34.3	16.3	24.3	28.3	31.0	34.3
140	16.5	24.6	28.7	31.4	34.7	16.5	24.6	28.7	31.4	34.7
141	16.6	24.7	28.8	31.5	34.8	16.6	24.7	28.8	31.5	34.8
142	16.7	24.8	28.9	31.6	35	16.7	24.8	28.9	31.6	35.0
143	16.5	24.6	28.6	31.3	34.7	16.5	24.6	28.6	31.3	34.7
144	16.5	24.6	28.7	31.4	34.7	16.5	24.6	28.7	31.4	34.7
145	20.1	29.9	34.9	38.2	42.3	20.1	29.9	34.9	38.2	42.3
146	16.4	24.5	28.5	31.2	34.5	16.4	24.5	28.5	31.2	34.5
147	23.5	35	40.8	44.6	49.5	23.5	35.0	40.7	44.6	49.4
148	11.2	16.7	19.4	21.2	23.6	11.2	16.7	19.4	21.2	23.6
149	18.3	27.1	31.6	34.3	38.2	18.1	26.8	31.2	34.3	37.9
150	113.1	170.2	199	217.7	242.1	112.4	169.5	198.2	217.7	241.7
151	41.7	62.3	72.7	79.5	88.2	41.6	62.2	72.5	79.5	88.0
152	47.9	71.7	83.8	91.6	101.7	47.8	71.5	83.6	91.6	101.5
153	203.8	308.4	361	395.3	440	203.0	307.0	359.7	395.3	439.5
1203	5.5	8.1	9.5	10.4	11.5	5.5	8.1	9.5	10.4	11.5
1204	7.9	11.7	13.6	14.9	16.5	7.8	11.6	13.6	14.9	16.5
1205	8.1	12	14	15.3	17	8.0	12.0	14.0	15.3	17.0
1206	36.9	55.2	64.5	70.5	78.3	36.9	55.2	64.4	70.5	78.3
1207	42.4	63.6	74.3	81.3	90.3	42.4	63.6	74.2	81.3	90.3
1208	24.1	35.9	41.9	45.8	50.8	24.0	35.9	41.9	45.8	50.7
1229	28.3	42.3	49.3	53.9	59.8	28.2	42.2	49.2	53.9	59.7
1230	28.2	42.1	49.1	53.7	59.6	28.1	42.0	49.0	53.7	59.5
1543	4.6	6.7	7.8	8.5	9.5	4.6	6.7	7.8	8.5	9.5
1544	10.7	15.9	18.5	20.2	22.4	10.7	15.8	18.5	20.2	22.3
1753	14.2	21.1	24.6	26.8	29.8	14.1	21.0	24.5	26.8	29.7
1753_Prop	20.2	30	35	38.2	42.3	20.1	29.8	34.8	38.2	42.2

*Calculated the 50-year storm event peak flow using HEC-HMS with the interpolated storage coefficient

3.4 Hydraulic Methodology

Impact analyses were performed to determine whether proposed revisions to the drainage system could be expected to ameliorate flooding conditions in the project area, and to determine how much mitigation volume would be necessary to offset the increased flow to the channel. One existing conditions model was developed to determine the existing flooding conditions and one combined proposed conditions model was developed, showing both the project area benefits and the downstream mitigation.

3.4.1 HEC-RAS Analysis

HEC-RAS was selected for this analysis and was used in unsteady flow mode. Unsteady HEC-RAS simulates surface storage in storage area elements and connects the storage area elements with each other and with linear channels using weirs and culverts. The hydraulic methodology was the driving factor behind determining the drainage area sizes and shapes, as those areas were also used in the model as storage areas. Two of the three open channels with HCFCD unit number designations (A120-00-00 and A125-00-00) were modeled as linear channels within HEC-RAS. The third channel (A125-03-00) is small, and was modeled in HEC-RAS as three storage areas with culverts connecting the segments where roadways cross the channel.

The study area is largely drained through roadside ditches with culverts under multiple driveways and cross streets. The cross street roadway profiles are elevated above natural ground. Due to the roadway profiles being elevated, the hydraulics of the drainage system is similar to that of interconnected basins. The local area drained by roadside ditches is suitable for analysis with HEC-RAS using storage areas and storage area connectors.

Using HEC-RAS allows the physical properties of the system to be simplified to a level suitable for this analysis. The storage and drainage within one portion of the model is reduced to one volume-elevation curve and appropriate flow connections. In addition, HEC-RAS calculates the outfall channel's tailwater influence on the internal drainage systems. Using HEC-RAS also allows for automated mapping of the inundation areas both in expanse and depth giving a better representation of existing and proposed flooding conditons.

The study area was divided into drainage areas bounded by each cross street and connected to the HCFCD channels. A volume-elevation relationship within each storage area was computed using the HEC-GeoRAS and ArcHydro tools within the ArcGIS program. The HEC-RAS storage areas were placed so that the primary overland flow paths between the storage areas were over the tops of roadways, which were modeled as irregular weirs at the road crest elevation. Storage areas were also divided at the back lot line in some places where appropriate. The storage area connector locations and elevations were also developed using the ArcHydro and HEC-GeoRAS tools. The storage areas, volume-elevation relationships, and connecting weirs were exported by HEC-GeoRAS and imported into HEC-RAS.

At intersections having cross culverts, additional storage area connectors were added within HEC-RAS reflecting the existing and proposed sub surface drainage conveying flow across the roadways. This approach allows for flow to be conveyed in across drainage divides based on the physical topography and drainage infrastructure. The culvert sizes were taken from either current survey data in the subdivision, site visit notes or from provided reference plan sheets. In areas where pipe sizes were unavailable, they were assumed to be either 18 or 24 inches based on known sizes of other culverts in their vicinity. Culvert flow lines were set approximately five hundredths of a foot above the

higher of the two connecting storage areas' lowest ditch elevations. This modeling approach was done to improve model stability under initial "low flow" conditions and speed of model creation.

Storm sewers were modeled within HEC-RAS using small manhole storage areas and storage area connectors or lateral weirs, as appropriate. Where a storm sewer connects two storage areas, the length of the storm sewer is approximately the length between the centers of the storage area, but is guided by the location of inlets, and simulates the head loss between those two storage areas through the storm sewer. These links are modeled as culverts in storage area connectors. Where a storm sewer connects a storage area to a channel as part of a lateral weir, the length is guided by the distance from the last set of inlets to the channel. These links are modeled as culverts in lateral weirs from the channel.

4.0 Existing Conditions

4.1 HEC-RAS Model Development

Existing culvert capacity in roadway crossings was assumed as “as-built” conditions in that no reduction in capacity due to silting was assumed. The existing storage volumes within the watersheds are based on the NUSA LiDAR data, which reflects the 2008 condition silting within the ditches.

Survey data and HCFCD NUSA LiDAR data were used to determine channel conditions for HCFCD ditches A125-03-00 and A125-00-00. Survey data and City of Houston construction plans for Monroe Road Improvement (No. 43254) plans were used to determine channel conditions for A120-00-00. Additionally, City of Houston’s Almeda-Genoa Road plans were used to input the existing storm sewer system on Almeda-Genoa Road from Telephone Road to Moers Road. The models of the channels were extended beyond the study limits and normal depth used as their starting water surface elevation. By extending the models beyond the study limits the impact of the assumed starting water surface condition at the various storm sewer outfalls were minimized. **Exhibit 5** and **Exhibit 6** show the basic layout of the existing and proposed conditions HEC-RAS models, respectively, including cross-section locations and stationing, storage area boundaries, and storm sewer connectivity.

4.2 Existing Conditions Results and Analysis of Problem Areas

Exhibit 7 through **Exhibit 11** show estimated existing conditions inundation depths for each of the five modeled storms.

Overland flow is generally from the southwest to the northeast. The subdivision’s ditch systems are designed to allow the runoff to outfall to the three surrounding ditches, with the majority of the runoff flowing towards A120-00-00. A large portion of the area drains north to Almeda-Genoa Road during extreme events and then is carried by storm sewer towards A120-00-00. It appears that the Almeda-Genoa Road system does not have capacity to convey the peak flow from these extreme events and is causing runoff to pond in the northern section of the subdivision. Additionally, the roadside ditch system provides relief for the Almeda-Genoa Road system by conveying a portion of the flow east towards A120-00-00. The existing conditions model indicates that the outfall system and roadway cross culverts flowing toward A120-00-00 do not provide sufficient capacity and contribute to the flooding in the central portion of the subdivision. This is especially true for the area south of Gulick Lane between Randolph Street and Wingtip Drive, where greater flooding depths are noted.

Table 4-1 and **Table 4-2** summarize the water surface elevations (WSEs) in the storage areas and at the cross-sections, respectively, for existing conditions.

Table 4-1: Existing Water Surface Elevations for Storage Areas

Storage Area	Existing Water Surface Elevations (ft)				
	2-yr	10-yr	25-yr	50-yr	100-yr
100	43.55	43.73	43.81	43.86	43.92
101	44.29	44.44	44.50	44.54	44.59
102	46.11	46.24	46.27	46.29	46.31
103	42.08	42.29	42.36	42.40	42.45
104	42.60	42.95	43.19	43.51	43.74
105	42.50	42.88	43.17	43.49	43.74
106	42.89	43.34	43.51	43.68	43.89
107	43.01	43.50	43.69	43.85	44.12
108	44.06	44.40	44.67	44.89	44.98
109	43.87	44.18	44.48	44.74	44.89
110	42.98	43.66	44.02	44.23	44.41
111	42.89	43.70	44.04	44.26	44.44
112	43.61	44.10	44.36	44.52	44.70
113	43.06	43.92	44.23	44.41	44.65
114	43.02	43.80	44.12	44.30	44.61
115	43.03	43.74	44.03	44.11	44.22
116	42.26	42.84	43.06	43.36	43.58
117	42.09	42.36	42.43	42.48	42.57
118	40.01	40.22	40.30	40.34	40.40
119	42.17	42.66	43.10	43.44	43.70
120	42.17	42.70	43.11	43.45	43.71
1203	43.38	43.59	43.69	43.76	43.84
1205	42.45	42.91	43.04	43.37	43.62
1206	42.31	42.61	42.70	42.76	42.82
1207	40.24	41.44	42.08	42.48	42.97
1208	43.81	43.99	44.04	44.07	44.10
121	42.62	43.17	43.48	43.62	43.76
122	43.15	43.55	43.66	43.73	43.80
1229	46.14	46.30	46.36	46.40	46.44
123	43.94	44.26	44.36	44.42	44.47
1230	45.69	45.85	45.91	45.95	45.98
124	44.30	44.79	44.89	44.93	44.98
125	44.40	44.83	45.04	45.19	45.36
126	44.33	44.70	44.88	45.00	45.12
127	44.53	44.95	45.02	45.07	45.13
128	44.60	45.24	45.39	45.50	45.61
129	44.53	45.22	45.37	45.47	45.55
130	44.25	44.94	45.07	45.13	45.19
131	43.68	44.30	44.46	44.53	44.58

Table 4-1 continued.

Storage Area	Existing Water Surface Elevations (ft)				
	2-yr	10-yr	25-yr	50-yr	100-yr
132	42.65	42.91	42.98	43.03	43.09
133	40.57	40.71	40.77	40.80	40.85
134	41.67	42.55	43.04	43.37	43.63
135	41.42	42.48	43.02	43.36	43.61
136	42.00	42.65	43.10	43.46	43.72
137	42.33	42.66	42.85	43.00	43.21
138	42.47	42.77	42.94	43.06	43.19
139	42.79	43.12	43.29	43.40	43.54
140	42.83	43.23	43.43	43.58	43.73
141	42.87	43.30	43.52	43.66	43.80
142	43.24	43.86	44.25	44.58	44.75
143	43.98	44.25	44.36	44.45	44.58
144	44.09	44.34	44.44	44.52	44.63
145	44.27	44.45	44.58	44.67	44.78
146	43.13	43.55	43.76	43.91	44.17
147	42.88	43.28	43.41	43.49	43.65
148	43.59	43.67	43.70	43.72	43.74
150	41.44	42.74	42.82	42.89	43.02
151	38.57	40.19	41.12	41.59	42.10
152	39.40	40.21	40.72	40.97	41.47
153	37.91	41.12	41.41	41.62	41.79
1543	42.86	42.94	42.98	43.00	43.19
1544	43.19	43.32	43.37	43.41	43.44
1753	39.08	40.69	41.42	41.89	42.36
770	42.53	42.91	43.18	43.50	43.73

Table 4-2: Existing Water Surface Elevations for Channel Cross-Sections

River	Station	Existing Water Surface Elevations (ft)				
		2-yr	10-yr	25-yr	50-yr	100-yr
A125-00-00	5884.024	43.02	43.38	43.53	43.67	43.87
A125-00-00	5883	43.02	43.38	43.53	43.67	43.87
A125-00-00	5653.803	42.92	43.35	43.51	43.66	43.86
A125-00-00	5270.2	42.91	43.35	43.51	43.66	43.86
A125-00-00	4890.183	42.89	43.34	43.50	43.64	43.84
A125-00-00	4741.613	42.87	43.33	43.50	43.64	43.83
A125-00-00	4607.535	42.85	43.32	43.48	43.61	43.79
A125-00-00	4502.255	42.84	43.31	43.47	43.60	43.78
A125-00-00	4501	42.84	43.31	43.47	43.60	43.78
A125-00-00	4365	42.81	43.28	43.44	43.56	43.74
A125-00-00	4364.775	42.81	43.28	43.44	43.56	43.74
A125-00-00	4131.509	42.79	43.27	43.43	43.55	43.72
A125-00-00	3839.444	42.70	43.19	43.36	43.48	43.64
A125-00-00	3838	42.70	43.19	43.36	43.48	43.64
A125-00-00	3661	42.59	43.00	43.14	43.24	43.35
A125-00-00	3660.594	42.59	43.00	43.14	43.24	43.35
A125-00-00	3340.505	42.47	42.86	43.00	43.09	43.19
A125-00-00	2976.388	42.33	42.70	42.84	42.92	43.02
A125-00-00	2731.153	42.26	42.62	42.75	42.83	42.92
A125-00-00	2595.203	42.21	42.56	42.69	42.76	42.85
A125-00-00	2216.75	42.12	42.43	42.55	42.62	42.70
A125-00-00	2039.9	42.09	42.39	42.50	42.57	42.65
A125-00-00	1909.745	42.06	42.36	42.47	42.54	42.61
A125-00-00	1742.192	42.04	42.32	42.44	42.50	42.57
A125-00-00	1365.533	41.99	42.25	42.35	42.41	42.47
A125-00-00	1177.375	41.97	42.22	42.32	42.37	42.43
A125-00-00	1091.859	41.91	42.17	42.27	42.32	42.38
A125-00-00	904.8303	41.78	42.05	42.15	42.21	42.27
A125-00-00	714.9401	41.65	41.90	42.00	42.05	42.11
A125-00-00	435.7053	41.52	41.76	41.85	41.90	41.95
A125-00-00	252.342	41.44	41.67	41.76	41.81	41.87
A125-00-00	48.17893	41.34	41.57	41.66	41.71	41.77
A120-00-00	6677	39.72	41.23	41.96	42.51	43.02
A120-00-00	6676.133	39.72	41.23	41.96	42.51	43.02
A120-00-00	6666.071	39.72	41.23	41.96	42.51	43.02
A120-00-00	6665	39.72	41.23	41.96	42.51	43.02
A120-00-00	6597	39.64	41.18	41.91	42.44	42.95
A120-00-00	6596.218	39.64	41.18	41.91	42.44	42.95
A120-00-00	6522.756	39.64	41.18	41.91	42.44	42.95
A120-00-00	6442.091	39.64	41.18	41.91	42.44	42.95
A120-00-00	6441	39.64	41.18	41.91	42.44	42.95

Table 4-2 continued.

River	Station	Existing Water Surface Elevations (ft)				
		2-yr	10-yr	25-yr	50-yr	100-yr
A120-00-00	6344	39.56	41.13	41.86	42.38	42.87
A120-00-00	6343.886	39.56	41.13	41.86	42.38	42.87
A120-00-00	6253.667	39.55	41.12	41.85	42.37	42.87
A120-00-00	6168.896	39.55	41.12	41.85	42.37	42.87
A120-00-00	6167	39.55	41.12	41.85	42.37	42.87
A120-00-00	6088.58	39.42	41.01	41.76	42.26	42.75
A120-00-00	6071.75	39.42	41.01	41.76	42.26	42.75
A120-00-00	6034	39.42	41.01	41.76	42.26	42.75
A120-00-00	6033.248	39.42	41.01	41.76	42.26	42.75
A120-00-00	5950.333	39.30	40.91	41.66	42.15	42.63
A120-00-00	5919.103	39.29	40.90	41.65	42.14	42.62
A120-00-00	5760.517	39.29	40.90	41.65	42.14	42.62
A120-00-00	5517.931	39.29	40.90	41.65	42.14	42.62
A120-00-00	5490.661	39.28	40.89	41.65	42.14	42.62
A120-00-00	5398	39.11	40.72	41.46	41.92	42.39
A120-00-00	5396.893	39.11	40.72	41.46	41.92	42.39
A120-00-00	5297.553	39.11	40.72	41.45	41.92	42.39
A120-00-00	5166.616	39.11	40.72	41.45	41.92	42.39
A120-00-00	5132.16	39.10	40.71	41.45	41.91	42.39
A120-00-00	5098.96	39.10	40.71	41.45	41.91	42.39
A120-00-00	4892.784	39.10	40.71	41.45	41.91	42.38
A120-00-00	4805.481	39.10	40.71	41.45	41.91	42.38
A120-00-00	4721.921	39.10	40.71	41.44	41.91	42.38
A120-00-00	4522.572	39.10	40.71	41.45	41.91	42.38
A120-00-00	4407.552	39.08	40.68	41.41	41.87	42.35
A120-00-00	4323.584	39.08	40.68	41.41	41.87	42.34
A120-00-00	4106.692	39.07	40.68	41.41	41.87	42.35
A120-00-00	3870.654	39.04	40.65	41.39	41.85	42.33
A120-00-00	3869	39.04	40.65	41.39	41.85	42.33
A120-00-00	3805	38.64	39.98	40.55	40.83	41.15
A120-00-00	3804.442	38.64	39.98	40.55	40.83	41.15
A120-00-00	3692.636	38.52	39.89	40.47	40.75	41.07
A120-00-00	3261.867	38.23	39.66	40.24	40.53	40.85
A120-00-00	2741.711	37.95	39.43	40.01	40.30	40.61
A120-00-00	2192.549	37.69	39.21	39.80	40.09	40.41
A120-00-00	1112.6	37.20	38.76	39.34	39.62	39.93
A120-00-00	729.4103	36.98	38.53	39.11	39.39	39.70
A120-00-00	106.0942	36.60	38.16	38.74	39.02	39.33

5.0 Proposed Improvements

5.1 Proposed Drainage Improvements

The primary recommendation for lowering the peak 2-year WSE is to do general maintenance of road side ditches, which includes desilting ditches and upsizing driveway culverts to the minimum 24" diameter City of Houston standard. Additionally, it is necessary to provide more capacity to carry runoff east towards A120-00-00. **Exhibit 3** shows an overview of the proposed improvements. Full details of the improvements are in the plans, specifications, and estimates. **Exhibit 6** shows the basic layout of the proposed conditions HEC-RAS model, including cross-section locations and stationing, storage area boundaries, and storm sewer connectivity. Additional runoff cannot be sent west to A125-00-00 because its water surface elevation is higher than that east of Randolph Street and additional or increased connections to that ditch would allow more flood flows into the subdivision aggravating existing flooding conditions. Roadside ditch maintenance is not reflected in the modeling as extensive model revision and editing of the digital elevation model would have been required. By not including the slight increase in available storage volume within the ditch system a more conservative representation of flooding conditions is presented. As such, desilting of the existing ditches may result in slightly greater benefits than that reflected in the proposed conditions modeling.

