EPA Region 1 MS4 Stormwater General Permits and LID Training Clinic

Tools and Methodologies for Tracking/ Reducing Impervious Cover

MWRA
Chelsea, MA
April 27, 2011

Horsley Witten Group, Inc.

Topics to Cover

1. Defining impervious areas
2. Permit requirements
3. Methods for tracking changes in impervious cover
   - Establishing baseline conditions
   - Calculating annual change
   - Reporting net change
   - Redevelopment/Retrofit Group Exercise
4. BMP effectiveness

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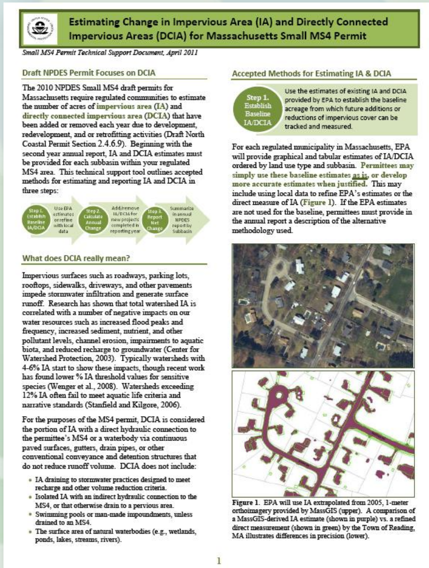
Technical Support Document

www.epa.gov/region1/npdes/stormwater/ma/MADCIA.pdf



Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit

Small MS4 Permit Technical Support Document, April 2011

Draft NPDES Permit Focuses on DCIA

The 2010 NPDES Small MS4 draft permits for Massachusetts require regulated communities to estimate the number of acres of impervious area (IA) and directly connected impervious area (DCIA) that have been added or removed each year due to development, redevelopment, and or retrofitting activities (Draft North Coastal Permit Section 2.4.6.9). Beginning with the second year annual report, IA and DCIA estimates must be provided for each subbasin within your regulated MS4 area. This technical support tool outlines accepted methods for estimating and reporting IA and DCIA in three steps:

Step 1. Establish Baseline IA/DCIA — Use EPA estimates or refine with local data
Step 2. Calculate Annual Change — Add/remove IA/DCIA for new projects completed in reporting year
Step 3. Report Net Change — Summarize in annual NPDES report by Subbasin

What does DCIA really mean?

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed IA is correlated with a number of negative impacts on our water resources such as increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater (Center for Watershed Protection, 2003). Typically watersheds with 4-6% IA start to show these impacts, though recent work has found lower % IA threshold values for sensitive species (Wenger et al., 2008). Watersheds exceeding 12% IA often fail to meet aquatic life criteria and narrative standards (Stanfield and Kilgore, 2006).

For the purposes of the MS4 permit, DCIA is considered the portion of IA with a direct hydraulic connection to the permittee's MS4 or a waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume. DCIA does not include:

- IA draining to stormwater practices designed to meet recharge and other volume reduction criteria.
- Isolated IA with an indirect hydraulic connection to the MS4, or that otherwise drain to a pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

Accepted Methods for Estimating IA & DCIA

Step 1. Establish Baseline IA/DCIA — Use the estimates of existing IA and DCIA provided by EPA to establish the baseline acreage from which future additions or reductions of impervious cover can be tracked and measured.

For each regulated municipality in Massachusetts, EPA will provide graphical and tabular estimates of IA/DCIA ordered by land use type and subbasin. Permittees may simply use these baseline estimates as is, or develop more accurate estimates when justified. This may include using local data to refine EPA's estimates or the direct measure of IA (Figure 1). If the EPA estimates are not used for the baseline, permittees must provide in the annual report a description of the alternative methodology used.

Figure 1. EPA will use IA extrapolated from 2005, 1-meter orthoimagery provided by MassGIS (upper). A comparison of a MassGIS-derived IA estimate (shown in purple) vs. a refined direct measurement (shown in green) by the Town of Reading, MA illustrates differences in precision (lower).

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1. Defining Impervious Areas

What is DCIA?

A. Impervious cover regardless of where it drains
B. Directly-connected impervious area
C. Disconnected impervious area
D. Effective impervious cover
E. B and D

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1. Defining Impervious Areas

2.4.6.9 DCIA is the portion of IA with a direct hydraulic connection to the MS4 or a waterbody via:

- continuous paved surfaces,
- gutters,
- drain pipes, or
- other conventional conveyance and detention structures that do not reduce runoff volume

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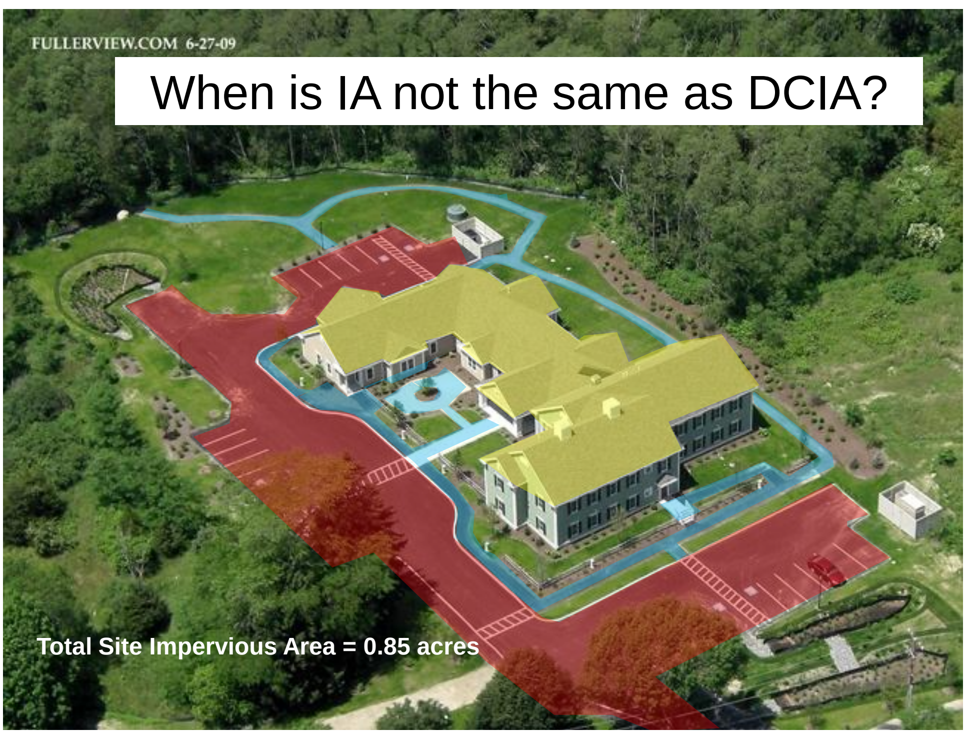

