LID Design Challenge

For

Northgate Mall

Team 16302

Introduction

The 79 acre commercial site is located at the intersection of Highway 153 & Hixson Pike, in Chattanooga, TN. The existing mall was constructed in 1972, but has seen recent construction around its ring road. In reviewing the facility, we not only looked at how to improve the sites storm water run-off, but also improve the sites aesthetics, pedestrian circulation, and retail growth for the future.

Existing Conditions

The property is currently developed with 95% impervious area. Flow is captured in catch basins then piped to a concrete channel on the north side of the property. Just off site the channel opens up into a natural stream bed.

According to soil maps the native soils are hydrologic group C and local infiltration rates range from 0.1-0.4 inch/hour. As most infiltration areas are to be constructed in land previously compacted under a parking lot the conservative end of the range was used, so the infiltration rate used for design was 0.1 inch/hour.

Redevelopment /Retrofit Concepts

- The planned development includes adding bio-retention and pervious pavements to the existing parking lot.
- Several micro-habitat areas will be created to develop meadows and forests.
- An infill area will be created between the Mall and Carmike Theatre to create a walkable outdoor mall between the theatre and mall.
- Two large parking areas will be replaced with pervious grass pavers to function as multi use spaces. The grass paver area in drainage subarea 2, see the attached Drainage Map will be used to intercept the roof runoff from the mall into a bio-aquifer below the grass pavers.
- The roof water from the theatre will be infiltrated into a pervious concrete paving unit pedestrian path through the parking lot near the theatre.
- Drive lanes will be enhanced to provide streetscape, pedestrian, and bicycle elements.
- Driveway will have reduced lanes, as traffic will be dispersed among more paths, instead of just the 4 lane loop road.

Enhanced Drive Lanes with Pedestrian & Bike facilities

To encourage alternative transportation methods, the vehicular traffic pattern has been dispersed into several 2 lane routes instead of the 4 lane loop road currently used around the mall. Each route will have limited connections of parking areas so pedestrians and cyclists can have a protected route between the mall, theatre, perimeter shopping, and offsite businesses. A bio-retention strip will be located along each drive. These areas will be planted with shade trees to provide a shaded streetscape. Several of the drive lanes will incorporate a 4-ft grass strip, 8-ft multi-use path. Other areas without the path will be marked with shared bicycle symbols and signs. At major pedestrian crossings, raised speed tables will be used instead of traditional denture dislodging speed bumps.

Proposed Infill Development

Instead of isolating proposed infill around the perimeter of the site, the infill is concentrated between the mall and the theatre. This creates an outdoor walking shopping area. Access will be available from the exterior toward the parking and from the interior for patrons coming from the mall or theatre. These units will be a mix of small shop retail and restaurants on the first floor, with some office space on the second floor. Inside of this walking area in addition to playgrounds and outdoor restaurant seating, will be educational displays explaining the various BMP's around the site. The new infill building roof's runoff will be directed into pervious paving between the buildings.
encourag

Landscaping

In order to increase stormwater infiltration and treatment, reduce maintenance, create wildlife habitat, and develop a self-sustaining landscape, the landscape plantings will be designed with a more natural feel than is typical for a shopping mall setting. In addition to the environmental benefits, this approach will also distinguish Northgate Mall from competing developments.

Along with the overall site plan, the landscape design will encourage visitors to linger throughout the property and create a seamless transition between the indoor and newly designed outdoor spaces on the property.

Planting Zones
The site is divided into two distinctive planting zones: the Forested Zone and the Meadow Zone. The plaza area between the proposed new buildings will serve as an educational space to demonstrate the stormwater handling strategies used throughout the site as well as alternative strategies not found on the site.

The Forested Zone
The Forested Zone is planted with a layered approach of canopy trees, lower canopy trees, understory trees, and shrubs. This layering replicates the natural layering found in our native forests. By utilizing fruit, berry, and nut producing species, areas of this zone can also serve as a "food forest," potentially serving as a food source for mall customers and employees, local schools, or charitable organizations. Throughout the Forested Zone, stormwater is handled in large rain garden areas and smaller sunken landscape islands.

The Meadow Zone
The Meadow Zone creates a more open feel to the planting by pushing canopy and understory trees to the edges and utilizing tall grasses, wildflowers, and small shrubs in the planted areas. This openness allows these large parking lot areas to be utilized for alternative functions such as farmers markets, fairs, carnivals, and outdoor movies. The plants in this zone would attract a wide range of wildlife to the area, particularly songbirds and pollinators, which would be beneficial for the flowering and fruiting trees on site as well as playing a key role in an Integrated Pest Management (IPM) strategy. Throughout the Meadow Zone, stormwater is handled through a series of bioretention swales which are connected by a row of permeable pavers. These bioretention areas are strategically placed within the parking lot to highlight the entrances to the mall and stores and serve as a guide for pedestrian traffic.

The Educational Plaza
In addition to its functions as an area for pedestrian circulation, outdoor shopping & dining, and a connection between the mall and theater, this area features small demonstrations of stormwater management strategies to serve as an educational component of the site. Models of the bioretention, permeable pavers, and rain gardens (complete with interpretive signage) would allow visitors to interact with the elements by cycling water through them and observing their function. Additional strategies, such as green roofs and cisterns are modeled on the proposed buildings. The plaza also features a children's playground and space for outdoor vendors.

Landscape Maintenance

Mulches
Mulch with natural organic mulches.

Turf
Maintained turf strips will be used along the edges of the bioswales and will serve as a buffer between the parking area and the swale. These will be planted with clumping grasses that will not creep into the plantings within the swale and create maintenance issues.

Chemicals
Since all areas are designed to drain to landscape beds, the use of chemical pesticides, herbicides, and fertilizers should be minimal, if not eliminated completely.

Fertilization
Fertilization should be done through the application of compost and compost teas rather than the use of synthetic fertilizers.

Parking

The number of parking spaces has been reduced per the design criteria. See *Parking Summary* table below. By re-configuring several of the existing angular parking lots to 90 degree parking the impervious area needed for parking was reduced. The massive parking lots have been divided in several smaller more focused lots divided up by the new 2 lane collector drive isles. Larger parking lots will include pedestrian corridors to provide protection for patrons coming to and from their vehicles. Several of these corridors will be constructed with permeable concrete paving units to provide storm water and aesthetic benefits. Just fewer than 10% of the parking spaces will be in permeable grass paving areas. The spaces will function as multi-use areas in off peak shopping times. These areas can be used for events such as weekly farmer's markets, drive-in movies projected onto screens, library events, or tent sales.

