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1.0 INTRODUCTION

Williams Creek Consulting (WCC) has completed a drainage analysis for a theoretical SITE within Marion County, Indiana in order to compute the relative advantages of Low Impact Development strategies. WCC used a conventional layout for a 5.2 acre retail SITE in Indiana which was to be used as the baseline for the comparative analysis and has used the general release rate requirements found in section 302.03 of the Indianapolis Draft Stormwater Standards. The conventional pipe networking as well as inlet spacing was copied from an existing plan completed by others. Therefore, detailed pipe sizing calculations were not performed but presumed to be more or less adequate. The Wet Pond and outlet control structure was then sized in order to meet allowable outfall rates. The distributed storage alternative modified the existing conventional layout in order to demonstrate the effectiveness of source control of stormwater and the associated reduced infrastructure costs.

2.0 EXISTING CONDITIONS

This example assumes the pre-development state to be fallow field containing primarily 'C' type soils with a curve number of 74, with a pre-development Time of Concentration of 31.2 minutes. All regulatory storm events were run in HydroCAD v. 8.00 in order to develop pre-development peak flows for a variety of storm durations in order to assess the critical duration storm event. A CN of 74 was assumed for the pre-development condition, and a 31 minute time of concentration was computed based upon an existing 1% slope across the 5.2 acre site. The peak outfall results are summarized below in Table 1.

Table 1

	Duration	Existing (cfs)		Duration	Existing (cfs)		Duration	Existing (cfs)		Duration	Existing (cfs)
2 yr	1 hr.	1.24	10 yr	1 hr.	3.45	25 yr	1 hr.	4.27	100 y	1 hr.	10.54
	2 hr.	1.29		2 hr.	3.1		2 hr.	4.23		2 hr.	6.36
	3 hr.	1.04		3 hr.	2.61		3 hr.	3.54		3 hr.	5.17
	6 hr.	0.84		6 hr.	1.9		6 hr.	2.41		6 hr.	3.41
	12 hr.	0.63		12 hr.	1.3		12 hr.	1.64		12 hr.	2.35
	24 hr.	0.11		24 hr.	0.82		24 hr.	1.03		24 hr.	1.43

Per section 302.03 of the Draft City of Indianapolis Stormwater Specifications Manual, the post-development release rates should meet the requirements listed in Table 2:

Table 2

$Q_{2p} = 0.5\ Q_{2e}$	0.65
$Q_{10p} = 0.5\ Q_{10e}$	1.73
$Q_{25p} = 0.75\ Q_{10e}$	2.59
$Q_{100p} = Q_{10e}$	3.45

3.0 PROPOSED CONDITIONS AND STORMWATER DESIGN

3.1 Conventional Approach:

This example assumes the conventional approach of routing parking lot areas to inlet structures which pipe to a proposed wet pond. The roof of the retail facility is also presumed to outlet to pipes which similarly are routed to the wet pond. No storage is distributed across the site, with all attenuation requirements being accomplished by the wet pond. The wet pond is also the sole source for meeting water quality requirements mandated by the City of Indianapolis. In order to promote long term bank stability, stage depths of greater than four feet are generally avoided. Preserving a 100 year stage depth of less than four feet requires a pond footprint greater than that required on the plan layout. Specifically, 4,000 square feet were added to the theoretical pond in order to meet allowable outfall rates. The hundred year stage depth was multiplied by the theoretical pond expansion in order to project the quantity of underground storage that would need to be specified in order to develop costs associated with the conventional layout.

The modeling results were based upon the Huff 2nd Quartile storm distribution. Appendix A provides the modeling output for the Conventional approach. In each case, the critical duration storm was used. The results for the 2, 10, 25, and 100 year storm events are provided in Table 3.

Table 3

Event	Rate	
2 year	0.57	cfs
10 year	1.40	cfs
25 year	2.26	cfs
100 year	3.27	cfs

3.2 Distributed Storage Approach:

This example utilizes open space in the site layout which conventionally consists of raised landscape islands or berms. In this approach, all open spaces are depressed in order to accept stormwater run-off. These depressions serve three functions. First, the storage volumes within the depressions serve to attenuate surface runoff. Second, the lengths of the depressions serve to convey surface runoff to subsequent depressions, eliminating the need for pipe infrastructure; the exception being road crossings which require a culvert crossing. Thirdly, the depressions can be designed to meet water quality design criteria of dry basins, infiltration basins, or constructed wetlands, etc… depending on Owner's preference. In this example, the design prescribes bioretention basins and dry basins. Specifically, the bioretention basins are specified in the parking lot to facilitate robust vegetative growth and healthy rooting. These are built by over-excavating during construction and backfilling with 2' of top soil with a sandy amendment in order to raise the void ratio within the subgrade to approximately 0.3 which is utilized as storage in the calculations. Dry basins are specified around the perimeter of the Site. Both types of BMPs are designed with zero longitudinal slope and are therefore prescribed underdrains with 6" of cover in order to completely drain the facilities after storm events. Note that downstream receiving basins are typically 1' lower than their upstream counterpart. This provides for a 4" underdrain with a minimum of 6" of cover.

This particular arrangement prescribes a retaining wall raised above the bottom of the basins. The strategy is to force runoff into the underdrain up to an overflow represented by the retain wall. At this point, the underdrain is short-circuited and the runoff is directed straight to the culvert outlet. Enclosed details and renderings attempt to show an example of this system.

Utilizing space that would have been raised conventionally and converting these into stormwater management facilities has multiple advantages. First, the storage in the wet pond is no longer necessary. Second, the design intent of the bioretention basins is not to require frequent mowing, but to be left, literally, as a rain garden decreasing annual maintenance costs. Thirdly, the monthly or bi-weekly discharge of grass clippings (TSS) is no longer evident in the Site discharge. The regulation of nutrient excesses is not yet regulated by the City of Indianapolis, but the affect of nutrient laden stormwater and the associated algal blooms are usually evident in stagnant water bodies throughout the County. Most importantly for the Owner of the development is that the usage of conventionally ignored stormwater capacity within and around parking lots frees up additional space for development.

The modeling results were based upon the Huff 2nd Quartile storm distribution. Appendix B provides the modeling output for the Distributed Storage approach. In each case, the critical duration storm was used. The results for the 2, 10, 25, and 100 year storm events are provided in Table 4.

Table 4

Event	Rate	
2 year	0.13	cfs
10 year	0.15	cfs
25 year	0.22	cfs
100 year	0.54	cfs

4.0 Water Quality Illustration

4.1 Conventional Layout

Chapter 700 of the Draft Stormwater Standards provides little guidance for the sizing of Wet Pond BMPs for the purposes of water quality. Of the 23 design criteria listed, it appears that only criteria 1, 2, 3, and 13 of the design criteria apply to water quality. So long as the inlet to the Wet Pond is reasonably separated from the outlet, and if a forebay sized to contain 0.1 inches of runoff from the entire upstream watershed, 85% TSS can be claimed. However, no outlet rate from the forebay is mandated except that the exit velocities should be non-erosive. Since stormwater can flow out of the forebay as it is flowing in, it is difficult to quantify the actual forebay size required; exit velocities into ponds are rarely erosive to the wet pond.

Detailed specifications of the Wet Pond design are beyond the scope of this theoretical analysis. However, it appears space requirements are available for the specification of the 23 design criteria and for water quality requirements to be met.

4.2 Distributed Storage

The concept of distributed storage will typically increase TSS removal above that claimed via conventional layout methods. With distributed storage, the BMPs do not just store, but also convey the water which provides a treatment train affect.

4.2.1 Bioretention

A detailed proof of all 16 design criteria is outside the scope of this theoretical analysis. However, the distributed storage design may fail to meet design criteria 1 and/or 2 which provide guidance for acceptable bioretention area size and acceptable drainage area. These two design criteria should not be viewed separately as it should be written as comparative. That is, the Standards allow for a 5 acre watershed draining to a 200 square foot bioretention area, or conversely, a 0.5 acre watershed draining to a 5 acre bioretention area. Additionally, the distributed storage design does not comply with a four foot minimum planting soil depth; this is not necessary. Nearly all of the dissolved metals, fecal coliform, and suspended solids will be removed in the top few inches of organic compost mulch (references available). If the four feet of planting soil is required, these bioretention areas would likely be designed as “biofilters” or “water quality swales”.

4.2.2 Dry Detention Basins

Given the selection of BMPs provided in the Standards, the exterior BMPs would likely be classified as either a “water quality swale” or a “biofilter”. This selection would be made based upon Owner preference. It appears that ample space is required in order to bring these BMPs into line with the Draft Standards, and a detailed proof is outside the scope of this theoretical analysis.

4.3 Results

As an example theoretical calculation, assuming the BMP design conforms to the Draft Standards, the typical removal rate of TSS in stormwater exiting the SITE would be as follows:

4.3.1 Conventional

Water Quality Volume Calculation

Watersheds to Wet Pond	S curb	S roof	N roof	N Curb	srv dr	SE Park	E Park	NE Park	Direct Pond	Totals	ac-ft
A	0.136	0.313	0.313	0.125	0.553	1.535	0.835	1.096	0.292	5.198	
Rv	0.95	0.95	0.95	0.95	0.95	0.815	0.815	0.77	0.95		
P	1	1	1	1	1	1	1	1	1		
WQv	0.011	0.025	0.025	0.010	0.044	0.104	0.057	0.070	0.023	0.368	ac-ft

Since the entire WQv is routed to the Wet Pond, if designed properly, this would yield an overall TSS removal rate of 85%.

4.3.2 Distributed Storage

The distributed storage alternative is a more complex calculation as the stormwater may be treated once, twice, or three times depending on location. Specifically, watersheds Parking areas B, C, and D will be routed to bioretention before discharge to the North Swale. Parking areas F, G, H, I, and J will be routed to bioretention before discharge to the South Swale. Parking areas E and K are routed first to the South Swale before discharge to the North Swale, while the service drive, roof, and parking area A are routed directly to the North Swale. The water quality calculation by watershed is shown below:

Watershed to bioretention areas	Park B	Park C	Park D	Park F	Park G	Park H	Park I	Park J	total
A	0.327	0.25	0.14	0.148	0.15	0.39	0.138	0.145	1.688
Rv	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	
P	1	1	1	1	1	1	1	1	
WQv	0.026	0.020	0.011	0.012	0.012	0.031	0.011	0.011	0.134

Watersheds directly to South Swale	Park E	Park K	total
A	0.589	0.511	1.1
Rv	0.95	0.95	
P	1	1	

WQv	0.047	0.040	0.087

Watersheds directly to North Swale	srv dr	Roof N	Roof S	Park A	total
A	0.765	0.488	0.488	0.674	2.415
Rv	0.95	0.95	0.95	0.95	
P	1	1	1	1	
WQv	0.061	0.039	0.039	0.053	0.191

Assuming the BMP meet acceptable design criteria within the Draft Standards an illustration of the treatment train affect on TSS removal rate would be computed as shown below.