1. Defining Impervious Areas

DCIA does not include:

- IA draining to stormwater BMPs designed to meet recharge and volume reduction criteria.
- Isolated IA with an indirect hydraulic connection to the MS4, or that drains to a qualified pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

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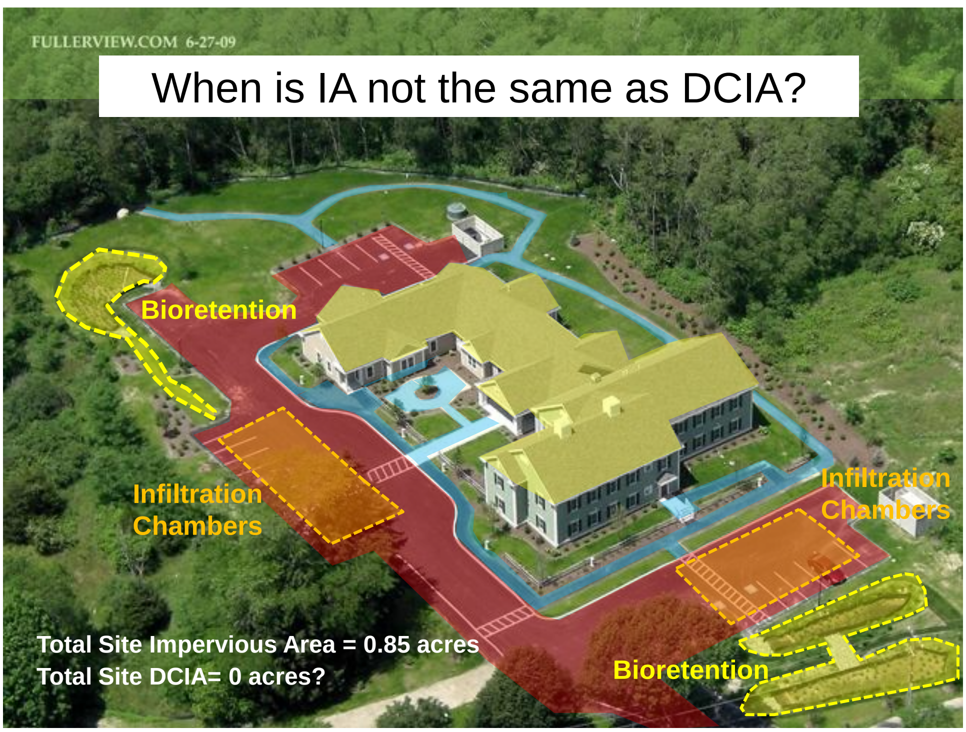

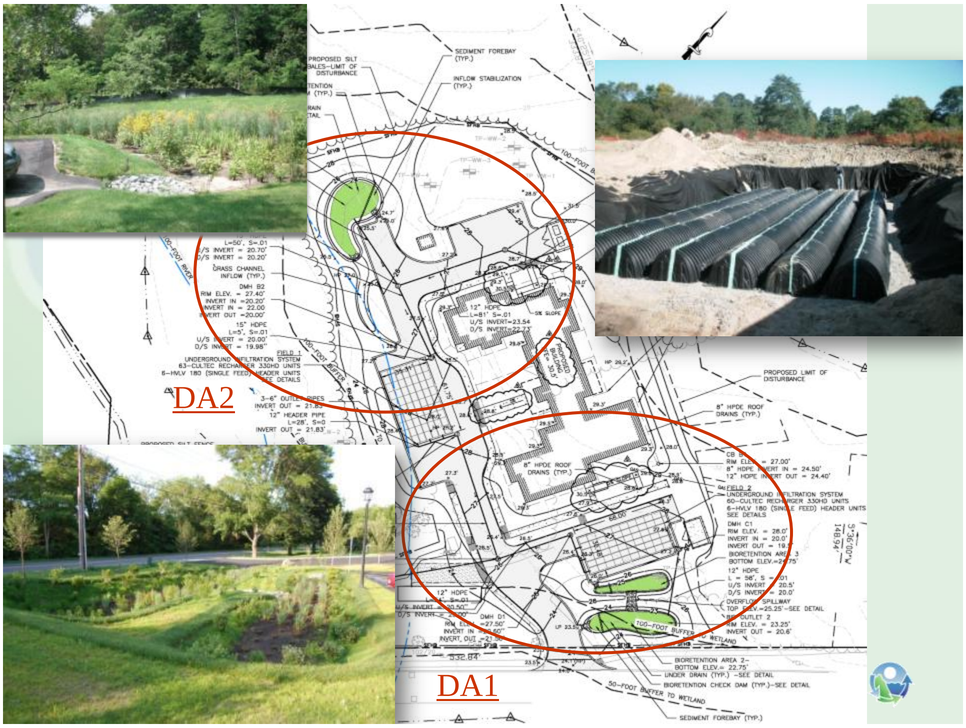

2. Draft MS4 Permit Requirements

2010 NPDES Small MS4 Draft North Coastal/MIMSC Permits Section 2.4.6.9 requires:

1. Annual estimates of IA and DCIA acres added or removed in each subbasin of the regulated MS4
2. Reporting in <u>second year </u>of permit
3. Use accepted methods for estimating DCIA, or provide written justification of alternative method

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Why do we care?

3. Methods for Tracking IA/DCIA

- How good is your GIS?
- How accurate do you need to be?
- What are the benefits of using local data?

- Do you know IA draining to each BMP on new project sites?
- Do you know which BMPs can be used to reduce DCIA?

- How do you track and report annual results to EPA?

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3. Methods for Tracking IA/DCIA

Step 1. Estimate Baseline IA/DCIA → Use EPA estimates or refine with local data

A Define subbasins

B Estimate/ Measure IA

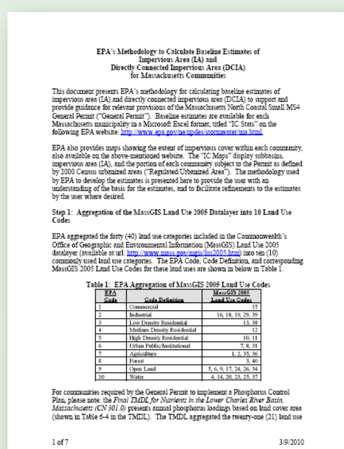
C Calculate DCIA with approved equations

- EPA to provide MA municipalities with current IA and DCIA by subwatershed
- GIS and spreadsheets
- Mapping based on MassGIS

Methods EPA used to calculate baseline

http://www.epa.gov/region1/npdes/stormwater/ma/IA-DCIA-Calculation-Methodology.pdf

- 2005 MassGIS land use
- USGS MA nested subbasins
- 2005 MassGIS Impervious Cover
- 2000 Census for Urbanized Areas
- Sutherland equations to generate DCIA



EPA's Methodology to Calculate Baseline Estimates of Impervious Area (IA) and Directly Connected Impervious Area (DCIA) for Massachusetts Communities

This document presents EPA's methodology for calculating baseline estimates of impervious area (IA) and directly connected impervious area (DCIA) to support and provide guidance for relevant provisions of the Massachusetts North Coastal Small MS4 General Permit ("General Permit"). Baseline estimates are available for each Massachusetts municipality in a Microsoft Excel format, titled "IC Stats" on the following EPA website: http://www.epa.gov/ne/npdes/stormwater/ma.html.

