Capital District Regional Planning Commission

Local Government Planning & Zoning Workshop

Hudson Valley Community College.

Wednesday June 20, 2012

IMPLEMENTING GREEN INFRASTRUCTURE IN LINEAR PROJECTS

Presented by
Barton & Loguidice, P.C.

GREEN INFRASTRUCTURE

Implementing green infrastructure in linear projects

NYSDEC Regulations

Photo source: http://www.ia.nrcs.usda.gov/features/urbanphotos.html

GP-0-10-001 Applicability

- Need permit for disturbance > 1 acre
  - Includes clearing, grading, and excavating
- Routine maintenance is exempt
  - Maintain the original line and grade
  - Maintain the hydraulic capacity
  - Maintain the original purpose of a facility
  - Repaving/Resurfacing
  - Still subject to Clean Water Act

GP-0-10-001 Applicability

- Reconstruction requiring a permit
  - If existing subbase is *not* processed crushed stone, washed stone, or NYSDOT subbase
  - If existing subbase is less than 6” in depth
  - If involves complete removal of subbase or disturbance of bottom 6”
- Resurfacing, regrading, and compaction of gravel roads is considered maintenance

GP-0-10-001 Applicability

- Not Larger Common Plan if:
  - ¼ mile apart
  - No interconnecting road, pipeline, or utility between the two is disturbed during construction

Construction Permit Requirements

>1-acre Disturbance

- May be required if less than 1 acre and other environmental permits are needed
- Road rehab may not count as disturbance

Stormwater Pollution Prevention Plan (SWPPP)

- Stormwater Quantity Plan
- Stormwater Quality Plan
- Runoff Reduction Volume
- Erosion & Sediment Control Plan

Submittal of Notice of Intent (NOI)

- 5 business day review or
- 60 business day review

Runoff Reduction Volume (RRv)

Purpose

- Formally recognize the water quality benefits of certain site design practices to address flow as a pollutant of concern.

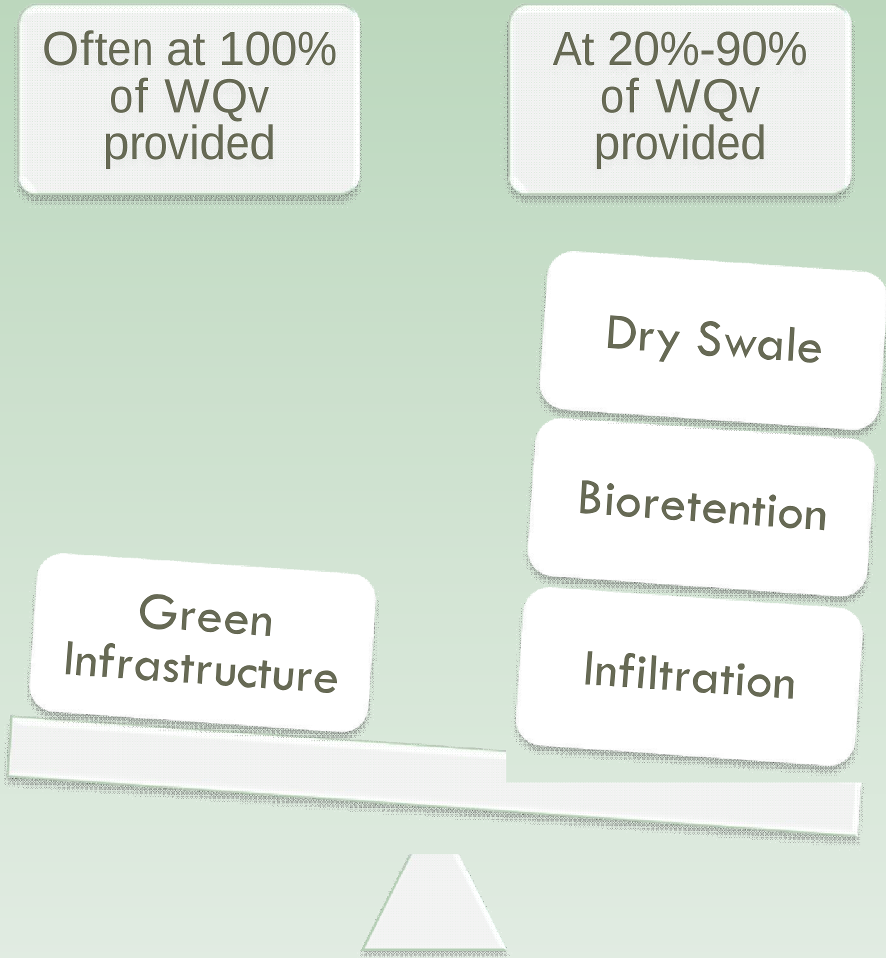
How to

- Reduce volume of runoff equal to water quality treatment volume by using green infrastructure planning and design
- Reduce equivalent contributing area in WQv
- Increase storage capacity of the stormwater management practice
- Use standard SMPs with runoff reduction capacity
- Note that the NYSSMDM Chapter 7 selection matrix has not been updated with GI practices

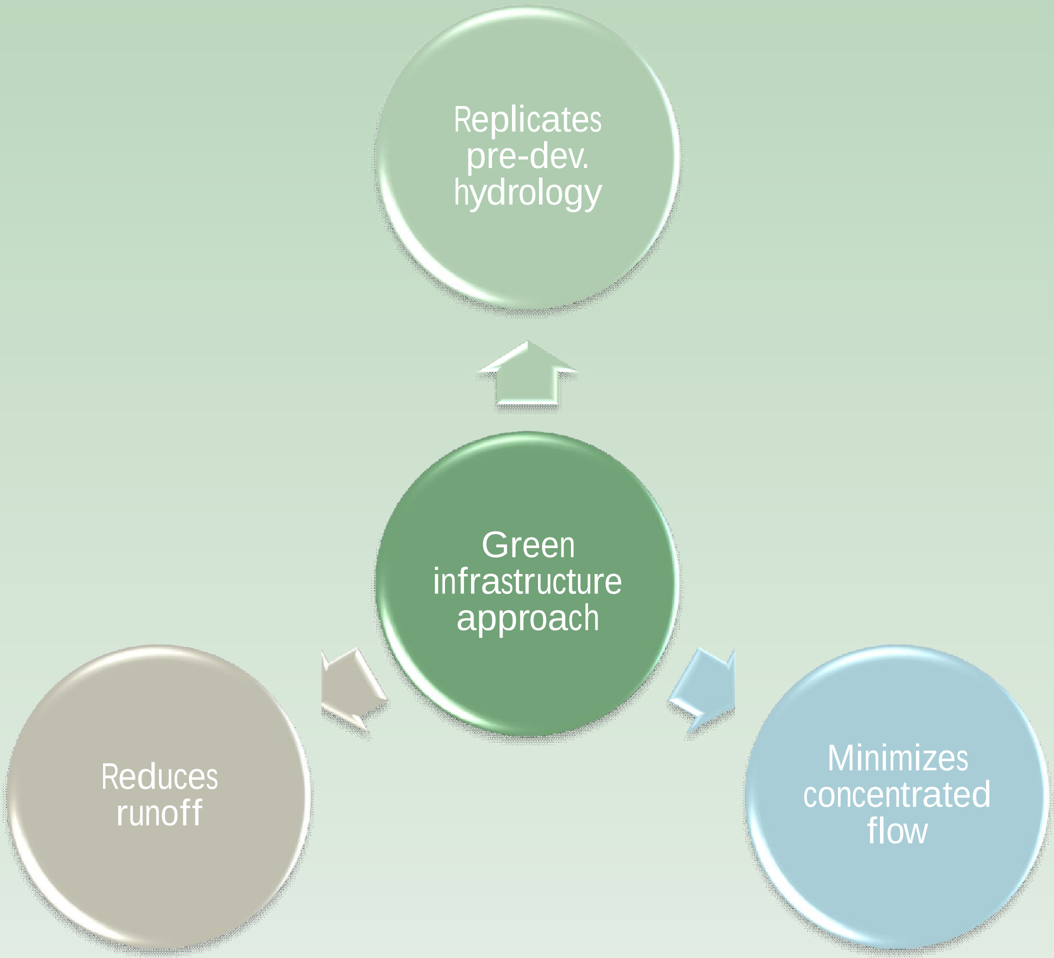
Exceptions

- Implementation of green infrastructure cannot not be considered infeasible unless physical constraints, hydraulic conditions, soil testing, existing and proposed slopes (detailed contour), or other existing technical limitations are objectively documented (cost and footprint are not acceptable justifications)
- Projects that do not achieve runoff must, at a minimum, reduce a percentage of the runoff from impervious areas to be constructed on the site. The percent reduction is based on the Hydrologic Soil Group(s) (HSG) of the site and is defined as Specific Reduction Factor (S)

Acceptable RRv Mgmt



Stormwater Management Planning – GI Approach



PDH Q1

- What is the purpose of reducing runoff?
  - Recognize and address stormwater as a pollutant of concern

Green Infrastructure

NYSTA Infiltration Trench (Albany Div; Exit 23)

Needs

- Can be compact
- Addresses WQv and RRv
- Easy to maintain
- Flexible design and implementation

Questions to Ask

- Is the pollutant removal capability of the proposed measures well-documented and effective for treatment of the road constituents?
  - If dissolved constituents, infiltration may not be beneficial
- Is there adequate space to accommodate all of the practices with minimal impact to adjacent sensitive environmental features?
  - Where do we draw the line on cost vs. benefit?
- Can the proposed pretreatment facilities treat runoff for coarse sediment removal prior to the primary practice?
  - Extends the life/reduces maintenance
- Are pretreatment facilities able to accommodate and contain spills?
- Is it possible to ensure adequate access for construction and maintenance, and is the maintenance burden reasonable?
  - Reasonable means different things to different people. Compare to other alternatives and review footprint. Is this really the BEST one?

Preserve Natural Features

Preservation of Undisturbed Areas	• Delineate and place into permanent conservation undisturbed forests, native vegetated areas, riparian corridors, and wetlands
Preservation of Buffers	• Define, delineate, and preserve naturally vegetated buffers along perennial streams, rivers, shorelines, and wetlands
Reduction of Clearing and Grading	• Limit clearing and grading to the minimum amount needed
Locating development in less sensitive areas	• Avoid sensitive resource areas by locating development to fit the terrain in areas that will create the least impact
Soil Restoration	• Restore the original properties of the soil to reduce the runoff and enhance the runoff reduction performance

Reduce Impervious Cover

Roadway Reduction	• Minimize roadway widths and lengths to reduce site impervious area (Within Standards)
Building Footprint Reduction	• Reduce the impervious footprint of residences and commercial buildings by using alternate or taller buildings while maintaining the same floor to area ratio.
Parking Reduction	• Eliminate unneeded spaces, provide compact car spaces and efficient parking lanes, minimize stall dimensions, use porous alternatives in overflow parking areas, and use multiple stories.

PDH Q2

- Name three ways to preserve natural resources:
  - Preserve undisturbed areas
  - Preserve buffers
  - Reduce clearing and grading
  - Locate sites in less sensitive areas
  - Soil restoration

Green Infrastructure at a Glance

Conservation of natural areas

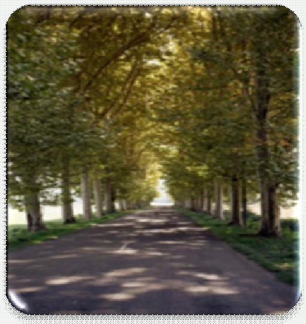
- Protect undisturbed natural areas by permanently conserving them.

Sheet flow to riparian buffers or filter strips

- Undisturbed natural areas can be used to treat and control stormwater runoff.

Vegetated open swale

- Vegetated channels can increase time of concentration, reduce the peak discharge, and provide infiltration.



Tree planting/tree box

- Plant or conserve trees to reduce runoff, increase nutrient uptake, and provide stabilization.

Disconnection of rooftop runoff

- Direct runoff from rooftops to designated pervious areas to reduce runoff volumes and rates.

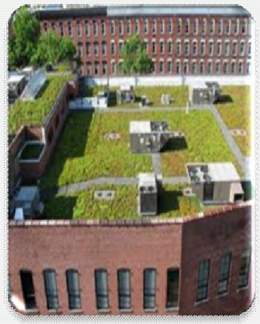
Green Infrastructure at a Glance

Stream daylighting

- Stream Daylight previously-culverted/piped streams.

Rain garden

- Manage and treat runoff using a conditioned soil bed and planting materials to filter runoff stored within a shallow depression.



Green roof

- Capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof.

Stormwater planter

- Small landscaped treatment devices that can be designed as infiltration or filtering practices.

Rain tank/Cistern

- Capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities.

Porous Pavement

- Pervious types of pavements that provide an alternative to conventional paved surfaces.

1. Conservation of Natural Areas

- Forest retention areas, stream and river corridors, wetlands, vernal pools and associated buffers, as well as other lands in protective easement
- Reduces runoff treatment volume & SMP storage volume and size
- Provides permanent protection of open space
- Promotes protection of natural hydrologic balance; maintains pre-developed groundwater recharge characteristics

Practical Application: Conservation of Natural Areas

- Subtract designated area from total contributing drainage area when computing water quality volume requirements
- Property owner must have sole control of the buffer – in ROW
- No change in area or curve number (CN) is allowed for Qp or Qf for this credit

2. Sheet flow to Buffers or Filter Strips

- Vegetated (grass) filter strips or undisturbed natural areas such as riparian buffers
- Can be used to filter & infiltrate stormwater runoff
- Reduces the runoff volume & SMP storage volume & size
- Promotes protection of natural hydrologic balance that maintains pre-developed groundwater recharge characteristics
- Reduces pollutant load delivery to receiving waters

Forest Buffer

NYSTA – Fonda Area
Photo Credit: 2012 Google Images

Practical Application: Sheet Flow to Buffers/Strips

Table 5.8 The Two Design Variations of the Filter Strip and Vegetative Buffer		
Design Issue	**Sheetflow to Riparian Buffer**	**Sheetflow to Grass Filter Strip**
Soil and Ground Cover	Undisturbed Soils and Native Vegetation	Amended Soils and Dense Turf Cover
Construction Stage	Located Outside the Limits of Disturbance and Protected by ESC controls	Prevent Soil Compaction by Heavy Equipment
Typical Application	Adjacent Drainage to Stream Buffer or Forest Conservation Area	Treat small areas of impervious cover (e.g., 5,000 sf) close to source
Compost Amendments	No	Yes
Boundary Spreader	GD at top of filter	GD at top of filter PB at toe of filter
Boundary Zone	10 feet of level grass	At 25 feet of level grass
Concentrated Flow	ELS with 40 to 65 feet long level spreader* per one cfs of low, depending on width of conservation area	ELS with 1ength of level spreader per one cfs of flow
Maximum Slope, First Ten Feet of Filter	Less than 4%	Less than 2%
Maximum Overall Slope	6%	8%

GD: Gravel Diaphragm PB: Permeable Berm. ELS: Engineered Level Spreader, * See the NY Standards and Specifications for Erosion and Sediment Control for the design of level spreaders

- Distribute flow as sheet flow to the buffer or natural conservation area
  - Bypass higher-flow events when possible to reduce erosion
- Subtract area draining by sheet flow to a riparian buffer or filter strip when computing the water quality volume
- ROW or Purchase/acquire adjacent land