The driveway culverts along Randolph Street will be upsized to 24" diameter from existing 18" to reduce flooding in the southern portion of the subdivision by allowing the runoff to flow to the north and then flow east through additional improvements. Nine 24" culverts on Wingtip Drive should be added to allow water to flow east towards A120-00-00. Wingtip Drive is currently acting as a flow divide between A120-00-00 and A125-00-00 because there are no culverts allowing water to travel east and west under Wingtip Drive. Since there is not enough right-of-way to deepen and widen the ditches to take the additional runoff to the east, storm sewers will need to be constructed in some areas to supplement the existing ditch capacities. City of Houston will also need to expand the detention pond east of Monroe Street to mitigate the additional flow the improvements will deliver into A120-00-00.

5.2 Analysis Results

Exhibit 7 through **Exhibit 11** illustrate the depth of inundation for the existing 2-, 10-, 25-, 50-, and 100-yr storm events. **Exhibit 12** through **Exhibit 16** illustrate the reduction in the area of inundation for existing versus proposed conditions for the 2-, 10-, 25-, 50-, and 100-yr events. **Table 5-1** and **Table 5-2** also shows the WSE elevation for the 2-, 10-, 25-, 50-, and 100-yr events storm events for proposed conditions along with their relative changes. It should be noted that several sub-areas indicated slight increases in WSE particularly in the smaller storm events. Review of the mapping for these areas indicates that the increases are fully contained within the existing ditches and will not adversely impact properties within these areas. **Exhibit 17** through **Exhibit 21** illustrate the depth of inundation for the proposed condition 2-, 10-, 25-, 50-, and 100-yr storm events.

The proposed improvements will contain the 2-year event within the ditches/storm sewers and provides approximately a 10- to 25-yr level of service by lowering WSE to below finished floor elevations within the study area.

Table 5-1: Proposed Water Surface Elevations for Storage Areas

Storage Area	2-yr WSE (ft)		10-yr WSE (ft)		25-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)	
	Proposed	Delta	Proposed	Delta	Proposed	Proposed	Delta	Proposed	Delta	Proposed
100	43.54	0.00	43.73	0.00	43.81	0.00	43.86	0.00	43.92	0.00
101	44.29	0.00	44.44	0.00	44.50	0.00	44.54	0.00	44.59	0.00
102	46.11	0.00	46.24	0.00	46.27	0.00	46.29	0.00	46.31	0.00
103	42.08	0.00	42.29	0.00	42.36	0.00	42.40	0.00	42.45	0.00
104	42.58	-0.03	42.93	-0.01	43.09	-0.10	43.29	-0.22	43.53	-0.21
105	42.45	-0.05	42.86	-0.02	43.05	-0.12	43.26	-0.23	43.51	-0.23
106	42.84	-0.05	43.33	-0.01	43.52	**0.01**	43.64	-0.04	43.82	-0.08
107	42.98	-0.03	43.53	**0.03**	43.73	**0.05**	43.88	**0.03**	44.08	-0.04
108	43.86	-0.20	44.17	-0.23	44.34	-0.33	44.51	-0.38	44.76	-0.22
109	43.78	-0.09	44.08	-0.10	44.26	-0.22	44.46	-0.28	44.70	-0.19
110	42.93	-0.04	43.60	-0.06	43.89	-0.13	44.13	-0.10	44.34	-0.08
111	42.69	-0.20	43.55	-0.15	43.89	-0.15	44.12	-0.14	44.33	-0.12
112	43.55	-0.05	44.03	-0.07	44.26	-0.10	44.40	-0.11	44.58	-0.12
113	43.01	-0.05	43.87	-0.04	44.17	-0.06	44.33	-0.08	44.56	-0.09
114	42.99	-0.02	43.77	-0.03	44.08	-0.04	44.26	-0.04	44.53	-0.08
115	43.01	-0.02	43.71	-0.03	44.01	-0.02	44.10	-0.01	44.21	-0.01
116	42.18	-0.08	42.69	-0.15	42.94	-0.12	43.19	-0.17	43.49	-0.09
117	42.08	-0.01	42.36	0.00	42.44	**0.01**	42.49	**0.01**	42.56	-0.02
118	40.01	0.00	40.22	0.00	40.30	0.00	40.35	0.00	40.40	0.00
119	42.10	-0.07	42.61	-0.05	42.93	-0.16	43.18	-0.25	43.45	-0.25
120	41.92	-0.25	42.64	-0.06	42.94	-0.17	43.19	-0.26	43.46	-0.25
1203	43.38	0.00	43.59	0.00	43.69	0.00	43.76	0.00	43.84	0.00
1205	42.45	0.00	42.91	0.00	42.97	-0.08	43.15	-0.22	43.41	-0.21
1206	42.31	0.00	42.60	0.00	42.70	0.00	42.76	0.00	42.82	0.00
1207	40.40	**0.16**	41.56	**0.13**	42.13	**0.05**	42.45	-0.02	42.94	-0.03
1208	43.81	0.00	43.99	0.00	44.04	0.00	44.07	0.00	44.09	0.00
121	41.93	-0.69	42.71	-0.47	42.98	-0.50	43.20	-0.41	43.47	-0.29
122	41.95	-1.19	42.73	-0.82	42.98	-0.68	43.20	-0.52	43.48	-0.33
1229	46.14	0.00	46.30	0.00	46.36	0.00	46.40	0.00	46.44	0.00
123	42.88	-1.07	43.22	-1.04	43.40	-0.96	43.53	-0.89	43.76	-0.71
1230	45.69	0.00	45.85	0.00	45.91	0.00	45.95	0.00	45.98	0.00
124	43.71	-0.59	44.04	-0.75	44.17	-0.72	44.28	-0.66	44.40	-0.57
125	44.29	-0.11	44.59	-0.24	44.72	-0.32	44.82	-0.37	44.95	-0.41
126	44.33	0.00	44.65	-0.05	44.78	-0.10	44.87	-0.13	44.99	-0.13
127	44.49	-0.04	44.91	-0.04	44.99	-0.03	45.04	-0.04	45.09	-0.04
128	44.58	-0.02	45.23	-0.01	45.37	-0.01	45.49	-0.01	45.60	-0.01
129	44.52	-0.02	45.21	-0.01	45.36	-0.01	45.46	-0.01	45.55	-0.01
130	44.25	-0.01	44.94	0.00	45.07	0.00	45.13	0.00	45.19	0.00
131	43.68	0.00	44.30	0.00	44.46	0.00	44.53	0.00	44.58	0.00
132	42.65	0.00	42.91	0.00	42.98	0.00	43.03	0.00	43.09	0.00
133	40.57	0.00	40.71	0.00	40.77	0.00	40.80	0.00	40.85	0.00

Table 5-1 continued.

Storage Area	2-yr WSE (ft)		10-yr WSE (ft)		25-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)	
	Proposed	Delta	Proposed	Delta	Proposed	Proposed	Delta	Proposed	Delta	Proposed
134	41.61	-0.06	42.52	-0.03	42.87	-0.16	43.14	-0.23	43.41	-0.22
135	41.48	**0.05**	42.47	-0.01	42.86	-0.16	43.13	-0.23	43.40	-0.21
136	41.76	-0.25	42.58	-0.07	42.91	-0.20	43.18	-0.28	43.46	-0.26
137	41.91	-0.42	42.54	-0.12	42.76	-0.09	42.98	-0.02	43.29	**0.08**
138	42.23	-0.24	42.56	-0.22	42.71	-0.23	42.86	-0.19	43.22	**0.03**
139	42.64	-0.15	42.94	-0.18	43.04	-0.24	43.13	-0.27	43.36	-0.18
140	42.39	-0.44	42.75	-0.48	42.88	-0.55	43.06	-0.52	43.36	-0.38
141	42.53	-0.35	42.88	-0.42	43.03	-0.49	43.15	-0.52	43.37	-0.43
142	43.24	0.00	43.78	-0.08	44.12	-0.13	44.42	-0.16	44.65	-0.10
143	43.98	0.00	44.25	0.00	44.36	0.00	44.43	-0.01	44.56	-0.02
144	44.09	0.00	44.34	0.00	44.44	0.00	44.52	0.00	44.62	0.00
145	44.27	0.00	44.45	0.00	44.58	0.00	44.66	0.00	44.78	0.00
146	43.13	0.00	43.55	0.00	43.76	0.00	43.91	0.00	44.16	-0.01
147	42.88	0.00	43.28	0.00	43.41	0.00	43.50	0.00	43.64	-0.01
148	43.59	0.00	43.67	0.00	43.70	0.00	43.72	0.00	43.74	0.00
150	41.55	**0.12**	42.74	-0.01	42.81	-0.01	42.89	0.00	43.02	-0.01
151	38.72	**0.15**	40.44	**0.25**	41.22	**0.10**	41.64	**0.06**	42.13	**0.03**
152	39.40	0.00	40.21	0.00	40.59	-0.13	41.10	**0.14**	41.53	**0.06**
153	37.94	**0.04**	41.14	**0.01**	41.43	**0.02**	41.63	**0.01**	41.79	0.00
1543	42.86	0.00	42.94	0.00	42.98	0.00	43.00	0.00	43.04	-0.15
1544	43.19	0.00	43.32	0.00	43.37	0.00	43.41	0.00	43.44	0.00
1753	38.39	-0.69	40.39	-0.30	41.26	-0.16	41.83	-0.06	42.35	-0.01

*Bolded numbers indicate an increase in WSEs

Table 5-2: Proposed Water Surface Elevations for Channel Cross-Sections

Station	2-yr WSE (ft)		10-yr WSE (ft)		25-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)	
	Proposed	Delta	Proposed	Delta	Proposed	Delta	Proposed	Delta	Proposed	Delta
A125-00-00										
5884.024	42.98	-0.03	43.37	-0.01	43.54	**0.01**	43.65	-0.02	43.81	-0.06
5883	42.98	-0.03	43.37	-0.01	43.54	**0.01**	43.65	-0.02	43.81	-0.06
5653.803	42.87	-0.05	43.34	-0.01	43.52	**0.01**	43.64	-0.02	43.80	-0.06
5270.2	42.86	-0.05	43.34	-0.01	43.52	**0.01**	43.64	-0.02	43.80	-0.06
4890.183	42.84	-0.05	43.33	-0.01	43.51	**0.01**	43.63	-0.02	43.78	-0.06
4741.613	42.82	-0.05	43.32	-0.01	43.50	**0.01**	43.62	-0.02	43.77	-0.06
4607.535	42.80	-0.06	43.30	-0.02	43.48	0.00	43.59	-0.02	43.74	-0.05
4502.255	42.78	-0.06	43.29	-0.02	43.47	0.00	43.58	-0.02	43.73	-0.05
4501	42.78	-0.06	43.29	-0.02	43.47	0.00	43.58	-0.02	43.73	-0.05
4365	42.75	-0.06	43.26	-0.02	43.44	0.00	43.54	-0.02	43.69	-0.05
4364.775	42.75	-0.06	43.26	-0.02	43.44	0.00	43.54	-0.02	43.69	-0.05
4131.509	42.73	-0.06	43.24	-0.02	43.42	-0.01	43.53	-0.02	43.68	-0.05
3839.444	42.64	-0.07	43.16	-0.03	43.34	-0.01	43.45	-0.02	43.60	-0.05
3838	42.64	-0.07	43.16	-0.03	43.34	-0.01	43.45	-0.02	43.60	-0.05
3661	42.52	-0.07	42.97	-0.03	43.12	-0.02	43.21	-0.02	43.32	-0.03
3660.594	42.52	-0.07	42.97	-0.03	43.12	-0.02	43.21	-0.02	43.32	-0.03
3340.505	42.41	-0.06	42.83	-0.03	42.98	-0.02	43.07	-0.02	43.17	-0.03
2976.388	42.28	-0.05	42.68	-0.03	42.82	-0.02	42.90	-0.02	43.00	-0.02
2731.153	42.21	-0.05	42.59	-0.02	42.73	-0.02	42.81	-0.02	42.90	-0.02
2595.203	42.17	-0.04	42.54	-0.02	42.67	-0.01	42.75	-0.01	42.84	-0.02
2216.75	42.08	-0.03	42.41	-0.02	42.54	-0.01	42.61	-0.01	42.69	-0.01
2039.9	42.05	-0.03	42.37	-0.02	42.49	-0.01	42.56	-0.01	42.64	-0.01
1909.745	42.04	-0.03	42.34	-0.01	42.46	-0.01	42.53	-0.01	42.60	-0.01
1742.192	42.01	-0.03	42.31	-0.01	42.43	-0.01	42.49	-0.01	42.57	-0.01
1365.533	41.97	-0.02	42.24	-0.01	42.35	0.00	42.41	0.00	42.47	0.00
1177.375	41.95	-0.02	42.22	-0.01	42.32	0.00	42.37	0.00	42.43	0.00
1091.859	41.89	-0.02	42.16	-0.01	42.26	0.00	42.32	0.00	42.38	0.00
904.8303	41.76	-0.02	42.04	-0.01	42.15	0.00	42.21	0.00	42.27	0.00
714.9401	41.63	-0.02	41.90	-0.01	42.00	0.00	42.05	0.00	42.11	0.00
435.7053	41.50	-0.02	41.75	-0.01	41.85	0.00	41.90	0.00	41.95	0.00
252.342	41.42	-0.02	41.67	-0.01	41.76	0.00	41.81	0.00	41.87	0.00
48.17893	41.32	-0.02	41.57	-0.01	41.66	0.00	41.71	0.00	41.77	0.00
A120-00-00										
6677	39.99	**0.28**	41.21	-0.02	41.83	-0.13	42.36	-0.15	42.89	-0.13
6676.133	39.99	**0.28**	41.21	-0.02	41.83	-0.13	42.36	-0.15	42.89	-0.13
6666.071	39.99	**0.28**	41.21	-0.02	41.83	-0.13	42.36	-0.15	42.89	-0.13
6665	39.99	**0.28**	41.21	-0.02	41.83	-0.13	42.36	-0.15	42.89	-0.13
6597	39.93	**0.29**	41.16	-0.02	41.79	-0.12	42.31	-0.13	42.84	-0.11
6596.218	39.93	**0.29**	41.16	-0.02	41.79	-0.12	42.31	-0.13	42.84	-0.11
6522.756	39.93	**0.29**	41.16	-0.02	41.79	-0.12	42.31	-0.13	42.84	-0.11

Table 5-2 continued.

Station	2-yr WSE (ft)		10-yr WSE (ft)		25-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)	
	Proposed	Delta	Proposed	Delta	Proposed	Delta	Proposed	Delta	Proposed	Delta
6442.091	39.93	**0.29**	41.16	-0.02	41.79	-0.12	42.31	-0.13	42.84	-0.11
6441	39.93	**0.29**	41.16	-0.02	41.79	-0.12	42.31	-0.13	42.84	-0.11
6344	39.86	**0.30**	41.10	-0.02	41.74	-0.12	42.27	-0.11	42.78	-0.09
6343.886	39.86	**0.30**	41.10	-0.02	41.74	-0.12	42.27	-0.11	42.78	-0.09
6253.667	39.85	**0.30**	41.10	-0.02	41.73	-0.12	42.27	-0.11	42.78	-0.09
6168.896	39.85	**0.30**	41.10	-0.02	41.73	-0.12	42.27	-0.11	42.78	-0.09
6167	39.85	**0.30**	41.10	-0.02	41.73	-0.12	42.27	-0.11	42.78	-0.09
6088.58	39.74	**0.32**	40.99	-0.02	41.64	-0.11	42.18	-0.08	42.70	-0.05
6071.75	39.74	**0.32**	40.99	-0.02	41.64	-0.11	42.18	-0.08	42.70	-0.05
6034	39.74	**0.32**	40.99	-0.02	41.64	-0.11	42.18	-0.08	42.70	-0.05
6033.248	39.74	**0.32**	40.99	-0.02	41.64	-0.11	42.18	-0.08	42.70	-0.05
5950.333	39.63	**0.33**	40.88	-0.03	41.56	-0.10	42.10	-0.05	42.61	-0.02
5919.103	39.61	**0.32**	40.86	-0.04	41.54	-0.11	42.09	-0.05	42.60	-0.02
5760.517	39.61	**0.32**	40.86	-0.04	41.54	-0.11	42.09	-0.05	42.60	-0.02
5517.931	39.61	**0.32**	40.86	-0.04	41.54	-0.11	42.09	-0.05	42.60	-0.02
5490.661	39.60	**0.32**	40.85	-0.04	41.54	-0.11	42.09	-0.05	42.60	-0.02
5398	39.38	**0.27**	40.59	-0.13	41.31	-0.14	41.87	-0.05	42.38	-0.01
5396.893	39.38	**0.27**	40.59	-0.13	41.31	-0.14	41.87	-0.05	42.38	-0.01
5297.553	39.38	**0.27**	40.59	-0.13	41.31	-0.14	41.87	-0.05	42.38	-0.01
5166.616	39.37	**0.27**	40.59	-0.13	41.31	-0.14	41.87	-0.05	42.38	-0.01
5132.16	39.36	**0.26**	40.57	-0.14	41.30	-0.15	41.86	-0.06	42.37	-0.02
5098.96	39.36	**0.26**	40.57	-0.14	41.30	-0.15	41.86	-0.06	42.37	-0.02
4892.784	39.36	**0.26**	40.57	-0.14	41.30	-0.15	41.86	-0.06	42.36	-0.02
4805.481	39.35	**0.26**	40.56	-0.15	41.30	-0.15	41.85	-0.06	42.36	-0.02
4721.921	39.34	**0.24**	40.55	-0.16	41.29	-0.16	41.85	-0.06	42.36	-0.02
4522.572	39.35	**0.24**	40.57	-0.14	41.29	-0.16	41.85	-0.06	42.36	-0.03
4407.552	39.29	**0.21**	40.51	-0.17	41.25	-0.16	41.81	-0.07	42.31	-0.03
4323.584	39.29	**0.21**	40.51	-0.17	41.25	-0.16	41.80	-0.07	42.31	-0.03
4106.692	39.29	**0.21**	40.51	-0.17	41.25	-0.16	41.81	-0.07	42.32	-0.03
3870.654	39.27	**0.23**	40.50	-0.15	41.23	-0.16	41.79	-0.06	42.30	-0.03
3869	39.27	**0.23**	40.50	-0.15	41.23	-0.16	41.79	-0.06	42.30	-0.03
3805	38.88	**0.24**	39.94	-0.04	40.44	-0.10	40.78	-0.05	41.10	-0.05
3804.442	38.88	**0.24**	39.94	-0.04	40.44	-0.10	40.78	-0.05	41.10	-0.05
3692.636	38.78	**0.25**	39.87	-0.02	40.37	-0.10	40.70	-0.06	41.01	-0.05
3261.867	38.50	**0.26**	39.65	-0.02	40.15	-0.09	40.47	-0.06	40.79	-0.05
2741.711	38.20	**0.26**	39.41	-0.02	39.92	-0.09	40.24	-0.06	40.56	-0.06
2192.549	37.94	**0.25**	39.19	-0.02	39.72	-0.09	40.03	-0.06	40.35	-0.06
1112.6	37.34	**0.14**	38.72	-0.04	39.26	-0.08	39.57	-0.05	39.88	-0.05
729.4103	37.12	**0.15**	38.49	-0.03	39.03	-0.08	39.34	-0.06	39.65	-0.05
106.0942	36.75	**0.15**	38.12	-0.03	38.66	-0.08	38.97	-0.06	39.28	-0.05

*Bolded numbers indicate an increase in WSEs

6.0 Impact Determination and Mitigation

6.1.1 Impact Determination

In the absence of any mitigation measures, the proposed improvements would cause increases in flow and water surface elevation along A120-00-00. To mitigate impacts along A120-00-00 additional storage capacity is required. This additional storage volume can be provided by expanding the existing City of Houston basin located along A120-00-00 near the intersection of Swiftwater Lane and Monroe Road. The basin can be expanded to the north by extending into the existing City of Houston owned approximately 4.3 acre tract, located adjacent to the existing basin. The current basin functions as an inline basin. In order to mitigate impacts from the proposed storm drainage improvements the basin must be converted to an off line basin and to be converted from a dry-bottom basin to a wet-bottom basin. Converting to an off line, wet-bottom basin allows the increased flow rates to be diverted into the basin over a weir structure and detained until downstream water surface elevations begin to recede. The revised grading provides approximately 40.2 acre-feet of storage at the 100-yr peak WSE elevation of 42.35.