EPA also provides maps showing the extent of impervious cover within each community, also available on the above-mentioned website. The "IC Maps" display subbasins, impervious area (IA), and the portion of each community subject to the Permit as defined by 2000 Census urbanized areas ("Regulated/Urbanized Area"). The methodology used by EPA to develop the estimates is presented here to provide the user with an understanding of the basis for the estimates, and to facilitate refinements to the estimates by the user where desired.

Step 1: Aggregation of the MassGIS Land Use 2005 Datalayer into 10 Land Use Codes

EPA aggregated the forty (40) land use categories included in the Commonwealth's Office of Geographic and Environmental Information (MassGIS) Land Use 2005 datalayer (available at url: http://www.mass.gov/mgis/lus2005.htm) into ten (10) commonly used land use categories. The EPA Code, Code Definition, and corresponding MassGIS 2005 Land Use Codes for these land uses are shown in below in Table 1.

Table 1: EPA Aggregation of MassGIS 2005 Land Use Codes

EPA Code	Code Definition	MassGIS 2005 Land Use Codes
1	Commercial	15
2	Industrial	16, 18, 19, 29, 39
3	Low Density Residential	13, 38
4	Medium Density Residential	12
5	High Density Residential	10, 11
6	Urban Public/Institutional	7, 8, 31
7	Agriculture	1, 2, 35, 36
8	Forest	3, 40
9	Open Land	5, 6, 9, 17, 24, 26, 34
10	Water	4, 14, 20, 23, 25, 37

For communities required by the General Permit to implement a Phosphorus Control Plan, please note: the *Final TMDL for Nutrients in the Lower Charles River Basin, Massachusetts (CN 301.0)* presents annual phosphorus loadings based on land cover area (shown in Table 6-4 in the TMDL). The TMDL aggregated the twenty-one (21) land use

1 of 7 3/9/2010

Complexities with GIS IC Data

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- Sutherland equations
- EPA estimates based on land use & assumed watershed conditions
- Permittees can refine if better information is available

Table 1. Sutherland Equations to Determine DCIA (%)

Watershed Selection Criteria	Assumed Land Use	Equation *(where IA(%) ≥1)*
Average: Mostly storm sewered with curb & gutter, no dry wells or infiltration, residential rooftops not directly connected	Commercial, Industrial, Institutional, Open land, and Med. density residential	$DCIA=0.1(IA)^{1.5}$
Highly connected: Same as above, but residential rooftops are connected	High density residential	$DCIA=0.4(IA)^{1.2}$
Totally connected: 100% storm sewered with all IA connected	--	DCIA=IA
Somewhat connected: 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	Low density residential	$DCIA=0.04(IA)^{1.7}$
Mostly disconnected: Small percentage of urban area is storm sewered, or 70% or more infiltrate/disconnected	Agricultural; Forested	$DCIA=0.01(IA)^{2}$

3. Methods for Tracking IA/DCIA

Step 2. Calculate Annual Change

Add/remove IA/DCIA for new projects completed in reporting year

A Determine former and new IA/site

B Define IA, soils, & runoff volume to each BMP

C Calculate DCIA using BMP **Disconnection Multiplier**

D Sum IA and DCIA for each site

- IA & DCIA change based on new development, redevelopment, and retrofit projects completed during reporting year
- For each BMP you need to know:
  - type
  - IA in drainage area
  - Soil infiltration rate* and runoff volume treated*
    (* for infiltration trench/basins)

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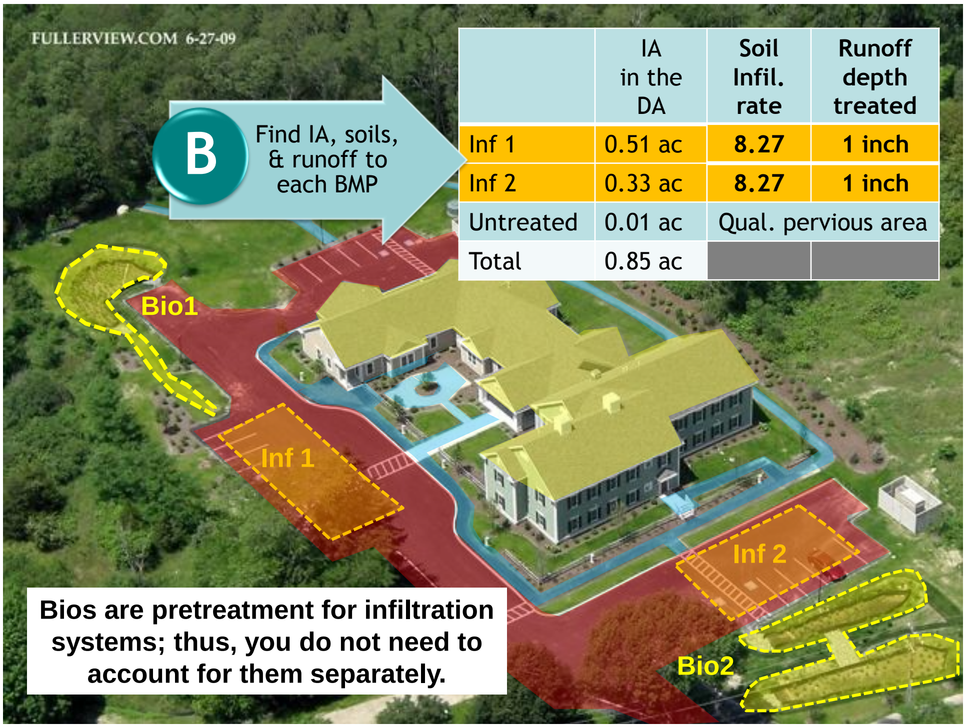
	Existing	Proposed
IA parking	0 ac	0.47 ac
IA roof	0 ac	0.21 ac
IA other	0 ac	0.17 ac
Total	**0 ac**	**0.85 ac**



	IA in the DA	Soil Infil. rate	Runoff depth treated
Inf 1	0.51 ac	**8.27**	**1 inch**
Inf 2	0.33 ac	**8.27**	**1 inch**
Untreated	0.01 ac	Qual. pervious area	
Total	0.85 ac		

Where do infiltration rates come from?

