

PART III, ATTACHMENT 2
APPENDIX III-2F
FLOODPLAIN EVALUATION

APPENDIX III-2F-1

Drainage and Detention Analysis for Hawthorn Park Landfill

Jones and Carter, Inc.

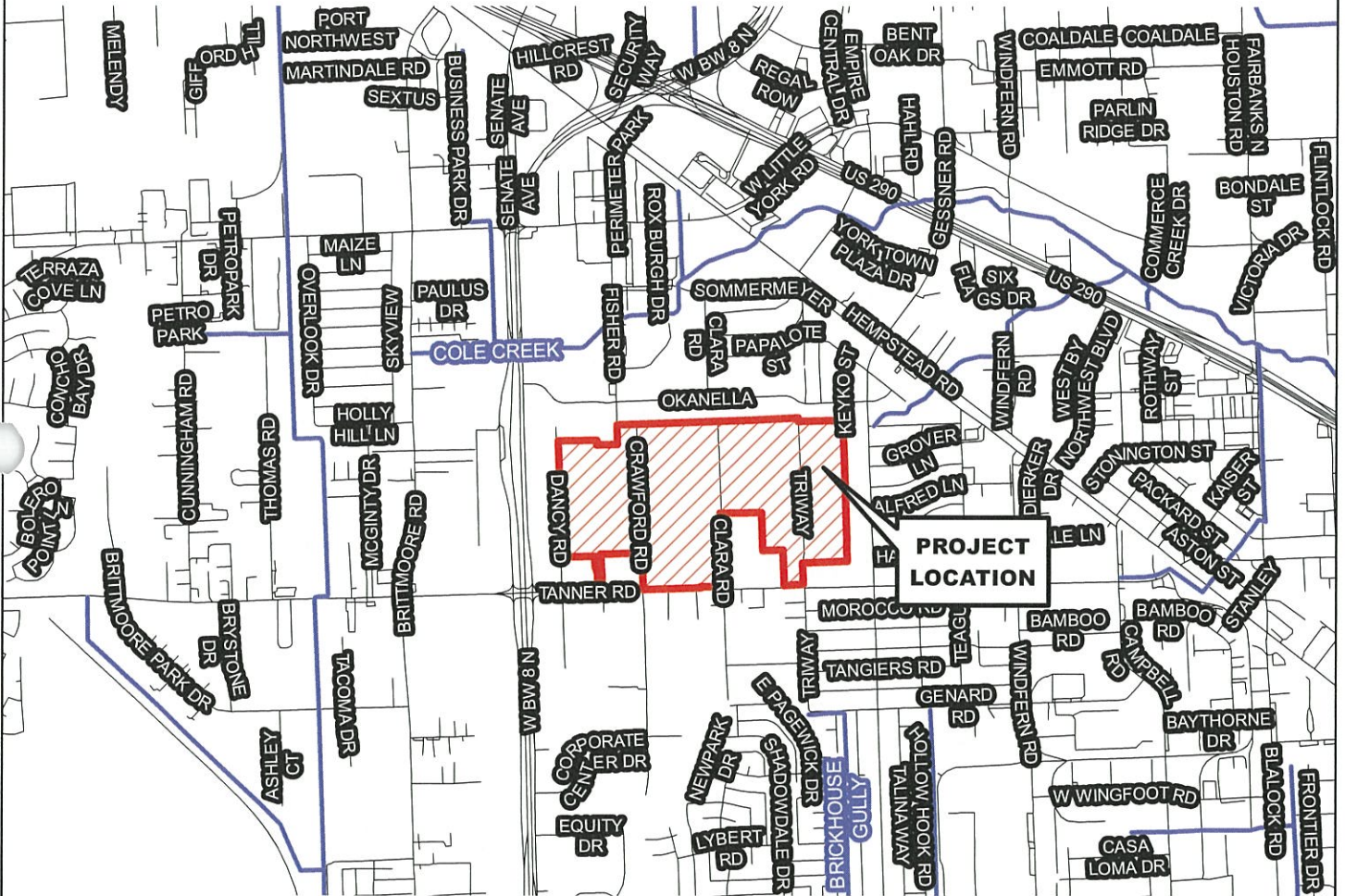
DRAINAGE AND DETENTION ANALYSIS

FOR

HAWTHORN PARK LANDFILL

IN

CITY OF HOUSTON, HARRIS COUNTY, TEXAS



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JC JOB No. 15222-0002-00



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DRAINAGE AND DETENTION ANALYSIS

For

Hawthorn Park Landfill

E117-07-00

CITY OF HOUSTON, HARRIS COUNTY, TEXAS

**Prepared by:
Jones & Carter, Inc.
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**DRAINAGE AND DETENTION ANALYSIS FOR
HAWTHORN PARK LANDFILL
E117-07-00
CITY OF HOUSTON, HARRIS COUNTY, TEXAS**

EXECUTIVE SUMMARY

This report identifies the drainage and detention requirements associated with the expansion of the Hawthorn Park landfill within the White Oak Bayou (E100-00-00) watershed. It evaluates existing and proposed stormwater detention storage for the landfill tract such that there are no adverse drainage impacts caused by the proposed site expansion based on Harris County Flood Control District (HCFCD) criteria. This report analyzes the hydrologic and hydraulic conditions of the tract using the Small Watershed Hydrograph Method (Method 2) as described in Section 6.11 of HCFCD's *Policy Criteria, and Procedure Manual (PCPM)*, dated July 2019.