The conversion to an off line basin requires that a berm be constructed along the channel with a top of bank elevation of 45.0 feet. A top width of 20 feet was assumed for the weir, equal to that of the maintenance berms around the remainder of the basin. A 40 foot long weir crest set at elevation 42.0 is required along the west edge of the detention basin. Adjacent to the weir, there will be a pair of 5' x 2' reinforced concrete box (RCB) culverts, providing the primary inflow capacity. The high point elevation on the inflow culverts is 38.4 ft. A 48 inch pipe is proposed to drain the basin after the storm event and maintain the wet bottom water surface elevation of 35.75 ft. No backflow prevention structures are necessary on the 48 inch pipe. The weir is assumed to be constructed with 3:1 side slopes. See **Exhibit 22** through **Exhibit 25** for a depiction of the proposed detention basin grading, control structures, cross-sections, and details.

The inclusion of the proposed detention facility results in a small reduction in flow to the two HCFCD channels for all except the two-year storm, as shown in **Figure 6-1** and **Figure 6-2**. During the 2-year storm, there are increases in peak flow and water surface elevation along A120-00-00, as shown in **Figure 6-1** and in **Table 5-2.** These increases in 2-year flow and water surface elevation are not an adverse impact to flood risk, because the channel has sufficient capacity to carry this flow, and the 2-year WSE is well within the banks of the channel.

Figure 6-1: Outflow Hydrograph for A120-00-00 (RS 106.1)

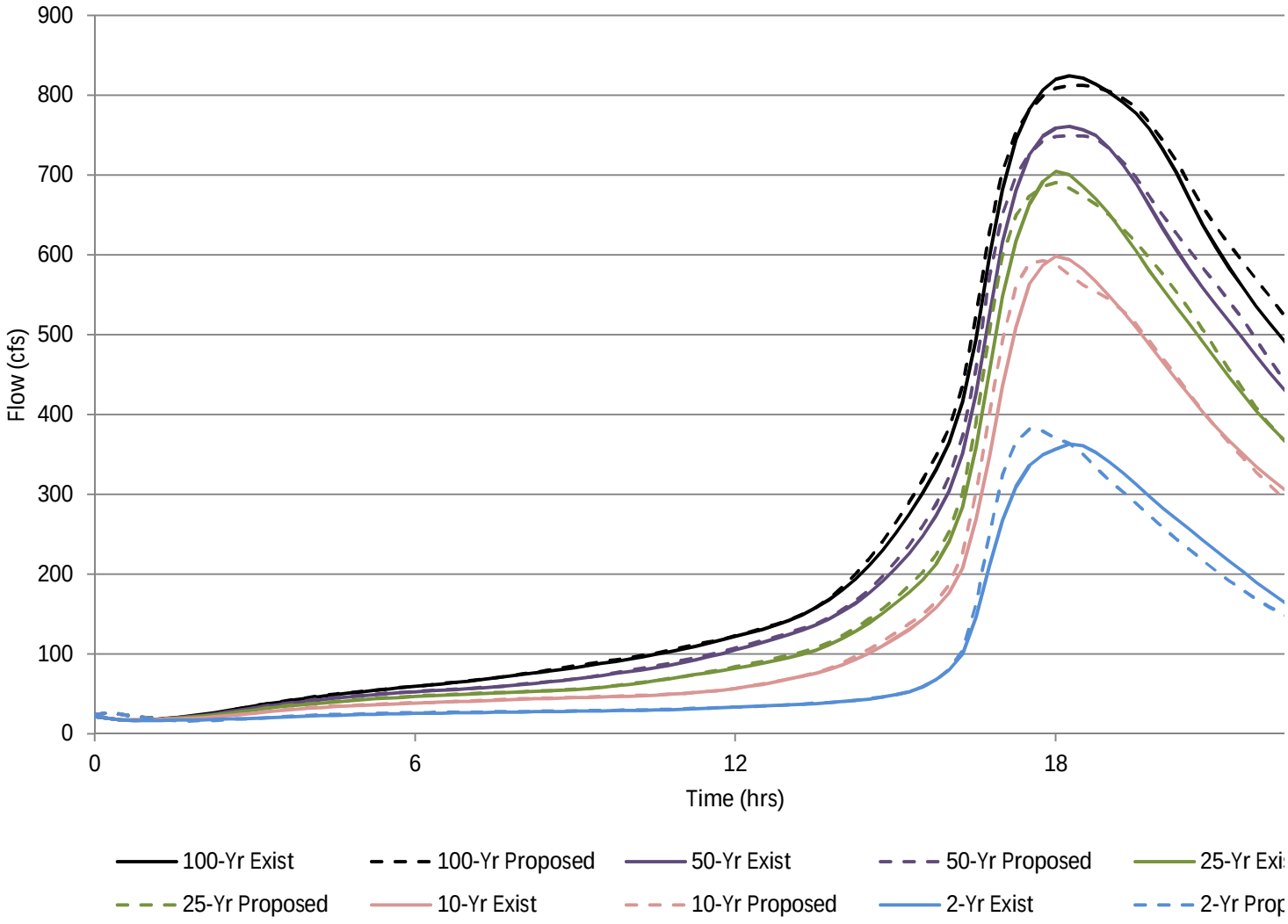
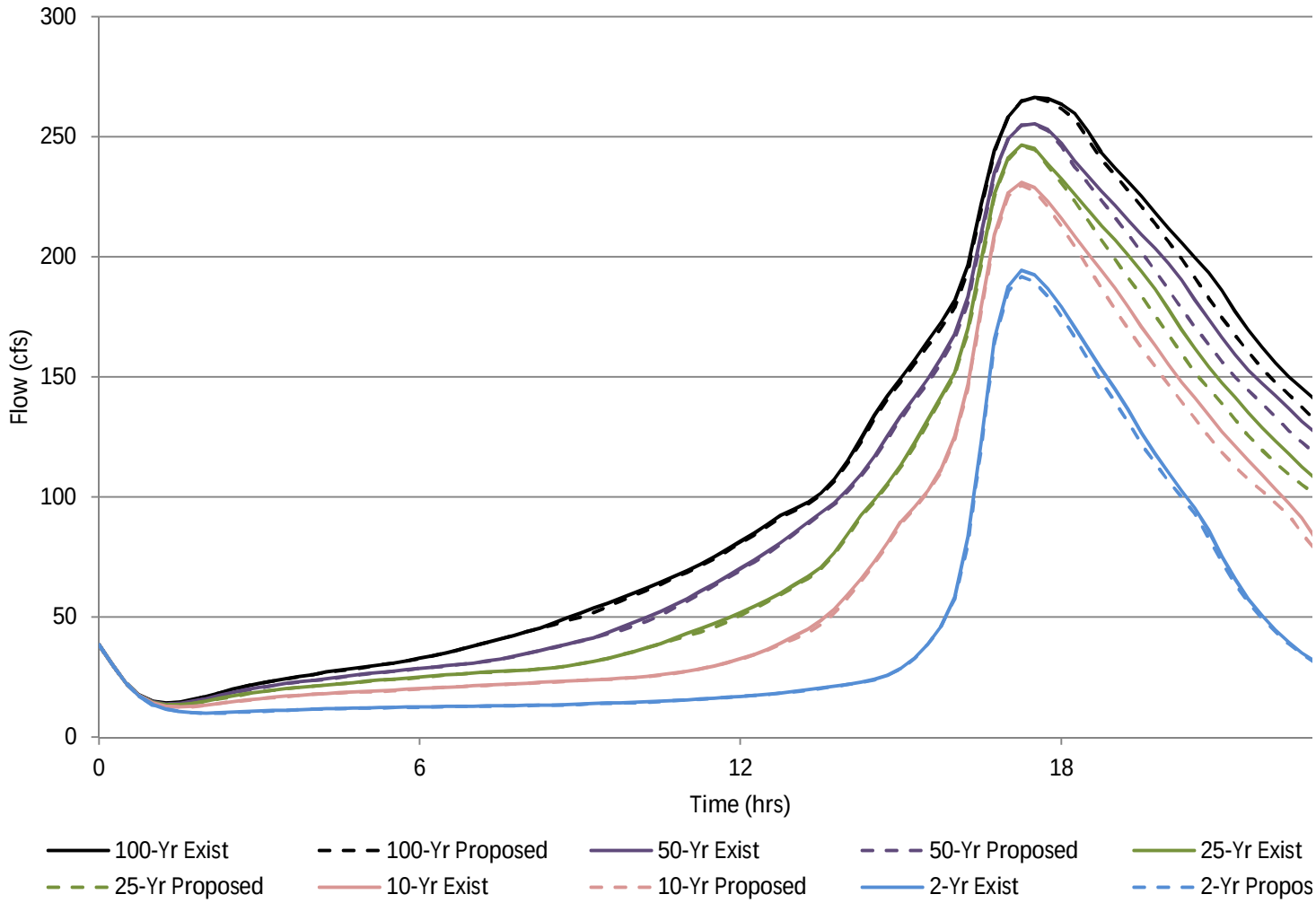


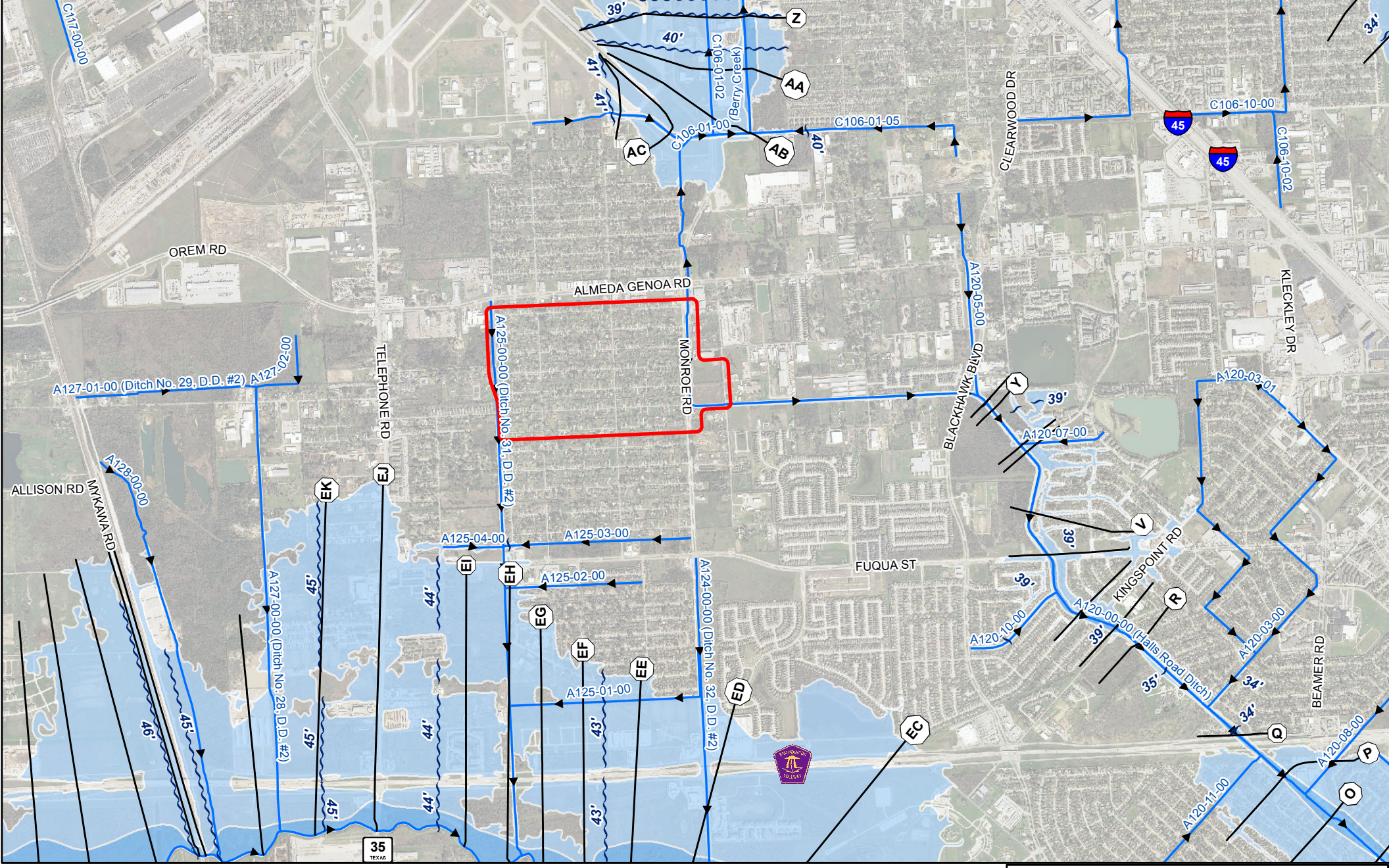
Figure 6-2: Outflow Hydrograph for A125-00-00 (RS 48.2)



7.0 Conclusions and Recommendations

The analysis performed by AECOM and described in this report considers proposed revisions to the Skyscraper Shadows subdivision, including regular maintenance of roadside ditches, improvement of driveway culverts to the minimum 24" diameter standard in the City of Houston, and proposed storm sewer systems along Gulick Lane and Holiday Lane, improvements to the outfalls on Wetherby Lane, and Swiftwater Lane, and new ditch safety end treatments on Lanham Lane, Swiss Lane, and Wayfarer Lane. The proposed revisions are designed to bring the subdivision's drainage capacity up to be adequate for a 2-year event, and to improve the extreme event performance. Based on LiDAR-estimated slab elevations, the design should result in mitigation of structural flooding for storms less than a 10-year to 25-year event. Residual structural flooding during larger storms is likely to continue, but less frequently and at reduced inundation depths.

Based on the analysis performed by AECOM and described in this report, the proposed drainage improvements, along with the proposed revisions to the detention basin, will result in no adverse impact to either A120-00-00 or A125-00-00 for rainfall events up to and including the 100-year storm.



Legend

Project Boundary

HCFCD Channel

FEMA Flood Hazard

Regulatory Floodway

1% Annual Chance Flood Hazard

Cross Section Line

Base Flood Elevation

N
W E
S

Miles

0 0.25 0.5 1

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Vicinity and Floodplain Map

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Date	December 2013	Job No.	60183142	Exhibit	1

Legend

Project Boundary

Overland Drainage Patterns

Overland Flow Direction

Existing Storm Sewer System

2008 LiDAR (NUSA)

High : 52 feet

Low : 32 feet

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Topography and Overland Drainage Patterns

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Date	December 2013	Job No.	60183142	Exhibit	2

Legend

- Potential Detention
- Proposed Outfall Improvements
- Storm Sewer Improvements
- Existing Storm Sewer
- Proposed New / Impr Culvert
- Existing Culvert to Remain
- Existing Ditch / Driveway Culvert
- Regrade Ditch / Min 24" Driveway Culvert
- HCFCD Channel

Note: All proposed culverts and storm sewers are 24" RCP unless otherwise noted. Trunk sizes shown only. See plan and profile for details.