3. Vegetated Swale

- Maintained, turf-lined swale specifically designed to convey stormwater at a low velocity, promoting natural treatment and infiltration
- The post-development peak discharges used to calculate “quantity” controls will likely be lower, due to a slightly longer T_c for the site
- Note that these vary from wet and dry swales (velocity, flow depth, RRv credit)

Practical Application: Vegetated Swale

- Used when the DA is <5 acres, and WQv peak flow is <3cfs.
- RRv credit
  - HSG A and B soils – 20%
  - HSG C and D soils – 10%
  - Amended* HSG C and D soil – 15%-12%
- Trapezoidal or parabolic (min. length:100')
- Bottom Width: 2-6'
- Slope: 0.5%-4%
- 6" freeboard for 10-yr storm
- Retention times:
  - 10 minutes (point discharge at the inlet)
  - 5 minutes (sheet flow or multiple point discharges)
- Lack of curbing may increase potential for failure of the pavement at the grass interface
  - May be alleviated by hardening the interface by installing grass pavers, geosynthetics, or placing a compacted granular material strip along the pavement edge

Dry or Vegetated Swale

Wilsonville Interchange (Oregon)
Photo Credit: Oregon DOT

US 199 (Oregon)
Photo Credit: Oregon DOT

4. Tree Planting/Tree Pit

- Tree planting: concentrated groupings of trees planted in landscaped areas
- Tree pits (tree boxes): individually planted trees in contained areas such as sidewalk cut-outs or curbed islands.
- Reduces stormwater volumes & velocities discharging from impervious areas through rainfall interception & evapotranspiration
- Increases nutrient uptake, aids in infiltration, can provide bird habitat, provides shading, & reduces mowing
- Contributes to air purification & oxygen regeneration
- Reduces urban heat island effect
- Buffers wind & noise

Practical Application: Tree Planting/Tree Pit

- The area considered for runoff reduction is limited to the pervious area in which trees are planted.
- Where trees are contained by impervious structures such as curbs and sidewalks, the area is calculated as follows:
  - For up to a 16-foot diameter canopy of a mature tree, the area considered for reduction shall be ½ the area of the tree canopy.
  - For larger trees, the area credited is 100 SF per tree. This can be considered the drainage area into the below grade tree pit.
- An alternative sizing for runoff reduction may follow the bioretention or stormwater planters (with infiltration) design and sizing
  - Sizing of the practice relies on storage capacity of the soil voids and the ponding area
  - The infiltration rate of the in-situ soil must be a minimum of 2 in/hr

Practical Application:
Tree Planting / Tree Pit

- Conservation of existing trees :
  - A directly connected impervious area reduction equal to one-half the canopy area
  - Existing trees with canopies within 20 horizontal feet of connected ground level impervious areas
    - Must be at least 4-inch caliper to be eligible for the reduction.
- New trees are planted (choose NYSDEC approved species):
  - Must be planted within 10’ of ground-level, directly connected impervious areas.
  - Deciduous trees must be at least 2-inch caliper and Evergreen trees must be at least 6 feet tall
  - A 100 square-foot directly connected impervious area reduction permitted for each new tree.
  - Recommend minimum 1,000 cubic feet soil media available per tree.
  - Average slope for the contributing area, including area under the canopy, must not be greater than 5%
- The maximum reduction permitted is 25% of directly connected ground level impervious area
- Consider safety issues such as sight distance, clear zones, etc.
  - Plant trees outside of these areas and direct runoff
  - Because of the distance requirements, utilizing existing trees may be a safer alternative

Marybank Highway, SC

NYSTA

5. Rooftop Disconnection

- Sending runoff to pervious areas and lower-impact practices increases overland flow time and reduces peak flows
- Vegetated and pervious areas can filter and infiltrate runoff, thus increasing water quality
- Can re-direct runoff from combined sewer systems in urban roadway applications or parking areas

Practical Application: Rooftop Disconnection

- Treat as pervious area when computing the WQv (resulting in a smaller Rv)
- Areas receiving rooftop runoff must be properly graded for infiltration and conveyance in a non-erosive manner
- Disconnections are encouraged on HSGs A and B
- In HSGs C and D, permeability & water table depth shall be evaluated
- Runoff shall not come from a designated hotspot
- Maximum contributing flow path length from impervious areas shall be 75 feet
- Facilities/sheds/garages
- Applicable Typically in Urban Type Linear Projects

Practical Application: Rooftop Disconnection

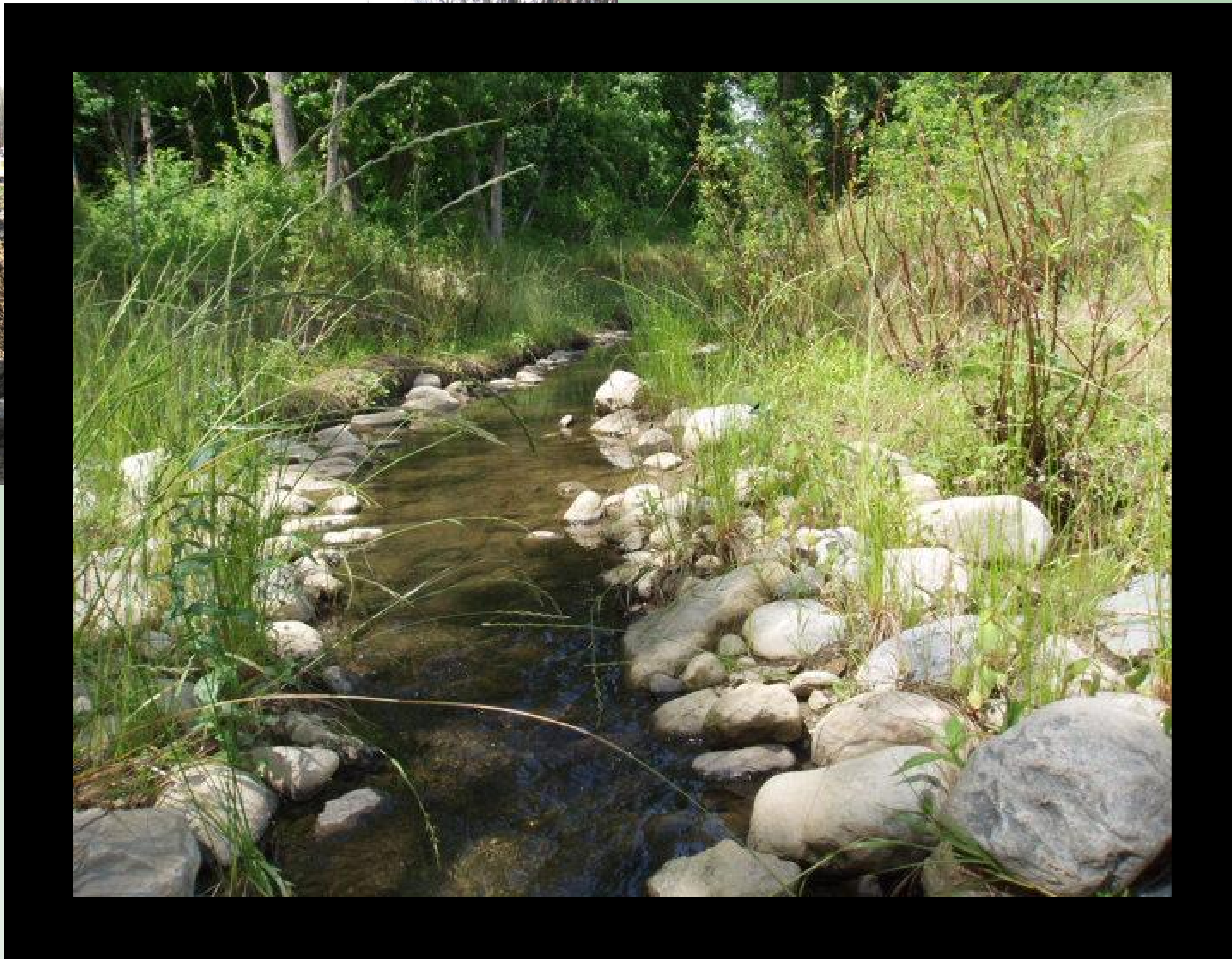
- Downspouts shall be at least 10' from the nearest impervious surface
- Roof areas between 500 and 2,000 square feet may be acceptable with a suitable flow dispersion technique
- The disconnected, contributing impervious area shall drain pretreatment for a distance equal to or greater than the disconnected, contributing impervious area length
- The entire vegetative filtration/infiltration area shall have an average slope of less than five (5) percent;
- For those areas draining directly to a buffer, <u>either</u> the Disconnection of Rooftop Runoff or Sheetflow to Riparian Buffer runoff reduction method can be used
- Use splash pads or level spreaders as required to distribute runoff to designated areas with infiltration capacity.

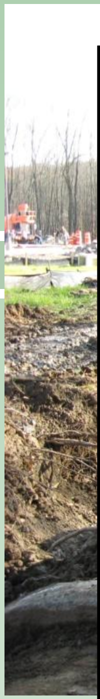
6. Stream Daylighting

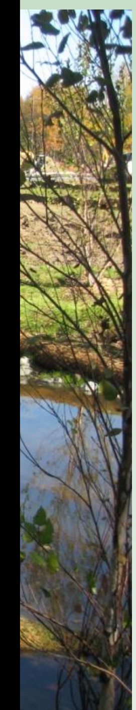
- Improves water quality
- Prevents flooding by increasing storage & reducing peak flows
- Increases habitat & wildlife value

Practical Application: Stream Daylighting

- Consider daylighting when a culvert replacement is scheduled
- Restore historic drainage patterns by removing closed drainage systems and constructing stabilized, vegetated streams
- Carefully examine flooding potential, utility impacts and/or prior contaminated sites
- Consider runoff pretreatment and erosion potential of restored streams/rivers
- Applicable only to redevelopment projects as an impervious area reduction type practice
- Sizing of the stream channel must, at minimum, equal or exceed the existing drainage capacity of the piped drainage system