Table 2.3.3. 1982 Rawls Rates[18]

Texture Class	NRCS Hydrologic Soil Group (HSG)	Infiltration Rate Inches/Hour
Sand	A	8.27
Loamy Sand	A	2.41
Sandy Loam	B	1.02
Loam	B	0.52
Silt Loam	C	0.27
Sandy Clay Loam	C	0.17
Clay Loam	D	0.09
Silty Clay Loam	D	0.06
Sandy Clay	D	0.05
Silty Clay	D	0.04
Clay	D	0.02

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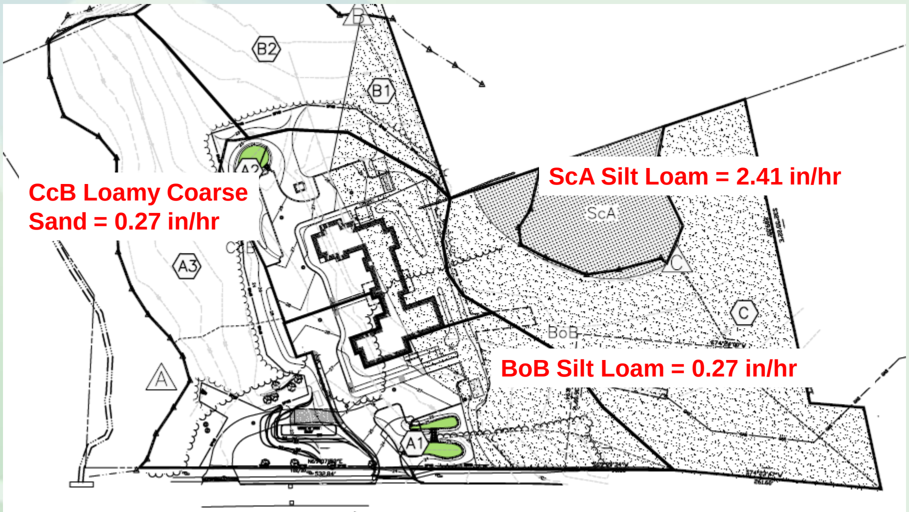
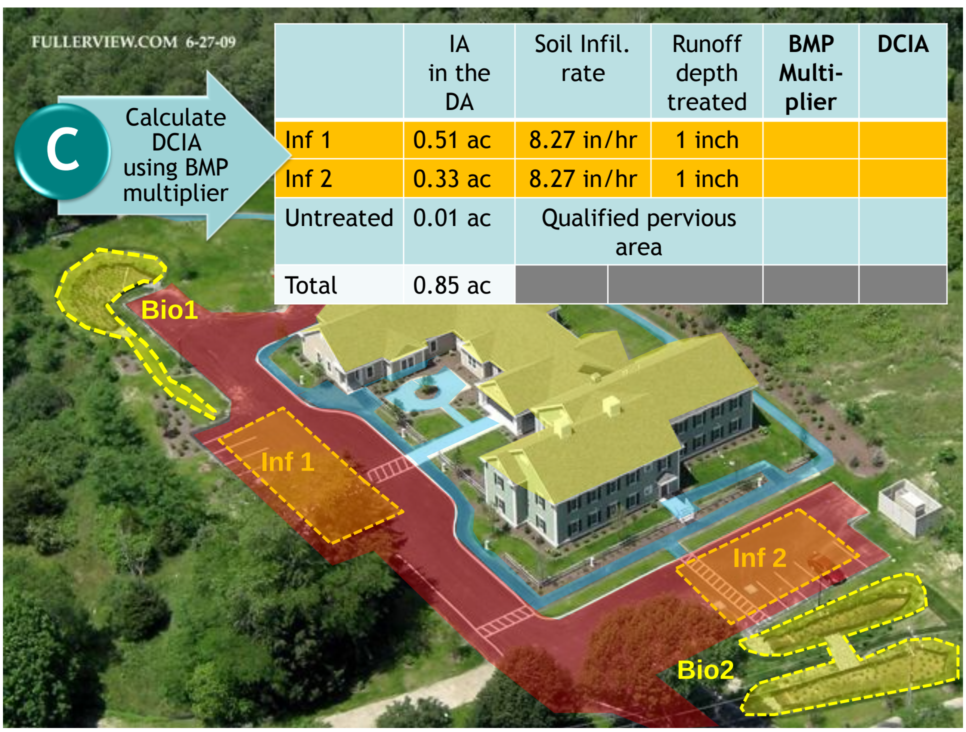
Were does soil info come from?



However, test pits showed better subsoils (sandy loams and loamy sands over medium sand), so used 8.27 in/hr



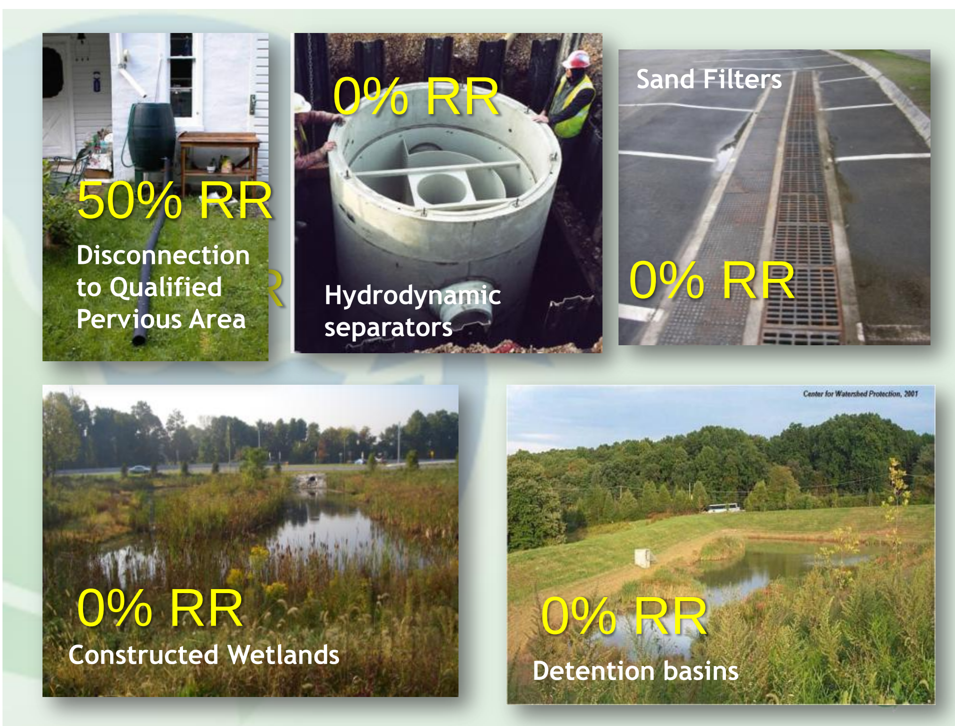
	IA in the DA	Soil Infil. rate	Runoff depth treated	BMP Multi-plier	DCIA
Inf 1	0.51 ac	8.27 in/hr	1 inch		
Inf 2	0.33 ac	8.27 in/hr	1 inch		
Untreated	0.01 ac	Qualified pervious area			
Total	0.85 ac				