N W E S

Feet

0 200 400 800

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Proposed Improvements

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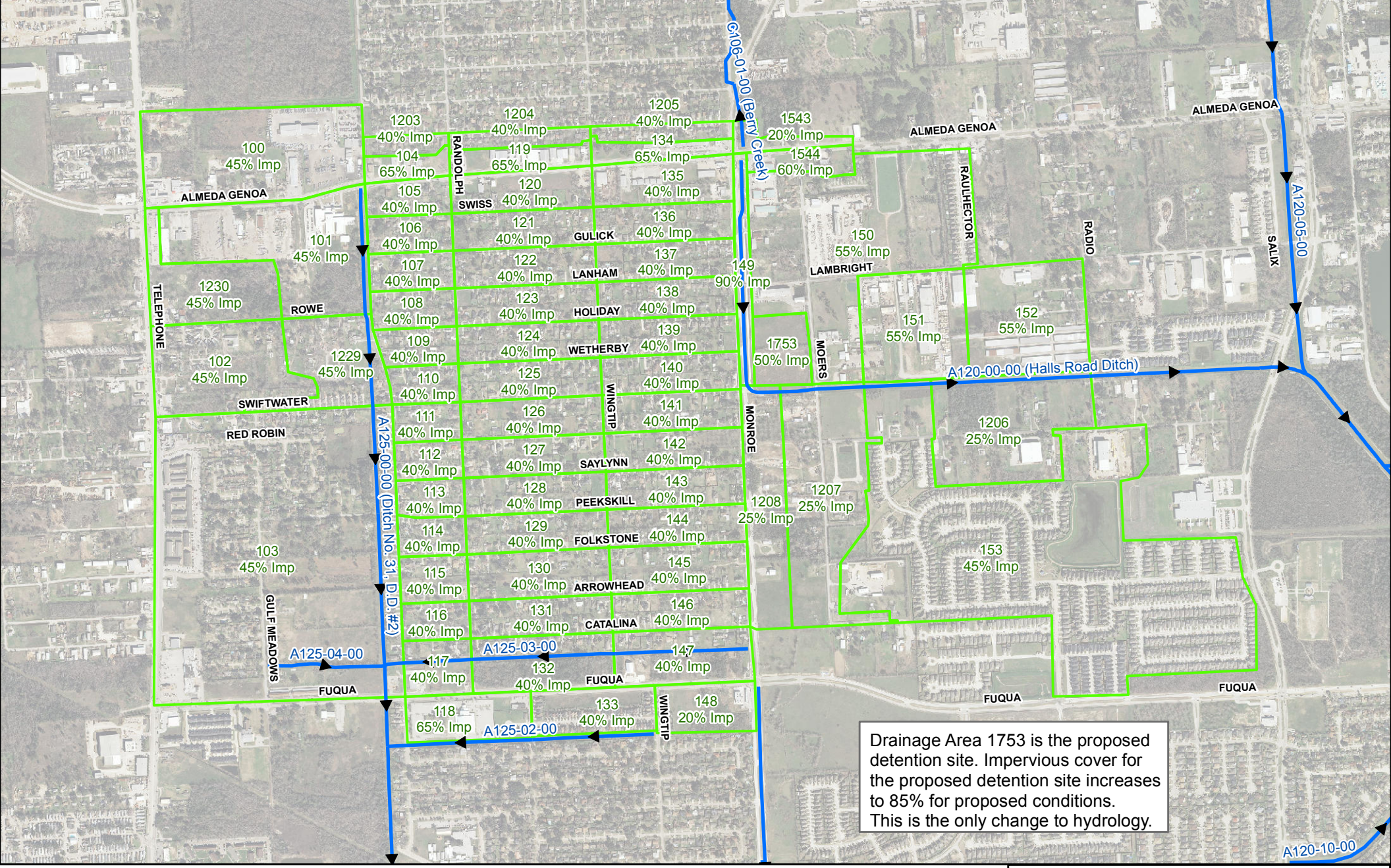
Date	Job No.	Exhibit
December 2013	60183142	3



Drainage Area 1753 is the proposed detention site. Impervious cover for the proposed detention site increases to 85% for proposed conditions. This is the only change to hydrology.

Legend

HCFCD Channel

Drainage Area

N W E S

Miles

0 0.125 0.25 0.5

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Drainage Area Map

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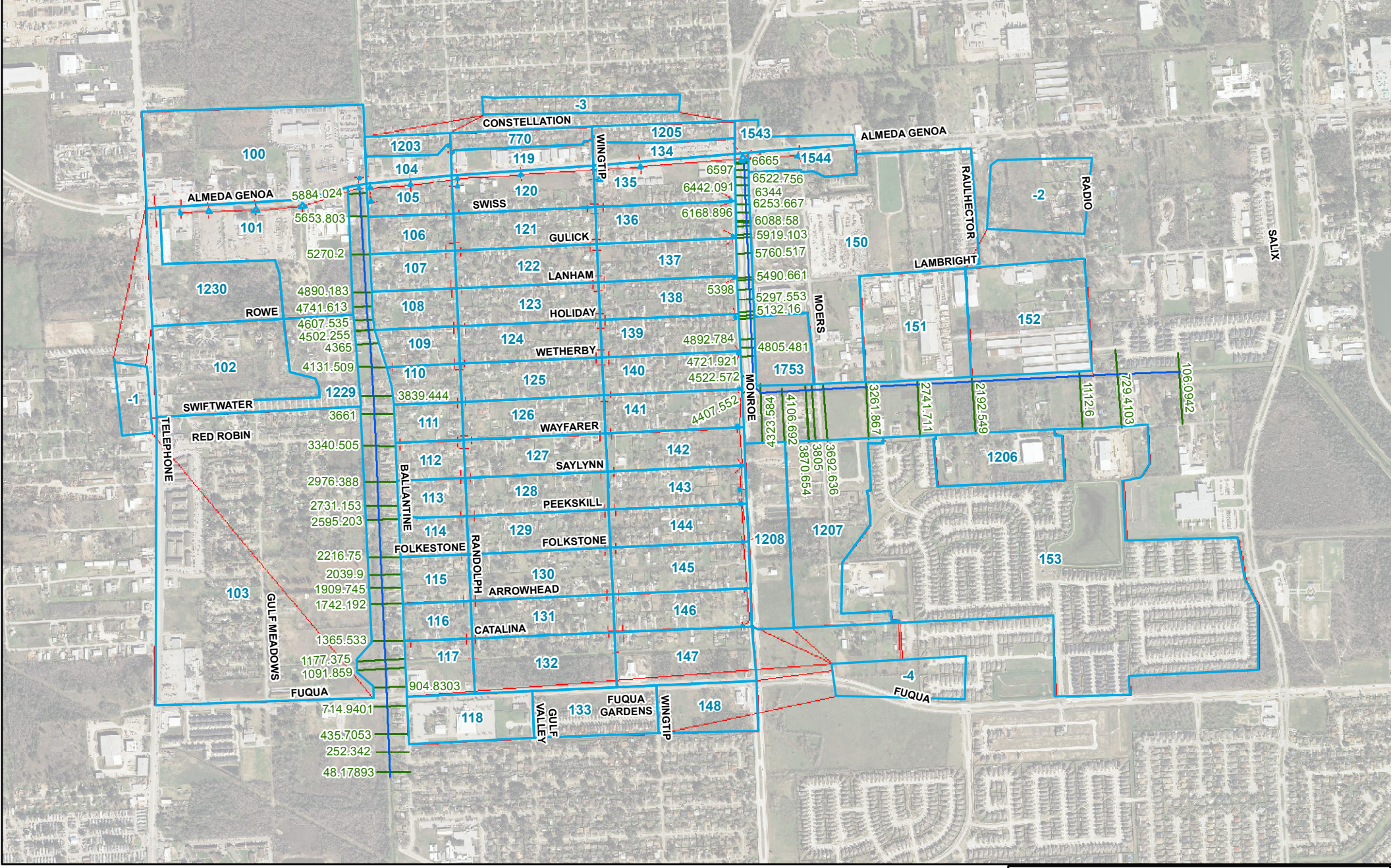
Date	Job No.	Exhibit
December 2013	60183142	4



Legend

- Storm Sewers and Culverts
- Existing Storage Areas
- Channel Centerline
- Cross-Sections

N
W E
S

Miles

0 0.125 0.25 0.5

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Existing HEC-RAS Layout Map

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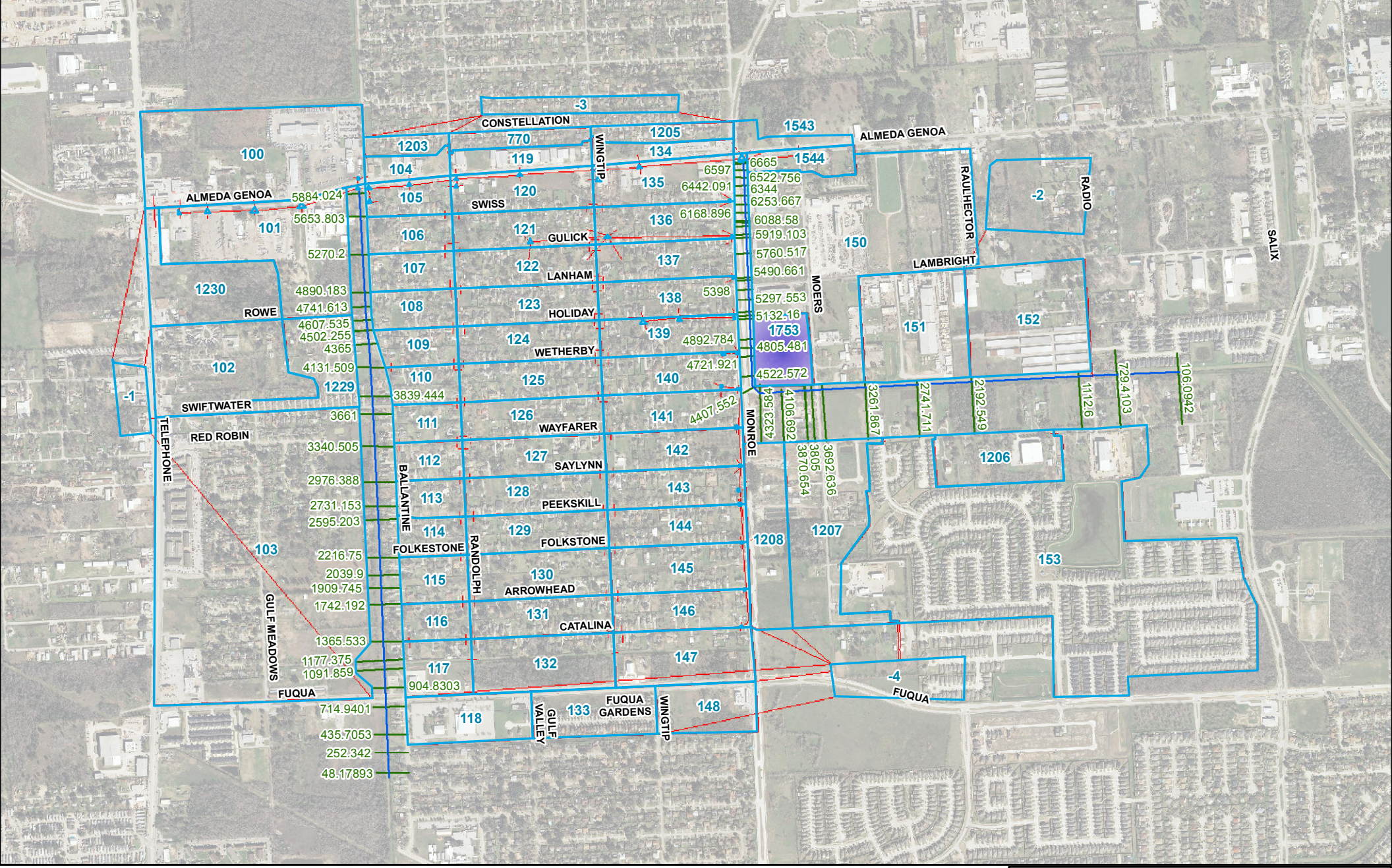
Date	Job No.	Exhibit
December 2013	60183142	5



Legend

- Storm Sewers and Culverts
- Proposed Storage Areas
- Proposed Detention
- Channel Centerline
- Cross-Sections

N
W E
S

Miles

0 0.125 0.25 0.5

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

Proposed HEC-RAS Layout Map

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Date	December 2013	Job No.	60183142	Exhibit	6

Legend

- HCFCD Channel
- Storage Area

Existing Conditions 2-Yr
Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N
W E
S

Feet
0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

2-Yr Existing Conditions Depth of Flooding

AECOM

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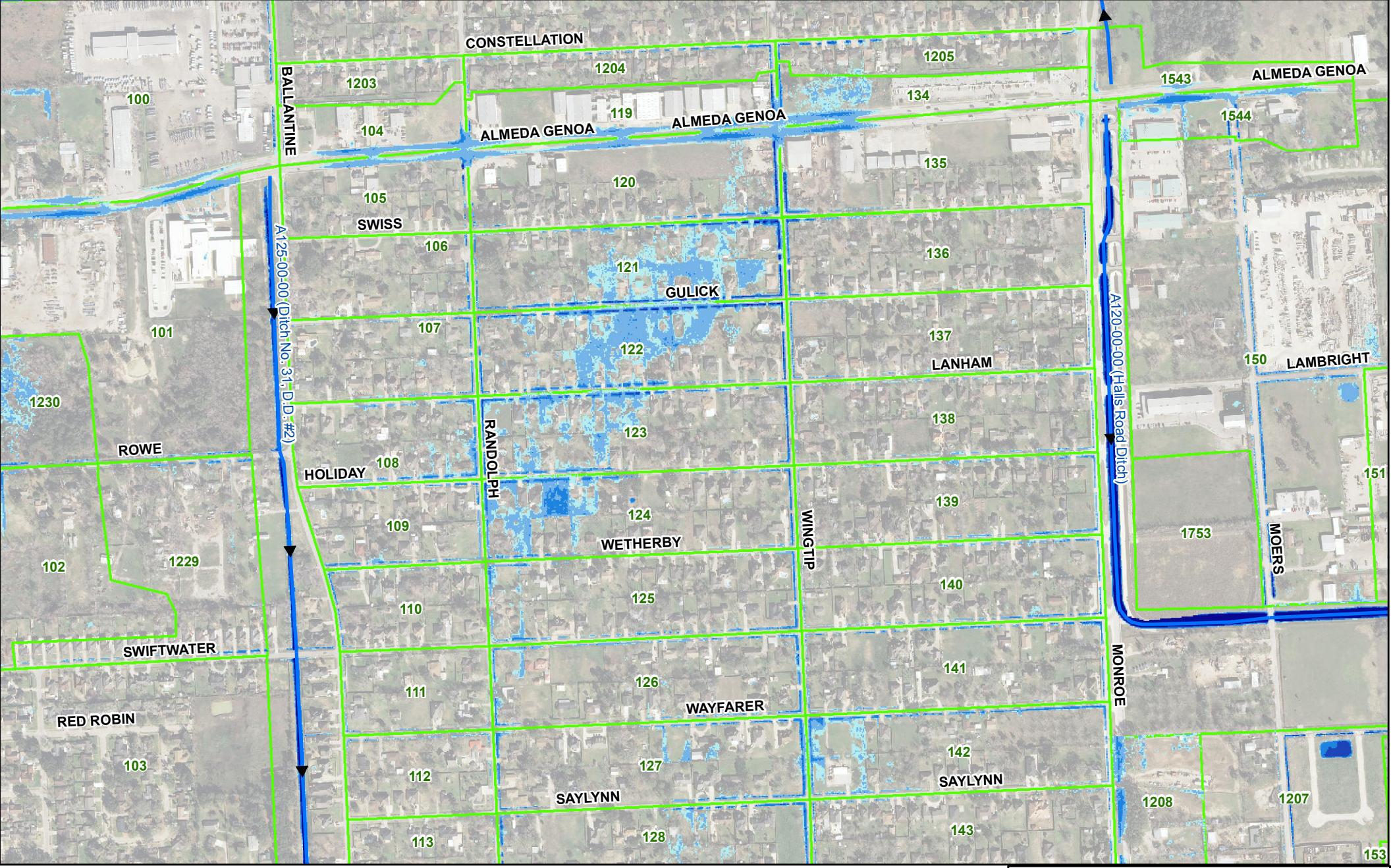
Date	Job No.	Exhibit
December 2013	60183142	7



Legend

HCFCD Channel

Storage Area

Existing Conditions 10-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

10-Yr Existing Conditions Depth of Flooding

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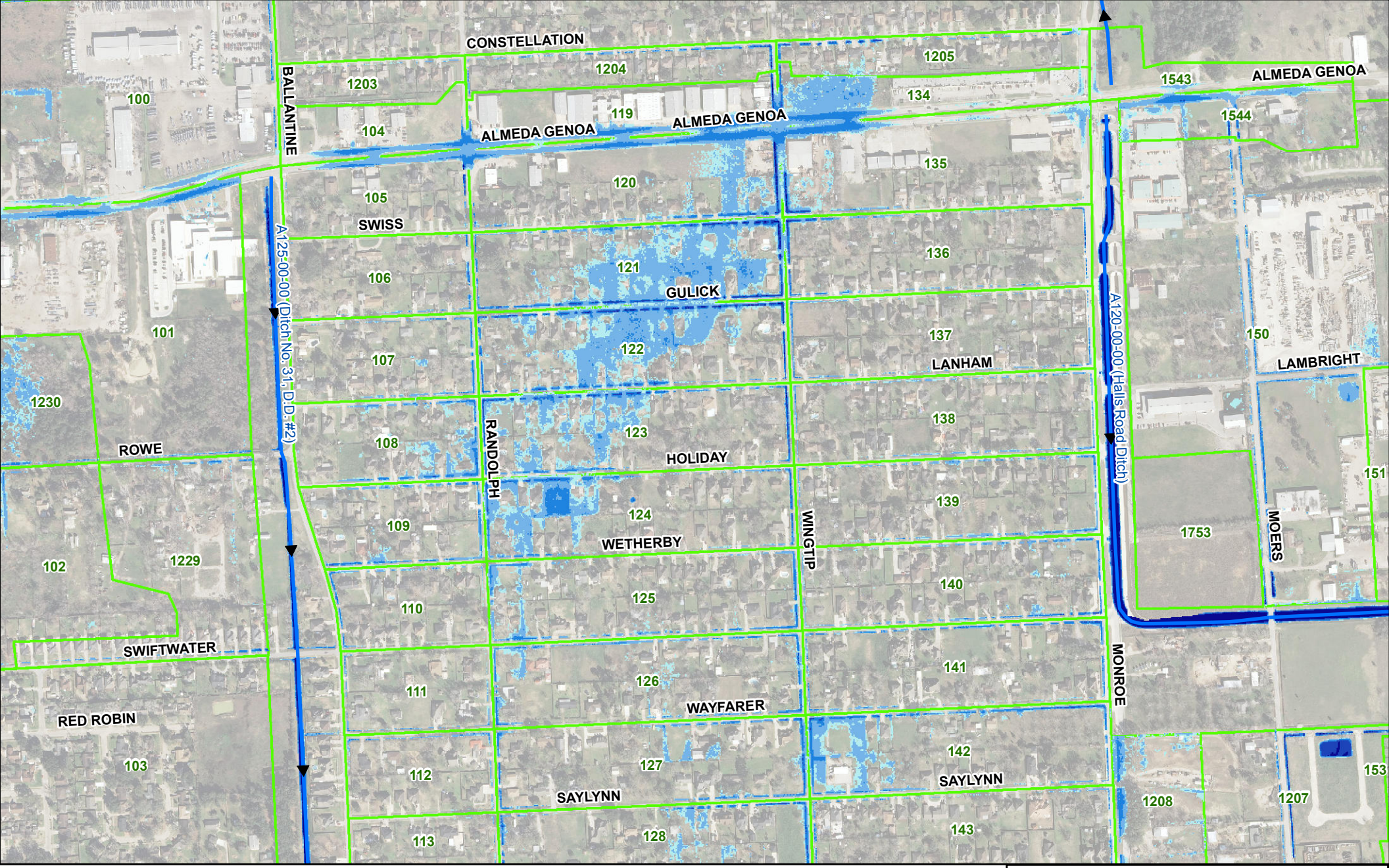
Date	Job No.	Exhibit
December 2013	60183142	8



