130 ENVIRONMENTAL PARK

ATTACHMENT C1

APPENDIX C1-C

POSTDEVELOPMENT HYDROLOGIC CALCULATIONS

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

Includes pages C1-C-1 through C1-C-38

Technically Complete October 28, 2014

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11-6-14

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POSTDEVELOPMENT NARRATIVE

30 TAC §§330.303 and 330.305(a)-(d)

The postdevelopment hydrologic analysis represents the hydrologic calculations after the proposed landfill is developed in accordance with §330.305(a)-(d).

POSTDEVELOPMENT DRAINAGE AREA DRAWINGS

The postdevelopment drainage area drawings depict 130 Environmental Park facility development and the offsite drainage areas. These drawings depict the drainage areas for the facility development including the entrance facilities, storage and processing facilities, and the landfill development. Further, the postdevelopment runoff summary provides peak discharge, volume, and velocity for the 25- and 100-year rainfall events at each comparison point along the facility and property boundary. Offsite drainage areas are designated by the prefix "OS". Drainage areas within the facility boundary that are affected by site development are designated by the prefix "P" or "Pond 1A".

Refer to Drawing C1-C-1; page C1-C-5, for the postdevelopment offsite drainage areas, and Drawing C1-C-2; page C1-C-6, for the postdevelopment areas within the facility boundary. Refer to Drawing C1-C-3; page C1-C-7, for the postdevelopment condition runoff summary.

WATERSHED CHARACTERISTICS

Watershed characteristics have been developed for the postdevelopment hydrologic evaluation. The watershed characteristics address drainage area runoff characteristics, unit hydrograph data, reach characteristics, and the proposed final condition drainage system including the detention ponds. This information is included on pages C1-C-8 through C1-C-11.

The first table, Postdevelopment Watershed Characteristics – page C1-C-9, provides the summary of drainage areas, soil types, Curve Number (CN) values, initial loss, reach slope calculations, and determination of Manning's "n" values. The Soil Conservation Service (SCS) CN were derived from watershed characteristic tables from the Urban Hydrology for Small Watersheds, Technical Report 55 (TR-55), which included evaluation of anticipated postdevelopment soil and surface cover/condition characteristics. The runoff characteristics for the offsite drainage areas did not change from the existing condition.

POSTDEVELOPMENT SURFACE WATER IMPOUNDMENTS DESIGN PARAMETERS

Pages C1-C-12 through C1-C-21 include pond and outlet structure data for the surface water impoundments incorporated in the hydrologic model.

HEC-HMS SCHEMATIC

The schematic for the HEC-HMS model is included on Drawing C1-C-4; page C1-C-23. The schematic provides the hydrologic element number and routing used for evaluating the postdevelopment condition in HEC-HMS.

HYDROLOGIC ANALYSIS

For the hydrologic evaluation, HEC-HMS was used for the precipitation runoff simulation for the postdevelopment condition. The following describes the various modeling components. The HEC-HMS hydrologic analysis results begin on page C1-C-24.

Watershed Subareas and Schematization

The landfill area that contributes flow to the detention ponds was delineated into sub-basins to derive peak discharge and hydrographs. Hydrographs developed for each sub-basin are appropriately combined and routed through the swales and perimeter channels. The sub-basins are shown on Drawing C1-C-2 – Post-developed Facility Boundary Areas, and page C1-C-6 for the HEC-HMS schematic of the postdevelopment condition.

Time Step

The time step, or the program computation interval, selected for the analysis is 1 minute, which results in 1441 hydrograph ordinates in 24 hours.

Hypothetical Precipitation

The rainfall depth, duration, and frequency relationships for the storm event for the facility were taken from the United States Geological Society (USGS) Atlas of Depth-Duration-Frequency of Precipitation Annual Maxima for Texas (USGS 2004) and U.S. Weather Bureau, Technical Paper 49 (TP-49). Return periods of 25, and 100 years and duration of 24 hours are used for the design storm. The rainfall distribution is the SCS 24-hour Type III storm. The precipitation is assumed to be evenly distributed over the entire basin for each time interval. Refer to page C1-B-14 for the rainfall data input.

Precipitation Losses

Precipitation losses (precipitation that does not contribute to the runoff) are calculated using the Soil Conservation Service (SCS) Curve Number (CN) method. CN is a function of soil cover, land use, and antecedent moisture conditions. The CN values used for each drainage area are shown in the Watershed Characteristics table on page C1-C-9.

Synthetic Unit Hydrographs and Flow Routing

The rainfall/runoff transformation was performed with the Unit Hydrograph Method. The synthetic unit hydrographs for each watershed used a single peak unit hydrograph model developed by the SCS and described in detail in Urban Hydrology for Small

Watersheds, (TR-55). The parameters and input values for this model are included in the Watershed Characteristics tables on pages C1-C-10 and C1-C-11.

The Kinematic Wave Method was used for routing of the flood wave through the existing and proposed drainage channels. This method is capable of accounting for hydrograph attenuation based on physical channel properties such as length, bottom slope, channel shape, bottom width, and channel roughness.

POSTDEVELOPMENT FLOW SUMMARY

The postdevelopment flow summary table on page C1-C-32 lists the peak flow rate and volume of runoff for each drainage area for the 25- and 100-year rainfall event. This table summarizes the results of the postdevelopment hydrologic evaluation.

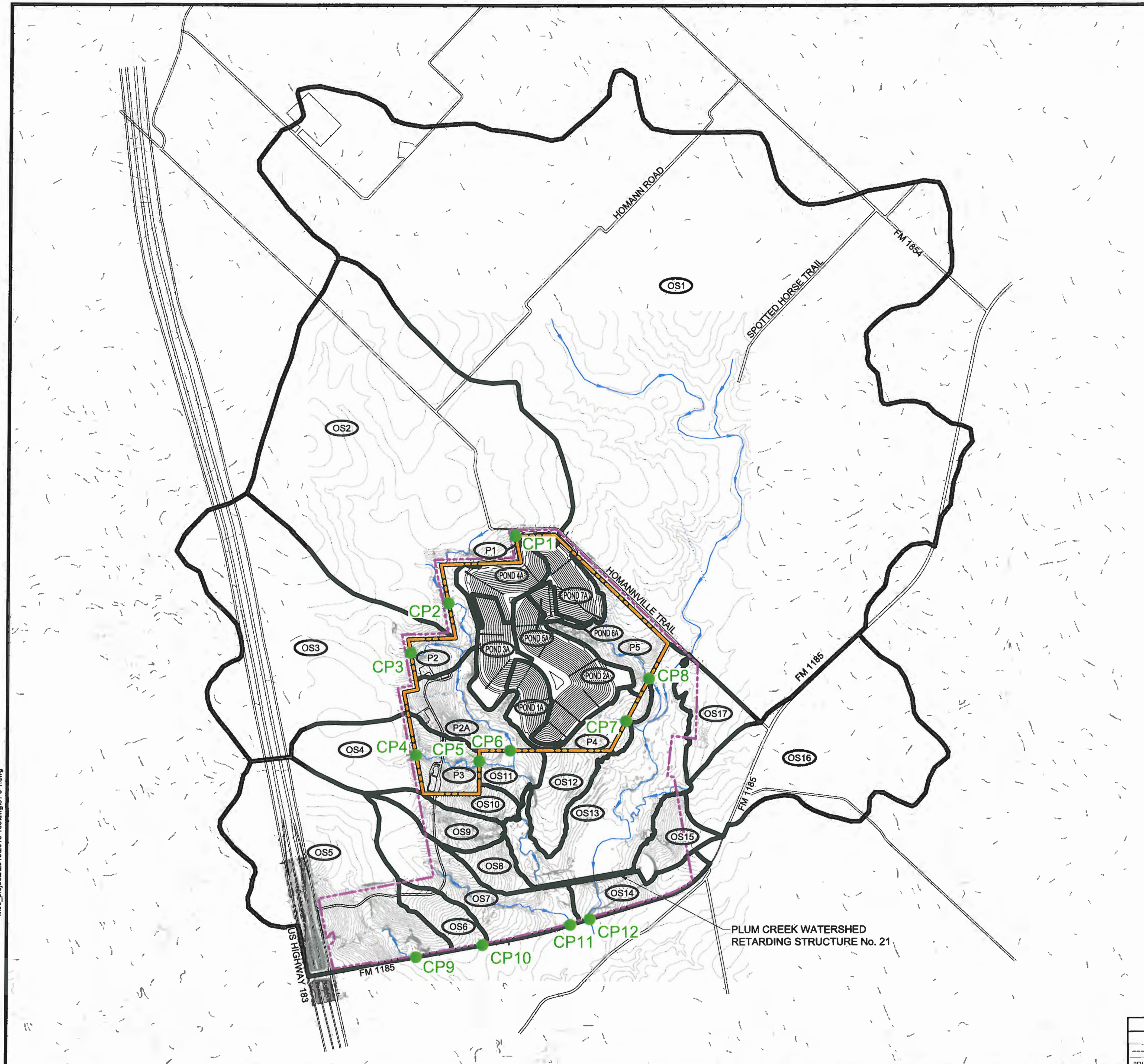
POSTDEVELOPMENT VELOCITY SUMMARY

Surface water velocities were determined for each discharge point where the surface water enters or exits the facility boundary. The 25- and 100-year, 24-hour peak flow rates were analyzed to determine the velocity at the facility boundary. Manning's Equation was used to evaluate the velocities. Refer to Drawing C1-C-3 for location of discharge points and peak flow rates. Refer to the postdevelopment velocity summary beginning on page C1-C-33 for postdevelopment velocity calculations.

POSTDEVELOPMENT DRAINAGE ANALYSIS SUMMARY

The analysis summary for the postdevelopment condition is provided on page C1-C-38. The table provides for each comparison point (CP01 through CP12) the peak flow rate, velocity, and volume resulting from the HEC-HMS evaluation for the 25- and 100-year, 24 hour rainfall.

POSTDEVELOPMENT DRAINAGE AREA DRAWINGS



0 1200 2400

SCALE IN FEET

LEGEND

	PROPERTY BOUNDARY
	FACILITY BOUNDARY
	EXISTING CONTOUR
N 13,900,000	STATE PLANE GRID
	DRAINAGE AREA BOUNDARY
	PRIMARY REACH
	SECONDARY REACH
A1	DRAINAGE AREA DESIGNATION
CP1	COMPARISON POINT
	FLOW DIRECTION

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.

2. ROADWAYS IN THE IMMEDIATE VICINITY OF THE SITE TAKEN FROM TNRIS AERIAL PHOTOGRAPHY FLOWN JUNE 11, 2012. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).

3. CONTOURS AND ELEVATIONS OUTSIDE THE PROPERTY BOUNDARY PROVIDED BY CAPCOG. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).

11-6-14

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
---	10/28/14	TECHNICALLY COMPLETE	MNG	TLT	TLT	TLT

POSTDEVELOPED OFFSITE DRAINAGE AREAS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

DSN. TLT	DATE : 2/14	DRAWING
DWN. MNG	SCALE : GRAPHIC	C1-C-5
CHK. TLT	DWG : C1-C-1.DWG	

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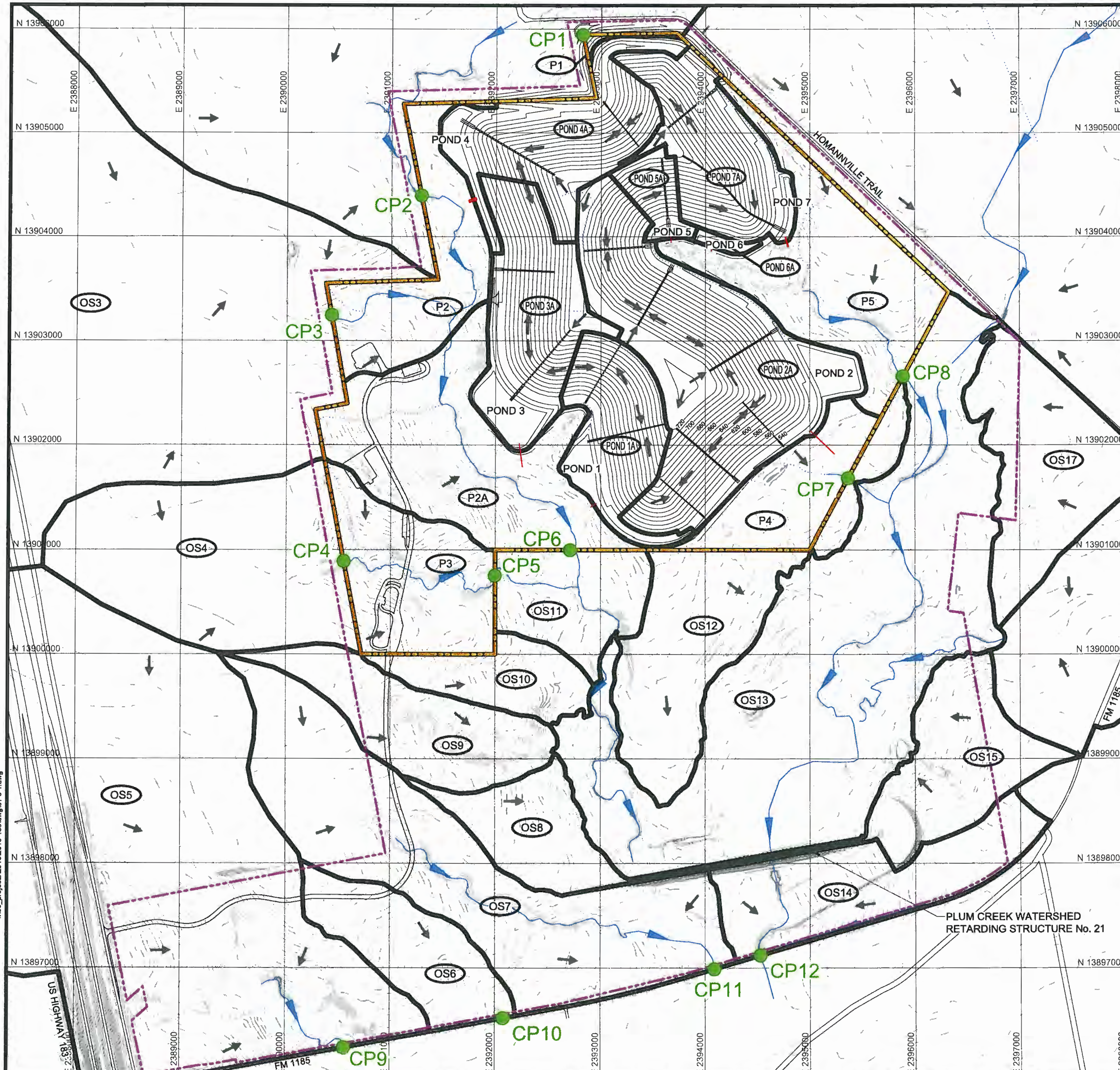

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- EXISTING CONTOUR
- N 13,900,000 — STATE PLANE GRID
- DRAINAGE AREA BOUNDARY
- PRIMARY REACH
- SECONDARY REACH
- A1 — DRAINAGE AREA DESIGNATION
- CP1 — COMPARISON POINT
- FLOW DIRECTION
- POND OUTLETS

0 500 1000
SCALE IN FEET

Postdeveloped Drainage Boundary Areas					
Drainage Area	Area (Ac.)	25-Year Peak Discharge (cfs)	25-Year Volume (ac-ft.)	100-Year Peak Discharge (cfs)	100-Year Volume (ac-ft.)
OS1	2882.56	3725.1	1283.8	5467.9	1898.7
OS2	820.48	1203.4	357.5	1775.3	531.5
OS3	443.52	706.2	201.8	1028.7	296.9
OS4	91.52	170	39	252	58.3
OS5	337.28	795.7	156.7	1149.3	229.4
OS6	34.56	117.5	15.4	171.4	22.8
OS7	122.88	293.6	53.5	431.5	79.6
OS8	28.80	100.5	12.6	147.4	18.7
OS9	42.88	116.1	18.7	170.5	27.8
OS10	23.68	90.7	10.5	132.2	15.6
OS11	30.72	94.4	13.4	138.5	19.9
OS12	64.64	150.1	28.2	220.6	41.9
OS13	208.00	1424.9	129.3	1926.7	176.1
OS14	49.92	121.7	22.2	177.7	32.9
OS15	44.80	95.9	19.5	141	29
OS16	333.44	626.6	142.1	928.4	212.4
OS17	56.96	150.5	23.7	223.8	35.7
P1	1.28	8	0.7	11.2	0.9
P2	41.60	160.6	18.1	235.4	27
P2A	75.52	282	33.6	411.1	49.7
P3	44.80	89.5	20.4	130.1	30
P4	28.80	135.1	12.3	199	18.3
P5	62.08	173.9	27.1	255.4	40.2
POND 1A	32.00	205.6	17	285.1	24.1
POND 2A	94.72	523.6	49.5	730.4	70.5
POND 3A	44.16	280.5	23.5	389.3	33.3
POND 4A	45.44	285.3	23.8	397.6	33.8
POND 5A	8.96	56.9	4.7	79.2	6.7
POND 6A	1.92	13	1.1	17.7	1.6
POND 7A	39.04	237.8	20.4	331.5	29

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.

2. ROADWAYS IN THE IMMEDIATE VICINITY OF THE SITE TAKEN FROM TNRIS AERIAL PHOTOGRAPHY FLOWN JUNE 11, 2012. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).

3. CONTOURS AND ELEVATIONS OUTSIDE THE PROPERTY BOUNDARY PROVIDED BY CAPCOG. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

POSTDEVELOPED PERMIT BOUNDARY AREAS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

DSN. TLT	DATE : 2/14	DRAWING
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CHK. TLT	DWG : C1-C-1.DWG	

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- EXISTING CONTOUR
- N 13,900,000 — STATE PLANE GRID
- DRAINAGE AREA BOUNDARY
- PRIMARY REACH
- SECONDARY REACH
- (A1) DRAINAGE AREA DESIGNATION
- ● CP1 COMPARISON POINT
- FLOW DIRECTION
- POND OUTLETS

0 500 1000
SCALE IN FEET

Postdeveloped Runoff Summary					
Comparison Point	25-Year Peak Discharge (cfs)	25-Year Volume (ac-ft.)	100-Year Peak Discharge (cfs)	100-Year Volume (ac-ft.)	Type of Flow
CP1	8	0.7	11.2	0.9	Runoff
CP2	1205.3	358.2	1777.7	532.4	Runon
CP3	706.2	201.8	1028.7	296.9	Runon
CP4	170	39	252	58.3	Runon
CP5	257.5	59.4	379.6	88.3	Runoff
CP6	2033.6	676	2976.1	997.2	Runoff
CP7	141.8	61.8	206.8	88.8	Runoff
CP8	327.2	53.3	454.7	77.5	Runoff
CP9	795.7	156.7	1149.3	229.4	Runoff
CP10	117.5	15.4	171.4	22.8	Runoff
CP11	293.6	53.5	431.5	79.6	Runoff
CP12	231	2554.5	904.4	3760.5	Runoff

NOTES:

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POSTDEVELOPED RUNOFF SUMMARY

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TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

DSN. TLT	DATE : 2/14	DRAWING
DWN. MNG	SCALE : GRAPHIC	C1-C-7
CHK. TLT	DWG : C1-C-1.DWG	

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WATERSHED CHARACTERISTICS

130 Environmental Park

Watershed Runoff Curve Numbers

Post-Developed Watershed Characteristics

				Partial Areas of Cover Type and Soil Group (ac)										
Watershed Name	**Watershed Area (ac)**	**Watershed Area q(Mi.²)**	**CN (Weighted)**	**Brush (fair), Soil Group D, CN = 77**	**Pasture (good), Soil Group D, CN = 80**	**Pasture (fair), Soil Group D, CN = 84**	**Paved (w/ROW), Soil Group D, CN = 93**	**Residential (1 ac), Soil Group D, CN = 84**	**Woods (fair), Soil Group D, CN = 79**	**Water, CN = 98**	**Landfill Top Deck, CN = 84**	**Landfill Side Slope, CN = 87**	**Gravel Perimeter Road, CN = 95**	**Paved/Impervious, CN = 98**
OS1	2882.43	**4.504**	**80**	665.40	1613.46		57.53	70.87	455.85	19.32				
OS2	820.33	**1.282**	**79**	244.96	545.10	1.22	11.02		13.92	4.11				
OS3	443.55	**0.693**	**81**	170.58	105.08	2.73	91.85		73.33					
OS4	91.50	**0.143**	**78**	82.26		2.35	0.32		3.91	2.66				
OS5	337.37	**0.527**	**82**	192.63		27.23	80.79		32.11	2.62				1.99
OS6	34.67	**0.054**	**80**	4.23		2.23	1.57		25.84					0.81
OS7	122.85	**0.192**	**79**	29.85	5.77	8.04	3.33		74.69					1.17
OS8	28.88	**0.045**	**79**	0.62	1.72	0.38			26.16					
OS9	42.91	**0.067**	**79**	13.81		2.38			25.65	0.27				0.81
OS10	23.37	**0.037**	**80**	0.51		4.70			17.92					0.25
OS11	30.74	**0.048**	**79**			2.70			28.04					
OS12	64.36	**0.101**	**79**	20.74		3.66			39.96					
OS13	208.13	**0.325**	**98**							208.13				
OS14	49.92	**0.078**	**80**		42.13		2.31		5.48					
OS15	44.52	**0.070**	**79**	17.66	14.61				12.24					
OS16	333.38	**0.521**	**78**	190.38	11.95		3.91		122.98	4.17				
OS17	56.96	**0.089**	**77**	51.45	4.86		0.43		0.21					
P1	1.07	**0.002**	**87**									1.07		
P2	41.60	**0.065**	**79**	23.28	0.01	3.91			11.07			1.61		1.72
P2A	75.31	**0.118**	**80**	5.74		3.65			58.60			3.11		4.21
P3	44.58	**0.070**	**81**	0.30		2.68			38.30					3.30
P4	28.55	**0.045**	**78**	23.62		0.93			1.78			2.23		
P5	61.93	**0.097**	**79**	27.80					29.23			4.79	0.11	
POND 1A	31.99	**0.050**	**89**							3.59		26.45	1.95	
POND 2A	94.70	**0.148**	**88**							7.74	13.37	69.76	3.83	
POND 3A	44.35	**0.069**	**89**							6.09	3.49	33.06	1.61	0.11
POND 4A	45.72	**0.071**	**88**							2.23	3.30	36.68	3.51	
POND 5A	8.86	**0.014**	**88**							0.97	0.83	6.50	0.56	
POND 6A	1.74	**0.003**	**95**							0.91		0.24	0.59	
POND 7A	39.28	**0.061**	**88**							1.18	1.69	34.50	1.90	

130 Environmental Park

SCS Unit Hydrograph Lag Time

Postdeveloped Watershed Characteristics

Watershed Name	Sheet Flow					Shallow Conc. Flow				Channel Flow			Total Time of Conc. (hr)	Total Lag Time (min)
	Manning's Roughness	Water Course Length (ft)	Precipitation 2yr Total (in.)	Water Course Slope (ft/ft)	Time (hr)	Water Course Length (ft)	Roughness Coefficient	Water Course Slope (ft/ft)	Time (hr)	Avg. Bank Full Velocity (fps)	Water Course Length (ft)	Time (hr)		
OS1	0.24	240	3.60	0.03	0.38	8,945	16.13	0.01	1.62	4.08	13,252	0.90	2.91	105
OS2	0.24	250	3.60	0.03	0.40	8,589	16.13	0.01	1.78	2.00	1,207	0.17	2.35	85
OS3	0.24	275	3.60	0.01	0.88	6,501	16.13	0.01	1.34	0.00	0	0.00	2.22	80
OS4	0.40	280	3.60	0.01	1.17	2,882	16.13	0.01	0.45	0.00	0	0.00	1.62	58
OS5	0.24	250	3.60	0.03	0.41	5,240	16.13	0.01	0.76	4.60	1,278	0.08	1.25	45
OS6	0.13	275	3.60	0.02	0.35	2,276	16.13	0.03	0.25	0.00	0	0.00	0.59	21
OS7	0.13	260	3.60	0.00	0.53	2,758	16.13	0.02	0.36	4.82	3,654	0.21	1.10	40
OS8	0.13	280	3.60	0.01	0.36	1,732	16.13	0.03	0.18	0.00	0	0.00	0.54	19
OS9	0.13	260	3.60	0.01	0.51	3,384	16.13	0.03	0.37	0.00	0	0.00	0.88	32
OS10	0.13	250	3.60	0.03	0.25	2,029	16.13	0.03	0.20	0.00	0	0.00	0.45	16
OS11	0.40	250	3.60	0.03	0.58	967	16.13	0.03	0.11	0.00	0		0.69	25
OS12	0.40	270	3.60	0.01	1.03	1,078	16.13	0.02	0.13	0.00	0	0.00	1.15	42
OS13	0.00	0	3.60	0.00	N/A	0	0.00	0.00	N/A	0.00	0	N/A	0.10	3.6
OS14	0.24	280	3.60	0.01	0.78	1,162	16.13	0.01	0.17	2.72	1,687	0.17	1.12	40
OS15	0.40	280	3.60	0.01	1.17	1,452	16.13	0.02	0.17	0.00	0	0.00	1.34	48
OS16	0.13	270	3.60	0.01	0.40	6,467	16.13	0.01	1.17	0.00	0	0.00	1.57	57
OS17	0.24	250	3.60	0.01	0.71	1,373	16.13	0.03	0.14	0.00	0	0.00	0.85	31
P1	0.07	158	3.60	0.30	0.04	0	16.13	0.00	0.00	0.00	0	0.00	0.04	1
P2	0.13	210	3.60	0.03	0.20	1,462	16.13	0.01	0.22	0.00	0	0.00	0.43	15
P2A	0.13	196	3.60	0.03	0.20	1,072	16.13	0.05	0.09	3.43	2,146	0.17	0.46	17
P3	0.60	250	3.60	0.01	1.29	2,400	16.13	0.02	0.28	0.00	0	0.00	1.57	57
P4	0.07	170	3.60	0.06	0.08	903	16.13	0.01	0.14	0.00	0	0.00	0.22	8
P5	0.25	275	3.60	0.02	0.55	1,377	16.13	0.02	0.16	1.83	790	0.12	0.83	30

130 Environmental Park

SCS Unit Hydrograph Lag Time

Postdeveloped Watershed Characteristics

Watershed Name	Sheet Flow					Swale Flow			Chute Flow			Channel Flow			Total Time of Conc. (hr)	Total Lag Time (min)
	Manning's Roughness	Water Course Length (ft)	Precipitation 2yr Total (in.)	Water Course Slope (ft/ft)	Time (hr)	Avg. Velocity (fps)	Water Course Length (ft)	Time (hr)	Avg. Velocity (fps)	Water Course Length (ft)	Time (hr)	Avg. Velocity (fps)	Water Course Length (ft)	Time (hr)		
Pond 1A	0.07	35	3.60	0.25	0.01	2.80	608	0.06	14.00	636	0.01	10.00	340	0.01	0.10	3.6
Pond 2A	0.07	184	3.60	0.09	0.08	2.60	515	0.06	14.00	660	0.01	9.00	1620	0.04	0.21	8
Pond 3A	0.07	179	3.60	0.08	0.08	2.80	187	0.02	14.00	810	0.02	0.00	0	0.00	0.11	4
Pond 4A	0.07	193	3.60	0.08	0.08	2.80	223	0.02	14.00	1000	0.02	0.00	0	0.00	0.12	4
Pond 5A	0.07	122	3.60	0.09	0.05	2.80	40	0.00	14.00	648	0.01	0.00	0	0.00	0.07	3.6
Pond 6A	0.07	86	3.60	0.18	0.03	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.03	3.6
Pond 7A	0.07	140	3.60	0.08	0.06	2.80	218	0.02	14.00	610	0.01	7.00	1113	0.04	0.14	5

130 Environmental Park

Kinematic Wave Routing Parameters

Proposed Watershed Characteristics

Reach Name	Water Course Length (ft)	Water Course Slope (ft/ft)	Manning's Roughness	Shape	Bottom Width (ft)	Side Slope (xH:1V)
Dry Creek	1000	0.002	0.065	Trapezoid	12.00	6
Reach-1	2496	0.006	0.065	Trapezoid	10.00	4
Reach-1A	1015	0.004	0.065	Trapezoid	6.00	8
Reach-2	1437	0.008	0.065	Trapezoid	13.00	25
Reach-3	1723	0.003	0.065	Trapezoid	8.00	3
Reach-4	3090	0.004	0.065	Trapezoid	6.00	3
Reach-5	368	0.005	0.065	Trapezoid	7.00	10
Reach-6	971	0.013	0.065	Triangle	N/A	30
Reach-7	1977	0.016	0.065	Trapezoid	7.00	10
Reach-8	686	0.009	0.065	Trapezoid	12.00	10
Reach-9	1486	0.009	0.065	Trapezoid	5.00	6
Reach-10	1445	0.016	0.065	Trapezoid	4.00	4
Reach-11	500	0.013	0.065	Trapezoid	4.00	10
Reach-CP7	100	0.010	0.065	Trapezoid	5.00	5
Reach-CP8	100	0.010	0.065	Trapezoid	5.00	5