Parking Summary				
Existing Parking Spaces	4,533			
Building	**GLA Sq Ft**	**Ratio Per 1000**	**Required**	**Provided**
Mall	677,364	4.00	2,710	2,795
Firestone	14,353	4.00	58	146
Chili's	5,997	4.00	24	104
Panera Bread	4,646	4.00	19	76
Outback	6,163	4.00	25	69
Arby's	2,550	4.00	11	dev
Logan's	7,900	4.00	32	125
Carmike 14	54,444	4.00	218	16
TJMaxx	30,000	4.00	120	67
Michael's	20,076	4.00	81	200
Ross	25,038	4.00	101	dev
New Mixed Use	55,376	3.00	167	dev
Total	**903,907**		**3,566**	**3,598**
Accessible Spaces			46	46
Vegetated Permeable Paving Space 10% Max			360	347

Economic Benefit

By retrofitting Northgate the economic payback would come via several means.

- The project would make the site eligible for approximately 85% reduction in yearly Storm Water Fees. As the site is currently 95% impervious the yearly fees for the whole site exceed $114,000, see the table below. The 85% credit would be approximately $97,000 each year.

- As the project provide significantly more stay on volume that would be required for a redevelopment the additional stay on volume can be sold to other developers as coupons for other projects in Chattanooga. The additional stay on volume of 65,000 cf could be worth over $1.3 million assuming a $20 per CF open market value.

- Today's businesses patrons are drawn to sustainable sites, business are likely to receive significantly more traffic due to the positive public perception.

- The additional landscaping and micro habitats will make Northgate a unique shopping environment for the region and will encourage new business to come to the mall and increase traffic for current business.

- For the proposed infill development using green BMPs will be comparable to traditional storm water design. As the site is currently entirely impervious redevelopment with traditional design would have not required any detention. However, using infiltration measures will reduce the need for large drainage pipes.

Northgate Mall Existing Conditions

Lot	Street	Impervious Area		Total Area	% Impervious	ERU	Storm Water Fee
		sf	ac	ac			
5256	Hixson Pike	58,415	1.34	1.67	0.803	18.25	$ 2,102.94
454	Northgate Mall Dr	54,965	1.26	1.54	0.819	17.18	$ 1,978.74
301	Northgate Mall Dr	542,579	12.46	12.50	0.996	169.56	$ 19,532.84
401	Northgate Mall Dr	520,659	11.95	12.11	0.987	162.71	$ 18,743.72
5000	Hixson PIke	1,588,455	36.47	38.00	0.960	496.39	$ 57,184.38
560	Northgate Mall Dr	124,000	2.85	3.00	0.949	38.75	$ 4,464.00
101	Northgate Mall Dr	111,441	2.56	2.56	0.999	34.83	$ 4,011.88
310	Northgate Mall Dr	91,153	2.09	3.24	0.646	28.49	$ 3,281.51
490	Northgate Mall Dr	88,163	2.02	2.19	0.924	27.55	$ 3,173.87
	Total	**3,179,830**	**73.00**	**76.81**	**0.950**	**993.70**	**$ 114,473.88**
				Yearly Credit Achieved		0.85	$ 97,302.80

Stormwater Management

The storm water management goals for this project are to detain the post-development peak run-off rate to at or below pre-developed rates and to infiltrate the first 1" of rainfall on the site.

The following calculations will compare both pre-development and post-development peak flow rates. The SCS Method was utilized to calculate the above mentioned peak flow rates along with the software model *Hydraflow Hydrographs Extension for Civil 3D, Version 10.* For peak flow calculations, the site was divided into three outfalls that all occur along the north perimeter of Northgate. The post developed CN was adjusted to account for infiltration using the City of Chattanooga LID Design spreadsheet.

Existing Conditions Peak Flow Rates

For Weighted "CN" value:

Grass Area:	4.0	ac	x	74	=	296	ac
Impervious Area:	75.0	ac	x	98	=	7350	ac
	79.0	ac				7646	ac

Where: CN= 7646 ac /79 ac CN = 96.8

Hydrologic Parameters:
A = 79 acres
CN = 96.8
Tc = 23 minutes

Table I: Existing Conditions Peak Flow Rates

Storm Event, year	Existing Conditions Peak Flow Rates, cfs
2	212
5	265
10	307
25	364

For further information, please see *Existing Conditions Calculations*.

Post-development Peak Flow Rates

For Weighted "CN" value:

Forested Area:	0.41	ac	x	70	=	28.92	ac
Meadow Area:	1.79	ac	x	71	=	127.13	ac
Grass Landscape Area:	8.80	ac	x	74	=	651.20	ac
Impervious Area:	68.00	ac	x	98	=	6664.0	ac
	79	ac				7471.25	ac

Where: CN= 7471.25 ac /79 ac CN = 94.57

Hydrologic Parameters:
A = 79 acres
C = 95
Tc = 23 minutes

Since runoff volume is reduced by the amount of water infiltrated or retained in each BMP the CN is adjusted per the attached City of Chattanooga, LID Design Worksheets.

Table II: Post-development Routed Peak Flow Rates

Storm Event, year	Proposed Curve Number	Adjusted Curve Number	Proposed Peak Rates, cfs	Existing Peak Flow Rates, cfs
2	95	83	122	212
5	95	85	170	265
10	95	85	205	307
25	95	86	275	364

For further information, please see *Post-development Calculations & City LID Worksheet 4 CN Adjustment*.

As shown in the table above, the peak flow rate comparisons show that the Post-development peak outflow rates are significantly below Existing Conditions Peak flow rates and may be approaching natural conditions for each storm event.

Even more significant than the peak flow reduction, is the yearly reduction in storm water runoff. Per calculations done on US EPA National Stormwater Calculator, of Chattanooga's 46.67 inches of yearly rainfall, the runoff will be reduced from 38.44 inches to 9.74 inches. **That's a 28.70 inch reduction, which over 79 acres equates to 61.5 million gallons (8,230,000 cf) of water per year saved. 63% of the rainfall will be infiltrated, 16 % will evaporated, while only 21% will runoff. This break up nearly reflects natural undeveloped conditions.** This provides for ground water recharge, reduced channel erosion, clean base flow for streams and rivers, reduced flooding, and less need for large gray storm water infrastructure.