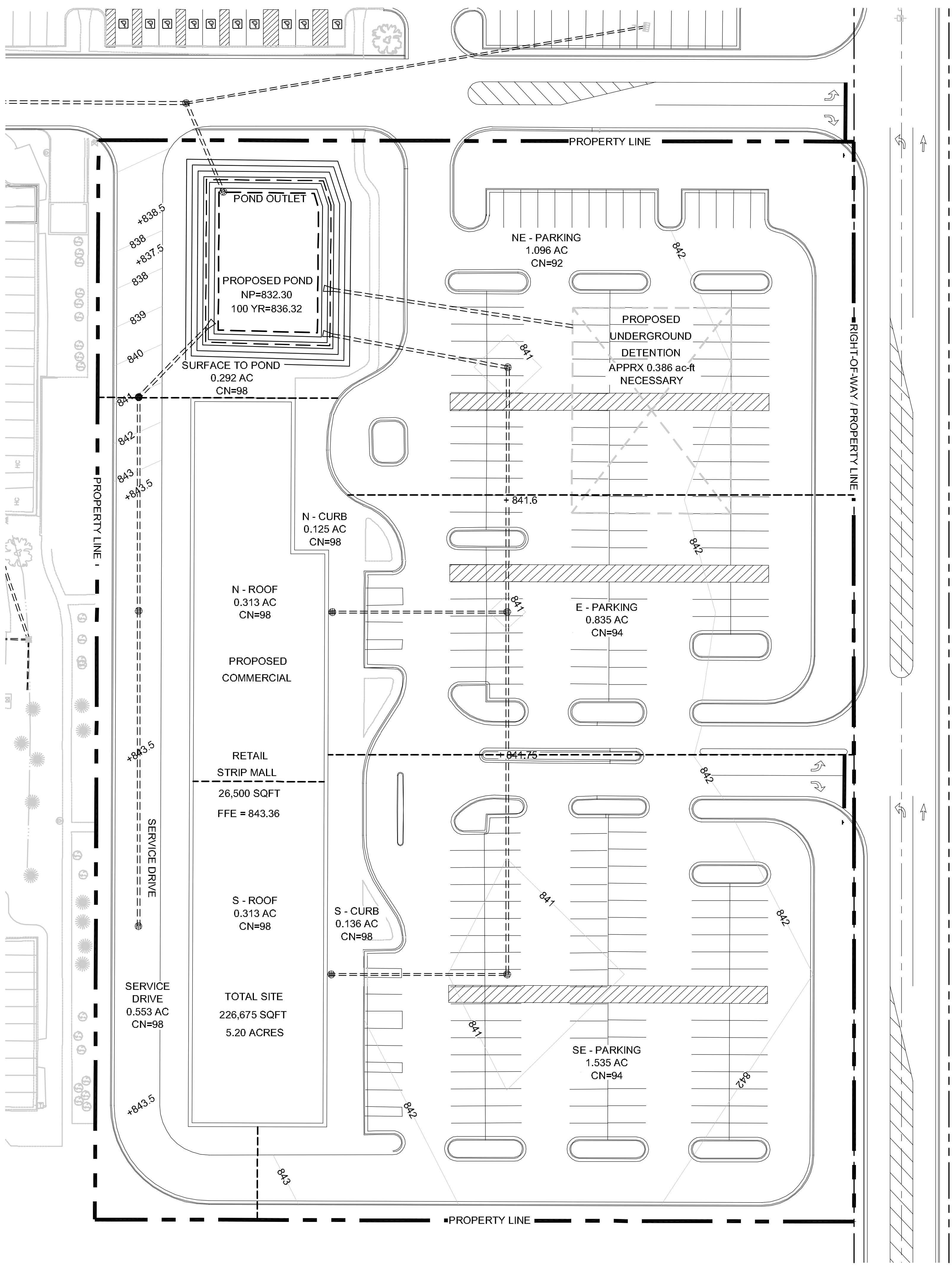
	WQv	Bioretention treatment Removal	%TSS Remaining	South Swale Removal	%TSS Remaining	North Swale Removal	%TSS Remaining
Parking Areas B, C, and D	0.057	0.81	19.0%	N/A	19.0%	0.8	3.8%
Parking Areas F, G, H, I, and J	0.077	0.81	19.0%	0.8	3.8%	0.8	0.8%
Parking Areas E, and K	0.087	N/A	100.0%	0.8	20.0%	0.8	4.0%
Areas directly to North Swale	0.191	N/A	100.0%	N/A	100.0%	0.8	20.0%
Weighted Average TSS Removal							95.6%

5.0 References

1. City of Indianapolis Stormwater Specifications Manual.
2. NRCS Web Soil Survey.
3. Technical Reference 55.
4. HydroCAD v. 8.00
5. City of Indianapolis and Marion County GIS

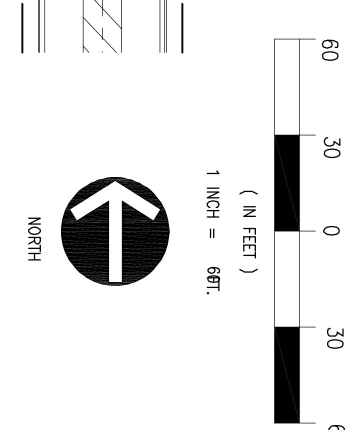
Appendix A

Conventional Model Output



LEGEND

- TYPICAL STORMWATER INLET STRUCTURE AND CONCRETE PIPE
- UNDERGROUND STORMWATER DETENTION
- PROPERTY BOUNDARY / RIGHT-OF-WAY
- DRAINAGE AREAS



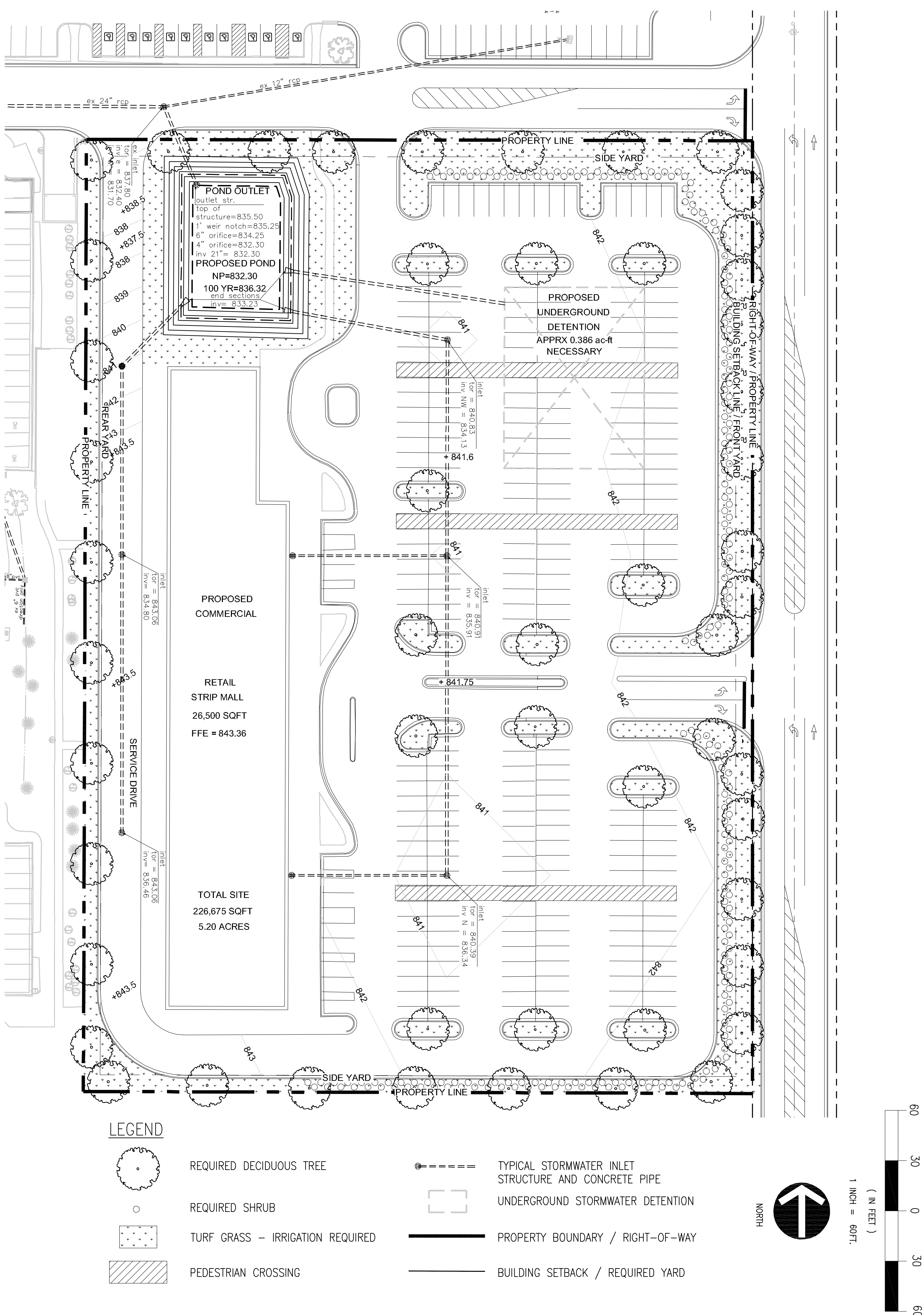
GREEN INFRASTRUCTURE SITE EXAMLPES	**CITY OF INDIANAPOLIS** AMEC EARTH & ENVIRONMENTAL INDIANAPOLIS, INDIANA
CONVENTIONAL LAYOUT WATERSHED AREAS	WILLIAMS CREEK CONSULTING, INC. 919 NORTH EAST STREET INDIANAPOLIS, INDIANA 46202 Ph: (317) 423-0690 Fax: (317) 423-0696