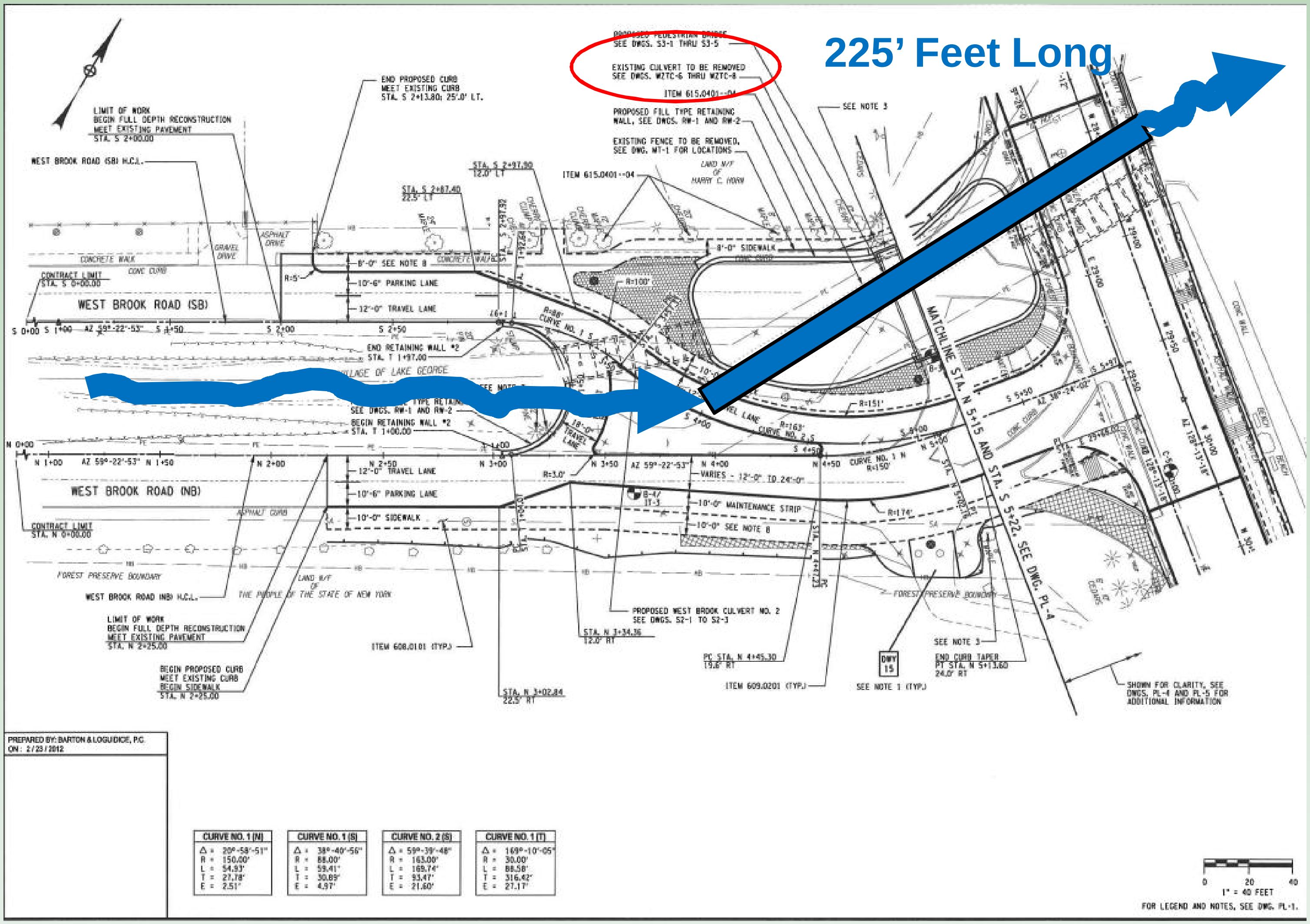






Taconic Regional Headquarters

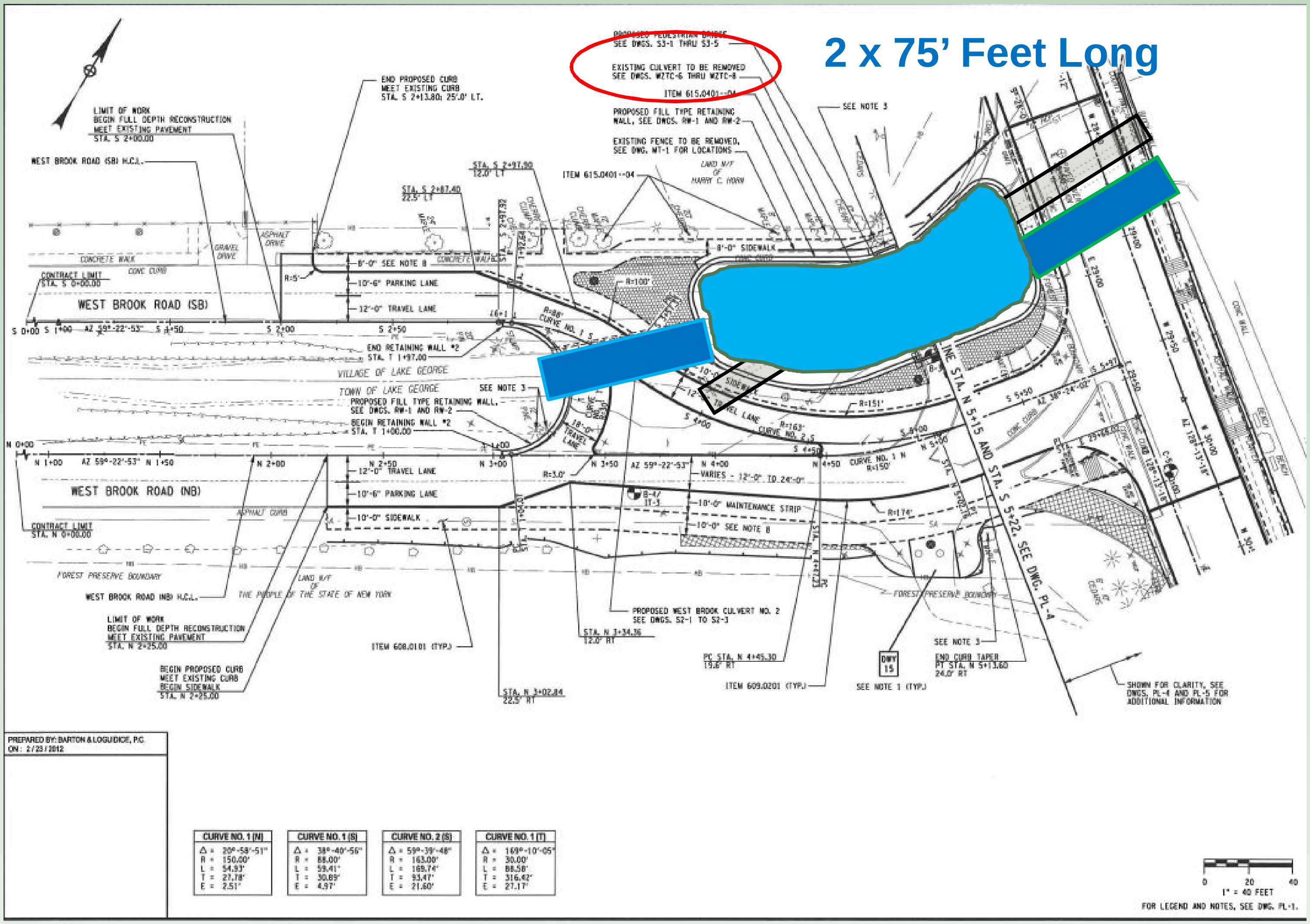
Beach Road – Lake George, NY

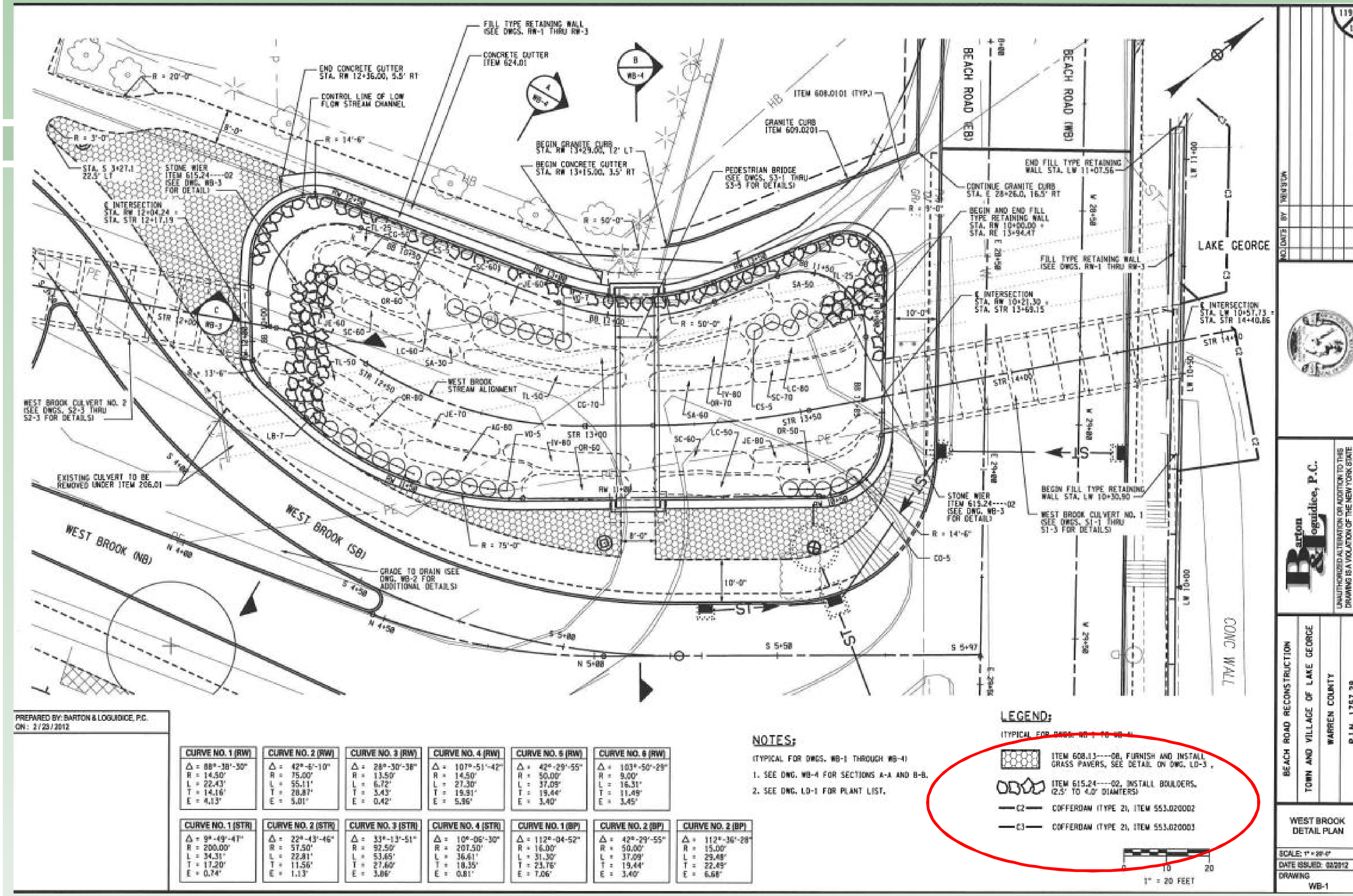


CURVE NO. 1 (N)	CURVE NO. 1 (S)	CURVE NO. 2 (S)	CURVE NO. 1 (T)
Δ = 20°-58'-51"	Δ = 38°-40'-56"	Δ = 59°-39'-48"	Δ = 169°-10'-05"
R = 150.00'	R = 88.00'	R = 163.00'	R = 30.00'
L = 54.93'	L = 59.41'	L = 169.74'	L = 88.58'
T = 27.78'	T = 30.89'	T = 93.47'	T = 316.42'
E = 2.51'	E = 4.97'	E = 21.60'	E = 27.17'

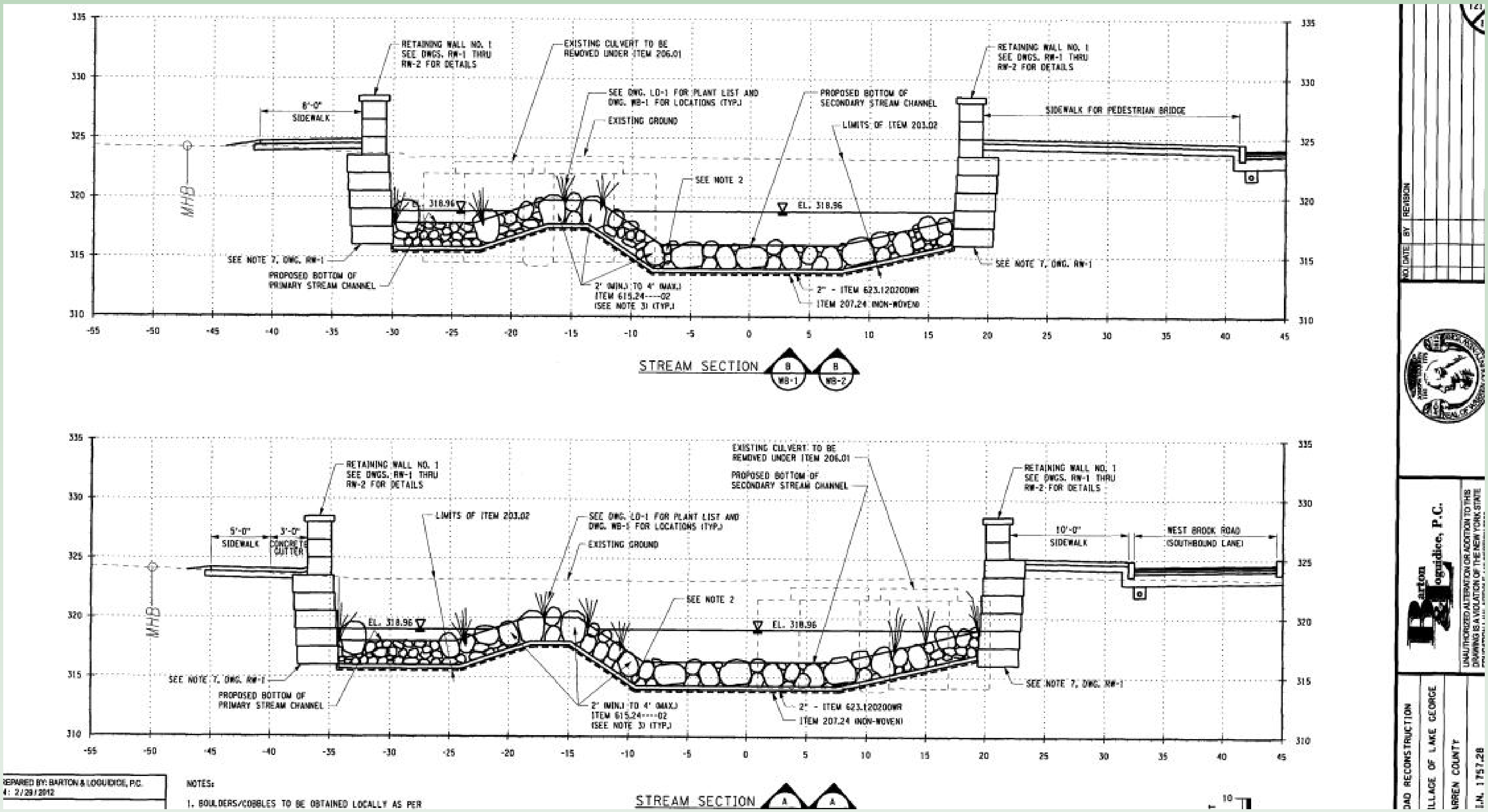
Beach Road – Lake George, NY

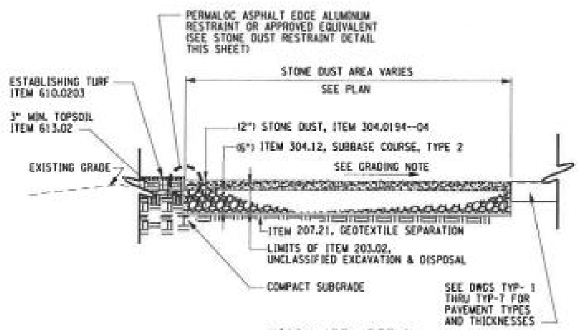
Beach Road – Lake George, NY




FILL TYPE RETAINING WALL (SEE DWGS. RW-1 THRU RW-3)
CONCRETE GUTTER ITEM 624.01
END CONCRETE GUTTER STA. RW 12+36.00, 5.5' RT
CONTROL LINE OF LOW FLOW STREAM CHANNEL
BEGIN GRANITE CURB STA. RW 13+29.00, 12' LT
BEGIN CONCRETE GUTTER STA. RW 13+15.00, 3.5' RT
PEDESTRIAN BRIDGE (SEE DWGS. S3-1 THRU S3-5 FOR DETAILS)
GRANITE CURB ITEM 609.0201
ITEM 608.0101 (TYP.)
BEACH ROAD (EB)
BEACH ROAD (WB)
END FILL TYPE RETAINING WALL STA. LW 11+07.56
CONTINUE GRANITE CURB STA. ℄ 28+26.0, 16.5' RT
BEGIN AND END FILL TYPE RETAINING WALL STA. RW 10+00.00 = STA. RE 13+94.47
FILL TYPE RETAINING WALL (SEE DWGS. RW-1 THRU RW-3)
LAKE GEORGE
℄ INTERSECTION STA. RW 10+21.30 = STA. STR 13+69.15
℄ INTERSECTION STA. LW 10+57.73 = STA. STR 14+40.86
STA. S 3+27.1 22.5' LT
STONE WIER ITEM 615.24----02 (SEE DWG. WB-3 FOR DETAIL)
℄ INTERSECTION STA. RW 12+04.24 = STA. STR 12+17.19
WEST BROOK CULVERT NO. 2 (SEE DWGS. S2-3 THRU S2-3 FOR DETAILS)
EXISTING CULVERT TO BE REMOVED UNDER ITEM 206.01
WEST BROOK STREAM ALIGNMENT
WEST BROOK (SB)
WEST BROOK (NB)
GRADE TO DRAIN (SEE DWG. WB-2 FOR ADDITIONAL DETAILS)
STONE WIER ITEM 615.24----02 (SEE DWG. WB-3 FOR DETAIL)
BEGIN FILL TYPE RETAINING WALL STA. LW 10+30.90
WEST BROOK CULVERT NO. 1 (SEE DWGS. S1-1 THRU S1-3 FOR DETAILS)
CONC WALL
PREPARED BY: BARTON & LOGUIDICE, P.C.
ON: 2/23/2012
CURVE NO. 1 (RW) Δ = 88°-38'-30" R = 14.50' L = 22.43' T = 14.16' E = 4.13'
CURVE NO. 2 (RW) Δ = 42°-6'-10" R = 75.00' L = 55.11' T = 28.87' E = 5.01'
CURVE NO. 3 (RW) Δ = 28°-30'-38" R = 13.50' L = 6.72' T = 3.43' E = 0.42'
CURVE NO. 4 (RW) Δ = 107°-51'-42" R = 14.50' L = 27.30' T = 19.91' E = 5.96'
CURVE NO. 5 (RW) Δ = 42°-29'-55" R = 50.00' L = 37.09' T = 19.44' E = 3.40'
CURVE NO. 6 (RW) Δ = 103°-50'-29" R = 9.00' L = 16.31' T = 11.49' E = 3.45'
CURVE NO. 1 (STR) Δ = 9°-49'-47" R = 200.00' L = 34.31' T = 17.20' E = 0.74'
CURVE NO. 2 (STR) Δ = 22°-43'-46" R = 57.50' L = 22.81' T = 11.56' E = 1.13'
CURVE NO. 3 (STR) Δ = 33°-13'-51" R = 92.50' L = 53.65' T = 27.60' E = 3.86'
CURVE NO. 4 (STR) Δ = 10°-06'-30" R = 207.50' L = 36.61' T = 18.35' E = 0.81'
CURVE NO. 1 (BP) Δ = 112°-04-52" R = 16.00' L = 31.30' T = 23.76' E = 7.06'
CURVE NO. 2 (BP) Δ = 42°-29'-55" R = 50.00' L = 37.09' T = 19.44' E = 3.40'
CURVE NO. 2 (BP) Δ = 112°-36'-28" R = 15.00' L = 29.48' T = 22.49' E = 6.68'
NOTES:
(TYPICAL FOR DWGS. WB-1 THROUGH WB-4)
1. SEE DWG. WB-4 FOR SECTIONS A-A AND B-B.
2. SEE DWG. LD-1 FOR PLANT LIST.
LEGEND:
ITEM 608.13----08, FURNISH AND INSTALL GRASS PAVERS, SEE DETAIL ON DWG. LD-3 .
ITEM 615.24----02, INSTALL BOULDERS. (2.5' TO 4.0' DIAMTERS)
COFFERDAM (TYPE 2), ITEM 553.020002
COFFERDAM (TYPE 2), ITEM 553.020003
1" = 20 FEET
Barton & Loguidice, P.C.
UNAUTHORIZED ALTERATION OR ADDITION TO THIS DRAWING IS A VIOLATION OF THE NEW YORK STATE EDUCATION LAW ARTICLE 145 SECTION 7209
BEACH ROAD RECONSTRUCTION
TOWN AND VILLAGE OF LAKE GEORGE
WARREN COUNTY
P.I.N. 1757.28
WEST BROOK DETAIL PLAN
DATE ISSUED: 02/2012
DRAWING WB-1

Beach Road – Lake George, NY



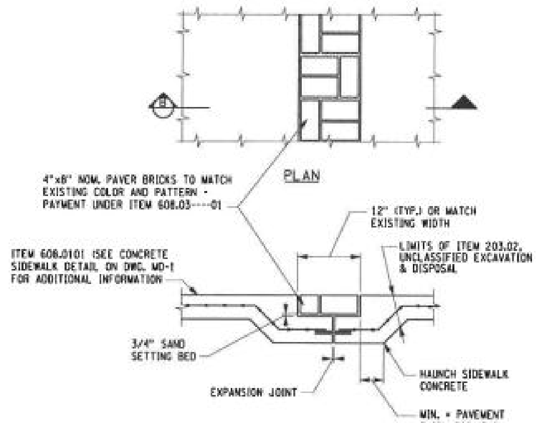


KIOSK AREA DETAIL

NTS

KIOSK AREA GRADING NOTE:

THE GRADE OF THE KIOSK AREA SHALL BE SLOPED FROM THE KIOSK TOWARD THE SURROUNDING GROUND. INITIAL GRADING SHALL TAKE PLACE DURING EXCAVATION OPERATIONS IN ORDER TO PROVIDE A TYPICAL DEPTH OF SUBBASE AND STONE DUST AS SHOWN IN SECTION.