1. Interim **default** values for RR based on Schueler, 2009
2. BMP **Multiplier**= 1-%RR/100
3. Based on MASWMS credits and %RR upper limits from Schueler 2009
4. Infiltration values based on EPA 2010 performance curves (soil infiltration rates and depth of runoff treated)

Table 2. Determining DCIA based on Interim Default BMP Disconnection Multipliers or EPA's Infiltration Curves

BMP Description	% Runoff Volume Reduction[1]	BMP Disconnection Multiplier[2]
Removal of pavement; restoration of infiltration capacity	100%	0
Redirection of rooftop runoff to infiltration areas, rain gardens or dry wells	85%	0.15
Permeable pavement, bioretention practices, dry/vegetated water quality swales	75%	0.25
Disconnection to qualified pervious area[3]	50%	0.50
Infiltration trenches	15-100%	0.85-0
Infiltration basins	13-100%	0.87-0
Non-runoff reduction practices (i.e., detention ponds, wetlands, sand filters, hydrodynamic separators, etc)	0%	1.0

75% RR
Bioretention
75% RR
Dry swale
?% RR
Green Roof
Permeable Pavements
75% RR



50% RR
Disconnection
to Qualified
Pervious Area
0% RR
Hydrodynamic
separators
Sand Filters
0% RR
0% RR
Constructed Wetlands
Center for Watershed Protection, 2001
0% RR
Detention basins

What is *Qualified Pervious Area*

CREDIT 1. Environmentally Sensitive Development
CREDIT 2. Rooftop Runoff Directed to Qualifying Pervious Area
CREDIT 3. Roadway, Driveway or Parking Lot Runoff Directed to Qualifying Pervious Area

"Qualifying Pervious Areas" are defined as natural or landscaped vegetated areas fully stabilized, with runoff characteristics at or lower than the NRCS Runoff Curve Numbers in the table set forth below. The Qualifying Pervious Area may be located in the outer 50-foot portion of a wetland buffer zone. However, it must not be located in the inner 50-foot portion of a wetland buffer zone (that portion of the buffer zone immediately adjacent to a wetland).

Maximum NRCS Runoff Curve Numbers for Qualifying Pervious Area

Cover Type	HSG A	HSG B	HSG C
Natural: Woods Good Condition	30	55	70
Natural: Brush Good Condition	30	48	65
Landscaped: Good Condition (grass cover > 75% or equivalent herbaceous plants)	39	61	74

Table 3. Percent Runoff Reduction based on EPA's 2010 Infiltration Curves

Depth of Runoff Treated (inches)	Soil Infiltration Rate (in/hr)					
	0.17	0.27	0.52	1.02	2.41	8.27
Infiltration Trench						
0.1	15%	18%	22%	26%	34%	54%
0.2	28%	32%	38%	45%	55%	76%
0.4	49%	55%	62%	68%	78%	93%
0.6	64%	70%	76%	81%	88%	97%
0.8	75%	79%	84%	88%	93%	99%
1.0	82%	85%	89%	92%	96%	100%
1.5	92%	93%	95%	97%	99%	100%
2.0	95%	96%	97%	98%	100%	100%
Infiltration Basin						
0.1	13%	16%	20%	24%	33%	55%
0.2	25%	30%	36%	42%	54%	77%
0.4	44%	51%	58%	66%	78%	93%
0.6	59%	66%	73%	79%	88%	98%
0.8	71%	76%	81%	87%	93%	99%
1.0	78%	82%	87%	91%	96%	100%
1.5	89%	91%	94%	96%	99%	100%
2.0	94%	95%	97%	98%	100%	100%


Stormwater Best Management Practices (BMP) Performance Analysis

Revised Document: March 2010
(Original Document: December 2008)

Prepared for:
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TETRA TECH

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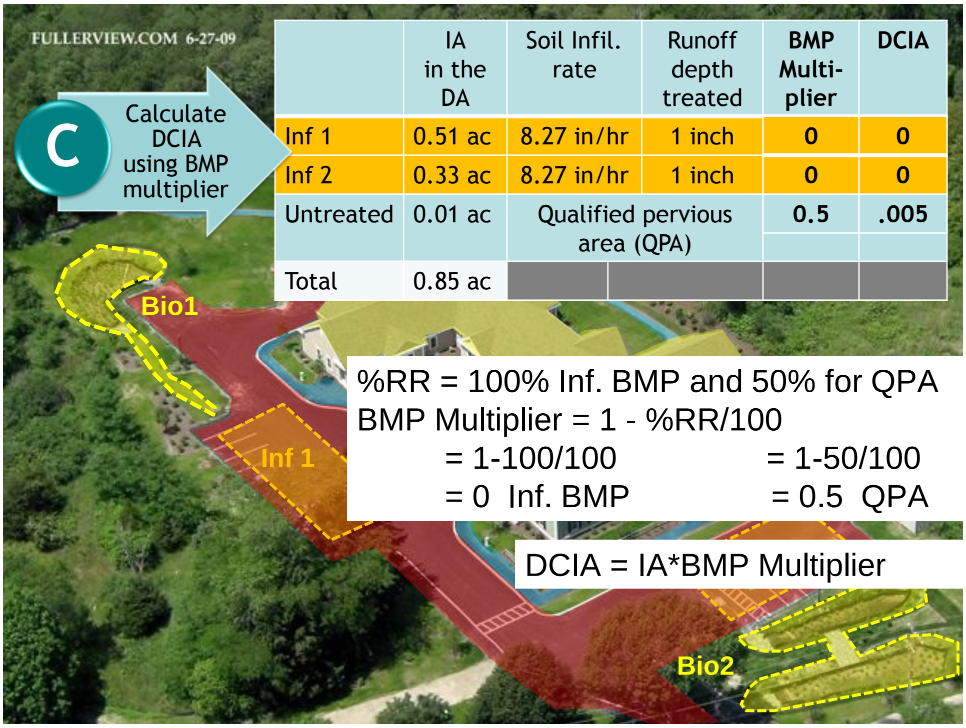


