Stormwater Calculations

City of Franklin – Parks Department
2012 Park Bond
Recreation Center Parking & Drainage Improvements
Franklin, Indiana

Drainage Submittal:
January 22, 2013

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STATE OF INDIANA
PROFESSIONAL ENGINEER

1.22.13

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Section 1: Stormwater Calculations Summary

Pre-Development Conditions

The existing site consists of a +/-9.85 acre parcel owned by the Parks and Recreation Department of the City of Franklin. The project site is located at the northwest corner of the intersection of Branigin Boulevard and South Street in Franklin, Indiana (see Exhibit 1: Vicinity and Location Map). The existing land use is the Recreation Center and city pool and is bordered by Province Park to the west, properties owned by Franklin College to the north and east, and residential property to the south. The existing conditions consist of the Recreation Center building, existing parking, and unimproved grass cover with some trees. Within the project limits, there are two (2) pre-development basins in which additional impervious area will be constructed for the parking expansion (see Exhibit 2: Pre-Development Watershed Map). The Pre-Development Basins are located and discharge runoff as follows:

> **<u>Basin #1:</u>** Grass area east of the main parking lot discharges to Branigin Boulevard via sheet flow just north of the main entrance to the Recreation Center.
> **<u>Basin #2:</u>** Grass area north of the main parking lot and west of the maintenance building discharges onto the main parking lot and eventually to Young's Creek.

The subject property lies within Flood Hazard Zone 'X' (areas determined to be outside the 0.2% annual chance of floodplain) and Flood Hazard Zone 'AE' (areas within the 1% annual chance flood flood (100 year flood) with base flood elevations determined) as plotted by hand on the Federal Emergency Management Agency Flood Insurance Rate Map for Johnson County, Indiana, community panel number 18081C0231D, which bears an effective date of August 2, 2007.

Post-Development Conditions

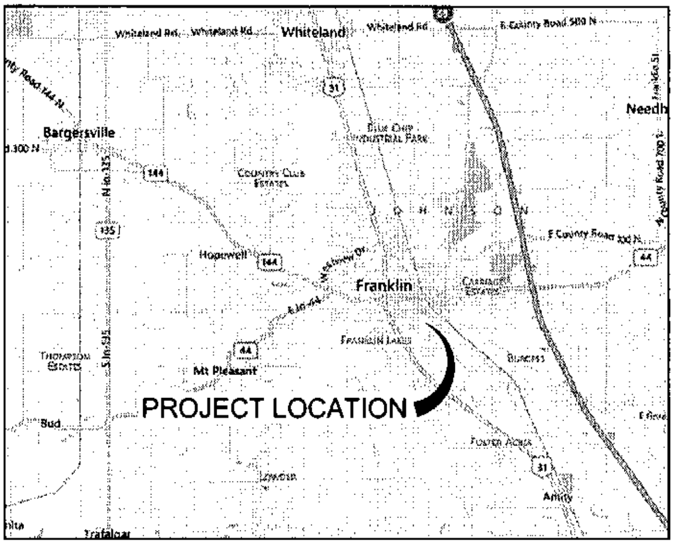
The proposed improvements include constructing a dry detention pond in the northern portion of the site to detain runoff from the parking lot expansion and installing new storm sewer around the building to improvement drainage. The post-development condition will consist of four drainage basins as opposed to five in the pre-development condition because runoff from the main parking lot expansion will be redirected to the new dry detention basin. The parking lot expansion and detention area are located in Post-Development Basin #1. The proposed drainage improvements around the building do not result in additional impervious area; therefore, no detention is provided for the drainage improvements.

Runoff from the southern parking expansion will be collected by a storm sewer system which drains into the dry detention area near the maintenance building. Runoff from the northern parking expansion and the unimproved area surrounding the parking will sheet flow into the detention pond (see Exhibit 3: Post-Development Watershed Map). The release rate of the runoff from the pond will be restricted by two (2) rectangular orifices within the outlet structure. The pond outlet structure and pipe, which will consist of a modified E-7 inlet and 12 inch RCP, will connect to the new storm sewer near the Recreation Center which discharges into the storm sewer being installed with the Aquatic Center project (currently under construction). The Aquatic Center storm sewer discharges into Young's Creek.

Due to site constraints and the need to retrofit a detention pond on the existing site with no viable outlet location, no emergency spillway has been proposed for the detention pond. During storm events which produce runoff in excess of the design 100 year events, water will overtop the pond banks and discharge to Young's Creek by flowing down the entrance to Province Park. The 730.75 finished floor elevation of the maintenance building is approximately 1.75 feet higher than the Province Park entrance allowing excess runoff from 100+ year storms to discharge away from the building. A waiver from the emergency spillway requirements described in Article 6.19, Section H, Item 1.d of the City of Franklin Subdivision Control Ordinance (SCO) has been submitted to the City.

In addition to the emergency spillway waiver request, we have requested waivers from the following requirements of Article 6.19 of the SCO; **Section C, Item 5** – the use of SCS hydrograph method for all detention design, **Section H, Item 1.a** – outlets being located in the upper two-thirds of the detention facility, **Section H, Item 1.c** – dedication of a 20 foot wide easement around the pond, and **Section H, Item 2** – underdrain in the bottom of dry detention facilities and maximum 4:1 side slopes.

In addition to treatment for water quantity, a rain garden will be constructed on the south side of the building and provide additional benefits for water quality treatment by detaining direct runoff from the roof area. Due to the size of the contributing watershed (approximately 0.01 acres), the methodology discussed in Article 6.19, Section H, which is used to calculate the water quality volume, results in a very small treatment volume when calculated per the SCO. In order to maximize the water quality treatment provided, the City of Indianapolis Stormwater Design and Construction Manual and Sustainable Green Infrastructure guidelines were used to determine the volume.



VICINITY MAP
NO SCALE

LOCATION MAP
NO SCALE

EXHIBIT 1
VICINITY AND LOCATION MAPS

3

PREPARED BY:

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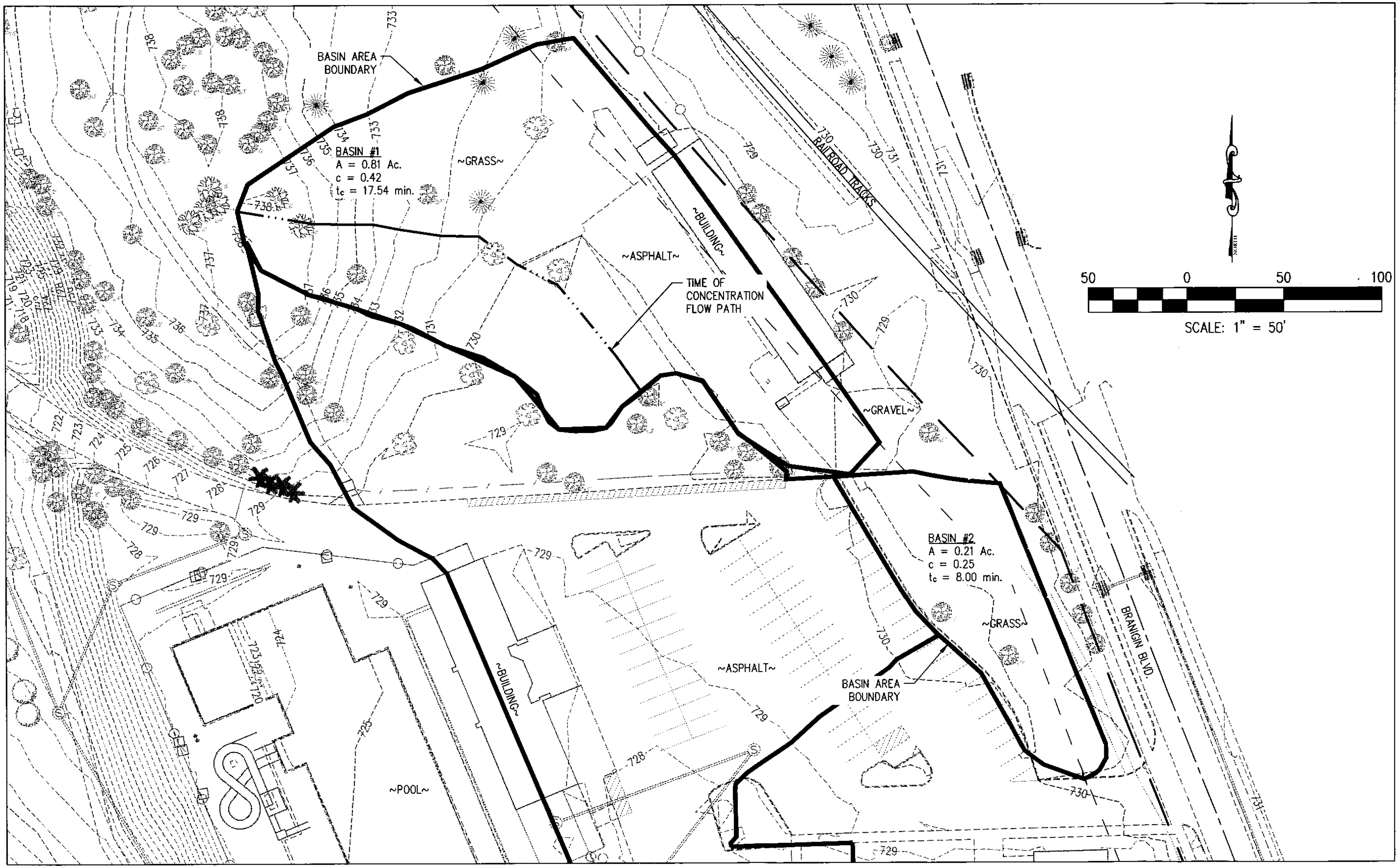
JANUARY 22, 2013



4

EXHIBIT 2

PRE DEVELOPEMENT WATERSHED MAP

PREPARED BY:

CROSSROAD ENGINEERS, PC

Transportation & Development Consultants

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JANUARY 22, 2013

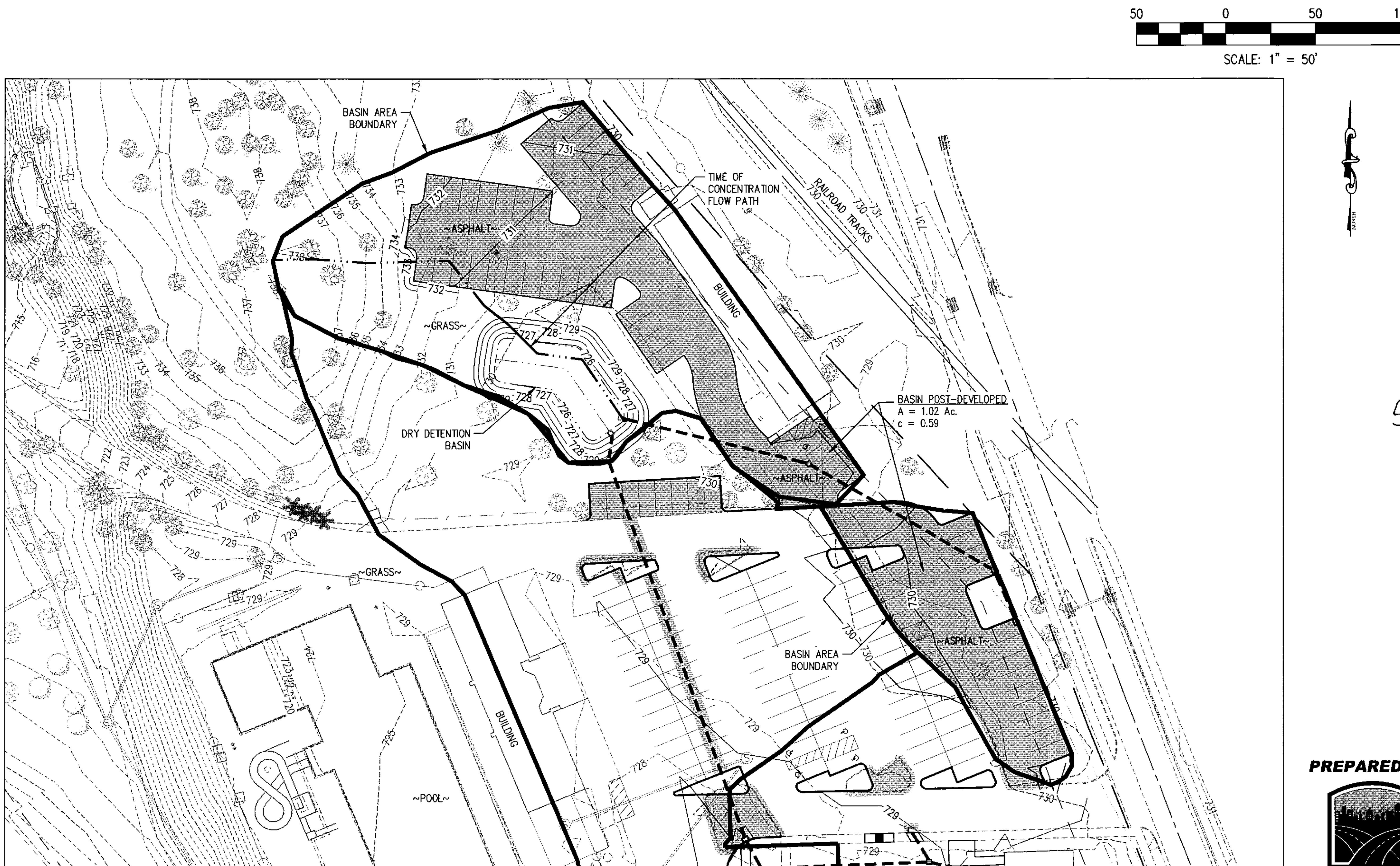

EXHIBIT 3

POST DEVELOPMENT WATERSHED MAP

PREPARED BY:

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Transportation & Development Consultants
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JANUARY 22, 2013

Section 2: Detention Calculations

All drainage calculations were completed using the Modified Rational Method. Although the current General Drainage Standards outlined in Article 6.19 of the SCO state that the SCS hydrograph method shall be utilized for detention design, the draft copy of the new stormwater management ordinance allows for the use of the Modified Rational Method for sites that are less than or equal to 5 acres. Due to the very small contributing watershed area for the detention basins (1.02 acres) and the inaccuracy of the SCS hydrograph method for small sites, the Modified Rational Method was utilized. The TR-55 Method was used to calculate the times of concentration.

Pre-Development Conditions

As mentioned in Section 1, the existing site consists of two (2) watershed basins. Furthermore, both pre-development basins (Pre-Development Basin #1 and #2) will be directed to the detention pond in the post-development condition; therefore, the following detention calculations reflect the combination of Pre-Development Basins #1 and #2 to accurately determine the post-development detention requirements. The existing site conditions within these basins were analyzed for release rate determination in accordance with the post-developed watershed area directed to the detention basin. Table 1 indicates the applicable runoff coefficients and the areas associated with those surface types for the pre-developed conditions.

Table 1
Pre-Development Watershed Basin Runoff Coefficient

Surface Type	Runoff Coefficient, C	Area, Ac.	C*A
Roof/Asphalt/Concrete	0.85	0.24	0.204
Grass	0.25	0.78	0.195
		Cumulative 'CA'	**0.399**
		Weighted 'C'	**0.39**

The above calculated cumulative runoff coefficients are used in conjunction with the time of concentrations, and associated rainfall intensities, to calculate the allowable runoff rates for the proposed development. The allowable release rates for the basin are calculated and included on the Detention Storage Calculations worksheets included within this report.

Post-Development Conditions

As discussed above, the post-developed condition results in one (1) detention basin. All proposed impervious areas within the basin shall be conveyed to the detention system via sheet flow or storm sewer pipe. Table 2 summarizes the cumulative runoff coefficient for the post development conditions in the basin.

Table 2
Post-Development Watershed Basin Runoff Coefficient

Surface Type	Runoff Coefficient, C	Area, Ac.	C*A
Asphalt/Concrete	0.85	0.58	0.493
Grass	0.25	0.44	0.110
		Cumulative 'CA'	**0.603**
		Weighted 'C'	**0.59**

Per Article 6.19, Section C of the SCO, the allowable release rate for the 10-year post-developed storm shall be limited to the 2-year pre-developed release rate and the 100-year post-developed release rate shall be limited to the 10-year pre-developed release rate. Using the Modified Rational Method, the following release rates were calculated;

Max. Allowable Release Rate for 10-Year Post Developed Storm =
2-Year Pre-Developed = **1.71 cfs**

Actual Release Rate for 10-Year Post Developed Storm through Outlet Structure = **1.70 cfs.**

10-year High Water Elevation = 727.32

Max. Allowable Release Rate for 100-Year Post Developed Storm =
10-Year Pre-Developed = **2.46 cfs**

Actual Release Rate for 100-Year Post Developed Storm through Outlet Structure = **2.46 cfs.**

100-year High Water Elevation = 727.68

Actual Release Rate ≤ Max. Release Rate, therefore the Stormwater Detention is sufficient.

Using the Modified Rational Method, the corresponding required storage volumes to release the 10-year and 100-year post-developed storms at the allowable release rates are 0.02 acre-feet (871.2 cu. ft.) for the 10-year and 0.03 acre-feet (1306.8 cu. ft.) for the 100-year storm event. Please refer to the attached Detention Storage Calculations worksheets (pages 10-13) for the Modified Rational Method calculations. The Civil3D Surface Reports (pages 14-15) are attached as well.

Proposed Outlet Structures

The allowable release rate of the basin will be accomplished using an outlet control structure. The structure is a modified INDOT Inlet Type 'E-7'. The outlet structure contains two (2) rectangular orifices. The orifice controlling the release of runoff from the 2-year to 10-year storm events is a 3 in. x 11 ½ in. rectangular orifice notched out of the inlet wall at an invert elevation of 725.17. The release rate of runoff from the 11-year to 100-year storms will be controlled by the 3 in. x 11 ½ in. orifice and by a 4 in. x 12 ¾ in. rectangular orifice notched out of the inlet wall at an invert elevation of 727.33. A trash guard screen will be installed over the 10-year orifice to prevent clogging from debris (see Exhibit 4: Detention Details).

Please note that the actual release rate resulting from the flow through the orifice was plugged back into the Detention Storage Calculations worksheets and the resulting storage volume for the actual release rate was calculated. The release rate restriction by way of the orifices does not result in additional required storage. Please refer to the attached Orifice Sizing Calculations (page 16) for the design release rate.

Hours	Minutes	Return Period - Rainfall Intensity (in/hr)					
		2	5	10	25	50	100
0.08	5	4.75	6.14	6.99	8.08	8.83	9.69
0.17	10	3.63	4.75	5.48	6.40	7.07	7.77
0.25	15	2.97	3.92	4.55	5.34	5.94	6.53
0.5	30	1.98	2.64	3.09	3.65	4.10	4.50
1	60	1.25	1.67	1.96	2.31	2.62	2.88
2	120	0.76	1.02	1.20	1.40	1.59	1.75
3	180	0.56	0.75	0.88	1.03	1.17	1.29
6	360	0.33	0.44	0.52	0.60	0.68	0.75
12	720	0.20	0.26	0.30	0.35	0.39	0.43
24	1440	0.11	0.15	0.17	0.20	0.22	0.25

Hours	Minutes	Return Period - Rainfall Depth (in)					
		2	5	10	25	50	100
0.08	5	0.40	0.51	0.58	0.67	0.74	0.81
0.17	10	0.61	0.79	0.91	1.07	1.18	1.30
0.25	15	0.74	0.98	1.14	1.34	1.49	1.63
0.5	30	0.99	1.32	1.55	1.83	2.05	2.25
1	60	1.25	1.67	1.96	2.31	2.62	2.88
2	120	1.52	2.04	2.40	2.80	3.18	3.50
3	180	1.68	2.25	2.64	3.09	3.51	3.87
6	360	1.98	2.64	3.12	3.60	4.08	4.50
12	720	2.40	3.12	3.60	4.20	4.68	5.16
24	1440	2.64	3.60	4.08	4.80	5.28	6.00

TABLE 202-02: IDF and IDD Tables for Indianapolis, IN

TIME OF CONCENTRATION or TRAVEL TIME WORKSHEET

Project: Franklin 2012 Park Bond

Designer: DMS **Date:** 22-Jan-13

Str. No.: Pre-Developed Condition

Sheet Flow

1.	**Surface Description**	grass	grass	pvmt
2.	**Manning's Roughness Coeff., (n)**	[redacted]	[redacted]	[redacted]
3.	**Flow Length, (L) **total L<= 300 ft**	238.00 ft.	0.00 ft.	ft.
4.	**Two-yr 24-hr Rainfall, (P2)**	[redacted] in.	[redacted] in.	[redacted] in.
5.	**Land Slope, (s)**	0.0336 ft./ft.	0.3300 ft./ft.	0.0200 ft./ft.
6.	**Travel Time, (Tt)** **(Tt = [0.007(nL)^0.8]/[P2^0.5*s^0.4])**	[redacted] hr +	[redacted] hr +	[redacted] hr

Shallow Concentrated Flow

7.	**Surface Description** **(paved or unpaved)**	**paved**	**paved**	**unpaved**
8.	**Flow Length, (L)**	0.00 ft.	n/a ft.	0.00 ft.
9.	**Watercourse Slope, (s)**	0.0103 ft./ft.	0.0050 ft./ft.	0.0100 ft./ft.
10.	**Average Velocity, (V)** **(Vp = 20.3282(s)^0.5)** **(Vup = 16.1345(s)^0.5)**	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
11.	**Travel Time, (Tt)** **(Tt = L/3600V)**	[redacted] hr +	[redacted] hr +	[redacted] hr

Watershed or Subarea Tc or Tt =

0.292 hr

or

17.54 min

Channel Flow

12.	**Cross Sectional Flow Area, (a)**	0.40 ft.^2	21.00 ft.^2	20.20 ft.^2
13.	**Wetted Perimeter, Pw**	2.04 ft.	18.20 ft.	18.20 ft.
14.	**Hydraulic Radius, (r)** **(r = a/Pw)**	[redacted] ft.	[redacted] ft.	[redacted] ft.
15.	**Channel Slope, (s)**	0.0030 ft./ft.	0.0460 ft./ft.	0.0050 ft./ft.
16.	**Manning's Roughness Coeff., (n)**	0.060	0.060	0.060
17.	**Velocity, (V)** **(V = [1.49*r^0.67*s^0.5]/n)**	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
18.	**Flow Length, (L)**	0.00 ft.	0.00 ft.	0.00 ft.
19.	**Travel Time, (Tt)** **(Tt = L/3600V)**	[redacted] hr +	[redacted] hr +	[redacted] hr

DETENTION STORAGE CALCULATIONS

Allowable 10-yr Release Rate

Project: Franklin Parks Dept. 2012 Bond - Rec Center Parking Expansion

Designer: DMS **Date: 01/22/13**

Release Rate Return Period	**2** yrs	**Design Return Period**	**10** yrs
Watershed Area, (AU) **(Undeveloped Watershed)**	1.02 acres	**Watershed Area, (AD)** **(Developed Watershed)**	1.02 acres
Time of Concentration **(Undeveloped Watershed)**	17.54 min.	**Developed Runoff** **Coefficient, (CD)**	0.59
Rainfall Intensity, (iU)	4.30 in./hr		
Undeveloped Runoff **Coefficient, (CU)**	0.39		
Undeveloped Runoff Rate, (O) **(O = CU*iU*AU)**	1.71 cfs		