Legend

HCFCD Channel

Storage Area

Existing Conditions 25-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N W E S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

25-Yr Existing Conditions Depth of Flooding

AECOM

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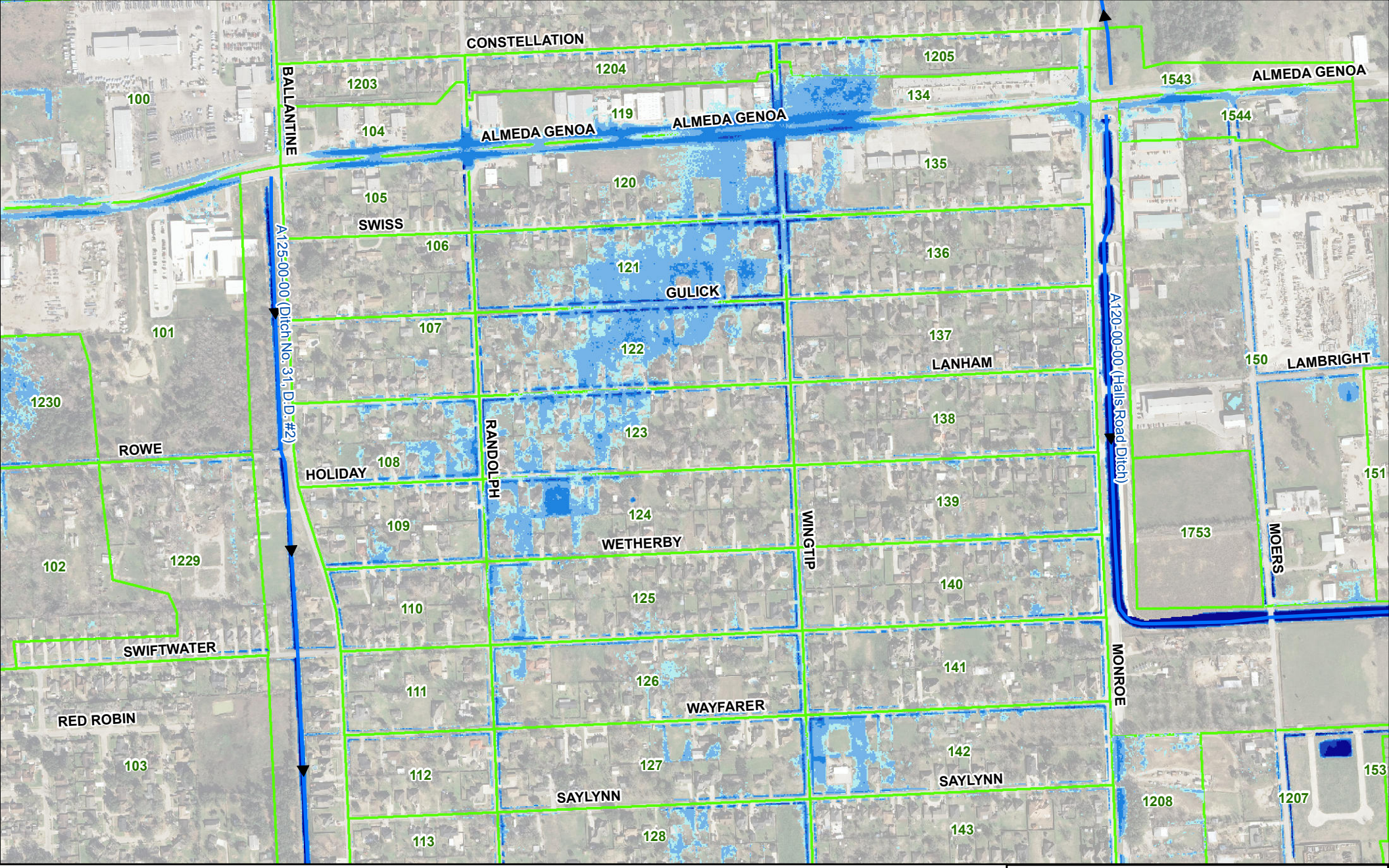
Date	Job No.	Exhibit
December 2013	60183142	9



Legend

HCFCD Channel

Storage Area

Existing Conditions 50-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N W E S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

50-Yr Existing Conditions Depth of Flooding

AECOM

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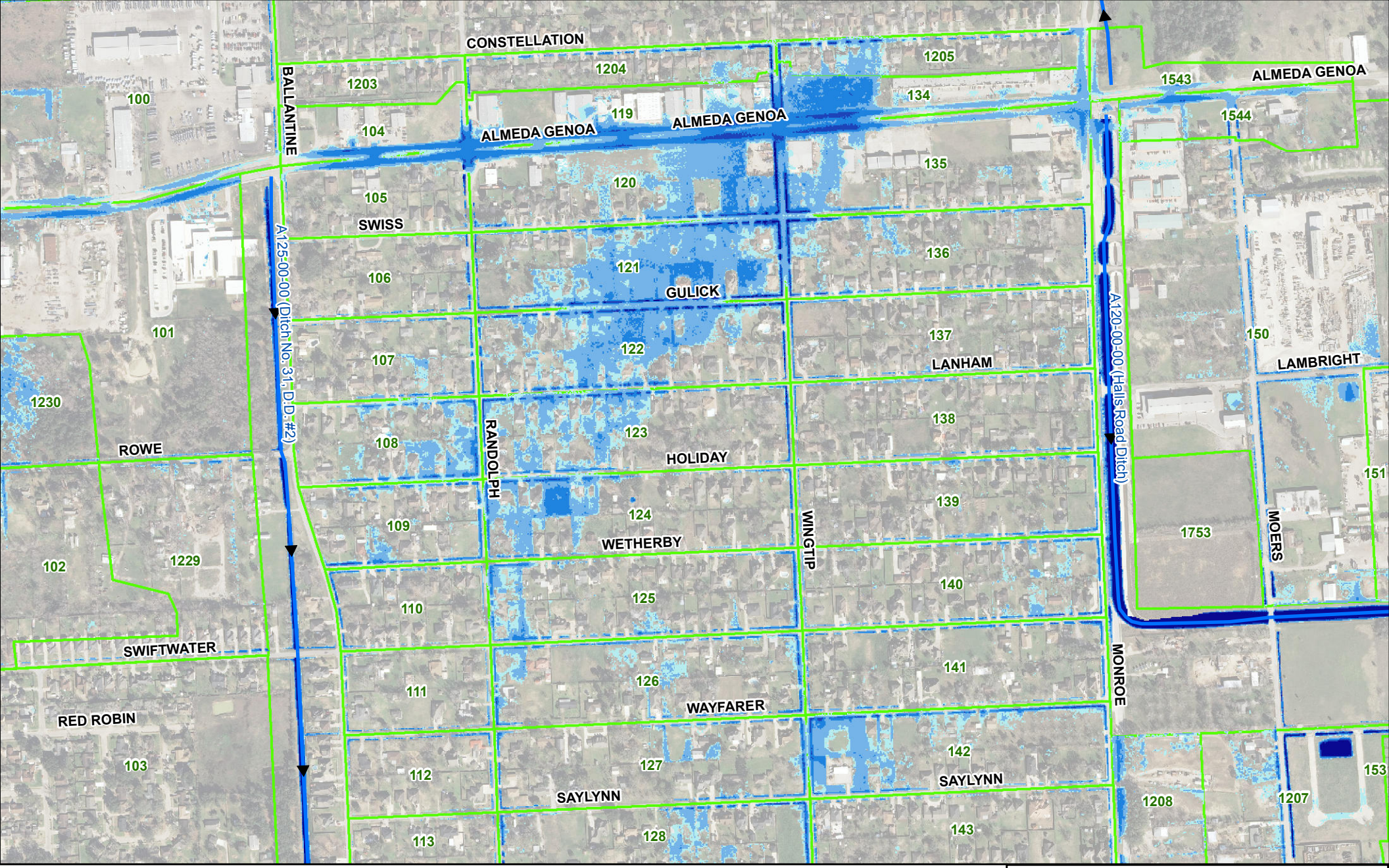
Date	Job No.	Exhibit
December 2013	60183142	10



Legend

- HCFCD Channel
- Storage Area

Existing Conditions 100-Yr
Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N
W E
S

Feet
0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

100-Yr Existing Conditions Depth of Flooding

AECOM

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Date	December 2013	Job No.	60183142	Exhibit	11

Legend

- HCFCD Channel
- Storage Area
- Proposed 2-Yr Flooding Extent
- Existing 2-Yr Flooding Extent

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

2-Yr Existing vs. Proposed Flooding Extent Comparison

AECOM

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Date	December 2013	Job No.	60183142	Exhibit	12

Legend

- HCFCD Channel
- Storage Area
- Proposed 10-Yr Flooding Extent
- Existing 10-Yr Flooding Extent

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

10-Yr Existing vs. Proposed Flooding Extent Comparison

AECOM

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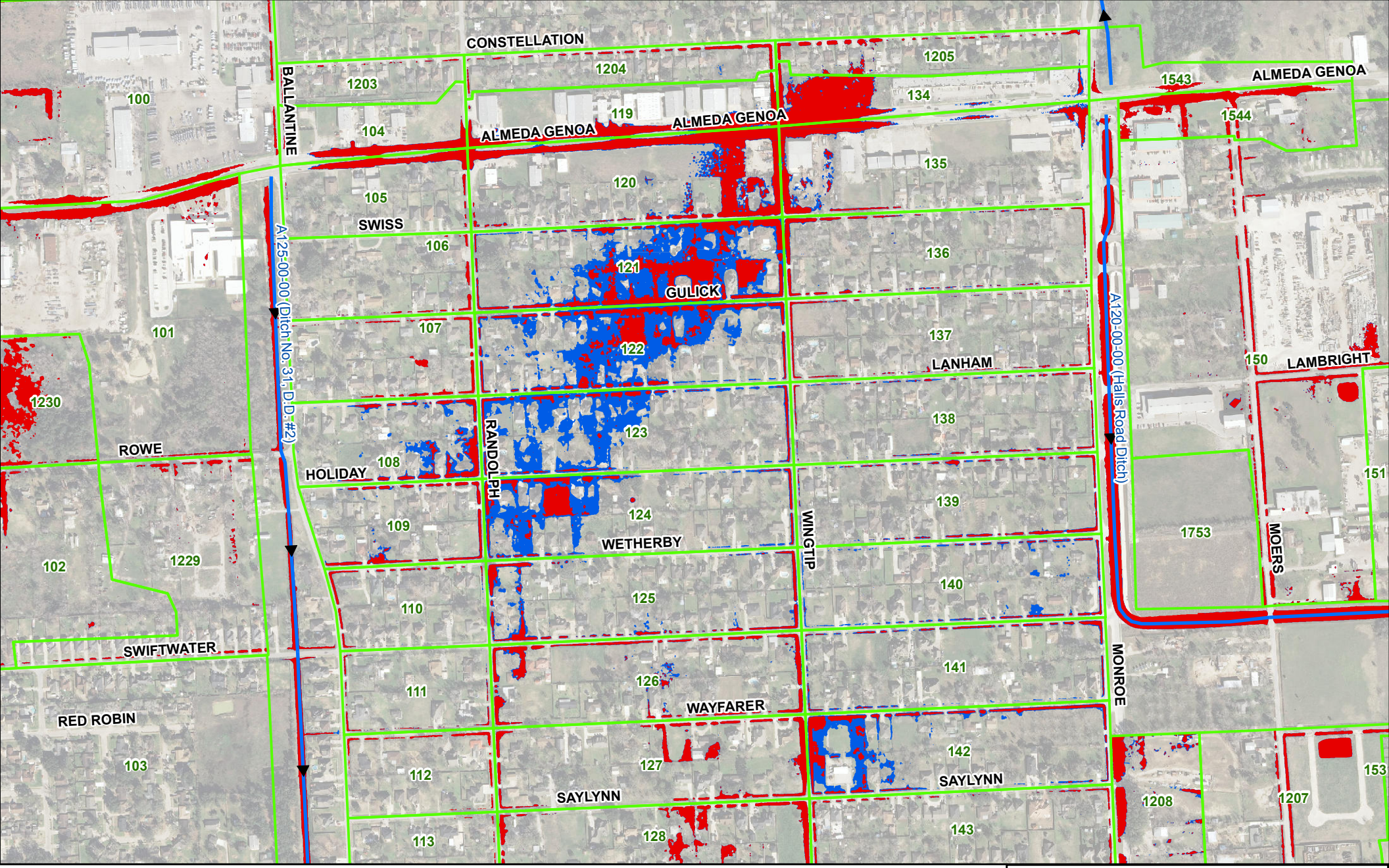
Date	December 2013	Job No.	60183142	Exhibit	13



Legend

- HCFCD Channel
- Storage Area
- Proposed 25-Yr Flooding Extent
- Existing 25-Yr Flooding Extent

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

25-Yr Existing vs. Proposed Flooding Extent Comparison

AECOM

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Date	December 2013	Job No.	60183142	Exhibit	14

Legend

- HCFCD Channel
- Storage Area
- Proposed 50-Yr Flooding Extent
- Existing 50-Yr Flooding Extent

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

50-Yr Existing vs. Proposed Flooding Extent Comparison

AECOM

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Date	December 2013	Job No.	60183142	Exhibit	15

Legend

- HCFCD Channel
- Storage Area
- Proposed 100-Yr Flooding Extent
- Existing 100-Yr Flooding Extent

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

100-Yr Existing vs. Proposed Flooding Extent Comparison

AECOM

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Date	Job No.	Exhibit
December 2013	60183142	16

Legend

HCFCD Channel

Storage Area

Proposed Conditions 2-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N W E S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

2-Yr Proposed Conditions Depth of Flooding

AECOM

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Date	Job No.	Exhibit
December 2013	60183142	17

Legend

HCFCD Channel

Storage Area

Proposed Conditions 10-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N
W E
S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

10-Yr Proposed Conditions Depth of Flooding

AECOM

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Date	Job No.	Exhibit
December 2013	60183142	18

Legend

HCFCD Channel

Storage Area

Proposed Conditions 25-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N W E S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

25-Yr Proposed Conditions Depth of Flooding

AECOM

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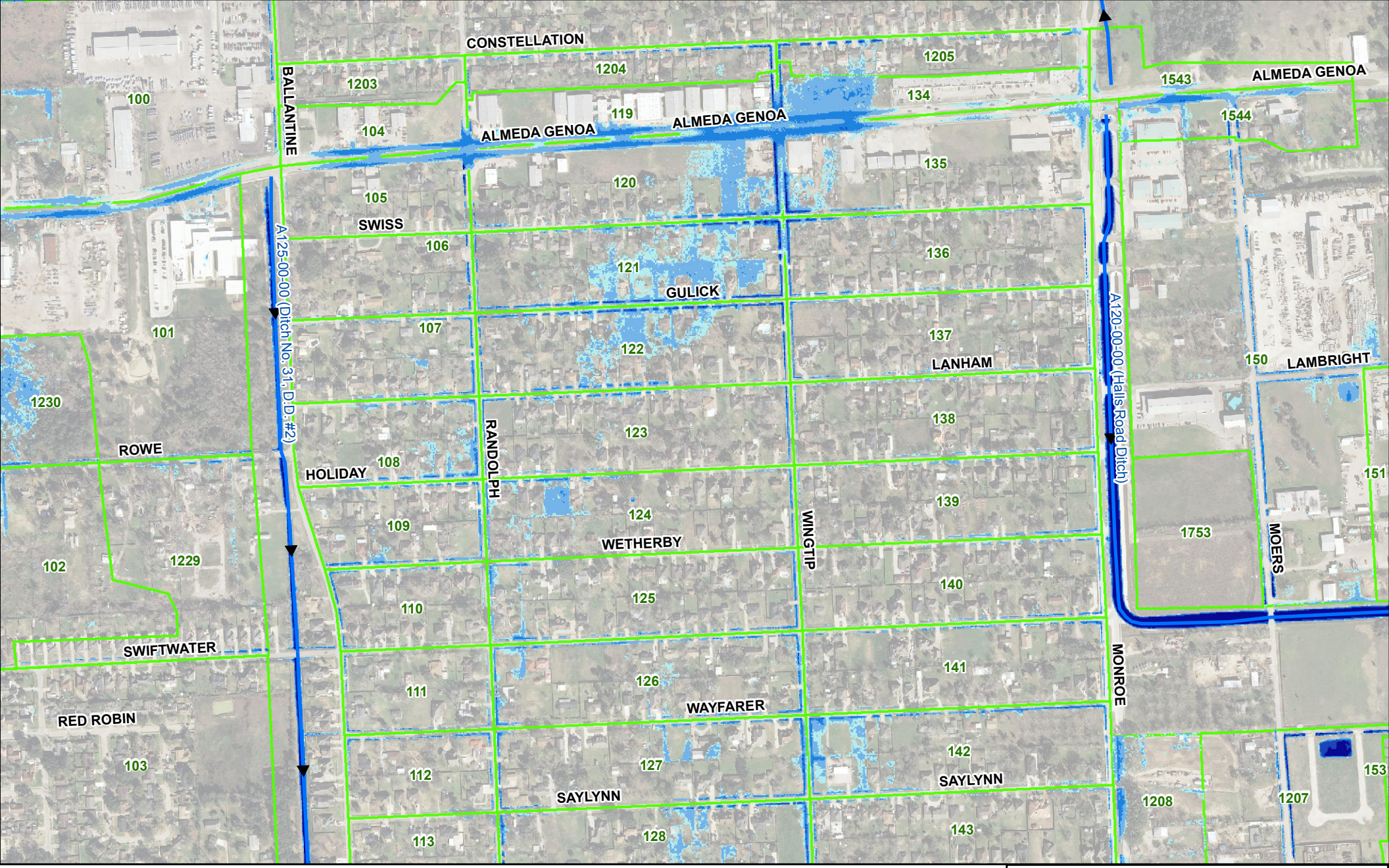
Date	Job No.	Exhibit
December 2013	60183142	19