The Hawthorn Park Landfill is located in the City of Houston within Harris County. The landfill is located north of Tanner Road, west of Gessner Road, and East of the Sam Houston Parkway. Hawthorn Park's existing land use is mostly landfill, with some areas of industrial, detention, road right-of-way, and undeveloped/wooded land uses. The project will utilize previously abandoned road right-of-way going through the site for expansion of the landfill. To accommodate the increase in runoff, the detention basin will be expanded, while keeping the existing outfall structure the same. The detention basin service area is approximately 253-acres.

A review of effective Flood Insurance Rate Map (FIRM) Panel No. 48201C0635M, revised June 9, 2014, shows the Hawthorn Park Landfill to be in various flood zones. Most of the tract is within Unshaded Zone X (areas outside of the 500-year floodplain) and Shaded Zone X (effective 500-year floodplain). The northern end of the detention basin is shown to be in Zone AO (Overflow Zone from Cole Creek - E117-00-00) and a small portion along the northern boundary of the tract is within Zone AE (effective 100-year floodplain). The small portion of the tract mapped in Zone AE has been removed and assigned as Shaded Zone X via a LOMA (Case No. 20-06-2644A), based on existing topographic survey data.

Using the peak flows developed by the Site Runoff Curves, the Small Watershed Hydrograph Method for small to moderate watersheds was used to define the required detention storage volume to offset the effects of the project and prevent increases in peak flows leaving the subject drainage area.

The proposed Hawthorn Park detention basin is utilized in an Atlas 14 100-year design storm as follows:

- Proposed Condition: The proposed detention facility receives a peak flow rate of 800 cfs from the 253-acre detention service area, and shows a peak storage of approximately 201.1 acre-feet (0.80 acre-feet per acre storage rate). The peak flow exiting the basin is shown to be approximately 262.2 cfs.

The hydrologic analyses show that onsite detention water surface elevations and peak discharges leaving the site are not increased by expansion of the Hawthorn Park Landfill with increased detention volume. Based on the results of this analysis, there is no adverse impact to existing flood hazards for storm events up to and including the Atlas 14 100-year event.

Table 1 – Detention Summary Table

<i>Project Name: Hawthorn Park Landfill</i>		<i>Date: 9-14-2020</i>		
Detention Basin Service Area		253 Acres		
Offsite Drainage Area		0 Acres		
Storm Event		50% (2-Year)	10% (10-Year)	1% (100-Year)
Flow (cfs)	Post-Project Flow	311	480	800
	Maximum Allowable Outflow (pre-development peak flow leaving existing basin)	136.8	195.7	291.2
	Maximum Outflow Provided (peak flow from proposed basin)	88.6	152.7	262.2
Elevations (1988 NAVD, 2001 Adj.)	Lowest Natural or Finished Ground Elevation Estimate	97.5		
	Maximum Allowable Water Surface	91.71	93.40	96.29
	Based on	Existing Condition Basin WSE Results		
	Design Water Surface Elevation	90.92	92.46	95.29
	Water Surface Elevation Calculated	90.92	92.46	95.29
Storage	Minimum Storage Required (ac-ft)	63.1	110.2	201.1
	Detention Storage Provided (ac-ft)	63.1	110.2	201.1
	Storage Rate Provided (ac-ft/acre)	0.25	0.44	0.80
Outflow Structure	Restrictor Size, if applicable	N/A		
	Outflow Pipe Size (Existing)	10'x3' RCB (30 square feet)		
	Outflow Velocity into Channel (ft/second)	3.7	5.1	8.7
	Weir Description, if applicable (type, size, elevation, etc.)	N/A; Weir not part of 1% design outflow structure		
	Drain Time – 1% only (hours)	20 hours (per Method 2 HMS Reservoir Routing)		
	Emergency Overflow (type, size, elevation, etc.)	100-foot Broad Crested Weir; Crest Elev at 96.5-feet; Passes 1% storm discharge @ 1-foot deep		

1.0 INTRODUCTION

1.1 PROJECT PURPOSE

This report details the detention storage and outfall structure serving the 253-acre Hawthorn Park Landfill. The landfill is already in use and proposes to utilize previously abandoned road right-of-ways as part of an expansion of the landfill. Additionally, a tract within the service area that is currently wooded and undeveloped is assumed to also be converted as part of the landfill. To offset any increase in impervious area, the detention basin is proposed to be expanded to provide additional storage. This report evaluates existing and proposed stormwater mitigation features for the development such that there are no adverse drainage impacts caused by the proposed expansion of the Hawthorn Park Landfill based on Harris County Flood Control District criteria. This report is being performed in conjunction with the revised TCEQ permit for the Hawthorn Park Landfill.