Storm Duration	Rainfall Intensity	Inflow Rate	Outflow Rate	Storage Rate	Required Storage
td	id	I(td) = (CD*id*AD)	O = (CU*iU*AU)	I(td)-O	[I(td)-O]*td/12
(hrs)	(in./hr)	(cfs)	(cfs)	(cfs)	(ac-ft)
0.08	6.99	4.21	1.71	2.50	0.02
0.17	5.48	3.30	1.71	1.59	0.02 = 871.2 ft^3
0.25	4.55	2.74	1.71	1.03	0.02
0.50	3.09	1.86	1.71	0.15	0.01
1.00	1.96	1.18	1.71	-0.53	-0.04
2.00	1.20	0.72	1.71	-0.99	-0.16
3.00	0.88	0.53	1.71	-1.18	-0.30
6.00	0.52	0.31	1.71	-1.40	-0.70
12.00	0.30	0.18	1.71	-1.53	-1.53
24.00	0.17	0.10	1.71	-1.61	-3.22

DETENTION STORAGE CALCULATIONS

Design 10-yr Release Rate

Project: Franklin Parks Dept. 2012 Bond - Rec Center Parking Expansion

Designer: DMS **Date: 01/22/13**

Release Rate Return Period	**2** yrs	**Design Return Period**	**10** yrs
Watershed Area, (AU) **(Undeveloped Watershed)**	1.02 acres	**Watershed Area, (AD)** **(Developed Watershed)**	1.02 acres
Time of Concentration **(Undeveloped Watershed)**	17.54 min.	**Developed Runoff** **Coefficient, (CD)**	0.59
Rainfall Intensity, (iU)	4.30 in./hr		
Undeveloped Runoff **Coefficient, (CU)**	0.39		
Undeveloped Runoff Rate, (O) **(O = CU*iU*AU)**	1.70 cfs	**Release Rate through 3"x11.5" rectangular orifice**	

Storm Duration (t) (hrs)	Rainfall Intensity (i) (in./hr)	Inflow Rate I(t) = (CD*i*AD) (cfs)	Outflow Rate (O = (CU*iU*AU)) (cfs)	Storage Rate I(t)-O (cfs)	Required Storage [I(t)-O]*t/12 (acre-ft)
[illegible]	6.99	4.21	1.70	2.51	0.02
[illegible]	5.48	3.30	1.70	1.60	0.02 = 871.2 ft³ ✓
[illegible]	4.55	[illegible]	1.70	[illegible]	0.02
[illegible]	3.09	[illegible]	1.70	[illegible]	0.01
[illegible]	1.96	[illegible]	1.70	[illegible]	-0.04
[illegible]	1.20	[illegible]	[illegible]	[illegible]	-0.16
[illegible]	0.88	[illegible]	[illegible]	[illegible]	-0.29
[illegible]	0.52	[illegible]	[illegible]	[illegible]	-0.69
[illegible]	0.30	[illegible]	[illegible]	[illegible]	-1.52
24.00	0.17	[illegible]	[illegible]	[illegible]	-3.20

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DETENTION STORAGE CALCULATIONS

Allowable 100-yr Release Rate

Project: Franklin Parks Dept. 2012 Bond - Rec Center Parking Expansion

Designer: DMS **Date: 01/22/13**

Release Rate Return Period	**10** yrs	**Design Return Period**	**100** yrs
Watershed Area, (AU) **(Undeveloped Watershed)**	1.02 acres	**Watershed Area, (AD)** **(Developed Watershed)**	1.02 acres
Time of Concentration **(Undeveloped Watershed)**	17.54 min.	**Developed Runoff** **Coefficient, (CD)**	0.59
Rainfall Intensity, (iU)	6.19 in./hr		
Undeveloped Runoff **Coefficient, (CU)**	0.39		
Undeveloped Runoff Rate, (O) **(O = CU*iU*AU)**	2.46 cfs		

Storm Duration	Rainfall Intensity	Inflow Rate	Outflow Rate	Storage Rate	Required Storage
[illegible]	id	[illegible]	O = (CU*iU*AU)	[illegible]	[illegible]
(hrs)	(in./hr)	(cfs)	(cfs)	(cfs)	(acre-ft)
[illegible]	9.69	[illegible]	[illegible]	[illegible]	0.02
[illegible]	7.77	[illegible]	[illegible]	[illegible]	0.03 = 1306.8 ft^3
[illegible]	6.53	[illegible]	[illegible]	[illegible]	0.03
[illegible]	4.50	[illegible]	[illegible]	[illegible]	0.01
[illegible]	2.88	[illegible]	[illegible]	[illegible]	-0.06
[illegible]	1.75	[illegible]	[illegible]	[illegible]	-0.23
[illegible]	1.29	[illegible]	[illegible]	[illegible]	-0.42
[illegible]	0.75	[illegible]	[illegible]	[illegible]	-1.01
[illegible]	0.43	[illegible]	[illegible]	[illegible]	-2.20
[illegible]	0.25	[illegible]	[illegible]	[illegible]	-4.62

12

DETENTION STORAGE CALCULATIONS

Design 100-yr Release Rate

Project: Franklin Parks Dept. 2012 Bond - Rec Center Parking Expansion

Designer: DMS **Date: 01/22/13**

Release Rate Return Period	**10** yrs	**Design Return Period**	**100** yrs
Watershed Area, (AU) (Undeveloped Watershed)	1.02 acres	**Watershed Area, (AD) (Developed Watershed)**	1.02 acres
Time of Concentration (Undeveloped Watershed)	17.54 min.	**Developed Runoff Coefficient, (CD)**	0.59
Rainfall Intensity, (iU)	6.19 in./hr		
Undeveloped Runoff Coefficient, (CU)	0.39		
Undeveloped Runoff Rate, (O) (O = CU*iU*AU)	2.46 cfs	**Release Rate through 3"x11.5" and 4"x12.75" rectangular orifices**	

Storm Duration td (hrs)	Rainfall Intensity id (in./hr)	Inflow Rate I(td) = (CD*id*AD) (cfs)	Outflow Rate O = (CU*iU*AU) (cfs)	Storage Rate I(td)-O (cfs)	Required Storage [I(td)-O]*td/12 (acre-ft)
0.08	9.69	[illegible]	2.46	[illegible]	0.02
0.17	7.77	[illegible]	[illegible]	[illegible]	0.03 = 1306.8 ft^3 ✓
0.25	6.53	[illegible]	[illegible]	1.47	0.03
[illegible]	4.50	[illegible]	[illegible]	[illegible]	0.01
[illegible]	2.88	[illegible]	[illegible]	-0.73	-0.06
2.00	1.75	[illegible]	[illegible]	-1.41	-0.23
[illegible]	1.29	[illegible]	[illegible]	[illegible]	-0.42
[illegible]	0.75	[illegible]	[illegible]	[illegible]	-1.00
12.00	0.43	[illegible]	[illegible]	[illegible]	-2.20
24.00	0.25	[illegible]	2.46	[illegible]	-4.62

13

Prismoidal Volume Results
10-YR

Surface Report

Client: Client Company

Project Name: R:\Active\Franklin, City\2012 Park Bond\CAD\PLANS\Recreation Center\C3D Data\C3D_MASTER - Recreation Center_Design.dwg

Project Description:

Report Date: 1/19/2013 3:59:43 PM

Prepared by: Preparer

Linear Units: foot	**Area Units:** squareFoot	**Volume Units:** cubicYard

Surface: 10 YR POND VOLUME
Description: Description

Area 2D: 2933.341	Area 3D: 3092.189
Elevation Max: 2.150	Elevation Min: -2.430
Number of Points: 6400	Number of Triangles: 12254

Surface: TOP OF BANK
Description: Description

Area 2D: 5200.125	Area 3D: 5200.125
Elevation Max: 727.320	Elevation Min: 727.320 = 10-yr Elevation
Number of Points: 318	Number of Triangles: 332

Volume Surface: 10 YR POND VOLUME
Description: Description

Volume Cut: 86.480	Volume Fill: 32.246	Volume Total: -54.234

Compare Surface: TOP OF BANK
Base Surface: DRY DETENTION (1)

Prismoidal Volume Results
100-YR

Surface Report

Client: Client Company

Project Name: R:\Active\Franklin, City\2012 Park Bond\CAD\PLANS\Recreation Center\C3D Data\C3D_MASTER - Recreation Center_Design.dwg

Project Description:

Report Date: 1/19/2013 4:13:24 PM

Prepared by: Preparer

Linear Units: foot	**Area Units:** squareFoot	**Volume Units:** cubicYard

Surface: 100 YR POND VOLUME

Description: Description

Area 2D: 2933.341	Area 3D: 3092.189
Elevation Max: 2.510	Elevation Min: -2.070
Number of Points: 6400	Number of Triangles: 12254

Surface: TOP OF BANK (100 YR)

Description: Description

Area 2D: 5200.125	Area 3D: 5200.125
Elevation Max: 727.680	Elevation Min: 727.680 = 100-yr Elevation
Number of Points: 318	Number of Triangles: 332

Volume Surface: 100 YR POND VOLUME

Description: Description

Volume Cut: 63.288 Volume Fill: 48.166 Volume Total: -15.123

Compare Surface: TOP OF BANK (100 YR)
Base Surface: DRY DETENTION (1)

CROSSROAD ENGINEERS, PC

CrossRoad Engineers, P.C.
3417 Sherman Drive
Beech Grove, IN 46107
Office: 317-780-1555 Fax: 317-780-6525
www.crossroadengineers.com

Date ______

Page ______ of ______

Project /Client ______

Prepared By ______ Date ______

Reviewed By ______ Date ______

Project Franklin 2012 Park Bond - Rec Center

Subject Orifice Sizing Calculations

Orifice Equ.

$Q = C_d A \sqrt{2gh}$

10 yr

Storage Volume Req'd = 871.2 ft³
10 yr. Elev. = 727.32

Orifice Inv. = 725.17

Assume orifice - 3" x 11½"

$H = 727.32 - 725.17 - \left(0.5 \times \frac{3}{12}\right) = 2.025$

$Q_{10} = 0.62 \times \frac{3" \times 11\frac{1}{2}"}{144 \text{ in}^2/\text{ft}^2} \times \sqrt{2 \times 32.2 \times 2.025} = 1.70$ cfs ✓