Legend

HCFCD Channel

Storage Area

Proposed Conditions 50-Yr

Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N W E S

Feet

0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

50-Yr Proposed Conditions Depth of Flooding

AECOM

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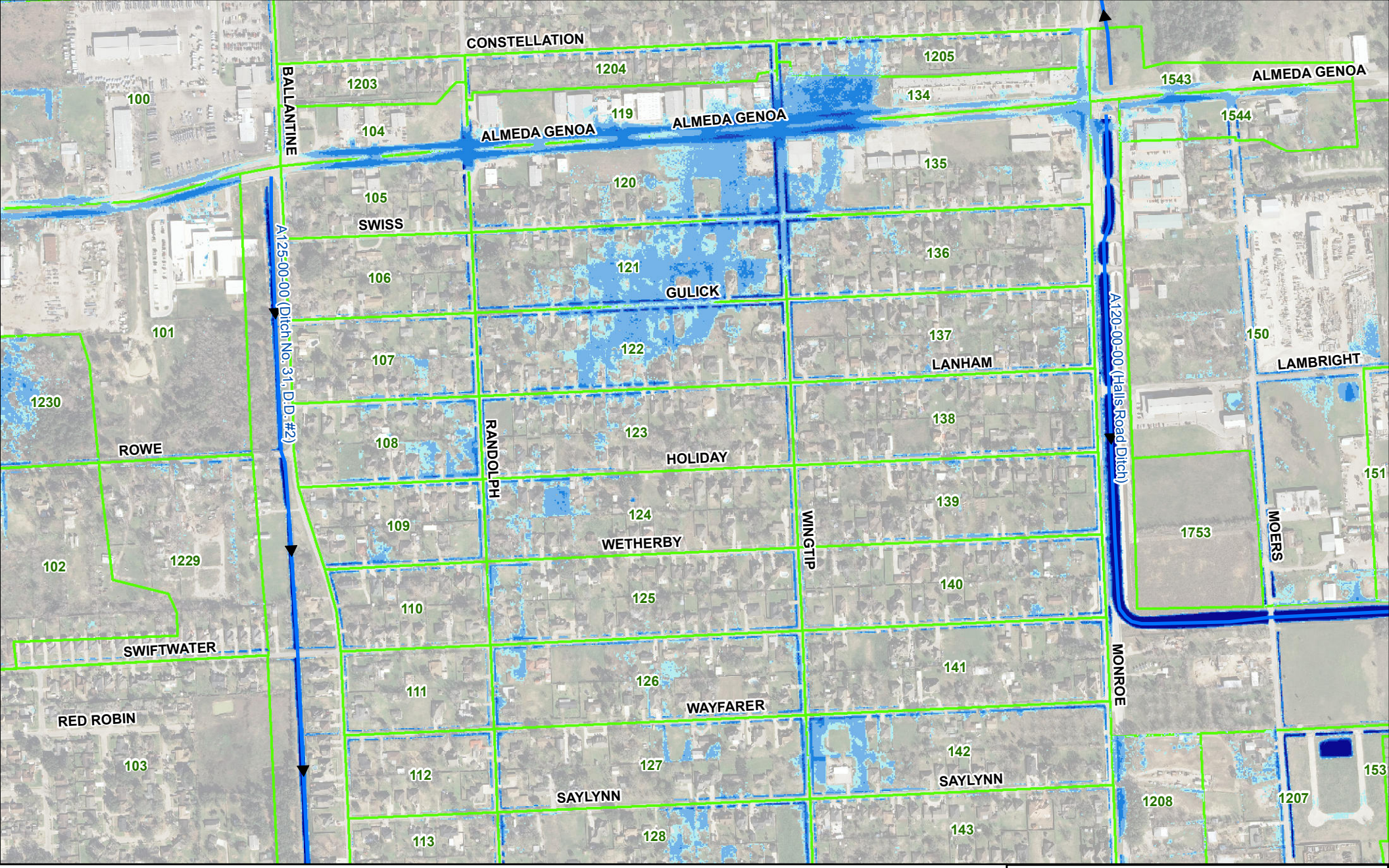
Date	Job No.	Exhibit
December 2013	60183142	20



Legend

- HCFCD Channel
- Storage Area

Proposed Conditions 100-Yr
Flood Depth (ft)

- 0.0 - 0.25
- 0.25 - 1
- 1 - 2
- 2 - 3
- > 3

N
W E
S

Feet
0 300 600 1,200

LOCAL DRAINAGE PROJECT
SKYSCRAPER SHADOWS SUBDIVISION

100-Yr Proposed Conditions Depth of Flooding

AECOM

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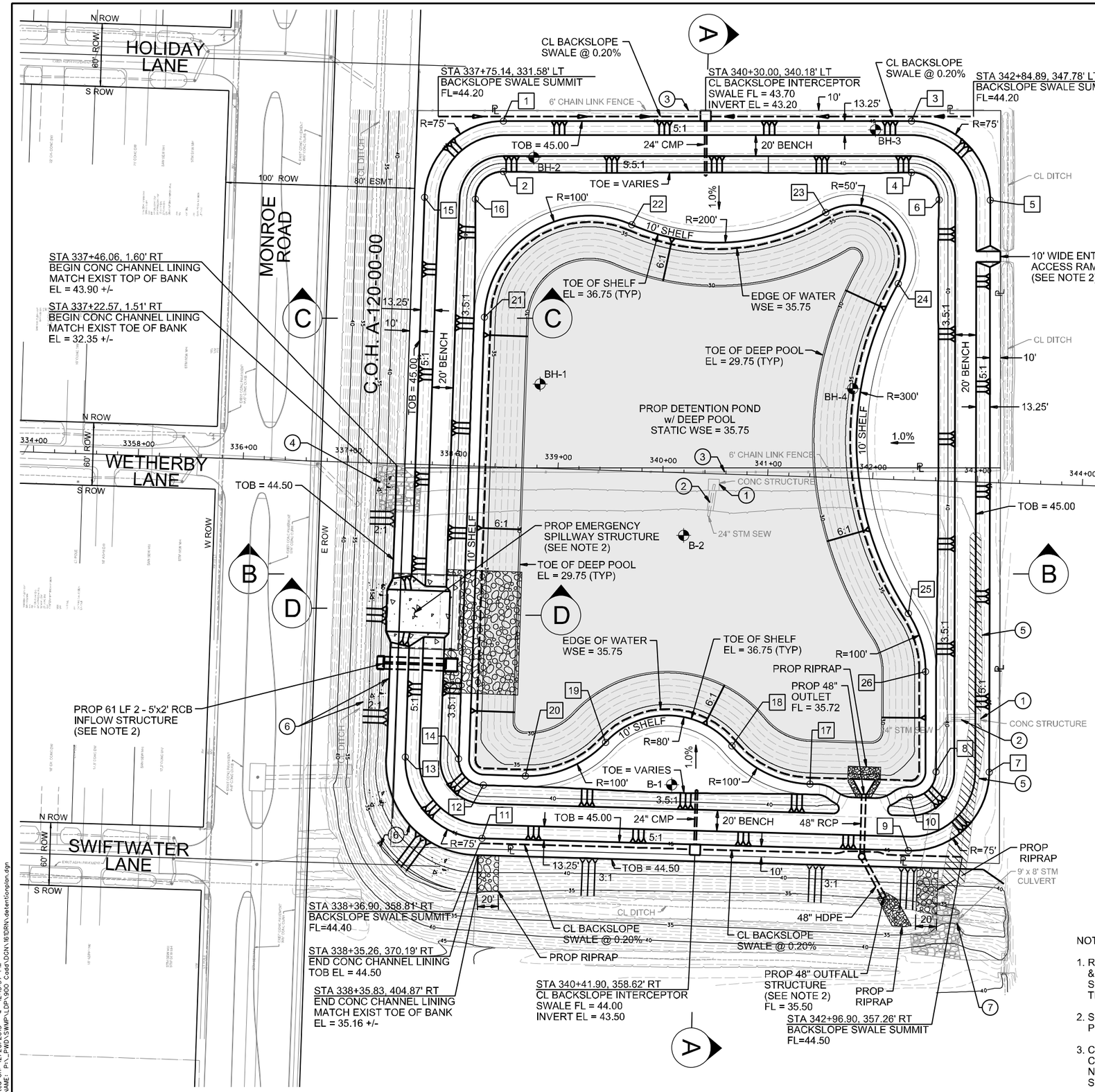
Date	Job No.	Exhibit
December 2013	60183142	21



BENCHMARK

TSARP MON 010528
LOCATED MOERS ROAD AT
HALLS ROAD DITCH
X = 13791871.81
Y = 3155153.57

ELEV = 44.65 NAVD 1988 (ADJ 2001)

TEMPORARY BENCHMARKS

SEE SURVEY CONTROL DRAWINGS
FOR THE FOLLOWING TEMPORARY
BENCHMARK(S): TBM 4411

FLOOD PLAIN NOTE

PROJECT LIES IN ZONE X (UNSHADED)
OUTSIDE OF LIMIT OF DETAILED STUDY
PER FIRM PANEL 48201C1035L
DATED JUNE 18, 2007
NEAREST BFE = 44.00 NAVD 88 (2001 ADJ)

LEGEND

- PROPOSED LIMITS OF STATIC WATER
- PROPOSED CONCRETE CHANNEL LINING
- PROPOSED BURIED STONE RIPRAP
- PROPOSED MAJOR CONTOUR (5' INTERVAL)
- PROPOSED MINOR CONTOUR (1' INTERVAL)

KEYED NOTES

1. REMOVE AND DISPOSE OF EXISTING CONCRETE STRUCTURE
2. REMOVE AND DISPOSE OF EXISTING STORM SEWER PIPE MH, INLET, ETC.
3. REMOVE AND REPLACE EXISTING FENCE WHERE NEEDED
4. REMOVE AND DISPOSE EXISTING RIPRAP
5. FILL EXISTING DITCH AS NEEDED TO DRAIN AREA
6. PROP 5" CONC CHANNEL LINING
7. PROTECT EXISTING 9' x 8' CULVERT. (SEE "PROPOSED SITE DETAILS, SHEET 1 OF 2")

No.	Date	Revisions	APD.

DETENTION BASIN STATION & OFFSET TABLE

#	STA	OFFSET	ELEV	DESCRIPTION
1	338+37.49	329.06 LT	45.00	TOP OF BANK
2	338+39.13	281.09 LT	37.74	TOE OF SLOPE
3	342+26.07	341.41 LT	45.00	TOP OF BANK
4	342+27.62	292.64 LT	37.51	TOE OF SLOPE
5	343+03.42	268.77 LT	45.00	TOP OF BANK
6	342+54.74	267.26 LT	37.54	TOE OF SLOPE
7	343+19.83	275.73 RT	45.00	TOP OF BANK
8	342+69.10	277.22 RT	36.95	TOE OF SLOPE
9	342+45.11	352.94 RT	45.00	TOP OF BANK
10	342+44.94	302.19 RT	36.95	TOE OF SLOPE
11	338+38.66	354.30 RT	45.00	TOP OF BANK
12	338+38.49	303.56 RT	36.95	TOE OF SLOPE
13	337+63.41	279.10 RT	45.00	TOP OF BANK
14	338+14.16	279.24 RT	36.95	TOE OF SLOPE
15	337+64.87	254.31 LT	45.00	TOP OF BANK
16	338+13.19	254.05 LT	37.64	TOE OF SLOPE
17	341+49.37	292.51 RT	36.75	TOE OF SHELF
18	340+73.98	258.59 RT	36.75	TOE OF SHELF
19	339+53.54	259.00 RT	36.75	TOE OF SHELF
20	338+78.37	293.42 RT	36.75	TOE OF SHELF
21	338+25.32	142.06 LT	36.75	TOE OF SHELF
22	339+62.97	234.43 LT	36.75	TOE OF SHELF
23	341+47.13	251.93 LT	36.75	TOE OF SHELF
24	342+18.48	186.49 LT	36.75	TOE OF SHELF
25	342+38.07	127.36 RT	36.75	TOE OF SHELF
26	342+56.29	182.02 RT	36.75	TOE OF SHELF

NOTES:

1. REFERENCE DRAINAGE REPORT TITLED "HYDROLOGIC & HYDRAULIC ANALYSIS FOR SKYSCRAPER SHADOWS SUBDIVISION", DATED DECEMBER 2013, BY AECOM TECHNICAL SERVICES, INC.
2. SEE "PROPOSED SITE DETAILS" AND "PROPOSED DETENTION PROFILE" SHEETS FOR ADDITIONAL INFORMATION.
3. CONTRACTOR SHALL BE RESPONSIBLE FOR THE CARE AND CONTROL OF WATER WITHIN THE COH A-120-00-00 CHANNEL NECESSARY TO CONSTRUCT THE 48" OUTFALL, THE SPILLWAY STRUCTURE, AND CONCRETE CHANNEL LINING.

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AECOM
AECOM TECHNICAL SERVICES, INC.
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TBPE REG. NO. F-3580

AMADA DURAN RODRIGUEZ, P.E.
TEXAS REGISTRATION NO. 107681
INTERIM SUBMITTAL
NOT FOR CONSTRUCTION PURPOSES

SURVEYED BY: AECOM
FB NO. P-5649

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SKYSCRAPER SHADOWS

EXHIBIT 22
PROPOSED DETENTION POND

WBS NO. M-000126-0070-4
DRAWING SCALE
1" = 50'
CITY OF HOUSTON PM
ROD PINHEIRO
SHEET NO. OF

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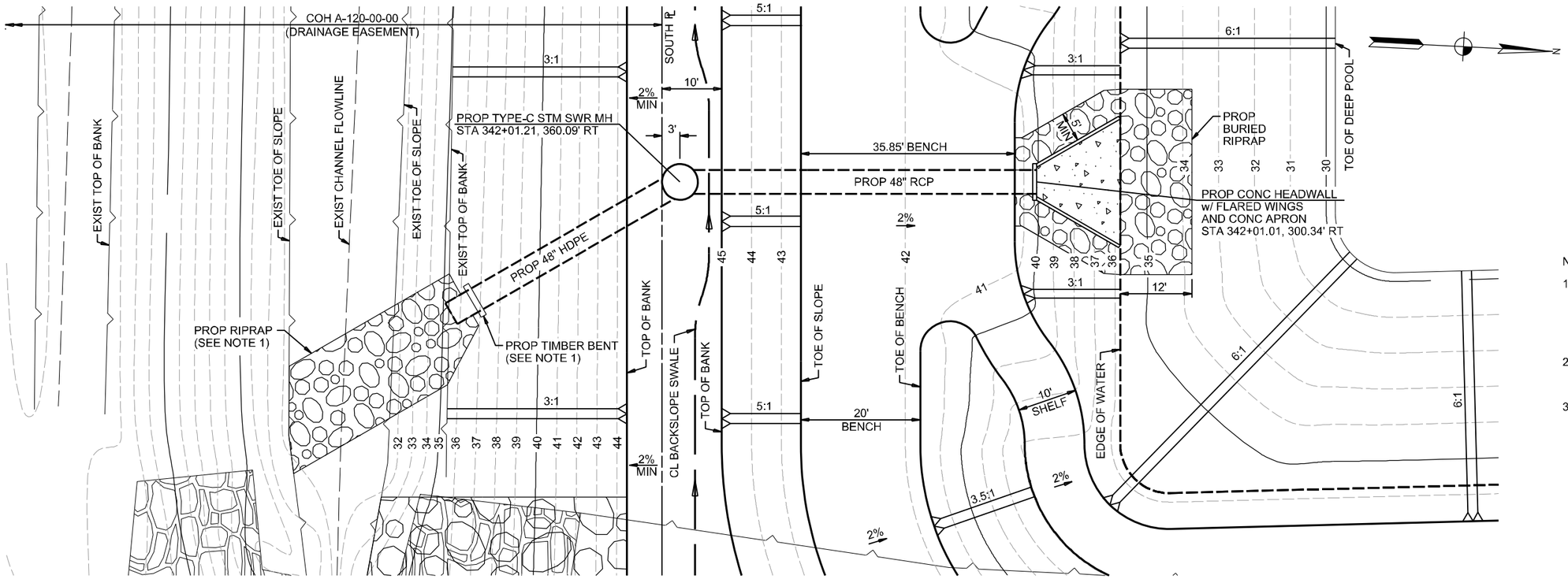


BENCHMARK

TSARP MON 010528
LOCATED MOERS ROAD AT
HALLS ROAD DITCH
X = 13791871.81
Y = 3155153.57

ELEV = 44.65 NAVD 1988 (ADJ 2001)

TEMPORARY BENCHMARKS

SEE SURVEY CONTROL DRAWINGS
FOR THE FOLLOWING TEMPORARY
BENCHMARK(S):

FLOOD PLAIN NOTE

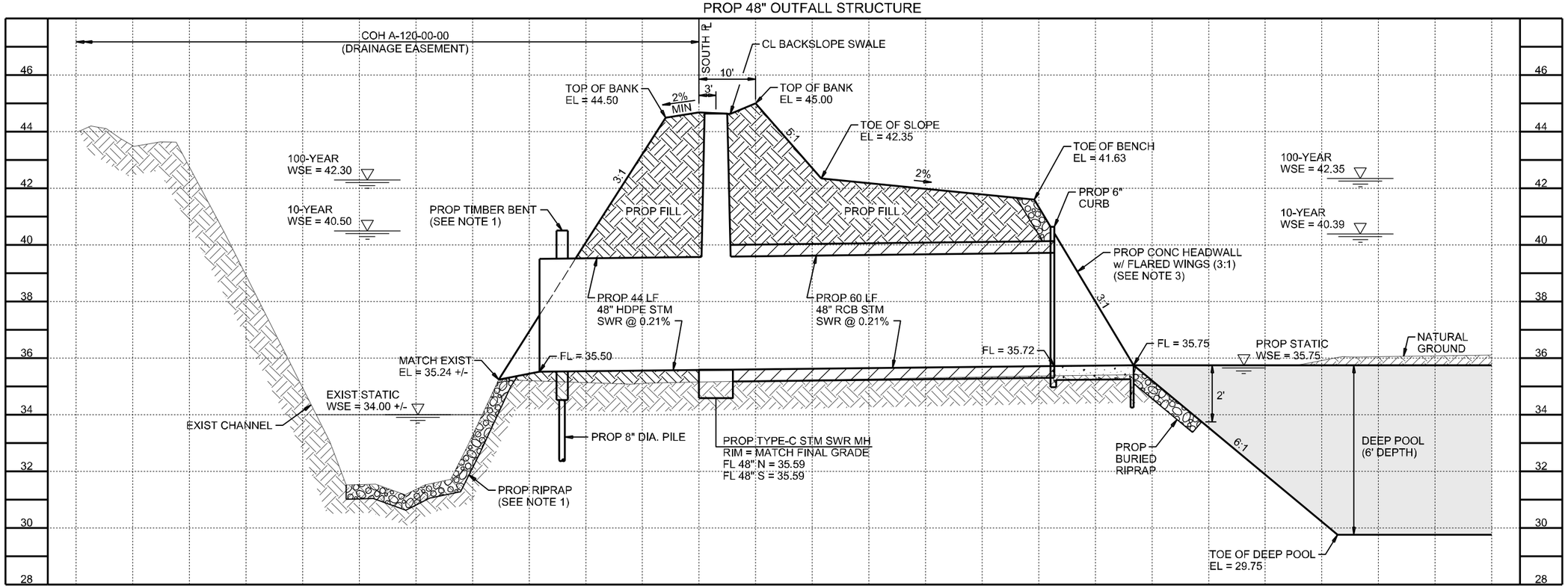
PROJECT LIES IN ZONE X (UNSHADED)
OUTSIDE OF LIMIT OF DETAILED STUDY
PER FIRM PANEL 48201C1035L
DATED JUNE 18, 2007
NEAREST BFE = 44.00 NAVD 88 (2001 ADJ)

No.	Date	Revisions	App.