1.2 PROJECT LOCATION

Hawthorn Park is a landfill in the City of Houston and Harris County. The tract is generally located north of Tanner Road, west of Gessner Road, and east of Sam Houston Parkway. The tract is being served by an existing detention basin and is primarily landfill and industrial land uses. The service area of the detention basin being analyzed in this report is approximately 253-acres. The project location can be seen in Exhibit 1 – Vicinity Map.

1.3 PROJECT OBJECTIVES

The objective of this drainage analysis is to evaluate the impact of the expansion of Hawthorn Park Landfill within the watershed and to define proposed detention storage that provides necessary mitigation for any increased peak flows. The expansion should not adversely impact flood hazard conditions in the watershed for events up to and including the Atlas 14 100-year design storm event in accordance with Harris County Flood Control District criteria.

1.4 ASSUMPTIONS AND CONSTRAINTS

There are abandoned roadways running through the landfill areas that are proposed to be part of the landfill expansion. Additionally, all remaining undeveloped areas are also assumed to become developed as either landfill or as part of the detention expansion.

This analysis uses Atlas 14 rainfall data for the HCFCD Site Runoff Curves and direct rainfall runoff based on the Harris County Flood Control District's (HCFCD) Policy, Criteria, and Procedure Manual, updated July 2019. The detention facility will be analyzed under Atlas 14 rainfall values for the 2-year, 10-year, and 100-year storm events.

2.0 EXISTING CONDITIONS

2.1 LOCATION AND TOPOGRAPHY

The Hawthorn Park Landfill facility is located in the City of Houston within Harris County. The onsite detention facility serves approximately 253 acres. Hawthorn Park is generally located north of Tanner Road, west of Gessner Road, and east of the Sam Houston Parkway. The Hawthorn Park Landfill proposes to expand the landfill facility and provide additional storage to offset any potential increases in peak flow associated with the landfill expansion. The project location can be seen in Exhibit 1 – Vicinity Map.

The entire Hawthorn Park Landfill drains to the onsite detention facility via onsite drainage ditches. The existing detention basin drains approximately 253-acres and features a 10'x3' reinforced concrete box (RCB) outfall and discharges into a Harris County Flood Control Ditch (E117-07-00) that is part of the White Oak Bayou watershed. Onsite elevations within the site range from approximately 85-feet to 133-feet (all elevations referenced are NAVD 1988, 2001 Adjustment). See Exhibit 2 – Site Topography.

2.2 LAND USE

Hawthorn Park is an existing landfill operation with an onsite detention basin. Additional areas within the detention basin service area are classified as industrial, road right-of way, and undeveloped/wooded land use. Existing land use for the tract is based on aerial photography data dated February 2019. See Exhibit 3 – Existing Land Use.

2.3 FLOODPLAIN

A review of effective Federal Emergency Management Agency Flood Insurance Rate Map (FIRM) Panel No. 48201C0635M, revised June 9, 2014, shows most of the Hawthorn Park Landfill to be in Unshaded Zone X (areas outside of the effective 500-year floodplain) and Shaded Zone X (within the effective 500-year floodplain). The northern portion of the detention basin is within Zone AO (overflow zone from Cole Creek E117-00-00), and a very small area at the northern tract boundary is mapped within Zone AE (within the effective 100-year floodplain). The effective floodplain can be seen in relation to the detention service area boundary on Exhibit 4 – Effective FEMA Floodplain.

The floodplain mapping for this panel was performed with 2001 HCFCD LiDAR, which reflects conditions prior to the construction of the existing detention basin and portions of the existing landfill. JC submitted a LOMA to FEMA

to request that areas within the site mapped as Zone AE (small area along northern property boundary) be removed based on existing conditions survey data. The LOMA (Case No. 20-06-2644A) was approved by FEMA on July 17, 2020, and the area previously mapped as Zone AE has been removed and assigned to Shaded Zone X. The FEMA determination letter is included as part of Appendix 1.

2.4 DETAILED FLOODPLAIN ANALYSIS

The owner recognizes that the Harris County Flood Control District is restudying the watersheds of Harris County due to the new Atlas 14 rainfall standards, including the White Oak Bayou watershed. It is Jones|Carter's understanding that the revised analysis will use 1D/2D HEC-RAS to create master watershed models that incorporate all primary reaches of a watershed into a single hydraulic model. To better understand potential future floodplain mapping in the area near the Hawthorn Park project, Jones|Carter (JC) has performed existing conditions 1D/2D modeling using HEC-HMS and HEC-RAS. While the results of this detailed modeling are not the basis of this report, they are included for reference and better understanding of the existing floodplain near the site. Modeling and results from the 1D-2D Analysis are discussed in Appendix 2.