POSTDEVELOPMENT SURFACE WATER IMPOUNDMENTS DESIGN PARAMETERS

130 Environmental Park
Pond Data for HEC-HMS
Pond 1

Reservoir	
Description:	
Downstream:	CP8
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 1 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	--None--
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	1	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	65	ft
Diameter:	2.5	ft
Inlet Elevation:	535	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	534	ft
Exit Coefficient:	1	
Manning's n:	0.013	

Spillway	
Method:	Broad-Crested Spillway
Direction:	Main
Elevation:	539 ft
Length:	10 ft
Coefficient:	2.62
Gates:	0

Paired Data
Elevation Storage Functions
Inflow=Outflow

Elevation (ft)	Area (ac)	Volume (ac-ft)
535	2.16	0.00
536	2.37	2.26
537	2.64	4.77
538	2.90	7.54
539	3.25	10.62
540	3.59	14.04
541	3.94	17.80

130 Environmental Park
Pond Data for HEC-HMS
Pond 2

Reservoir	
Description:	
Downstream:	CP7
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 2 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	CP8
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	1	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	320	ft
Diameter:	1.25	ft
Inlet Elevation:	520	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	519	ft
Exit Coefficient:	1	
Manning's n:	0.013	

Spillway	
Method:	Broad-Crested Spillway
Direction:	Auxillary
Elevation:	530 ft
Length:	70 ft
Coefficient:	2.62
Gates:	0

Paired Data
Elevation Storage Functions
Outflow Structures

Elevation (ft)	Area (ac)	Volume (ac-ft)
520	4.08	0.00
521	4.32	4.20
522	4.55	8.64
523	4.80	13.31
524	5.05	18.24
525	5.30	23.41
526	5.55	28.84
527	5.87	34.55
528	6.18	40.57
529	6.55	46.94
530	6.92	53.68
531	7.33	60.80
532	7.74	68.34

130 Environmental Park
Pond Data for HEC-HMS
Pond 3

Reservoir	
Description:	
Downstream:	CP6
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 3 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	--None--
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Spillway	
Method:	Broad-Crested Spillway
Direction:	Main
Elevation:	543 ft
Length:	10 ft
Coefficient:	2.62
Gates:	0

Paired Data
Elevation Storage Functions
Elevation-Area

Elevation (ft)	Area (ac)	Volume (ac-ft)
533	3.98	0.00
534	4.15	4.07
536	4.51	12.72
538	4.88	22.11
540	5.26	32.25
542	5.66	43.17
544	6.07	54.90
545	6.28	61.07

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	1	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	225	ft
Diameter:	1	ft
Inlet Elevation:	533	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	532	ft
Exit Coefficient:	1	
Manning's n:	0.013	

130 Environmental Park
Pond Data for HEC-HMS
Pond 4

Reservoir	
Description:	
Downstream:	J-2
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 4 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	--None--
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Spillway	
Method:	Broad-Crested Spillway
Direction:	Main
Elevation:	549 ft
Length:	30 ft
Coefficient:	2.62
Gates:	0

Paired Data
Elevation Storage Functions
Inflow=Outflow

Elevation (ft)	Area (ac)	Volume (ac-ft)
545.75	1.78	0.00
546	1.99	0.47
548	2.55	5.01
550	3.13	10.70
551	3.43	13.98

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	4	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	75	ft
Diameter:	3	ft
Inlet Elevation:	545.75	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	545	ft
Exit Coefficient:	1	
Manning's n:	0.013	

130 Environmental Park
Pond Data for HEC-HMS
Pond 5

Reservoir	
Description:	
Downstream:	J-4
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 5 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	Pond 6
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	1	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	75	ft
Diameter:	1	ft
Inlet Elevation:	560	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	559	ft
Exit Coefficient:	1	
Manning's n:	0.013	

Spillway	
Method:	Broad-Crested Spillway
Direction:	Auxillary
Elevation:	565 ft
Length:	5 ft
Coefficient:	2.62
Gates:	0

Paired Data
Elevation Storage Functions
Pond 5 Elev Area

Elevation (ft)	Area (ac)	Volume (ac-ft)
560	0.32	0.00
561	0.39	0.36
562	0.46	0.78
563	0.53	1.28
564	0.61	1.85
565	0.69	2.50
566	0.77	3.23
567	0.87	4.05
568	0.97	4.97

130 Environmental Park
Pond Data for HEC-HMS
Pond 6

Reservoir	
Description:	
Downstream:	J-4
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 6 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	--None--
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Spillway	
Method:	Broad-Crested Spillway
Direction:	Main
Elevation:	556.25 ft
Length:	10 ft
Coefficient:	2.62
Gates:	0

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	1	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	70	ft
Diameter:	1	ft
Inlet Elevation:	554	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	553	ft
Exit Coefficient:	1	
Manning's n:	0.013	

Paired Data
Elevation Storage Functions
Pond 6 Elev Area

Elevation (ft)	Area (ac)	Volume (ac-ft)
554	0.32	0.00
555	0.41	0.37
556	0.51	0.83
557	0.61	1.39
558	0.72	2.05
559	0.81	2.82
560	0.91	3.68

130 Environmental Park
Pond Data for HEC-HMS
Pond 7

Reservoir	
Description:	
Downstream:	Reach-11
Method:	Outflow Structures
Storage Method:	Elevation-Area
Elev-Area Function:	Pond 7 Elev Area
Initial Condition:	Inflow=Outflow
Main Tailwater:	Assume None
Auxillary:	--None--
Time Step Method:	Automatic Adaption
Outlets:	1
Spillways:	1
Dam Tops:	0
Pumps:	0
Dam Break:	No
Dam Seepage:	No
Release:	No
Evaporation:	No

Spillway	
Method:	Broad-Crested Spillway
Direction:	Main
Elevation:	540 ft
Length:	15 ft
Coefficient:	2.62
Gates:	0

Outlet		
Method:	Culvert Outlet	
Direction:	Main	
Number Barrels:	3	
Solution Method:	Automatic	
Shape:	Circular	
Chart:	Concrete Pipe Culvert	
Scale:	Groove end entrance, pipe projecting from fill	
Length:	100	ft
Diameter:	2.5	ft
Inlet Elevation:	534	ft
Entrance Coefficient:	0.5	
Outlet Elevation:	533	ft
Exit Coefficient:	1	
Manning's n:	0.013	

Paired Data
Elevation Storage Functions
Pond 7 Elev Area

Elevation (ft)	Area (ac)	Volume (ac-ft)
534	0.14	0.00
536	0.38	0.52
537	0.50	0.96
538	0.62	1.52
539	0.77	2.22
540	0.92	3.06
541	1.05	4.05
542	1.18	5.16

130 Environmental Park
Pond Data for HEC-HMS
Site 21

Reservoir

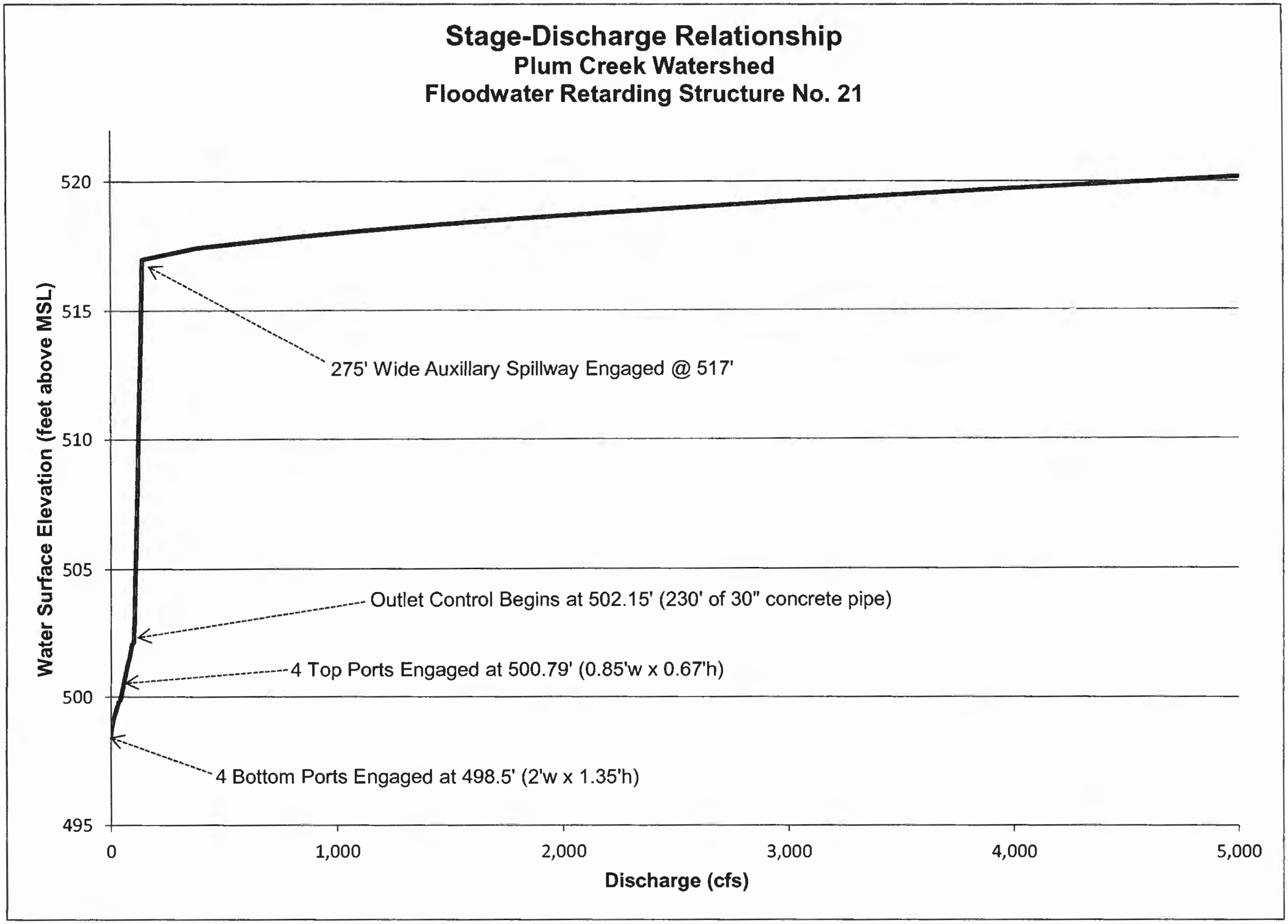
Description:	
Downstream:	CP12
Method:	Outflow Structures
Storage Method:	Elevation-Area-Discharge
Elev-Area Function:	Site 21 Elev Area
Elev-Dis Function	Site 21 Elev-Discharge
Primary:	Elevation-Discharge
Initial Condition:	Elevation
Initial Elevation:	498.5 ft

Paired Data
Elevation Storage Functions
Site 21 Elev Area

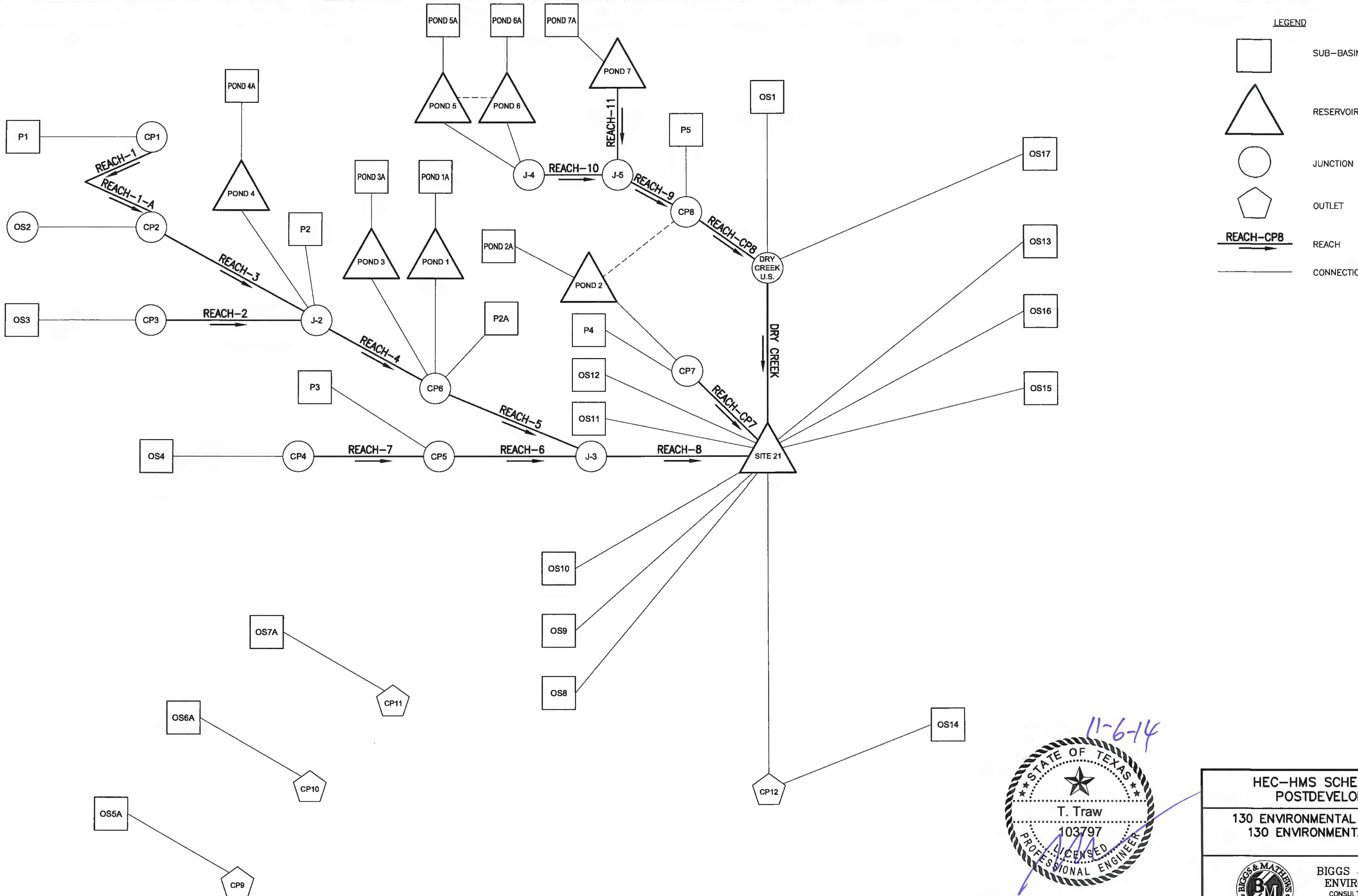
Elevation (ft)	Area (ac-ft)	Volume (ac-ft)
498.10	22.00	0.00
502	54.75	149.66
504	81.00	285.41
506	113.05	479.45
508	141.47	733.97
510	173.17	1048.60
512	204.87	1426.65
514	256.45	1887.97
516	296.24	2440.66
518	343.69	3080.59
520	411.10	3835.38
522	455.40	4701.88

Paired Data
Elevation Discharge Functions
Site 21 Elev-Discharge

Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
498.50	0.02	500.20	48.50	501.90	88.33	516.32	137.50
498.60	0.83	500.30	50.78	502.00	90.35	516.98	139.00
498.70	2.18	500.40	52.97	502.10	92.31	517.43	382.71
498.80	3.91	500.50	55.08	502.15	100.00	517.87	839.48
498.90	5.94	500.60	57.10	502.96	102.50	518.10	1134.54
499.00	8.25	500.70	59.06	503.78	105.00	518.32	1447.38
499.10	10.79	500.80	60.96	504.62	107.50	518.56	1819.62
499.20	13.54	500.90	63.11	505.49	110.00	518.78	2187.12
499.30	16.50	501.00	65.43	506.37	112.50	519.23	3010.38
499.40	19.65	501.10	67.84	507.28	115.00	519.70	3963.76
499.50	22.98	501.20	70.33	508.20	117.50	520.16	4981.12
499.60	26.48	501.30	72.88	509.16	120.00	520.63	6100.01
499.70	30.13	501.40	75.49	510.12	122.50	520.86	6675.17
499.80	33.95	501.46	77.08	511.10	125.00	521.10	7293.83
499.84	39.16	501.50	79.45	512.10	127.50	521.57	8558.14
499.90	40.87	501.60	81.82	513.13	130.00	522.04	9889.19
500.00	43.56	501.70	84.07	514.17	132.50		
500.10	46.09	501.80	86.24	515.24	135.00		


Stage-Discharge Relationship
Plum Creek Watershed
Floodwater Retarding Structure No. 21
Water Surface Elevation (feet above MSL)
Discharge (cfs)
495
500
505
510
515
520
0
1,000
2,000
3,000
4,000
5,000
275' Wide Auxillary Spillway Engaged @ 517'
Outlet Control Begins at 502.15' (230' of 30" concrete pipe)
4 Top Ports Engaged at 500.79' (0.85'w x 0.67'h)
4 Bottom Ports Engaged at 498.5' (2'w x 1.35'h)

HEC-HMS SCHEMATIC



11-6-14

STATE OF TEXAS
T. TRAW
103797
LICENSED
PROFESSIONAL ENGINEER

ISSUED FOR PERMITTING PURPOSES ONLY

HEC-HMS SCHEMATICS POSTDEVELOPED

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

REVISIONS						
---	10/28/14	TECHNICALLY COMPLETE	MNG	TLT	TLT	TLT
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

DSN. TLT	DATE : 2/14	DRAWING
DWN. MNG	SCALE : GRAPHIC	C1-C-23
CHK. TLT	DWG : C1-C-1.DWG	

HYDROLOGIC ANALYSIS

25-YEAR, 24-HOUR STORM EVENT
100-YEAR, 24-HOUR STORM EVENT

Project: 130 Environmental Park Simulation Run: Post 25yr 24hr SCS

Start of Run: 01Jan2014, 00:00
End of Run: 04Jan2014, 00:00
Compute Time: 11Jun2014, 10:42:57

Basin Model: Post Developed
Meteorologic Model: 25 yr 24hr (SCS)
Control Specifications: 72 hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
CP1	0.002	8.0	01Jan2014, 12:05	0.7
CP10	0.054	117.5	01Jan2014, 12:23	15.4
CP11	0.192	293.6	01Jan2014, 12:44	53.5
CP12	8.816	231.0	01Jan2014, 12:45	696.1
CP2	1.284	1205.3	01Jan2014, 13:31	358.2
CP3	0.693	706.2	01Jan2014, 13:26	201.8
CP4	0.143	170.0	01Jan2014, 13:03	39.0
CP5	0.213	257.5	01Jan2014, 13:08	59.4
CP6	2.350	2033.6	01Jan2014, 13:41	670.9
CP7	0.193	141.8	01Jan2014, 12:10	50.6
CP8	0.175	327.2	01Jan2014, 12:30	53.3
CP9	0.527	795.7	01Jan2014, 12:49	156.7
Dry Creek	4.768	3817.6	01Jan2014, 13:55	1360.8
Dry Creek U.S.	4.768	3817.8	01Jan2014, 13:52	1360.8
J-2	2.113	1966.6	01Jan2014, 13:34	601.8
J-3	2.563	2240.7	01Jan2014, 13:38	730.3
J-4	0.017	10.0	01Jan2014, 12:32	5.8
J-5	0.078	160.3	01Jan2014, 12:17	26.2
OS1	4.504	3725.1	01Jan2014, 13:53	1283.8
OS10	0.037	90.7	01Jan2014, 12:18	10.5
OS11	0.048	94.4	01Jan2014, 12:28	13.4
OS12	0.101	150.1	01Jan2014, 12:46	28.2
OS13	0.325	1424.9	01Jan2014, 12:05	129.3
OS14	0.078	121.7	01Jan2014, 12:44	22.2
OS15	0.070	95.9	01Jan2014, 12:52	19.5
OS16	0.521	626.6	01Jan2014, 13:02	142.1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
OS17	0.089	150.5	01Jan2014, 12:35	23.7
OS2	1.282	1203.4	01Jan2014, 13:31	357.5
OS3	0.693	706.2	01Jan2014, 13:26	201.8
OS4	0.143	170.0	01Jan2014, 13:03	39.0
OS5	0.527	795.7	01Jan2014, 12:49	156.7
OS6	0.054	117.5	01Jan2014, 12:23	15.4
OS7	0.192	293.6	01Jan2014, 12:44	53.5
OS8	0.045	100.5	01Jan2014, 12:21	12.6
OS9	0.067	116.1	01Jan2014, 12:35	18.7
P1	0.002	8.0	01Jan2014, 12:05	0.7
P2	0.065	160.6	01Jan2014, 12:17	18.1
P2A	0.118	282.0	01Jan2014, 12:19	33.6
P3	0.070	89.5	01Jan2014, 13:01	20.4
P4	0.045	135.1	01Jan2014, 12:10	12.3
P5	0.097	173.9	01Jan2014, 12:33	27.1
Pond 1	0.050	32.8	01Jan2014, 12:35	16.8
Pond 1A	0.050	205.6	01Jan2014, 12:05	17.0
Pond 2	0.148	9.2	01Jan2014, 20:22	38.3
Pond 2A	0.148	523.6	01Jan2014, 12:09	49.5
Pond 3	0.069	4.5	01Jan2014, 19:54	18.7
Pond 3A	0.069	280.5	01Jan2014, 12:05	23.5
Pond 4	0.071	130.1	01Jan2014, 12:17	23.7
Pond 4A	0.071	285.3	01Jan2014, 12:05	23.8
Pond 5	0.014	6.8	01Jan2014, 12:46	4.7
Pond 5A	0.014	56.9	01Jan2014, 12:05	4.7
Pond 6	0.003	3.2	01Jan2014, 12:28	1.1
Pond 6A	0.003	13.0	01Jan2014, 12:05	1.1
Pond 7	0.061	152.2	01Jan2014, 12:14	20.4
Pond 7A	0.061	237.8	01Jan2014, 12:06	20.4
Reach-1	0.002	7.9	01Jan2014, 12:33	0.7
Reach-10	0.017	10.0	01Jan2014, 12:41	5.8

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-11	0.061	152.1	01Jan2014, 12:16	20.4
Reach-1A	0.002	7.8	01Jan2014, 12:48	0.7
Reach-2	0.693	706.1	01Jan2014, 13:32	201.8
Reach-3	1.284	1205.1	01Jan2014, 13:37	358.2
Reach-4	2.113	1966.1	01Jan2014, 13:41	601.8
Reach-5	2.350	2033.5	01Jan2014, 13:42	670.9
Reach-6	0.213	257.4	01Jan2014, 13:12	59.4
Reach-7	0.143	169.9	01Jan2014, 13:11	39.0
Reach-8	2.563	2240.5	01Jan2014, 13:40	730.2
Reach-9	0.078	160.1	01Jan2014, 12:23	26.2
Reach-CP7	0.193	141.7	01Jan2014, 12:10	50.6
Reach-CP8	0.175	327.1	01Jan2014, 12:30	53.3
Site 21	8.738	135.6	02Jan2014, 02:31	673.8

Project: 130 Environmental Park Simulation Run: Post 100yr 24hr SCS

Start of Run: 01Jan2014, 00:00 Basin Model: Post Developed
End of Run: 04Jan2014, 00:00 Meteorologic Model: 100 yr 24hr (SCS)
Compute Time: 11Jun2014, 10:47:27 Control Specifications: 72 hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
CP1	0.002	11.2	01Jan2014, 12:05	0.9
CP10	0.054	171.4	01Jan2014, 12:23	22.8
CP11	0.192	431.5	01Jan2014, 12:43	79.6
CP12	8.816	904.4	01Jan2014, 20:42	1453.3
CP2	1.284	1777.7	01Jan2014, 13:30	532.5
CP3	0.693	1028.7	01Jan2014, 13:25	296.9
CP4	0.143	252.0	01Jan2014, 13:02	58.3
CP5	0.213	379.6	01Jan2014, 13:06	88.3
CP6	2.350	2976.1	01Jan2014, 13:39	986.8
CP7	0.193	206.8	01Jan2014, 12:09	63.8
CP8	0.175	454.7	01Jan2014, 12:26	82.6
CP9	0.527	1149.3	01Jan2014, 12:48	229.4
Dry Creek	4.768	5599.6	01Jan2014, 13:53	2017.0
Dry Creek U.S.	4.768	5599.9	01Jan2014, 13:50	2017.0
J-2	2.113	2882.2	01Jan2014, 13:32	890.1
J-3	2.563	3284.3	01Jan2014, 13:35	1075.1
J-4	0.017	12.4	01Jan2014, 12:52	8.2
J-5	0.078	222.0	01Jan2014, 12:16	37.2
OS1	4.504	5467.9	01Jan2014, 13:51	1898.7
OS10	0.037	132.2	01Jan2014, 12:18	15.6
OS11	0.048	138.5	01Jan2014, 12:28	19.9
OS12	0.101	220.6	01Jan2014, 12:45	41.9
OS13	0.325	1926.7	01Jan2014, 12:05	176.1
OS14	0.078	177.7	01Jan2014, 12:43	32.9
OS15	0.070	141.0	01Jan2014, 12:52	29.0
OS16	0.521	928.4	01Jan2014, 13:01	212.4

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
OS17	0.089	223.8	01Jan2014, 12:34	35.7
OS2	1.282	1775.3	01Jan2014, 13:30	531.5
OS3	0.693	1028.7	01Jan2014, 13:25	296.9
OS4	0.143	252.0	01Jan2014, 13:02	58.3
OS5	0.527	1149.3	01Jan2014, 12:48	229.4
OS6	0.054	171.4	01Jan2014, 12:23	22.8
OS7	0.192	431.5	01Jan2014, 12:43	79.6
OS8	0.045	147.4	01Jan2014, 12:21	18.7
OS9	0.067	170.5	01Jan2014, 12:35	27.8
P1	0.002	11.2	01Jan2014, 12:05	0.9
P2	0.065	235.4	01Jan2014, 12:17	27.0
P2A	0.118	411.1	01Jan2014, 12:19	49.7
P3	0.070	130.1	01Jan2014, 13:01	30.0
P4	0.045	199.0	01Jan2014, 12:09	18.3
P5	0.097	255.4	01Jan2014, 12:33	40.2
Pond 1	0.050	53.0	01Jan2014, 12:32	23.9
Pond 1A	0.050	285.1	01Jan2014, 12:05	24.1
Pond 2	0.148	10.4	01Jan2014, 15:58	45.5
Pond 2A	0.148	730.4	01Jan2014, 12:09	70.5
Pond 3	0.069	5.3	01Jan2014, 21:15	23.2
Pond 3A	0.069	389.3	01Jan2014, 12:05	33.3
Pond 4	0.071	210.8	01Jan2014, 12:14	33.8
Pond 4A	0.071	397.6	01Jan2014, 12:05	33.8
Pond 5	0.014	7.7	01Jan2014, 12:32	6.1
Pond 5A	0.014	79.2	01Jan2014, 12:05	6.7
Pond 6	0.003	4.9	01Jan2014, 13:08	2.1
Pond 6A	0.003	17.7	01Jan2014, 12:05	1.6
Pond 7	0.061	212.3	01Jan2014, 12:14	29.0
Pond 7A	0.061	331.5	01Jan2014, 12:06	29.0
Reach-1	0.002	11.2	01Jan2014, 12:30	0.9
Reach-10	0.017	12.4	01Jan2014, 13:01	8.2

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-11	0.061	212.0	01Jan2014, 12:16	29.0
Reach-1A	0.002	11.0	01Jan2014, 12:44	0.9
Reach-2	0.693	1028.5	01Jan2014, 13:31	296.9
Reach-3	1.284	1777.3	01Jan2014, 13:35	532.5
Reach-4	2.113	2881.7	01Jan2014, 13:39	890.1
Reach-5	2.350	2976.0	01Jan2014, 13:40	986.8
Reach-6	0.213	379.6	01Jan2014, 13:11	88.3
Reach-7	0.143	251.8	01Jan2014, 13:09	58.3
Reach-8	2.563	3284.2	01Jan2014, 13:37	1075.0
Reach-9	0.078	221.7	01Jan2014, 12:22	37.2
Reach-CP7	0.193	206.8	01Jan2014, 12:10	63.8
Reach-CP8	0.175	454.7	01Jan2014, 12:27	82.6
Site 21	8.738	897.7	01Jan2014, 20:43	1420.4

POSTDEVELOPMENT FLOW SUMMARY

Post-Developed Runoff Summary					
Comparison Point	25-Year Peak Discharge (cfs)	25-Year Volume (ac-ft.)	100-Year Peak Discharge (cfs)	100-Year Volume (ac-ft.)	Type of Flow
CP1	8	0.7	11.2	0.9	Runoff
CP2	1205.3	358.2	1777.7	532.5	Runon
CP3	706.2	201.8	1028.7	296.9	Runon
CP4	170	39	252	58.3	Runon
CP5	257.5	59.4	379.6	88.3	Runoff
CP6	2033.6	670.9	2976.1	986.8	Runoff
CP7	138.7	36	203.2	46.2	Runoff
CP8	318	58.1	507.6	87.5	Runoff
CP9	795.7	156.7	1149.3	229.4	Runoff
CP10	117.5	15.4	171.4	22.8	Runoff
CP11	293.6	53.5	431.5	79.6	Runoff
CP12	231	696	903	1449.4	Runoff

POSTDEVELOPMENT VELOCITY SUMMARY

130 Environmental Park
Post-Developed Condition 25-Year Velocity Calculations at Comparison Points

Required: Determine the 25-year flow depths and velocities at each comparison point.