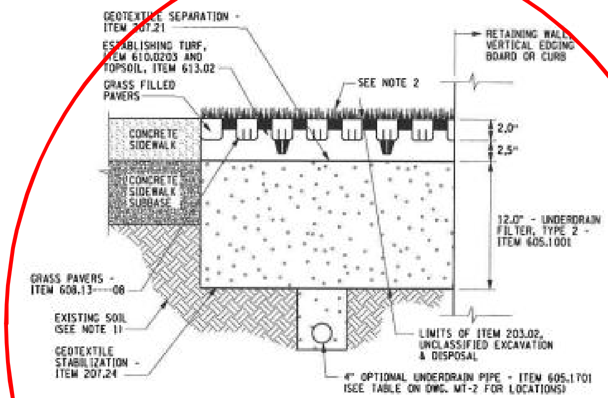


PAVER BAND DETAILS

NTS

PAVER BAND NOTES:

1. NOTIFY THE ENGINEER PRIOR TO BEGINNING WORK OF ANY CONFLICTS BETWEEN MAPPED AND EXISTING CONDITIONS THAT WILL AFFECT WORK.
2. JOINTS BETWEEN PAVERS SHALL BE BETWEEN 1/16" AND 1/8" WIDE.
3. CUT PAVERS WHERE NEEDED WITH A MASONRY SAW.
4. FINAL SURFACE ELEVATIONS OF PAVERS SHALL NOT DEVIATE GREATER THAN 1/8" UNDER A 10' LONG STRAIGHT EDGE.
5. EDGE OF PAVERS SHALL BE A MAXIMUM OF 1/8" ABOVE OR BELOW ADJACENT PAVEMENTS.
6. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PROVIDE A SAMPLE MOCK-UP AREA INCORPORATING PATTERN AS SHOWN ON THE PLAN FOR FIELD APPROVAL BY THE ENGINEER.
7. PAYMENT FOR ALL WORK ASSOCIATED WITH PAVER BAND, NOT INCLUDED IN OTHER ITEM NUMBERS, SHALL BE INCLUDED IN ITEM 608.03----01.

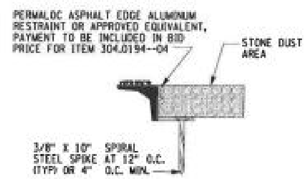


STRUCTURAL GRASS PAVEMENT DETAIL

NTS

STRUCTURAL GRASS PAVEMENT NOTES:

1. COMPACTED SUBGRADE, 95% MODIFIED PROCTOR DENSITY.
2. GRASS/PLANT TYPES SHALL BE AS SPECIFIED IN THE CONTRACT DOCUMENTS.
3. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL PROVIDE A SAMPLE MOCK-UP AREA (5' X 5' MINIMUM) FOR FIELD APPROVAL BY THE ENGINEER.
4. NOTIFY THE ENGINEER PRIOR TO BEGINNING WORK OF ANY CONFLICTS BETWEEN MAPPED AND EXISTING CONDITIONS THAT WILL AFFECT WORK.
5. PAYMENT FOR ALL WORK ASSOCIATED WITH STRUCTURAL GRASS PAVEMENT, NOT INCLUDED IN OTHER ITEM NUMBERS, SHALL BE INCLUDED IN ITEM 608.13----08



ITEM 608.13----08 - FURNISH AND INSTALL GRASS PAVERS

NTS

STONE DUST RESTRAINT NOTES:

1. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS.
2. NOTIFY THE ENGINEER PRIOR TO INSTALLATION OF ANY CONFLICTS BETWEEN MAPPING AND EXISTING CONDITIONS.
3. ALL VISIBLE EDGE RESTRAINT COMPONENTS TO BE BLACK FINISH.
4. TOP OF EDGING TO BE A MAXIMUM OF 1/2" ABOVE FINISHED GRADE OF SURFACING OR TURF.
5. PAYMENT FOR ALL WORK ASSOCIATED WITH STONE DUST EDGE RESTRAINT SHALL BE INCLUDED IN ITEM 304.0194--04.

PREPARED BY: BARTON & LOGUIDICE, P.C.
ON: 2/23/2012

NO | DATE | BY | REVISION

Barton & Loguidice, P.C.

BEACH ROAD RECONSTRUCTION
TOWN AND VILLAGE OF LAKE GEORGE
WARREN COUNTY
P.I.N. 1757.28

LANDSCAPE DETAILS - 3

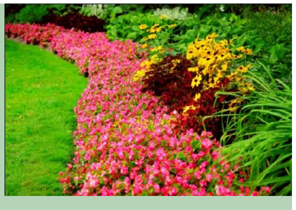
SCALE: AS SHOWN
DATE ISSUED: 02/2012
DRAWING
LD-3

PDH Q3

- What special condition applies if you intend to use Conservation of Natural Areas or Sheetflow to Riparian Buffer?
  - Must have sole control of land because it has to be placed in an easement per the NYSDEC requirement.

Examples

7. Rain Gardens



- Pollutant treatment for rooftops and driveways
- Groundwater recharge augmentation
- Micro-scale habitat
- Aesthetic improvement to turf grass or otherwise hard urban surfaces
- Ease of maintenance (couple with routine landscaping maintenance)
- Modest land area
- RRv Credit: 100% for A&B, 40% for C&D

Credit[1]: LIDC; Credit[2]: Long Island Sound Study

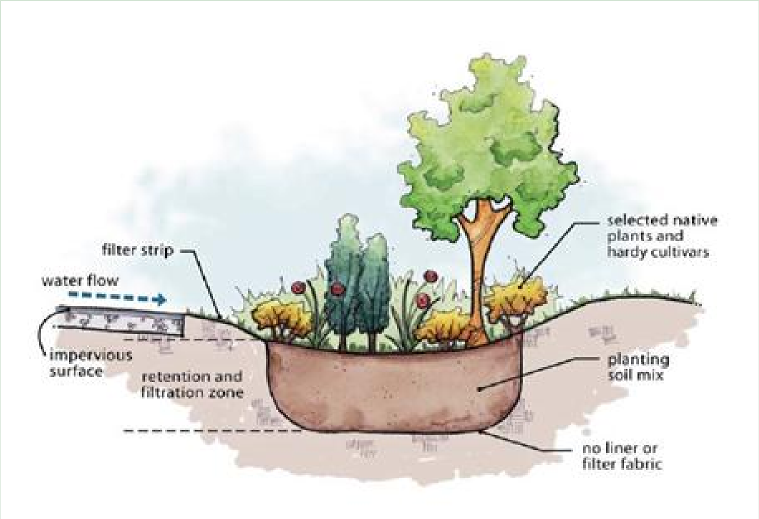
Practical Application: Rain Gardens

- Garages, access roads, storage sheds, medians, etc.
- Can be molded to fit unique shape, but maintenance safety must be considered; design like bioretention area
- Consider sight distance requirements and clear zone requirements; but keep practice in ROW.

Monroe County, Indiana: Highway Garage Rain Garden

Photo Source: http://www.co.monroe.in.us/tsd/Government/Infrastructure/HighwayDepartment/StormWaterQuality/Photos.aspx

Bioretention/Rain Garden



Highway (Delaware)
Photo Credit: Delaware DOT

8. Green Roofs

- Reduces total annual runoff volumes
- Moderates interior building temperatures & provides insulation from the heat & cold
- *May* extend the life of a standard roof by as long as 20 years by protecting rooftop materials from UV radiation & extreme temperature fluctuations
- Can be designed to insulate the building interior from outside noise
- Reduce the urban heat island effect by cooling & humidifying the surrounding air
- Filters & binds airborne dust & other particulates, improving air quality
- Creates habitat for birds and butterflies
- Can be aesthetically pleasing & improve views from neighboring buildings
- A benefit specific to intensive green roofs is pedestrian access to a scenic space within an urban environment

Practical Application: Green Roofs

- Garages, storage sheds, etc.
- Will likely be extensive, rather than intensive, and will likely use sedum over grass.

Neglected Garage – Nature Happens
Photo Courtesy of Patrick Carey

Rensselaer Co. Master Gardeners
http://www.dec.ny.gov/lands/73089.html

9. Stormwater Planter

- When no site infiltration, flow-through or contained stormwater planters enable filtration treatment
- Reduces stormwater discharge volumes & velocities
- Flow-through or contained planters do not require a setback from a building foundation
- Creates an aesthetic landscape element, as well as providing micro-habitat within an urban environment

Practical Application: Stormwater Planters

- Lower speed areas (travel plazas), median barriers and curb extensions (traffic calming), retrofits
- Need pretreatment if used for roadway runoff

Ardsley Bus Shelter
Photo Source: http://www.dec.ny.gov/lands/74996.html

Stormwater Planter - Portland
http://cstreetne.blogspot.com/2009/12/traffic-calming-green-streetscape.html

10. Rain Barrel/Cistern

- Reduced stormwater runoff (volume and delayed/reduced rates) entering the drainage system
- Reduced transport of pollutants associated with atmospheric deposition onto rooftops
- Reduced water consumption for nonpotable uses
- Use as retrofits in redevelopment scenarios where there is a high percentage of impervious cover, compacted soils, high groundwater, and/ or hot-spot conditions

Practical Application: Rain Barrel/Cistern

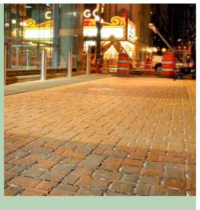
- Buildings along your Urban Roadway Project
- Not suitable for management of road runoff

NYSTA Pattersonville Service Area

Cistern – Lake County, IL.

http://www.lakecountyil.gov/Stormwater/LakeCountyWatersheds/BMPs/Pages/RainBarrelCistern.aspx

11. Porous “Pavement”



- Groundwater recharge augmentation
- Runoff reduction
- Effective pollutant treatment for solids, metals, nutrients, and hydrocarbons
- Safety Improvements – Glare, Road Spray
- Reduced Hydroplaning
- Noise Reduction
- Reduced de-icing materials necessary

Porous Concrete

Photo Source: http://www.concreteresources.net/category/pervious-concrete/

Practical Application: Porous "Pavement"

- Typically Parking areas, Low Volume, Low Speed Roads, Driveways

Permeable Pavers
http://hort.ufl.edu/woody/urban-parking8.shtml0

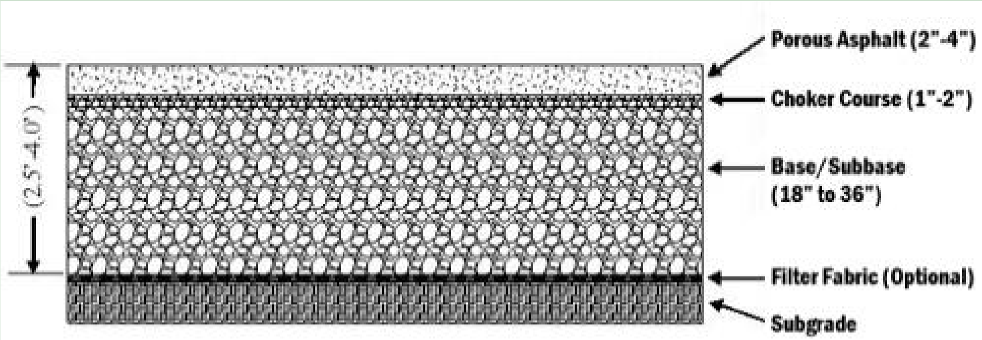


Figure 3. Typical Porous Asphalt Pavement Section *(diagram adapted from US EPA)*

Porous Asphalt Pavement

Porous Asphalt Pavements

New Heavier Duty Applications

Maine Mall Road (Portland, Maine)
Photo Credit: Maine DOT

Maine Mall Road (Portland, Maine)
Photo Credit: Maine DOT

PDH Q4

- What are 3 GI techniques that reduce runoff?
  - Conservation of natural areas
  - Sheet flow to riparian buffer/filter strip
  - Vegetated swale
  - Tree planting/tree pit
  - Rooftop disconnection
  - Stream daylighting
  - Rain gardens
  - Green roofs
  - Stormwater planter
  - Rain barrel/cistern
  - Porous Pavement

Acceptable RRv Mgmt

Infiltration
- 90% Credit
- Flexible design, no issues with sight distance (no plants)

Bioretention
- HSG A or B: 80% credit
- HSG C or D: 40% credit
- For many linear projects, preferred over rain gardens

Dry Swale
- HSG A or B: 40%
- HSG C or D: 20%
- More credit than vegetated, less restrictions, greater construction costs

SMPs for RRv

- Must capture runoff near the source
- Must be localized systems that are installed throughout the site at each runoff source,
- Minimize use of traditional “end-of-pipe” treatment systems.

Roadway Pollutants

Photo credit: Jeremy Walker, Science Photo Library

NYSDEC Requirements

- Remove:
  - 80% TSS
    - Total Suspended Solids (particulate) (Approx. 120 microns)
  - 40% Phosphorus

Pollutants and Sources of Highway Runoff

Pollutant	Source
Particulates	Pavement wear, vehicles, atmospheric deposition, maintenance activities.
Nitrogen, Phosphorus	Atmospheric deposition and fertilizer application.
Lead	Tire wear.
Zinc	Tire wear, motor oil, and grease.
Iron	Auto body rust, steel highway structures such as bridges and guardrails, and moving engine parts.
Copper	Metal plating, bearing and brush wear, moving engine parts, brake lining wear, fungicides and insecticides.
Cadmium	Tire wear and insecticide application.
Chromium	Metal plating, moving engine parts, and brake lining wear.
Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, bushing wear, brake lining wear, and asphalt paving.
Manganese	Moving engine parts.
Cyanide	Anti-caking compounds used to keep deicing salts granular.
Sodium, Calcium, Chloride	Deicing salts.
Sulphates	Roadway beds, fuel, and deicing salts.
Petroleum	Spills, leaks, antifreeze and hydraulic fluids, and asphalt surface leachate.
Trash/Litter	Items discarded or fallen out of moving vehicles found alongside roadways (e.g., paper/plastic cups, food containers, etc.)