DWN BY: EEK
CHKD. BY: JTB
SCALE: 60
DATE: AUGUST 2008

PROJECT NUMBER 01.0026.A.1

DRAWING NUMBER **C.3**

SHEET 3 OF 4



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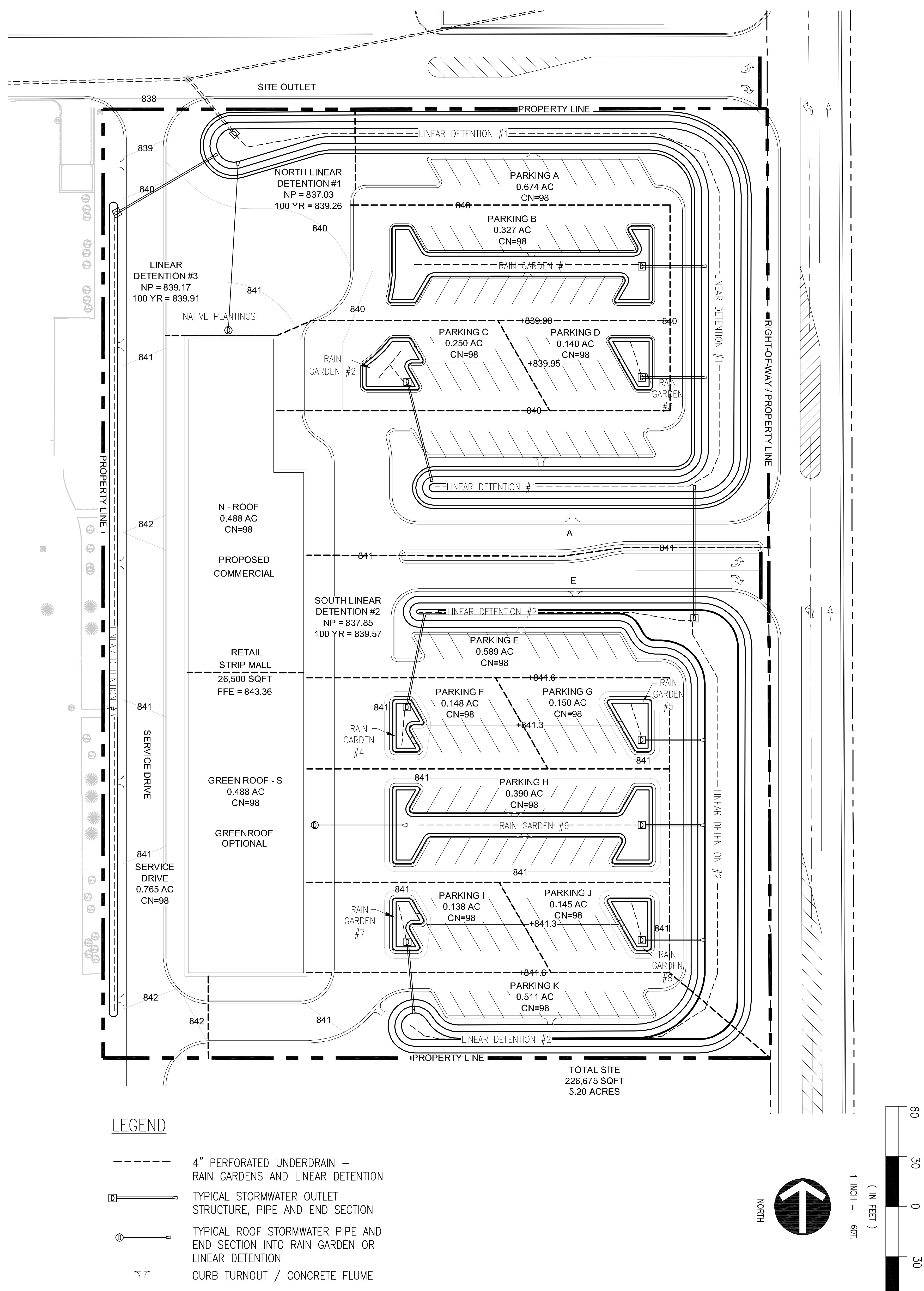
		DWN BY: EEK CHKD. BY: JTB SCALE: 60 DATE: AUGUST 2008	
		CONVENTIONAL LAYOUT SITE PLAN	WILLIAMS CREEK CONSULTING, INC. 919 NORTH EAST STREET INDIANAPOLIS, INDIANA 46202 Ph: (317) 423-0690 Fax: (317) 423-0696

Appendix B

Distributed Storage Model Output



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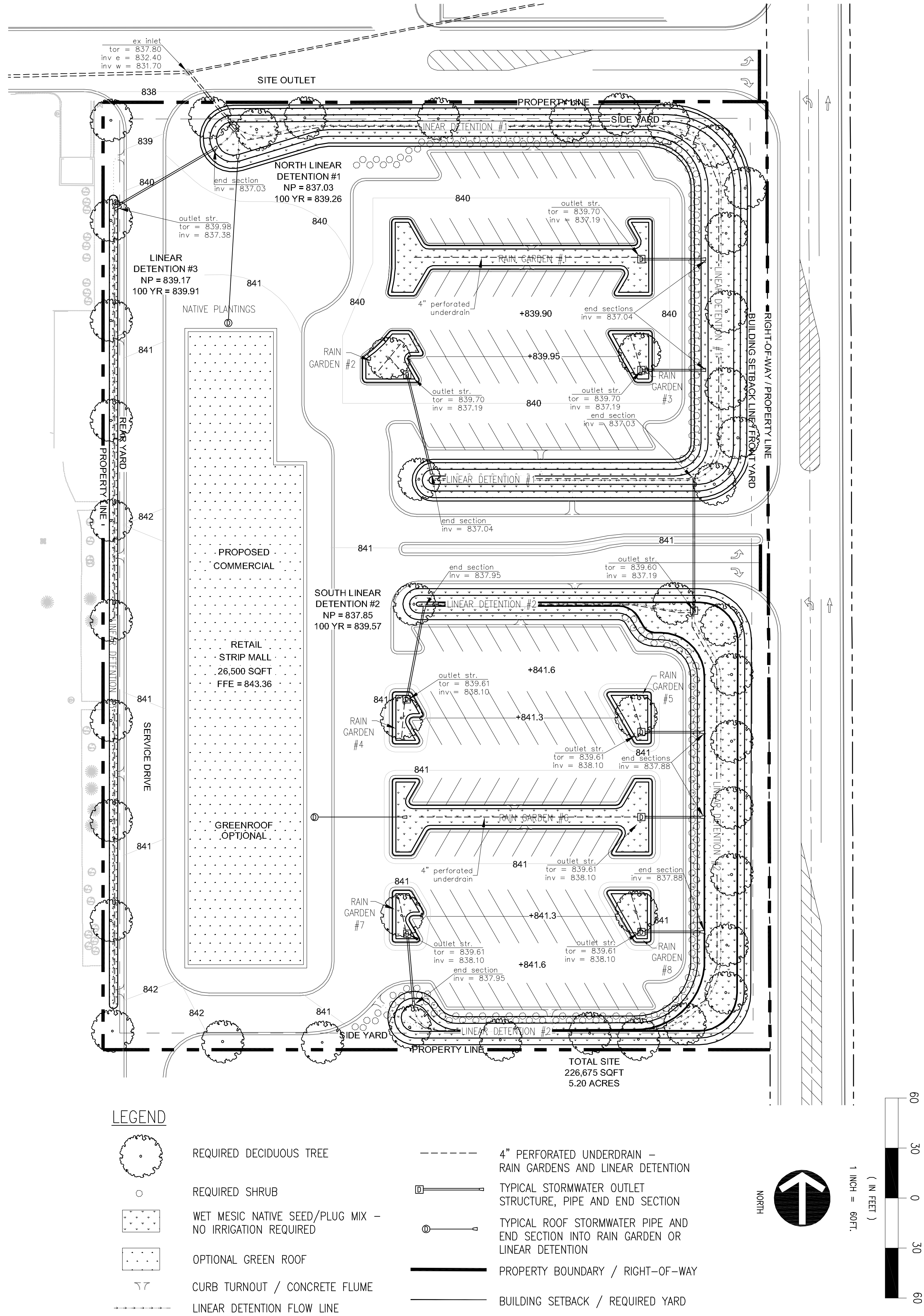
		LID LAYOUT WATERSHED AREAS	