Method: Calculate the flow depths and velocities using Manning's Equation.

Solution: Manning's Equation, Q = 1.486 * R^(2/3) * S^(1/2) * A / n, was used to calculate the flow depth and velocity. See page C1-B-31 for example calculations.

		Velocity Calculations						
Comparison Point	Q (cfs)	Width[1] (ft)	Bottom Slope[2] (%)	Side Slopes[3] (h:v)	Manning's n	Depth (ft)	Velocity (fps)	Shear Stress (psf)
CP1	8.0	500	2.90	0.0	0.100	**0.05**	**0.33**	**0.09**
CP2	1205.3	6	0.35	8.0	0.065	**6.61**	**3.09**	**1.44**
CP3	706.2	13	0.70	25.0	0.065	**3.02**	**2.65**	**1.32**
CP4	170.0	7	1.60	10.0	0.065	**2.00**	**3.16**	**1.99**
CP5	257.5	1	1.30	30.0	0.065	**1.84**	**2.48**	**1.50**
CP6	2033.6	7	0.52	10.0	0.065	**6.90**	**3.87**	**2.24**
CP7	141.8	1	2.10	20.0	0.085	**1.73**	**2.32**	**2.26**
CP8	327.2	4	1.60	4.0	0.065	**3.73**	**4.64**	**3.72**
CP9*	795.7	20	1.30	6.0	0.065	**3.86**	**4.78**	**3.13**
CP10*	117.5	3	2.80	6.0	0.065	**1.97**	**4.03**	**3.44**
CP11*	293.6	12	1.40	4.5	0.065	**2.88**	**4.09**	**2.51**
CP12*	231.0	10	0.20	3.0	0.065	**4.68**	**2.05**	**0.58**

Notes:

1. Comparison points where surface water runoff enters or exits the permit or property boundaries in established natural or constructed channels; width refers to the bottom width of the channel.
   Comparison points where surface water runoff enters or exits the permit or property boundaries as sheet flow or not well established channels; width refers to the sheet flow width.
2. For channels, bottom slope is the slope of the channel bottom where surface water enters or exits the permit or property boundaries.
   For sheet flow, bottom slope is the slope of the ground where surface water enters or exits the permit or property boundaries.
3. For channels, side slope is the average side slope of the channel where surface water enters or exits the permit or propery boundaries.
   For sheet flow, there are no side slopes and are represented by "0" in this table.

* Comparison points where surface water runoff enters or exits the property boundary at a culvert, the velocity is calculated downstream of the culvert.

130 Environmental Park

Post-Developed Condition 100-Year Velocity Calculations at Comparison Points

Required: Determine the 100-year flow depths and velocities at each comparison point.

Method: Calculate the flow depths and velocities using Manning's Equation.

Solution: Manning's Equation, Q = 1.486 * R^(2/3) * S^(1/2) * A / n, was used to calculate the flow depth and velocity. See page C1-B-31 for example calculations.

		Velocity Calculations						
Comparison Point	Q (cfs)	Width[1] (ft)	Bottom Slope[2] (%)	Side Slopes[3] (h:v)	Manning's n	Depth (ft)	Velocity (fps)	Shear Stress (psf)
CP1	11.2	500	2.90	0.0	0.100	**0.06**	**0.38**	**0.11**
CP2	1777.7	6	0.35	8.0	0.065	**7.71**	**3.41**	**1.68**
CP3	1028.7	13	0.70	25.0	0.065	**3.51**	**2.91**	**1.53**
CP4	252.0	7	1.60	10.0	0.065	**2.36**	**3.49**	**2.36**
CP5	379.6	1	1.30	30.0	0.065	**2.13**	**2.74**	**1.73**
CP6	2976.1	7	0.52	10.0	0.065	**8.01**	**4.26**	**2.60**
CP7	206.8	1	2.10	20.0	0.085	**1.99**	**2.54**	**2.61**
CP8	454.7	4	1.60	4.0	0.065	**4.28**	**5.04**	**4.27**
CP9*	1149.3	20	1.30	6.0	0.065	**4.59**	**5.27**	**3.72**
CP10*	171.4	3	2.80	6.0	0.065	**2.30**	**4.43**	**4.02**
CP11*	431.5	12	1.40	4.5	0.065	**3.45**	**4.53**	**3.02**
CP12*	904.3	10	0.20	3.0	0.065	**8.65**	**2.91**	**1.08**

Notes:

1. Comparison points where surface water runoff enters or exits the permit or property boundaries in established natural or constructed channels; width refers to the bottom width of the channel.
   Comparison points where surface water runoff enters or exits the permit or property boundaries as sheet flow or not well established channels; width refers to the sheet flow width.
2. For channels, bottom slope is the slope of the channel bottom where surface water enters or exits the permit or property boundaries.
   For sheet flow, bottom slope is the slope of the ground where surface water enters or exits the permit or property boundaries.
3. For channels, side slope is the average side slope of the channel where surface water enters or exits the permit or propery boundaries.
   For sheet flow, there are no side slopes and are represented by "0" in this table.

* Comparison points where surface water runoff enters or exits the property boundary at a culvert, the velocity is calculated downstream of the culvert.

130 Environmental Park
Example Velocity Calculation at Comparison Point

Required: Determine the depths and velocities at each comparison point.

Method: Calculate the flow depths and velocities using Manning's Equation.

Solution: Manning's Equation was used to calculate the flow depth and velocity.

Given: Comparison Point 6 and the 25-year, 24-hour flow rate are used for this example.

Comparison Point	Q (cfs)	Width (ft)	Bottom Slope (%)	Side Slopes (h:v)	Manning's n	Depth (ft)	Velocity (fps)	Shear Stress (psf)
CP6	**2033.6**	7	0.52	10.0	0.065	**6.90**	**3.87**	**2.24**

Given Values

Q = Flow rate
W = Bottom width of flow
S = Bottom slope
SS = Side slope
n = Manning's roughness coefficient

Calculated Values

D = Depth of Flow
V = Flow Velocity
Flow Area (A) = (W+SS*D)*D
Wetted Perimeter (WP) = W+2*(D^2+(SS*D)^2)^(0.5)
Hydraulic Radius (R) = A/WP

Manning's Equation
Calculated Flow Rate (Q) = 1.486*R^(2/3)*S^(1/2)*A/n

Depth was varied until the correct flow rate obtained.

Assume D = 4.0000 ft
A = 188.00 sf
WP = 87.40 ft
R = 2.1511
Calculated Q = 516.5 cfs

Assume D = 6.9100 ft
A = 525.85 sf
WP = 145.89 ft
R = 3.6045
Calculated Q = 2038.0 cfs

The calculated flow rate matches the given flow rate.

Calculate flow velocity.
Flow Velocity (V) = Q/A
V = 3.88 fps

Shear stress was calculated for erosion control purposes.
Shear Stress = 62.4*D*S/100
Shear Stress = 2.24 psf

POSTDEVELOPMENT DRAINAGE ANALYSIS SUMMARY

130 Environmental Park

Table 2 - Postdeveloped Conditions Drainage Analysis Summary

Comparison Point	25-Year Peak Discharge (cfs)	25-Year Volume (ac-ft)	Peak Velocity (fps)	Runon/ Runoff	Drainage Areas
CP1	8.0	0.7	0.33	Runoff	P1
CP2	1205.3	358.2	3.09	Runon	OS2, P1
CP3	706.2	201.8	2.65	Runon	OS3
CP4	170.0	39.0	3.16	Runon	OS4
CP5	257.5	59.4	2.48	Runoff	OS4, P3
CP6	2033.6	676.0	3.87	Runoff	OS2, OS3, P1, P2, P2A, Pond 1A, Pond 3A, Pond 4A
CP7	141.8	61.8	2.32	Runoff	Pond 2A, P4
CP8	327.2	53.3	4.64	Runoff	Pond 5A, Pond 6A, Pond 7A, P5
CP9	795.7	156.7	4.78	Runoff	OS5
CP10	117.5	15.4	4.03	Runoff	OS6
CP11	293.6	53.5	4.09	Runoff	OS7
CP12	231.0	2554.5	2.05	Runoff	OS1, OS2, OS3, OS4, OS8, OS9, OS10, OS11, OS12, OS13, OS14, OS15, OS16, OS17, P1, P2, P2A, P3, P4, P5, Pond 1A, Pond 2A, Pond 3A, Pond 4A, Pond 5A, Pond 6A, Pond 7A

130 ENVIRONMENTAL PARK

ATTACHMENT C1

APPENDIX C1-D

PERIMETER DRAINAGE SYSTEM DESIGN

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

Includes pages C1-D-1 through C1-D-15

Technically Complete October 28, 2014

CONTENTS

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

NARRATIVE

30 TAC §§330.303 and 330.305

This appendix presents the design of 130 Environmental Park perimeter drainage channels and detention ponds in accordance with §330.305(a)-(d).

PERIMETER DRAINAGE PLAN

Drawing C1-D-1 – Perimeter Drainage Plan depicts the perimeter drainage system and detention pond locations for 130 Environmental Park. The plan reflects the perimeter channel design and stationing. The perimeter channel hydraulic analysis is included for the 25-year rainfall event.

PERIMETER CHANNEL DESIGN SUMMARY

The perimeter channels are designed for peak discharge resulting from the 25-year storm event and will pass the 100-year storm event. The perimeter channel depths and calculated normal depths are summarized in the table below. In several locations along the perimeter channel, the depths are much greater than necessary to convey the predicted stormwater flow rates; however, minimum channel slopes were maintained to help prevent excessive velocity and erosion. The perimeter channel design calculations are shown beginning on page C1-D-5. Perimeter channel profiles are included in Attachment C3.

Perimeter Channel Summary

Perimeter Channel	Minimum Channel Depth to Perimeter Road (feet)	Minimum Channel Depth to Perimeter Berm (feet)	25-Year Maximum Flow Depth (feet)	100-Year Maximum Flow Depth (feet)
North	6	6	1.89	2.21
Northeast	8	6	1.63	1.92
West	7	6	1.89	2.22
East	6	6	2.25	2.62
Southwest	7	8	1.21	1.44
Southeast	8	5	2.34	2.74
South	9	5	0.55	0.66

DETENTION POND ANALYSIS

The detention ponds are designed to provide the necessary storage and outlet control to mitigate impacts to the receiving channels downstream of 130 Environmental Park. The hydraulic design parameters for the detention ponds are provided on pages C1-C-13 through C1-C-19. Detention pond design information is included in Attachment C3. The following tables provide storage volumes and water surface elevations for the 25-year and 100-year, 24-hour storm events.

25-Year, 24-Hour Storm Events Analysis

Detention Pond	Maximum Water Surface Elevation	Perimeter Pond Berm Elev.	Freeboard (feet)	Access Road Elev.
Pond 1	538.4	540.93	2.5	547.29
Pond 2	527.9	532.00	4.1	535.99
Pond 3	537.4	544.82	7.4	564.00
Pond 4	548.8	551.76	3.0	552.00
Pond 5	564.5	568.00	3.5	568.11
Pond 6	555.3	558.61	3.3	558.00
Pond 7	539.4	542.00	2.6	557.76

100-Year, 24-Hour Storm Events Analysis

Detention Pond	Maximum Water Surface Elevation	Perimeter Pond Berm Elev.	Freeboard (feet)	Access Road Elev.
Pond 1	539.4	540.93	1.5	547.29
Pond 2	530.2	532.00	1.8	535.99
Pond 3	539.1	544.82	5.7	564.00
Pond 4	549.5	551.76	2.3	552.00
Pond 5	565.7	568.00	2.3	568.11
Pond 6	556.2	558.61	2.4	558.00
Pond 7	540.9	542.00	1.1	557.76

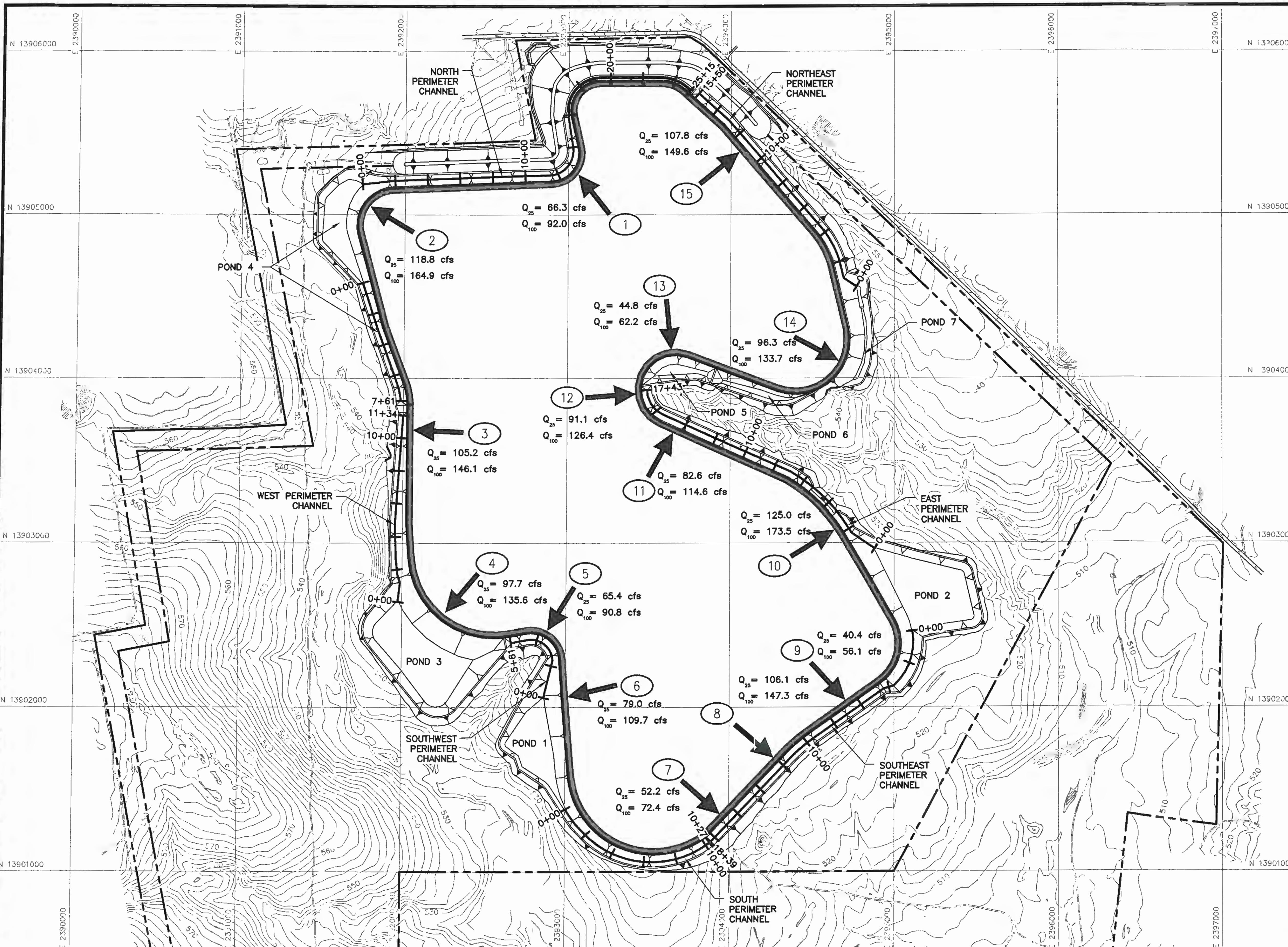
As an additional design parameter the detention ponds were sized to not overtop if back-to-back 100-year, 24-hour storm events were to occur. This analysis was performed using HEC-HMS by simulating a 48-hour storm event by creating a custom hyetograph using the SCS Type III rainfall distribution for the first 24 hours and again for the second 24 hours. The maximum pond elevations from the back-to-back 100-year, 24-hour storm event were compared to perimeter berm elevations to confirm that the detention ponds would not overtop in the event of back-to-back, 100-year, 24-hour storm events.

The following table summarizes the results of the 100-year, 24-hour, back-to-back storm events analysis. The maximum elevation is the maximum water surface elevation in the detention pond during the back-to-back 100-year, 24-hour storm event. The berm elevation is the elevation of the perimeter detention pond berm, which demonstrates that the detention pond will not overtop. The access road elevation is the elevation of the perimeter access road between the waste disposal area and the pond. The access road elevation demonstrates that the landfill is further protected from the detention ponds overtopping.

100-Year, 24-Hour, Back-to-Back Storm Event Analysis

Detention Pond	Maximum Water Surface Elevation (ft)	Perimeter Pond Berm Elevation (ft)	Freeboard (ft)	Perimeter Road Elevation (ft)
Pond 1	539.7	540.93	1.2	547.29
Pond 2	531.8	532.00	0.2	535.99
Pond 3	543.5	544.82	1.3	564.00
Pond 4	549.5	551.76	2.3	552.00
Pond 5	565.9	568.00	2.1	568.11
Pond 6	556.4	558.61	2.2	558.00
Pond 7	540.9	542.00	1.1	557.76

PERIMETER DRAINAGE PLAN



LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- EXISTING CONTOUR (510)
- STATE PLANE GRID (N 13903000)
- DRAINAGE SWALE
- DRAINAGE CHUTE DESIGNATION (1)

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.

STATE OF TEXAS
T. TROW
103797
LICENSED
PROFESSIONAL ENGINEER
11-6-14

J:\129\06 130 Park\102\Drainage\C1-D-1.dwg Layout: C1-D-1 User: scundiff

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
–	10/28/14	TECHNICALLY COMPLETE	BBB	TLT	TLT	TLT
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

PERIMETER DRAINAGE PLAN

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
TYPE I PERMIT APPLICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

DSN. CRH	DATE : 02/14	DRAWING
DWN. BBB	SCALE : GRAPHIC	C1–D–1
CHK. TLT	DWG : C1–D–1.dwg	

PERIMETER CHANNEL DESIGN CALCULATIONS

130 ENVIRONMENTAL PARK
Perimeter Drainage Channel Design

Required: Determine the 25-year peak flow for each drainage ditch sub-area.

Method: Determine the 25-year peak flow for each drainage ditch sub-area using the Rational Method.

References:
1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: Determine the 25-year peak flow for each drainage ditch sub-area using the Rational Method.

25-Year Rainfall Depth (Pd) = 1.52 in
Time of Concentration (tc) = 10 min
Rainfall Intensity (I) = 9.1 in/hr

Runoff Coefficient (C) = 0.45

25-Year Peak Flow Rate (Q) = CIA cfs

Pond	Sub-Drainage Area/Perimeter Channel	Area (acre)	25-Year Peak Flow (cfs)
Pond 1	Southwest	1.92	7.9
Pond 2	South	2.78	11.4
Pond 2	East (upstream)	3.12	12.8
Pond 2	East (downstream)	1.36	5.6
Pond 2	Southeast	5.19	21.3
Pond 3	West	3.59	14.7
Pond 4	North	6.18	25.4
Pond 4	North (upstream)	3.62	14.9
Pond 5	N/A	N/A	N/A
Pond 6	N/A	N/A	N/A
Pond 7	Northeast	4.33	17.8

* Perimeter drainage channel areas contributing to total flow, 25-year.

130 ENVIRONMENTAL PARK
Perimeter Drainage Channel Design

Required: Determine the 100-year peak flow for each drainage ditch sub-area.

Method: Determine the 100-year peak flow for each drainage ditch sub-area using the Rational

References:
1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: 100-year peak

100-Year Rainfall Depth (Pd) =	2.11	in
Time of Concentration (tc) =	10	min
Rainfall Intensity (I) =	12.7	in/hr
Runoff Coefficient (C) =	0.45	
100-Year Peak Flow Rate (Q) =	CIA	cfs

Pond	Sub-Drainage Area/Perimeter Channel	Area (acre)	100-Year Peak Flow (cfs)
Pond 1	Southwest	1.92	10.9
Pond 2	South	2.78	15.8
Pond 2	East (upstream)	3.12	17.8
Pond 2	East (downstream)	1.36	7.7
Pond 2	Southeast	5.19	29.6
Pond 3	West	3.59	20.5
Pond 4	North	6.18	35.2
Pond 4	North (upstream)	3.62	20.6
Pond 5	N/A	N/A	N/A
Pond 6	N/A	N/A	N/A
Pond 7	Northeast	4.33	24.7

* Perimeter drainage channel areas contributing to total flow, 100-year.

130 ENVIRONMENTAL PARK
Downchute Design

Required: Determine the flowrates for each final cover downchute.

Method: Determine the 25-year and 100-year peak flow for each downchute using the Rational Method.

Reference

1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution 1: Determine the 25-year peak flow for each downchute using the Rational Method.

25-Year Rainfall Depth (Pd) = 1.52 in
Time of Concentration (tc) = 10 min
Rainfall Intensity (I) = 9.1 in/hr
Runoff Coefficient (C) = 0.70
25-Year Peak Flow Rate (Q) = CIA cfs

Chute Drainage Area	Drainage Area (acre)	25-Year Peak Flow (cfs)	Pond Contributing To
1	10.38	66.3	4
2	18.61	118.8	4
3	16.49	105.2	3
4	15.30	97.7	3
5	10.24	65.4	1
6	12.38	79.0	1
7	8.17	52.2	2
8	16.62	106.1	2
9	6.33	40.4	2
10	19.58	125.0	2
11	12.93	82.6	2
12	14.26	91.1	2
13	7.02	44.8	5
14	15.09	96.3	7
15	16.88	107.8	7

Solution 2: Determine the 100-year peak flow for each downchute using the Rational Method.

100-Year Rainfall Depth (Pd) = 2.11 in
Time of Concentration (tc) = 10 min
Rainfall Intensity (I) = 12.7 in/hr
Runoff Coefficient (C) = 0.70
100-Year Peak Flow Rate (Q) = CIA cfs

Chute Drainage Area	Drainage Area (acre)	100-Year Peak Flow (cfs)	Pond Contributing To
1	10.38	92.0	4
2	18.61	164.9	4
3	16.49	146.1	3
4	15.30	135.6	3
5	10.24	90.8	1
6	12.38	109.7	1
7	8.17	72.4	2
8	16.62	147.3	2
9	6.33	56.1	2
10	19.58	173.5	2
11	12.93	114.6	2
12	14.26	126.4	2
13	7.02	62.2	5
14	15.09	133.7	7
15	16.88	149.6	7

130 ENVIRONMENTAL PARK

Depth and Velocity Calculations for the Perimeter Channels for the 25-Year Peak Runoff

Required: Determine the velocity and depth for the perimeter channels and compare to the permissible non-erodible flow velocity.

Method: Manning's Equation for flow velocity.

References: 1. Texas Department of Transportation, *Hydraulic Design Manual,* March 2004.

Solution: Equation

$$V = \left(\frac{k}{n}\right)(R_h)^{2/3}(S)^{1/2}$$

V = Velocity (fps)
k = n Factor = 1.486
n = Manning's Roughness Coefficient = 0.03 Grass-lined channel
R_h = Hydraulic Radius = A/P_w
A = Cross-Sectional Area (ft^2)
P_w = Wetted Perimeter (ft)
S = Channel Slope (ft/ft)
b = Bottom Width (ft)

Perimeter Channel	Channel Station		Q (cfs)	Bottom Width (ft)	Slope (ft/ft)	Side Slopes (h:v)	Manning's n	Normal Depth (ft)	Velocity (fps)	Shear Stress (psf)
Southwest	5+61	2+37	73.3	8	0.011	4	0.030	**1.21**	**4.71**	0.83
Southwest	2+37	0+00	73.3	8	0.100	4	0.030	**0.67**	**10.25**	4.18
South	10+27	0+00	11.4	8	0.005	4	0.030	**0.55**	**2.04**	0.17
East (upstream)	17+43	15+48	186.5	8	0.006	4	0.030	**2.25**	**4.89**	0.84
East (upstream)	15+48	6+96	186.5	8	0.026	4	0.030	**1.57**	**8.35**	2.54
East (upstream)	6+96	5+35	186.5	8	0.013	4	0.030	**1.86**	**6.49**	1.51
East (box)	5+35	3+25	186.5	8	0.013	4	0.013	**1.62**	**14.35**	1.32
East (downstream)	3+25	1+70	317.1	8	0.018	4	0.030	**2.23**	**8.43**	2.50
East (downstream)	1+70	0+00	317.1	8	0.071	4	0.030	**1.59**	**13.90**	7.04
Southeast	18+39	11+45	220.0	8	0.013	4	0.030	**2.02**	**6.78**	1.64
Southeast	11+45	9+52	220.0	8	0.010	4	0.030	**2.15**	**6.16**	1.34
Southeast	9+52	4+35	220.0	8	0.007	4	0.030	**2.34**	**5.41**	1.02
Southeast	4+35	0+00	220.0	8	0.097	4	0.030	**1.22**	**14.04**	7.37
West	11+34	1+16	119.9	8	0.005	4	0.030	**1.89**	**4.06**	0.59
West	1+16	0+00	119.9	8	0.110	4	0.030	**0.85**	**12.30**	5.86
North (upstream)	25+15	23+13	14.9	N/A	0.007	3	0.030	**1.29**	**2.99**	0.56
North (upstream)	23+13	19+34	14.9	N/A	0.017	3	0.030	**1.09**	**4.17**	1.16
North (upstream)	19+34	15+96	14.9	N/A	0.002	3	0.030	**1.63**	**1.87**	0.20
North	15+96	9+00	106.6	8	0.004	4	0.030	**1.89**	**3.63**	0.47
North	9+00	1+86	106.6	8	0.030	4	0.030	**1.13**	**7.51**	2.12
North	1+86	0+00	106.6	8	0.080	4	0.030	**0.87**	**10.62**	4.36
Northeast	15+50	13+05	125.6	8	0.010	4	0.030	**1.63**	**5.29**	1.02
Northeast	13+05	9+23	125.6	8	0.040	4	0.030	**1.14**	**8.72**	2.86
Northeast	9+23	7+38	125.6	8	0.030	4	0.030	**1.23**	**7.87**	2.31
Northeast	7+38	0+96	125.6	8	0.020	4	0.030	**1.37**	**6.80**	1.71
Northeast	0+96	0+00	125.6	8	0.200	4	0.030	**0.74**	**15.37**	9.29

130 ENVIRONMENTAL PARK

Depth and Velocity Calculations for the Perimeter Channels for the 100-Year Peak Runoff

Required: Determine the velocity and depth for the perimeter channels and compare to the permissible non-erodible flow velocity.

Method: Manning's Equation for flow velocity.

References: 1. Texas Department of Transportation, *Hydraulic Design Manual,* March 2004.