Source: Stormwater Management Planning Guide for Transportation Projects, NYSDEC, 2005

Green Highways

- Green highway construction can incorporate several technical elements including, but not limited to:
  - Bioretention Areas/Rain Gardens
  - Dry Swales or Vegetated Swales
  - Porous Pavements
  - Forest Buffer
  - Stream Day-lighting
  - Flattened Side Slopes

Challenges and Solutions to Highway Stormwater Management

Space and Geometry - Issues

- Physical limitations, particularly for reconstruction
- Build-out or near build-out conditions in metropolitan areas
- Projects typically cut across multiple watersheds, sub-watersheds, catchments, and subcatchments
- Constraining hydraulic gradients between road surfaces and final discharge point
- Topography that is too steep or too flat
- Alignment criteria and safety requirements

Space and Geometry - Strategies

- Utilize spaces available in medians and ROW
- Rain gardens have modest head requirements and likely can fit into the existing hydraulic gradient of the storm drain system
  - Cannot be used to treat roadway runoff unless designed more similar to a bioretention area
  - Pretreatment is required
    - Grass Filter Strip
    - Stone Diaphragm
- Utilize flow diversion structures to divert only WQv
- Divert larger storms to centralized management areas, where more land area is available

Space and Geometry - Strategies

- Use mitigation “banking”
- Use easements or outright land acquisition to construct offsite SMPs
  - Stormwater easements are permanent and survive any sale of the property
  - Include a provision to allow access for maintenance and proper functioning of the system by the facility owner

Banking and Credit

- MS4 permit includes a provision for a Banking and Credit system
- Must have an existing watershed plan based on which “in lieu of” practices are evaluated
- The individual project must be reviewed and approved by NYSDEC
- Use of a banking and credit system for new development is only acceptable in impaired watersheds to achieve the no net increase requirement and watershed improvement strategy areas to achieve pollutant reductions in accordance with watershed plan load reduction goals.
- A banking and credit system must at minimum include:
  - Offset exceeds a standard reduction by factor of at least 2
  - Offset is implemented within the same watershed
  - Proposed offset addresses the POC of the watershed
  - Tracking system is established for the watershed
  - Mitigation is applied for retrofit or redevelopment
  - Offset project is completed prior to beginning of the proposed construction
  - A legal mechanism is established to implement the banking and credit system

Presence of Existing Infrastructure - Issues

- Above ground features (e.g., poles, lights, trees, etc.), and existing infrastructure (e.g., water and sewer piping, natural gas lines, and telephone and electrical conduits) may create conflicts
  - Frequently located in ROW, which may also be the only available space for a SMP
- Lack of information on existing conditions
  - Difficulties in locating utilities with existing maps
  - Unavailability of utility maps
  - Discovering unidentified flows

Presence of Existing Infrastructure - Strategies

- Modify SMP to fit the space available without disrupting existing utilities (know utility location in advance)
- Possibility of utility relocation in order to install the SMP
  - Requires advance notice and cooperation
- Maintain same alignment and grade for a new drainage infrastructure as the existing drainage system
- Modifying existing dry extended detention ponds or catch basins.
  - Incorporate features that encourage water quality control and/or channel protection

Balancing Cost with Need- Issues

- Costly land acquisition for stormwater management purposes
- Higher SMP implementation costs associated with construction in urban and suburban areas
- Expensive SMP implementation for reconstruction projects where existing drainage, topographic, utility and natural resources constrain the design

Balancing Cost with Need- Strategies

- Consider topo when choosing SMPs in order to reduce grading and excavation
  - Existing low areas *may* be well- suited to serve as SMP areas.
- The pollution control benefits must have a reasonable relationship to the costs
- A form of stormwater crediting (banking, trading, or pooling) may be suggested in areas where site constraints create costly or impracticable SMP implementation situations – check with DEC regional

Limited Options for Stormwater Practices - Issues

- Large-scale projects with abundant impervious surfaces
- Greater water quality volumes to be treated

Limited Options for SW Practices - Strategies

- Use incremental water quality controls using flow diversion devices that bypass larger flows
- Retrofit retrofit retrofit
- For new roads, plan ahead! Inventory the project area for prime soils, amendable topography, existing natural areas, adequate ROW, etc. prior to designing project

Hwy Drainage Facilities That Collect Runon- Issues

- Addressing runoff from off-site areas that has mixed with highway runoff (e.g., adjacent development sites, hillsides, other roads, surface waters or piped)

Hwy Drainage Facilities That Collect Runon - Strategies

- Bypass runoff – keep off-site runoff off of roadways by bypassing it from the drainage system
- Treat off –site runoff on the project site for credit.
  - Going above SPDES requirements may make you eligible for a "banking" credit for this additional level of treatment. This arrangement must be made with NYSDEC in advance
- Use "pooling" to address off-site runoff
  - An organization (e.g. local commercial business) contributes funding to NYSTA's/NYSCC's project in exchange for combined management of all runoff
  - Could also include an arrangement where several owners, who are individually responsible for stormwater management, implement SMPs on a single project together
    - Who does maintenance?

Multiple Watersheds in a Single Project - Issues

- Addressing multiple drainage system outlets and downstream impacts to varying water resources
  - Project may bisect sub-watersheds that have different management objectives

Multiple Watersheds in a Single Project - Strategies

- Prioritize efforts where the receiving waters are most sensitive to impacts
- Select outlets where peak rate control and water quality controls are most important, and cost effective for treatment

Maintenance Capabilities- Issues

- Access and safety considerations
- Know-how/knowledge regarding system and maintenance
- Long-term maintenance requirements and budget

Maintenance Capabilities - Strategies

- Locate SMPs in areas that would avoid impacts to traffic flow
  - Avoid the necessity for temporary lane closures to conduct maintenance
- Balance the selected SMP design with the maintenance budget and resources of the owner
- Incorporate features that ease maintenance burdens
  - Sediment forebays, access roads, storage areas, pre-treatment sediment traps, etc
- Choose SMPs that have more straight-forward maintenance requirements where needed
  - Dry and vegetated swales generally require less maintenance (mowing to maintain vegetation at a certain height)
  - Vegetative filter strips of only a few feet in width can remove a significant amount of suspended constituents; maintenance consists chiefly of trash removal (if necessary), grass mowing, replacement of plant cover, and inspection to determine need for erosion control.

Cold Climate Considerations - Issues

- Treating plowed snow and/or spring snowmelt
- Roadway safety (i.e., freeze/thaw conditions, packed snow clogging the drainage system, plugging outlets, and acting as a berm)
- Salting

Cold Climate Considerations - Strategies

- Conduct roadway improvement projects that will reduce the need for salting regularly
- Modify SMP to treat snowmelt that causes large runoff events by increasing the volume available for detention
- Dry detention structures may be used as snow storage facilities to promote some treatment of plowed snow
  - Landscaping should incorporate salt-tolerant species
  - Sediment from road sanding might need to be removed from the forebay more frequently
- Vegetative filter strips with salt tolerant vegetation provide a convenient area for snow storage and treatment

Design Calculation Guidance

STORMWATER MANAGEMENT PRACTICES FOR RUNOFF REDUCTION

Date: 1/26/11

NOTE: This table provides only a generated overview of each practice. Reference the New York State Stormwater Design Manual for complete standards, details, specifications, and design variations.

	PRACTICE (Design Manual Page)	LAND USE	CONTRIBUTING DRAINAGE AREA	DESIGN ELEMENTS	SLOPE	SOILS	HEAD	GROUND WATER SEPARATION	ALLOWABLE RUNOFF REDUCTION
Area Reduction	**Conservation of Natural Areas** (5-47)	Commercial/ Residential	If any contributing area, maximum contributing length = 75-180' (depending on soil & impervious)	• Minimum size = 10,000 s.f. • Sheet flow inlet	< 8%	Native	---	> 6"	Area and contributing area deducted
	Reparian Buffers/Filter Strips (5-51)	Commercial/ Residential	Maximum contributing length = 75-180' (depending on soil & impervious) Maximum 5,000 s.f. for filter strip	• Sheet flow inlet or flow dissipation • Minimum width = 50-100' (Depends on slope)	< 15%	Native	---	> 6"	Area and contributing area deducted
	Tree planting/Preservation (5-64)	Commercial/ Residential	Maximum contributing area = ½ crown diameter or maximum 100 s.f. impervious area/tree	• Minimum 4" caliper – existing • Minimum 2" caliper – new deciduous or 6' high (new conifer)	< 5%	Native/ constructed	---	> 6"	100 s.f./tree
	Rooftop Disconnection (5-69)	Commercial/ Residential No hotspots	Maximum contributing area = 2,000 s.f. Maximum length = 75'	• Flow dissipation required for discharges from > 500 s.f. • Minimum vegetated area width – 50'	< 5%	Native/ constructed	---	> 6"	Impervious area changed to pervious for R_v
Volume Reduction	**Infiltration Trench** (6-31)	Commercial/ Residential No hotspots	Maximum 5 acres	• 25-100% pre-treatment • Monitoring required • Soil testing required	< 15%	k> 0.5"/hr.	1'	> 3'	90% contributing WQ_v
	Drywell (6-31)	Commercial/ Residential No hotspots	Maximum 1 acre	• Roof top runoff only • Pre-treatment - sump • Soil testing required	< 15%	k> 0.5"/hr.	1'	> 3'	90% contributing WQv
	Infiltration Basin (6-31)	Commercial/ Residential No hotspots	Maximum 10 acres	• 25-100% pre-treatment • Monitoring required • Soil testing required	< 15%	k> 0.5"/hr.	3'	> 3'	90% contributing WQv
	Bioretention (6-44)	Commercial/ Residential	Maximum 5 acres	• Sheet drainage/flow inlet dissipation • Monitoring required • Sized using Darcy's Law	< 6%	Constructed	5'	> 2'	80% contributing WQv for A & B soils, 40% for C & D soils
	Dry Swale (6-59)	Commercial/ Residential/ Highway	Maximum 5 acres	• Non erodible 2-year flows • Check dams if slope is > 2% • Minimum 30-minute retention time • 0% pre-treatment • Maximum depth 18"	< 4%	Constructed	3-5'	> 2'	40% contributing WQv for A & B soils, 20% for C & D soils
	Vegetated Swale (5-58)	Commercial/ Residential/ Highway	Maximum 5 acres	• Peak WQ_v flow < 3cfs • Convey at < 1.0 fps at depth of < 4" • Minimum length – 100' • 10 minute retention time	< 0.5% to 4%	Native	1-4'	> 2'	20% contributing WQv for A & B soils, 10% for C & D soils
	Green Roof (5-86)	Commercial	Roof area	• Roof loading 16-200 lb/s.f.	<30%	Constructed	.25'- 2.0'	---	100% contributing WQv
	Rain Garden (5-76)	Residential/ Commercial	Maximum 1,000 s.f.	• Located within 30' of contributing source • Max. loading ratio of 5:1 (DA to surface area) • Max. ponding depth = 6"	< 6%	Constructed	2-3'	> 2'	100% contributing WQv for A & B soils 40% for C & D soils
	Planters (5-97)	Commercial	< 15,000 s.f.	• Underdrain for "flow through" & C & D soils • Sized using Darcy's Law	---	Constructed	3.5'	> 2'	100% contributing WQv
	Cisterns/Rain Barrels (5-106)	Commercial/ Residential	Roof area	• Require use of collected water • Approximately 625 gal/1,000 s.f. of roof/1" rain	---	---	---	---	100% contributing WQv
	Porous Pavement (5-114)	Commercial/ Residential No hotspots	Surface area plus small adjacent area	• Requires loading analysis • Sheet flow for contributing area	<5%	Constructed over HSG A, B, or C	2-3'	> 3'	100% contributing WQv

Step 1: Plan to protect natural resources and reduce impervious cover

Step 2: Determine Water Quality Treatment Volume (WQv)

Input WQv from "Total WQv Calculation"	

Step 3: Determine Adjusted WQv and minimum RRv

Input Adjusted WQv	
Minimum RRv	

Step 4: Calculate Runoff Reduction Volume by GI Techniques

GI Practice	RRv
Rain Garden	
Green Roof (intensive)	
Stormwater Planter (infiltration)	
Stormwater Planter (flow through)	
Cistern	
Permeable Pavement	
Infiltration Area	
Bioretention #1	
Bioretention #2	
Bioretention #3	
Dry Swale	
Vegetated Swale	

Total Runoff Reduction	

Step 4: Apply Standard Practices

Is RRv > WQv?	
Is RRv > minimum WQv?	

Step 5: Apply Peak Flow Attenuation

PERMABLE PAVEMENT WORKSHEET

Ap = Vw / (n x dt)

where:

Ap	Required porous pavement surface area	*ft2*	
Vw	Design volume	*ft3*	
n	porosity of gravel bed/reservoir		*Assume 0.4 for gravel*
dt	depth of gravel bed/reservoir	*ft*	*Maximum of four feet, and separated by at least three feet from seasonally high groundwater*

Step 1: Calculate WQv

Precipitation =		*in*
Area =		*ft2*
Impervious Area =		*ft2*
Rv =		
WQv =		*ft3*

Step 2: Calculate the available storage volume in the storage reservoir:

Pavement Width		
Pavement Length		
Pavement Area =		
Porosity (n) =		
Gravel Bed depth =		
Storage Volume =		*ft3*

Step 3: Determine the Runoff Reduction

RRv		*ft3*

CISTERN OR RAINBARREL WORKSHEET

CALCULATE WQv OF AREA CONTRIBUTING TO PRACTICE

Precipitation	P		*inches*
Area	A		*acres*
Impervious Area	I		*acres*
Percent Impervious	%I		
Rv	Rv		
WQv =	WQv		*ft3*

CALCULATE REQUIRED CISTERN/RAIN BARREL VOLUME

WQv		*ft3*
Cistern volume =		*Gallons*
Cistern Selected =		*Gallons*

DETERMINE RUNOFF REDUCTION

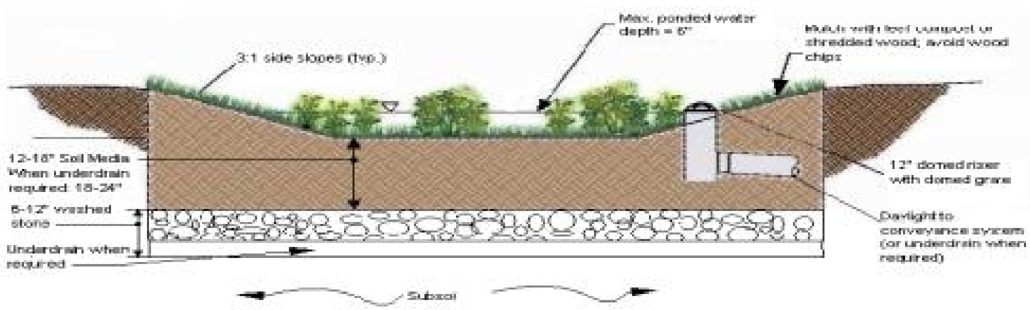
Runoff Reduction		*ft3*

RAIN GARDEN WORKSHEET

WQv ≤ VSM + VDL + (DP x ARG)
VSM = ARG x DSM x nSM
VDL (optional) = ARG x DDL x nDL