CITY OF INDIANAPOLIS
AMEC EARTH & ENVIRONMENTAL
INDIANAPOLIS, INDIANA

WILLIAMS CREEK CONSULTING, INC.
919 NORTH EAST STREET
INDIANAPOLIS, INDIANA 46202
Ph: (317) 423-0690 Fax: (317) 423-0696



GREEN INFRASTRUCTURE
SITE EXAMLPES

LID LAYOUT
SITE PLAN

DWN BY:	EEK
CHKD BY:	JTB
SCALE:	60
DATE:	AUGUST 2008

PROJECT NUMBER 01.0026.A.1

DRAWING NUMBER **C.2**
SHEET 2 OF 4

CITY OF INDIANAPOLIS
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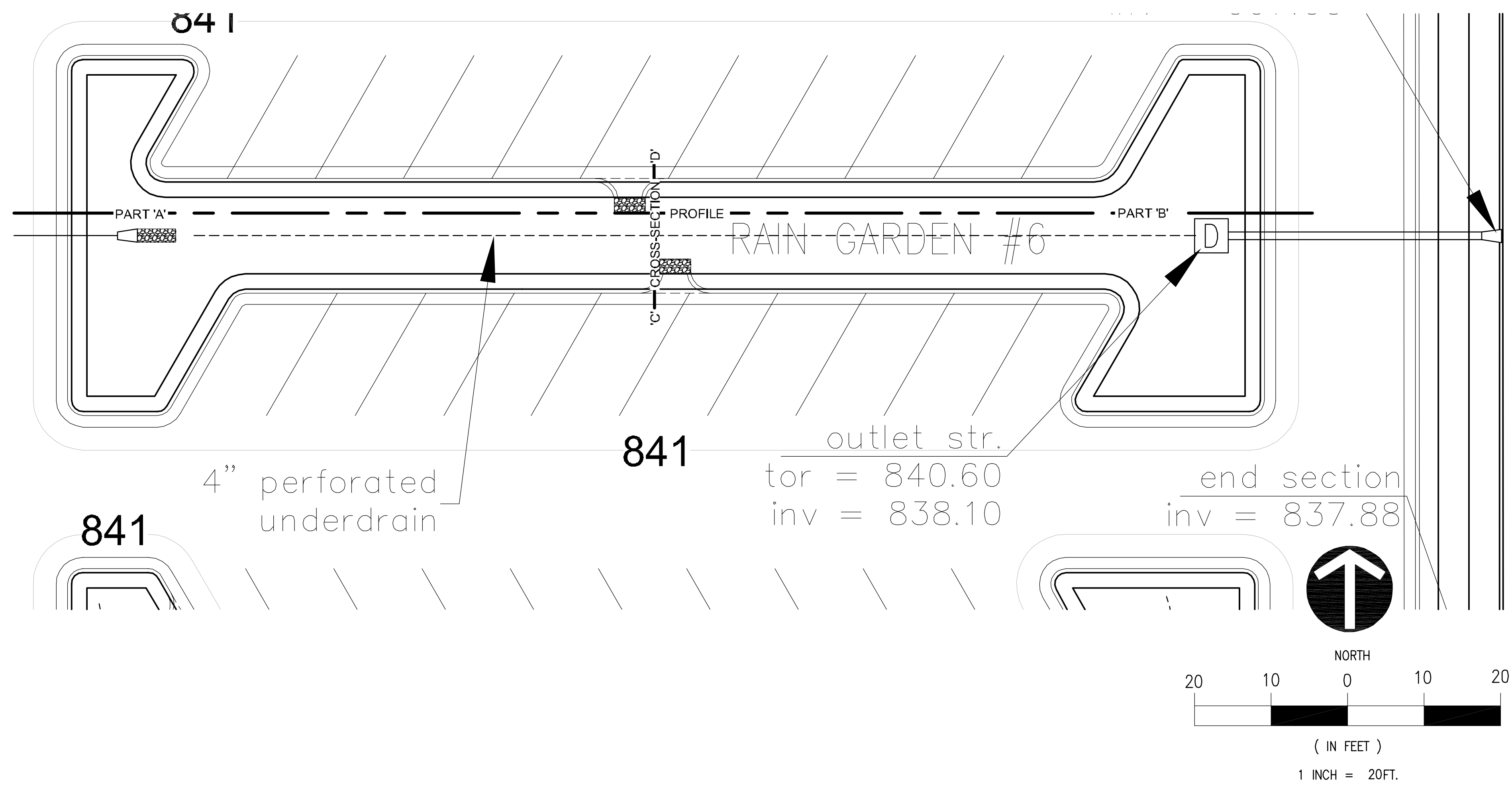
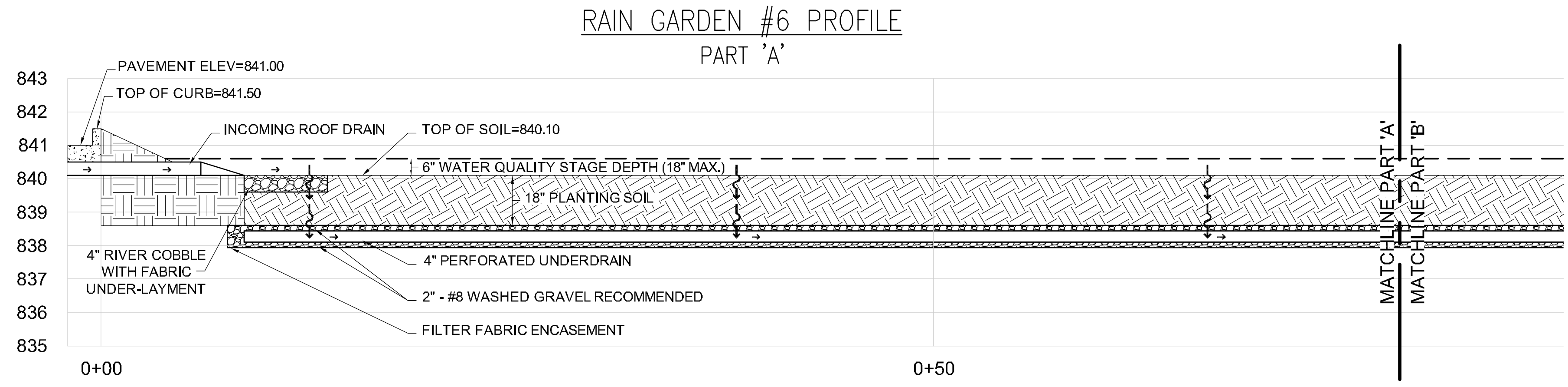
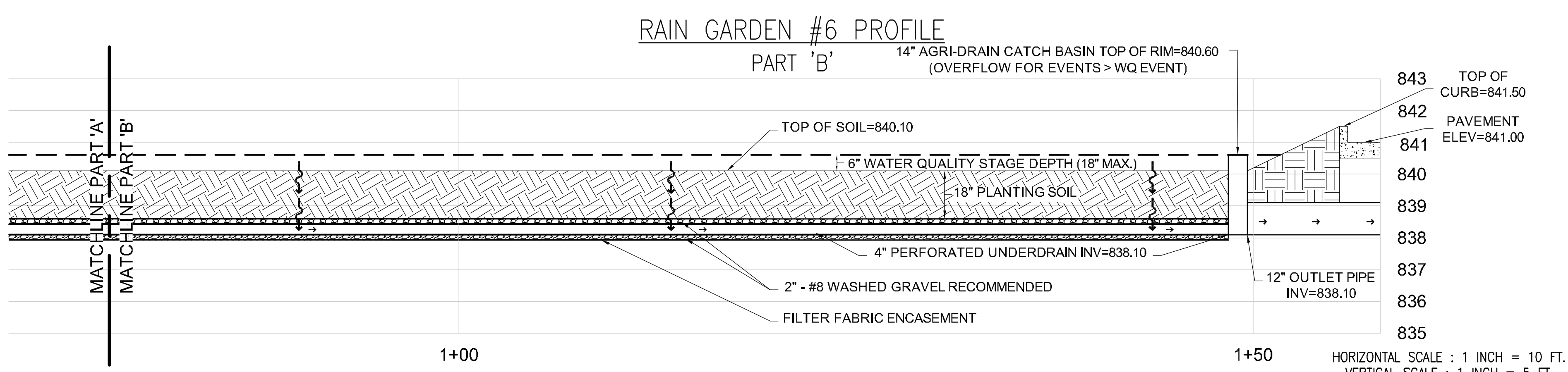
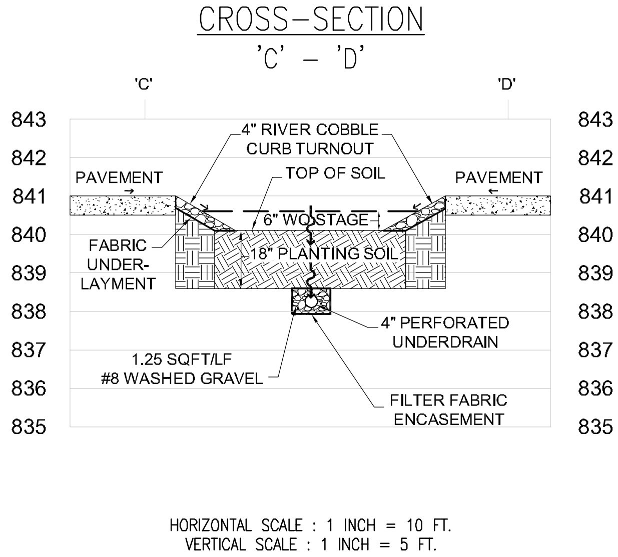
INDIANAPOLIS, INDIANA

WILLIAMS CREEK CONSULTING, INC.
919 NORTH EAST STREET
INDIANAPOLIS, INDIANA 46202
Ph: (317) 423-0690 Fax: (317) 423-0696









PLANTING SOIL - NOTES

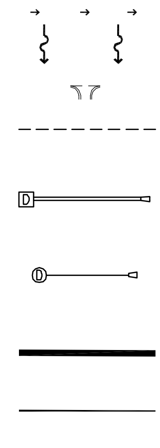
THE SOIL SHALL BE A UNIFORM MIX, FREE OF STONES, STUMPS, ROOTS OR OTHER SIMILAR OBJECTS LARGER THAN TWO INCHES. NO OTHER MATERIALS OR SUBSTANCES SHALL BE MIXED OR DUMPED WITHIN THE BIORETENTION AREA THAT MAY BE HARMFUL TO PLANT GROWTH, OR PROVE A HINDRANCE TO THE PLANTING OR MAINTENANCE OPERATIONS. THE PLANTING SOIL SHALL BE FREE OF BERMUDA GRASS, QUACKGRASS, JOHNSON GRASS, OR OTHER NOXIOUS WEEDS. THE PLANTING SOIL FOR BIORETENTION FACILITIES SHALL CONSIST OF A MIXTURE OF SAND, TOPSOIL, AND COMPOST WITH A PH RANGE OF 5.5 AND 6.5. IN ADDITION, THE SOIL SHALL HAVE INFILTRATION RATES NO LESS THAN 0.5 INCHES PER HOUR, ACHIEVED THROUGH THE FOLLOWING STANDARDS:

A. 1 PARTS SAND (PER CMSC 703.06),
B. 1 PARTS TOPSOIL (PER CMSC 653.02), AND
C. 1 PARTS COMPOST (PER ODOT CMSC 659.06).

ADDITIONAL RECOMMENDATIONS FOR THE PLANTING SOIL INCLUDE A 1.5 TO 3 PERCENT ORGANIC CONTENT AND A MAXIMUM 500 PPM CONCENTRATION OF SOLUBLE SALTS.