US EPA National Stormwater Calculator Results

Parameter	Current Scenario	Baseline Scenario
Site Area (acres)	79	79
Hydrologic Soil Group	C	C
Hydraulic Conductivity (in/hr)	0.1	0.1
Surface Slope (%)	5	5
Precip. Data Source	CHATTANOOGA AP	CHATTANOOGA AP
Evap. Data Source	CHATTANOOGA AP	CHATTANOOGA AP
Climate Change Scenario	None	None
% Forest	0	0
% Meadow	5	5
% Lawn	10	0
% Desert	0	0
% Impervious	85	95
Years Analyzed	1	1
Ignore Consecutive Wet Days	False	False
Wet Day Threshold (inches)	6.00	6.00

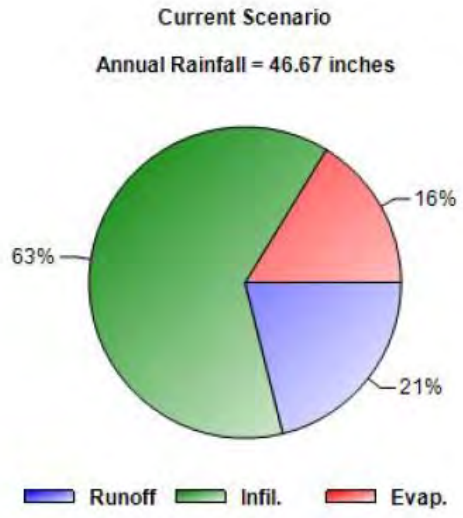
LID Control	Current Scenario	Baseline Scenario
Disconnection	0	0
Rain Harvesting	0	0
Rain Gardens	70 / 10	0
Green Roofs	0	0
Street Planters	0	0
Infiltration Basins	0	0
Porous Pavement	17 / 100	0

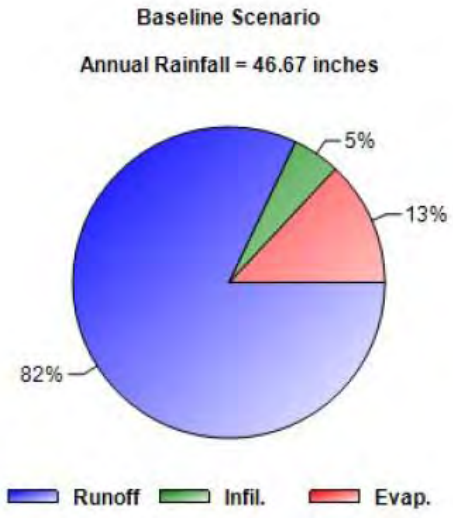
% of impervious area treated / % of treated area used for LID

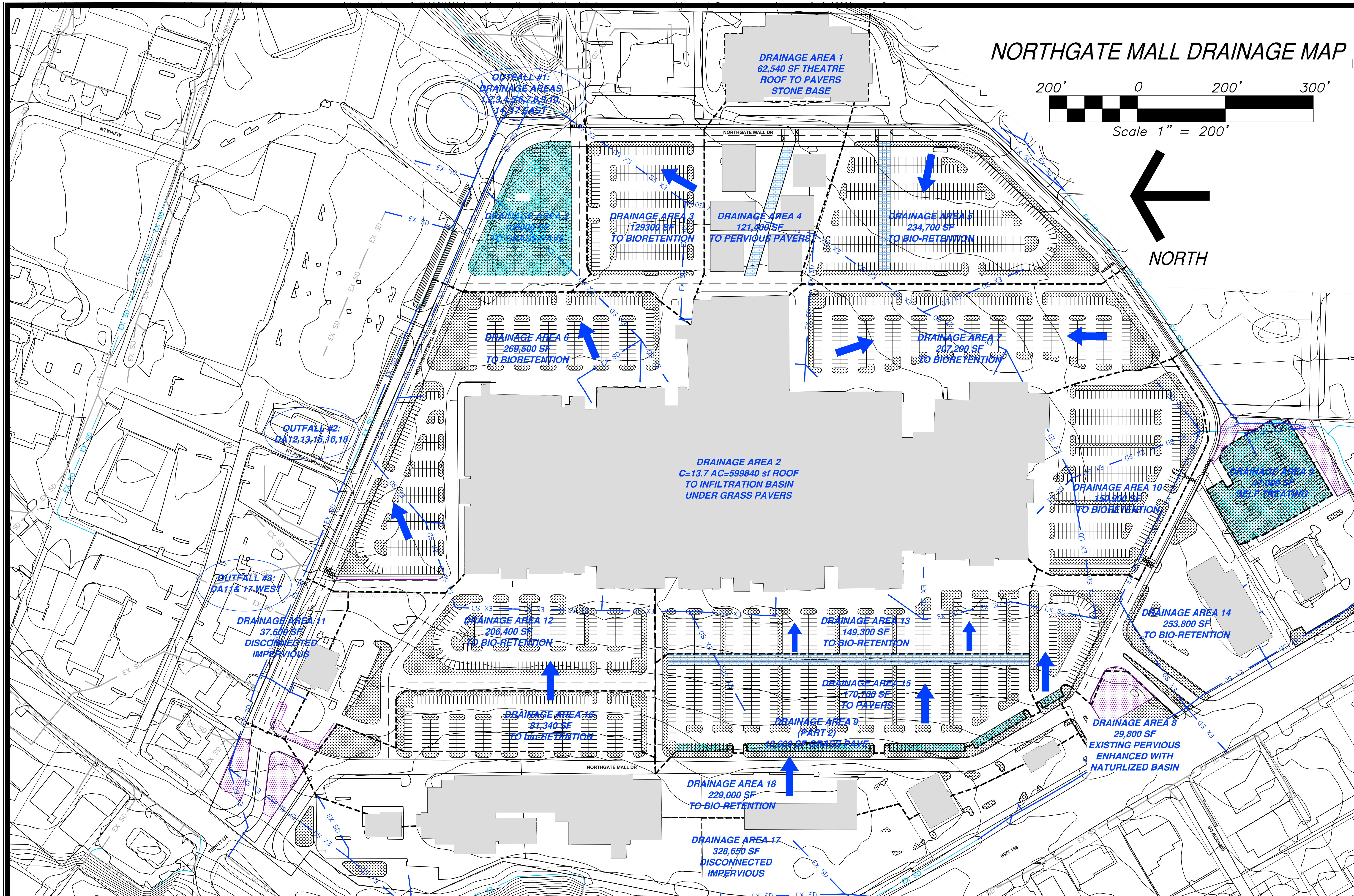
National Stormwater Calculator Report

Summary Results

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	46.67	46.67
Average Annual Runoff (inches)	9.74	38.44