ENTER DATA FOR PROPOSED RAIN GARDEN

		Input	Unit	Restriction
Enter rain garden surface area	ARG		*sf*	
Enter depth of the soil media	DSM		*ft*	*1.0 to 1.5*
Enter depth of the drainage layer	DDL		*ft*	*≥0.5 ft*
Enter depth of ponding above surface	DP		*ft*	*≤ 0.5 ft*
Enter porosity of the soil media	nSM			*≥20%*
Enter porosity of the drainage layer	nDL			*≥40%*
Volume provided in soil media	VSM			
Volume provided in Drainal Layer	VDL			
Volume provided in ponding area				
Total Volume provided				



ENTER SITE DATA FOR DRAINAGE AREA TO BE TREATED BY PRACTICE

Enter Design Storm (inches)	P		*in*
Enter Impervious Area (ft2)	I		*ft2*
Enter Area (ft2)	A		*ft2*
Percent Impervious	%I	100	%
Runoff Volume	Rv	0.95	
WQv	WQv		ft3

RUNOFF REDUCTION

Good soils (no underdrains)	RRv	
Poor soils (with underdrains)	RRv	

STORMWATER PLANTER WORKSHEET

Af = WQv x (df)/ [k x (hf + df)(tf)]

where:

Af = the required surface area [square feet]

WQv = water quality volume [cubic feet]

df = depth of the soil medium [feet]

k = the hydraulic conductivity [ft/day], usually set at 4 ft/day when soil is loosely placed in the planter, but can be varied depending on the properties of the soil media. Some other reported conductivity values are:

- Sand: 3.5 ft/day (City of Austin 1988).
- Peat: 2.0 ft/day (Galli 1990).
- Leaf compost: 8.7 ft/day (Claytor and Schueler, 1996).
- Bioretention Soil: 0.5 ft/day (Claytor and Schueler, 1996).

hf = average height of water above the planter bed

tf = the design time to filter the treatment volume through the filter media

STORMWATER PLANTER WORKSHEET

Step 1: Calculate WQv for drainage area to planter

Enter Design Storm (inches)	P		*in*	
Enter Impervious Area (ft2)	I			*Must be less than 15,000 sf*
Enter Area (ft2)	A		*ft2*	
Percent Impervious	%I			
Runoff Volume	Rv			
WQv =	WQv		ft3	

Step 2: Calculate the minimum filter area

		Value	Units	Restrictions
Enter WQv	WQv			
Enter depth of Soil Media	df		*ft*	
Enter hydraulic conductivity	k		*ft/d*	
Enter Average height of ponding	hf		*ft*	*Maximum depth = 12 inches*
Enter filter time	tf		*d*	*usually 3-4 hours*
Required Area of Filter >>>>>>>>>	Af		*ft2*	
Filter Width			*ft*	
Filter Length			*ft*	
Actual filter Area		0	*ft2*	

Step 3: Determine the Runoff Reduction

Runoff Reduction			
Flow through	RRv		*ft3*
Infiltration	RRv		*ft3*

BIORETENTION WORKSHEET

Af = WQv x (df)/ [k x (hf + df)(tf)]

where:

Af = the required surface area [square feet]

WQv = water quality volume [cubic feet]

df = depth of the soil medium [feet]

k = the hydraulic conductivity [ft/day], usually set at 4 ft/day when soil is loosely placed in the planter, but can be varied depending on the properties of the soil media. Some other reported conductivity values are:

- Sand: 3.5 ft/day (City of Austin 1988).
- Peat: 2.0 ft/day (Galli 1990).
- Leaf compost: 8.7 ft/day (Claytor and Schueler, 1996).
- Bioretention Soil: 0.5 ft/day (Claytor and Schueler, 1996).

hf = average height of water above the planter bed

tf = the design time to filter the treatment volume through the filter media

STEP 1: DETERMINE WQv FOR DRAINAGE TO BIORETENTION AREA

		Value	Units	Restrictions
Enter Design Storm	P		*in*	
Enter Impervious Area	I		*ft2*	
Enter Area	A		*ft2*	*<5 acres < 217,800 sf*
Percent Impervious Area	%I		*%*	
Runoff Volume	Rv			
WQv	WQv		*ft3*	

STEP 2: CALCULATE THE MINIMUM FILTER AREA

		Value	Units	Restrictions
Enter WQv	WQv		*ft3*	
Enter depth of Soil Media	df		*ft*	*2.5 - 4 ft*
Enter hydraulic conductivity	k		*ft/day*	
Enter Average height of ponding	hf		*ft*	*6 in maximum*
Enter filter time	tf		*days*	
Required Area of Filter	Af		*ft2*	

STEP 3: DETERMINE ACTUAL BIORETENTION AREA

	Value	Units
Filter Width		*ft*
Filter Length		*ft*
Calculated filter Area		*ft2*
or		
Measured filter Area		*ft2*
Actual Volume Provided		

Step 4: DETERMINE RUNOFF REDUCTION

	Value
w/underdrains	
w/o underdrains	

INTENSIVE GREEN ROOF WORKSHEET

WQv ≤ VSM + VDL + (DP x AGR)
VSM = AGR x DSM x nSM
VDL = AGR x DDL x nDL

ENTER DATA FOR PROPOSED GREEN ROOF

		Input	unit	Allowable
Enter green roof surface area	AGR		sf	
Enter depth of the soil media	DSM		ft	0.5-2.0
Enter depth of the drainage layer	DDL		ft	
Enter depth of ponding above surface	DP		ft	
Enter porosity of the soil media	nSM			~20%
Enter porosity of the drainage layer	nDL			~25%
Volume provided in soil media	VSM			
Volume provided in Drainage Layer	VDL			
Volume Provided in Ponding area				
WQv (Provided)				

ENTER SITE DATA FOR DRAINAGE AREA TO BE TREATED BY PRACTICE

		Input	units
Enter Design Storm	P		in
Enter Impervious Area	I		ft2
Enter Area	A		ft2
Percent Impervious Area	%I		%
Runoff Volume	Rv		
WQv =	WQv		ft3

RUNOFF REDUCTION

Extensive GREEN ROOF WORKSHEET

WQv ≤ VSM + VDL + (DP x AGR)

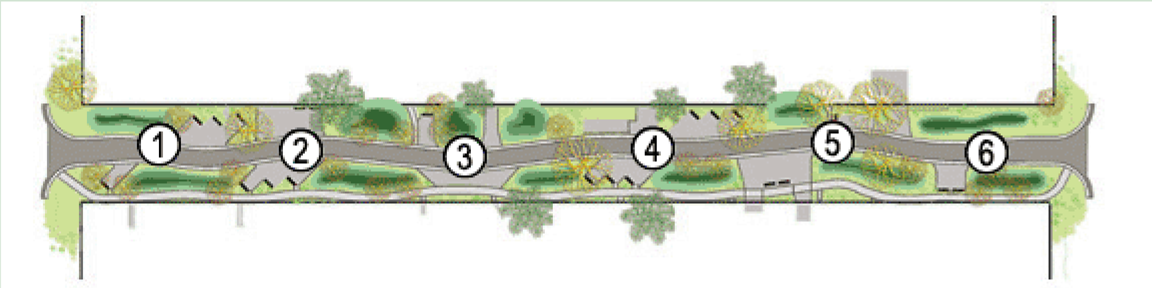
VSM = AGR x DSM x nSM

VDL = AGR x DDL x nDL

INPUTS:			Units	Restrictions
Enter green roof surface area	AGR		*sf*	
Enter depth of the soil media	DSM		*ft*	*0.25 - 0.5*
Enter depth of the drainage layer	DDL		*ft*	
Enter depth of ponding above surface	DP		*ft*	
Enter porosity of the soil media	nSM			*~20%*
Enter porosity of the drainage layer	nDL			*~25%*
Volume provided in soil media	VSM			
Volume provided in Drainal Layer	VDL			
WQv (Provided)				

ENTER SITE DATA FOR DRAINAGE AREA TO BE TREATED BY PRACTICE			
Enter Design Storm (inches)	P		*in*
Enter Impervious Area	I		*ft2*
Enter Area	A		*ft2*
Percent Impervious Area	%I		*%*
Runoff Volume	Rv		
WQv =	**WQv**		*ft3*

Project Examples



Linear Transportation

- Suburban
- Urban
- Rural

- Roadways
- Sidewalks
- Multi-use Paths
- Rail
- Runways

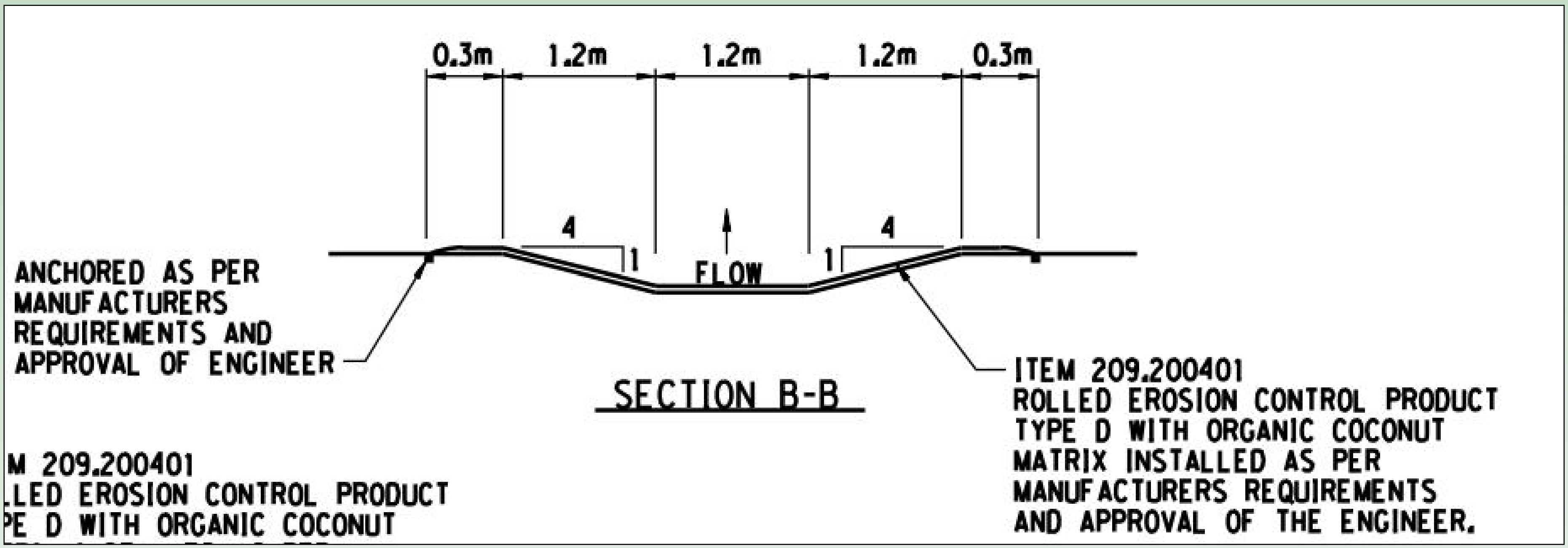
Rural

Implementing Green Infrastructure on a Rural Highway

Swales

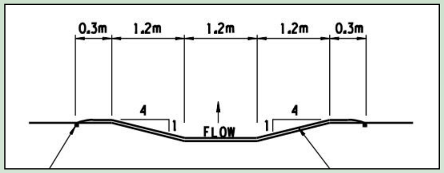
In Permeable Soils………….(A and B Type Soils)

No Underdrain or Soil Amendments Required

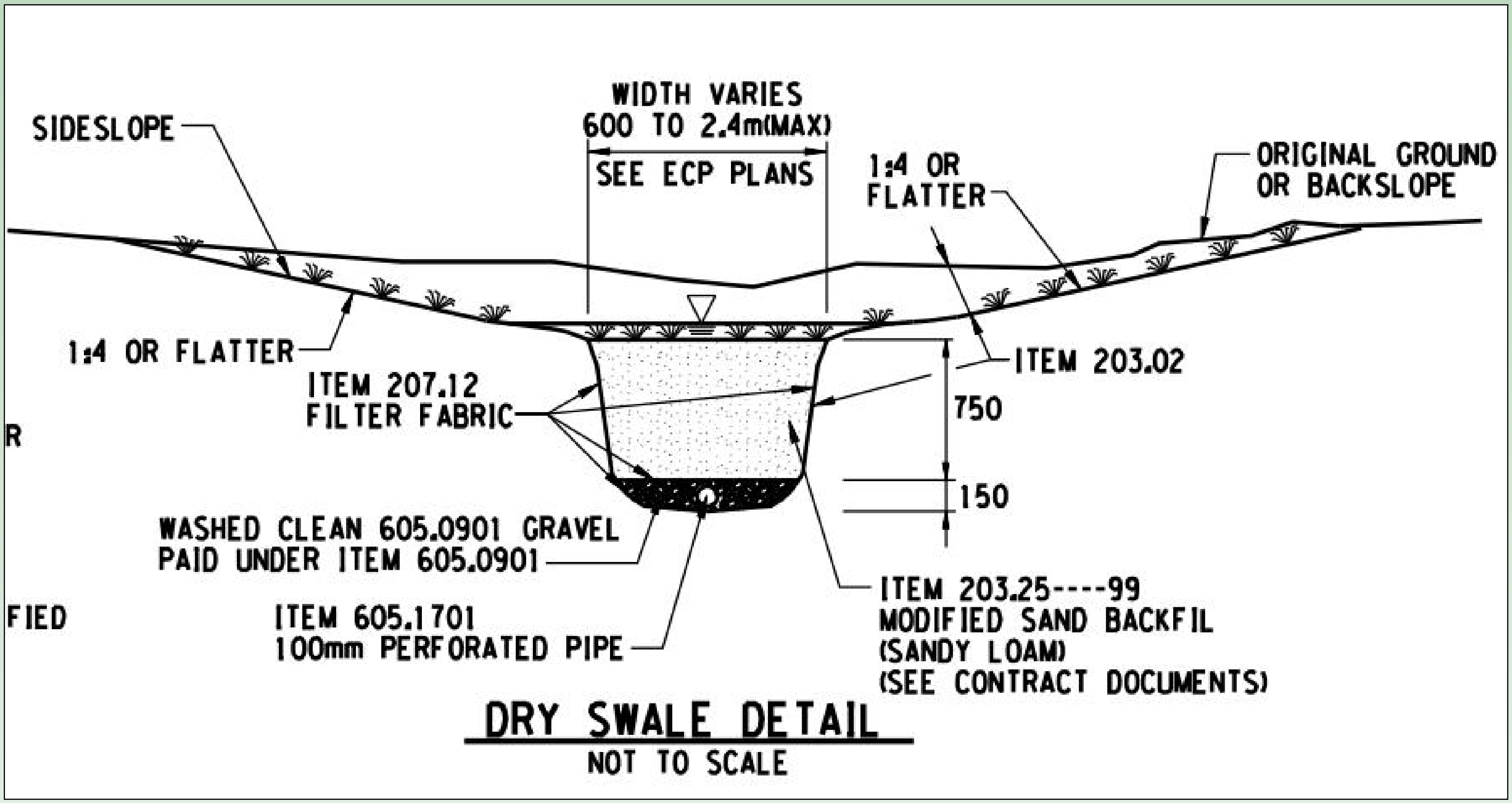


Good Infiltration – Less Runoff, Lower Velocity, etc.