IF THE EXISTING SOIL DOES NOT MEET THE ABOVE CHARACTERISTICS, THEN IT SHALL EITHER BE ADJUSTED TO MEET THE CRITERIA OR REMOVED AND REPLACED WITH AN ACCEPTABLE PLANTING SOIL. SOIL TESTS SHALL BE PERFORMED FOR EVERY 500 CUBIC YARDS OF PLANTING SOIL, WITH THE EXCEPTION OF PH AND ORGANIC CONTENT TESTS, WHICH ARE REQUIRED ONLY ONCE PER RAIN GARDEN AREA.

LEGEND



- FLOW ARROWS
- INFILTRATION ARROWS
- CURB TURNOUT / CONCRETE FLUME
- 4" PERFORATED UNDERDRAIN - RAIN GARDENS AND LINEAR DETENTION
- TYPICAL STORMWATER OUTLET STRUCTURE, PIPE AND END SECTION
- TYPICAL ROOF STORMWATER PIPE AND END SECTION INTO RAIN GARDEN OR LINEAR DETENTION
- PROPERTY BOUNDARY / RIGHT-OF-WAY
- BUILDING SETBACK / REQUIRED YARD

DRAWING NUMBER	C.5a
SHEET	5 OF 6
PROJECT NUMBER	01.0026.A.1
DWN BY:	EEK
CHKD BY:	JTB
SCALE:	NA
DATE:	NOVEMBER 2008

GREEN INFRASTRUCTURE
SITE EXAMLPES

LID LAYOUT
RAIN GARDEN #6 PROFILE & SECTION

CITY OF INDIANAPOLIS
AMEC EARTH & ENVIRONMENTAL
INDIANAPOLIS, INDIANA

WILLIAMS CREEK CONSULTING, INC.
919 NORTH EAST STREET
INDIANAPOLIS, INDIANA 46202
Ph: (317) 423-0690 Fax: (317) 423-0696

Appendix C

Cost Differential Illustration

The following cost estimate is based upon variables which most likely would represent large discrepancies between strategies and easiest to quantify in this theoretical context. Due to the theoretical pre-development topography at the site, mass earthwork is not included; only the excavation necessary to build the BMPs was considered valid.

These computed differentials are minimized with the small site considered. As site area increases, earthwork and pipe cost differentials can be expected to increase geometrically. Pipe cost per acre increase as larger pipes would be required moving towards the downstream end. Assuming a flat site, earthwork cost per acre increase as more fill per acre is required moving towards the upstream end of the drainage system.

Generally, a low impact development strategy will, by definition, propose less change to the existing topography while conventional strategies require it for pipe slope and cover. For the distributed storage strategy, a green roof was not specified. The storage in the rain gardens and linear swales was adequate to meet allowable outfall rates. Despite operating cost savings, green roofs are generally require larger capital investment per cubic foot of storage than the BMPs specified. Had a greater density been sought by the Owner, a green roof may have been necessary. Generally, there will be a critical density at which point stormwater storage becomes much more expensive. The Engineer should advise the Owner to weigh profit rather than revenue against construction cost associated with increased density developments.

The totals that follow basically weigh the cost of pipe conveyance versus a system that uses BMPs to convey stormwater.

CONVENTIONAL INFRASTRUCTURE DIFFERENTIAL

ITEMS CONSIDERED					
PIPES					
SIZES	LENGTH (LF)	COST/LF		TOTAL	
4" (UNDERDRAIN)	0	$	4.00	$	-
12"	190	$	35.00	$	6,650.00
15"	334	$	35.50	$	11,857.00
18"		$	36.50	$	-
21"	413	$	38.00	$	15,694.00
Total Pipe cost				$	34,201.00
STRUCTURES					
SIZE	QUANTITY	COST/STR		TOTAL	
4' Diameter Manhole Basins complete	6	$	1,500.00	$	9,000.00
UNDERGROUND STORAGE					
	QUANTITY (AC-FT)	COST/AC-FT		TOTAL	
Stormtech Chambers	0.386	$	250,000.00	$	96,500.00
WET POND EXCAVATION					
	QUANTITY (CYD.)	COST/YARD		TOTAL	
	18069	$	5.00	$	90,345.00
PLANTING					
TURF GRASS SEED					
	QUANTITY (SQ.FT)	COST/SQ.FT.		TOTAL	
	192535	$	0.04	$	7,701.41
TOTAL DIFFERENTIAL ESTIMATE				$	237,747.41

DISTRIBUTED STORAGE INFRASTRUCTURE DIFFERENTIAL

ITEMS CONSIDERED			
PIPES			
SIZES	LENGTH (LF)	COST/LF	TOTAL
4" (UNDERDRAIN)	1050	$ 4.00	$ 4,200.00
12"	390	$ 35.00	$ 13,650.00
15"	0	$ 35.50	$ -
18"	0	$ 36.50	$ -
21"	0	$ 38.00	$ -
Total Pipe cost			$ 17,850.00
STRUCTURES			
SIZE	QUANTITY	COST/STR	TOTAL
32" Agridrain Raingarden outlets Comple	4	$ 950.00	$ 3,800.00
BMP EXCAVATION			
	QUANTITY (CYD.)	COST/YARD	TOTAL
	13086	$ 5.00	$ 65,430.00
RAINGARDEN RETAIN WALLS			
	QUANTITY (SF)	COST/SF	TOTAL
	72	$ 15.00	$ 1,080.00
PLANTING			
BMP 2' ENGINEERED BACKFILL			
	QUANTITY (CYD.)	COST/YARD	TOTAL
	341	$ 60.00	$ 20,444.44
LIVE PLUG MATERIAL 3' O.C.			
	QUANTITY (SQ.FT)	COST/SQ.FT.	TOTAL
	667	$ 4.00	$ 2,666.67
TOTAL DIFFERENTIAL ESTIMATE			$ 111,271.11

Appendix D

Green Roof Evaluation

Curve Number Reductions for Green Roofs

This Appendix serves to lend guidance to Engineers in order to account for the hydrologic analysis of green roofs. Simply looking up curve numbers for green roofs generally yields a wide variety of curve numbers which may or may not respect the specific characteristics of the roof. There are methods to calculate the behavior of the roof based upon the specific design. The first would be to model the roof with a curve number of 98 which discharges to a "pond" with a stage-storage relationship respective of the porosity of the material specified for planting and outletting as designed. The second method is to utilize SCS methods to assign an adjusted curve number to the green roof. The NRCS provides equations for this. The equations basically subtract the roof top storage from the expected runoff volume. Then the curve number that would produce the new runoff volume is assigned to the roof. The methods below can also be used beyond the green roof analysis as a tool to project how much distributed storage would be necessary per acre to yield a desired reduced curve number. This can be particularly useful in regions which regulate runoff *volume*.

SCS hydrologic methods calculate storm runoff volumes using rainfall, initial abstraction, potential retention based on land use and soil type, and retained rainfall volume. These relationships can be expressed in the SCS equations:

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

$$S = 1000/CN – 10$$

Where;
Q = runoff volume in inches
P = design storm rainfall volume in inches
S = potential maximum retention and initial abstraction
CN = runoff curve number based on land use and soil type

Step 1 is the calculation of additional storage specified as part of the green roof:

Assuming a 4" depth planting soil with a void ratio of 0.3 would allow **0.099 cu-ft per sq-ft** of green roof.
Define Storage Depth, S_d = 0.099 ft.

Step 2 is the calculation of runoff depth without the green roof:

$Q_d = (P – Ia)^2 / (P – Ia) + 1000/CN – 10$

Where;
Q_d = Default runoff depth
Ia = Initial abstraction (0.2S)
CN = Default curve number

Therefore:
$Q_d = (6.00 – 0.04)^2 / (6.00 – 0.04) + 1000/98 – 10$
Q_d = 5.76 in.

Step 3 is the calculation of the revised runoff volume given the green roof:

$Q_g = Q_d – S_d*12$
Q_g = 4.57 in.

Step 4 is the back calculation of reduced curve number:

$$RCN = 200 / \{(P + 2* Q_g +2) – (5* Q_g *P + 4* Q_g {}^2)^{1/2}$$

RCN = 88

Once a spreadsheet is created, the designer can quickly calculate how much distributed storage would be required to, for example, maintain the pre-development curve number.

Other depths of green roofs would produce the reduced curve numbers in Table 1. The designer could also design the media depth and engineer the void ratio to account for the water quality volume, if desired.

Table 1

Media Depth		Void Ratio	Default CN	RCN
4	in.	0.3	98	88
6	in.	0.3	98	82
9	in.	0.3	98	73
12	in.	0.3	98	63

Details of the use and derivation of the above equations can be found in Technical Reference 55. The above results reflect the assumption that runoff is effectively removed from the storm.

Appendix E

Stormwater BMP Inspection Fee Calculation

The City of Indianapolis via Section 103.04 in the Draft Stormwater Manual provides for drainage fees. This includes inspection fees for City inspection of BMPs. Example sites are discussed in order to aide Applicants in the filing of appropriate fees. These examples even include a scenario with 6 raingardens throughout a ¾ acre parking lot and classify this as a single BMP for the calculation of fees. However, more guidance may be warranted. It is currently unclear how many raingardens, or how large of a parking lot can be classified as a single BMP. Also, it is intuitive to presume that not all BMPs are equally easy to inspect; i.e. a catch basin insert which requires inspection beneath the pavement seems more difficult to inspect than wet ponds.