Solution: Equation $$V = \left(\frac{k}{n}\right)(R_h)^{2/3}(S)^{1/2}$$

V = Velocity (fps)
k = n Factor = 1.486
n = Manning's Roughness Coefficient = 0.03 Grass-lined channel
R_h = Hydraulic Radius = A/P_w
A = Cross-Sectional Area (ft^2)
P_w = Wetted Perimeter (ft)
S = Channel Slope (ft/ft)
b = Bottom Width (ft)

Perimeter Channel	Channel Station		Q (cfs)	Bottom Width (ft)	Slope (ft/ft)	Side Slopes (h:v)	Manning's n	Normal Depth (ft)	Velocity (fps)	Shear Stress (psf)
Southwest	5+61	2+37	102.9	8	0.011	4	0.030	**1.44**	**5.19**	0.99
Southwest	2+37	0+00	102.9	8	0.100	4	0.030	**0.81**	**11.36**	5.03
South	10+27	0+00	15.8	8	0.005	4	0.030	**0.66**	**2.27**	0.20
East (upstream)	17+43	15+48	258.8	8	0.006	4	0.030	**2.62**	**5.33**	0.98
East (upstream)	15+48	6+96	258.8	8	0.026	4	0.030	**1.84**	**9.13**	2.99
East (upstream)	6+96	5+35	258.8	8	0.013	4	0.030	**2.18**	**7.08**	1.77
East (box)	5+35	3+25	258.8	8	0.013	4	0.013	**2.03**	**15.91**	1.65
East (downstream)	3+25	1+70	440.0	8	0.018	4	0.030	**2.60**	**9.19**	2.92
East (downstream)	1+70	0+00	440.0	8	0.071	4	0.030	**1.87**	**15.20**	8.28
Southeast	18+39	11+45	305.4	8	0.013	4	0.030	**2.36**	**7.40**	1.92
Southeast	11+45	9+52	305.4	8	0.010	4	0.030	**2.52**	**6.72**	1.57
Southeast	9+52	4+35	305.4	8	0.007	4	0.030	**2.74**	**5.89**	1.19
Southeast	4+35	0+00	305.4	8	0.097	4	0.030	**1.44**	**15.40**	8.72
West	11+34	1+16	166.6	8	0.005	4	0.030	**2.22**	**4.44**	0.69
West	1+16	0+00	166.6	8	0.110	4	0.030	**1.02**	**13.56**	6.99
North (upstream)	25+15	23+13	20.6	N/A	0.007	3	0.030	**1.46**	**3.24**	0.64
North (upstream)	23+13	19+34	20.6	N/A	0.017	3	0.030	**1.23**	**4.52**	1.31
North (upstream)	19+34	15+96	20.6	N/A	0.002	3	0.030	**1.84**	**2.02**	0.23
North	15+96	9+00	147.8	8	0.004	4	0.030	**2.21**	**3.96**	0.55
North	9+00	1+86	147.8	8	0.030	4	0.030	**1.34**	**8.24**	2.51
North	1+86	0+00	147.8	8	0.080	4	0.030	**1.04**	**11.69**	5.19
Northeast	15+50	13+05	174.3	8	0.010	4	0.030	**1.92**	**5.79**	1.20
Northeast	13+05	9+23	174.3	8	0.040	4	0.030	**1.36**	**9.57**	3.39
Northeast	9+23	7+38	174.3	8	0.030	4	0.030	**1.46**	**8.63**	2.73
Northeast	7+38	0+96	174.3	8	0.020	4	0.030	**1.62**	**7.45**	2.02
Northeast	0+96	0+00	174.3	8	0.200	4	0.030	**0.89**	**16.96**	11.10

100-YEAR, 24-HOUR BACK-TO-BACK STORM EVENT HYDROLOGIC ANALYSIS

Project: 130 Environmental Park Simulation Run: Post 100yr 24hr SCS

Start of Run: 01Jan2014, 00:00 Basin Model: Post Developed
End of Run: 04Jan2014, 00:00 Meteorologic Model: 100 yr 24hr (SCS)
Compute Time: 11Jun2014, 10:47:27 Control Specifications: 72 hr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
CP1	0.002	11.2	01Jan2014, 12:05	0.9
CP10	0.054	171.4	01Jan2014, 12:23	22.8
CP11	0.192	431.5	01Jan2014, 12:43	79.6
CP12	8.816	904.4	01Jan2014, 20:42	1453.3
CP2	1.284	1777.7	01Jan2014, 13:30	532.5
CP3	0.693	1028.7	01Jan2014, 13:25	296.9
CP4	0.143	252.0	01Jan2014, 13:02	58.3
CP5	0.213	379.6	01Jan2014, 13:06	88.3
CP6	2.350	2976.1	01Jan2014, 13:39	986.8
CP7	0.193	206.8	01Jan2014, 12:09	63.8
CP8	0.175	454.7	01Jan2014, 12:26	82.6
CP9	0.527	1149.3	01Jan2014, 12:48	229.4
Dry Creek	4.768	5599.6	01Jan2014, 13:53	2017.0
Dry Creek U.S.	4.768	5599.9	01Jan2014, 13:50	2017.0
J-2	2.113	2882.2	01Jan2014, 13:32	890.1
J-3	2.563	3284.3	01Jan2014, 13:35	1075.1
J-4	0.017	12.4	01Jan2014, 12:52	8.2
J-5	0.078	222.0	01Jan2014, 12:16	37.2
OS1	4.504	5467.9	01Jan2014, 13:51	1898.7
OS10	0.037	132.2	01Jan2014, 12:18	15.6
OS11	0.048	138.5	01Jan2014, 12:28	19.9
OS12	0.101	220.6	01Jan2014, 12:45	41.9
OS13	0.325	1926.7	01Jan2014, 12:05	176.1
OS14	0.078	177.7	01Jan2014, 12:43	32.9
OS15	0.070	141.0	01Jan2014, 12:52	29.0
OS16	0.521	928.4	01Jan2014, 13:01	212.4

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
OS17	0.089	223.8	01Jan2014, 12:34	35.7
OS2	1.282	1775.3	01Jan2014, 13:30	531.5
OS3	0.693	1028.7	01Jan2014, 13:25	296.9
OS4	0.143	252.0	01Jan2014, 13:02	58.3
OS5	0.527	1149.3	01Jan2014, 12:48	229.4
OS6	0.054	171.4	01Jan2014, 12:23	22.8
OS7	0.192	431.5	01Jan2014, 12:43	79.6
OS8	0.045	147.4	01Jan2014, 12:21	18.7
OS9	0.067	170.5	01Jan2014, 12:35	27.8
P1	0.002	11.2	01Jan2014, 12:05	0.9
P2	0.065	235.4	01Jan2014, 12:17	27.0
P2A	0.118	411.1	01Jan2014, 12:19	49.7
P3	0.070	130.1	01Jan2014, 13:01	30.0
P4	0.045	199.0	01Jan2014, 12:09	18.3
P5	0.097	255.4	01Jan2014, 12:33	40.2
Pond 1	0.050	53.0	01Jan2014, 12:32	23.9
Pond 1A	0.050	285.1	01Jan2014, 12:05	24.1
Pond 2	0.148	10.4	01Jan2014, 15:58	45.5
Pond 2A	0.148	730.4	01Jan2014, 12:09	70.5
Pond 3	0.069	5.3	01Jan2014, 21:15	23.2
Pond 3A	0.069	389.3	01Jan2014, 12:05	33.3
Pond 4	0.071	210.8	01Jan2014, 12:14	33.8
Pond 4A	0.071	397.6	01Jan2014, 12:05	33.8
Pond 5	0.014	7.7	01Jan2014, 12:32	6.1
Pond 5A	0.014	79.2	01Jan2014, 12:05	6.7
Pond 6	0.003	4.9	01Jan2014, 13:08	2.1
Pond 6A	0.003	17.7	01Jan2014, 12:05	1.6
Pond 7	0.061	212.3	01Jan2014, 12:14	29.0
Pond 7A	0.061	331.5	01Jan2014, 12:06	29.0
Reach-1	0.002	11.2	01Jan2014, 12:30	0.9
Reach-10	0.017	12.4	01Jan2014, 13:01	8.2

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-11	0.061	212.0	01Jan2014, 12:16	29.0
Reach-1A	0.002	11.0	01Jan2014, 12:44	0.9
Reach-2	0.693	1028.5	01Jan2014, 13:31	296.9
Reach-3	1.284	1777.3	01Jan2014, 13:35	532.5
Reach-4	2.113	2881.7	01Jan2014, 13:39	890.1
Reach-5	2.350	2976.0	01Jan2014, 13:40	986.8
Reach-6	0.213	379.6	01Jan2014, 13:11	88.3
Reach-7	0.143	251.8	01Jan2014, 13:09	58.3
Reach-8	2.563	3284.2	01Jan2014, 13:37	1075.0
Reach-9	0.078	221.7	01Jan2014, 12:22	37.2
Reach-CP7	0.193	206.8	01Jan2014, 12:10	63.8
Reach-CP8	0.175	454.7	01Jan2014, 12:27	82.6
Site 21	8.738	897.7	01Jan2014, 20:43	1420.4

130 ENVIRONMENTAL PARK

ATTACHMENT C1

APPENDIX C1-E

FINAL COVER DRAINAGE STRUCTURE DESIGN

Includes pages C1-E-1 through C1-E-20

Technically Complete October 28, 2014

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

CONTENTS

11-6-14

STATE OF TEXAS
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103797
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Firm Registration No. F-834

NARRATIVE

30 TAC §§330.303 and 330.305

This appendix presents the supporting documentation for evaluation of the final cover erosion layer and drainage structures.

FINAL COVER PLAN

The final cover plans depict the proposed final cover drainage system, which consists of a series of swales and chutes designed to convey the flow of surface water produced during the 25-year storm event. The drainage area for the largest area contributing to a side slope swale is shown on Drawing C1-E-1. Drainage areas for each chute are shown on Drawing C1-E-2. Final cover details are included in Attachment C3.

EROSION LAYER EVALUATION

The erosion layer evaluation is based on the Universal Soil Loss Equation (USLE) following Natural Resource Soil Conservation Service (NRCS) procedures. The evaluation is based on a 25-year storm event. The proposed 24-inch thick erosion layer is shown to provide sufficient erosion protection. Calculations are included beginning on page C1-E-5.

SHEET FLOW VELOCITY

The sheet flow velocity calculations are presented for the top deck and side slope configurations. The procedures outlined in the TxDOT *Hydraulic Design Manual*, October 2011 were used to determine velocities. Sheet flow velocities were calculated based on the maximum length of sheet flow for the top slopes and for the side slopes. The calculated maximum sheet flow velocities are less than the permissible non-erodible flow velocity of 5 feet per second. Calculations are shown on page C1-E-14.

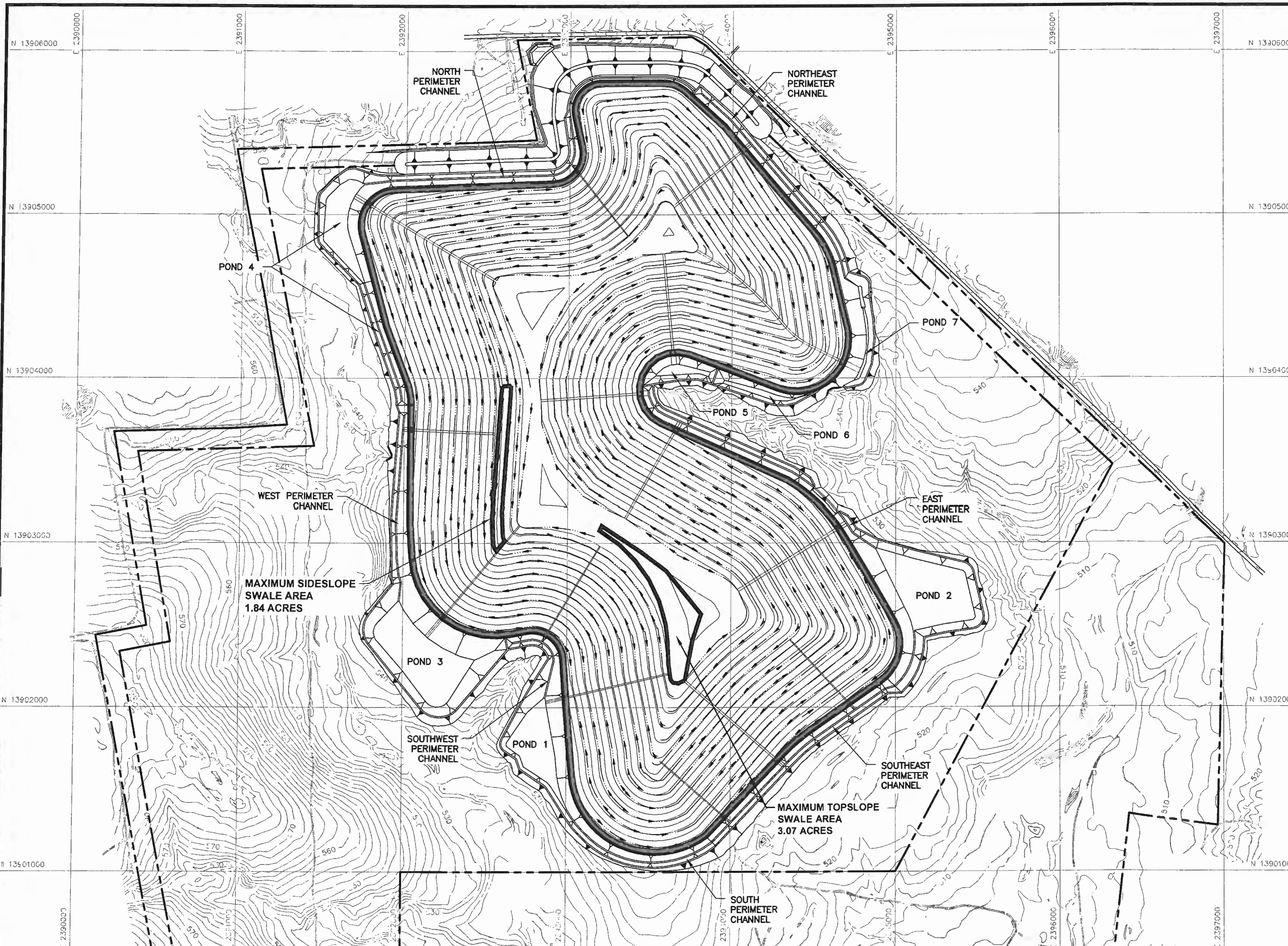
DRAINAGE SWALE DESIGN

The drainage swale design calculations are presented for the typical proposed swale flowline slope of 0.5 percent. The procedures in the TxDOT *Hydraulic Design Manual*, October 2011 were used to determine the flow depth, swale capacity, and contributing drainage area. Calculations are shown beginning on page C1-E-15.

CHUTE DESIGN

The drainage letdown chutes have been evaluated to determine critical velocities, flow depths in the chute, and receiving perimeter channel. Calculations are shown beginning on page C1-E-18. Erosion protection within each chute is provided by Reno Mattress or articulating concrete blocks. Typical chute profiles are included in Attachment C3.

FINAL COVER PLANS



0 300 600
SCALE IN FEET

LEGEND

— — —	PROPERTY BOUNDARY
— — —	FACILITY BOUNDARY
510	EXISTING CONTOUR
N 1390;3000	STATE PLANE GRID
— · · ◄	DRAINAGE SWALE

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.
2. CONTOURS WITHIN LANDFILL FOOTPRINT DEPICT TOP OF FINAL COVER.

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

J:\129\06 130 Park\102\Drainage\C1-E-1.dwg Layout: C1-E-1 User: scundiff

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MAXIMUM SWALE AREAS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
TYPE I PERMIT APPLICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

REVISIONS

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
–	10/28/14	TECHNICALLY COMPLETE	BBB	TLT	TLT	TLT

DSN. CRH	DATE : 02/14	DRAWING
DWN. BBB	SCALE : GRAPHIC	C1–E–1
CHK. TLT	DWG : C1–E–1.dwg	

0 300 600
SCALE IN FEET

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- 510 EXISTING CONTOUR
- N 13904000 STATE PLANE GRID
- CHUTE DRAINAGE AREA
- (1) DRAINAGE CHUTE DESIGNATION

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.

2. CONTOURS WITHIN LANDFILL DEPICT TOP OF FINAL COVER ELEVATIONS.

CHUTE DRAINAGE AREA

CHUTE DRAINAGE AREA	CHUTE AREA (AC)
CHUTE 1	10.4
CHUTE 2	18.6
CHUTE 3	16.5
CHUTE 4	15.3
CHUTE 5	10.2
CHUTE 6	13.4
CHUTE 7	8.2
CHUTE 8	16.6
CHUTE 9	6.3
CHUTE 10	19.6
CHUTE 11	12.9
CHUTE 12	14.3
CHUTE 13	7.0
CHUTE 14	15.1
CHUTE 15	16.9

CHUTE AREAS

130 ENVIRONMENTAL PARK, LLC
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LICENSED PROFESSIONAL ENGINEER
11-6-14

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REVISIONS

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
–	10/28/14	TECHNICALLY COMPLETE	BBB	TLT	TLT	TLT

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

DSN. CRH	DATE : 02/14	DRAWING
DWN. BBB	SCALE : GRAPHIC	C1–E–2
CHK. TLT	DWG : C1–E–2.dwg	

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EROSION LAYER EVALUATION

EROSION LAYER EVALUATION

This appendix presents the supporting documentation for evaluation of the thickness of the erosion layer for the final cover system at 130 Environmental Park. The evaluation is based on the premise of adding excess soil to increase the time required before maintenance is needed as recommended in the EPA Solid Waste Disposal Facility Criteria Technical Manual (EPA 530-R-93-017, November 1993).

The design procedure is as follows:

1. The minimum thickness of the erosion layer is based on the depth of frost penetration, or six inches, whichever is greater. For Caldwell County, the approximate depth of frost penetration is less than three inches.

2. Soil loss is calculated using the Universal Soil Loss Equation (USLE) by following NRCS procedures. The expected soil loss is adjusted by a safety factor of 2 and is then converted to a thickness. Application of the USLE shows that the maximum expected soil loss over the 30 year period is 0.08 inches for the top slopes and 0.65 inches on the side slopes. Combined with the minimum thickness requirements (from Step 1), these results show that the thickness of the proposed 24-inch erosion layer is a sufficiently conservative design. These calculations begin on page C1-E-7.

3. Sheet flow velocities were calculated based on a 25-year design storm event. The calculated maximum sheet flow velocities are less than the permissible non-erodible flow velocity of 5 feet per second. The supporting calculations are presented on page C1-E-14.

4. Vegetation for the site will be native and introduced grasses with root depths of 6 inches to 8 inches.

5. Native and introduced grasses will be hydroseeded with fertilizer on the disked (parallel to contours) erosion layer upon final grading. Temporary cold weather vegetation will be established if needed. Irrigation may be employed for 6 to 8 weeks or until vegetation is well established. Erosion control measures such as silt fences and straw bales will be used to minimize erosion until the vegetation is established. Areas that experience erosion or do not readily vegetate after hydroseeding will be reseeded until vegetation is established.

6. Slope stability information is included in Attachment D5 – Geotechnical Design.

130 Environmental Park
Erosion Loss Evaluation

Required: Determine the erosion loss for the final cover system design and compare to the actual final cover erosion layer thickness.

Method: Expected soil loss is calculated using the Universal Soil Loss Equation. Minimum erosion layer thickness is determined by adding the minimum thickness allowed by TCEQ to the expected thickness of soil loss.

References:

1. Schwab, Glen O., *Soil and Water Conservation Engineering, 3rd Ed.,* 1981.
2. Texas Department of Transportation, *Bridge Division Hydraulic Manual,* December 1985.
3. United States Soil Conservation Service, *Hydrology for Small Watersheds,* December 1989.
4. United States Soil Conservation Service, *Predicting Rainfall Erosion Losses, Guidebook 537,* 1978

Solution: Annual Soil Loss in tons/acre/year (A) = RKLSCP

Design Parameters	Top Slope (6%)	Perimeter Slope (25%)	
Rainfall Factor (R) =	288	288	(Caldwell County)
Soil Erodibility Factor (K) =	0.20	0.20	(clay)
Longest Run =	275	80	ft
Slope =	6	25	%
Topographic Factor (LS) =	1.11	5.27	
Crop Management Factor (C) =	0.009	0.009	(tall grass with 85% cover)
Erosion Control Practice Factor (P) =	0.50	0.90	(Contouring)
Soil Loss (A) =	0.29	2.46	tons/acre/yr

Erosion Layer Thickness Evaluation:

Required Thickness (T) = 6 inches* + AYF/w

* - Includes required 6 inch minimum

	Top Slope (6%)	Perimeter Slope (25%)	
Soil Loss (A) =	0.29	2.46	tons/acre/yr
Postclosure Period =	30	30	years
Factor of Safety (F) =	2	2	
Specific Weight of Soil (w) =	125	125	pcf
Required Soil Thickness (T)	**6.08**	**6.65**	**inches**
Actual Soil Thickness	24.00	24.00	inches

Summary: As noted in the permit drawings, the erosion layer will be a minimum of 24 inches thick. As shown above, this is a conservative design considering the maximum expected soil loss for a 30 year period is 0.65 inches.

130 Environmental Park
LS Factor Calculations

Required: Determine the length slope factor based on slope length and slope gradient.

References: 1. United States Soil Conservation Service, *Predicting Rainfall Erosion Losses, Guidebook 537,* 1978

Solution: Length/Slope Factor (LS): $$LS = \left(\frac{L}{72.6}\right)^m (65.41sin^2\theta + 4.56sin\theta + .065)$$

LS = Length/Slope Factor
L = Slope Length (ft)
θ = Slope (radians)
m = Exponent dependent on the slope gradient

m =	0.2	for S <= 1.0%
	0.3	for 1.0% < S <= 3.5%
	0.4	for 3.5% < S < 5.0%
	0.5	for S => 5.0%

L (ft)	Slope, S (%)	Slope, S (ft/ft)	θ (radians)	θ (degrees)	m	LS
275	6.0	0.06	0.060	3.434	0.5	1.115
80	25	0.25	0.245	14.036	0.5	5.268

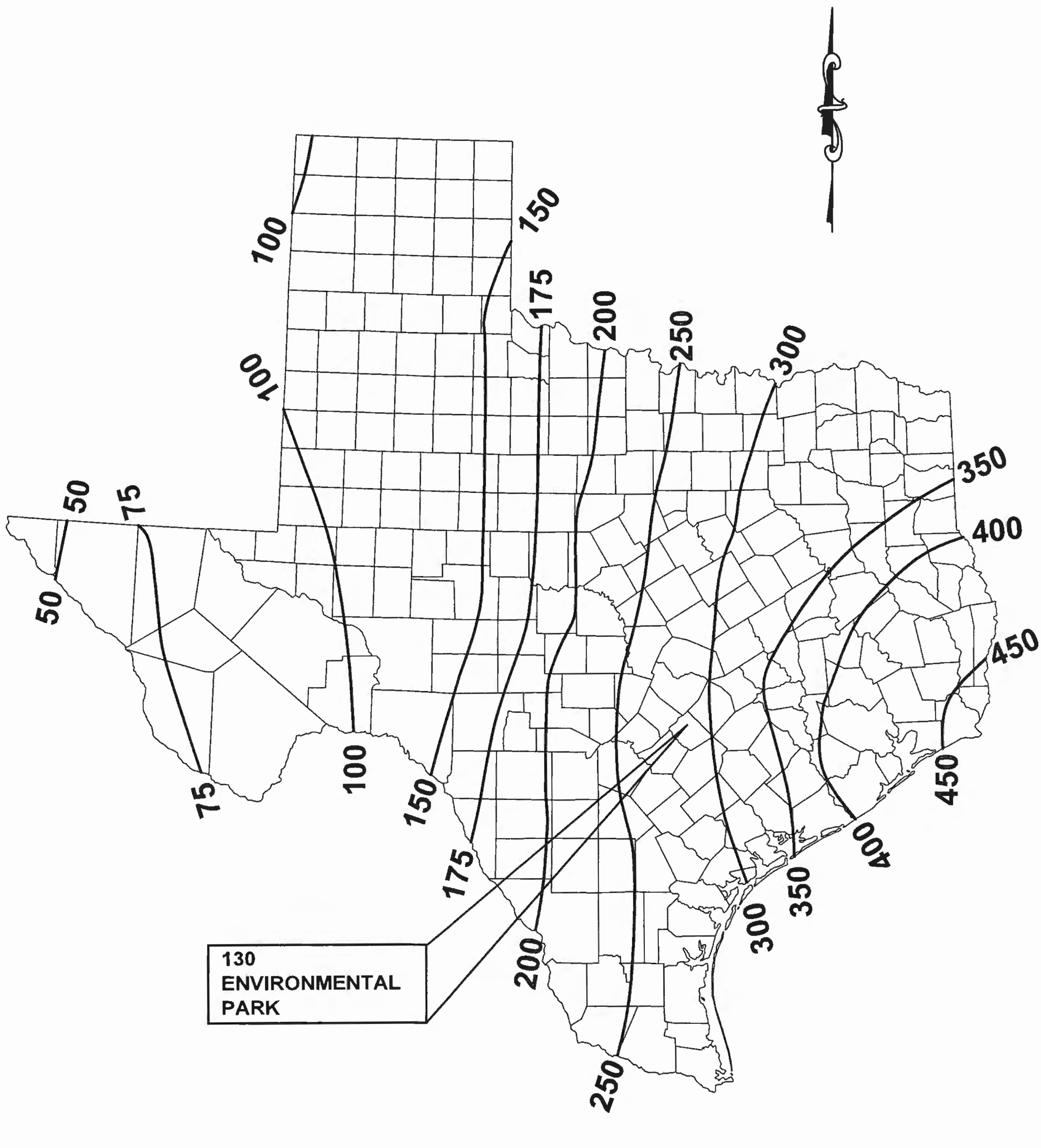

FIGURE 1 - AVERAGE ANNUAL VALUES OF THE RAINFALL EROSION INDEX

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Table 1: Approximate Values of Factor K for USDA Textural Classes

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Texture Class	Organic Matter Content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Fine Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.32	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	0.32	0.26
Sandy Clay	0.14	0.13	0.12
Silty Clay	0.25	0.23	0.19
Clay	0.13 - 0.29		

The values shown are estimated averages of broad ranges of specific soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

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Table 2: Factor C for Permanent Pasture, Range, and Idle Land[1]

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Vegetative Canopy		Cover that Contacts the Soil Surface					
Type and Height[2]	Percent Cover[3]	Percent Ground Cover					
		0	20	40	60	80	95+
No Appreciable Canopy		0.45	0.20	0.10	0.042	0.013	0.003
Tall weeds or short brush with average drop fall height of 20 in.	25	0.36	0.17	0.09	0.038	0.013	0.011
	50	0.26	0.13	0.07	0.035	0.012	0.003
	75	0.17	0.10	0.06	0.032	0.011	0.003

Extracted from: United States Department of Agriculture, AGRICULTURE HANDBOOK NUMBER 537

[1] The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 feet.

[3] Portions of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's eye view).

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Table 3: P Factors for Contouring, Contour Stripcropping and Terracing

Reproduced from: Ponce, Victor M., *Engineering Hydrology Principles and Practices, 1st Ed.*, 1989.

VALUES OF EROSION-CONTROL-PRACTICE FACTOR *P*[1]				
Land Slope (percent)	For Farm Planning		For Computing Sediment Yield[2]	
	Contour Factor[3]	Strip Crop Factor	Graded Channels, Sod Outlets	Steep Backslope, Underground Outlets
1-2	0.60	0.30	0.12	0.05
3-8	0.50	0.25	0.10	0.05
9-12	0.60	0.30	0.12	0.05
13-16	0.70	0.35	0.14	0.05
17-20	0.80	0.40	0.16	0.06
21-25	0.90	0.45	0.18	0.06

[1]Slope length is the horizontal terrace interval. The listed values are for contour farming. No additonal contour factor is used in the computation.

[2]These values include entrapment effeciency and are used for the control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

[3]Use these values for control of interterrace erosion within specified soil-loss tolereances.

Table 4: Guide for Assigning Soil Loss Tolerance Values (T)
to Solid Having Different Rooting Depths

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Rooting Depth	Soil Loss Tolerance Values Annual Soil Loss (Tons/Acre)	
Inches	Renewable Soil a/	Renewable Soil b/
0 - 10	1	1
10 - 20	2	1
20 - 40	3	2
40 - 60	4	3
60	5	4

(This table appeared in SCS (6), p.4)

a/ Soil with favorable substrata that can be renewed by tillage, fertilizer, organic matter, and other management practices. This column does not represent MSWLF final covers under normal conditions.

b/ Soil with unfavorable substrata such as rock or soft rock that cannot be renewed by economical means. Most of the MSWLF covers with constructed clay cap and/or flexible membrane should use this performance criteria.

SHEET FLOW

130 Environmental Park
Sheet Flow Velocity

Required: Determine the sheet flow velocity for the final cover system design and compare to the permissible non-erodible flow velocity.

Method:
1. Determine the 25-year peak flow rate using the Rational Method.
2. Calculate flow depth using Manning's Equation.
3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.

References:

1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:

1. Determine the 25-year peak flow rate (Q) using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52	in	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10	min	(conservative minimum value)
Rainfall Intensity (I) =	9.1	in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70		(typical value for final cover systems)
25-Year Peak Flow Rate (Q) =	CIA	cfs	

	Top Slope (6%)	Perimeter Slope (25%)		
Longest Run =	275	80	ft	(longest sheet flow distance to swale)
Width =	1	1	ft	(unit width of flow)
Area =	0.0063	0.0018	acre	
Q	0.040	0.012	cfs	

2. Calculate the flow depth using Manning's Equation.
 - Rearrange Manning's Equation for wide and shallow flow to calculate flow depth:

$$y = \left(\frac{Qn}{1.49S^{0.5}}\right)^{0.6}$$

Manning's Roughness (n) =		0.03		(typical value for final cover systems)
Slope =	0.06	0.25	ft/ft	(final cover design slopes)
Depth (y) =	0.0325	0.0101	ft	

3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.
 - A permissible non-erodible velocity of 5 ft/sec is typical for vegetated final covers.
 - Refer to page C1-E-7 for soil loss calculations.

V = Q / (y * width)

Sheet flow velocity	**1.24**	**1.16**	**ft/sec**

Summary: Permissible non-erodible velocity is 5.0 ft/sec with vegetated final cover. Therefore, the expected sheet flow velocity is acceptable on the final cover system top and side slopes with vegetation provided.

DRAINAGE SWALE DESIGN

130 Environmental Park
Drainage Swale Analysis - Topslopes

Required: Determine the topslope drainage swale capacity.

Method:

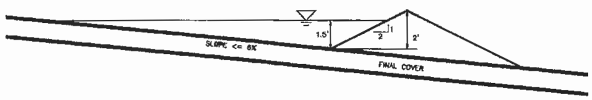
1. Calculate the topslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable topslope drainage area using the Rational Method.
3. Provide the maximum proposed topslope drainage area for comparison.

References:

1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Maxima for Texas*, 2004.

Solution:

1. Calculate flow capacity using Manning's Equation.
 - Swale Characteristics:



Max swale flow depth (D) =	1.50	ft
Running swale slope (S) =	0.5	%
Manning's Roughness (n) =	0.03	
Left slope (LS) =	16.67	:1
Right slope (RS) =	2	:1
Flow Area (A) =	((LS+RS)*D^2)/2	
Wetted Perimeter (WP) =	((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)	
Hydraulic Radius (R) =	A/WP	

Flow Area (A) =	21.000	ft²
Wetted Perimeter (WP) =	28.399	ft
Hydraulic Radius (R) =	0.739	ft

 - Use Manning's Equation to determine the flow velocity in the swale.

Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n

Velocity (V) = 2.872 ft/sec

 - Calculate the swale's flow capacity.

Swale capacity (Q) = V * A

Q = 60.3 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52	in	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10	min	(conservative minimum value)
Rainfall Intensity (I) =	9.1	in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70		(typical value for final cover systems)
25-Year Peak Flow Rate (Q) =	CIA	cfs	

 - Rearrange the Rational Formula to calculate allowable drainage area:

Drainage Area = Q / (CI)

Maximum Allowable Swale Drainage Area = 9.45 acres

3. Provide the maximum proposed topslope drainage area for comparison.

Maximum Proposed Swale Drainage Area = 3.07 acres

Summary: The maximum proposed topslope swale drainage area is 3.07 acres. This is less than the maximum allowable drainage area of 9.45 acres for the proposed swale configuration.

130 Environmental Park
Drainage Swale Analysis - Sideslopes

Required: Determine the sideslope drainage swale capacity.

Method:

1. Calculate sideslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable topslope drainage area using the Rational Method.
3. Provide the maximum proposed sideslope drainage area for comparison.

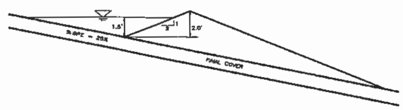
References:

1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Maxima for Texas*, 2004.

Solution:

1. Calculate flow capacity using Manning's Equation.

- Swale Characteristics:



Max swale flow depth =	1.50 ft
Running swale slope =	0.5 %
Manning's Roughness =	0.03
Left slope =	4.00 :1
Right slope =	2 :1
Flow Area (A) =	((LS+RS)*D^2)/2
Wetted Perimeter (WP) =	((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)
Hydraulic Radius (R) =	A/WP

Flow Area (A) =	6.750 ft²
Wetted Perimeter (WP) =	9.539 ft
Hydraulic Radius (R) =	0.708 ft

- Use Manning's Equation to determine the flow velocity in the swale.

Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n

Velocity (V) = 2.789 ft/sec

- Calculate the swale's flow capacity.

Swale capacity (Q) = V * A

Q = 18.8 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

- Rainfall Intensity (I) is calculated as described in the *Hydraulic Design Manual,* I = Pd / tc.
- A minimum time of concentration (tc) of 10 minutes was used for conservatism.
- Rainfall Depth (Pd) was extrapolated for 10 minutes from the *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas.*
- A runoff coefficient (C) of 0.70 is typical for landfill final cover design.

25-Year Rainfall Depth (Pd) =	1.52 in	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	9.1 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for final cover systems)
25-Year Peak Flow Rate (Q) =	CIA cfs	

- Rearrange the Rational Formula to calculate allowable drainage area:

Drainage Area = Q / (CI)

Maximum Allowable Swale Drainage Area = 2.95 acres

3. Provide the maximum proposed sideslope drainage area for comparison.

Maximum Proposed Swale Drainage Area = 1.84 acres

Summary: The maximum proposed sideslope swale drainage area is 1.84 acres. This is less than the maximum allowable drainage area of 2.95 acres for the proposed swale configuration.

DRAINAGE LETDOWN (OR CHUTE) DESIGN

130 Environmental Park
Downchute Calculations

Required: Determine the flow depth and velocity in the downchutes and low-water crossings.

Method: Calculate the flow depth and velocity using Manning's Equation.

Solution: Manning's Equation, Q = 1.486 * R^(2/3) * S^(1/2) * A / n, was used to calculate the flow depth and velocity. See page C1-E-20 for example calculations.

		Chute						Low-Water Crossing						Erosion Protection after Low-Water Crossing					
Chute	Q (cfs)	Width (ft)	Slope (%)	Side Slopes (h:v)	Manning's n	Depth (ft)	Velocity (fps)	Width (ft)	Slope (%)	Side Slopes (h:v)	Manning's n	Depth (ft)	Velocity (fps)	Width (ft)	Slope (%)	Side Slopes (h:v)	Manning's n	Depth (ft)	Velocity (fps)
1	66.3	6	25	4	0.030	**0.56**	**14.26**	12	2	12	0.017	**0.54**	**6.68**	12	24	12	0.025	**0.34**	**12.17**
2	118.8	12	17	4	0.030	**0.62**	**13.27**	30	2	12	0.017	**0.48**	**6.88**	30	25	12	0.025	**0.29**	**12.20**
3	105.2	12	25	4	0.030	**0.52**	**14.48**	24	2	12	0.017	**0.50**	**6.93**	24	25	12	0.025	**0.31**	**12.42**
4	97.7	8	22	4	0.030	**0.63**	**14.70**	20	2	12	0.017	**0.53**	**7.00**	20	25	12	0.025	**0.32**	**12.65**
5	65.4	6	25	4	0.030	**0.56**	**14.20**	12	2	12	0.017	**0.53**	**6.66**	12	25	12	0.025	**0.33**	**12.29**
6	79.0	8	25	4	0.030	**0.54**	**14.36**	16	2	12	0.017	**0.52**	**6.79**	16	26	12	0.025	**0.32**	**12.54**
7	52.2	6	25	4	0.030	**0.49**	**13.25**	12	2	12	0.017	**0.47**	**6.23**	12	25	12	0.025	**0.29**	**11.45**
8	106.1	12	25	4	0.030	**0.52**	**14.52**	24	2	12	0.017	**0.51**	**6.95**	24	25	12	0.025	**0.31**	**12.45**
9	40.4	6	25	4	0.030	**0.43**	**12.22**	12	2	12	0.017	**0.41**	**5.77**	12	25	12	0.025	**0.25**	**10.54**
10	125.0	15	25	4	0.030	**0.51**	**14.52**	30	2	12	0.017	**0.50**	**7.00**	30	25	12	0.025	**0.30**	**12.43**
11	82.6	12	25	4	0.030	**0.45**	**13.33**	24	2	12	0.017	**0.44**	**6.40**	16	25	12	0.025	**0.33**	**12.56**
12	91.1	12	25	4	0.030	**0.48**	**13.78**	24	2	12	0.017	**0.47**	**6.61**	20	25	12	0.025	**0.31**	**12.36**
13	44.8	6	25	4	0.030	**0.45**	**12.63**	12	2	12	0.017	**0.44**	**5.95**	12	25	12	0.025	**0.27**	**10.90**
14	96.3	12	25	4	0.030	**0.49**	**14.05**	24	2	12	0.017	**0.48**	**6.73**	20	25	12	0.025	**0.32**	**12.59**
15	107.8	12	25	4	0.030	**0.52**	**14.60**	24	2	12	0.017	**0.51**	**6.99**	24	25	12	0.025	**0.31**	**12.52**

Notes:

1. Flow rates are calculated based on the 25-year storm event extrapolated from United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.
2. Erosion protection on downchute will be reno mattress or articulating concrete blocks.
   Erosion protection at low-water crossing will be 12-inch-thick concrete.

Erosion Protection at Perimeter Channel Entrance		
Permissible Velocity (fps)	Thickness (in)	Rock Fill Gradation (in)
6	6	3 - 6
12	6 - 10	3 - 6
15	10 - 12	3 - 6
18	12 - 18	4 - 6
22	> 18	5 - 9

130 Environmental Park
Example Flow Depth and Velocity Calculations

Required: Determine the depths and velocities at each comparison point.

Method: Calculate the flow depths and velocities using Manning's Equation.

Solution: Manning's Equation was used to calculate the flow depth and velocity.

Given: Chute 2 and the 25-year, 24-hour flow rate are used for this example.

Comparison Point	Q (cfs)	Width (ft)	Bottom Slope (%)	Side Slopes (h:v)	Manning's n	Depth (ft)	Velocity (fps)
Chute 2	118.8	12	17.00	4.0	0.030	**0.62**	**13.27**

Given Values

Q = Flow rate
W = Bottom width of flow
S = Bottom slope
SS = Side slope
n = Manning's roughness coefficient

Calculated Values

D = Depth of Flow
V = Flow Velocity
Flow Area (A) = (W+SS*D)*D
Wetted Perimeter (WP) = W+2*(D^2+(SS*D)^2)^(0.5)
Hydraulic Radius (R) = A/WP

Manning's Equation
Calculated Flow Rate (Q) = 1.486*R^(2/3)*S^(1/2)*A/n

Depth was varied until the correct flow rate obtained.

Assume D = 0.2000 ft
A = 2.56 sf
WP = 13.65 ft
R = 0.1876
Calculated Q = 17.1 cfs

Assume D = 0.6186 ft
A = 8.95 sf
WP = 17.10 ft
R = 0.5236
Calculated Q = 118.8 cfs

The calculated flow rate matches the given flow rate.

Calculate flow velocity.
Flow Velocity (V) = Q/A
V = 13.27 fps

130 ENVIRONMENTAL PARK

ATTACHMENT C1

APPENDIX C1-F

INTERMEDIATE COVER EROSION AND SEDIMENTATION CONTROL PLAN

Includes pages C1-F-1 through C1-F-10

Technically Complete October 28, 2014

11-6-14

STATE OF TEXAS
T. Traw
108797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

CONTENTS

11-6-14

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NARRATIVE

This appendix presents temporary erosion and sediment control structures for the intermediate cover phase of landfill development. "Temporary", for the purposes of this narrative, is defined as the time between the construction of intermediate cover and the construction of final cover or the placement of additional waste, as the case may be. Intermediate topslope surfaces and external sideslopes, for the purposes of compliance with 30 TAC §330.305(d), are those above-grade slopes that:

a) Drain directly to the site perimeter stormwater management system (i.e., areas where the stormwater directly flows to a perimeter channel or detention pond),

b) Have received intermediate or final cover, and

c) Have either reached their permitted elevation, or will subsequently remain inactive for longer than 180 days.

Slopes that drain to ongoing waste placement, pre-excavated areas, areas that have received only daily cover, or areas under construction that have not received waste are not covered under this appendix and do not contribute to offsite runoff.

EROSION AND SEDIMENT CONTROL LANDFILL COVER PHASES

The purpose of this section is to define the landfill cover phases and where they are addressed throughout the 130 Environmental Park Site Development Plan:

Daily Cover – Daily cover is defined in §330.165(a). Daily cover consists of 6 inches of well compacted earthen material not previously mixed with garbage, rubbish, or other solid waste applied at the end of each operating day. The placement and erosion control practices for daily cover areas are defined in Part IV – Site Operating Plan and in the Best Management Practices Section of this appendix.

Intermediate Cover – Intermediate cover is defined in §330.165(c). Intermediate cover consists of at least 12 inches of suitable earthen material and is graded and maintained to prevent erosion and ponding of water. The placement requirements and erosion control practices for intermediate cover areas are defined in this appendix.

Final Cover – Final cover is defined in Subchapter K. The placement and erosion control practices for final cover areas are defined in Attachment C1, Appendix C1-E. Final cover at 130 Environmental Park will be managed as provided for in the closure and postclosure plan required by 30 TAC 330 Subchapter K, Closure and Post-Closure.

BEST MANAGEMENT PRACTICES

Vegetation and temporary erosion control structures provide the most effective means of reducing the amount of soil loss during operation of the landfill. Best management practices utilized for erosion and sediment control may be broadly categorized as nonstructural and structural controls.

Nonstructural controls addressing erosion include the following:

- Minimization of the disruption of the natural features, drainage, topography, or vegetative cover features
- Phased development to minimize the area of bare soil exposed at any given time
- Disturbing only the smallest area necessary to perform current activities
- Confining sediment to the construction area during the construction phase
- Scheduling of construction activities during the time of year with the least erosion potential, when applicable
- Stabilization of exposed surfaces in a timely manner

Structural controls are preventative and also mitigative since they control erosion and sediment movement. In the event that additional soil stabilization or erosion control measures are deemed necessary, one or more of the following measures will be implemented:

- Vegetative and Non-Vegetative Stabilization. A soil stabilization and vegetation schedule is provided in this appendix.
- Check Dams. Check dams shall be constructed using gravel, rock, gabions, compost socks, or sand bags to reduce flow velocity and therefore erosion in a perimeter channel or detention pond.
- Filter Berms. Filter berms shall be constructed of mulch, woodchips, brush, compost, shredded woodwaste, or synthetic filter materials. Mesh socks shall be filled with compost, mulch, woodchips, brush, or shredded woodwaste. Filter berms or filled mesh socks shall be installed at the bottom of slopes, throughout the perimeter drainage system, and on sideslopes. The maximum drainage area to the filter berm or filled mesh sock will not exceed two acres. Specifications for the filter berms are provided on Drawing C1-F-3, Detail TD11.
- Baled Hay. Hay bales, straw bales, or baled hay shall be approximately 30 inches in length and be composed entirely of vegetable matter. Hay bales shall be embedded in the soil a minimum of four inches.
- Sediment Traps. Sediment traps are small excavated areas that function as sediment basins. Sediment traps allow for the settling of suspended sediment in stormwater runoff. Sediment traps shall be constructed in perimeter channels,

temporary internal channels, and at entrances to detention ponds. The maximum drainage area contributing to a sediment trap will not exceed 10 acres.

- Temporary Sediment Control Fence or Silt Fence. Silt fences or fabric filter fences shall be used where there is sheet flow and sediment transport. The maximum drainage area to the silt fence will not exceed the manufacturer's specification, but will in no case be greater than 0.5 acre per 100 feet of fence. To ensure sheet flow, a gravel collar or level spreader may be used upslope of the silt fence.

- Swales. These structures will be constructed of earthen material with the top six inches capable of sustaining native plant growth. Rolled erosion control mats or blankets made from natural materials or synthetic fiber, grass, or compost/mulch/straw may be used as erosion protection along the flowline. These structures direct the flow to the drainage system. These structures decrease downslope velocities of runoff that could cause erosion on the intermediate cover slopes.

- Letdown Chutes. Letdown chutes are bermed conveyance structures constructed on the intermediate cover slopes. Flow will be directed to the letdown chutes via swales, then conveyed to the perimeter drainage system. The letdown chutes will be lined with an FML geomembrane, turf reinforcement mats, riprap, concrete, gabions, crushed concrete, or stone.

Erosion will be controlled by vegetation on topslopes, sideslopes, and in drainage conveyance structures with flow velocities less than or equal to 5 fps. For drainage conveyance structures with flow velocities greater than 5 fps, turf reinforcement, rock riprap, concrete, gabions, or other appropriate materials will be used for surface reinforcement.

Intermediate cover erosion and sediment control structures are shown on Drawings C1-F-1 through C1-F-4. During site development, both structural and non-structural BMPs will be employed to control erosion.

The potential for wind erosion of the intermediate cover surface will be mitigated through the placement of temporary intermediate cover erosion control measures and establishment of vegetative cover. Temporary erosion control measures include surface roughening, surface wetting, application of tackifiers, or hydromulching the intermediate cover surface.

SOIL STABILIZATION AND VEGETATION SCHEDULE

The soil stabilization and vegetation schedule is as follows:

- Areas that will remain inactive for periods greater than 180 days will receive intermediate cover.

- Intermediate cover on slopes will be stabilized by tracking into the slope. Soil stabilization can be enhanced by mulching, the addition of soil tackifiers, soil treatment, or any combination of these measures. The intermediate cover will be graded to provide positive drainage.

- Temporary erosion control structures will be installed within 180 days from when intermediate cover is constructed.

- The intermediate cover area will be seeded or sodded as soon as practical, following placement of intermediate cover and will be documented in the site operating record. All intermediate cover areas will be managed to control erosion and achieve a predicted soil loss of less than 50 tons per acre per year. A 60 percent vegetative cover will be established over the intermediate cover areas within 180 days from intermediate cover construction unless prevented by climatic events (e.g., drought, rainfall, etc.). Additional temporary erosion control measures will be implemented during these events to promote establishment of vegetative cover.

- Mulch, woodchips, or compost may be used as a layer placed over the intermediate cover to protect the exposed soil surface from erosive forces and conserve soil moisture until vegetation can be established. The mulch, woodchips, or compost will be used to stabilize recently graded or seeded areas. The mulch, woodchips, or compost will be spread evenly over a recently seeded area and tracked into the surface to protect the soil from erosion and moisture loss, if required to promote the establishment of vegetation. These materials are not required for the establishment of vegetation on the intermediate cover; however, they may be used if 130 Environmental Park determines they are needed to promote vegetative growth or to provide additional erosional stability to the intermediate cover surface. These materials will vary in thickness but will not be placed to a thickness to inhibit vegetative growth.

- The intermediate cover and temporary erosion control structures will be maintained as detailed in the Stormwater System Maintenance Plan.

- Final cover will be constructed as the site develops. Temporary erosion control features will be removed as permanent erosion control structures are constructed.

STORMWATER SYSTEM MAINTENANCE PLAN

130 Environmental Park will restore and repair temporary stormwater systems such as channels, drainage swales, chutes, and flood control structures in the event of wash-out or failure. In addition, the BMPs discussed in this appendix will also be replaced or repaired in the event of failure. Excessive sediment will be removed, as needed, so that the drainage structures function as designed. Site inspections by facility personnel will be performed weekly or within 48 hours of a rainfall event of 0.5 inches or more. The final cover system and the erosion sediment control structures will be maintained throughout the site life and postclosure period.

The following items will be evaluated during the inspections:

- Erosion of intermediate cover areas, perimeter ditches, temporary chutes, swales, detention ponds, berms, and other drainage features
- Settlement of intermediate cover areas, final cover areas, perimeter ditches, chutes, swales, and other drainage features
- Silt and sediment build-up in perimeter ditches, chutes, swales, and detention ponds
- Presence of ponded water on intermediate cover or behind temporary erosion control structures
- Obstructions in drainage features
- Presence of erosion or sediment discharge at offsite stormwater discharge locations
- Temporary erosion and sediment control features

Maintenance activities will be performed to correct damaged or deficient items noted during the site inspections. These activities will be performed as soon as possible after the inspection. The time frame for correction of damaged or deficient items will vary based on weather, ground conditions, and other site-specific conditions.

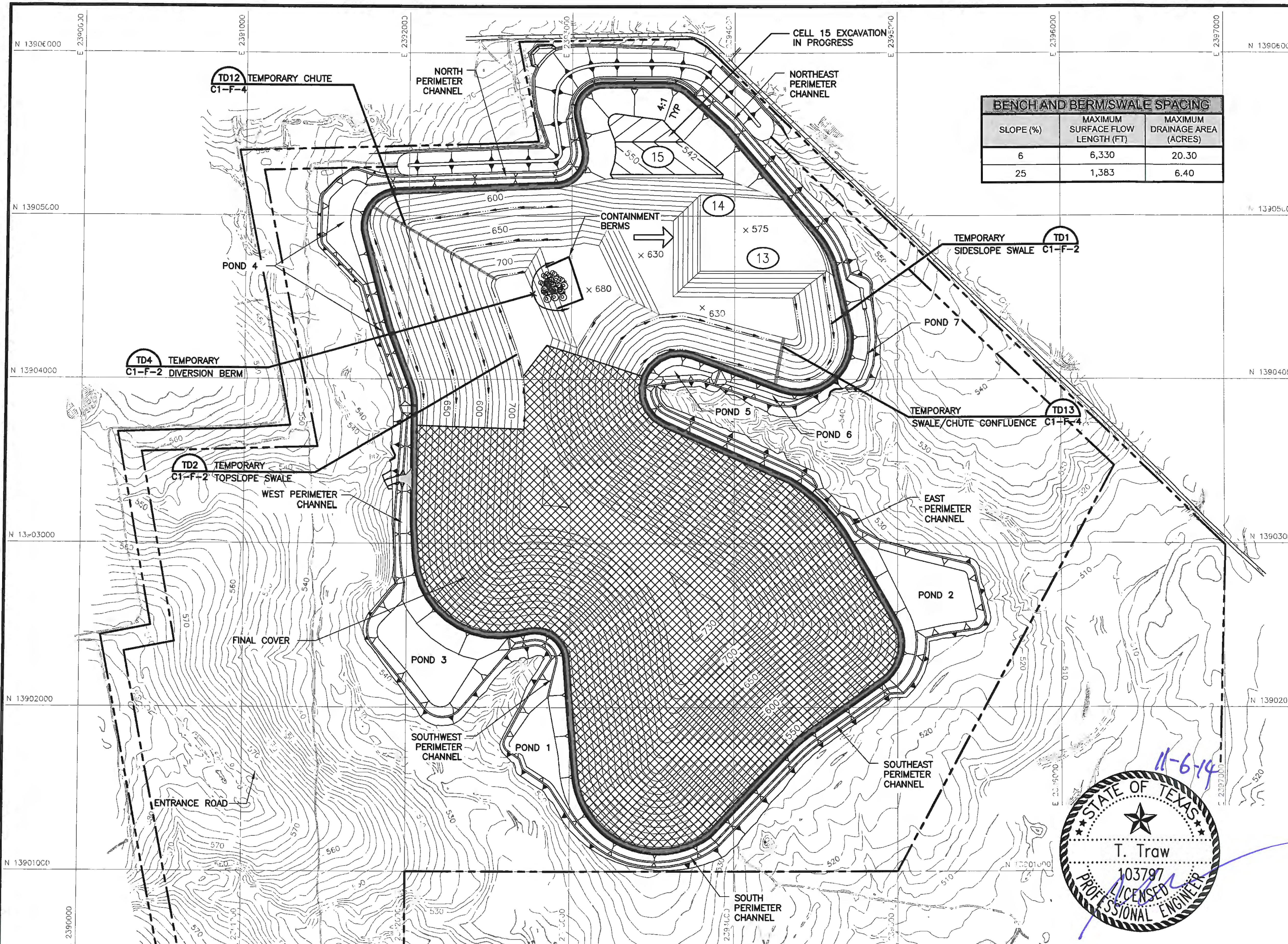
Maintenance activities will consist of the following, as needed:

- Placement of additional temporary or permanent vegetation
- Placement, grading, and stabilization of additional soils in eroded areas or in areas which have settled
- Replacement of riprap or other structural lining
- Removal of obstructions from drainage features
- Removal of silt and sediment build-up from the temporary erosion control structures
- Removal of ponded water on the intermediate cover or behind temporary erosion control structures
- Repairs to erosion and sedimentation controls
- Installation of additional erosion and sedimentation controls

Documentation and training requirements are discussed below:

- Site inspections by facility personnel will be performed weekly or within 48 hours of a rainfall event of 0.5 inches or more.

- Documentation of the inspection will be included in the site operating record.
- Documentation of maintenance activities that were performed to correct damaged or deficient items noted during the site inspections will be included in the site operating record.
- Facility personnel will be trained to perform inspections, and to install and maintain temporary erosion control structures.



BENCH AND BERM/SWALE SPACING

SLOPE (%)	MAXIMUM SURFACE FLOW LENGTH (FT)	MAXIMUM DRAINAGE AREA (ACRES)
6	6,330	20.30
25	1,383	6.40

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- 510 EXISTING CONTOUR
- N 13903000 STATE PLANE GRID
- DRAINAGE SWALE
- 13 CELL DESIGNATION
- DIRECTION OF FILL
- 630 x APPROXIMATE TOP OF WASTE SPOT ELEVATION
- APPROXIMATE LIMITS OF FINAL COVER

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.
2. THIS PLAN REPRESENTS GENERAL CONDITIONS FOR INTERMEDIATE COVER EROSION CONTROLS AND MAY NOT REFLECT THE EXACT CONFIGURATION OF THE LANDFILL OR LOCATION OF TEMPORARY CONTROLS.
3. THE TEMPORARY STORMWATER RUN-OFF CONTROL SYSTEM WILL CONSIST OF CONTAINMENT AND DIVERSION BERMS LOCATED AT THE ACTIVE FACE, SWALES, LETDOWNS, DIVERSION CHANNELS, AND SEDIMENT TRAPS.
4. ADDITIONAL EROSION CONTROL STRUCTURES (i.e. SEDIMENT TRAPS, CHECK DAMS, HAY BALES) WILL BE CONSTRUCTED AT THE LETDOWN DRAINAGE POINT.
5. THE BENCH AND BERM SWALE SPACING TABLE PROVIDES MAXIMUM SPACING AND DRAINAGE AREAS FOR TYPICAL BENCH AND BERM/SWALE CONFIGURATION. THE DESIGN CALCULATIONS ARE PRESENTED IN APPENDIX C1-G.
6. THE TEMPORARY INTERMEDIATE COVER EROSION CONTROL FEATURE ARE SHOWN AS EXAMPLES. ACTUAL EROSION CONTROL FEATURES WILL VARY BASED ON LANDFILL DEVELOPMENT AND ABILITY OF FACILITY TO ESTABLISH STABILIZED INTERMEDIATE SLOPES WITH VEGETATION.

11-6-14

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INTERMEDIATE COVER EROSION FEATURES

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817-563-1144

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

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DSN. CRH	DATE : 02/14	DRAWING
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CHK. TLT	DWG : C1-F-1.dwg	

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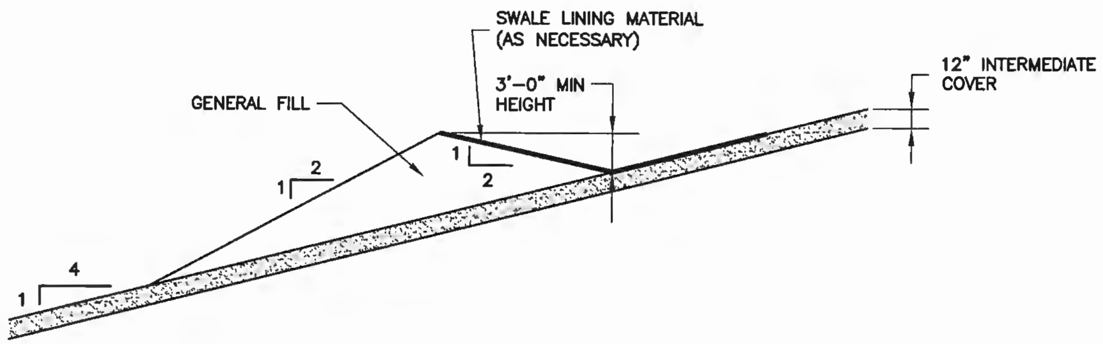
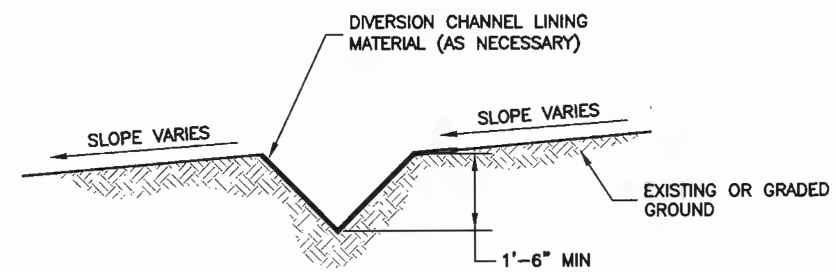
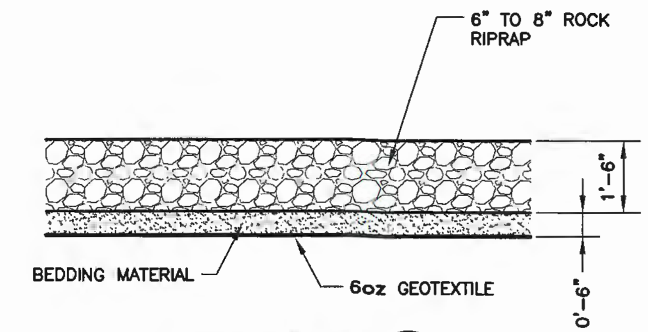


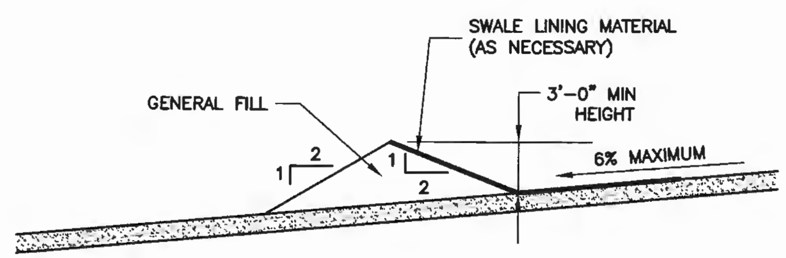
TEMPORARY SIDESLOPE SWALE (TD1 / C1-F-2)
NTS



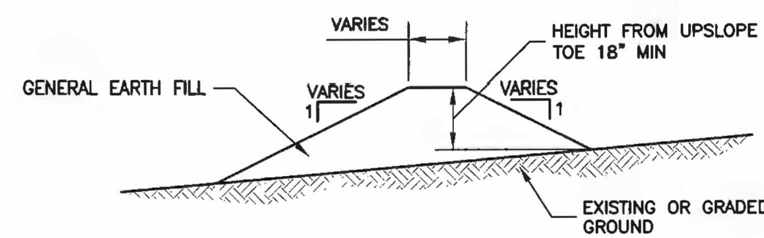
TEMPORARY DIVERSION CHANNEL (TD3 / C1-F-2)
NTS



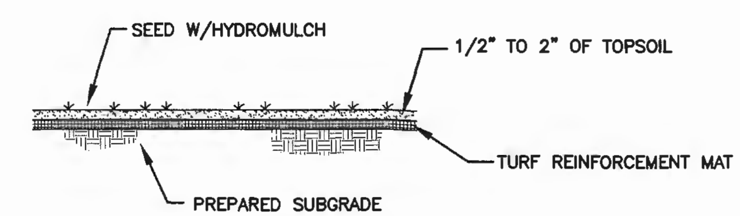
ROCK RIPRAP (TD5 / C1-F-2)
NTS



TEMPORARY TOPSLOPE SWALE (TD2 / C1-F-2)
NTS



TEMPORARY DIVERSION BERM (TD4 / C1-F-2)
NTS



TEMPORARY TURF REINFORCEMENT MATTING (TD6 / C1-F-2)
NTS

NOTE:

1. LINING MATERIAL FOR THE TEMPORARY DRAINAGE SWALES OR THE TEMPORARY DIVERSION CHANNEL, IF NECESSARY, WILL BE TURF REINFORCEMENT MATTING OR OTHER SUITABLE MATERIALS.