	IA in the DA	Soil Infil. rate	Runoff depth treated	**BMP Multi-plier**	**DCIA**
Inf 1	0.51 ac	8.27 in/hr	1 inch	**0**	**0**
Inf 2	0.33 ac	8.27 in/hr	1 inch	**0**	**0**
Untreated	0.01 ac	Qualified pervious area (QPA)		**0.5**	**.005**
Total	0.85 ac				

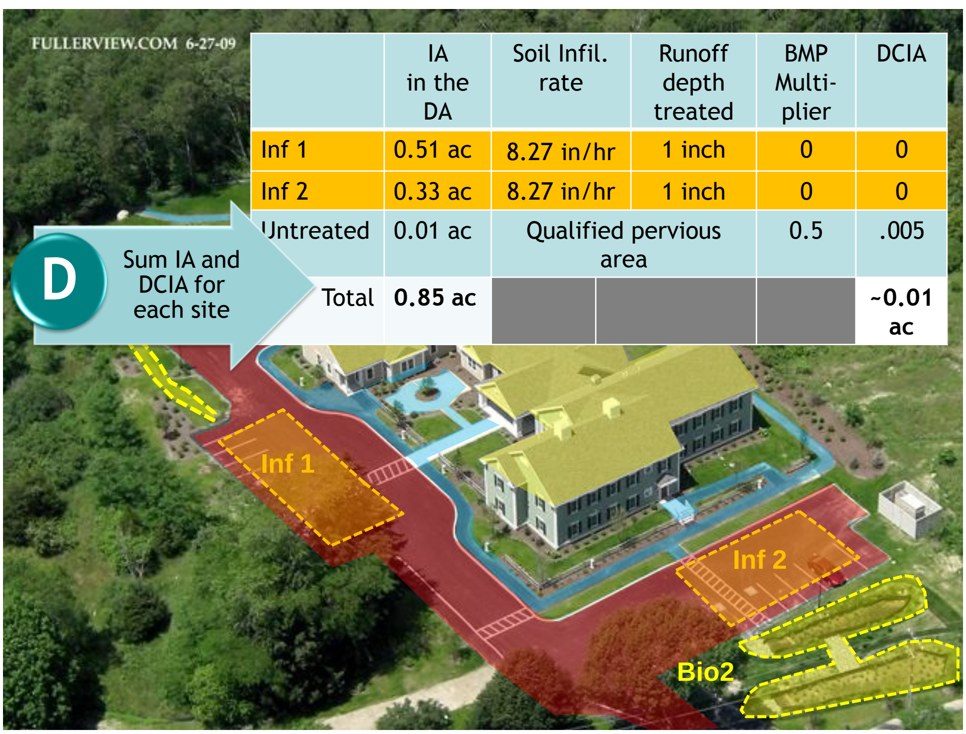
%RR = 100% Inf. BMP and 50% for QPA

BMP Multiplier = 1 - %RR/100

= 1-100/100 = 1-50/100

= 0 Inf. BMP = 0.5 QPA

DCIA = IA*BMP Multiplier



	IA in the DA	Soil Infil. rate	Runoff depth treated	BMP Multi-plier	DCIA
Inf 1	0.51 ac	8.27 in/hr	1 inch	0	0
Inf 2	0.33 ac	8.27 in/hr	1 inch	0	0
Untreated	0.01 ac	Qualified pervious area		0.5	.005
Total	**0.85 ac**				**~0.01 ac**

3. Methods for Tracking IA/DCIA

Step 3. Report Net Change

Summarize in annual NPDES report by subbasin

Subbasin: A		
Site	**Total new IA**	**Total new DCIA**
Lombard	0.85 ac	0.01
Retrofit 1	0 ac	-0.42
YR 1 Baseline	25 ac	13.0 ac
Yr 2 Net Change	**25.85 ac**	**12.59 ac**

- EPA to provide tracking spreadsheet
  - Per site
  - Per subwatershed
  - Relative to baseline
- In general:
  - ADD new IA & DCIA to baseline for new development
  - SUBTRACT new DCIA for retrofits
  - ADD or SUBTRACT IA & DCIA for redevelopment

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Questions?

1. Where do I get site specific soil and BMP information?
2. What is the best process for permittees to track IA/DCIA?
3. What if the BMP isn't on the list of default disconnection multipliers?
4. Can BMP treatment trains produce higher %RR and lower DCIA?
5. Others?

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Summary of what EPA will provide you:

- Subbasin boundaries
- Baseline estimates of IA for each subbasin in your MS4 in tabular and GIS format
- Baseline estimate of DCIA for each subbasin in your MS4 in tabular format
- IA & DCIA calculation and annual tracking spreadsheet

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Practice Example

- Hypothetical Case Study: Retail Plaza
- Redevelopment/Retrofit scenario
- Various practices
  - -Bioretention
  - -Infiltration
  - -Pervious pavement
  - -Pavement removal/soil amendments