2.5 DRAINAGE AREAS

Aerial photography, site visits, and 2018 Harris County LiDAR contours were used to confirm the 253-acre detention basin service area. For all calculations, the detention basin service area is considered as a single drainage area.

2.6 RIGHT-OF-WAY, PIPELINES, AND UTILITIES

General locations of pipelines and underground utilities have been determined. No conflicts with the proposed detention expansion is anticipated. Any conflicts will be addressed in the final design process.

3.0 HYDROLOGY AND HYDRAULICS

3.1 ANALYSIS OBJECTIVE

The objective of this analysis is to size detention facilities that mitigate any drainage impact created by the proposed expansion of the Hawthorn Park Landfill facility. The proposed expansion with detention facilities should cause no adverse impact to 2-year, 10-year, and 100-year Atlas 14 flood hazard conditions in accordance with Harris County Flood Control District criteria.

3.2 HYDROLOGIC METHODOLOGY

Per Section 6.11 of the HCFCO PCPM, the site hydrology was analyzed using the HCFCO Site Runoff Curves to calculate peak flow rates, and the Small Watershed Hydrograph Method (Malcom's Equations) to develop inflow hydrographs. The Site Runoff Curve calculations are largely based on drainage area and impervious cover. The existing condition composite impervious cover for the Hawthorn Park detention service area is shown to be 68.3% (See Table 6 – Land Use Calculations).

To determine the detention storage and water surface elevations (WSEs) the inflow hydrographs were routed through a simplistic HEC-HMS reservoir model. The HEC-HMS model features a source node with the Malcom's hydrograph draining into a reservoir, which has an elevation-storage relationship and an outflow structure for the existing 10'x3' RCB outfall.

3.3 EXISTING HYDROLOGIC RESULTS

The Hawthorn Park detention basin service area was analyzed for the Atlas 14 2-year, 10-year, and 100-year storm events. The existing condition Site Runoff Curve calculations for the 253-acre site are shown in Table 2.

Table 2 – Existing Peak Flow Rate Calculation

	Existing Condition	
Impervious Cover	68.3%	
Storm Event	b	Q (cfs)
2-year	3.93	304
10-year	6.08	471
100-year	10.16	787

The peak flows from the existing condition represent the current peak flow rates entering the detention basin. These flows represent the existing condition of the basin before the expansion of the landfill, to be used as a comparison to the proposed condition in the Small Watershed Hydrograph Method calculations.

3.4 HYDRAULIC METHODOLOGY

The existing 10'x3' RCB culvert was modeled using the Outflow Structures method in HEC-HMS. The box culvert's flowline in the basin is set at an elevation of 88.52 feet and enters E117-07-00 at an elevation of 88.01 feet, per Jones|Carter (JC) topographic survey, taken in April 2019. Entrance and exit coefficients of 0.5 and 1.0 were assigned, respectively. The RCB was assigned a Manning's coefficient of 0.013.

The existing basin does not have a defined emergency overflow swale. The proposed basin will feature an emergency overflow swale, designed to pass the 100-year peak discharge from the pond.

Per section 6.11.4 of the HCFCFDC PCPM, the top of the outfall pipe (91.01 feet) was set as the tailwater condition for the 1% and 10% storm events, and the midpoint of the outfall pipe (89.51 feet) was set as the tailwater condition for the 2% storm event.

The hydrographs developed as part of the Small Watershed Hydrograph Method were routed through the detention basin storage to determine the peak WSEs, detention storage, and discharge rates through the existing 10'x3' box culvert. Table 3 shows the elevation-storage relationship used in the existing HEC-HMS model.

Table 3 - Existing Basin Elevation-Storage Relationship

Elevation (feet)	Storage (acre-feet)
88.52	0.0
89.50	3.7
90.50	18.3
91.52	40.2
92.50	63.7
93.50	90.3
94.50	119.6
95.50	150.3
96.50	183.0
97.50	218.1

3.5 EXISTING HYDRAULIC RESULTS

HEC-HMS (v 3.5) was used to route the Small Watershed Inflow Hydrograph through the existing detention basin and 10'x3' RCB outfall. Tables 9-11 show the existing Small Watershed Method calculations and the HEC-HMS summary table for the existing Hawthorn detention basin. The existing Hawthorn Park detention basin is utilized in an Atlas 14 100-year design storm as follows:

- The existing detention facility receives a peak flow rate of 787 cfs from the 253-acre service area, and shows a peak storage of approximately 176.1 acre-feet (0.70 acre-feet per acre storage rate). The peak flow exiting the basin is shown to be approximately 291.2 cfs.

4.0 PROPOSED DRAINAGE PLAN

4.1 DESCRIPTION

The proposed condition of the Hawthorn Park Landfill consists of expanding the landfill into previously abandoned road right-of-way that runs through the site. The analysis also assumes the remaining undeveloped areas within the detention service area will be converted to either landfill or detention. See Exhibit 4 – Proposed Land Use.