TEMPORARY EROSION CONTROL STRUCTURES

1. TEMPORARY EROSION CONTROL STRUCTURE DETAILS DEPICT VARIOUS TYPES OF EROSION CONTROL FEATURES FOR CURRENT AND FUTURE DEVELOPMENT.
2. ALL TEMPORARY EROSION CONTROL STRUCTURES SHOWN MAY NOT BE CONSTRUCTED DEPENDING ON SITE CONDITIONS.
3. LANDFILL WILL SELECT EROSION CONTROL DETAILS TO BE USED FOR SITE SPECIFIC CONDITIONS.
4. ACTUAL DIMENSIONS OF TEMPORARY EROSION CONTROL STRUCTURES MAY VARY BASED ON SITE CONDITIONS.

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TEMPORARY EROSION CONTROL STRUCTURES

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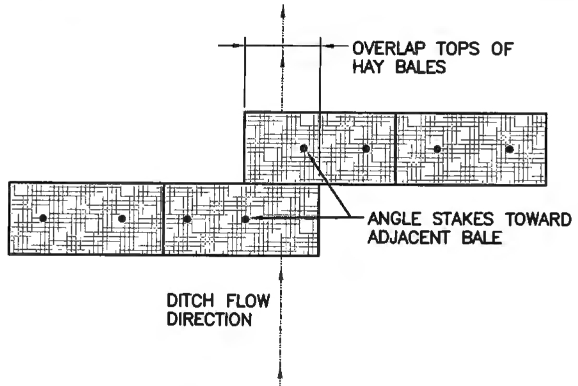
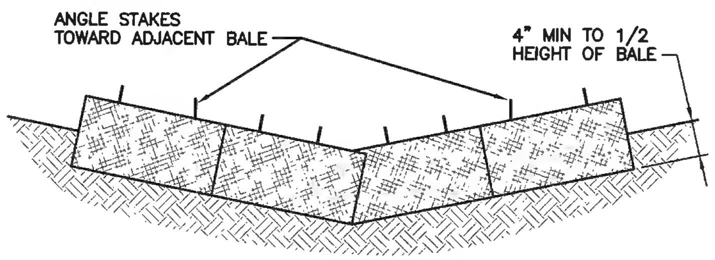


PLAN VIEW



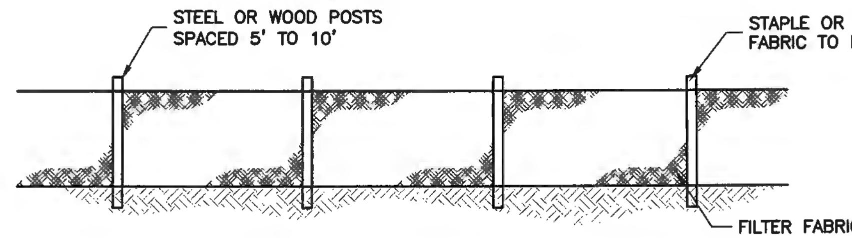
PROFILE VIEW

BALED HAY FOR EROSION CONTROL (TD7)

NTS C1-F-3

NOTE:

1. HAY BALES SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF 4" AND WHERE POSSIBLE 1/2 THE HEIGHT OF THE BALE.

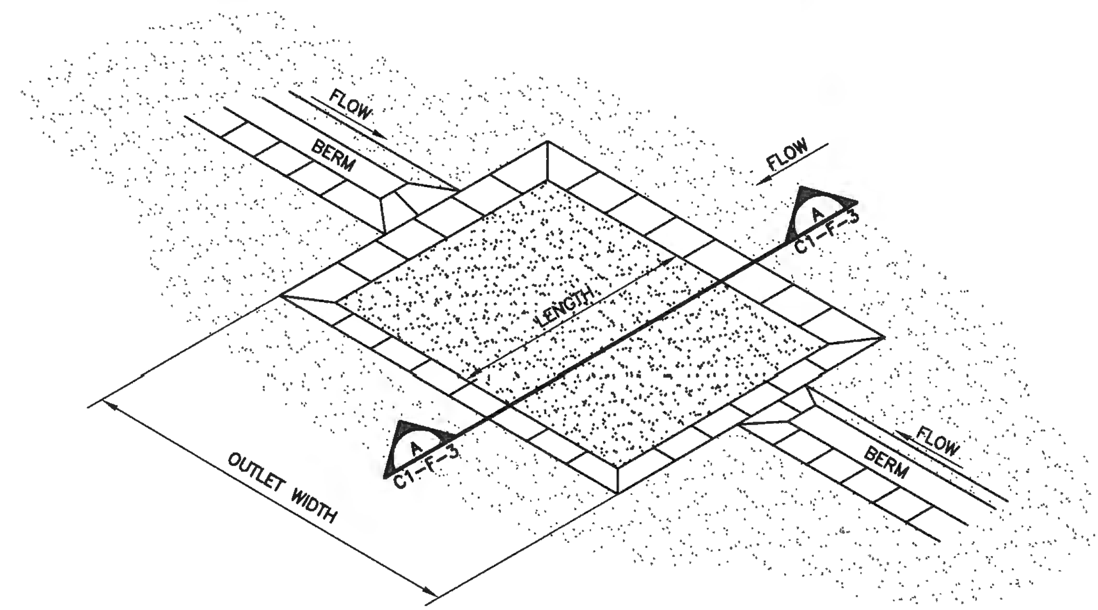


TEMPORARY SEDIMENT CONTROL (SILT) FENCE (TD9)

NTS C1-F-3

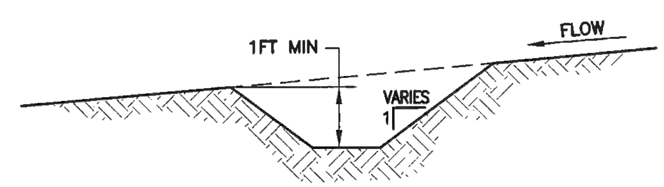
NOTES:

1. MAXIMUM DRAINAGE AREA TO THE FENCE SHOULD NOT EXCEED THE MANUFACTURER'S SPECIFICATION BUT IN NO CASE BE GREATER THAN 0.5 ACRE PER 100 FEET OF FENCE.
2. TO ENSURE SHEET FLOW, A GRAVEL COLLAR OR LEVEL SPREADER MAY BE USED UPSLOPE OF THE SILT FENCE.



SEDIMENT TRAP PLAN

NTS



SEDIMENT TRAP SECTION (A-A)

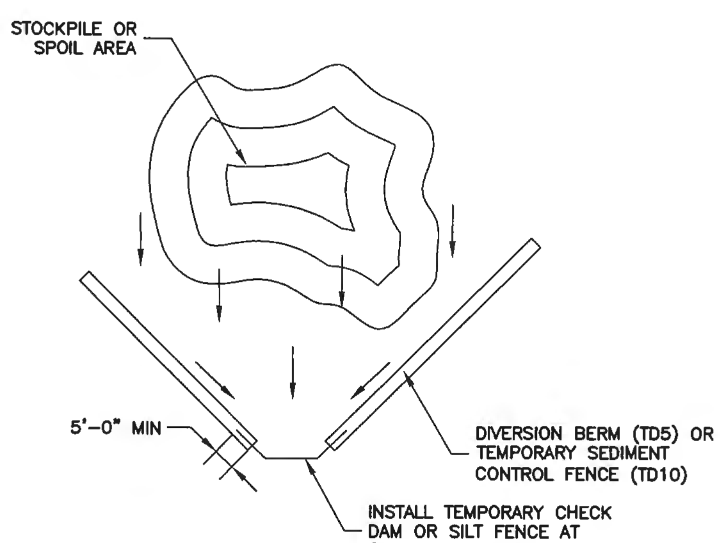
NTS C1-F-3

SEDIMENT TRAP (TD10)

NTS C1-F-3

NOTE:

1. OUTLET INTO STABILIZED AREA (VEGETATION, ROCK, ETC.)
2. THE MAXIMUM AREA CONTRIBUTING TO A SEDIMENT TRAP SHOULD BE LESS THAN 10 ACRES.

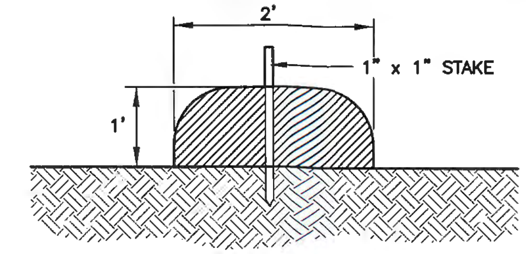


STOCKPILE EROSION CONTROL (TD8)

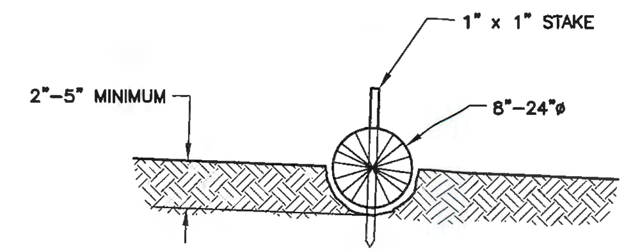
NTS C1-F-3

NOTE:

1. CONSTRUCT DIVERSION DIKE TO DIVERT STORMWATER RUN-OFF FROM STOCKPILE OR SPOIL AREA THROUGH CHECK DAM, HAY BALES, OR SILT FENCE.



OPTION 1



OPTION 2

FILTER BERM (TD11)

NTS C1-F-3

NOTES:

1. FILTER BERMS MAY BE CONSTRUCTED OF MULCH, WOODCHIPS, BRUSH, COMPOST, SHREDDED WOODWASTE, OR SIMILAR MATERIALS.
2. FILTER BERMS MAY ALSO CONSIST OF MESH SOCKS FILLED WITH MULCH, WOODCHIPS, BRUSH, COMPOST, SHREDDED WOODWASTE, OR SIMILAR MATERIALS.
3. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND THE COMPOST FILTER BERM.
4. STAKES WILL BE PLACED 2"-5" DEEP.
5. MAXIMUM DRAINAGE AREA TO THE FILTER BERM SHOULD NOT EXCEED 2 ACRES.

TEMPORARY EROSION CONTROL STRUCTURES

1. TEMPORARY EROSION CONTROL STRUCTURE DETAILS DEPICT VARIOUS TYPES OF EROSION CONTROL FEATURES FOR CURRENT AND FUTURE DEVELOPMENT.
2. ALL TEMPORARY EROSION CONTROL STRUCTURES SHOWN MAY NOT BE CONSTRUCTED DEPENDING ON SITE CONDITIONS.
3. LANDFILL WILL SELECT EROSION CONTROL DETAILS TO BE USED FOR SITE SPECIFIC CONDITIONS.
4. ACTUAL DIMENSIONS OF TEMPORARY EROSION CONTROL STRUCTURES MAY VARY BASED ON SITE CONDITIONS.

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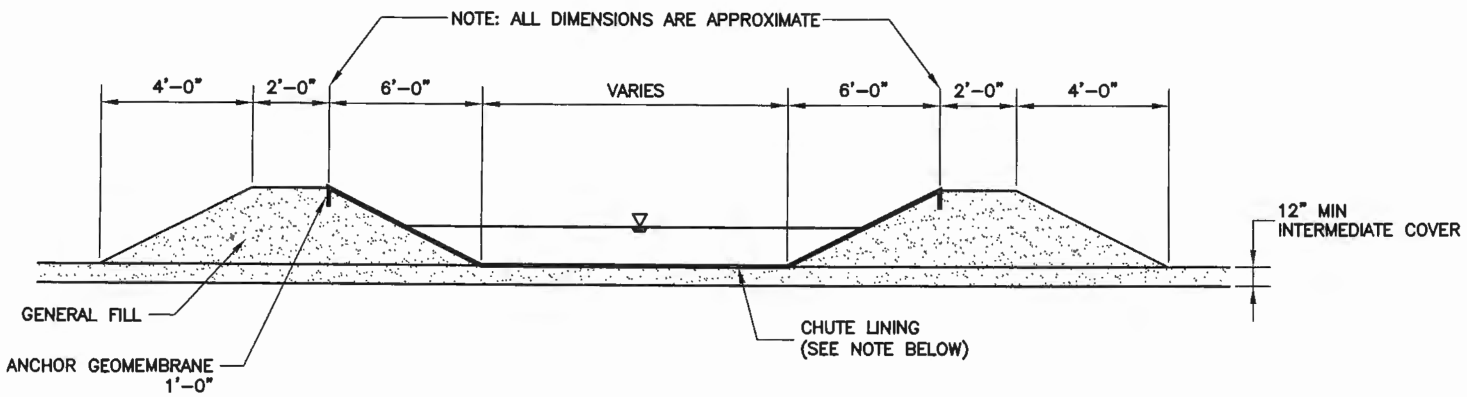
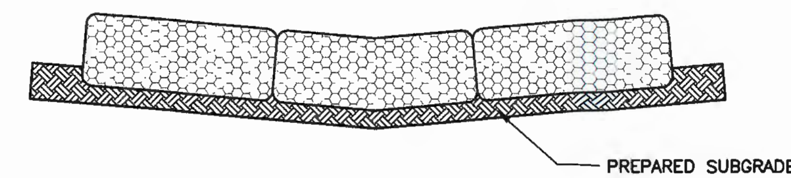


TEMPORARY CHUTE LETDOWN (TD12 / C1–F–4)

NTS

NOTE:

1. CHUTE LINING WILL CONSIST OF ONE OF THE FOLLOWING: TURF REINFORCEMENT, SACRIFICIAL GEOMEMBRANE, GABIONS, ROCK RIPRAP, CONCRETE, CRUSHED CONCRETE, OR STONE.

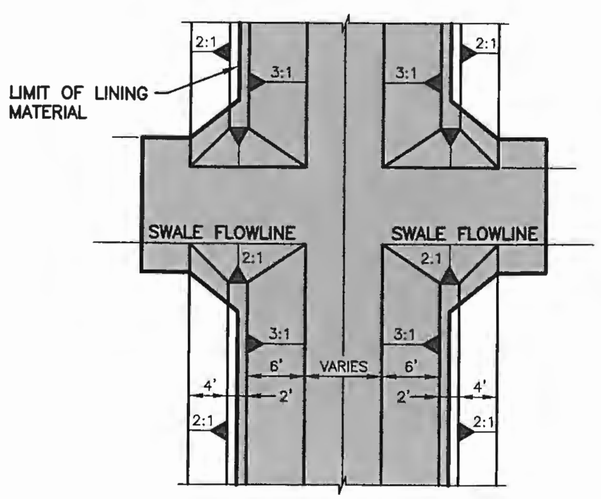


CHECK DAM (TD14 / C1–F–4)

NTS

NOTES:

1. CHECK DAM MAY BE CONSTRUCTED USING GRAVEL, ROCK, GABIONS, COMPOST SOCKS, OR SAND BAGS.
2. CHECK DAM MAY BE PLACED ON PREPARED SUBGRADE OR BEDDING MATERIAL ALONG THE CONTOUR AT 0% GRADE OR AS NEAR AS POSSIBLE.
3. TOP WIDTH OF CHECK DAM SHALL BE TWO FEET MINIMUM.
4. SIDESLOPES OF CHECK DAM 2H:1V OR FLATTER.
5. CHECK DAM MAY BE USED WHEN CONTRIBUTING DRAINAGE AREAS ARE LESS THAN 10 ACRES. MULTIPLE CHECK DAMS MAY BE INSTALLED IF DRAINAGE AREAS ARE GREATER THAN 10 ACRES.
6. CHECK DAMS SHOULD BE USED WHEN THE VOLUME OF RUNOFF IS TOO GREAT FOR OTHER EROSION CONTROL FEATURES (i.e. SILT FENCES, HAY BALES).



SWALE/CHUTE CONFLUENCE (TD13 / C1–F–4)

NTS

TEMPORARY EROSION CONTROL STRUCTURES

1. TEMPORARY EROSION CONTROL STRUCTURE DETAILS DEPICT VARIOUS TYPES OF EROSION CONTROL FEATURES FOR CURRENT AND FUTURE DEVELOPMENT.
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130 ENVIRONMENTAL PARK

ATTACHMENT C1

APPENDIX C1-G

INTERMEDIATE COVER EROSION CONTROL STRUCTURE DESIGN

Includes pages C1-G-1 through C1-G-27

Technically Complete October 28, 2014

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

CONTENTS

11-6-14

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Firm Registration No. F-834

NARRATIVE

This appendix presents the supporting documentation to evaluate and design temporary erosion and sediment control structures for the intermediate cover phase of landfill development.

INTERMEDIATE COVER PLAN

As intermediate cover is constructed, temporary chutes and swales will be constructed to prevent erosion and sedimentation. Erosion control features (i.e., filter berms, rock check dams, hay bales, or equivalent) may be constructed at the toe of filled areas to minimize erosion and prevent disturbance of the existing grassed slopes. Otherwise, temporary erosion and sediment control features will be installed within 180 days from when the intermediate cover is constructed. An existing conditions summary and Best Management Practices are included in Appendix C1-F. Example intermediate cover drainage calculations are included in this appendix for use in site operations.

INTERMEDIATE COVER EVALUATION

The intermediate cover evaluation is based on the Universal Soil Loss Equation (USLE) following Natural Resource Conservation Service (NRCS) procedures. The evaluation is based on a 12-inch thick intermediate cover layer with 60 percent vegetated cover. Calculations for the soil loss for intermediate cover on external 6 percent and 25 percent slopes have been provided on pages C1-G-6 through C1-G-7.

SHEET FLOW DESIGN

The sheet flow calculations are presented for external 6 percent and 25 percent slope configurations. The permissible non-erodible velocities should be less than 5 ft/sec (clayey soil) or 4 ft/sec (sandy soil) on vegetated intermediate cover. The Manning's Equation and Rational Method were used to calculate sheet flow velocity.

TEMPORARY DRAINAGE SWALE DESIGN

The temporary drainage swales are designed for typical drainage areas and flowline slopes. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and swale capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

TEMPORARY DIVERSION CHANNEL DESIGN

The temporary diversion channels are designed for typical drainage areas and flowline slopes. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and diversion channel capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

TEMPORARY DRAINAGE LETDOWN DESIGN

The temporary drainage letdowns are designed for typical drainage areas on a 25 percent external side slope. The procedures in the TxDOT Hydraulic Design Manual, October 2011, were used to determine peak flow, flow depth, flow velocity, and letdown capacity. The Rational Method and the Manning's Equation were used to calculate the design parameters.

INTERMEDIATE COVER EVALUATION

INTERMEDIATE COVER EVALUATION

SOIL LOSS

This section presents the supporting documentation for evaluation of the potential for intermediate cover soil erosion loss at 130 Environmental Park. The evaluation is based on the premise of adding excess soil to increase the time required before maintenance is needed as recommended in the EPA Solid Waste Disposal Facility Criteria Technical Manual (EPA 530-R-93-017, November 1993).

The design procedure is as follows:

1. Minimum thickness of the intermediate cover is evaluated based on the maximum soil loss of 50 tons per acre per year.

	6% Slope	**25% Slope**
Maximum Sheet Flow Length	140 ft	200 ft
Soil Loss	1.20 tons/acre/year	22.67 tons/acre/year

2. Soil loss is calculated using the Universal Soil Loss Equation (USLE) by following NRCS procedures. The soil loss is based on 60 percent vegetative cover as recommended in the TNRCC, *Use of the Universal Soil Loss Equation in Final Cover/Configuration Design Procedural Handbook* (October 1993). These calculations are provided on pages C1-G-6 and C1-G-7.

3. Sheet flow velocities for a 25-year storm event are calculated to be less than permissible non-erodible velocities. The supporting calculations are presented on page C1-G-13.

4. Temporary vegetation for the intermediate cover areas will be native and introduced grasses with root depths of six inches to eight inches.

5. Native and introduced grasses will be hydroseeded, drill seeded, or broadcast seeded with fertilizer on the disked (parallel to contours) intermediate cover layer as soon as practical following placement of intermediate cover and will be documented in the site operating record. All intermediate cover areas will be managed to control erosion and achieve a predicted soil loss of less than 50 tons per acre per year. Temporary erosion and sediment control features (including at least 60 percent vegetative cover) will be installed within 180 days from when the intermediate cover is constructed. Areas that experience erosion or do not readily vegetate will be reseeded and additional temporary erosion control measures will be implemented until vegetation is established or the soil will be replaced with soil that will support the grasses.

SHEET FLOW VELOCITY

The sheet flow velocity calculations are presented for external 6 percent and 25 percent slope configurations. The procedures outlined in the TxDOT Hydraulic Manual were used to determine velocities. Maximum sheet flow lengths for all three conditions were evaluated. Calculations are provided on page C1-G-13.

130 Environmental Park
Intermediate Cover Erosion Loss Evaluation

Required: 1. Determine the erosion loss for the intermediate cover design based on a maximum soil loss of 50 tons/acre/year.

Method: Expected soil loss is calculated using the Universal Soil Loss Equation.

References:

1. Schwab, Glen O., *Soil and Water Conservation Engineering, 3rd Ed.,* 1981.
2. Texas Department of Transportation, *Hydraulic Design Manual,* March 2004.
3. United States Soil Conservation Service, *Hydrology for Small Watersheds,* December 1989.
4. United States Soil Conservation Service, *Predicting Rainfall Erosion Losses, Guidebook 537*, 1978

Solution: Annual Soil Loss in tons/acre/year (A) = RKLSCP

Design Parameters	External Top Slope (6%)	External Side Slope (25%)	
Rainfall Factor (R) =	288	288	(Caldwell County)
Soil Erodibility Factor (K) =	0.25	0.25	(Sandy Clay Loam)
Longest Run =	140	200	ft
Slope =	6	25	%
Topographic Factor (LS) =	0.80	8.33	
Crop Management Factor (C) =	0.042	0.042	(60% vegetative cover)
Erosion Control Practice Factor (P) =	0.50	0.90	(Contouring)
Soil Loss (A) =	1.20	22.67	tons/acre/year

Summary: As noted in the permit drawings, the intermediate cover will be a minimum of 12 inches thick. As shown above, the maximum soil loss is 22.67 tons/acre/year, which is less than the maximum allowable soil loss of 50 tons/acre/year.

130 Environmental Park
Intermediate Cover LS Factor Calculations

Required: 1. Determine the Length/Slope Factor based on slope length and slope gradient.

References: 1. TNRCC, *Use of the Universal Soil Loss Equation in Final Cover/Configuration Design Procedural Handbook,* October 1993.

Solution: Length/Slope Factor (LS) = $(L / 72.6)^m * (65.41*\sin^2 \upsilon + 4.56 * \sin \upsilon + 0.065)$

LS = Length/Slope Factor
L = Slope Length (ft)
υ = Slope (radians)
m = Exponent dependent on the slope gradient

m = 0.2 for S <= 1.0%
0.3 for 1.0% < S <= 3.5%
0.4 for 3.5% < S < 5.0%
0.5 for S => 5.0%

Length, L (ft)	Slope, S %	Slope, S (ft/ft)	υ (radians)	υ (degrees)	m	LS
140	6	0.06	0.060	3.434	0.5	0.80
200	25	0.25	0.245	14.036	0.5	8.33

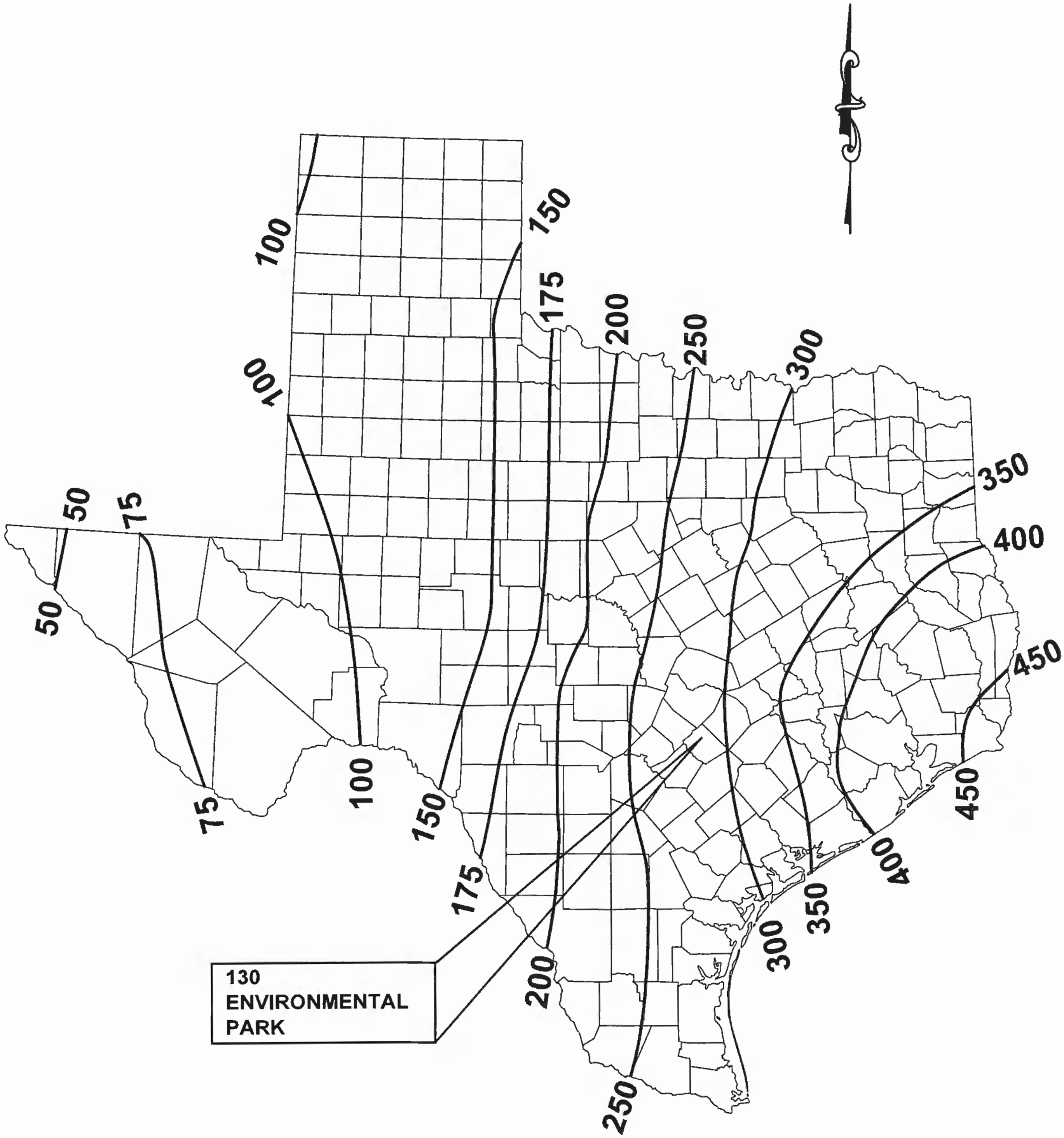

FIGURE 1 - AVERAGE ANNUAL VALUES OF THE RAINFALL EROSION INDEX

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Table 1: Approximate Values of Factor K for USDA Textural Classes

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Texture Class	Organic Matter Content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Fine Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.32	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	0.32	0.26
Sandy Clay	0.14	0.13	0.12
Silty Clay	0.25	0.23	0.19
Clay	0.13 - 0.29		

The values shown are estimated averages of broad ranges of specific soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

Table 2: Factor C for Permanent Pasture, Range, and Idle Land[1]

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Vegetative Canopy		Cover that Contacts the Soil Surface					
Type and Height[2]	Percent Cover[3]	Percent Ground Cover					
		0	20	40	60	80	95+
No Appreciable Canopy		0.45	0.20	0.10	0.042	0.013	0.003
Tall weeds or short brush with average drop fall height of 20 in.	25	0.36	0.17	0.09	0.038	0.013	0.011
	50	0.26	0.13	0.07	0.035	0.012	0.003
	75	0.17	0.10	0.06	0.032	0.011	0.003

Extracted from: United States Department of Agriculture, AGRICULTURE HANDBOOK NUMBER 537

[1] The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 feet.

[3] Portions of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's eye view).