NORTHGATE MALL DRAINAGE MAP
200' 0 200' 300'
Scale 1" = 200'
NORTH
DRAINAGE AREA 1
62,540 SF THEATRE
ROOF TO PAVERS
STONE BASE
OUTFALL #1:
DRAINAGE AREAS
1,2,3,4,5,6,7,8,9,10,
14,17 EAST
DRAINAGE AREA 2
C=13.7 AC=599840 sf ROOF
TO INFILTRATION BASIN
UNDER GRASS PAVERS
DRAINAGE AREA 3
129300 SF
TO BIORETENTION
DRAINAGE AREA 4
121,400 SF
TO PERVIOUS PAVERS
DRAINAGE AREA 5
234,700 SF
TO BIO-RETENTION
DRAINAGE AREA 6
269,500 SF
TO BIORETENTION
DRAINAGE AREA 7
207,200 SF
TO BIORETENTION
DRAINAGE AREA 10
150,800 SF
TO BIORETENTION
OUTFALL #2:
DA12,13,15,16,18
OUTFALL #3:
DA11& 17 WEST
DRAINAGE AREA 11
37,600 SF
DISCONNECTED
IMPERVIOUS
DRAINAGE AREA 12
206,400 SF
TO BIO-RETENTION
DRAINAGE AREA 13
149,300 SF
TO BIO-RETENTION
DRAINAGE AREA 14
253,800 SF
TO BIO-RETENTION
DRAINAGE AREA 15
170,700 SF
TO PAVERS
DRAINAGE AREA 16
81,340 SF
TO bio-RETENTION
DRAINAGE AREA 9
(PART 2)
13,600 SF GRASS PAVE
DRAINAGE AREA 8
29,800 SF
EXISTING PERVIOUS
ENHANCED WITH
NATURLIZED BASIN
DRAINAGE AREA 18
229,000 SF
TO BIO-RETENTION
DRAINAGE AREA 17
328,650 SF
DISCONNECTED
IMPERVIOUS
NORTHGATE MALL DR
HWY 183
TRINITY LN
EX SD

Chattanooga LID Design Tool Calculations

Worksheet 1 Preliminary Design SOV & BMP area

Worksheet 2 Restorative Credits

Worksheet 3 BMP Sizing

Worksheet 4 Curve Number Adjustment

Summary Table

Project Name: Northgate Design Challenge
Date Prepared: June 20th, 2014
Prepared by: Team #16302

WORKSHEET 1: SOV and BMP AREA

=> Denotes input by user

SOV DESIGN RAINFALL =	1 in.	
TARGET LOADING RATIO =	10	(See Ch. 5 for details)

Concept Design

Total Parcel Area =	3,449,000 $ft.^2$	or	79.18 ac
Total Proposed Impervious Area =	2,931,700 $ft.^2$	or	67.30 ac
Protected Areas			0.00 ac
5.2.1 Area of Protected Undisturbed and Healthy Soils	138,000 $ft.^2$	or	3.17 ac
5.2.1.1 Area of Minimized Land Disturbance	0 $ft.^2$	or	0.00 ac
5.2.1.2 Area of Protected Soils/Steep Slopes	0 $ft.^2$	or	0.00 ac
5.2.2 Area of Protected Natural Flow Paths	0 $ft.^2$	or	0.00 ac
5.2.3 Area of Protected/Enhanced Riparian Corridors	12,500 $ft.^2$	or	0.29 ac
5.2.4 Area of Protected/Preserved Vegetation	34,600 $ft.^2$	or	0.79 ac
Total Protected Area	185,100 $ft.^2$	or	4.25 ac
Total Disturbed Area	3,263,900 $ft.^2$	or	74.93 ac
			0.00 ac
Total Impervious Area	2,931,700 $ft.^2$	or	67.30 ac
Total Pervious Area	332200 $ft.^2$	or	7.63 ac
Concept Level BMP Area (Based on Proposed Impervious Area)	293,170 $ft.^2$	or	6.73 ac

Disturbed Area Requiring Stormwater Management =	3,263,900 ft^2	**(A)**
=	74.93 ac	

Runoff Coefficients, Rv for Design Rainfall

Land Use Type	Surface Condition		0.5	0.6	0.7	0.8
-	-	-	-	-	-	-
Clayey Soils	Pervious		0.19	0.194	0.198	0.202
Flat Roof	Impervious		0.79	0.802	0.814	0.826
Large Impervious	Impervious		0.97	0.972	0.974	0.976
Pitched Roof	Impervious		0.95	0.954	0.958	0.962
Sandy Soils	Pervious		0.02	0.022	0.024	0.026
Small Impervious	Impervious		0.64	0.652	0.664	0.676
Typical Urban Soils	Pervious		0.10	0.104	0.108	0.112

- Large impervious includes parking lots with curbs, roads with curbs, highways, etc.
- Small impervious includes roads without curbs, small parking lots without curbs, and sidewalks.

Preliminary Design

INITIAL TARGET BMP AREA = 296,469 ft^2

Sub-Drainage ID per BMP	Land Use Type	Surface Condition	Disturbed Land Area	Disturbed Land Area	Rv Value, from Table	Stay on Volume

Note: Runoff Volume based on Small Storm Hydrology Method, where Rv is the ratio of runoff to rainfall volume.

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WORKSHEET 1: SOV and BMP AREA