Based upon Section 103.04, the following represents the presumption of applicable inspection fees for both the Conventional and Distributed Storage Alternatives. For the Distributed Storage Alternative, the raingardens were grouped according to common outlet point. For example, raingardens 1 - 3 all discharge to the north swale and are counted as a single BMP while raingardens 4 – 9 all discharge to the south swale and are counted as a single BMP:

<u>Conventional:</u>

Number of BMPs	1	
First three years LS	$ 705.00	per BMP
Annual inspection	$ 235.00	per BMP
additional inspections	$ 235.00	per hour
capital cost	$ 705.00	
operating cost	$ 235.00	

<u>Distributed Storage:</u>

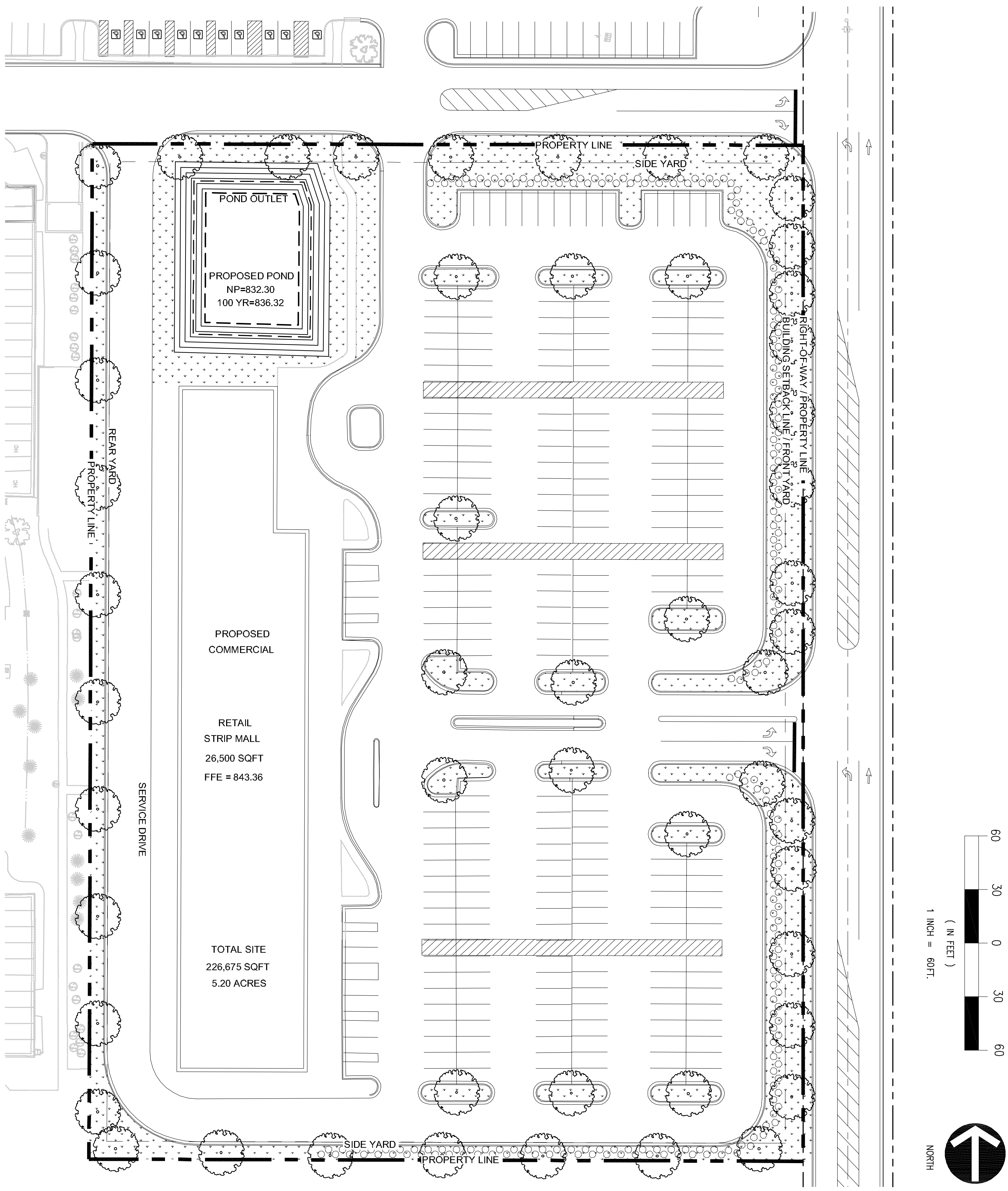
Number of BMPs	5	
First three years LS	$ 705.00	per BMP
Annual inspection	$ 235.00	per BMP
additional inspections	$ 235.00	per hour
capital cost	$ 3,525.00	
operating cost	$ 1,175.00	

The results above indicate that the inspection fees mandated by the City represent an additional cost to Owner should the distributed storage approach be selected. The design life of the facility is too hypothetical to analyze the payback period for the capital cost. However, a typical lease rate for the 26,500 square foot facility could likely be between $10 and $15 per square foot. The operating cost differential above is $940 per year. Therefore, the increased aethstetic appeal of the distributed storage alternative would need to merit an additional $ 0.04 per square foot on the lease rate in order to discount for the apparent increased cost of inspection.

Inspection and maintenance of BMPs is most directly related to the amount of suspended solids accrued within them. Suspended solids generally originate from stormwater flow off impervious surfaces. Therefore, as the City moves toward more distributed storage and source control alternatives, it may become more equitable and easier to quantify inspection fees based upon impervious surface acreage, rather than "number of BMPs".

Appendix F

Landscape plan



LEGEND

- REQUIRED DECIDUOUS TREE
- REQUIRED SHRUB
- TURF GRASS – IRRIGATION REQUIRED
- PEDESTRIAN CROSSING
- PROPERTY BOUNDARY / RIGHT-OF-WAY
- BUILDING SETBACK / REQUIRED YARD

LANDSCAPE REQUIREMENTS

FRONT YARD (570')
1. TREES (40' O.C.)
   15 DECIDUOUS TREES REQUIRED
   15 DECIDUOUS TREES PROVIDED
2. SCREENING (500' PARKING – 4' O.C.)
   125 SHRUBS REQUIRED
   125 SHRUBS PROVIDED

SIDE YARD – NORTH (400')
1. TREES (60' O.C.)
   7 DECIDUOUS TREES REQUIRED
   7 DECIDUOUS TREES PROVIDED
2. SCREENING (190' PARKING – 4' O.C.)
   48 SHRUBS REQUIRED
   48 SHRUBS PROVIDED

SIDE YARD – SOUTH (400')
1. TREES (60' O.C.)
   7 DECIDUOUS TREES REQUIRED
   7 DECIDUOUS TREES PROVIDED
2. SCREENING (237' PARKING – 4' O.C.)
   60 SHRUBS REQUIRED
   60 SHRUBS PROVIDED

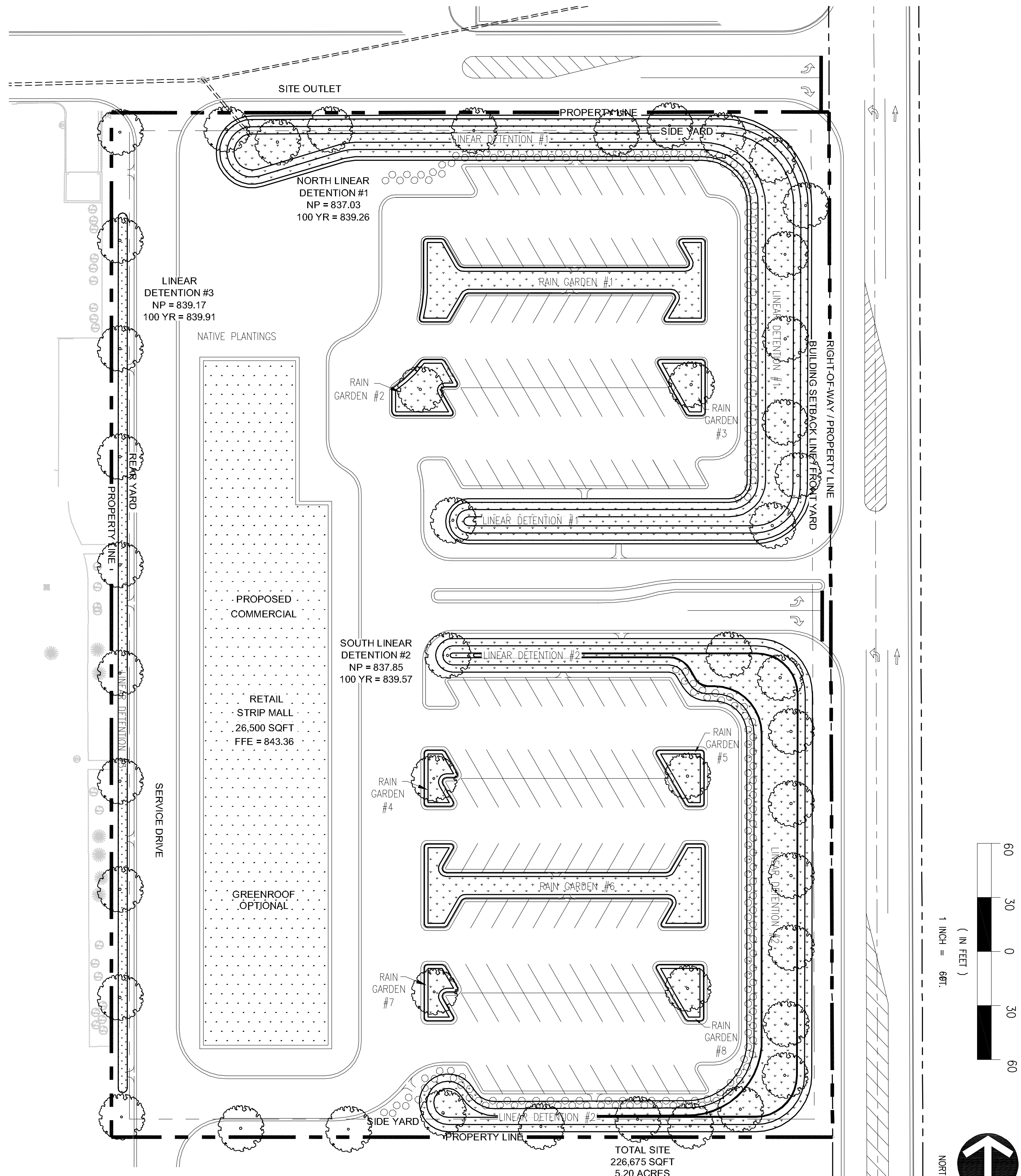
REAR YARD (570')
1. TREES (60' O.C.)
   10 DECIDUOUS TREES REQUIRED
   10 DECIDUOUS TREES PROVIDED

INTERIOR PARKING LOT (247 PARKING SPACES)
1. ISLAND AREA (15 SQFT/PARKING SPACE)
   3,705 SQFT REQUIRED
   4,440 SQFT PROVIDED
2. TREES (1 TREE/20 PARKING SPACES)
   13 DECIDUOUS TREES REQUIRED
   13 DECIDUOUS TREES PROVIDED