4.2 HYDROLOGIC ANALYSIS

The proposed site hydrology was analyzed using the HCFCD Site Runoff Curves to calculate peak flow rates, and the Small Watershed Hydrograph Method (Malcom's Equations) to develop inflow hydrographs. The Site Runoff Curve calculations are largely based on drainage area and impervious cover. The proposed condition composite impervious cover for the Hawthorn Park Tract is shown to be 72.3%. See Exhibit 5 – Proposed Land Use and Table 6 – Land Use Calculations.

To determine the proposed condition detention storage and water surface elevations (WSEs) the proposed inflow hydrographs were routed through a simplistic HEC-HMS reservoir model. The HEC-HMS model features a source node with the Malcom's hydrograph draining into a reservoir, which has an elevation-storage relationship for the proposed detention basin and an outflow structure for the existing 10'x3' RCB outfall and extreme event swale.

4.3 HYDROLOGIC RESULTS

The proposed Hawthorn Park tract draining to the existing onsite detention basin was analyzed for the Atlas 14 2-year, 10-year, and 100-year storm events. The proposed condition site runoff curve calculations for the 253-acre site are shown in Table 2.

Table 4 – Proposed Peak Flow Rate Calculation

	Proposed Condition	
Impervious Cover	72.3%	
Storm Event	b	Q (cfs)
2-year	4.02	311
10-year	6.21	480
100-year	10.34	800

4.4 HYDRAULIC ANALYSIS

The Small Watershed Hydrograph Method was performed to determine the required storage for the 253-acre detention service area. The detention basin is proposed to be expanded to accommodate increased runoff from the change in land use within the detention service area. As the existing 10'x3' RCB outfall is remaining in place, that structure is the restriction for the basin, and is modeled in the same matter as described in Section 3.4.

Table 5 shows the proposed detention basin elevation-storage-discharge relationship. The proposed expanded basin provides an additional 57.3 acre-feet of storage at the highest elevation in the table (Top of Berm). The hydrographs developed as part of the Small Watershed Hydrograph Method were routed through the detention basin storage to determine the peak WSEs, detention storage, and discharge rates through the existing 10'x3' box culvert. Table 3 shows the elevation-storage relationship used in the existing HEC-HMS model.

Table 5 – Proposed Basin Elevation-Storage Relationship

Elevation (feet)	Storage (acre-feet)
88.52	0.0
89.50	21.1
90.50	50.4
91.52	80.6
92.50	111.4
93.50	142.8
94.50	174.9
95.50	207.9
96.50	241.4
97.50	275.4

4.5 HYDRAULIC RESULTS

HEC-HMS (v 3.5) was used to route the proposed Small Watershed Inflow Hydrographs through the proposed detention basin and 10'x3' RCB outfall. Tables 12-14 show the existing Small Watershed Method calculations and the HEC-HMS summary table for the proposed Hawthorn detention basin. The proposed Hawthorn Park detention basin is utilized in an Atlas 14 100-year design storm as follows:

- Proposed Condition: The proposed detention facility receives a peak flow rate of 800 cfs from the 253-acre detention service area, and shows a peak storage of approximately 201.1 acre-feet (0.80 acre-feet per acre storage rate). The peak flow exiting the basin is shown to be approximately 262.2 cfs. For the 2-, 10-, and 100-year events, water surface elevations within the pond were decreased and peak discharges through the existing outfall were decreased in the proposed condition.

The proposed condition of the Hawthorn detention basin will feature an extreme event weir spillway. The proposed condition 100-year water surface elevation is shown to be at 95.29 feet. The extreme event weir spillway will be set at an elevation of 96.50 feet. The detention top of bank elevation is approximately 97.5 feet.

The weir should pass the proposed 100-year peak discharge (262.2 cfs). Based on the broad crested weir calculation, the weir crest needs to be 100-feet long, and will pass a flow of approximately 265 cfs at 1-foot of head (elevation 97.5 feet). See Table 15 – Extreme Event Weir Calculation.

4.6 FLOODPLAIN CONSIDERATIONS

No floodplain fill is proposed as part of the detention basin expansion. There may be some re-grading of maintenance berms to ensure there is a consistent berm elevation of at least 97.5-feet, but no new fill is anticipated in the floodplain.

As mentioned in Section 2.3, the floodplain mapping was performed using 2001 HCFCD LiDAR elevation data, which reflects site conditions prior to the construction of the existing detention basin and portions of the existing landfill. Thus, the floodplain mapping in the project area is not representative of existing conditions.

JC submitted a LOMA to FEMA to request that portions of the site mapped as Zone AE (small area along northern property boundary) be removed based on existing conditions survey data. The LOMA (Case No. 20-06-2644A) was approved by FEMA on July 17, 2020, and the area previously mapped as Zone AE has been removed and reclassified as Shaded Zone X. The FEMA determination letter is included as part of Appendix 1.