100 yr

Storage Volume Req'd = 1306.8 ft³
100 yr. Elev. = 727.68

Q_{max} = 100 yr Allowable − Actual 10 yr Release Rate

$Q_{max} = 2.46$ cfs − 1.70 cfs = 0.76 cfs

Orifice Inv. = 727.33

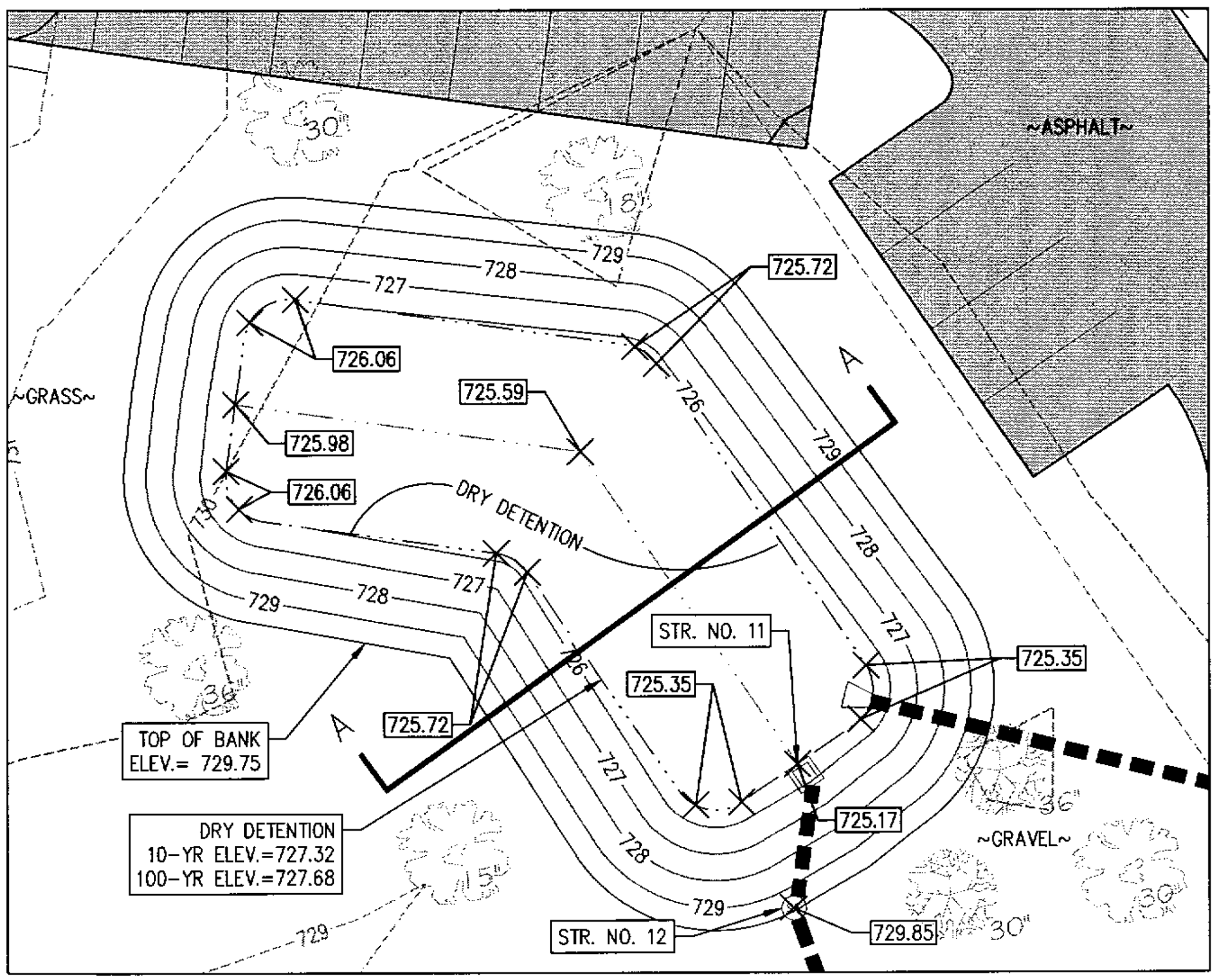
$h = Q_{100}$ Elev. − Center of orifice $= 727.68 - \underset{\text{Inv.}}{727.33} - \frac{0.33}{2} = 0.185$

$0.70 = 0.62 A \sqrt{2 \times 32.2 \times 0.185}$

$A = L \times H = 0.33 L = 0.372$

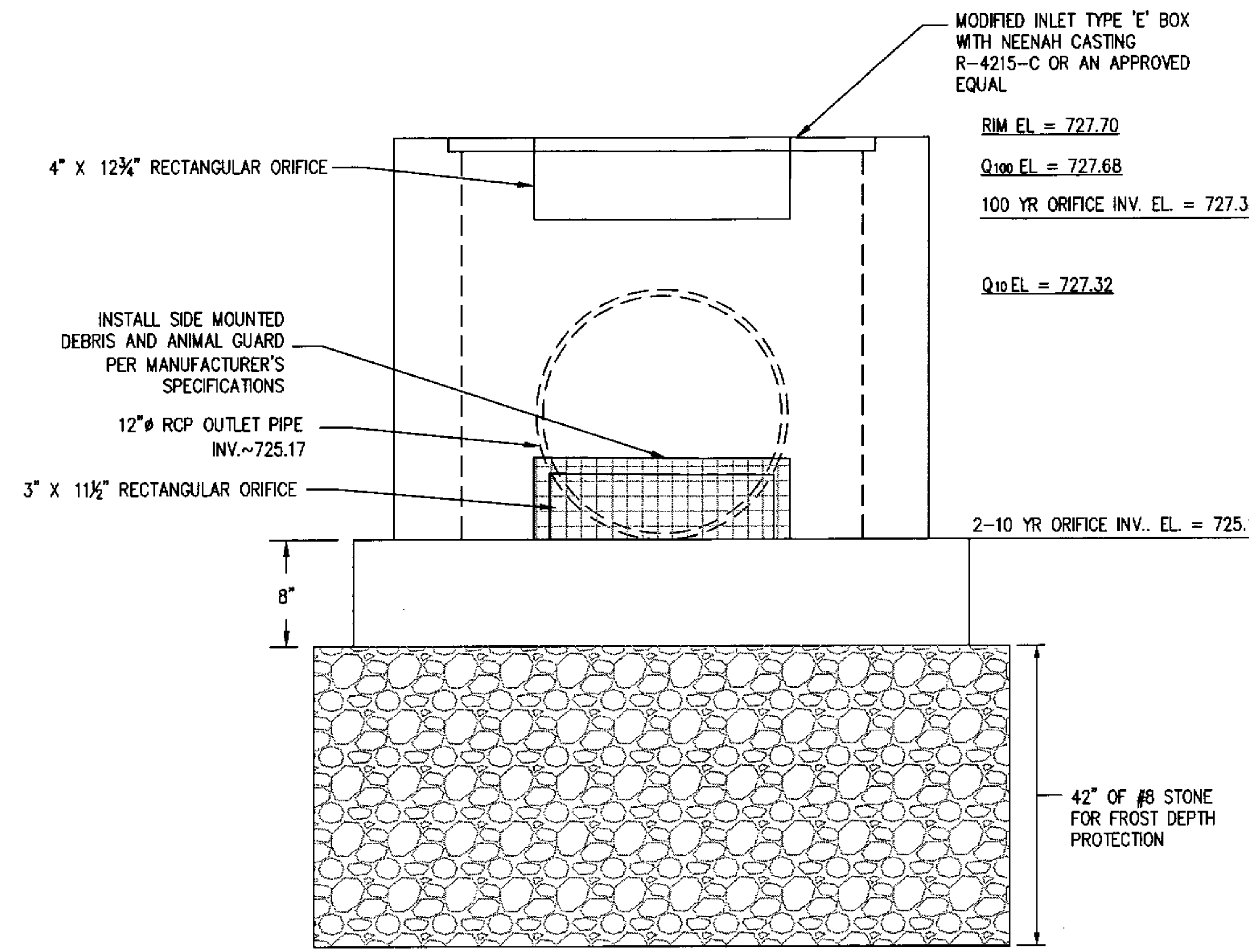
$L = 1.127'$ → use $12\frac{3}{4}"$

Orifice Size = 4" x 12¾" ✓



DRY BASIN PLAN VIEW

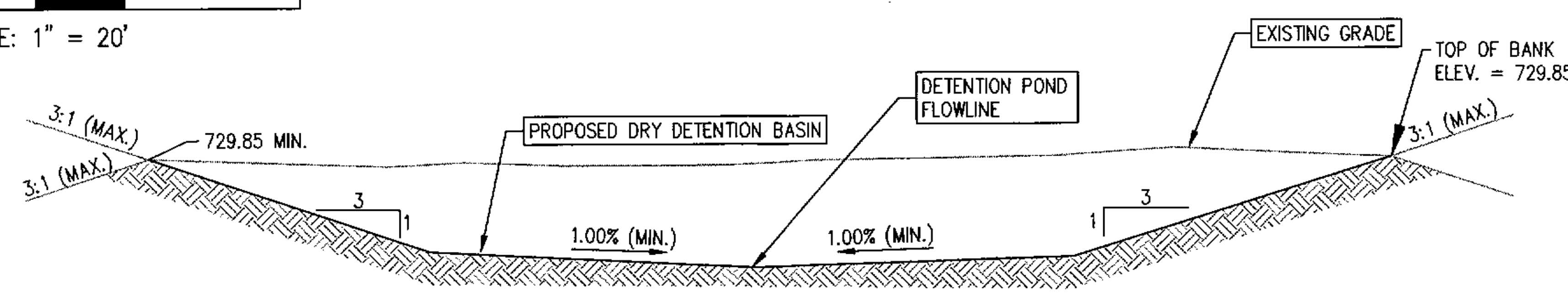
SCALE: 1" = 20'



STR. NO. 11

PROPOSED POND OUTLET STRUCTURE

(TYPE 'E' BOX)
NOT TO SCALE



TYPICAL DRY BASIN SECTION A-A

NOT TO SCALE

EXHIBIT 4

DETENTION POND & OUTLET STRUCTURE DETAILS

17

PREPARED BY:

CROSSROAD ENGINEERS, PC

Transportation & Development Consultants

3417 S. SHERMAN DR. BEECH GROVE, IN 46107 (317) 780-1555

JANUARY 22, 2013

Section 3: Pipe Sizing Calculations

Pipe Sizing Summary

The Rational Method was used to size the pipes to convey the peak runoff from the 10-year storm. The TR-55 Method was used to calculate the times of concentration. Pipe sizing calculations (pages 22-28), Exhibit 5: Inlet Basin Map, and the time of concentration worksheets (pages 20-21) are included within this section.

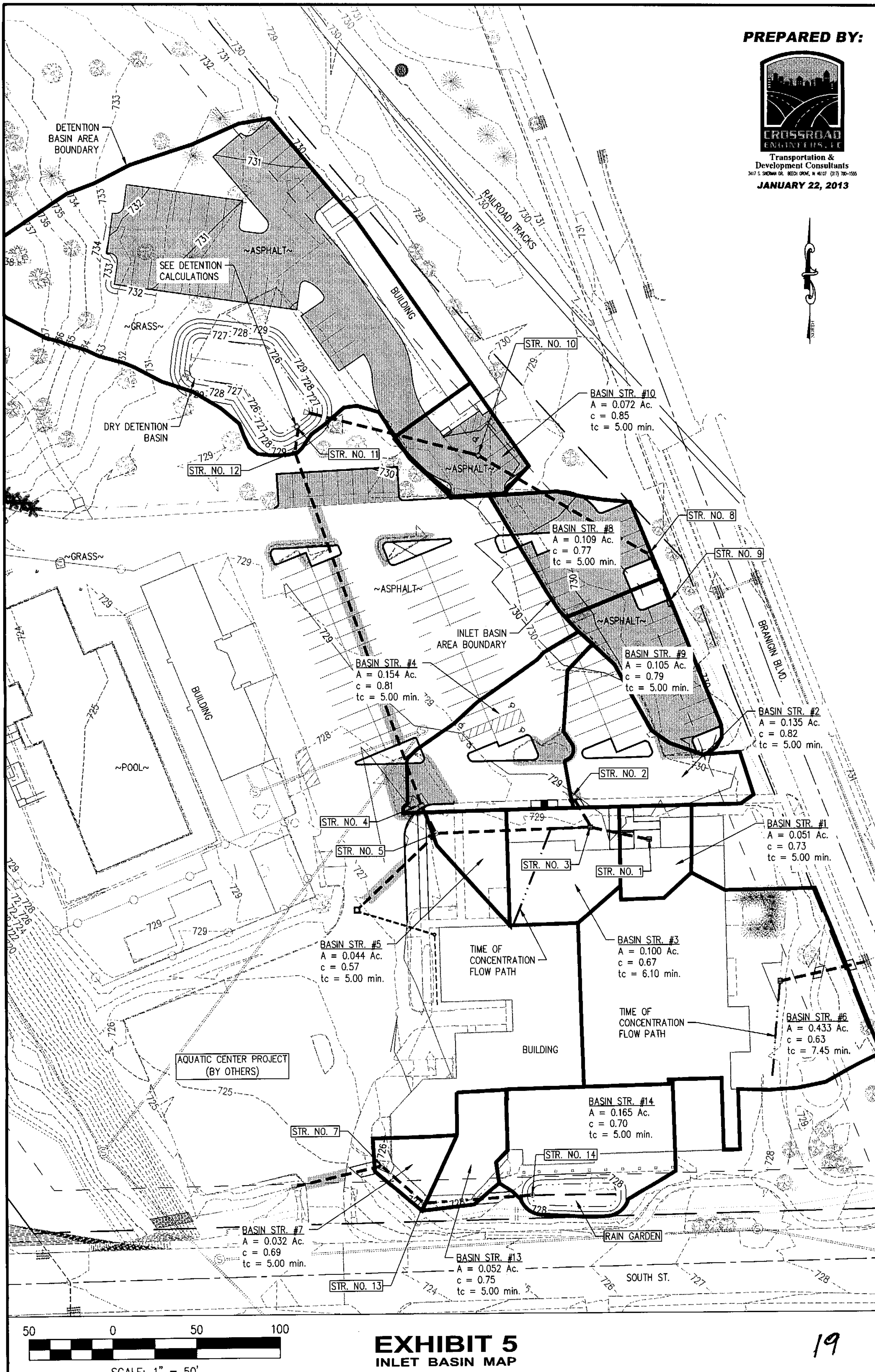


EXHIBIT 5
INLET BASIN MAP

TIME OF CONCENTRATION or TRAVEL TIME WORKSHEET

Project: Franklin 2012 Park Bond

Designer: DMS **Date:** 22-Jan-13

Str. No.: [redacted]