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Table 3: P Factors for Contouring, Contour Stripcropping and Terracing

Reproduced from: Ponce, Victor M., *Engineering Hydrology Principles and Practices, 1st Ed.*, 1989.

VALUES OF EROSION-CONTROL-PRACTICE FACTOR *P*[1]				
Land Slope (percent)	For Farm Planning		For Computing Sediment Yield[2]	
	Contour Factor[3]	Strip Crop Factor	Graded Channels, Sod Outlets	Steep Backslope, Underground Outlets
1-2	0.60	0.30	0.12	0.05
3-8	0.50	0.25	0.10	0.05
9-12	0.60	0.30	0.12	0.05
13-16	0.70	0.35	0.14	0.05
17-20	0.80	0.40	0.16	0.06
21-25	0.90	0.45	0.18	0.06

[1]Slope length is the horizontal terrace interval. The listed values are for contour farming. No additonal contour factor is used in the computation.

[2]These values include entrapment effeciency and are used for the control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

[3]Use these values for control of interterrace erosion within specified soil-loss tolereances.

Table 4: Guide for Assigning Soil Loss Tolerance Values (T)
to Solid Having Different Rooting Depths

Reproduced from: Texas Natural Resource Conservation Commission, Municipal Solid Waste Division, Use of the Universal Soil Loss Equation in Final Cover/Configuration Design: Procedural Handbook, 1993.

Rooting Depth	Soil Loss Tolerance Values Annual Soil Loss (Tons/Acre)	
Inches	Renewable Soil a/	Renewable Soil b/
0 - 10	1	1
10 - 20	2	1
20 - 40	3	2
40 - 60	4	3
60	5	4

(This table appeared in SCS (6), p.4)

a/ Soil with favorable substrata that can be renewed by tillage, fertilizer, organic matter, and other management practices. This column does not represent MSWLF final covers under normal conditions.

b/ Soil with unfavorable substrata such as rock or soft rock that cannot be renewed by economical means. Most of the MSWLF covers with constructed clay cap and/or flexible membrane should use this performance criteria.

SHEET FLOW

130 Environmental Park
Intermediate Cover Sheet Flow Velocity

Required: Determine the sheet flow velocity for the intermediate cover design and compare to the permissible non-erodible flow velocity.

Method:
1. Determine the 25-year peak flow rate using the Rational Method.
2. Calculate flow depth using Manning's Equation.
3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.

References:
1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:
1. Determine the 25-year peak flow rate (Q) using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52		(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10	min	(conservative minimum value)
Rainfall Intensity (I) =	9.1	in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70		(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA	cfs	

	External Top Slope (6%)	External Side Slope (25%)		
Longest Run =	140	200	ft	(longest sheet flow distance to swale)
Width =	1	1	ft	(unit width of flow)
Area =	0.0032	0.0046	acre	
Q	0.021	0.029	cfs	

2. Calculate the flow depth using Manning's Equation.
   - Rearrange Manning's Equation for wide and shallow flow to calculate flow depth:

$$y = (Qn/1.49S^{0.5})^{0.6}$$

Manning's Roughness (n) =	0.03		(typical value for intermediate cover)

Slope =	0.06	0.25	ft/ft
Depth (y) =	0.022	0.018	ft

3. Calculate sheet flow velocity and compare to permissible non-erodible velocity.
   - A permissible non-erodible velocity of 5 ft/sec (clayey soil) or 4 ft/sec (sandy soil) is typical for vegetated intermediate covers. Refer to page C1-G-6 for soil loss calculations.

	V = Q / (y * width)		
Sheet flow velocity	**0.95**	**1.67**	**ft/sec**

Summary: The permissible non-erodible velocity should be less than 5.0 ft/sec (clayey soil) or 4.0 ft/sec (sandy soil) on vegetated intermediate cover. Therefore, the expected sheet flow velocity is acceptable on the external intermediate cover slopes with 60% vegetative cover.

TEMPORARY DRAINAGE SWALE DESIGN

TEMPORARY DRAINAGE SWALE DESIGN

The temporary drainage swale design for intermediate cover areas is presented for the typical swale flowline of 0.5 percent. The procedures in the TxDOT Hydraulic Design Manual were used to determine peak flow, flow depth, flow velocity, and swale capacity. The temporary swales will be located on the intermediate cover to prevent erosion as follows:

Slope (%)	Maximum Sheet Flow Length (ft)	Maximum Drainage Area (acres)	Maximum Swale Length (ft)
6	140	20.3	6,330
25	200	6.4	1,383

All temporary swales shall be designed to minimize erosion and provide a maximum flow depth of two feet. The total height of the swales at the flowline is a minimum of three feet, as depicted in Appendix C1-F on page C1-F-7 and Attachment C1-F-2, Detail TD1. As noted in the calculations, the velocities in the swales are less than permissible non-erodible velocities. If sustained erosion is observed, facility management will evaluate and construct additional temporary drainage swales. Example drainage swale calculations for a grassed intermediate cover are provided on pages C1-G-16 and C1-G-17.

TEMPORARY DIVERSION CHANNEL DESIGN

The temporary diversion channel design for diverting surface water runon around excavations is presented for three typical slopes of 0.5 percent, 1 percent and 2 percent and three typical drainage areas of 1, 5, and 10 acres. The procedures in the TxDOT Hydraulic Design Manual were used to determine peak flow, flow depth, flow velocity, and diversion channel capacity. Temporary diversion channels will be designed to minimize erosion and sedimentation.

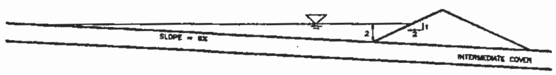
130 Environmental Park
Drainage Swale Analysis - External Intermediate Cover Topslopes

Required: Determine the intermediate cover topslope drainage swale capacity.

Method:
1. Calculate the intermediate cover topslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable topslope drainage area using the Rational Method.
3. Determine the maximum swale length based on the maximum sheet flow length.

References:
1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:
1. Calculate flow capacity using Manning's Equation.
- Swale Characteristics:



Max swale flow depth =	2.00 ft
Running swale slope =	0.5 %
Manning's Roughness =	0.03
Left slope =	16.67 :1
Right slope =	2 :1
Flow Area (A) =	((LS+RS)*D^2)/2
Wetted Perimeter (WP) =	((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)
Hydraulic Radius (R) =	A/WP

Flow Area (A) =	37.333
Wetted Perimeter (WP) =	37.865
Hydraulic Radius (R) =	0.986

- Use Manning's Equation to determine the flow velocity in the swale.

Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n

Velocity (V) = 3.479 ft/sec

- Calculate the swale's flow capacity.

Swale capacity (Q) = V * A

Q = 129.9 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	9.1 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA cfs	

Rearrange the Rational Formula to calculate allowable drainage area:

Drainage Area = Q / (CI)

Maximum Swale Drainage Area = 20.3 acres

3. Determine the maximum swale length based on the maximum sheet flow length.

Maximum Sheet Flow Length = 140 ft

$$\text{Maximum Swale Length} = \frac{\text{Maximum Swale Drainage Area} * 43560}{\text{Maximum Sheet Flow Length}}$$

Maximum Swale Length = 6330 ft

Summary: The maximum sheet flow length will be 140 feet and maximum drainage area is 20.3 acres. The calculated velocity is less than the permissible non-erodible velocity.

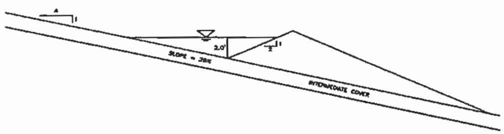
130 Environmental Park
Drainage Swale Analysis - External Intermediate Cover Sideslopes

Required: Determine the intermediate cover sideslope drainage swale capacity.

Method:
1. Calculate the intermediate cover sideslope swale's flow capacity using Manning's Equation.
2. Determine the maximum allowable sideslope drainage area using the Rational Method.
3. Determine the maximum swale length based on the maximum sheet flow length.

References:
1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Maxima for Texas*, 2004.

Solution:
1. Calculate flow capacity using Manning's Equation.
- Swale Characteristics:



Max swale flow depth = 2.00 ft
Running swale slope = 0.5 %
Manning's Roughness = 0.03
Left slope = 4.00 :1
Right slope = 2 :1
Flow Area (A) = ((LS+RS)*D^2)/2
Wetted Perimeter (WP) = ((LS*D)^2+D^2)^(0.5) + ((RS*D)^2+D^2)^(0.5)
Hydraulic Radius (R) = A/WP

Flow Area (A) = 12.000
Wetted Perimeter (WP) = 12.718
Hydraulic Radius (R) = 0.944

- Use Manning's Equation to determine the flow velocity in the swale.

Velocity (V) = 1.49*R^(2/3)*S^(1/2)/n
Velocity (V) = 3.378 ft/sec

- Calculate the swale's flow capacity.

Swale capacity (Q) = V * A
Q = 40.5 cfs

2. Determine the maximum allowable drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52	(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	9.1 in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70	(typical value for intermediate cover)
25-Year Peak Flow Rate (Q) =	CIA cfs	

- Rearrange the Rational Formula to calculate allowable drainage area:

Drainage Area = Q / (CI)

Maximum Swale Drainage Area = 6.4 acres

3. Determine the maximum swale length based on the maximum sheet flow length.

Maximum Sheet Flow Length = 200 ft

$$\text{Maximum Swale Length} = \frac{\text{Maximum Swale Drainage Area} * 43560}{\text{Maximum Sheet Flow Length}}$$

Maximum Swale Length = 1383 ft

Summary: The maximum sheet flow length will be 200 feet and maximum drainage area is 6.4 acres. The calculated velocity is less than the permissible non-erodible velocity.

TEMPORARY DIVERSION CHANNEL DESIGN

130 Environmental Park
Temporary Diversion Channel

Diversion channel drainage areas are based on the typical size that may occur during the development of the site.
The diversion channels are intended to prevent surface water from entering the active or excavated areas.
1-, 5-, and 10-acre drainage areas are considered:

Diversion Channel Slope	Diversion Channel Area (Acres)	Flow (cfs)	Side Slopes (H:V)	Manning's number (n)	Normal Depth (ft)	Flow Area (ft^2)	Velocity (ft/s)	Energy Head (ft)
0.5	1	6.38	3	0.03	0.98	2.89	2.10	1.05
0.5	5	31.92	3	0.03	1.80	9.67	3.15	1.95
0.5	10	63.84	3	0.03	2.33	16.27	3.74	2.55
1	1	6.38	3	0.03	0.86	2.23	2.73	0.98
1	5	31.92	3	0.03	1.58	7.46	4.08	1.84
1	10	63.84	3	0.03	2.05	12.55	4.85	2.42
2	1	6.38	3	0.03	0.76	1.72	3.54	0.95
2	5	31.92	3	0.03	1.38	5.75	5.29	1.81
2	10	63.84	3	0.03	1.80	9.67	6.29	2.41

Notes:

1. The calculations shown in the table above are normal depths from a 25-year rainfall event.
2. The required diversion channel depth will have 0.5 foot of freeboard.
3. Diversion channels shall be grassed. Erosion control features will be provided for velocities exceeding 5 fps.
4. During operation of the site different configurations of diversion channels may be used to minimize erosion and erosive velocities. The landfill operator will determine the sizing of diversion channels if different lining materials is used.
5. The shading represents sample calculation presented on pages C1-G-20 and C1-G-21.

130 Environmental Park
Temporary Diversion Channel
Example Calculations

Required: Determine the necessary dimensions of the temporary diversion channel for routing surface water around excavations.

Methods:
1. Calculate the 25-year peak flow rate (Q) for a 5-acre drainage area using the Rational Method.
2. Calculate the normal depth for the temporary diversion channel for a drainage area of 5 acres with a slope of 1.0%.

References:
1. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.
2. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
3. Strum, Terry W., *Open Channel Hydraulics, 2nd. Edition*, 2010

Solution:
1. Calculate the 25-year peak flow rate (Q) for a 5-acre drainage area using the Rational Method.

25-Year Rainfall Depth (Pd) =	1.52	in	(ref 1, extrapolated for 10 minutes)
Time of Concentration (tc) =	10	min	(conservative minimum value)
Rainfall Intensity (I) =	9.1	in/hr	(ref 2, I = Pd/tc)
Runoff Coefficient (C) =	0.70		(ref 2, Table 4-11)
Area (A) =	5	acre	
25-Year Peak Flow Rate (Q) =	CIA	cfs	

Q = (0.7)(9.1)(1)

Q = 31.920 cfs

2. Use Manning's equation to calculate the normal depth for the temporary diversion channel for a drainage area. This process uses iterations to calculate the normal depth of flow in the diversion berm to satisfy Manning's Equation.

List of Symbols:

Q_o = design flow rate for channel, cfs
R = hydraulic radius, ft
n = Manning's roughness coefficient
S = channel slope, ft/ft
m = ratio of run to rise for channel sideslope
A_o = flow area, sf
g = gravitational acceleration = 32.2 ft/s^2
B = top width of flow, ft
y = normal flow depth of diversion channel, ft

Design Inputs:

Q_o = 31.92 cfs
S = 0.01 ft/ft
m = 3 (H) : 1 (V)
n = 0.03 (ref 3, Table 4.1, Typical value for excavated channel)

130 Environmental Park
Temporary Diversion Channel

Step 1 - Based on the geometry of the swale cross-section, solve for R and A_0 :

$$R = \frac{my^2}{2y(1+m^2)^{0.5}}$$ (ref 3, Table 2.1)

$$A_o = my^2$$ (ref 3, Table 2.1)

assume: y = 1.61 ft

R = 0.761 ft

A_o = 7.73 sf

solve for Q: Q = 31.920 cfs

Note: Repeat iterations of flow depth (y) until Q is equal to previously calculated Q_0.

Step 2 - solve for velocity, B, Froude number, velocity head, and energy head

Q = VA => V = Q/A

V = 4.13 ft/s

B = 2my (ref 3, Table 2.1)

B = 9.63 ft

$$F_r = \frac{V}{(gA/T)^{0.5}}$$

F_r = 0.812 (Froude number should be limited such that it is less than 0.86 or greater than 1.13 to avoid the depth range of 0.9 to 1.1 times the critical depth. Ref 3)

$$\text{Velocity Head} = \frac{V^2}{2g}$$

Velocity Head = 0.26 ft

Energy Head = flow depth + velocity head

Energy Head = 1.87 ft

TEMPORARY DRAINAGE LETDOWN DESIGN

TEMPORARY DRAINAGE LETDOWN DESIGN

The temporary letdown design is applicable for external sideslopes of the landfill with intermediate cover. Temporary letdown chutes will typically consist of channels lined with erosion control material. The flow capacity of the letdown structures was determined based on the Manning's Equation. The maximum flow calculated from the Manning's Equation is used to determine the maximum drainage area based on the Rational Method. The design calculations presented on pages C1-G-24 through C1-G-26 represent typical calculations for letdown chutes lined with different materials on a 25 percent slope. If sustained erosion is observed, facility management will evaluate the use and construction of temporary letdowns.

130 Environmental Park
Temporary Letdown/Chute Flow Evaluation

Required: 1. Determine the capacity of a variety of letdown chutes with different lining materials.

Method: 1. Use Manning's Equation to calculate the temporary chute capacity for a variety of lining materials.
2. Use the Rational Method to determine the maximum drainage area for a variety of temporary chute lining materials and temporary chute bottom widths.

References: 1. Texas Department of Transportation, *Hydraulic Design Manual,* Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: 1. Chutes will be designed to carry the surface water capacity generated during a 25-year storm event.

Where: Q = Chute Capacity (cfs)
n = Manning's Coefficient (unitless)[(1)]
A = Cross-Sectional Area (ft^2)
P = Wetted Perimeter (ft)
R = Hydraulic Radius (ft)
S = Letdown Slope (ft/ft)
y = Normal Depth (ft)
b = Bottom Width of Chute (ft)
m = Chute Side Slope (ft/ft)

$$A = y(b + my)$$

$$P = b + 2y(1 + m^2)^{1/2}$$

$$R = A / P$$

$$Q = \frac{1.486(A)(R^{2/3})(S^{1/2})}{n}$$

[(1)] The Manning's Coefficient was selected from the references for the applicable lining material.

130 Environmental Park
Temporary Letdown/Chute Flow Evaluation

HDPE Geomembrane Lined Chute

Depth y (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope m (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.3	8	0.25	3	0.013	2.67	9.90	0.270	23.86	63.7
0.3	30	0.25	3	0.013	9.27	31.90	0.291	25.08	232.5

* Manning's coefficient selected for a temporary HDPE geomembrane lined chute.

Concrete Lined Chute

Depth y (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope m (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.3	8	0.25	3	0.015	2.67	9.90	0.270	20.68	55.2
0.3	30	0.25	3	0.015	9.27	31.90	0.291	21.73	201.5

* Manning's coefficient selected for a temporary concrete lined chute.

Turf Reinforcement Mat Lined Chute

Depth y (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope m (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.4	8	0.25	3	0.030	3.68	10.53	0.349	12.29	45.2
0.4	30	0.25	3	0.030	12.48	32.53	0.384	13.08	163.2

* Manning's coefficient selected for a temporary turf reinforcement mat lined chute.

Gabion, Riprap, Crushed Stone, or Crushed Concrete Lined Chute

Depth y (ft)	Bottom Width b (ft)	Letdown Slope S (ft/ft)	Chute Side Slope m (ft/ft)	Manning's Coefficient* n	Area A (sf)	Wetted Perimeter P (ft)	Hydraulic Radius R (ft)	Velocity V (fps)	Flow Rate Q (cfs)
0.5	8	0.25	3	0.035	4.75	11.16	0.426	12.01	57.0
0.5	30	0.25	3	0.035	15.75	33.16	0.475	12.92	203.5

* Manning's coefficient selected for a temporary gabion, riprap, crushed stone, or crushed concrete lined chute.

130 Environmental Park
Temporary Letdown/Chute Flow Evaluation

2. Use the Rational Method to determine the maximum drainage area for a variety of temporary chute lining materials and temporary chute bottom widths.

25-Year Rainfall Depth (Pd) =	1.52		(ref 2, extrapolated for 10 minutes)
Time of Concentration (tc) =	10	min	(conservative minimum value)
Rainfall Intensity (I) =	9.1	in/hr	(ref 1, I = Pd/tc)
Runoff Coefficient (C) =	0.70		(ref 1, Table 4-11)

- Rearranging the rational formula, the maximum drainage area is determined as follows:

Q = Flow Rate
A = Maximum Drainage Area
A = Q/(CI)
A = 63.7/(0.7*9.1)
A = 10.0 acres

HDPE Geomembrane Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	63.7	10.0
30	232.5	36.4

Concrete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	55.2	8.6
30	201.5	31.6

Turf Reinforcement Mat Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	45.2	7.1
30	163.2	25.6

Gabion, Riprap, Crushed Stone, or Crushed Concete Lined Chute

Bottom Width (ft)	Flow Rate (cfs)	Maximum Drainage Area (acres)
8	57.0	8.9
30	203.5	31.9

DESIGN SUMMARY

130 Environmental Park will implement the erosion and sediment control features on the intermediate cover as the landfill develops. The following items will be implemented as filling operations are ongoing:

- Intermediate cover will be established on all areas that have received waste but will remain inactive for periods greater than 180 days.
- Sufficient permanent and temporary erosion and sediment control features shall be constructed to redirect surface water and prevent erosion.
- Temporary erosion and sediment control features shall be constructed within 180 days of placement of intermediate cover.
- Temporary erosion control structures (e.g., rock check dams, filter berms) may be established along the toe of existing vegetated intermediate cover areas with approximately 70-90 percent coverage.
- Final cover will be constructed as the site develops. Temporary erosion control features will be removed as permanent erosion controls are constructed.

130 ENVIRONMENTAL PARK
CALDWELL COUNTY, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 2383

TYPE I PERMIT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN

ATTACHMENT C2
FLOOD CONTROL ANALYSIS

Prepared for

130 ENVIRONMENTAL PARK, LLC

Technically Complete October 28, 2014

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED
PROFESSIONAL ENGINEER

Biggs & Mathews, Inc.
Firm Registration No. F-834

Prepared by

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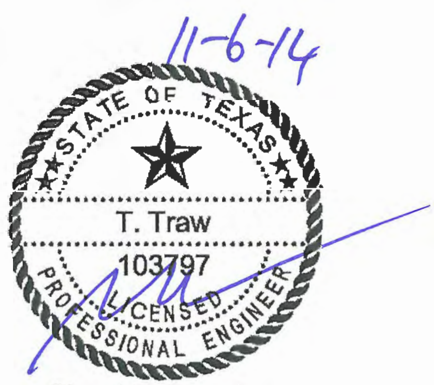
CONTENTS



Biggs & Mathews, Inc.
Firm Registration No. F-834

1 INTRODUCTION

1.1 Purpose

The flood control and analysis report is prepared as part of a permit application for 130 Environmental Park and includes the demonstrations consistent with the requirements of §§330.63(c)(2), 330.307, and 330.547. The flood control and analysis report demonstrates that solid waste disposal operations will not be located within the 100-year floodway as defined by the Federal Emergency Management Administration (FEMA), restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste so as to pose a hazard to human health and the environment.

130 Environmental Park is located in the San Marcos River drainage basin. Dry Creek traverses the property in a northeast to southwest direction and an unnamed tributary to Dry Creek traverses the property in a northwest to southeast direction. Both Dry Creek and the unnamed tributary enter the Soil Conservation Service (SCS) Site 21 Reservoir, located on Dry Creek, within the 130 Environmental Park property. Dry Creek exits the SCS Site 21 Reservoir and enters Plum Creek approximately five miles south of the property. Plum Creek flows generally in a northwest to southeast direction, and enters the San Marcos River about 23 miles downstream from the property.

The flood control and analysis report is organized to include a narrative description of the existing and postdeveloped conditions and a discussion of the various demonstrations. Drainage calculations are included in the appendices. Drainage design plans and details are included in Attachment C3. The following is a brief description of each of the appendices.

Appendix C2-A – Floodplain Maps

Appendix C2-A includes drawings demonstrating that no waste disposal operations shall be permitted in areas that are located in a 100-year floodway as defined by the Federal Emergency Management Agency (FEMA) and that the municipal solid waste storage and processing facilities shall be located outside of the 100-year floodplain. Appendix C2-A also includes drawings demonstrating that development of the 130 Environmental Park will not restrict the flow of the 100-year flood, will not reduce the temporary water storage capacity of the floodplain, and will not adversely impact Dry Creek, its unnamed tributary, or the SCS Site 21 Reservoir.

FEMA has defined the limits of the 100-year floodplain in the vicinity of the landfill as Zone A; no base flood elevations have been determined by FEMA. The limits of the floodplain are depicted on Drawing C2-A-1 - Flood Insurance Rate Map (FIRM), which is the drawing compiled from the FIRM Community Panel Number 48055C0125E, with an effective date of June 19, 2012. Drawing C2-A-1 includes the facility boundary, landfill footprint, and the limits of landfill grading depicted along with the limit of the FEMA

100-year floodplain. This drawing demonstrates that the proposed waste disposal units will not be located within the limits of the 100-year floodplain, based on the FEMA defined Zone A limits.

Drawing C2-A-2 – Existing Conditions Drainage Areas depicts the drainage areas contributing to Dry Creek, its unnamed tributary, and the SCS Site 21 Reservoir. A table is included with the area for each of the delineated areas. The facility and property boundary limits are also shown.

Drawing C2-A-3 – Existing Conditions Workmap depicts the delineation of the 100-year floodplain limits based upon the existing conditions. The facility and property boundary limits, and HEC-RAS cross section locations are shown. The limits of the FEMA Zone A are also depicted for information.

Drawing C2-A-4 – Postdeveloped Floodplain Workmap depicts the delineation of the 100-year floodplain limits based upon the existing conditions. The landfill footprint, limits of landfill grading, entrance road, and storage and processing facility locations are shown along with the facility and property boundary limits, and HEC-RAS cross section locations. The limits of the FEMA Zone A are also depicted for information.

Drawing C2-A-5 – Postdeveloped Floodplain Workmap Detail depicts the delineation of the 100-year floodplain limits based upon the existing conditions. This map depicts the landfill final completion plan and is produced at a scale to provide more detail comparing the limits of the 100-year floodplain with the landfill development. The landfill footprint, limits of landfill grading, entrance road, and storage and processing facility locations are shown along with the facility and property boundary limits, and HEC-RAS cross section locations. The limits of the FEMA Zone A are also depicted for information.

Appendix C2-B – Existing Condition HEC-HMS Evaluation

The existing condition HEC-HMS results for the floodplain evaluation are included in Appendix C2-B. The existing condition analysis includes delineation of drainage areas contributing to Dry Creek, its unnamed tributary, and the SCS Site 21 Reservoir. The results of the existing condition HEC-HMS evaluation are provided in the existing conditions summary, which provides results for the 25-year and 100-year events.

Appendix C2-C – Existing Condition HEC-RAS Evaluation

The existing condition HEC-RAS results are included in Appendix C2-C and represent the existing conditions. A summary table shows the results of the hydraulic analysis. The water surface elevation and energy grade line are graphically shown for each cross section.

Appendix C2-D – Postdeveloped Condition HEC-RAS Evaluation

The postdeveloped condition HEC-RAS results are included in Appendix C2-D and represent the postdeveloped conditions. A summary table shows the results of the hydraulic analysis. The water surface elevation and energy grade line are graphically shown for each cross section.

2 METHODOLOGY

2.1 Concepts and Methods

The hydrologic and hydraulic methods employed in this study are consistent with the TCEQ regulations. The United States Corps of Engineers (COE) HEC-HMS and HEC-RAS computer programs were used in the hydrologic and hydraulic analysis, respectively.

- Maps were prepared that provided information about the surface water runoff characteristics based on the existing conditions. These maps are included in Appendix C2-A.

- Surface water runoff hydrographs for the existing condition were developed in HEC-HMS. The HEC-HMS evaluation for the existing condition is in Appendix C2-B.

- Hydraulic models for the existing condition were developed to evaluate water surface elevations for Dry Creek, its unnamed tributary, and the SCS Site 21 Reservoir, under peak flow conditions using HEC-RAS is in Appendix C2-C.

- Hydraulic models for the postdeveloped condition were developed to evaluate water surface elevations for Dry Creek, its unnamed tributary, and the SCS Site 21 Reservoir under peak flow conditions using HEC-RAS is in Appendix C2-D.

3 HYDROLOGIC AND HYDRAULIC MODELING

3.1 HEC-HMS

The COE HEC-HMS program was developed to simulate the surface water runoff response of a watershed. The HEC-HMS model represents a watershed as a network of hydrologic and hydraulic components such as: sub-basins, reaches, reservoirs, junctions, and outlets. Specifically, HEC-HMS v3.5 was used to perform all of the hydrologic modeling. The following assumptions were made as part of the hydrologic modeling process:

- Precipitation: The meteorological model used was the frequency storm method which assumes precipitation rates that are temporally varied in 15 minute increments, but remain spatially unvaried across the entire watershed. This method uses the alternating block method of hyetograph distribution with the highest rainfall intensity occurring midway (50 percent) through the storm. A storm duration of 10 days was used in the model because it yielded the highest water surface elevation in the Site 21 reservoir and the largest peak discharges.

- Watershed Characteristics: The watershed characteristics considered in the analysis consist of rainfall loss, transform, and routing. *Urban Hydrology for Small Watersheds, TR-55*, describes the methods used for both rainfall loss and transform. Specifically, the (Soil Conservation Service) SCS runoff curve number method was used to analyze rainfall loss, while the SCS unit hydrograph method was used for transform. The routing method used in the analysis was the Kinematic Wave method.

3.2 Hydrologic Elements Naming Convention

The following naming convention was used in the existing hydrologic evaluations:

- UNT-1 – drainage area contributing to the Unnamed Tributary west of the proposed landfill

- DC-1 – drainage area contributing to Dry Creek on the east side of the proposed landfill

3.2.1 HEC-RAS

The COE HEC-RAS program was developed to evaluate gradually varied open channel flow in natural and man-made streams, as well as, the hydraulics related to structures such as bridges, culverts, dams, levees, etc. In this situation, separate models were created for both Dry Creek and the Unnamed Tributary network with both models using the same downstream boundary condition resulting from the maximum water surface elevation in the Site 21 reservoir of 518.9 ft. Both streams were modeled in steady state and, as a result, the peak discharge applied does not change with time. The cross-sections for both models were taken from a combination of data listed in order of priority: on the ground survey delineating waters of the US, contours developed from aerial photography flown May 13, 2013, and contours available from CAPCOG. Manning's roughness coefficients for the channels and floodplain were determined through on-site investigation and aerial photos.

3.2.2 Hydraulic Elements Naming Convention

The following naming convention was used in the existing and post–developed hydraulic evaluations:

- A1.93 – cross-section on Dry Creek at river station 1.93
- B0.59 – cross-section on Unnamed Tributary at river station 0.59
- C0.41 – cross-section on Tributary A at river station 0.41
- D0.53 – cross-section on Tributary B at river station 0.53

4 EXISTING CONDITIONS

The existing conditions modeling reflects the peak discharges and maximum water surface elevations in the Site 21 reservoir as identified from the hydrologic model.