Additionally, JC has performed a detailed 1D2D floodplain analysis, shown in Appendix 2. The results of the floodplain analysis mapping show that in the Atlas 14 100-year event, only the detention basin and drainage channels on site are inundated. No other portions of the site shown ponding or flooding in the Atlas 14 100-year event, which is comparable to the effective (TP40) 500-year storm.

5.0 SUMMARY AND CONCLUSIONS

1. This report identifies the drainage and detention requirements associated with the expansion of the Hawthorn Park Landfill facility north of Tanner Road, west of Gessner Road, and east of the Sam Houston Parkway. Hawthorn Park is located within the City of Houston in Harris County, Texas. The site has an existing onsite detention basin, with a service area of approximately 253 acres.
2. The Hawthorn Park Landfill facility proposes utilize abandoned road right-of-ways which run through the site for the landfill expansion. The increased stormwater runoff associated with this change will be mitigated by expanding the existing onsite detention basin storage.
3. The existing Hawthorn Park Landfill detention facility discharges via a 10'x3' RCB to HCFCO Channel E117-07-00, within the White Oak Bayou Watershed. The detention pond is proposed to be expanded further to prevent increases in onsite water surface elevations and peak discharges leaving the basin. The outfall culvert is proposed to remain unchanged.
4. The report evaluates existing and proposed drainage conditions using Method 2 for Moderate Drainage Areas, as described in Section 6.11 of the Harris County Flood Control District *Policy, Criteria, and Procedures Manual*. This method uses the HCFCO Site Runoff Curves and the Small Watershed Hydrograph Method (Malcom's Equations) to analyze the runoff in existing and proposed conditions. The Malcom's hydrographs are then routed through a simple HEC-HMS reservoir model to determine the peak detention storage, water surface elevations, and discharges through the existing 10'x3' RCB.
5. A review of effective Flood Insurance Rate Map (FIRM) Panel No. 48201C0635M, revised June 9, 2014, shows the Hawthorn Park tract to be in various flood zones. Most of the tract is within Unshaded Zone X (areas outside of the 500-year floodplain) and Shaded Zone X (effective 500-year floodplain). The northern end of the detention basin is shown to be in Zone AO (Overflow Zone from Cole Creek E117-00-00) and a small portion along the northern boundary of the tract is within Zone AE (effective 100-year floodplain). JC has removed the portion of the tract mapped as Zone AE via a LOMA based on existing topographic survey data.
6. The Hawthorn Park detention basin was analyzed in existing and proposed conditions for the 2-year, 10-year, and 100-year Atlas 14 storm events using the HCFCO Site Runoff Curves, the Small Watershed Hydrograph Method, and HEC-HMS (v. 3.5). For all 3 storm event scenarios, water surface elevations

within the pond were decreased and peak discharges through the existing outfall were decreased in the proposed condition.

7. The proposed Hawthorn Park detention basin is utilized in an Atlas 14 100-year design storm as follows:
 - Proposed Condition: The proposed detention facility receives a peak flow rate of 800 cfs from the 253-acre detention service area, and shows a peak storage of approximately 201.1 acre-feet (0.80 acre-feet per acre storage rate). The peak flow exiting the basin is shown to be approximately 262.2 cfs.
8. Based on this analysis, the proposed expansion of the Hawthorn Park facility with increased detention shows no adverse impact to existing flood hazards of E117-07-00 for storm events up to and including the Atlas 14 100-year design storm.

Hawthorn Park Landfill Drainage and Detention Analysis
Table 6 - Land Use Calculations

Existing Land Use Calculation

Land Use	Area (ac)	% Imp	A*I
Detention	34.68	100%	34.7
Road/ROW	11.38	80%	9.1
Landfill	170.08	65%	110.6
Industrial(High Density)	21.8	85%	18.5
Undeveloped	15.06	0%	0.0
Total	253		172.9
Impervious Cover		68.3%	

Proposed Land Use Calculation

Land Use	Area (ac)	% Imp	A*I
Detention	40.26	100%	40.3
Landfill	190.94	65%	124.1
Industrial(High Density)	21.8	85%	18.5
Total	253		182.9
Impervious Cover		72.3%	

Hawthorn Park Landfill Drainage and Detention Analysis
Table 7 - Site Runoff Curve Calculations

Existing Site Runoff Curve Calculations

A (acres)	253		
m	0.786		
%Imp	68.3%		
	2-Year	10-Year	100-Year
*b	3.93	6.08	10.16
Q	304	471	787

*Values for the "b" coefficient were interpolated from the table on page 3-4 of HCFCD's *Interim Guidelines and Criteria for Atlas 14 Implementation*, dated July 2019.