Sheet Flow

1.	Surface Description	grass	grass	pvmt
2.	Manning's Roughness Coeff., (n)	[redacted]	[redacted]	[redacted]
3.	Flow Length, (L) **total L<= 300 ft	49.00 ft.	0.00 ft.	0.00 ft.
4.	Two-yr 24-hr Rainfall, (P2)	[redacted] in.	[redacted] in.	[redacted] in.
5.	Land Slope, (s)	0.0200 ft./ft.	0.3300 ft./ft.	0.0200 ft./ft.
6.	Travel Time, (Tt) (Tt = [0.007(nL)^0.8]/[P2^0.5*s^0.4])	[redacted] hr +	[redacted] hr +	[redacted] hr

Shallow Concentrated Flow

7.	Surface Description (paved or unpaved)	paved	paved	unpaved
8.	Flow Length, (L)	0.00 ft.	n/a ft.	0.00 ft.
9.	Watercourse Slope, (s)	0.0103 ft./ft.	0.0050 ft./ft.	0.0100 ft./ft.
10.	Average Velocity, (V) (Vp = 20.3282(s)^0.5) (Vup = 16.1345(s)^0.5)	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
11.	Travel Time, (Tt) (Tt = L/3600V)	[redacted] hr +	[redacted] hr +	[redacted] hr

Watershed or Subarea Tc or Tt = **0.102 hr** or **6.10 min**

Channel Flow

12.	Cross Sectional Flow Area, (a)	7.35 ft.^2	21.00 ft.^2	20.20 ft.^2
13.	Wetted Perimeter, Pw	11.20 ft.	18.20 ft.	18.20 ft.
14.	Hydraulic Radius, (r) (r = a/Pw)	[redacted] ft.	[redacted] ft.	[redacted] ft.
15.	Channel Slope, (s)	0.0010 ft./ft.	0.0460 ft./ft.	0.0050 ft./ft.
16.	Manning's Roughness Coeff., (n)	0.120	0.060	0.060
17.	Velocity, (V) (V = [1.49*r^0.67*s^0.5]/n)	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
18.	Flow Length, (L)	0.00 ft.	0.00 ft.	0.00 ft.
19.	Travel Time, (Tt) (Tt = L/3600V)	[redacted] hr +	[redacted] hr +	[redacted] hr

TIME OF CONCENTRATION or TRAVEL TIME WORKSHEET

Project: Franklin 2012 Park Bond

Designer: DMS **Date:** 22-Jan-13

Str. No.: [redacted]

Sheet Flow

1. Surface Description	grass	grass	pvmt
2. Manning's Roughness Coeff., (n)	[redacted]	[redacted]	[redacted]
3. Flow Length, (L) **total L<= 300 ft	63.00 ft.	0.00 ft.	0.00 ft.
4. Two-yr 24-hr Rainfall, (P2)	[redacted] in.	[redacted] in.	[redacted] in.
5. Land Slope, (s)	0.0200 ft./ft.	0.3300 ft./ft.	0.0200 ft./ft.
6. Travel Time, (Tt) (Tt = [0.007(nL)^0.8]/[P2^0.5*s^0.4])	[redacted] hr +	[redacted] hr +	[redacted] hr

Shallow Concentrated Flow

7. Surface Description (paved or unpaved)	paved	paved	unpaved
8. Flow Length, (L)	0.00 ft.	n/a ft.	ft.
9. Watercourse Slope, (s)	0.0103 ft./ft.	0.0050 ft./ft.	0.0100 ft./ft.
10. Average Velocity, (V) (Vp = 20.3282(s)^0.5) (Vup = 16.1345(s)^0.5)	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
11. Travel Time, (Tt) (Tt = L/3600V)	[redacted] hr +	[redacted] hr +	[redacted] hr

Watershed or Subarea Tc or Tt = **0.124 hr**
or
7.45 min

Channel Flow

12. Cross Sectional Flow Area, (a)	3.00 ft.^2	21.00 ft.^2	20.20 ft.^2
13. Wetted Perimeter, Pw	6.32 ft.	18.20 ft.	18.20 ft.
14. Hydraulic Radius, (r) (r = a/Pw)	[redacted] ft.	[redacted] ft.	[redacted] ft.
15. Channel Slope, (s)	0.0100 ft./ft.	0.0460 ft./ft.	0.0050 ft./ft.
16. Manning's Roughness Coeff., (n)	0.060	0.060	0.060
17. Velocity, (V) (V = [1.49*r^0.67*s^0.5]/n)	[redacted] ft./s	[redacted] ft./s	[redacted] ft./s
18. Flow Length, (L)	0.00 ft.	0.00 ft.	0.00 ft.
19. Travel Time, (Tt) (Tt = L/3600V)	[redacted] hr +	[redacted] hr +	[redacted] hr

Str. No. 1

① $A = 0.051$ Ac.

② $CA = (0.010 \times 0.25) + (0.041 \times 0.85) = 0.037$

③ t_c 5 min. (assumed)
$i = 6.99$ in/hr

④ $Q = \Sigma C i A = 0.037 \times 6.99$ in/hr $= 0.26$ cfs

S_{min} @ Q_{act} = 0.01 %

⑤ Pipe = 36 LFT of 12"ϕ RCP @ 1.28%

Q_{max} @ S_{act} = 4.37 cfs

⑥ time in pipe = $\frac{1\ s.}{5.56\ ft.} \times 36\ ft. \times \frac{1\ min}{60\ s.}$

V_{max} @ S_{act} = 5.56 fps

⑦ = 0.11 min.

⑧

Str. No. 2

① $A = 0.135$ Ac.

② $CA = (0.007 \times 0.25) + (0.128 \times 0.85) = 0.111$

③ $t_c = .5$ min.
$i = 6.99$ in/hr

④ $Q = \Sigma C i A = 0.111 \times 6.99$ in/hr $= 0.78$ cfs

S_{min} @ Q_{act} = 0.04 %

⑤ Pipe = 20 LFT of 12"ϕ RCP @ 1.00%

Q_{max} @ S_{act} = 3.86 cfs

⑥ time in pipe = $\frac{1\ s.}{4.91\ ft.} \times 20\ ft. \times \frac{1\ min.}{60\ s.}$

V_{max} @ S_{act} = 4.91 fps

⑦ = 0.07 min.

⑧

DES: ______ DATE: ______

REV: ______ DATE: ______

Str. No. 3

① $A = 0.100$ Ac.

② $CA = (0.030 \times 0.25) + (0.070 \times 0.85) = 0.067$

③ t_c 6.10 min.
$i = 6.66$ in/hr

④ $Q = \Sigma C i A = 6.66$ in/hr $\times (\underbrace{0.067 + \overset{\text{St. \#1}}{0.037} + \overset{\text{St. \#2}}{0.111}}_{0.215})$
$= 1.43$ cfs

⑤ Pipe = 84 LFT of 12" ϕ RCP @ 1.20%

⑥ time in pipe $= \frac{1 \text{ s.}}{5.38 \text{ ft.}} \times 84 \text{ ft} \times \frac{1 \text{ min}}{60 \text{ s.}}$

⑦ $= 0.26$ min.

⑧

S_{min} @ Q_{act} = 0.14 %

Q_{max} @ S_{act} = 4.23 cfs

V_{max} @ S_{act} = 5.38 fps

Str. No. 4

① $A = 0.154$ Ac.

② $CA = (0.25 \times 0.010) + (0.85 \times 0.144) = 0.125$

③ $t_c = 5$ min ≤
$i = 6.99$ in/hr

④ $Q = \Sigma C i A = 6.99$ in/hr $\times (0.125) = 0.87$ cfs

⑤ + 1.70 cfs (10-yr discharge from detention pond)

⑥ $= 2.57$ cfs

⑦ Pipe = 27 LFT of 12" ϕ RCP @ 1.00%

⑧ time in pipe $= \frac{1 \text{ s.}}{4.91 \text{ ft.}} \times 27 \text{ ft.} \times \frac{1 \text{ min.}}{60 \text{ s.}} = 0.09$ min

S_{min} @ Q_{act} = 0.44 %

Q_{max} @ S_{act} = 3.86 cfs

V_{max} @ S_{act} = 4.91 fps

DES:________ DATE:________

REV:________ DATE:________

Str. No. 5

① $A = 0.044$ Ac.

② $CA = (0.25 \times 0.020) + (0.85 \times 0.024) = 0.025$

③ t_c 5 min. (local) < $6.10 + \underset{}{\overset{\text{str \#3}}{0.26}} = 6.36$ min.

$i = 6.58$ in/hr

④ $Q = \Sigma CiA = 6.58$ in/hr $\times (0.025 + \overset{\text{str \#3}}{0.215} + \underset{\text{str \#4}}{0.125}) + 1.70$ cfs (10-yr discharge from pond)

⑤

$= 4.10$ cfs

⑥

S_{min} @ Q_{act} = 0.34 %

Q_{max} @ S_{act} = 7.92 cfs

V_{max} @ S_{act} = 6.45 fps

⑦ Pipe = 65 LFT of 15" ϕ RCP @ 1.28%

⑧ time in pipe = $\frac{1\ s.}{6.45\ ft.} \times 65\ ft. \times \frac{1\ min.}{60\ s.} = 0.17$ min.

Str. No. 6

① A =

② CA =

③ t_c =

i =

④ $Q = \Sigma CiA$ =

⑤ Pipe =

⑤ time in pipe =

⑦

⑧

S_{min} @ Q_{act} = ______ %

Q_{max} @ S_{act} = ______ cfs

V_{max} @ S_{act} = ______ fps

DES: ________ DATE: ________

REV: ________ DATE: ________

Str. No. 6

① $A = 0.433$ Ac.

② $CA = (0.25 \times 0.159) + (0.85 \times 0.274) = 0.273$

③ t_c 7.49 min.
$i = 6.25$ in/hr

④ $Q = \Sigma C i A = 6.25$ in/hr $\times 0.273 = 1.71$ cfs

S_{min} @ Q_{act} = 0.20 %

⑤ Pipe = 50 LFT of 12" ϕ RCP @ 0.40%

Q_{max} @ S_{act} = 2.44 cfs

V_{max} @ S_{act} = 3.11 fps

⑥ time in pipe $= \frac{1\ s}{3.11\ ft} \times 50\ ft \times \frac{1\ min}{60\ s}$

⑦ $= 0.27$ min.