- Refer to 4 page Handout
- 5 Questions

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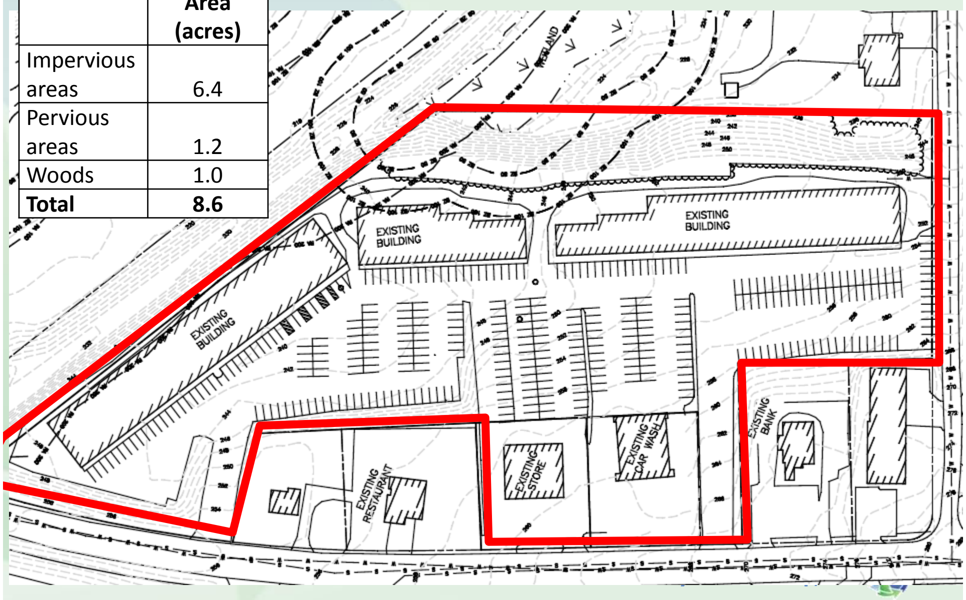
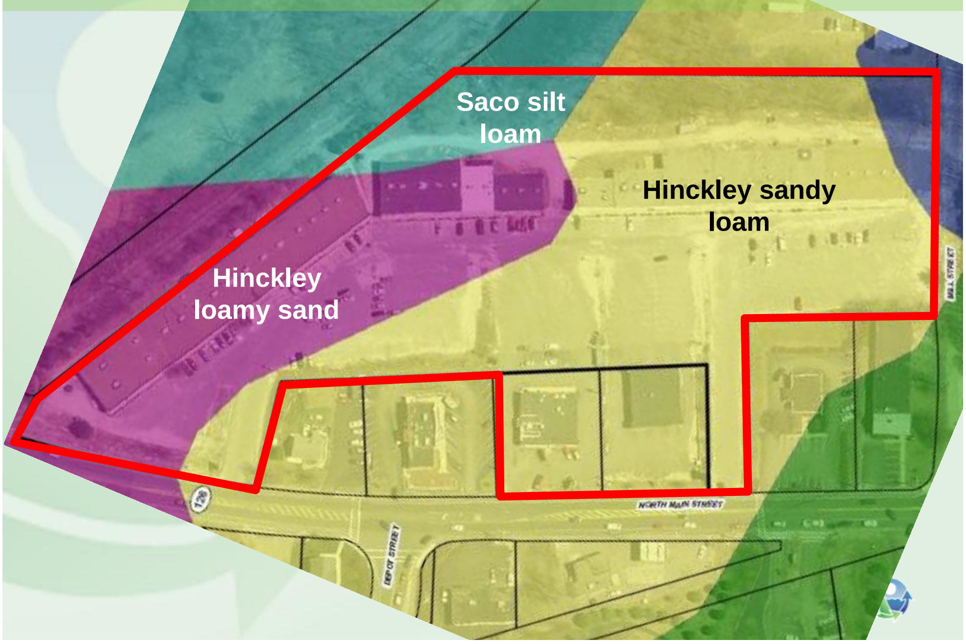
Existing Site Conditions

	Area (acres)
Impervious areas	6.4
Pervious areas	1.2
Woods	1.0
Total	**8.6**



Soils

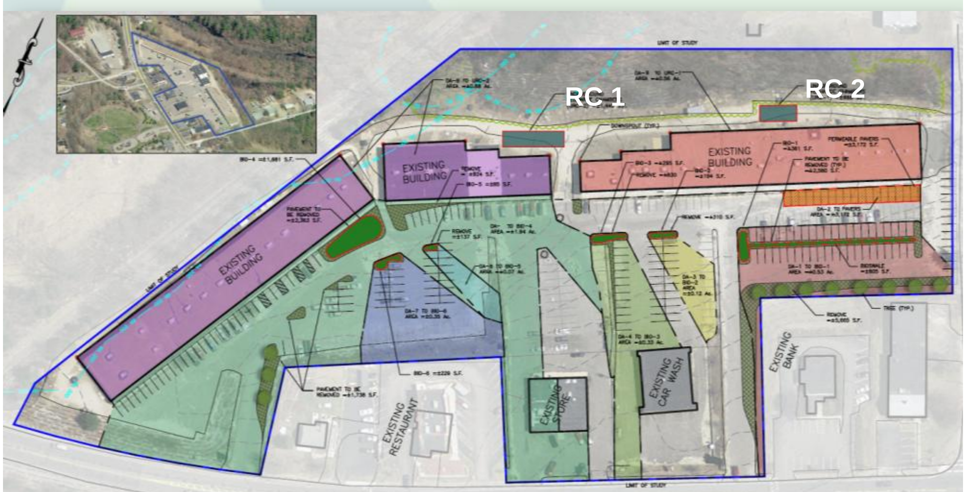


Were does soil info come from?

Norfolk and Suffolk Counties, Massachusetts (MA616)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
5	Saco silt loam, 0 to 3 percent slopes		
10	Scarboro and Birdsall soils, 0 to 3 percent slopes		
245B	Hinckley sandy loam, 3 to 8 percent slopes		
245C	Hinckley sandy loam, 8 to 15 percent slopes		
253D	Hinckley loamy sand, 15 to 35 percent slopes		
255C	Windsor loamy sand, 8 to 15 percent slopes		
315B	Scituate fine sandy loam, 3 to 8 percent slopes		
420B	Canton fine sandy loam, 3 to 8 percent slopes		
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony		
602	Urban land, 0 to 15 percent slopes		
653	Udorthents, sandy		
Totals for Area of Interest			

NRCS Web Soil Survey

Proposed Redevelopment Condition



The Answers

Answer the following Questions:

1. What is the existing IA for the site? $\boxed{6.4}$ acres (1.7 acres of roof + 4.7 acres other IA)
2. What is proposed IA for the redeveloped site? $\boxed{6.0}$ acres (*Hint*: subtract removed pavement and new landscape/bioretention footprints from existing IA). (6.4 -0.1 -0.3)
3. Sum DCIA for each area managed by proposed infiltration, bioretention, and permeable pavement BMPs by: a) determining the soil infiltration rates in areas of proposed infiltration using the attached soils map and Rawls table; and b) assigning the appropriate BMP multipliers using interim default BMP disconnection multiplier table. **Fill in the blanks in Table 1**. Note that pavement removal is accounted for previously under question #2.