Proposed Site Runoff Curve Calculations

A (acres)	253		
m	0.786		
%Imp	72.3%		
	2-Year	10-Year	100-Year
*b	4.02	6.21	10.34
Q	311	480	800

*Values for the "b" coefficient were interpolated from the table on page 3-4 of HCFCD's *Interim Guidelines and Criteria for Atlas 14 Implementation*, dated July 2019.

**Hawthorn Park Landfill Drainage and Detention Analysis
Table 8 - Direct Runoff Calculations**

Direct Runoff (White Oak Bayou Watershed)

Impervious Cover (%)	100-Year (inches)	10-Year (inches)	2-Year (inches)
0%	14.9	7.0	3.6
40%	15.6	7.6	4.1
85%	16.4	8.3	4.8

*From the tables on page 3-10 through 3-13 of HCFC's *Interim Guidelines and Criteria for Atlas 14 Implementation*, dated July 2019.

Existing Condition Direct Runoff Calculations

Impervious Cover (%)		68.3%		
Direct Runoff (inches)	2-Year (in)	10-Year (in)	100-Year (in)	
	4.54	8.04	16.10	

Proposed Condition Direct Runoff Calculations

Impervious Cover (%)		72.3%		
Direct Runoff (inches)	2-Year (in)	10-Year (in)	100-Year (in)	
	4.60	8.10	16.17	

Hawthorn Park Landfill Drainage and Detention Analysis
Table 9 - Existing 100-Year Small Watershed Method Calculation

Existing 100-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253
 Rainfall Excess (inches): 16.10
 % Impervious: 68.3%
 Allowable Peak Discharge (cfs): 787

HEC-HMS Existing 100-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
 Simulation Run: Existing 100-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Existing 100-Yr
 End of Run: 03Jan2020, 00:00 Meteorologic Model: 100-Year (Atlas 14)
 Compute Time: 14Sep2020, 10:26:41 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 786.5 (CFS)	Date/Time of Peak Inflow : 01Jan2020, 03:45
Peak Outflow : 291.2 (CFS)	Date/Time of Peak Outflow : 01Jan2020, 07:00
Total Inflow : 16.16 (IN)	Peak Storage : 176.1 (AC-FT)
Total Outflow : 14.76 (IN)	Peak Elevation : 96.3 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	8.6
30	33.9
45	74.8
60	129.6
75	195.9
90	270.8
105	351.0
120	433.0
135	513.3
150	588.4
165	655.0
180	710.2
195	751.6
210	777.4
225	786.5
240	778.5
255	753.7
270	713.2
285	660.0
300	605.3
315	555.2
330	509.2
345	467.0
360	428.3
375	392.8
390	360.3



Hawthorn Park Landfill Drainage and Detention Analysis
Table 10 - Existing 10-Year Small Watershed Method Calculation

Existing 10-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253
 Rainfall Excess (inches): 8.04
 % Impervious: 68.3%
 Allowable Peak Discharge (cfs): 471

HEC-HMS Existing 10-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
 Simulation Run: Existing 10-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Existing 10-Yr
 End of Run: 03Jan2020, 00:00 Meteorologic Model: 10-Year (Atlas 14)
 Compute Time: 14Sep2020, 10:28:35 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 469.2 (CFS)	Date/Time of Peak Inflow : 01Jan2020, 03:15
Peak Outflow : 195.7 (CFS)	Date/Time of Peak Outflow : 01Jan2020, 05:45
Total Inflow : 8.07 (IN)	Peak Storage : 87.5 (AC-FT)
Total Outflow : 6.66 (IN)	Peak Elevation : 93.4 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	7.4
30	28.9
45	63.4
60	108.7
75	161.8
90	219.6
105	278.3
120	334.4
135	384.2
150	424.8
165	453.6
180	468.7
195	469.2
210	455.2
225	427.4
240	388.9
255	350.6
270	316.1
285	284.9
300	256.9
315	231.6
330	208.8
345	188.2
360	169.7
375	153.0

Hawthorn Park Landfill Drainage and Detention Analysis
Table 11 - Existing 2-Year Small Watershed Method Calculation

Existing 2-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253

Rainfall Excess (inches): 4.54

% Impervious: 68.3%

Allowable Peak Discharge (cfs): 304

HEC-HMS Existing 2-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
 Simulation Run: Existing 2-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Existing 2-Yr
 End of Run: 03Jan2020, 00:00 Meteorologic Model: 2-Year (Atlas 14)
 Compute Time: 14Sep2020, 10:29:02 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 304.2 (CFS)	Date/Time of Peak Inflow : 01Jan2020, 02:45
Peak Outflow : 136.8 (CFS)	Date/Time of Peak Outflow : 01Jan2020, 04:45
Total Inflow : 4.56 (IN)	Peak Storage : 45.1 (AC-FT)
Total Outflow : 4.37 (IN)	Peak Elevation : 91.7 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	6.2
30	24.3
45	52.9
60	89.5
75	131.3
90	174.8
105	216.4
120	252.7
135	280.9
150	298.5
165	304.2
180	297.5
195	278.9
210	250.8
225	222.7
240	197.8
255	175.7
270	156.0
285	138.6
300	123.1
315	109.3
330	97.1
345	86.2
360	76.6
375	68.0
390	60.4