⑧

Str. No. 14

① $A = 0.165$ Ac

② $CA = (0.25 \times 0.042) + (0.85 \times 0.123) = 0.115$

③ $t_c = 5$ min. (assumed)
$i = 6.99$ in/hr

④ $Q = \Sigma C i A = 6.99$ in/hr $\times 0.115 = 0.80$ cfs

S_{min} @ Q_{act} = 0.04 %

⑤ Pipe = 63 LFT of 12" ϕ RCP @ 1.44%

Q_{max} @ S_{act} = 4.63 cfs

V_{max} @ S_{act} = 5.90 fps

⑥ time in pipe $= \frac{1\ s}{5.90\ ft} \times 63\ ft \times \frac{1\ min}{60\ s}$

⑦ $= 0.18$ min.

⑧

DES:________ DATE:________

REV:________ DATE:________

Str. No 13

① $A = 0.052$ Ac.

② $CA = (0.25 \times 0.008) + (0.85 \times 0.044) = 0.039$

③ t_c 5.18 min. (Str. No 14)
$i = 6.94$ in/hr

④ $Q = \Sigma C i A = 6.94 \text{ in/hr} \times (\underbrace{0.039 + \overset{\text{str. \#14}}{0.115}}_{0.154})$ S_{min} @ Q_{act} = 0.08 %
$= 1.07$ cfs

⑤ Pipe = 34 LFT of 12" ϕ RCP @ 1.44% Q_{max} @ S_{act} = 4.63 cfs

V_{max} @ S_{act} = 5.90 fps

⑥ time in pipe = $\frac{1 \text{ s.}}{5.90 \text{ ft.}} \times 34 \text{ ft.} \times \frac{1 \text{ min}}{60 \text{ s.}}$

⑦ $= 0.10$ min.

⑧

Str. No. 7

① $A = 0.032$ Ac.

② $CA = (0.25 \times 0.008) + (0.85 \times 0.024) = 0.022$

③ $t_c = 5.28$ min. (Str. No. 13)
$i = 6.91$ in/hr

④ $Q = \Sigma C i A = 6.91 \text{ in/hr} \times (\underbrace{0.022 + \overset{\text{str. \#13}}{0.154}}_{0.176})$ S_{min} @ Q_{act} = 0.10 %
$= 1.22$ cfs

⑤ Pipe = 52 LFT of 12" ϕ RCP @ 1.00% Q_{max} @ S_{act} = 3.86 cfs

V_{max} @ S_{act} = 4.91 fps

⑥ time in pipe = $\frac{1 \text{ s.}}{4.91 \text{ ft.}} \times 52 \text{ ft.} \times \frac{1 \text{ min.}}{60 \text{ s.}}$

⑦ $= 0.18$ min.

⑧

DES:______ DATE:______

REV:______ DATE:______

Str. No. 9

① $A = 0.105$ Ac.

② $CA = (0.25 \times 0.010) + (0.85 \times 0.095) = 0.083$

③ $t_c = 5$ min.
$i = 6.99$ in/hr

S_{min} @ Q_{act} = 0.02 %

④ $Q = \Sigma CiA = 6.99$ in/hr $\times 0.083$
$= 0.58$ cfs

Q_{max} @ S_{act} = 2.86 cfs

⑤ Pipe = 30 LFT of 12" ϕ RCP @ 0.55%

V_{max} @ S_{act} = 3.64 fps

⑥ time in pipe $= \frac{1 \text{ s.}}{3.64 \text{ ft.}} \times 30 \text{ ft.} \times \frac{1 \text{ min.}}{60 \text{ s.}}$

⑦ $= 0.14$ min.

⑧

Str. No. 8

① $A = 0.109$ Ac.

② $CA = (0.25 \times 0.014) \times (0.85 \times 0.095) = 0.084$

③ $t_c = 5.14$ min.
$i = 6.95$ in/hr

S_{min} @ Q_{act} = 0.09 %

④ $Q = \Sigma CiA = 6.95$ in/hr $\times (0.084 + \underbrace{0.083}_{\text{str \#9}})$ ... $\underbrace{0.084+0.083}_{0.167}$
$= 1.16$ cfs

Q_{max} @ S_{act} = 2.86 cfs

⑤ Pipe = 119 LFT of 12" ϕ RCP @ 0.55%

V_{max} @ S_{act} = 3.64 fps

⑥ time in pipe $= \frac{1 \text{ s.}}{3.64 \text{ ft.}} \times 119 \text{ ft.} \times \frac{1 \text{ min.}}{60 \text{ s.}}$

⑦ $= 0.55$ min.

⑧

DES: ______ DATE: ______

REV: ______ DATE: ______

Str. No. 10

① $A = 0.072$ Ac.

② $CA = (0.25 \times 0.00) + (0.85 \times 0.072) = 0.061$

③ $t_c = \overset{\text{Str \#8}}{5.14} + 0.55$ min. $= 5.69$ min

$i = 6.79$ in/hr

④ $Q = \Sigma C i A = 6.79$ in/hr $\times \overset{\text{Str. \#8}}{(\underbrace{0.061 + 0.167}_{0.228})}$ S_{min} @ Q_{act} = 0.16 %

$= 1.55$ cfs

⑤ Pipe = 98 LFT of 12" ϕ RCP @ 0.55% Q_{max} @ S_{act} = 2.86 cfs

⑥ time in pipe $= \frac{1 \text{ s.}}{3.64 \text{ ft.}} \times 98 \text{ ft.} \times \frac{1 \text{ min.}}{60 \text{ s.}}$ V_{max} @ S_{act} = 3.64 fps

⑦ $= 0.45$ min.

⑧

Str. No. ________

① $A =$

② $CA =$

③ $t_c =$

$i =$

④ $Q = \Sigma C i A =$ S_{min} @ Q_{act} = ______ %

⑤ Pipe = Q_{max} @ S_{act} = ______ cfs

⑥ time in pipe = V_{max} @ S_{act} = ______ fps

⑦

⑧

DES: ________ DATE: ________

REV: ________ DATE: ________

Section 4: Storm Inlet Calculations

Storm Inlet Summary

Per Article 6.19, Section F of the SCO, the proposed storm inlets have been checked to ensure that the inlet grate will be adequate to pass the design 10-year flow with 50% of the grate clogged and with the maximum depth of water not exceeding 0.75 feet (depth from adjacent pavement grade to rim elevation). The attached chart is a Discharge vs. Depth on Grate charts provided by Neenah Foundry Company.

Structure No.	Casting Type	Watershed Runoff	Total Runoff	Grate Capacity	Depth Over Grate	Bypass
1	R-4215-C	0.26 cfs	0.26 cfs	1.2 cfs	0.10'	0 cfs
2	R-3246-CL	0.78 cfs	0.78 cfs	0.8 cfs	0.12'	0 cfs
3	R-4215-C	0.45 cfs	0.45 cfs	1.2 cfs	0.10'	0 cfs
4	R-3246-CL	0.87 cfs	0.87 cfs	0.9 cfs	0.13'	0 cfs
5	R-2500	0.17 cfs	0.17 cfs	0.6 cfs	0.10'	0 cfs
6	R-4215-C	1.65 cfs	1.65 cfs	1.7 cfs	0.13'	0 cfs
7	R-4370-5	0.15 cfs	0.15 cfs	0.5 cfs	0.10'	0 cfs
8	R-3246-CL	0.59 cfs	0.59 cfs	0.6 cfs	0.10'	0 cfs
9	R-3246-CL	0.58 cfs	0.58 cfs	0.6 cfs	0.10'	0 cfs
10	R-3472-A	0.43 cfs	0.43 cfs	0.8 cfs	0.10'	0 cfs
13	R-4370-5	0.27 cfs	0.27 cfs	0.5 cfs	0.10'	0 cfs

STR. NO. 1 and 3

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-4215-C:Beehive

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
11.3	0.13	3.3

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
1.7		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STK. NO. 2

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: **$Q = 3.3P(h)^{1.5}$**

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: **$Q = 0.6A\sqrt{2gh}$**

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-3246-CL:L

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
5.9	0.12	1.6

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.8		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 4

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-3246-CL:L

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
5.9	0.13	1.6

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.8		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 5

HOME // MUNICIPAL // ENGINEERING TOOLS & CALCULATORS // WEIR AND ORIFICE CALCULATOR

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-2500:G

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
6.2	0.1	0.9

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.6		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 6

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-4215-C:Beehive

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
11.3	0.13	3.3

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
1.7		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 7 and 13

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-4370-5:G

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
4.7	0.1	0.8

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.5		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 8 and 9

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- Q = Capacity in CFS
- P = Feet perimeter
- h = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- Q = Capacity in CFS
- A = Free open area of grate in sq. ft.
- g = 32.2 (feet per sec/sec)
- h = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-3246-CL:L

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
5.9	0.1	1.6

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.6		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

STR. NO. 10

WEIR & ORIFICE CALCULATOR

The Weir and Orifice Calculator is used to determine the inlet capacity in sag (ponding) conditions by use of the Weir and Orifice equations. Knowing this information will allow you to select the proper grate type and size for your specific job or project.

Weir Flow Calculations

Weir Equation: $Q = 3.3P(h)^{1.5}$

- **Q** = Capacity in CFS
- **P** = Feet perimeter
- **h** = Head in feet
- Weir Information

Orifice Flow Calculations

Orifice Flow Equation: $Q = 0.6A\sqrt{2gh}$

- **Q** = Capacity in CFS
- **A** = Free open area of grate in sq. ft.
- **g** = 32.2 (feet per sec/sec)
- **h** = Head in feet
- Orifice Information

Instructions:

1. Select a catalog number (will automatically fill in Open Area and Perimeter) or enter your own values
2. Enter head value
3. Click "calculate"

The results will determine automatically if your situation falls into a Weir, Transitional or Orifice flow. Additionally, Neenah grates which fall within the parameters chosen will appear below the calculator.

Catalog Number and Grate Type:

R-3472:A or C

Feet perimeter (P):	Head in feet (h):	Free open area in sq. ft. (A):
7.3	0.1	1.3

Calculate

Weir capacity in cfs:	Transitional flow in cfs:	Orifice capacity in cfs:
0.8		

Based on weir flow, the following grates match the criteria you entered.

Catalog Number	Grate Type

For additional information regarding Neenah Inlet Grate Capacities, please contact Steven Akkala P.E., at (920) 729.3653 or email at steve.akkala@neenahenterprises.com.

Section 5: Water Quality Calculations

Article 6.19, Section H of the SCO requires developers to provide a water quality detention system designed to detain, for over 24 hours after the peak runoff from a 24-hour storm, 20% of either the runoff from a 1-1/4" storm event or ½" of direct runoff, whichever is greater. As discussed in Section 2, the Modified Rational Method was utilized for the detention calculations due to the small project site and inaccurate numbers obtained by the SCS hydrograph method for such a small site (1.02 acre). The following tables provide water quality calculations verifying that the proposed rain garden is appropriately designed to detain the water quality storm event from ½" of direct runoff over the entire site per the Franklin SCO and the water quality storm volume as calculated per the City of Indianapolis Green Infrastructure Guide. Due to the wide use of rain gardens within the City of Indianapolis, the Green Infrastructure Guide was consulted for the proposed Recreation Center rain garden to ensure that it was designed in accordance with water quality standards that more directly address the rain garden design.