(numbers and lowercase letters only)			(ft^2)	(ac)		(ft^3)
1a	Flat Roof	Impervious	62,542	1.44	0.85	4,430
2a	Small Impervious	Impervious	55,328	1.27	0.70	3,227
2b	Sandy Soils	Pervious	53,672	1.23	0.03	134
2c	Flat Roof	Impervious	599,840	13.77	0.85	42,489
3a	Small Impervious	Impervious	116,421	2.67	0.70	6,791
3b	Sandy Soils	Pervious	12,879	0.30	0.03	32
4a	Flat Roof	Impervious	38,485	0.88	0.85	2,726
4b	Small Impervious	Impervious	75,175	1.73	0.70	4,385
4c	Typical Urban Soils	Pervious	7,500	0.17	0.12	75
4d	Sandy Soils	Pervious	240	0.01	0.03	1
5a	Small Impervious	Impervious	207,213	4.76	0.70	12,087
5b	Sandy Soils	Pervious	27,487	0.63	0.03	69
6a	Small Impervious	Impervious	227,880	5.23	0.70	13,293
6b	Sandy Soils	Pervious	41,620	0.96	0.03	104
7a	Small Impervious	Impervious	177,840	4.08	0.70	10,374
7b	Sandy Soils	Pervious	29,360	0.67	0.03	73
8	Typical Urban Soils	Pervious	29,800	0.68	0.12	298
9	Small Impervious	Impervious	60,600	1.39	0.70	3,535
10a	Small Impervious	Impervious	118,860	2.73	0.70	6,934
10b	Sandy Soils	Pervious	32,040	0.74	0.03	80
11a	Large Impervious	Impervious	34,600	0.79	0.98	2,826
11b	Typical Urban Soils	Pervious	3,000	0.07	0.12	30
12a	Small Impervious	Impervious	180,060	4.13	0.70	10,504
12b	Sandy Soils	Pervious	26,340	0.60	0.03	66
13a	Small Impervious	Impervious	132,300	3.04	0.70	7,718
13b	Sandy Soils	Pervious	17,000	0.39	0.03	43
14a	Flat Roof	Impervious	27,892	0.64	0.85	1,976
14b	Small Impervious	Impervious	203,628	4.67	0.70	11,878
14c	Sandy Soils	Pervious	10,260	0.24	0.03	26
14d	Typical Urban Soils	Pervious	12,020	0.28	0.12	120
15a	Small Impervious	Impervious	157,200	3.61	0.70	9,170
15b	Sandy Soils	Pervious	13,500	0.31	0.03	34
16a	Small Impervious	Impervious	65,710	1.51	0.70	3,833
16b	Sandy Soils	Pervious	15,630	0.36	0.03	39
17a	Small Impervious	Impervious	169,730	3.90	0.70	9,901
17b	Sandy Soils	Pervious	14,377	0.33	0.03	36
17c	Flat Roof	Impervious	59,389	1.36	0.85	4,207
17d	Typical Urban Soils	Pervious	85,154	1.95	0.12	852
18a	Small Impervious	Impervious	194,000	4.45	0.70	11,317
18b	Sandy Soils	Pervious	35,000	0.80	0.03	88
Documented Disturbed Land Areas (from above) =			3,431,572 ft^2			**(B)**
		=	78.78 ac			
Total SOV Capture Volume =			185797.86 ft^3			

Lines (A) and (B) should equal if all Disturbed Land Areas have been entered correctly

Note: Runoff Volume based on Small Storm Hydrology Method, where Rv is the ratio of runoff to rainfall volume.

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WORKSHEET 2: Restorative Credits

=> Denotes input by user

Restorative Volume Credit Worksheet

Sub-Drainage ID	Sub-Drainage SOV (ft^3)	Restorative Practice Credit Type	Area (ft^2)	# of Trees	Volume Credit (ft^3)	Total Volume Credit (limit to maximum of 25% of SOV) (ft^3)	Net Drainage Area SOV (ft^3)
1	4,430	None		10	0	0	4,430
		None			0		
		None			0		
2	45,850	Naturalize Swales and Drainage Ditches	5,000	15	104	104	45,746
		None			0		
		None			0		
3	6,823	Tree Planting - Deciduous		14	84	84	6,739
		None			0		
		None			0		
4	7,187	Tree Planting - Deciduous		8	48	48	7,139
		None			0		
		None			0		
5	12,156	Change Cover Type to Meadow	5,000		104	206	11,950
		Tree Planting - Deciduous		17	102		
		None			0		
6	13,397	Change Cover Type to Forest	8,000		167	659	12,738
		Tree Planting - Deciduous		36	216		
		Naturalize Swales and Drainage Ditches	13,250		276		
7	10,447	Tree Planting - Deciduous		28	168	251	10,196
		Change Cover Type to Meadow	4,000		83		
		None			0		

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Sub-Drainage ID	Sub-Drainage SOV (ft^3)	Restorative Practice Credit Type	Area (ft^2)	# of Trees	Volume Credit (ft^3)	Total Volume Credit (limit to maximum of 25% of SOV) (ft^3)	Net Drainage Area SOV (ft^3)
8	298	Enhance Native cover Types	11,000		229	75	224
		None			0		
		None			0		
9	3,535	Enhance Native cover Types	11,000		229	241	3,294
		Tree Planting - Deciduous		2	12		
		None			0		
10	7,014	Change Cover Type to Meadow	4,000		83	179	6,834
		Tree Planting - Deciduous		16	96		
		None			0		
11	2,856	Tree Planting - Deciduous		8	48	48	2,808
		None			0		
		None			0		
12	10,569	Change Cover Type to Forest	10,000		208	298	10,271
		Tree Planting - Deciduous		15	90		
		None			0		
13	7,760	Tree Planting - Deciduous		18	108	108	7,652
		None			0		
		None			0		
14	14,000	Change Cover Type to Meadow	15,000		313	373	13,627
		Tree Planting - Deciduous		10	60		
		None			0		

Project Name: Northgate Design Challenge
Date Prepared: June 20th, 2014
Prepared by: Team #16302

WORKSHEET 2: Restorative Credits

=> Denotes input by user

Restorative Volume Credit Worksheet

Sub-Drainage ID	Sub-Drainage SOV (ft^3)	Restorative Practice Credit Type	Area (ft^2)	# of Trees	Volume Credit (ft^3)	Total Volume Credit (limit to maximum of 25% of SOV) (ft^3)	Net Drainage Area SOV (ft^3)
15	9,204	Tree Planting - Deciduous		18	108	108	9,096
		None			0		
		None			0		
16	3,872	Tree Planting - Deciduous		15	90	90	3,782
		None			0		
		None			0		
17	14,995	Change Cover Type to Meadow	50,000		1,042	1,042	13,953
		None			0		
		None			0		
18	11,404	None			0	0	11,404
		None			0		
		None			0		
19	0	None			0	0	0
		None			0		
		None			0		
20	0	None			0	0	0
		None			0		
		None			0		

Project Name: Northgate Design Challenge
Date Prepared: June 20th, 2014
Prepared by: Team #16302