Swales



In Clay or Slow Draining Soils…………(C and D)



Outside Clear Zones, Check Dams Required

Diversion Swale

- Clear Zone
- Flat Side Slopes
- Strong Vegetation
- Permanent TRM
- Amended Soil
- Underdrain
- Construction Quality

Diversion Swale

- Clear Zone
- Flat Side Slopes
- Strong Vegetation
- Permanent TRM
- Amended Soil
- Underdrain
- No Closed Drainage
- Minimal Maintenance

Flat Slopes (1:4 or Flatter)

- Pre-Treatment
- No Closed Drainage
- Very Effective
- Promotes Infiltration
- Little to No Maintenance
- Good Practice by Highway Engineers

Rural Conditions – Challenges to Minimize Erosion

Suburban

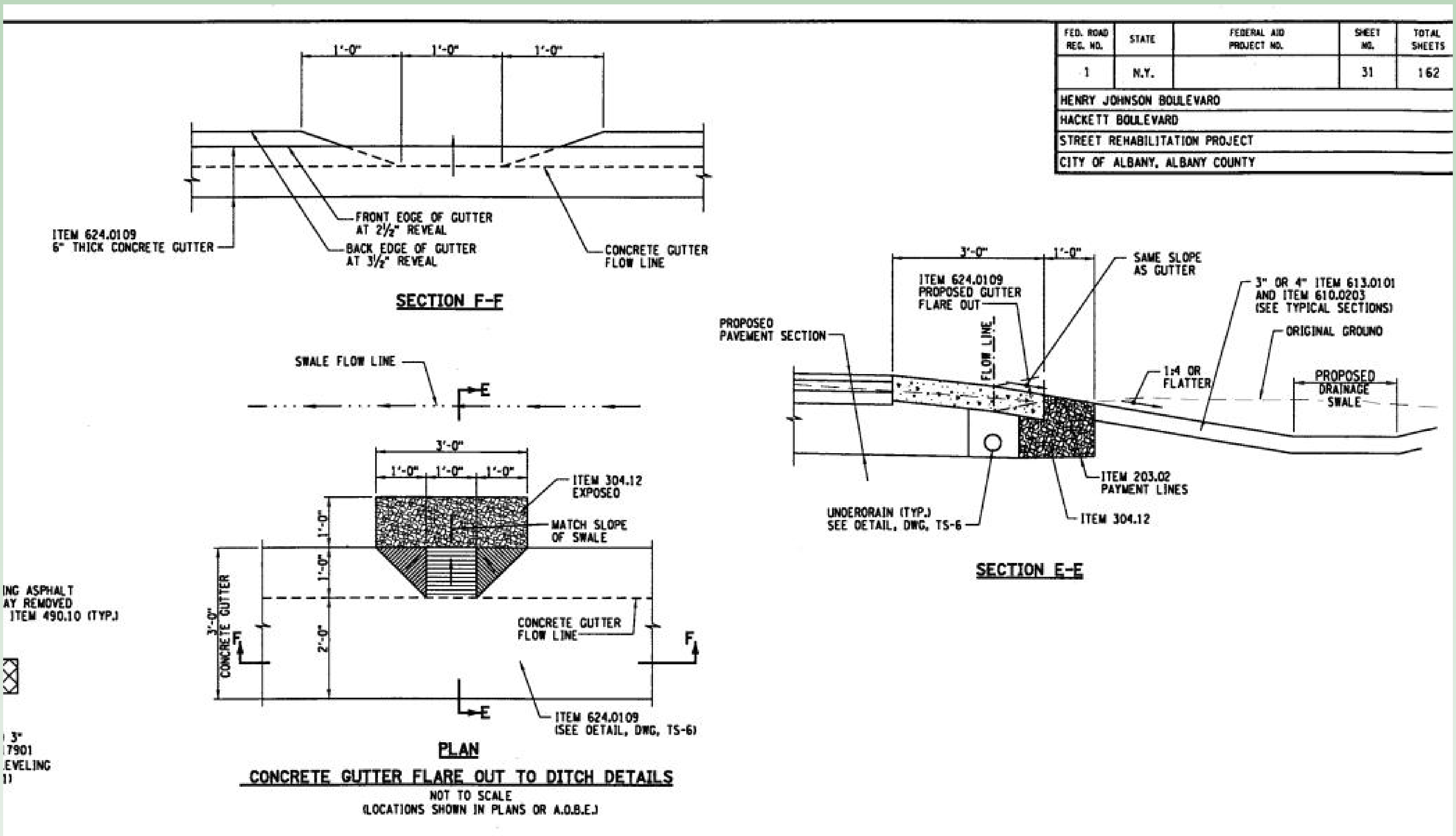
Implementing Green Infrastructure in Suburban Areas

Suburban Roadway and Multi-Use Path

- Closed Drainage
- Little to No Maintenance
- Combined Sewer and Storm System
- Stone Dust

Suburban Roadway and Multi-Use Path

Suburban Roadway and Multi-Use Path



Suburban Roadway and Multi-Use Path

Elements for Final Condition

- Closed Drainage
- Combined Sewer and Storm System
- Infiltration System
- Reduced Peak Flow
- No Additional Cost

Suburban and Urban Applications

Conservation of natural areas

- Protect undisturbed natural areas by permanently conserving them.

Sheet flow to riparian buffers or filter strips

- Undisturbed natural areas can be used to treat and control stormwater runoff.

Vegetated open swale

- Vegetated channels can increase time of concentration, reduce the peak discharge, and provide infiltration.

Tree planting/tree box

- Plant or conserve trees to reduce runoff, increase nutrient uptake, and provide stabilization.

Disconnection of rooftop runoff

- Direct runoff from rooftops to designated pervious areas to reduce runoff volumes and rates.

Suburban and Urban Applications

Stream daylighting

- Stream Daylight previously-culverted/piped streams.

Rain garden

- Manage and treat runoff using a conditioned soil bed and planting materials to filter runoff stored within a shallow depression.

Green roof

- Capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof.

Stormwater planter

- Small landscaped treatment devices that can be designed as infiltration or filtering practices.

Rain tank/Cistern

- Capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities.

Porous Pavement

- Pervious types of pavements that provide an alternative to conventional paved surfaces.

Suburban Roadway and Multi-Use Path

Beach Road – Lake George NY

Implementing Green Infrastructure on a Site with Challenging Constraints

Background

- Multi-lane, 1-mile long Collector Road
- Southern end of Lake George
  - Impaired Water – Chlorides
  - Silt & sediment from urban runoff & erosion

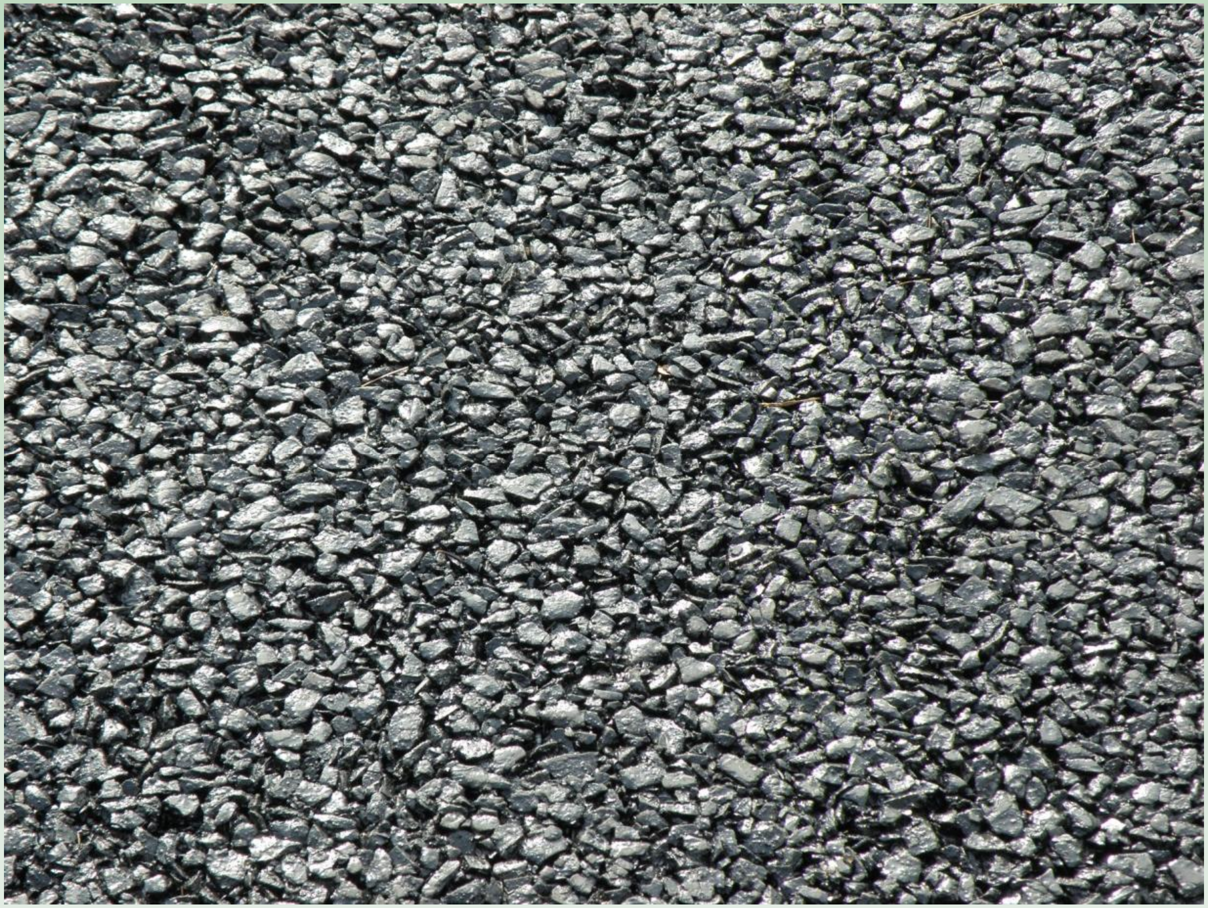
…Background

- Currently Roadway drains directly to Lake
- Subbase failure
- Funded for full-depth reconstruction
- Federal, State and Local Funds

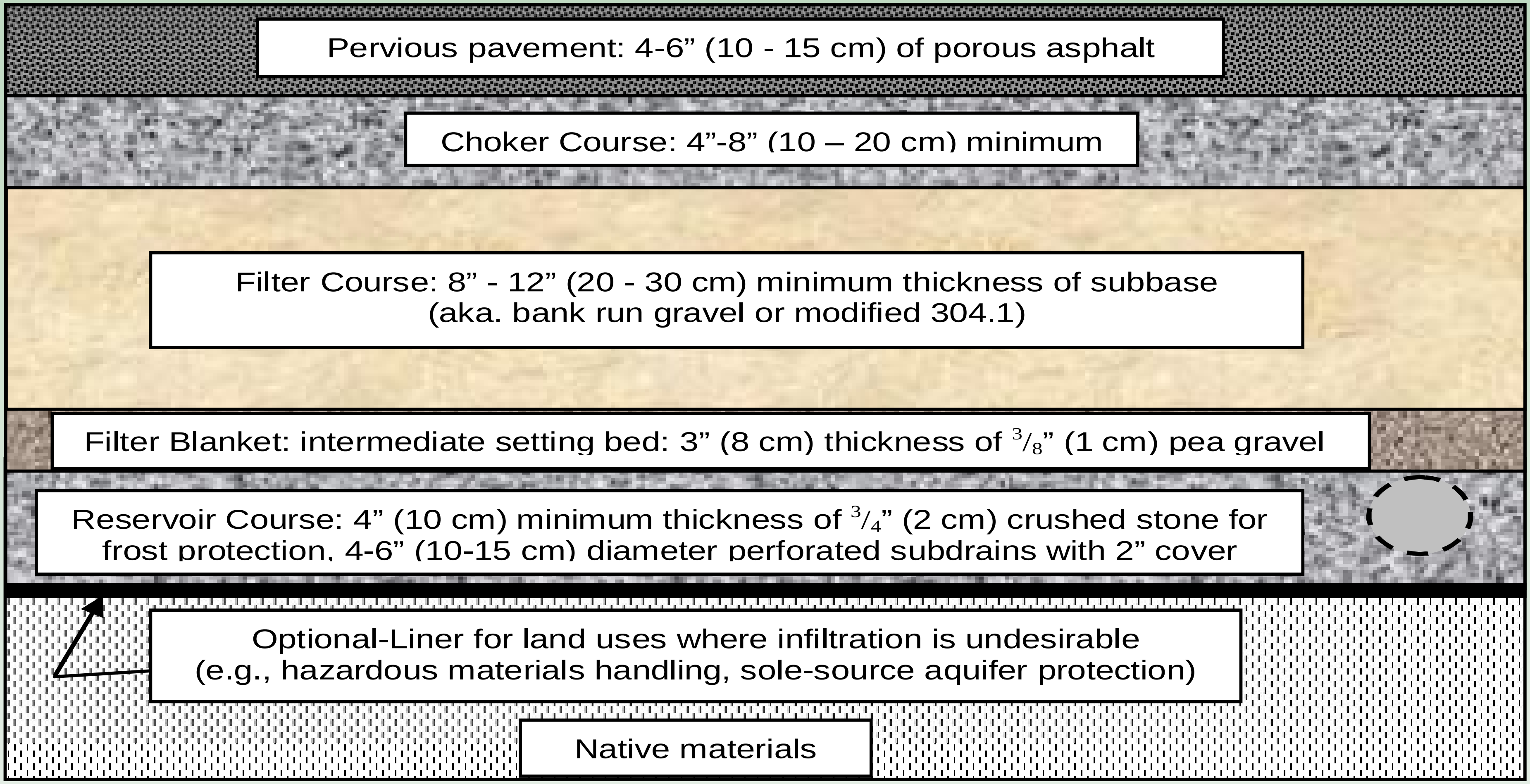
Constraints

- Little to no opportunity to obtain ROW
- Virtually flat roadway
- Elevation 4’ above Lake Level
- High Water Table
- Curbed Section

Opportunity – Porous Asphalt



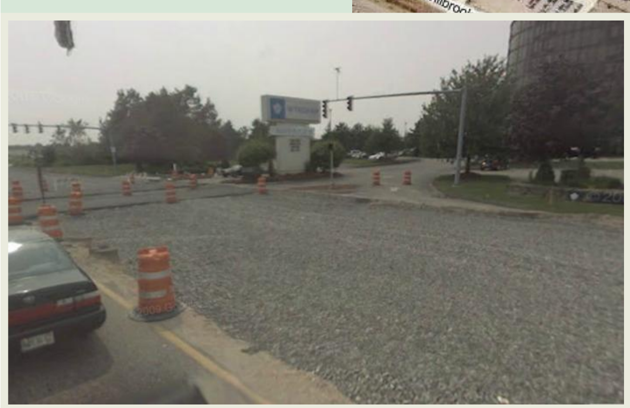
University of New Hampshire Model



Research: Maine Pilot Project

- Custom mix designed for test section
- 4-lane arterial in South Portland
- Warmer Temperatures than Lake George
- Retail mall intersection with significant turning movements
- Highly developed retail and commercial corridor
- Installed in Fall of 2009
- Designed for 3.0 M ESALS (Equivalent Single Axle Loads)
- No signs of rutting or deterioration In July, 2011