NOTES:

1. CONTRACTOR SHALL CONSTRUCT CHANNEL LINING, TIMBER BENT, AND OUTFALL STRUCTURE IN ACCORDANCE WITH HCFCD STANDARDS AND SPECIFICATIONS. SEE PLAN FOR LIMITS OF CONCRETE CHANNEL LINING.
2. SEE "PROPOSED SITE DETAILS" SHEET FOR ADDITIONAL GRADING INFORMATION AROUND OUTFALL STRUCTURE.
3. CONSTRUCT PROPOSED HEADWALL AND WINGWALL STRUCTURES IN ACCORDANCE WITH TxDOT STANDARD DETAIL (CH-FW-0)

PROP 48" OUTFALL STRUCTURE



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5444 WESTHEIMER RD. SUITE 200
HOUSTON, TEXAS 77056
WWW.AECOM.COM
TBPE REG. NO. F-3580

Approved
Date
QUALITY CONTROL
Date

NOTICE:

AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE LONE STAR NOTIFICATION 713-223-4567.

PRIVATE UTILITIES LINES SHOWN

DATE:
CENTERPOINT ENERGY/ELECTRIC FACILITIES
(APPROVED ONLY FOR CROSSING UNDERGROUND DUCTLINES. UNLESS NOTED.) VALID AT TIME OF REVIEW ONLY

DATE:
AT&T TEXAS/SWBT
APPROVED FOR AT&T TEXAS/SWBT UNDERGROUND CONDUIT FACILITIES ONLY. SIGNATURE VALID FOR ONE YEAR

DATE:
CENTERPOINT ENERGY, GAS FACILITIES
(GAS SERVICE LINES ARE NOT SHOWN.)

AMADA DURAN RODRIGUEZ, P.E.
TEXAS REGISTRATION NO. 107691
INTERIM SUBMITTAL
NOT FOR CONSTRUCTION PURPOSES

SURVEYED BY: AECOM
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CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SKYSCRAPER SHADOWS

EXHIBIT 23
PROPOSED DETENTION PROFILES
(SHEET 1 OF 2)

WBS NO. M-000126-0070-4
DRAWING SCALE
HOR:1"=10' VERT:1"=2'
CITY OF HOUSTON PM
ROD PINHEIRO
SHEET NO. OF

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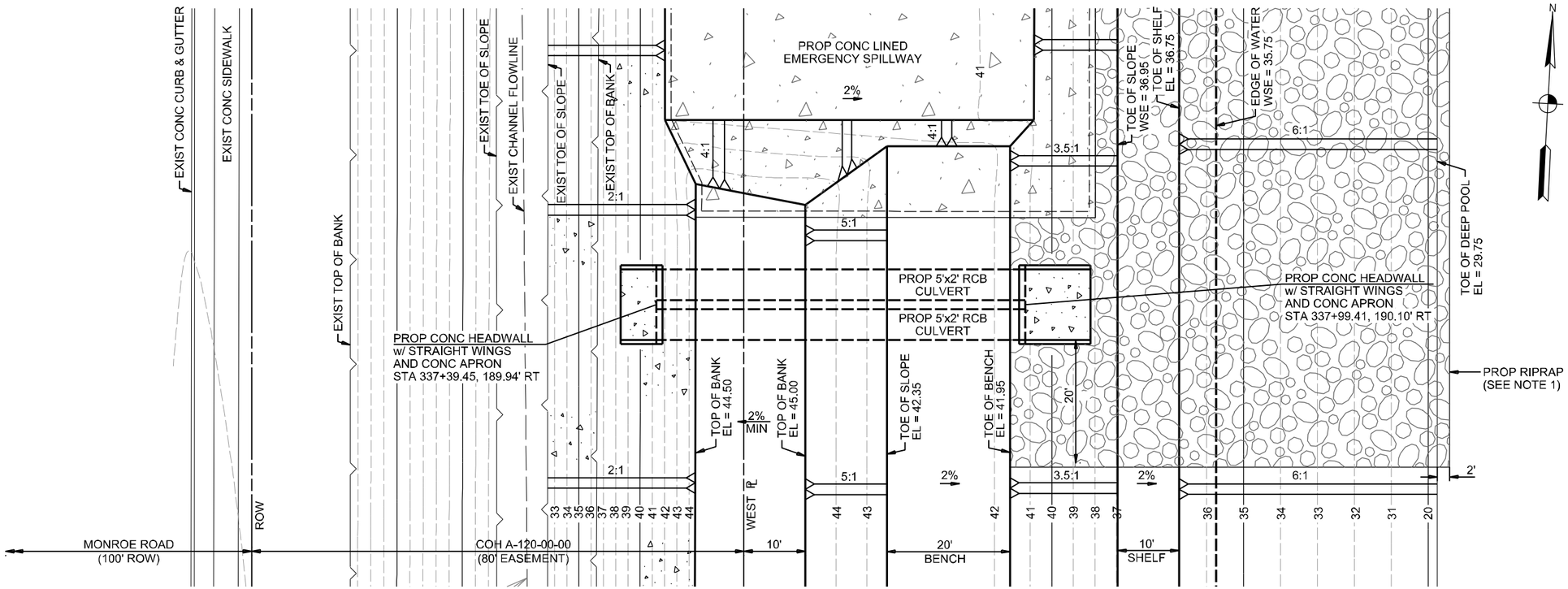


BENCHMARK

TSARP MON 010528
LOCATED MOERS ROAD AT
HALLS ROAD DITCH
X = 13791871.81
Y = 3155153.57

ELEV = 44.65 NAVD 1988 (ADJ 2001)

TEMPORARY BENCHMARKS

SEE SURVEY CONTROL DRAWINGS FOR THE FOLLOWING TEMPORARY BENCHMARK(S):

FLOOD PLAIN NOTE

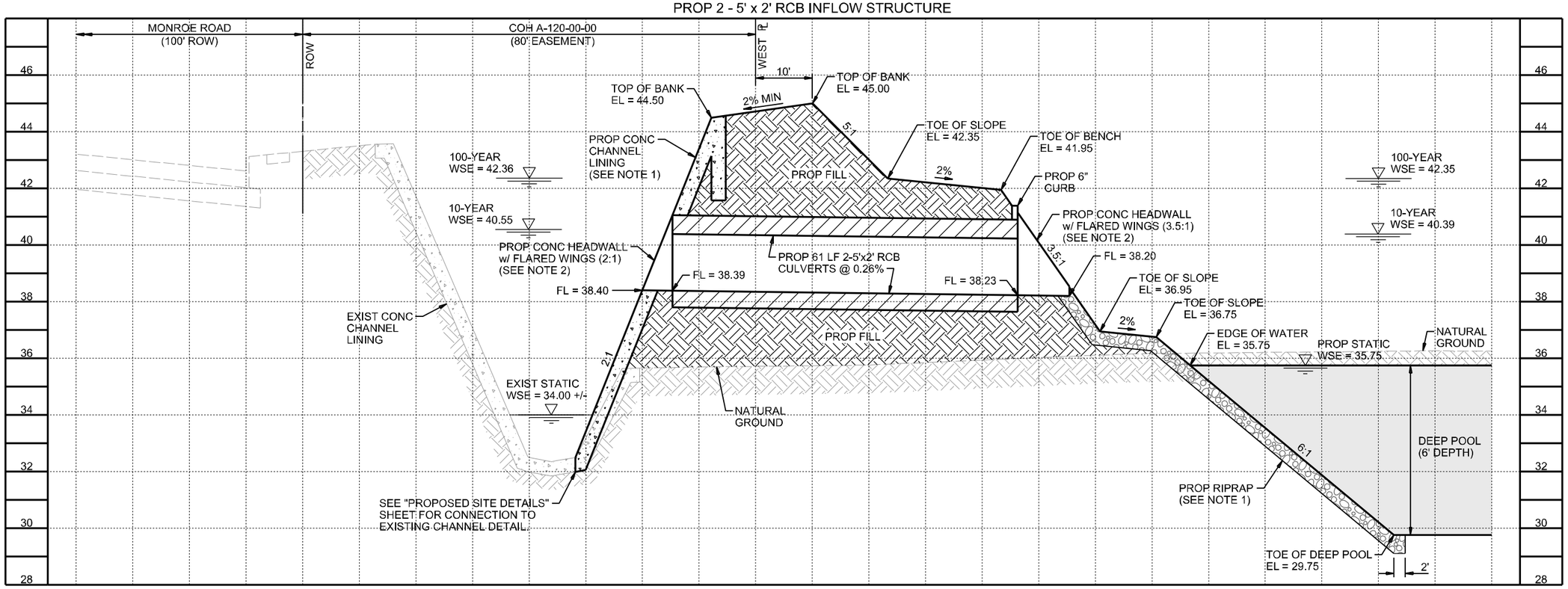
PROJECT LIES IN ZONE X (UNSHADED) OUTSIDE OF LIMIT OF DETAILED STUDY PER FIRM PANEL 48201C1035L DATED JUNE 18, 2007.
NEAREST BFE = 44.00 NAVD 88 (2001 ADJ)

No.	Date	Revisions	App.

NOTES:

1. CONTRACTOR SHALL CONSTRUCT CHANNEL LINING AND RIPRAP IN ACCORDANCE WITH HCFCD STANDARDS AND SPECIFICATIONS. SEE PLAN FOR LIMITS OF CONCRETE CHANNEL LINING.
2. CONSTRUCT PROPOSED HEADWALL AND WINGWALL STRUCTURES IN ACCORDANCE WITH TxDOT STANDARD DETAIL (SW-0). OMIT CURB ("C") AND 4" WING CUT-OFF AT THE BASE/END OF WINGWALL ON THE UPSTREAM (COH A-120-00-00 ADJACENT) STRUCTURE, ENSURING IT FLUSH WITH PROPOSED CONCRETE CHANNEL LINING.

PROP 2 - 5' x 2' RCB INFLOW STRUCTURE



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HOUSTON, TEXAS 77056
WWW.AECOM.COM
TBPE REG. NO. F-3580

Approved — QUALITY CONTROL
Date — Date

NOTICE:

AT LEAST 48 HOURS BEFORE EXCAVATING IN STREET R.O.W. OR EASEMENTS CALL THE LONE STAR NOTIFICATION 713-223-4567.

PRIVATE UTILITIES LINES SHOWN

DATE:
CENTERPOINT ENERGY/ELECTRIC FACILITIES
(APPROVED ONLY FOR CROSSING UNDERGROUND DUCTLINES. UNLESS NOTED.) VALID AT TIME OF REVIEW ONLY

DATE:
AT&T TEXAS/SWBT
APPROVED FOR AT&T TEXAS/SWBT UNDERGROUND CONDUIT FACILITIES ONLY. SIGNATURE VALID FOR ONE YEAR

DATE:
CENTERPOINT ENERGY, GAS FACILITIES
(GAS SERVICE LINES ARE NOT SHOWN.)

AMADA DURAN RODRIGUEZ, P.E.
TEXAS REGISTRATION NO. 107691
INTERIM SUBMITTAL
NOT FOR CONSTRUCTION PURPOSES

SURVEYED BY: AECOM
FB NO. P-5649

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SKYSCRAPER SHADOWS

EXHIBIT 23
PROPOSED DETENTION PROFILES
(SHEET 2 OF 2)

WBS NO. M-000126-0070-4
DRAWING SCALE
HOR:1"=10' VERT:1"=2'
CITY OF HOUSTON PM
ROD PINHEIRO
SHEET NO. OF

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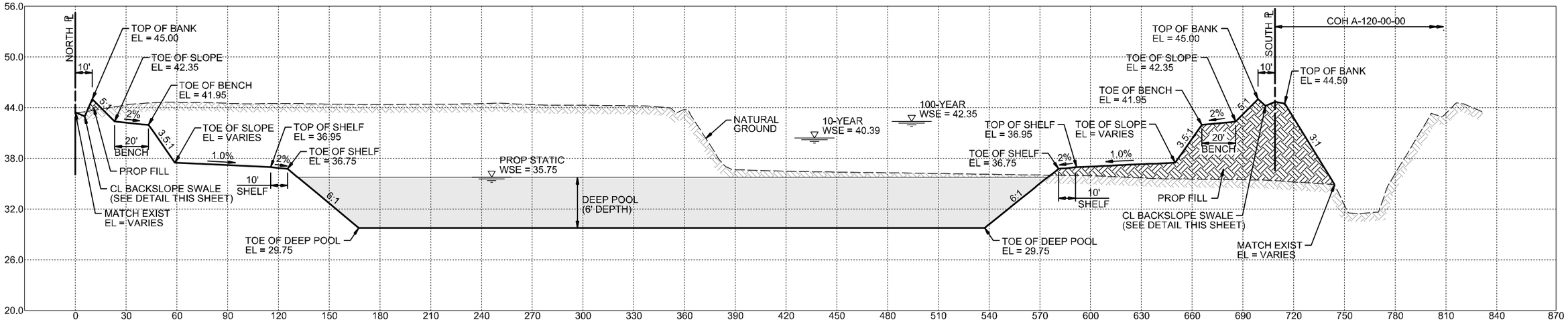
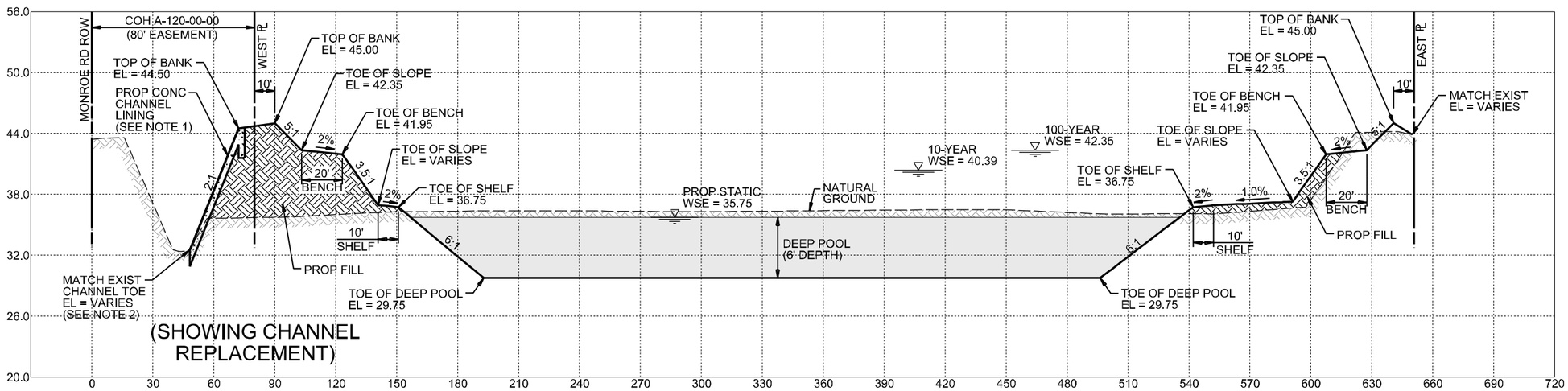


SECTION A-A

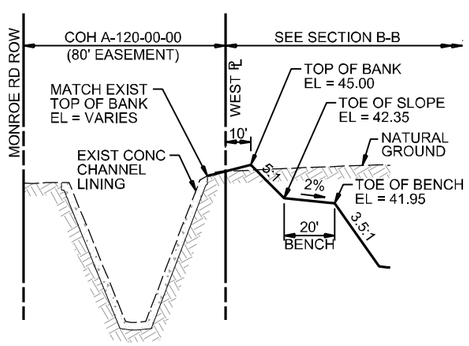


(SHOWING CHANNEL REPLACEMENT)

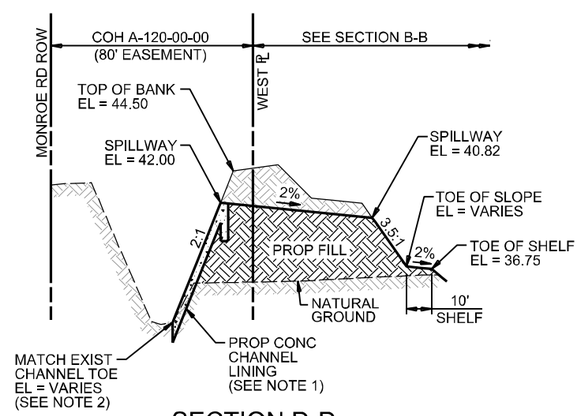
SECTION B-B

NOTES:

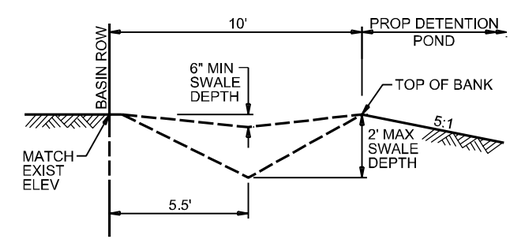
1. CONTRACTOR SHALL CONSTRUCT CHANNEL LINING IN ACCORDANCE WITH HCFCD STANDARDS AND SPECIFICATIONS. SEE PLAN FOR LIMITS OF CONCRETE CHANNEL LINING.
2. SEE "PROPOSED SITE DETAILS" SHEET FOR CONNECTION TO EXISTING CHANNEL DETAIL.



SECTION C-C
(NON- CHANNEL REPLACEMENT)



SECTION D-D
EMERGENCY SPILLWAY



BACKSLOPE SWALE DETAIL

AMADA DURAN RODRIGUEZ, P.E.
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CITY OF HOUSTON
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SKYSCRAPER SHADOWS

EXHIBIT 24
PROPOSED DETENTION
CROSS SECTIONS

WBS NO. M-000126-0070-4
DRAWING SCALE
HOR: 1"=30' VERT:1"=6'
CITY OF HOUSTON PM
ROD PINHEIRO
SHEET NO. OF

No.	Date	Revisions	App.