Table 3
Post-Development Stormwater Quality Volume – Using Franklin SCO

Area (ac.)	Runoff Depth (in.)	Total Volume (cu. ft.)	WQ Volume (20% of Total)
0.165	1/2	300.0	60

Table 4
Post-Development Stormwater Quality Volume – Using Indianapolis Guidelines

Area (ac.)	Percent Impervious	Total Volume Req'd (ac-ft)	WQ Volume Req'd (cu. ft.)
0.165	75%	0.01 ac-ft	435.6

To meet the requirements for water quality, the rim elevation of the 18 inch Nyoplast Drain Basin in the rain garden was set just above the rain garden water quality elevation providing 435.6 cu. ft. of storage for the water quality event. As a conservative measure, this method assumes evaporation and infiltration through the planting soil in the rain garden for the "release" of the water quality storm. This assumption yields a detention time in excess of the required 24-hour period. This approach results in rim elevations of 727.82 for the Nyoplast Drain Basin. Please see Exhibit 6: Rain Garden Plan, Exhibit 6A: Rain Garden Details, and Exhibit 6B: Rain Garden Details for additional information.

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Date

Page of

Project /Client

Project

Prepared By Date

Subject Rain Garden Design

Reviewed By Date

$$WQ_v = \frac{PR_vA}{12}$$

$A =$ Roof $5330\ ft^2 +$ Walk $49\ ft^2 +$ Landscaping $1808\ ft^2 = 7187\ ft^2$
$= 0.165\ Ac.$

$$WQ_v = \frac{1 \times (0.05 + 0.009(75\%)) * 0.165}{12}$$

$WQ_v = 0.01\ ac\text{-}ft$

R.G. footprint area $= 644\ ft^2 = 0.0148\ Ac$

Pond Depth $= \frac{0.01\ Ac\text{-}ft}{0.0148\ Ac.} = 0.68' = 8'' \pm > 6''$ min.

WQ_v Elev. = 727.81

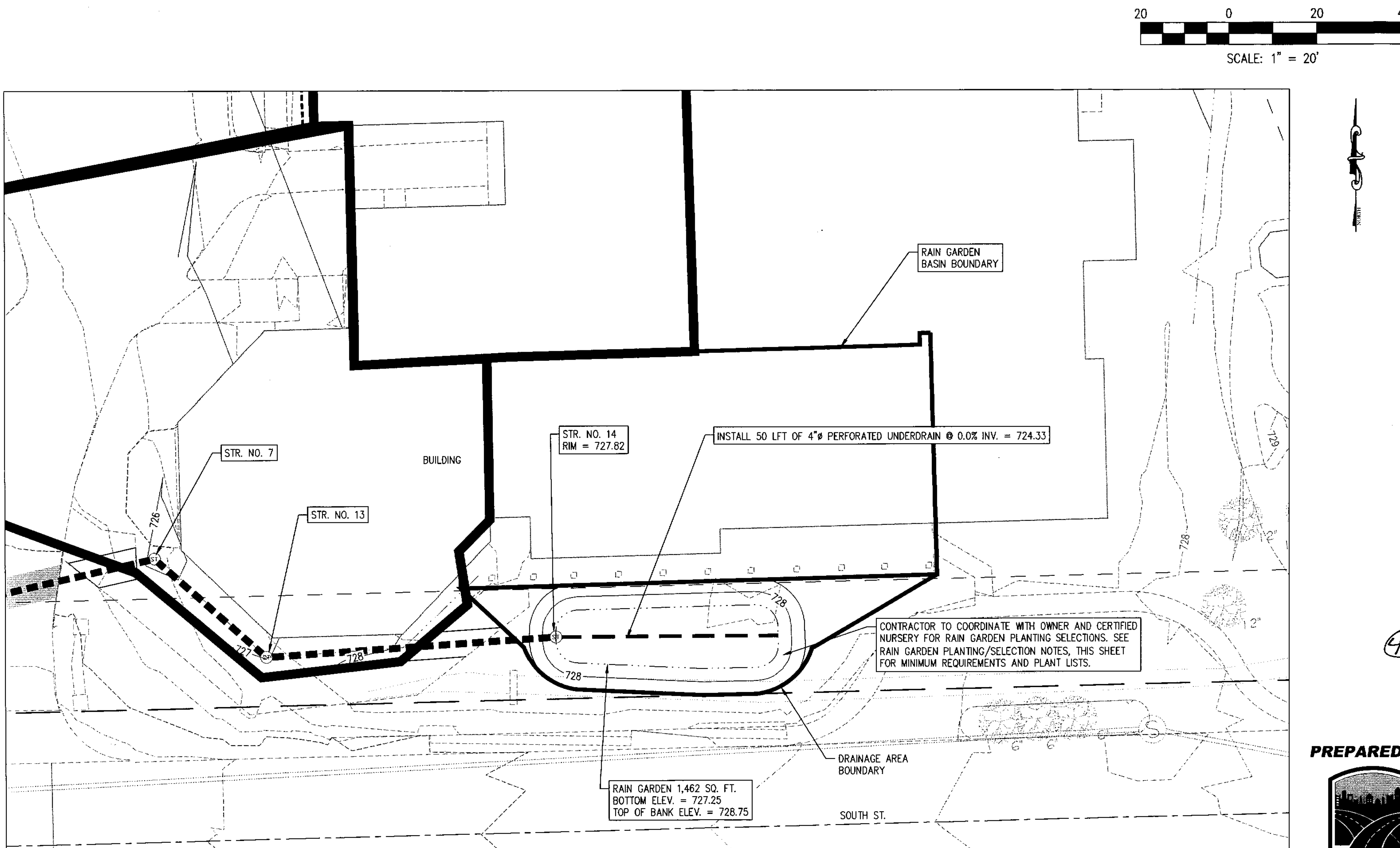

EXHIBIT 6
RAIN GARDEN PLAN

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PREPARED BY:

CROSSROAD ENGINEERS, P.C.
Transportation & Development Consultants
3417 S. SHERMAN DR. BEECH GROVE, IN 46107 (317) 780-1555

JANUARY 22, 2013

RAIN GARDEN GENERAL NOTES AND SPECIFICATIONS

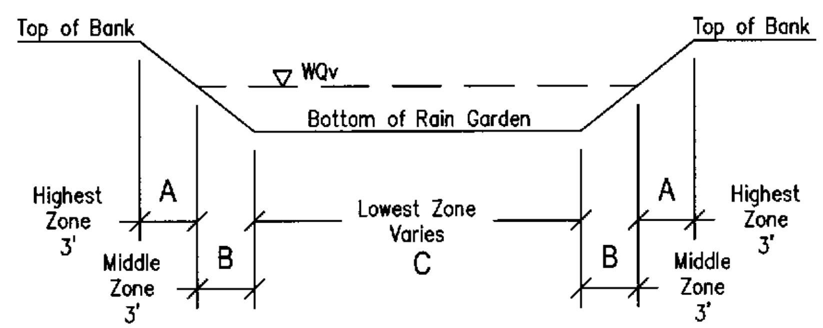
1. PLANTING SOIL SHALL MEET THE FOLLOWING SPECIFICATIONS:
   - CLAY CONTENT: LESS THAN 5%
   - SAND CONTENT: 50–60%
   - LEAF COMPOST OR AGED LEAF MULCH: 20–30%
   - HIGH QUALITY TOP SOIL: 20–30%
2. PLANTING SOIL SHOULD BE FREE OF STONES, STUMPS, ROOTS, OR OTHER WOODY MATERIAL OVER 1–INCH DIAMETER. IT SHOULD ALSO BE FREE OF BRUSH OR SEEDS FROM NOXIOUS WEEDS. PLACEMENT OF THE PLANTING SOIL SHOULD BE IN LIFTS OF 12–18 INCHES. LOOSELY COMPACTED (TAMPED LIGHTLY WITH A DOZER OR BACKHOE BUCKET.)
3. PLANTING SOIL MUST HAVE A MINIMUM PERMEABILITY OF 1.0 FT/DAY (0.5 INCHES PER HOUR)
4. ORGANIC MULCH SHALL BE AGED, DOUBLE–SHREDDED HARDWOOD BARK MULCH, OR COMPOSTED LEAF MULCH.

RAIN GARDEN CONSTRUCTION GUIDELINES

1. AREAS OF BIORETENTION SHALL BE CLEARLY MARKED BEFORE ANY SITE WORK BEGINS TO AVOID SOIL DISTURBANCE AND COMPACTION DURING CONSTRUCTION.
2. PROVIDE EROSION AND SEDIMENTATION CONTROL PROTECTION ON THE SITE SUCH THAT CONSTRUCTION RUNOFF IS DIRECTED AWAY FROM THE PROPOSED BIORETENTION LOCATION. PROPOSED BIORETENTION AREAS MAY ONLY BE USED AS SEDIMENT TRAPS DURING CONSTRUCTION IF AT LEAST TWO FEET OF SOIL ARE REMOVED AND REPLACED.
3. COMPLETE SITE ELEVATION GRADING AND STABILIZE THAT SOIL DISTURBED WITHIN THE LIMITS OF DISTURBANCE. DO NOT FINALIZE BIORETENTION EXCAVATION AND CONSTRUCTION UNTIL THE DRAINAGE AREA IS FULLY STABILIZED.
4. EXCAVATE BIORETENTION AREA TO PROPOSED INVERT DEPTH AND MANUALLY SCARIFY THE EXISTING SOIL SURFACES. DO NOT COMPACT IN–SITU SOILS. HEAVY EQUIPMENT SHALL NOT BE USED WITHIN THE BIORETENTION BASIN. ALL EQUIPMENT SHALL BE KEPT OUT OF THE EXCAVATED AREA TO THE MAXIMUM EXTENT POSSIBLE.
5. IF USING AN UNDERDRAIN AND/OR A GRAVEL STORAGE BED, PLACE FILTER FABRIC OR GRAVEL FILTER, THEN PLACE THE ROCK, AND SET THE UNDERDRAIN ACCORDING TO THE PLANS.
6. BACKFILL THE EXCAVATED AREA AS SOON AS THE SUBGRADE PREPARATION IS COMPLETE TO AVOID ACCUMULATION OF DEBRIS. PLACE BIORETENTION SOIL IN 12–18 INCH LIFTS WITHOUT COMPACTION. OVERFILLING WILL BE NECESSARY TO ACCOUNT FOR SETTLEMENT. PRESOAK SOIL AT LEAST ONE DAY PRIOR TO FINAL GRADING AND LANDSCAPING TO ALLOW FOR SETTLEMENT.
7. AFTER ALLOWING SOIL TO SETTLE, COMPLETE FINAL GRADING WITHIN 3 INCHES OF THE PROPOSED DESIGN ELEVATIONS, LEAVING SPACE FOR TOP DRESSING OF MULCH OR MULCH/COMPOST BLEND.
8. SEED AND PLANT VEGETATION AS INDICATED ON THE PLANS AND SPECIFICATIONS.
9. PLACE MULCH AND HAND GRADE TO FINAL ELEVATIONS.
10. WATER VEGETATION REGULARLY DURING FIRST YEAR TO ENSURE SUCCESSFUL ESTABLISHMENT.