DRAWING NUMBER **C.1a** SHEET 1a OF 4	PROJECT NUMBER 01.0026.A.1	**GREEN INFRASTRUCTURE** SITE EXAMLPES	DWN BY: EEK; CHKD BY: JTB; SCALE: 60; DATE: AUGUST 2008
		CONVENTIONAL LAYOUT LANDSCAPE PLAN	

CITY OF INDIANAPOLIS
AMEC EARTH & ENVIRONMENTAL
INDIANAPOLIS, INDIANA

WILLIAMS CREEK CONSULTING, INC.
919 NORTH EAST STREET
INDIANAPOLIS, INDIANA 46202
Ph: (317) 423-0690 Fax: (317) 423-0696



LEGEND

- REQUIRED DECIDUOUS TREE
- REQUIRED SHRUB
- WET MESIC NATIVE SEED/PLUG MIX – NO IRRIGATION REQUIRED
- OPTIONAL GREEN ROOF
- PROPERTY BOUNDARY / RIGHT-OF-WAY
- BUILDING SETBACK / REQUIRED YARD

LANDSCAPE REQUIREMENTS

FRONT YARD (570')

1. TREES (40' O.C.)
   15 DECIDUOUS TREES REQUIRED
   15 DECIDUOUS TREES PROVIDED
2. SCREENING (414' PARKING – 4' O.C.)
   104 SHRUBS REQUIRED
   116 SHRUBS PROVIDED

SIDE YARD – NORTH (400')

1. TREES (60' O.C.)
   7 DECIDUOUS TREES REQUIRED
   7 DECIDUOUS TREES PROVIDED
2. SCREENING (178' PARKING – 4' O.C.)
   45 SHRUBS REQUIRED
   46 SHRUBS PROVIDED

SIDE YARD – SOUTH (400')

1. TREES (60' O.C.)
   7 DECIDUOUS TREES REQUIRED
   7 DECIDUOUS TREES PROVIDED
2. SCREENING (178' PARKING – 4' O.C.)
   45 SHRUBS REQUIRED
   50 SHRUBS PROVIDED

REAR YARD (570')

1. TREES (60' O.C.)
   10 DECIDUOUS TREES REQUIRED
   10 DECIDUOUS TREES PROVIDED

INTERIOR PARKING LOT (150 PARKING SPACES)

1. ISLAND AREA (15 SQFT/PARKING SPACE)
   2,250 SQFT REQUIRED
   9,852 SQFT PROVIDED
2. TREES (1 TREE/20 PARKING SPACES)
   8 DECIDUOUS TREES REQUIRED
   8 DECIDUOUS TREES PROVIDED

DRAWING NUMBER **C.2a** SHEET 2a OF 4

PROJECT NUMBER 01.0026.A.1

GREEN INFRASTRUCTURE

SITE EXAMLPES

LID LAYOUT

LANDSCAPE PLAN

DWN BY:	EEK
CHKD BY:	JTB
SCALE:	60
DATE:	AUGUST 2008

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INDIANAPOLIS, INDIANA

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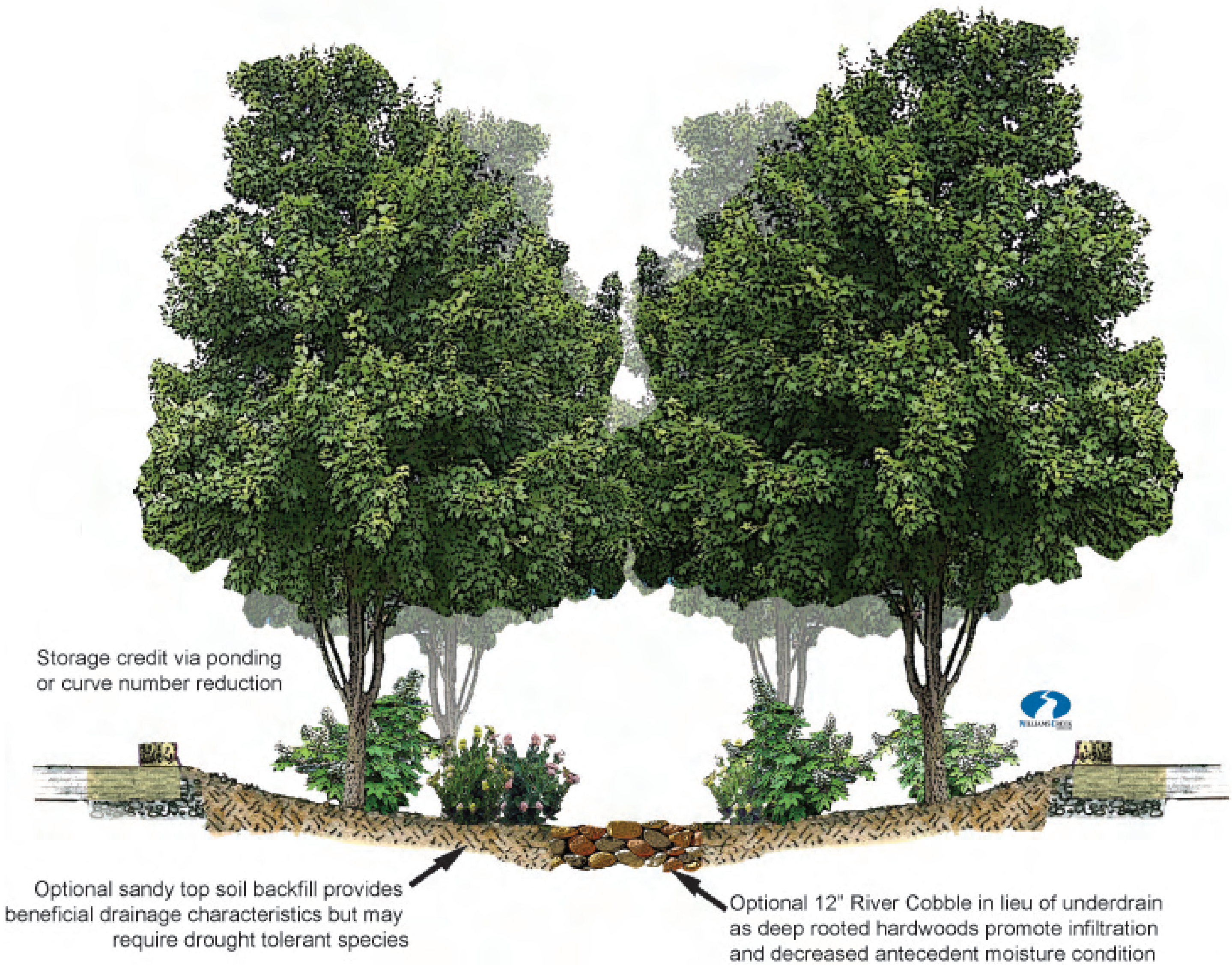
Ph: (317) 423-0690 Fax: (317) 423-0696

LID CONCEPTUAL DESIGN



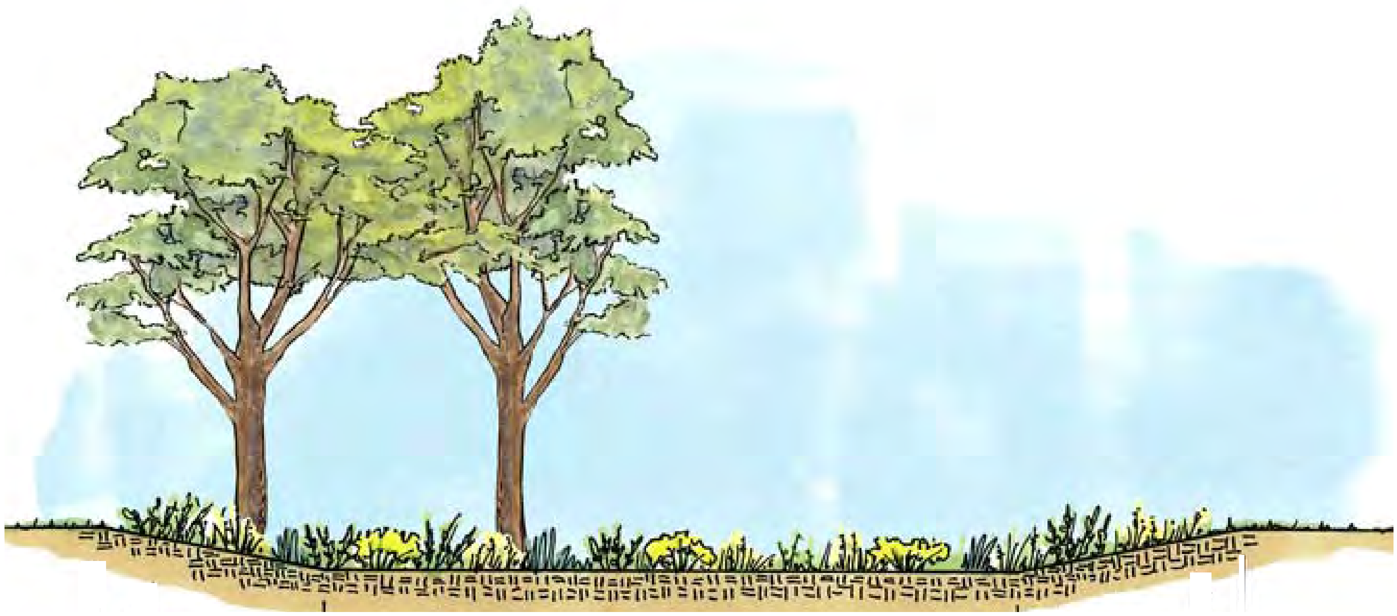
SECTION OF RAINGARDEN ISLANDS

SECTION OF SWALE WITH NATIVE VEGETATION

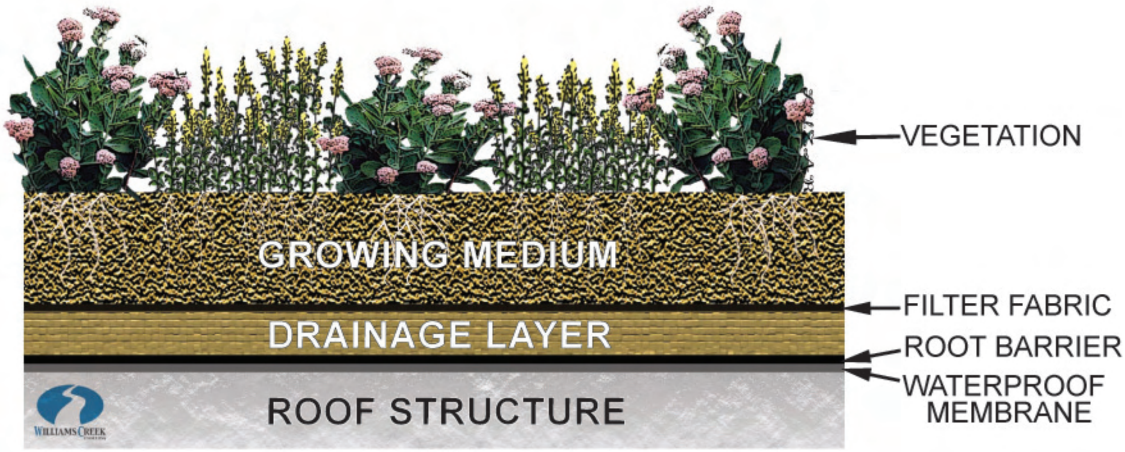
Note: Native plantings may have low post-established maintenance requirements, such as only 1-2 mowings annually. Mowing creates continual grass clipping discharges (TSS). Clippings are not discharged with native plantings at conventional rates due to reduced mowing needs.