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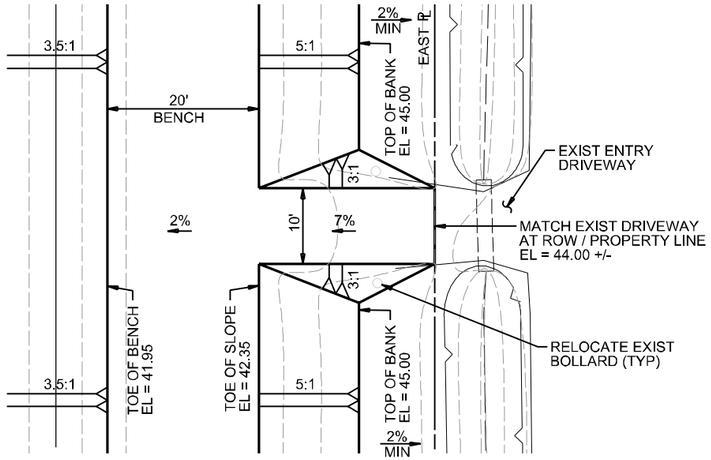
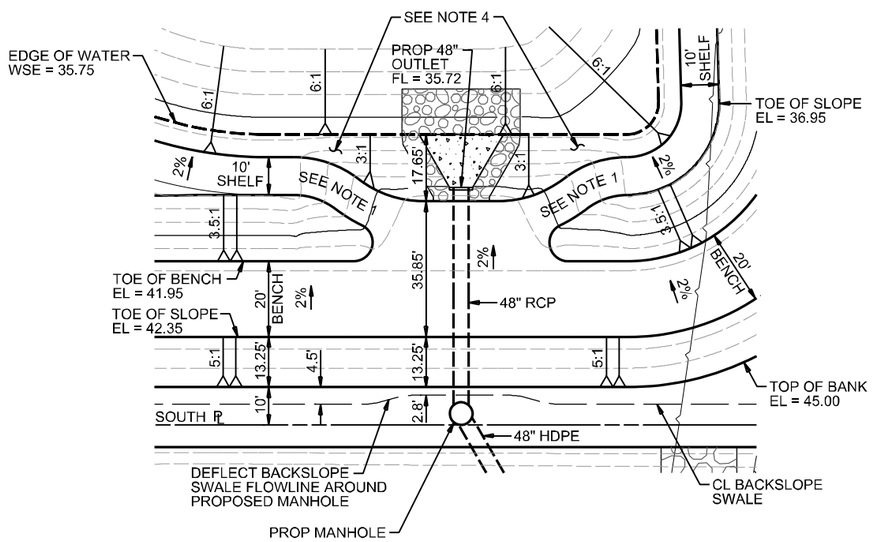
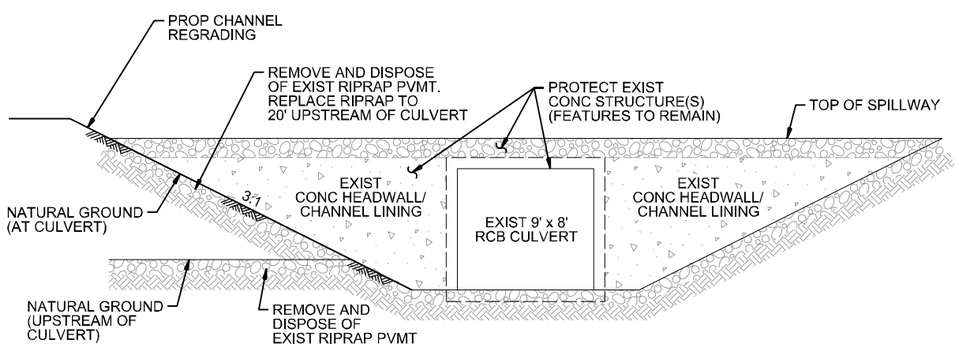


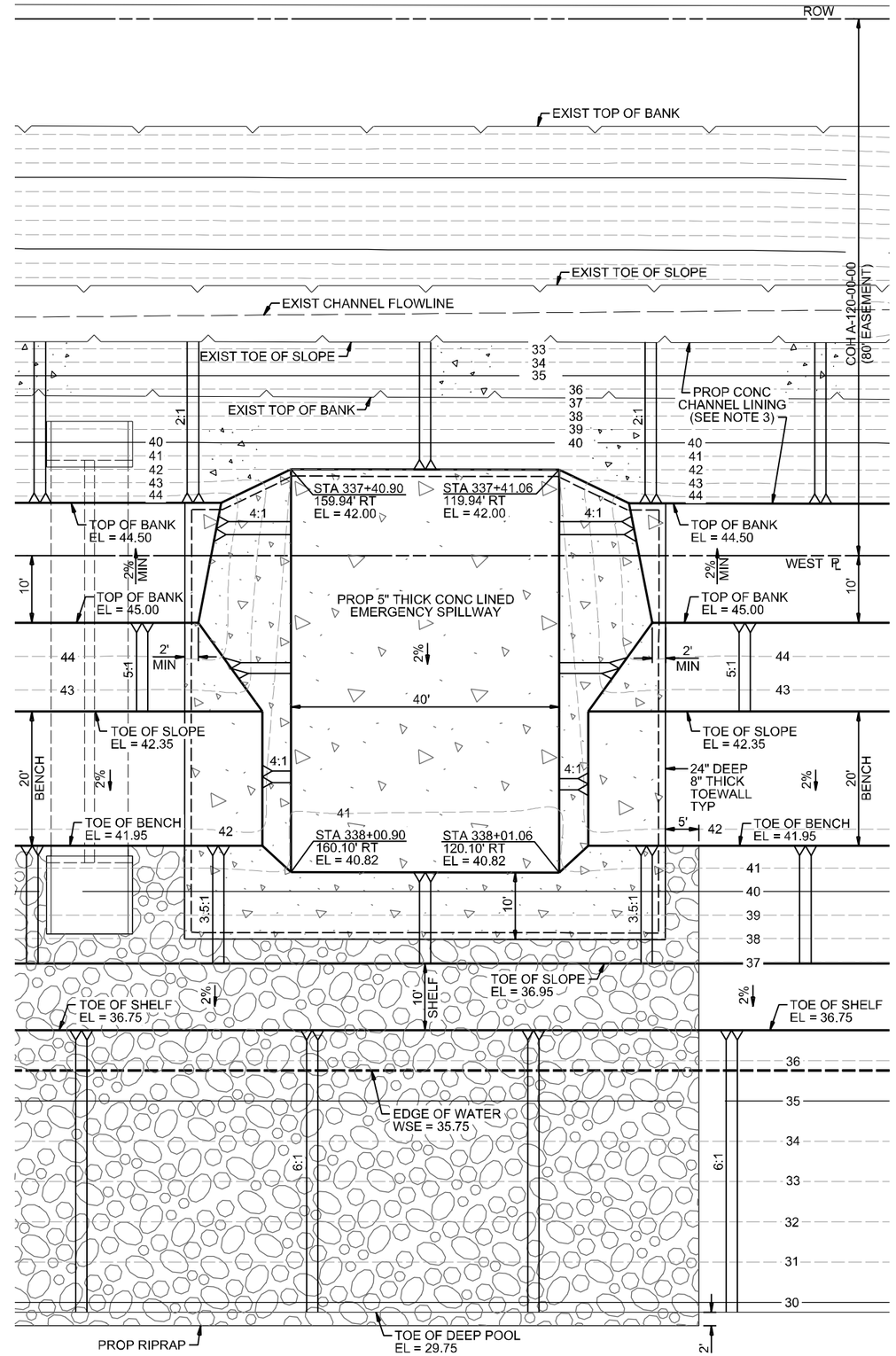
ENTRY / ACCESS DETAIL



GRADING AT OUTLET DETAIL



GRADING AT EXIST 9' x 8' CULVERT DETAIL (FACING DOWNSTREAM)



PROP EMERGENCY SPILLWAY DETAIL

NOTES:

1. TRANSITION 10'-SHELF AROUND AND OVER PROPOSED OUTLET STRUCTURE. MAINTAIN 1-FOOT MINIMUM COVER OVER PROPOSED 48" RCP. ADJUST GRADING IN FIELD AS REQUIRED.
2. SEE "PROPOSED DETENTION POND" SHEET FOR LOCATION OF STRUCTURES AND ADDITIONAL INFORMATION.
3. CONTRACTOR SHALL CONSTRUCT CHANNEL LINING IN ACCORDANCE WITH HCFCD STANDARDS AND SPECIFICATIONS. SEE PLAN FOR LIMITS OF CONCRETE CHANNEL LINING.
4. TRANSITION SIDE SLOPE FROM 6:1 TO 3:1 ABOVE THE EDGE OF WATER. MAINTAIN 6:1 SIDE SLOPE BELOW THE EDGE OF WATER.

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AECOM TECHNICAL SERVICES, INC.
5444 WESTHEIMER RD. SUITE 200
HOUSTON, TEXAS 77056
WWW.AECOM.COM
TBPE REG. NO. F-3580

SURVEYED BY: AECOM
FB NO. P-5649

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
SKYSCRAPER SHADOWS

EXHIBIT 25
PROPOSED DETENTION
SITE DETAILS
(SHEET 1 OF 2)

WBS NO. M-000126-0070-4	
DRAWING SCALE	
N.T.S.	
CITY OF HOUSTON PM	
ROD PINHEIRO	
SHEET NO. OF	

No.	Date	Revisions	App.

User: $$USTN_USERNAME$$
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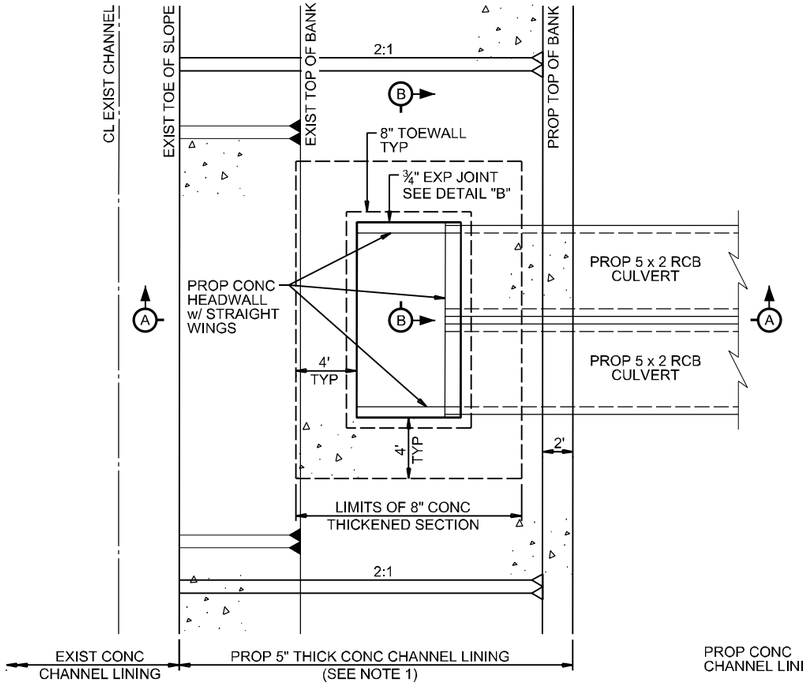
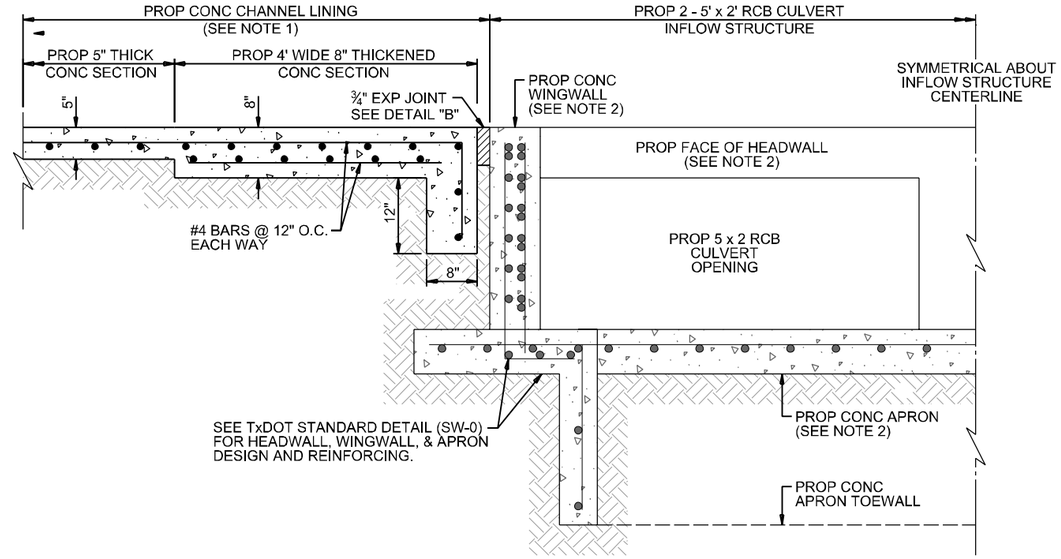
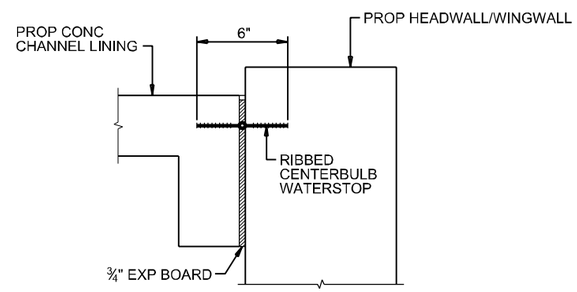


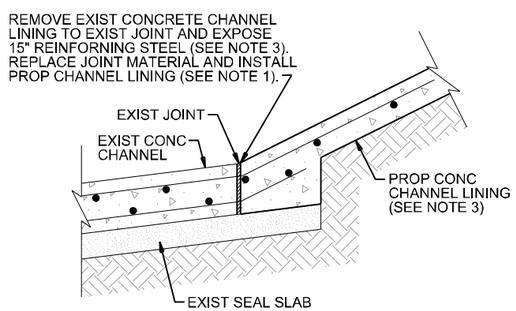
PLAN



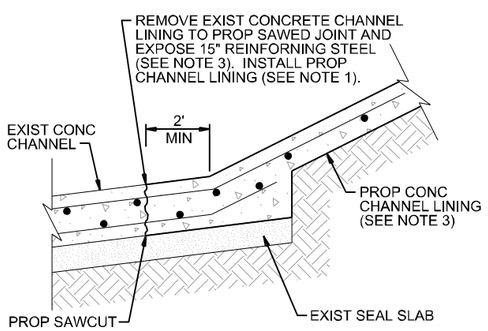
SECTION B-B



DETAIL "B"

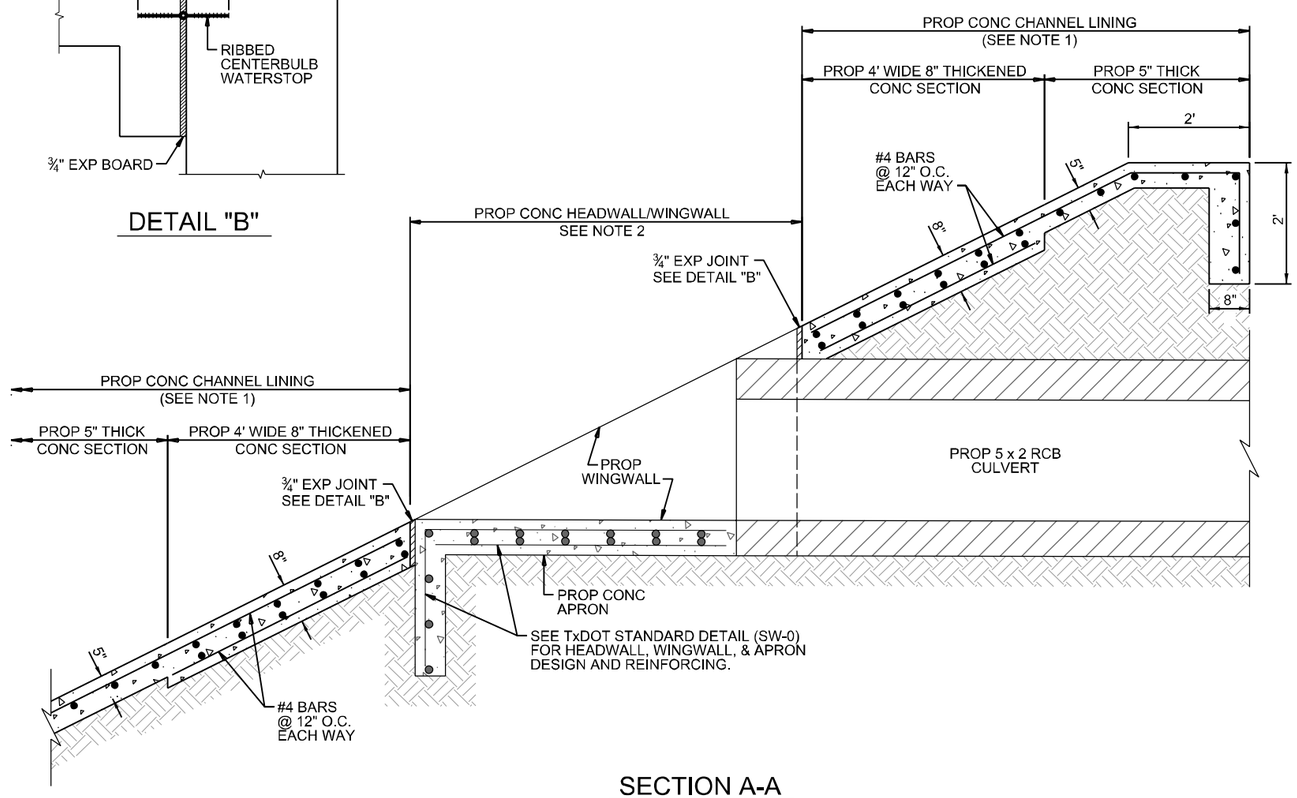


OPTION 1 (EXIST JOINT)



OPTION 2 (SAWCUT)

CONNECTION TO EXIST CHANNEL



SECTION A-A

NOTES:

1. CONTRACTOR SHALL CONSTRUCT CHANNEL LINING IN ACCORDANCE WITH HCFCD STANDARDS AND SPECIFICATIONS. SEE PLAN FOR LIMITS OF CONCRETE CHANNEL LINING.
2. CONTRACTOR SHALL CONSTRUCT HEADWALL/WINGWALL STRUCTURE IN ACCORDANCE WITH TxDOT STANDARD DETAIL (SW-0).
3. IF NO REINFORCING STEEL EXISTS, USE PO ROC HORIZONTAL DOWELS, OR APPROVED EQUAL. DOWELS SHALL BE 24" LONG #6 BARS AT 12" SPACING C-C, AND SHALL BE EMBEDED 12" INTO THE CENTER OF THE EXISTING SLAB.

AMADA DURAN RODRIGUEZ, P.E.
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TBPE REG. NO. F-3580

SURVEYED BY: AECOM
FB NO. P-5649

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

SKYSCRAPER SHADOWS

EXHIBIT 25
PROPOSED DETENTION
SITE DETAILS
(SHEET 2 OF 2)

WBS NO. M-000126-0070-4
DRAWING SCALE
N.T.S.
CITY OF HOUSTON PM
ROD PINHEIRO
SHEET NO. OF

No.	Date	Revisions	App.

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