WORKSHEET 3: BMP SIZING

=> Denotes input by user

Sub-Drainage ID	BMP Type	Infiltration Rate (in./hr)	Runoff Storage Type	Mid-height Area (ft^2)	Depth of Storage (ft)	Storage Capacity (%)	Storage Volume (ft^3)	BMP Surface Area (ft^2)	BMP Capture Volume (ft^3)	Net Drainage Area SOV (ft^3)	Drawdown Time (hrs)	Loading Ratio
1	**Pervious Pavement**	0.10	Surface		0	0%	0	7,935	4,761	4430	72	8
			Soil			0%	0					
			Stone	7,935	1.5	40%	4,761					
2	**Pervious Pavement**	0.10	Surface			0%	0	73,700	51,590	45746	84	9
			Soil	73,700	0.5	20%	7,370					
			Stone	73,700	1.5	40%	44,220					
3	**Bioretention**	0.10	Surface	12,800	0.5	100%	6,400	11,520	11,008	6739	108	10
			Soil	11,520	1	20%	2,304					
			Stone	11,520	0.5	40%	2,304					
4	**Pervious Pavement**	0.10	Surface			0%	0	12,000	12,000	7139	120	9
			Soil			0%	0					
			Stone	12,000	2.5	40%	12,000					
5	**Bioretention**	0.10	Surface	22,950	0.5	100%	11,475	20,655	19,737	11950	108	10
			Soil	20,655	1	20%	4,131					
			Stone	20,655	0.5	40%	4,131					
6	**Bioretention**	0.10	Surface	24,358	0.5	100%	12,179	21,922	20,948	12738	108	10
			Soil	21,922	1	20%	4,384					
			Stone	21,922	0.5	40%	4,384					
7	**Bioretention**	0.10	Surface	20,553	0.5	100%	10,276	18,497	17,675	10196	108	10
			Soil	18,497	1	20%	3,699					
			Stone	18,497	0.5	40%	3,699					

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Date Prepared: June 20th, 2014
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WORKSHEET 3: BMP SIZING

=> Denotes input by user

Sub-Drainage ID	BMP Type	Infiltration Rate (in./hr)	Runoff Storage Type	Mid-height Area (ft^2)	Depth of Storage (ft)	Storage Capacity (%)	Storage Volume (ft^3)	BMP Surface Area (ft^2)	BMP Capture Volume (ft^3)	Net Drainage Area SOV (ft^3)	Drawdown Time (hrs)	Loading Ratio
8	**Naturalized Basin**	0.10	Surface	9,000	1	100%	9,000	0	9,000	224	120	N/A
			Soil			0%	0					
			Stone			0%	0					
9	**Self-Managing Pervious Pavement**	0.10	Surface			0%	0	60,600	0	3294	0	1
			Soil	60,600		0%	0					
			Stone			0%	0					
10	**Bioretention**	0.10	Surface	12,600	0.5	100%	6,300	11,340	10,836	6834	108	10
			Soil	11,340	1	20%	2,268					
			Stone	11,340	0.5	40%	2,268					
11	**NONE**		Surface			0%	0	0	0	2808	-	N/A
			Soil			0%	0					
			Stone			0%	0					
12	**Bioretention**	0.10	Surface	19,757	0.5	100%	9,878	17,781	16,991	10271	108	10
			Soil	17,781	1	20%	3,556					
			Stone	17,781	0.5	40%	3,556					
13	**Bioretention**	0.10	Surface	14,400	0.5	100%	7,200	12,960	12,384	7652	108	10
			Soil	12,960	1	20%	2,592					
			Stone	12,960	0.5	40%	2,592					
14	**Bioretention**	0.10	Surface	21,576	0.5	100%	10,788	15,589	17,574	13627	108	15
			Soil	18,340	1	20%	3,668					
			Stone	15,589	0.5	40%	3,118					

Project Name: Northgate Design Challenge
Date Prepared: June 20th, 2014
Prepared by: Team #16302

WORKSHEET 3: BMP SIZING

=> Denotes input by user

Sub-Drainage ID	BMP Type	Infiltration Rate (in./hr)	Runoff Storage Type	Mid-height Area (ft^2)	Depth of Storage (ft)	Storage Capacity (%)	Storage Volume (ft^3)	BMP Surface Area (ft^2)	BMP Capture Volume (ft^3)	Net Drainage Area SOV (ft^3)	Drawdown Time (hrs)	Loading Ratio
15	**Pervious Pavement**	0.10	Surface			0%	0	22,190	11,095	9096	60	7
			Soil			0%	0					
			Stone	22,190	1.25	40%	11,095					
16	**Bioretention**	0.10	Surface	7,790	0.5	100%	3,895	7,011	6,699	3782	108	9
			Soil	7,011	1	20%	1,402					
			Stone	7,011	0.5	40%	1,402					
17	**Bioretention**	0.10	Surface	6,800	0.5	100%	3,400	6,801	7,480	13953	132	34
			Soil	6,801	2	20%	2,720					
			Stone	6,801	0.5	40%	1,360					
18	**Bioretention**	0.10	Surface	26,000	0.5	100%	13,000	18,785	21,177	11404	108	10
			Soil	22,100	1	20%	4,420					
			Stone	18,785	0.5	40%	3,757					
19	**NONE**		Surface			0%	0	0	0	0	-	N/A
			Soil		1	20%	0					
			Stone			0%	0					
20	**NONE**		Surface			0%	0	0	0	0	-	N/A
			Soil			0%	0					
			Stone			0%	0					

Project Name: Northgate Design Challenge
Date Prepared: June 20th, 2014
Prepared by: Team #16302

WORKSHEET 4: CN Adjustment

=> Denotes input by user

Outfall #	Area (ft²)	Weighted CN	Storm Frequency	Rainfall (in)	S	Q (in)	BMP Capture Volume (ft³)	Infiltration Volume (12 hrs) (ft³)	Total BMP Volume Reduction (ft³)	Q minus Total Volume Reduction (in)	Adjusted CN
1	2,392,907	93	2	3.70		2.93				1.90	81
			5	4.50		3.71				2.68	83
			10	5.10	0.75	4.30	178,869	25,716	204,585	3.27	83
			25	6.00		5.18				4.16	84
			100	7.40		6.57				5.54	84
2	666,040	95	2	3.70		3.14				2.66	90
			5	4.50		3.92				3.45	90
			10	5.10	0.53	4.52	85,920	9,432	95,351	4.04	91
			25	6.00		5.41				4.93	91
			100	7.40		6.80				6.33	91
3	201,925	91	2	3.70		2.73				2.71	91
			5	4.50		3.50				3.48	91
			10	5.10	0.99	4.08	3,740	340	4,080	4.06	91
			25	6.00		4.96				4.94	91
			100	7.40		6.33				6.31	91
			2	3.70		3.70				3.70	100
			5	4.50		4.50				4.50	100
			10	5.10	0.00	5.10			0	5.10	100
			25	6.00		6.00				6.00	100
			100	7.40		7.40				7.40	100
			2	3.70		3.70				3.70	100
			5	4.50		4.50				4.50	100
			10	5.10	0.00	5.10			0	5.10	100
			25	6.00		6.00				6.00	100
			100	7.40		7.40				7.40	100
			2	3.70		3.70				3.70	100
			5	4.50		4.50				4.50	100
			10	5.10	0.00	5.10			0	5.10	100
			25	6.00		6.00				6.00	100
			100	7.40		7.40				7.40	100