RAIN GARDEN PLANTING/SELECTION NOTES

1. CONTRACTOR SHALL COORDINATE WITH OWNER AND CERTIFIED NURSERY FOR PLANTING SELECTION AND LAYOUT.
2. ALL LANDSCAPE PLANTINGS SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF CHAPTER 5 OF THE CITY OF INDIANAPOLIS GREEN SUPPLEMENTAL DOCUMENT AND OFFICE OF SUSTAINABILITY.
3. THE MINIMUM PLANTING QUANTITIES LISTED BELOW SHALL BE SATISFIED:
   - 10 LARGE TREES
   - 20 SMALL TREES OR SHRUBS
   - 60 FERNS OR GRASS–LIKE PLANTS (1–GALLON CONTAINERS)
   - GROUND COVER PLANTINGS AND WILD FLOWER PLUGS – 12 INCHES ON CENTER – TRIANGULAR SPACING (NOTE: A NATIVE GRASS/WILD FLOWER SEED MIX CAN BE USED AS AN ALTERNATIVE TO GROUND COVER PLANTING. SEED MIX SHALL BE FREE OF WEED SEEDS.)
4. THE PLANTING MATERIALS SHALL BE IN ACCORDANCE WITH THE TABLES BELOW:
   - TABLE 5.2.1 : LOWEST ZONE
   - TABLE 5.2.2 : MIDDLE ZONE
   - TABLE 5.2.3 : HIGHEST ZONE
   - RAIN GARDEN PLANTING ZONE DETAIL



RAIN GARDEN PLANTING ZONE DETAIL

NOT TO SCALE

Lowest Zone (Hydrologic zones 2-4):
Plant species adapted to standing and fluctuating water levels. Frequently used native plants include * :

Table 5.2.1 : Lowest Zone (Hydrologic zones 2-4) Suggested Plants

asters (Aster spp.)	winterberry (Ilex vericillata)
goldenrods (Solidago spp.)	arrowwood (Viburnum dentatum)
bergamot (Monarda fistulosa)	sweet pepperbush (Clethra alnifolia)
blue–flag iris (Iris versicolor)	bayberry (Myrica pensylvanica)
sedges (Carex spp.)	button bush (Cephalanthus occidentalis)
ironweed (Vernonia spp.)	white oak (Quercus bicolor)
blue vervain (Verbena hastate)	elderberry (Sambucus Canadensis)
joe–pye weed (Eupatorium spp.)	bald cypress (Taxodium distichum)
swamp milkweed (Asclepias incarnata)	river birch (Betula nigra)
switchgrass (Panicum virgatum)	sweetgum (Liquidambar styraciflua)
shrub dogwoods (Cornus spp.)	northern white cedar (Juniperus virginiana)
swamp rose (Rosa palustris)	red maple (Acer rubrum)

* Refer to the plant list for a complete listing

Middle Zone (Hydrologic zones 4-5):
This zone is slightly drier than the lowest zone, but plants should still tolerate fluctuating water levels. Some commonly planted native species include * :

Table 5.2.2 : Middle Zone (Hydrologic zones 4-5)

black snakeroot (Cimicifua racemosa)	spicebush (Lindera benzoin)
switchgrass (Panicum virgatum)	hackberry (Celtis occidentalis)
spotted joe–pye weed (Eupatorium maculatum)	willow oak (Quercus phellos)
cutleaf coneflower (Rudbeckia lacinata)	winterberry (Ilex verticillata)
frosted hawthorn (Crategus pruinosa)	slippery elm (Ulmus rubra)
ostrich fern (matteuccia struthiopteris)	blackhaw viburnum (Viburnum prunifolium)
sensitive fern (onoclea sensibilis)	Nannyberry (Virburnum)
ironwood (Carpinus caroliniana)	witch–hazel (Hamamelis virginiana)
obedient plant (Physostegia virginiana)	steeplebush (Spiraea tomentosa)

* Refer to the plant list for a complete listing

Outer Zone (Hydrologic zones 5-6):
Generally supports plants adapted to drier conditions. Examples of commonly planted native species include * :

Table 5.2.3 : Outer Zone (Hydrologic zones 5-6)

many grasses & wildflowers	juniper (Juniperus communis)
basswood (Tilia americana)	sweet–fern (Comptonia peregrina)
willow oak (Quercus alba)	eastern red cedar (Juniperus virginiana)
scarlet oak (Quercus coccinea)	smooth serviceberry (Amelanchier laevis)
black oak (Quercus velutina)	american holly (Ilex opaca)
american beech (Fagus grandifolia)	sassafras (Sassafras albidum)
burr oak (Quercus macrocarpa)**	shummard oak (Quercus shumardii)**
mapleleaf viburnum (viburnum acerifolium)	wild hydrangea (Hydrangea arborescens)
black chokecherry (Aronia melanocarpa)	white pine (Pinus strobus)

* Refer to the plant list for a complete listing
** Can be used in both the middle zone and outer zone–most adaptable oaks to constructed sites and variable hydrology.

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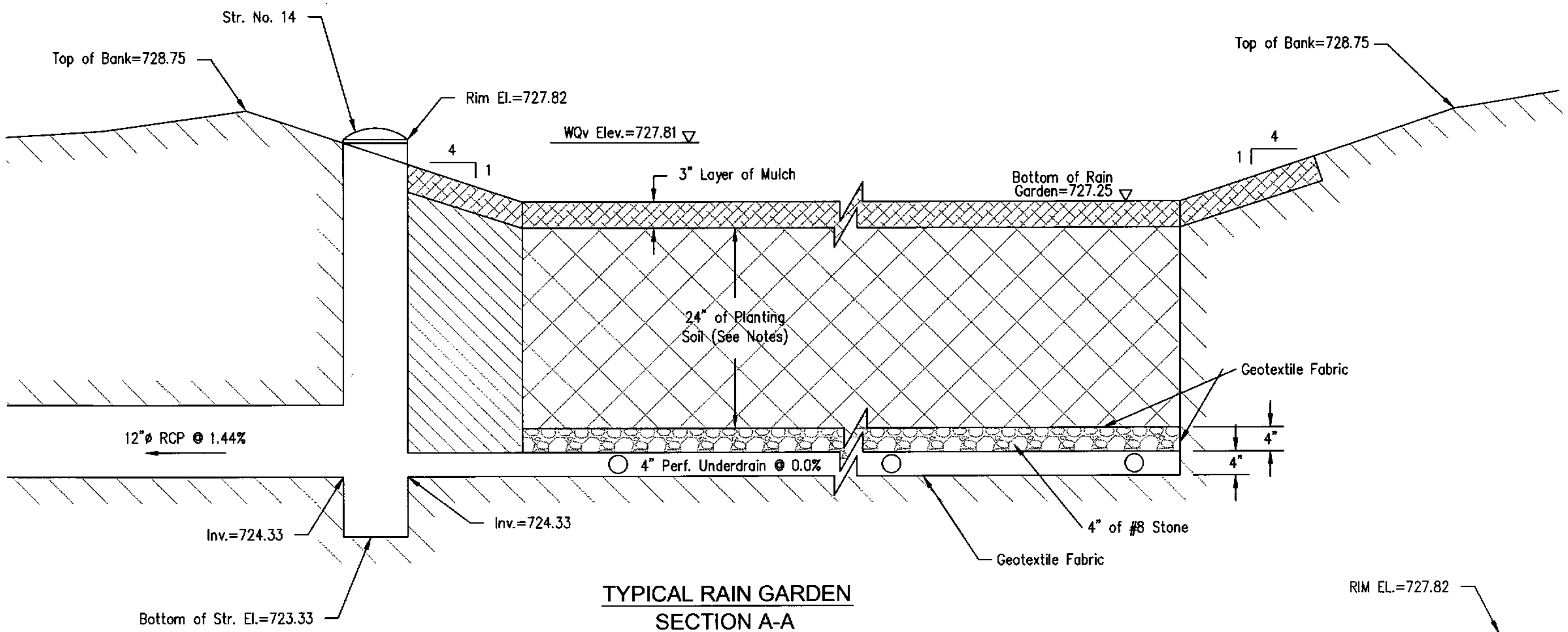
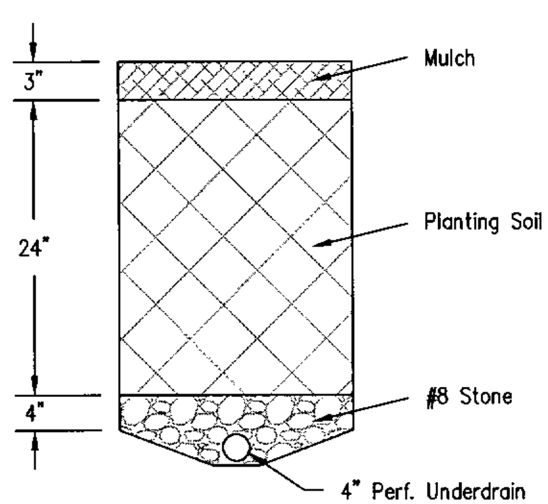
JANUARY 22, 2013

EXHIBIT 6A
RAIN GARDEN DETAILS



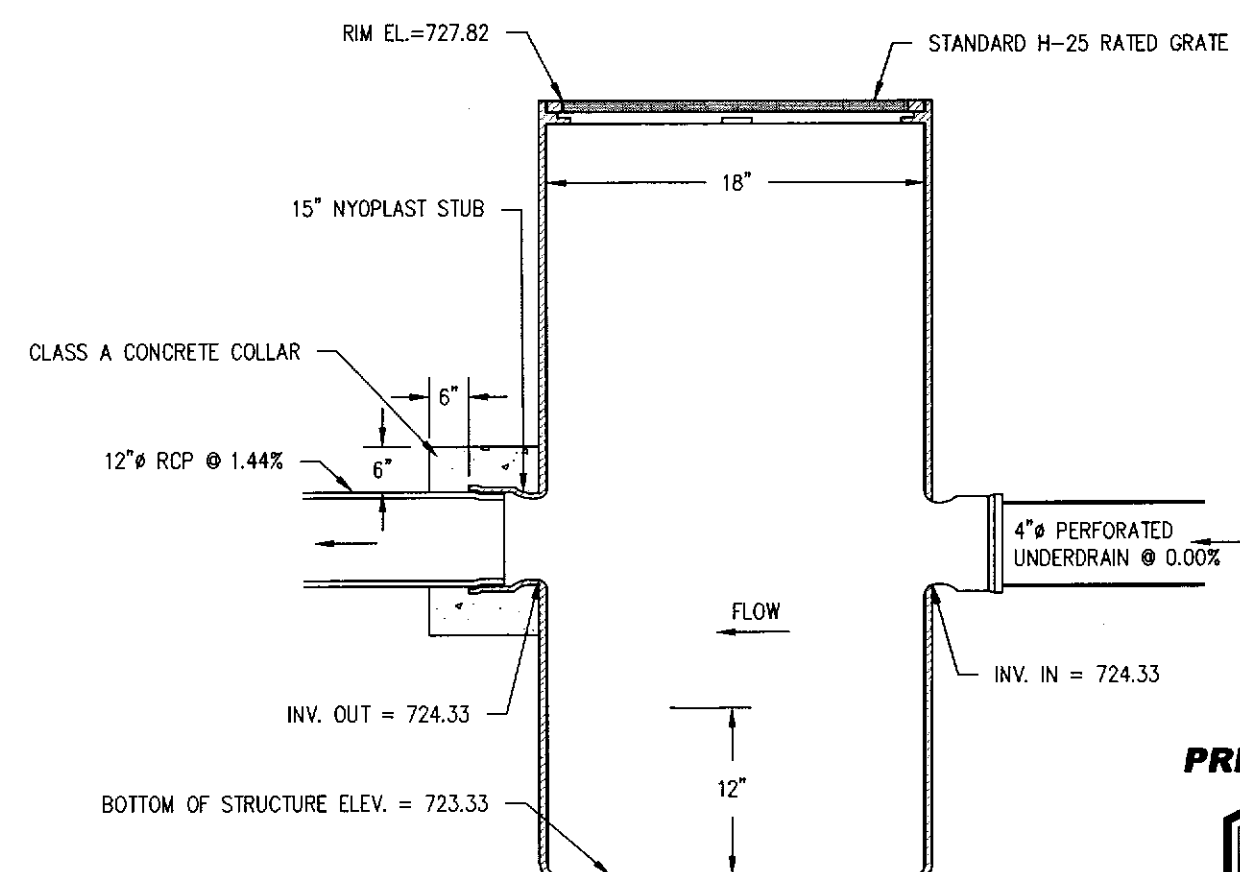
TYPICAL RAIN GARDEN SECTION A-A

NOT TO SCALE



UNDERDRAIN DETAIL

NOT TO SCALE



RAIN GARDEN OUTLET STRUCTURE DETAIL

NOT TO SCALE

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EXHIBIT 6B

RAIN GARDEN DETAILS

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