   What are the total IA and DCIA managed by BMPs? $\boxed{4.2}$ acres $IA_{managed}$

   $\boxed{0.77}$ acres $DCIA_{managed}$

The Answers

Table 1. DCIA for each BMP. *Fill in the missing cells using the information provided.*

BMP	IA in the BMP drainage area *(acres)*	Soil Infiltration Rate (in/hr) *(See Rawls)*	% RR *(see Tables 2 and 3)*	BMP Disconnection Multiplier (1-RR%/100)	DCIA (acres) *(IA * BMP Multiplier)*
Recharge Chambers 1	0.6	2.41	96%	0.04	0.02
Recharge Chambers 2	0.9	1.02	92%	0.08	0.07
Bioretention (1-6)	2.6	--	75%	0.25	0.65
Permeable Pavement	0.1	--	75%	0.25	0.03
Total Area Managed	**4.2**	--	--	--	**0.77**

Determine Soil Infiltration Rates

RC1= Hinkley Loamy Sand RC2= Hinkley Sandy Loam

Table 2.3.3. 1982 Rawls Rates[18]

Texture Class	NRCS Hydrologic Soil Group (HSG)	Infiltration Rate Inches/Hour
Sand	A	8.27
Loamy Sand	A	2.41
Sandy Loam	B	1.02
Loam	B	0.52
Silt Loam	C	0.27
Sandy Clay Loam	C	0.17
Clay Loam	D	0.09
Silty Clay Loam	D	0.06
Sandy Clay	D	0.05
Silty Clay	D	0.04
Clay	D	0.02

Assign BMP Disconnection Multiplier

Table 2. Determining DCIA based on Interim Default BMP Disconnection Multipliers or EPA's Infiltration Curves

BMP Description	% Runoff Volume Reduction[1]	BMP Disconnection Multiplier[2]
Removal of pavement; restoration of infiltration capacity	100%	0
Redirection of rooftop runoff to infiltration areas, rain gardens or dry wells	85%	0.15
Permeable pavement, bioretention practices, dry/vegetated water quality swales	75%	0.25
Disconnection to qualified pervious area[3]	50%	0.50
Infiltration trenches	15-100%	0.85-0
Infiltration basins	13-100%	0.87-0
Non-runoff reduction practices (i.e., detention ponds, wetlands, sand filters, hydrodynamic separators, etc)	0%	1.0

Table 3. Percent Runoff Reduction based on EPA's 2010 Infiltration Curves

Depth of Runoff Treated (inches)	Soil Infiltration Rate (in/hr)					
	0.17	0.27	0.52	1.02	2.41	8.27
Infiltration Trench						
0.1	15%	18%	22%	26%	34%	54%
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0.8	75%	79%	84%	88%	93%	99%
1.0	82%	85%	89%	92%	96%	100%
1.5	92%	93%	95%	97%	99%	100%
2.0	95%	96%	97%	98%	100%	100%

Disconnection Multiplier=1-RR%/100)
=0.08 and 0.04

The Answers

Answer the following Questions:

1. What is the existing IA for the site? $\boxed{6.4}$ acres (1.7 acres of roof + 4.7 acres other IA)
2. What is proposed IA for the redeveloped site? $\boxed{6.0}$ acres (*Hint*: subtract removed pavement and new landscape/bioretention footprints from existing IA). (6.4 -0.1 -0.3)
3. Sum DCIA for each area managed by proposed infiltration, bioretention, and permeable pavement BMPs by: a) determining the soil infiltration rates in areas of proposed infiltration using the attached soils map and Rawls table; and b) assigning the appropriate BMP multipliers using interim default BMP disconnection multiplier table. **Fill in the blanks in Table 1**. Note that pavement removal is accounted for previously under question #2.

   What are the total IA and DCIA managed by BMPs? $\boxed{4.2}$ acres $IA_{managed}$

   $\boxed{0.77}$ acres $DCIA_{managed}$
4. What is DCIA for all remaining, unmanaged IA? $\boxed{1.8}$ acres $DCIA_{unmanaged}$. *Hint*: Subtract IA managed (Question #3) from proposed site IA [Question #2). Assume 100% is connected. (6.0-4.2)
5. What is the total DCIA for proposed conditions? $\boxed{2.57}$ acres total DCIA. *Hint*: Sum of $DCIA_{managed}$ (Question #3) and $DCIA_{unmanaged}$ (Question #4). (0.77 + 1.8)

How does LID Influence DCIA?

LID

- Site design minimizes total IA;
- Protects qualified pervious areas and more opportunities for disconnection;
- BMPs provide for better runoff reduction to reduce DCIA

Conventional

- Site designs create more total site IA to manage
- Detention basins have 0% runoff reduction; therefore, no DCIA reduction credit

PERVIOUS PAVER PALE ALE

INFILTRATING YOUR TASTE BUDS SINCE 2011

Chester Arnold and Mike Dietz, CT NEMO Brewmasters

Triple filtered through pervious asphalt, concrete, and paver blocks. In strict adherence to NEMO purity law, this refreshing ale is made with only barley malt and Cascade hops, and never touches geotextile fabric…

Please drink responsibly. A proper subbase of clam chowder with oyster crackers is recommended. Do not drive a vacuum truck after enjoying a PPPA. May impair your ability to distinguish between connected and disconnected impervious cover.

4. Ensuring BMP Effectiveness

Planning and Design

- Good planning (concept plans, integrated with site design);
- Good design and agency review;
- Designer should envision maintenance requirements
- Plan sheet(s) showing practice locations/types and maintenance access (easements);
- O&M plan includes required inspection and maintenance frequency and estimated annual costs

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4. Ensuring BMP Effectiveness

Construction

- Clearly defined construction specifications and bidding documents;
- Contractor expertise (minimum qualifications/experience identified in bid docs);
- Construction layout by a surveyor;
- Pre-construction meeting and regular progress meetings;
- Construction observations at clearly identified milestones (by the designer where possible – using checklists);
- Interim and final As Built plans

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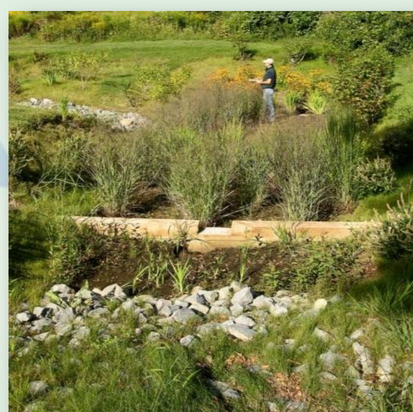
4. Ensuring BMP Effectiveness

Maintenance

- Make short-term maintenance easy (e.g. forebay with easy access for sediment removal);
- Implement long-term vegetation management;
- Incorporate progressive enforcement and corrections;
- Instill owner inspection co-responsibility



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Additional Resources

- Chesapeake Stormwater Network. 2009. CSN Technical Bulletin No. 4: Technical Support for the Bay-wide Runoff Reduction Method Version 2.0. www.chesapeakestormwater.net/documents/research-files/CSN20TB20No.2042020Baywide20Runoff20Reduction20Method1.pdf
- EPA, 2010. Stormwater BMP Performance Analysis. www.epa.gov/region1/npdes/stormwater/assets/pdfs/BMP-Performance-Analysis-Report.pdf
- Sutherland. 2000. Methods for Estimating Effective Impervious Cover. Article 32 in *The Practice of Watershed Protection*, Center for Watershed Protection, Ellicott City, MD.

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Questions?