Project Summary								
Sub-Drainage ID	**Total Disturbed Area** (ft^2)	**Total Disturbed Impervious Area** (ft^2)	**Sub-Drainage Area SOV** (ft^3)	**Volume Credit** (ft^3)	**Net Sub-Drainage Area SOV** (ft^3)	**Loading Ratio**	**BMP Capture Volume** (ft^3)	**Capture > SOV?**
1	62,542	62,542	4,430	0	4,430	8	4,761	YES
2	708,840	655,168	45,850	104	45,746	9	51,590	YES
3	129,300	116,421	6,823	84	6,739	10	11,008	YES
4	121,400	113,660	7,187	48	7,139	9	12,000	YES
5	234,700	207,213	12,156	206	11,950	10	19,737	YES
6	269,500	227,880	13,397	659	12,738	10	20,948	YES
7	207,200	177,840	10,447	251	10,196	10	17,675	YES
8	29,800	0	298	75	224	N/A	9,000	YES
9	60,600	60,600	3,535	241	3,294	1	0	NO
10	150,900	118,860	7,014	179	6,834	10	10,836	YES
11	37,600	34,600	2,856	48	2,808	N/A	0	NO
12	206,400	180,060	10,569	298	10,271	10	16,991	YES
13	149,300	132,300	7,760	108	7,652	10	12,384	YES
14	253,800	231,520	14,000	373	13,627	15	17,574	YES
15	170,700	157,200	9,204	108	9,096	7	11,095	YES
16	81,340	65,710	3,872	90	3,782	9	6,699	YES
17	328,650	229,119	14,995	1,042	13,953	34	7,480	NO
18	229,000	194,000	11,404	0	11,404	10	21,177	YES
19	0	0	0	0	0	N/A	0	N/A
20	0	0	0	0	0	N/A	0	N/A
Totals	3,431,572	2,964,693	185,798	3,914	181,884		250,955	YES

Hydrographs

See separate report for 2 Year, 10 Year, 25 Year, and 100 Year Hydrographs.

2 Year

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	80.17	2	736	365,756	------	------	------	Outfall 1 Adjusted CN
2	SCS Runoff	49.50	2	722	141,613	------	------	------	Outfall 2 Adjusted CN
3	SCS Runoff	15.43	2	722	44,440	------	------	------	Outfall 3 Adjusted CN
4	Combine	122.03	2	726	551,809	1, 2, 3	------	------	Total Postdeveloped
6	SCS Runoff	150.81	2	728	570,995	------	------	------	Outfall 1 Existing
7	SCS Runoff	64.04	2	720	178,349	------	------	------	Outfall 2 Existing
8	SCS Runoff	15.43	2	722	44,440	------	------	------	Outfall 3 Existing
9	Combine	212.02	2	724	793,784	6, 7, 8	------	------	Total Existing

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	142.77	2	734	647,154	------	------	------	Outfall 1 Adjusted CN
2	SCS Runoff	75.39	2	722	221,800	------	------	------	Outfall 2 Adjusted CN
3	SCS Runoff	22.83	2	722	67,164	------	------	------	Outfall 3 Adjusted CN
4	Combine	204.76	2	726	936,117	1, 2, 3	------	------	Total Postdeveloped
6	SCS Runoff	219.36	2	728	847,103	------	------	------	Outfall 1 Existing
7	SCS Runoff	91.28	2	720	259,766	------	------	------	Outfall 2 Existing
8	SCS Runoff	22.83	2	722	67,164	------	------	------	Outfall 3 Existing
9	Combine	307.70	2	724	1,174,032	6, 7, 8	------	------	Total Existing

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	193.97	2	732	843,446	------	------	------	Outfall 1 Adjusted CN
2	SCS Runoff	89.87	2	722	267,201	------	------	------	Outfall 2 Adjusted CN
3	SCS Runoff	27.21	2	722	80,912	------	------	------	Outfall 3 Adjusted CN
4	Combine	274.52	2	726	1,191,560	1, 2, 3	------	------	Total Postdeveloped
6	SCS Runoff	259.96	2	728	1,013,365	------	------	------	Outfall 1 Existing
7	SCS Runoff	107.43	2	720	308,605	------	------	------	Outfall 2 Existing
8	SCS Runoff	27.21	2	722	80,912	------	------	------	Outfall 3 Existing
9	Combine	364.39	2	724	1,402,883	6, 7, 8	------	------	Total Existing

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2013 by Autodesk, Inc. v10

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	253.33	2	732	1,110,742	------	------	------	Outfall 1 Adjusted CN
2	SCS Runoff	113.29	2	722	341,623	------	------	------	Outfall 2 Adjusted CN
3	SCS Runoff	34.30	2	722	103,448	------	------	------	Outfall 3 Adjusted CN
4	Combine	354.90	2	726	1,555,814	1, 2, 3	------	------	Total Postdeveloped
6	SCS Runoff	325.64	2	728	1,285,194	------	------	------	Outfall 1 Existing
7	SCS Runoff	133.60	2	720	388,293	------	------	------	Outfall 2 Existing
8	SCS Runoff	34.30	2	722	103,448	------	------	------	Outfall 3 Existing
9	Combine	456.13	2	724	1,776,935	6, 7, 8	------	------	Total Existing

resource:Rain
Low Impact Development Design Challenge

NORTHGATE MALL

team 16302

PARKING and VEHICLE ACCESS

1 Parking divided into smaller more focused lots
2 90 degree parking as more efficient use of impervious space
3 Longer medians on either side of drive aisle to create visual corridor to main mall entrances
4 Raised speed tables at pedestrian and bike crossings
5 Second collector drive to divide traffic into narrower roadways
6 Utilize existing asphalt paving throughout
7 Fewer vehicle lanes to encourage pedestrian circulation through shortened lane crossing distances