WET AND/OR DRY POND EDGE OPTIONS- CONVENTIONAL TURF EDGE

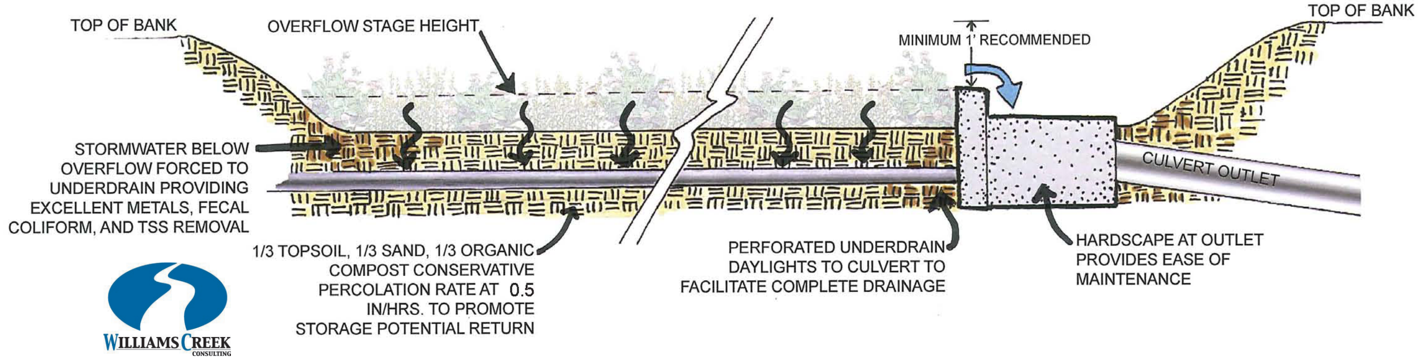
WET AND/OR DRY POND EDGE OPTIONS- NATIVE FORB AND GRASS EDGE



SECTION OF BASIN WITH NATIVE VEGETATION

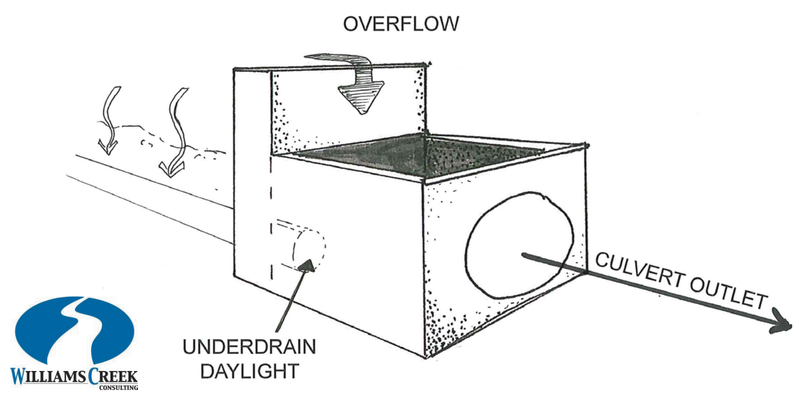


GREEN ROOF SECTION WITH TYPICAL LAYERS

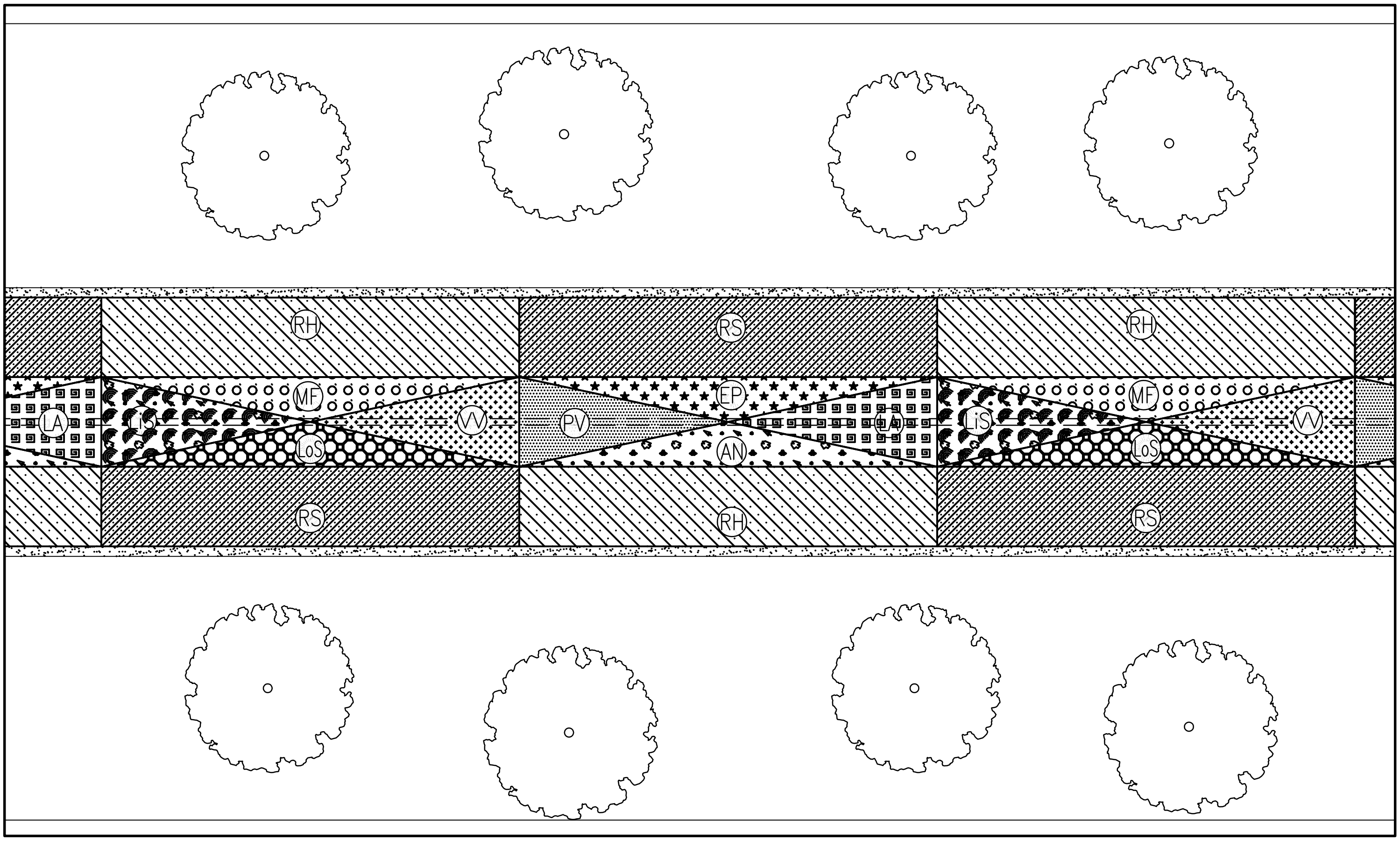


TYPICAL LINEAR SWALE OUTLET DIAGRAM
PROFILE VIEW

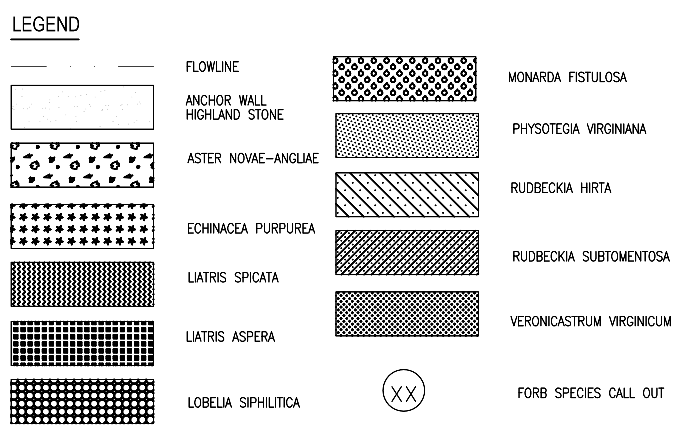
NTS



TYPICAL LINEAR SWALE HARDSCAPE OUTLET
BASIC DETAIL VIEW



NATIVE PLANT RAINGARDEN PLUG MIX		
TYPE OF PLUGS - FORBS		
LATIN NAME	COMMON NAME	LABEL
Aster novae-angliae	New England Aster	AN
Echinacea purpurea	Purple Coneflower	EP
Liatris spicata	Dense Blazing Star	LiS
Liatris aspera	Rough Blazing Star	LA
Lobelia siphilitica	Great Lobelia	LoS
Monarda fistulosa	Bergamot	MF
Physotegia virginiana	Obedient Plant-White	PV
Rudbeckia hirta	Black-Eyed Susan	RH
Rudbeckia subtomentosa	Sweet Black-Eyed Susan	RS
Veronicastrum virginicum	Culver's Root	VV
TOTAL PLUGS		



PLANTING PLAN EXAMPLE UTILIZING NATIVES IN A FORMALIZED PATTERN