Hawthorn Park Landfill Drainage and Detention Analysis
Table 12 - Proposed 100-Year Small Watershed Method Calculation

Proposed 100-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253

Rainfall Excess (inches): 16.17

% Impervious: 72.3%

Allowable Peak Discharge (cfs): 800

HEC-HMS Proposed 100-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
Simulation Run: Proposed 100-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Proposed 100-Yr
End of Run: 03Jan2020, 00:00 Meteorologic Model: 100-Year (Atlas 14)
Compute Time: 14Sep2020, 10:29:25 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 800.1 (CFS) Date/Time of Peak Inflow : 01Jan2020, 03:45
Peak Outflow : 262.2 (CFS) Date/Time of Peak Outflow : 01Jan2020, 07:15
Total Inflow : 16.23 (IN) Peak Storage : 201.1 (AC-FT)
Total Outflow : 13.10 (IN) Peak Elevation : 95.3 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	8.9
30	35.3
45	78.0
60	135.1
75	204.1
90	281.7
105	364.7
120	449.3
135	531.6
150	608.1
165	675.3
180	730.2
195	770.4
210	794.0
225	800.1
240	788.2
255	759.1
270	713.9
285	657.3
300	602.2
315	551.7
330	505.4
345	463.0
360	424.1
375	388.6
390	356.0

Hawthorn Park Landfill Drainage and Detention Analysis
Table 13 - Proposed 10-Year Small Watershed Method Calculation

Proposed 10-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253

Rainfall Excess (inches): 8.10

% Impervious: 72.3%

Allowable Peak Discharge (cfs): 480

HEC-HMS Proposed 10-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
 Simulation Run: Proposed 10-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Proposed 10-Yr
 End of Run: 03Jan2020, 00:00 Meteorologic Model: 10-Year (Atlas 14)
 Compute Time: 14Sep2020, 10:29:48 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 479.3 (CFS)	Date/Time of Peak Inflow : 01Jan2020, 03:00
Peak Outflow : 152.7 (CFS)	Date/Time of Peak Outflow : 01Jan2020, 06:15
Total Inflow : 8.13 (IN)	Peak Storage : 110.2 (AC-FT)
Total Outflow : 5.02 (IN)	Peak Elevation : 92.5 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	7.7
30	30.3
45	66.3
60	113.5
75	168.8
90	228.6
105	289.2
120	346.7
135	397.3
150	437.9
165	465.9
180	479.3
195	477.5
210	460.5
225	429.3
240	388.6
255	349.9
270	315.0
285	283.6
300	255.3
315	229.9
330	207.0
345	186.4
360	167.8

Hawthorn Park Landfill Drainage and Detention Analysis
Table 14 - Proposed 2-Year Small Watershed Method Calculation

Proposed 2-Year

Watershed Name: Hawthorn Park

Pond Service Area (acres): 253

Rainfall Excess (inches): 4.60

% Impervious: 72.3%

Allowable Peak Discharge (cfs): 311

HEC-HMS Proposed 2-Year Results

Summary Results for Reservoir "Hawthorn Pond"

Project: Hawthorn Park_Method2
Simulation Run: Proposed 2-Yr Reservoir: Hawthorn Pond

Start of Run: 01Jan2020, 00:00 Basin Model: Proposed 2-Yr
End of Run: 03Jan2020, 00:00 Meteorologic Model: 2-Year (Atlas 14)
Compute Time: 14Sep2020, 10:30:26 Control Specifications: Control 1

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 311.0 (CFS)	Date/Time of Peak Inflow : 01Jan2020, 02:45
Peak Outflow : 88.6 (CFS)	Date/Time of Peak Outflow : 01Jan2020, 05:45
Total Inflow : 4.62 (IN)	Peak Storage : 63.1 (AC-FT)
Total Outflow : 3.61 (IN)	Peak Elevation : 90.9 (FT)

Malcom's Hydrograph	
Time (min)	Developed Discharge (cfs)
0	0
15	6.5
30	25.3
45	55.0
60	93.0
75	136.2
90	181.1
105	223.8
120	260.8
135	289.1
150	306.3
165	311.0
180	302.8
195	282.3
210	252.7
225	224.2
240	198.9
255	176.5
270	156.6
285	138.9
300	123.3
315	109.4
330	97.0
345	86.1
360	76.4
375	67.7
390	60.1



Hawthorn Park Landfill Drainage and Detention Analysis
Table 15 - Extreme Event Weir Calculation

Emergency Overflow Weir Broad Crested Weir Calculation		
100-Year Discharge: 262.2 cfs		
$Q = C * L * H^{(3/2)}$		
H	1	ft
C	2.65	
L	100	ft
Q	265.0	cfs