VEGITATION / INFILTRATION

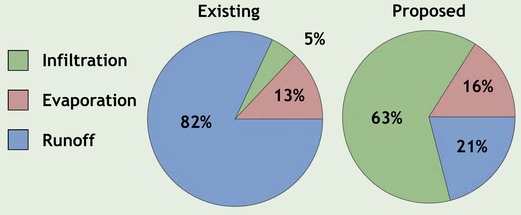
1 Forested micro-habitat areas for restorative SOV credits
2 Additional landscaping serves as an enhanced visual screen and pretreatment for runoff toward right-of-way and restorative volume credits
3 Pervious paving to intercept runoff and provide pedestrian route through parking lot
4 Retrofit existing parking median as bio-retention medians
5 Save existing established trees at entry and enhance with undergrowth species to create micro-habitat along new retention pond
6 Meadow micro-habitat areas for restorative Stay on Volume credits
7 Grass paving for seasonal overflow parking or community events
8 Planter boxes and living wall at main mall entrances
9 Stream restoration using living walls adjusting stream slopes to save existing trees — See Section 1
10 Maintain existing established tree vegetation throughout

PEDESTRIAN / BIKE ACCESS

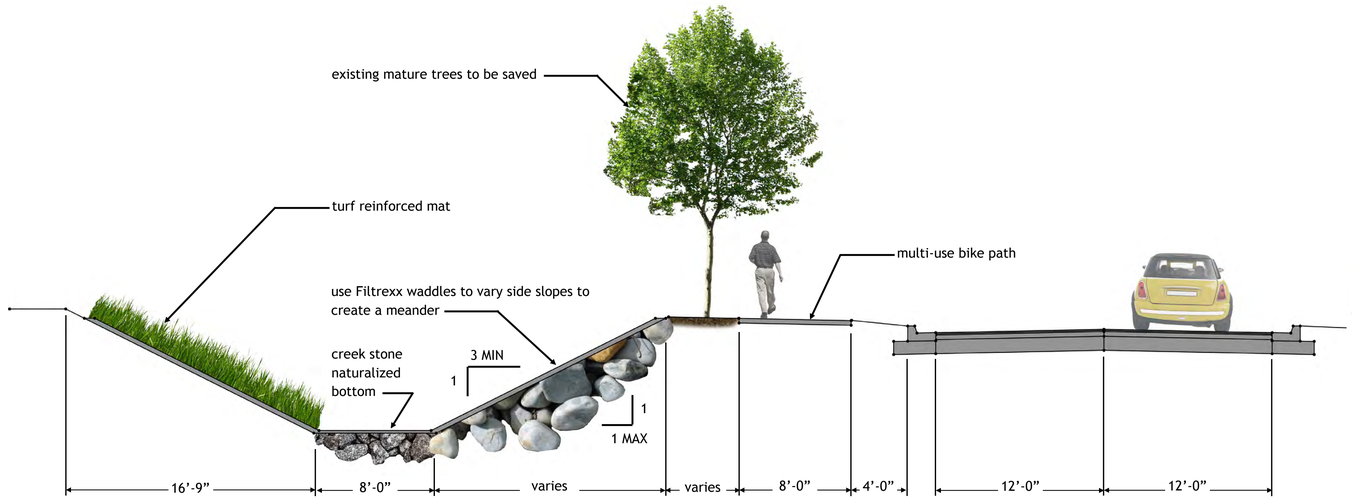
1 8’ Mixed use bike path connecting various areas around the mall campus
2 Bike racks
3 Bus stops
4 Protected pedestrian path between perimeter retail and mall
5 Crosswalks for access to overflow parking
6 Maintain and improve pedestrian access to neighboring property
7 Connection of mixed use bike path to proposed extension of Chickamauga Creek Greenway

STORM WATER FACTS

- With an average annual rainfall of 46.67”, the current annual runoff from the site is 38.44”. With the proposed changes, the ***AVERAGE ANNUAL RUNOFF*** will be ***CUT BY 61%*** reducing the amount to 9”.



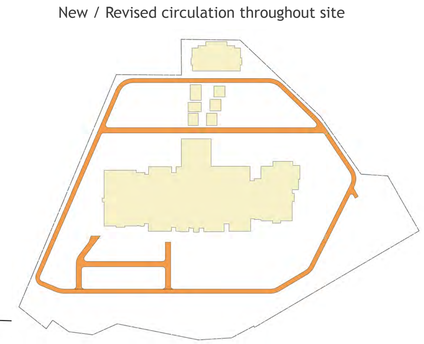
- ***61.5 MILLION GALLONS*** of storm water per year ***INFILTRATED*** instead of runoff to gray infrastructure.
- Yearly ***STORM WATER FEE CREDITS*** of ***$97,300.00***.
- Design ***EXCEEDS THE 1” STAY ON VOLUME*** required of 185,800 CF to 251,000 CF. The ***65,200 CF EXTRA VOLUME*** can be sold as coupons worth $20/CF totaling ***$1,304,000***.

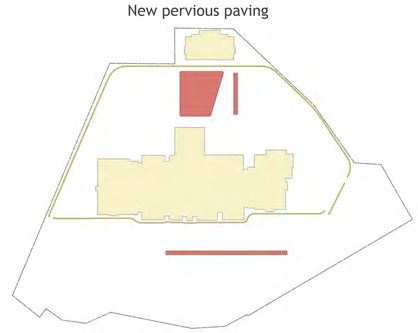


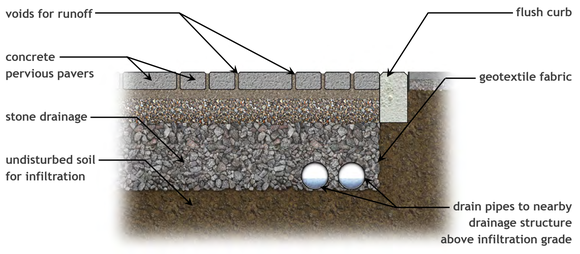
Section 1 at stream adjacent to mall campus

Photo 1 — West facing perspective of new development

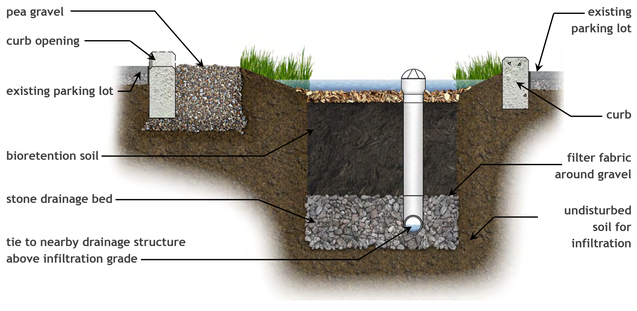
Photo 2 — East facing perspective of new development







Detail 1 — Typical at pervious paver pedestrian paths



Detail 2 — Typical at medians