The hydraulic model for existing conditions uses the existing topographic data with one culvert located on Dry Creek at the Hommanville Trail crossing. Both the 25 and 100 year events significantly overtop, by as much as 7 feet, the limited capacity of the 2 - 5 foot diameter corrugated metal pipes under Hommanville Trail.

5 POSTDEVELOPMENT CONDITIONS

The postdeveloped conditions modeling reflect the same peak discharges that were identified in the existing conditions hydrologic model. The changes to the postdeveloped conditions hydraulic model are limited to changes to the channel and floodplain geometry immediately upstream and downstream of where the proposed entrance road crosses the Unnamed Tributary and Tributary B. At the Unnamed Tributary crossing, 7 box culverts (7'H x 12'W) carry both the 100 and 25 year events without overtopping the entrance road. At the Tributary B crossing, two box culverts (4'H x 8'W) carry both the 100 and 25 year events without overtopping the road. In both locations, the culverts result in slight increases in the upstream water surface elevations. However, these increases terminate within the property boundary at cross-sections B8.74 and D2.48. A comparison of existing/postdeveloped water surface elevations at each cross-section upstream of the culverts is shown in Tables 1 and 2.

130 Environmental Park

Table 1 - Unnamed Tributary Existing/Postdeveloped Cross-section Comparison

X-sec Label	River Station	25-Year Water Surface Elevation (ft.)			100-Year Water Surface Elevation (ft.)		
		Existing	Post-developed	Difference	Existing	Post-developed	Difference
B12	12	558.52	558.52	0.00	559.03	559.02	-0.01
B10.1	10.1	550.30	550.30	0.00	550.74	550.74	0.00
B9.73	9.73	548.18	548.18	0.00	548.64	548.63	-0.01
B9.12	9.12	545.68	545.68	0.00	546.15	546.15	0.00
B8.74	8.74	544.46	544.46	0.00	545.06	545.07	0.01
B8.19	8.19	543.20	543.22	0.02	543.85	543.91	0.06
B7.9	7.9	542.57	542.62	0.05	543.21	543.32	0.11
B7.56	7.56	541.24	541.48	0.24	541.97	542.37	0.40
B7.26	7.26	540.15	540.28	0.13	540.99	541.28	0.29

130 Environmental Park

Table 2 - Tributary B Existing/Postdeveloped Cross-section Comparison

X-sec Label	River Station	25-Year Water Surface Elevation (ft.)			100-Year Water Surface Elevation (ft.)		
		Existing	Post-developed	Difference	Existing	Post-developed	Difference
D3.88	3.88	581.30	581.30	0.00	581.50	581.50	0.00
D3.16	3.16	568.43	568.43	0.00	568.68	568.68	0.00
D2.99	2.99	565.14	565.14	0.00	565.43	565.43	0.00
D2.9	2.9	563.55	563.55	0.00	563.82	563.82	0.00
D2.72	2.72	557.32	557.32	0.00	557.72	557.72	0.00
D2.65	2.65	556.21	556.20	-0.01	556.58	556.58	0.00
D2.48	2.48	553.39	553.42	0.03	553.70	553.70	0.00
D2.36	2.36	551.52	551.48	-0.04	551.79	551.79	0.00
D2.29	2.29	549.62	550.43	0.81	549.93	551.32	1.39

6 CONCLUSIONS

In accordance with §330.547(a), 130 Environmental Park's waste disposal operations are not located in the 100-year floodway. In accordance with §330.547(b), 130 Environmental Park's new municipal solid waste disposal units are not located in the 100-year floodplain, will not restrict the flow of the 100-year flood, will not reduce the temporary water storage capacity of the floodplain, and will not result in the washout of solid waste. Further, in accordance with §330.547(c), 130 Environmental Park's processing and/or storage units are not located within the 100-year floodplain.

130 ENVIRONMENTAL PARK

ATTACHMENT C2

APPENDIX C2-A

FLOODPLAIN MAPS

11-6-14

STATE OF TEXAS
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Biggs & Mathews, Inc.
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Includes pages C2-A-1 through C2-A-5

Technically Complete October 28, 2014

CONTENTS

11-6-14

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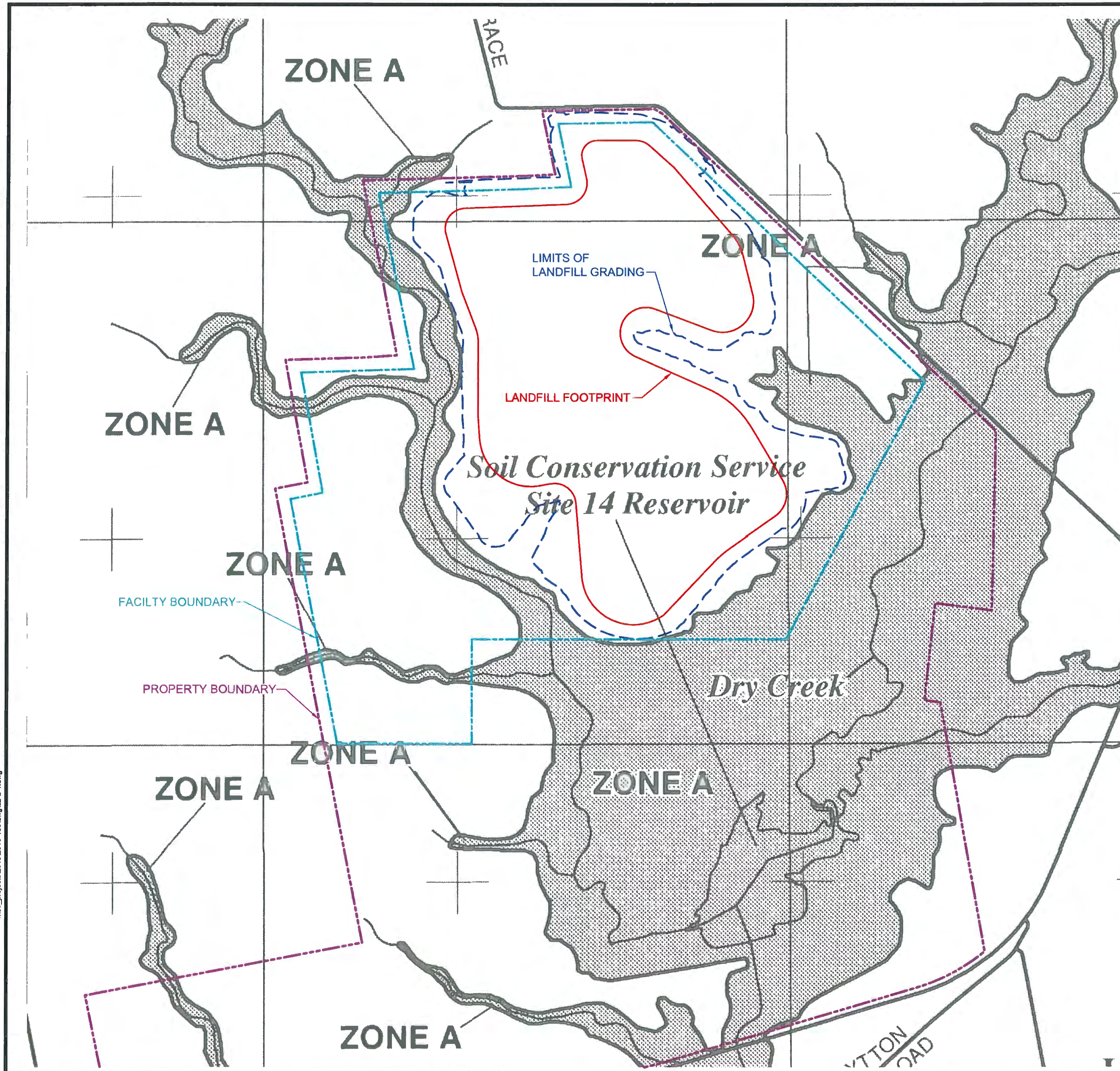

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

- **ZONE A** No Base Flood Elevations determined.
- **ZONE AE** Base Flood Elevations determined.
- **ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- **ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- **ZONE AR** Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
- **ZONE A99** Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
- **ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- **ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- **ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- **ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.
- **ZONE D** Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- Floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

- (A)—(A) Cross section line
- (23)- - -(23) Transect line
- 97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
- 4275000mN — 1000-meter Universal Transverse Mercator grid ticks, zone 14
- 6000000 FT — 5000-foot grid values: Texas State Plane coordinate system, south central zone (FIPSZONE 4204), Lambert Conformal Conic
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile
- Property Boundary
- Facility Boundary
- Limits of Landfill Grading
- Landfill Footprint

0 500 1000
SCALE IN FEET

NOTES:

1. THIS MAP HAS BEEN COMPILED FROM FEMA FLOOD INSURANCE RATE MAPS (FIRM) OF CALDWELL COUNTY, TEXAS AND UNINCORPORATED AREAS COMMUNITY PANEL: 48055C1025E EFFECTIVE DATE: 6-19-2012
2. LABELING OF THE RESERVOIR SITE AS "SOIL CONSERVATION SITE 14 RESERVOIR" IS AN APPARENT ERROR ON THE FIRM. THE RESERVOIR SITE SHOWN IS ACTUALLY SITE 21, ALSO KNOWN AS PLUM CREEK WATERSHED RETARDING STRUCTURE No. 21.

11-6-14

STATE OF TEXAS
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FLOOD INSURANCE RATE MAP (FIRM)

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

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CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

REVISIONS							
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TBPE FIRM NO. F-256 & F-834	TBPG FIRM NO. 50222	
DSN. TLT	DATE : 2/14	DRAWING
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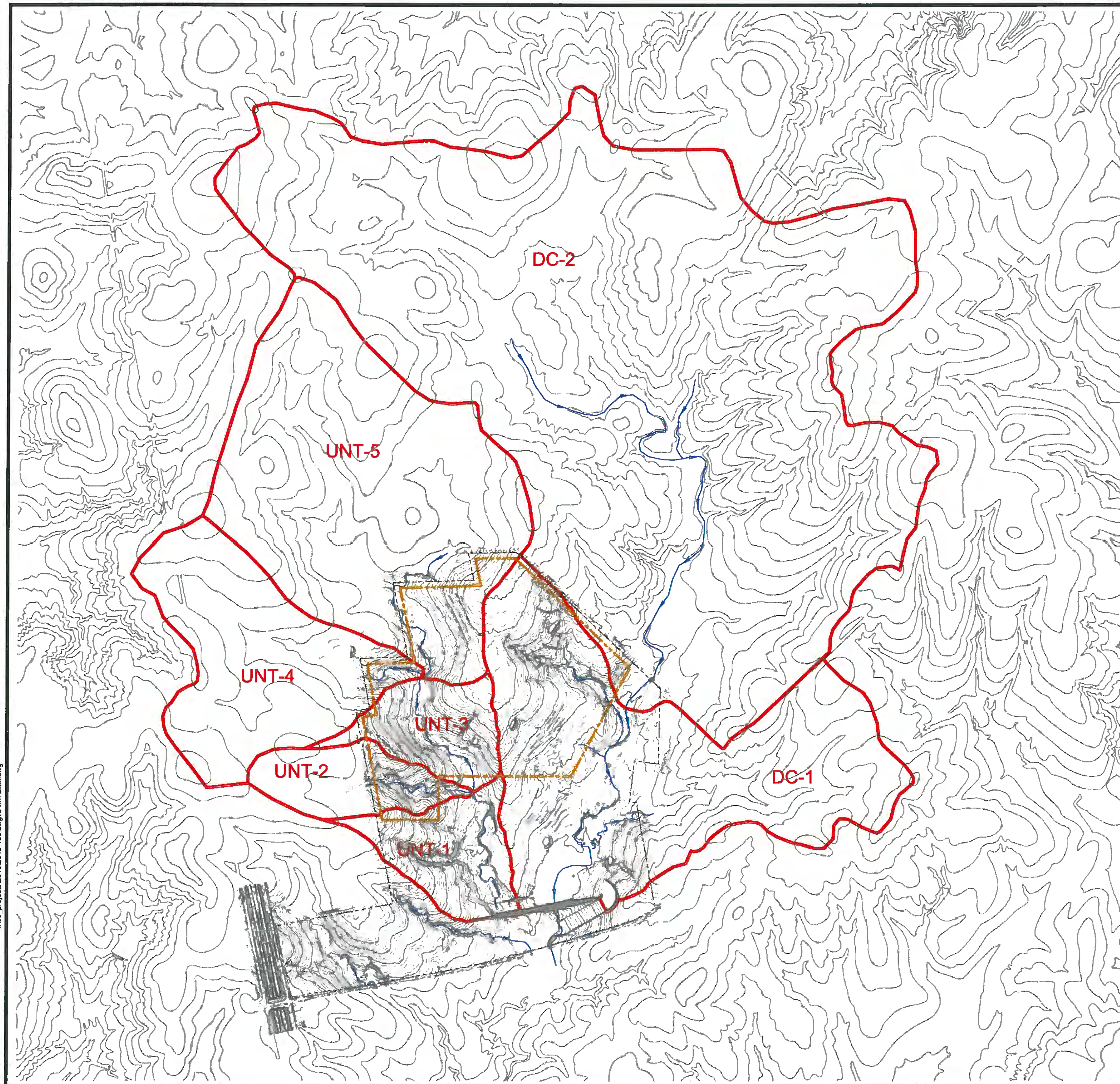

DRAINAGE AREA CHART

DA	AREA (ac.)
UNT-1	161.82
UNT-2	134.66
UNT-3	141.81
UNT-4	448.48
UNT-5	913.94
DC-1	884.64
DC-1	2905.38

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 - GEOID 12A.
2. ROADWAYS IN THE IMMEDIATE VICINITY OF THE SITE TAKEN FROM TNRIS AERIAL PHOTOGRAPHY FLOWN JUNE 11, 2012. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).
3. CONTOURS AND ELEVATIONS OUTSIDE THE PROPERTY BOUNDARY PROVIDED BY CAPCOG. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).

11-6-14

STATE OF TEXAS
T. Traw
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EXISTING CONDITIONS DRAINAGE AREAS

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
---	10/28/14	TECHNICALLY COMPLETE	MNG	TLT	TLT	TLT

TBPE FIRM NO. F-256 & F-834 | TBPG FIRM NO. 50222

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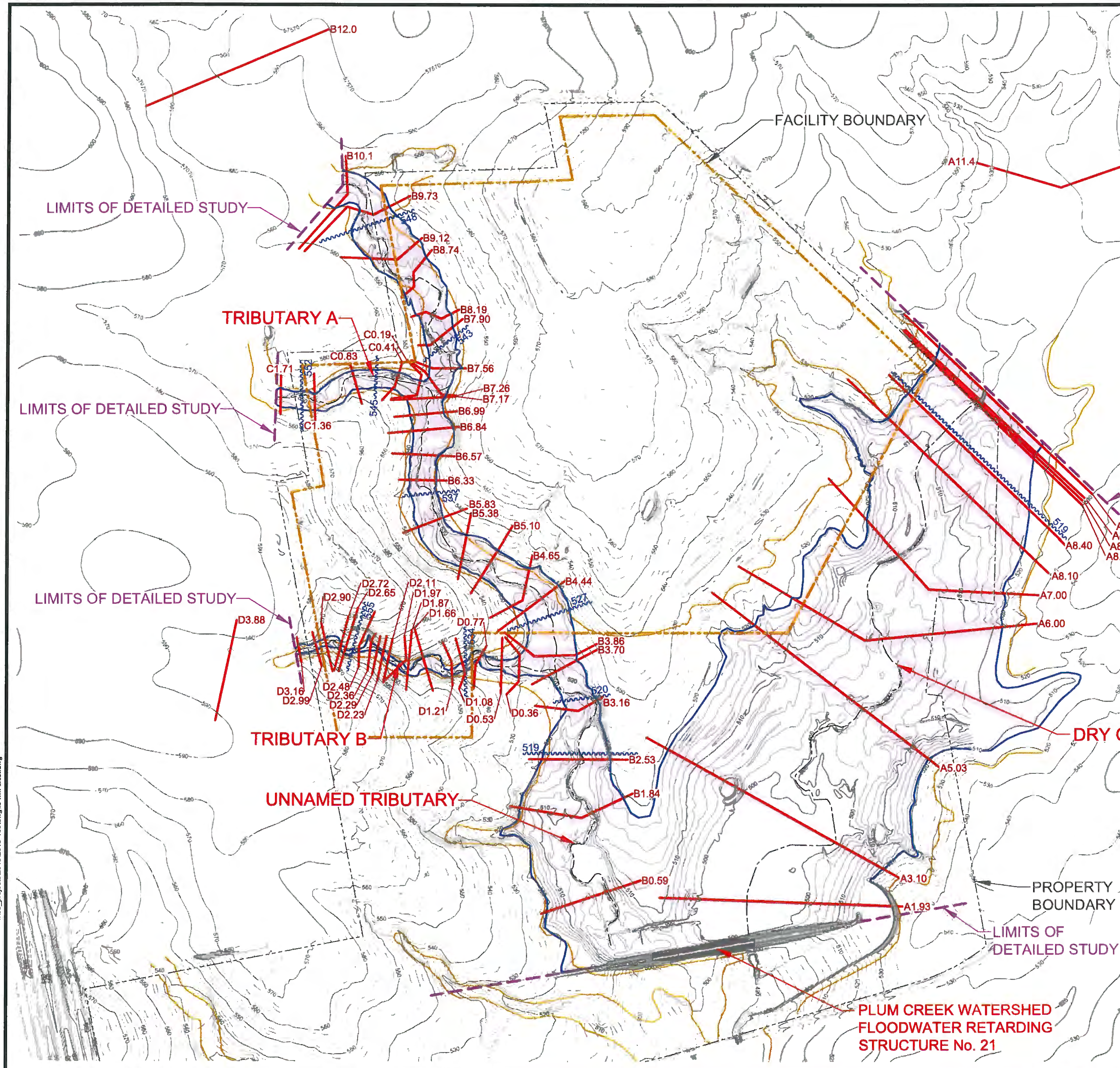

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LEGEND

- LIMITS OF DETAILED STUDY
- STREAM CENTER LINE
- SECTION AND IDENTIFIER
- W.S.E. ELEVATION (FT)
- FEMA ZONE A
- 100 YR. FLOODPLAIN

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 - GEOID 12A.
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3. CONTOURS AND ELEVATIONS OUTSIDE THE PROPERTY BOUNDARY PROVIDED BY CAPCOG. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).
4. THE FEMA ZONE A LIMIT HAS BEEN COMPILED FROM FEMA FLOOD INSURANCE RATE MAPS (FIRM) OF CALDWELL COUNTY, TEXAS AND UNINCORPORATED AREAS COMMUNITY PANEL: 48055C1025E EFFECTIVE DATE: 6-19-2012

11-6-14

STATE OF TEXAS
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REVISIONS						
	10/28/14	TECHNICALLY COMPLETE	MNG	TLT	TLT	TLT
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

EXISTING CONDITIONS FLOODPLAIN WORKMAP

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

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TBPE FIRM NO. F-256 & F-834	TBPG FIRM NO. 50222	
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CHK. TLT	DWG : FS WM EXIST.DWG	

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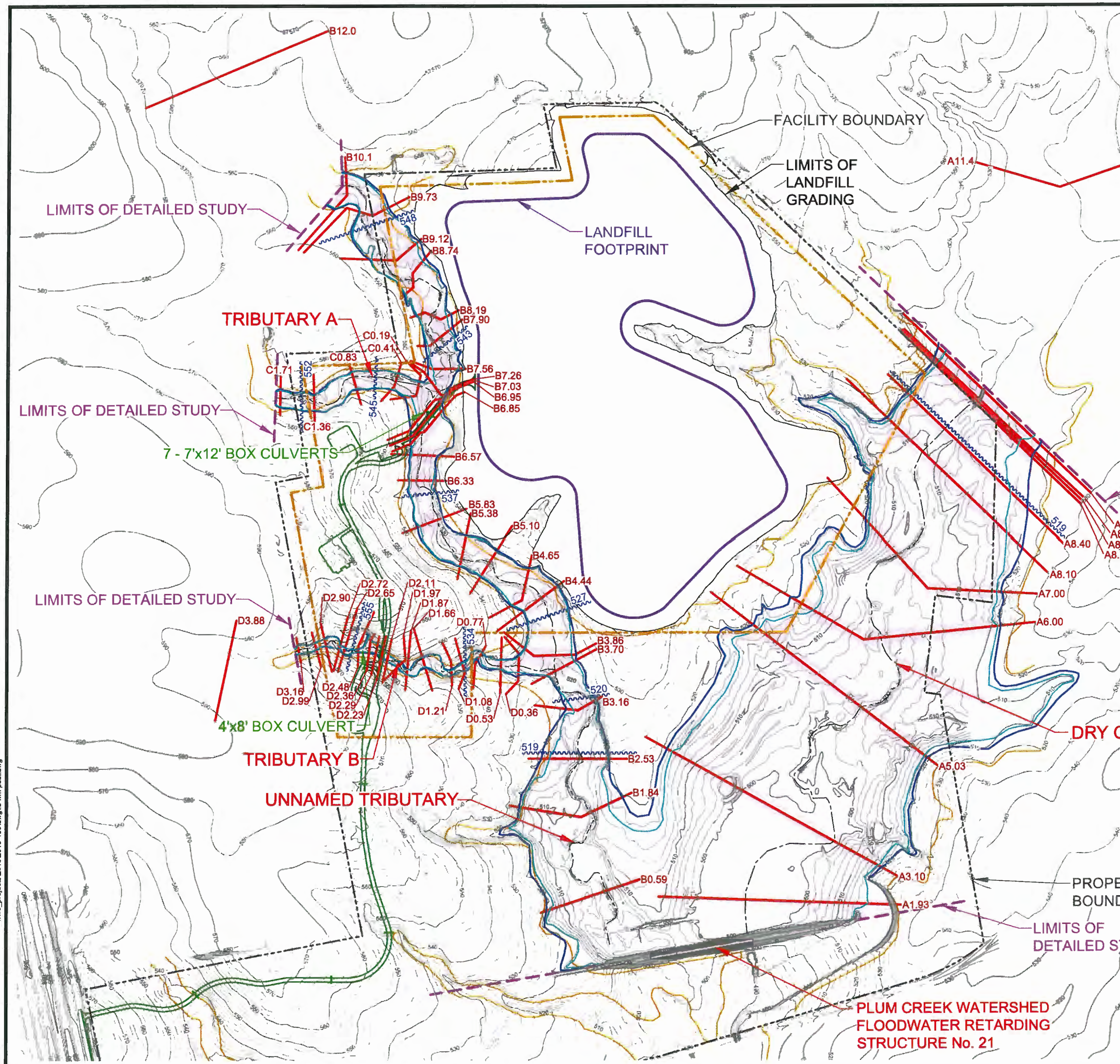

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SCALE IN FEET

LEGEND

- LIMITS OF DETAILED STUDY
- STREAM CENTER LINE
- XXX SECTION AND IDENTIFIER
- W.S.E. ELEVATION (FT)
- FEMA ZONE A
- 100 YR. FLOODPLAIN
- 25 YR. FLOODPLAIN
- LANDFILL FOOTPRINT

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 - GEOID 12A.
2. ROADWAYS IN THE IMMEDIATE VICINITY OF THE SITE TAKEN FROM TNRIS AERIAL PHOTOGRAPHY FLOWN JUNE 11, 2012. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).
3. CONTOURS AND ELEVATIONS OUTSIDE THE PROPERTY BOUNDARY PROVIDED BY CAPCOG. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).
4. THE FEMA ZONE A LIMIT HAS BEEN COMPILED FROM FEMA FLOOD INSURANCE RATE MAPS (FIRM) OF CALDWELL COUNTY, TEXAS AND UNINCORPORATED AREAS COMMUNITY PANEL: 48055C1025E EFFECTIVE DATE: 6-19-2012

11-6-14

STATE OF TEXAS
T. Traw
103797
LICENSED PROFESSIONAL ENGINEER

ISSUED FOR PERMITTING PURPOSES ONLY

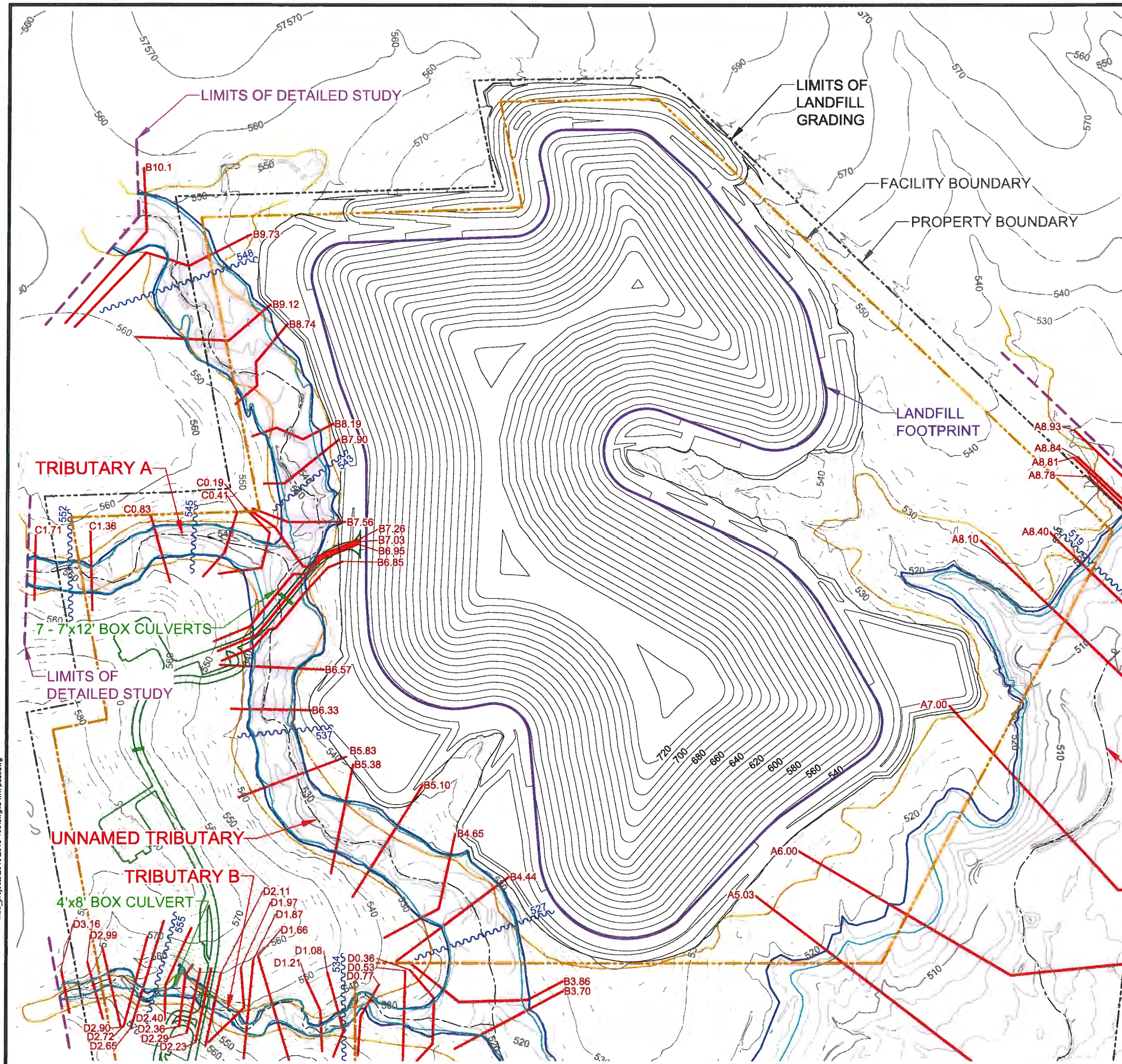
REVISIONS							
---	10/28/14	TECHNICALLY COMPLETE	MNG	TLT	TLT	TLT
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

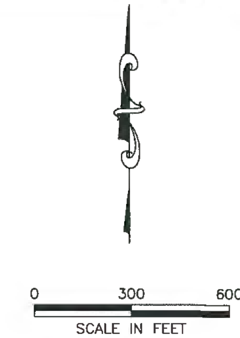
POSTDEVELOPED FLOODPLAIN WORKMAP

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 & F-834		TBPG FIRM NO. 50222
DSN. TLT	DATE : 2/14	DRAWING
DWN. MNG	SCALE : GRAPHIC	C2-A-4
CHK. TLT	DWG : FS WM POST.DWG	





LEGEND

- LIMITS OF DETAILED STUDY
- STREAM CENTER LINE
- XXX SECTION AND IDENTIFIER
- W.S.E. ELEVATION (FT)
- FEMA ZONE A
- 100 YR. FLOODPLAIN
- 25 YR. FLOODPLAIN
- LANDFILL FOOTPRINT
- 519 CONTOUR

NOTES:

1. CONTOURS AND ELEVATIONS WITHIN THE PROPERTY BOUNDARY PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 - GEOID 12A.
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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

POSTDEVELOPED FLOODPLAIN WORKMAP DETAIL

130 ENVIRONMENTAL PARK, LLC
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DSN. TLT	DATE : 2/14	DRAWING
DWN. MNG	SCALE : GRAPHIC	C2-A-5
CHK. TLT	DWG : FS WM POST.DWG	

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