Maine Mall Road – Portland Maine

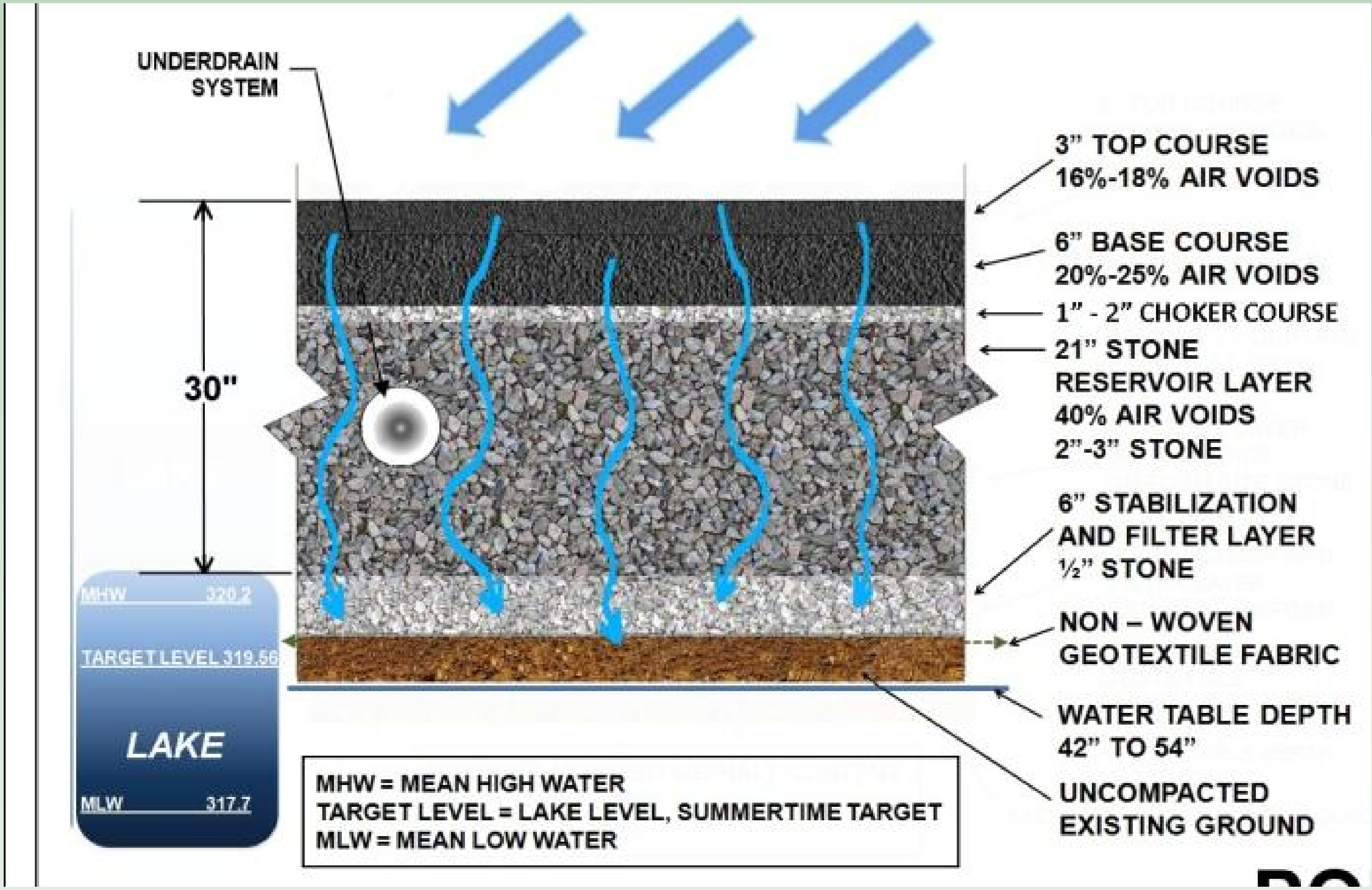


The Maine Section

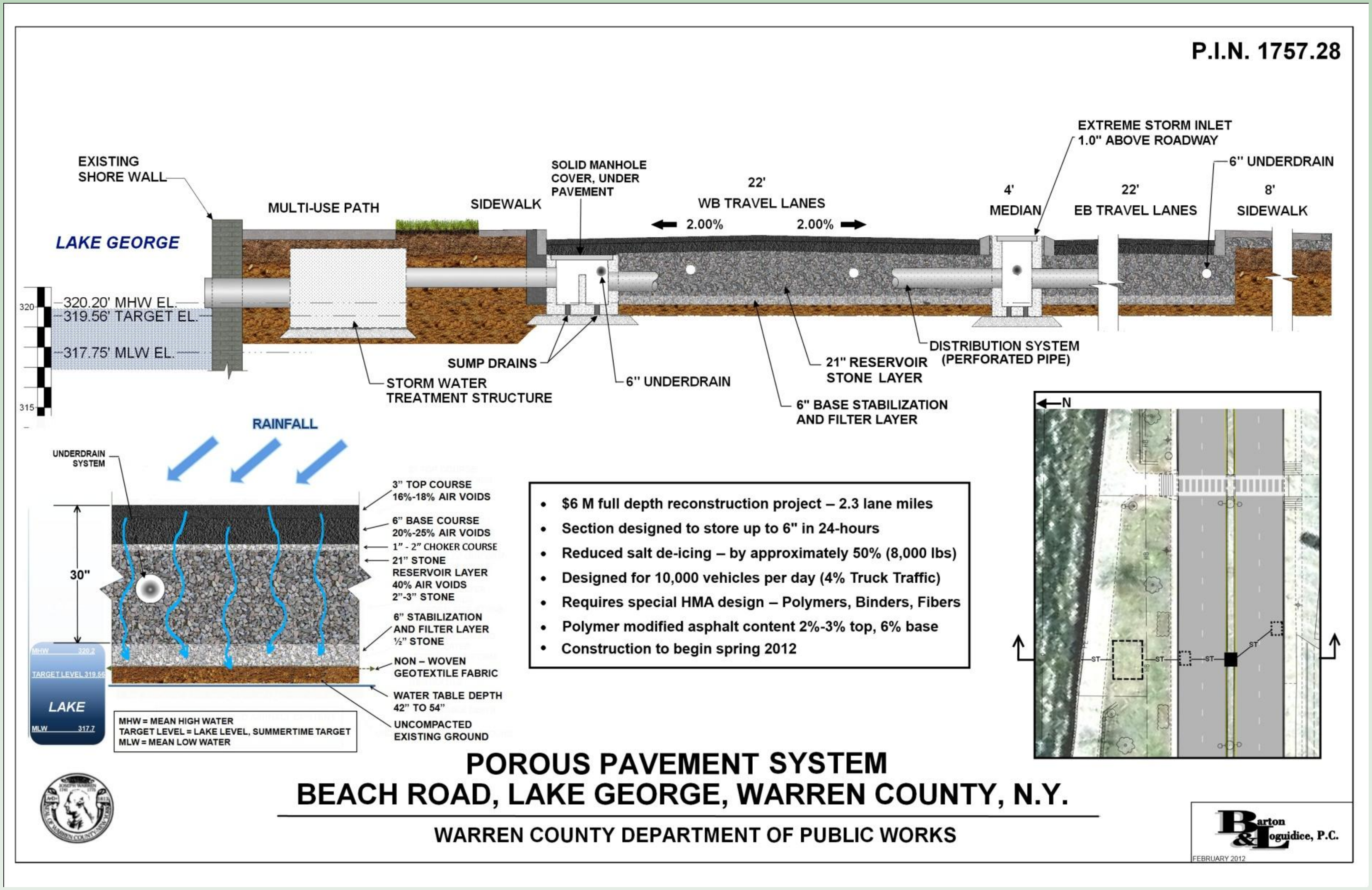
9" Asphalt, 15" Reservoir Course, Variable Sand Layer

Photo Credit: Maine DOT

Beach Road Section



Beach Road System



Beach Road Design

- Infiltration Tests
- Design Traffic Loading 1.05 M ESALS
- Asphalt Mix Design - PG 76-22 High Rut Avoidance - Polymers
- No intermediate Sand Layer – (in UNH and Maine design)
- Frost Penetration requirements (FAA Design)
- Constructability Requirements – Economic Impact to Area
- Primary Pollutants targeted – Chlorides, Automotive Contaminants such as Petroleum, Metals Cu, Pb, Zn
- High Water Table
- Proactive approach to minimize contamination from offsite
- Redundant Drainage System

ITEM 623.120100WR – POROUS ASPHALT CRUSHED STONE STABILIZATION COURSE (CY)
ITEM 623.120200WR – POROUS ASPHALT CRUSHED STONE RESERVOIR COURSE (CY)

GRADATION:

Material shall be graded in accordance with size designations shown in Table 703-4 from the NYSDOT Standard Specifications.

Stabilization Course – Size Designation No. 2

Reservoir Course - Size Designation No. 4A

TABLE 703-4(1) SIZES OF STONE, GRAVEL AND SLAG

	Screen Sizes									
Size Designation	4 in	3 in	2 1/2 in	2 in	1 1/2 in	1 in	1/2 in	1/4 in	1/8 in	# 80	#200(3)
Screenings(2)	-	-	-	-	-	-	100	90-100	-	-	0-1.0
1B	-	-	-	-	-	-	-	100	90-100	0-15	0-1.0
1A	-	-	-	-	-	-	100	90-100	0-15	-	0-1.0
1ST	-	-	-	-	-	-	100	0-15	-	-	0-1.0
1	-	-	-	-	-	100	90-100	0-15	-	-	0-1.0
2	-	-	-	-	100	90-100	0-15	-	-	-	0-1.0
3A	-	-	-	100	90-100	0-15	-	-	-	-	0-0.7
3	-	-	100	90-100	35-70	0-15	-	-	-	-	0-0.7
4A	-	100	90-100	-	0-20	-	-	-	-	-	0-0.7
4	100	90-100	-	0-15	-	-	-	-	-	-	0-0.7
5	90-100	0-15	-	-	-	-	-	-	-	-	0-0.7

(1)Percentage by weight passing the following square openings.
(2)Screenings shall include all of the fine material passing a 1/4 in. screen.

475.10130101 - Top Course Porous Asphalt Pavement with Mineral Fiber F3
475.10190101 - Top Course Porous Asphalt Pavement with Mineral Fiber F9
475.01190101 - Binder Course Porous Asphalt Pavement F9

DESCRIPTION:

Furnish and place Porous Asphalt Pavement courses in accordance with the contract documents as directed by the Engineer-in-Charge. The top course mixture requires the use of Mineral Fibers as outlined in this specification. A Test Panel(s) will be required as outlined in this specification and other contract documents.

MATERIALS:

The materials and composition for the Porous Asphalt Pavement mixtures shall meet the requirements specified in §401-2 Materials, except as noted herein.

Formulate a job mix formula (JMF) that satisfies the design limits listed below and submit it to the Regional Materials Engineer (RME), at least one week prior to placement of the test section.

Porous Asphalt Pavement Mixtures Gradation Requirements

Screen Sizes	Top Course General Limits % Passing	Binder Course General Limits % Passing
2 inch	---	100
1 ½ inch	---	75-100
1 inch	---	55-80
3/4 inch	100	---
1/2 inch	85-100	23-42
3/8 inch	55-75	5-20
No. 4	10-25	2-15
No. 8	5-10	---
No. 16	---	---
No. 30	---	---
No. 200	2-4	---

Beach Road Testing Protocol

Test Panel(s). A minimum of 1000 sq. ft. test panel will be required to be constructed. The test panel will be constructed at a location designated by the Engineer-in-charge or as directed in the contract documents, and will remain in place for the duration of the project to be used as a visual reference for acceptance of the pavement surface. Produce, deliver, and construct the test panel in accordance with this specification and the thicknesses specified in the contract documents. The final in-place air voids of each pavement layer shall be 16% to 22%.

Test Panel Evaluation. The following will be performed on each Test Panel:

1. The owner will provide a density gauge operator that possesses a current Density Gauge Inspector Certification from The Associated General Contractors, New York State, or its equivalent. The density gauge operator will monitor the in-place density of the pavement course.
2. The owner will cut a minimum of three, 6 inch diameter, cores from each asphalt course prior to placing any subsequent courses. These cores will be used to determine:
    a. In-place air void of the asphalt course, and will be used to determine an acceptable density gauge correlation for use on the routine paving courses.
    b. Compacted thickness of the asphalt course.
3. Porosity Test. Allow a minimum of 24 hours after completion of the Top Course, before testing. Perform a porosity test at 3 locations chosen by the Engineer-in-charge. At each location, test the porosity for a minimum of 3 minutes. The test is accomplished by applying clean water at a measured rate of at least 5 gal/min over the surface, using a hose or other distribution device. Water used for the test shall be clean, free from suspended solids and deleterious materials and will be provided at no additional cost. All applied water shall infiltrate the test panel directly, without puddle formation or surface runoff, and shall be observed by the Engineer-in-charge.

Water Quality

- UNHSC concludes that de-icing materials can be reduced by approximately 50%
- NYSSMDM, Chapter 5 resource references
  - Metal Removal Zinc (99%), Lead (98%)
  - COD: 82%

Table 5.14 Estimated Pollutant Removal Performance of Porous Pavement (Porous Asphalt) (EPA, 1999)

Pollutant Parameter	% Removal
Total Phosphorus	65
Total Nitrogen	80 – 85
Total Suspended Solids	82 – 95

Beach Road: Water Quality

- Redevelopment Project with reduction in impervious
  - From 94% impervious to 50% impervious
  - WQv treatment and Water Quantity not actually required since Greater than 25% reduction in impervious
- Installing 3 Proprietary SWTS to treat non porous runoff
- Biological activity within the asphalt layers – 98%

"*Oil bio-degradation in permeable pavements by microbial Communities*" , A.P. Newman, C.J. Pratt, S.J. Coupe and N. Cresswell

Green Infrastructure Acceptance

- FHWA involved at the onset
  - Experimental status
  - Request testing and monitoring
  - Should project not function as intended, repairs will be reimbursed (prorated) by FHWA during certain time frame (8 yrs)
- NYSDOT (regional and main) involved at the onset
  - Work w/B&L to develop testing and monitoring protocols
- WORK CLOSELY WITH AGENCIES
  - Lake George Association, Warren County Soil and Water Conservation District, NYSDEC, EFC – GIGP, EPA, Bruce K. Ferguson, University of Georgia
- INVOLVE KEY PLAYERS AND STAKEHOLDERS EARLY ON
- Each Project is unique

Porous Pavement Highway Benefits

- No water build-up on surface
  - Risk of hydroplaning decreased
  - Less road glare; increasing visibility in low light conditions (oncoming lights)
- Little to no road-spray
- Black ice reduction
- Pores of pavement provide acoustic absorption
- Elimination of surface drainage structures and grates provides smoother riding surface
  - Less jarring = less deleterious material release

Demonstration

ILLINOIS

WISCONSIN
Lake Michigan
MICHIGAN
IOWA
Rockford
Elgin
Waukegan
De Kalb
Chicago
Rock
Aurora
Elmhurst
Rock Island
Joliet
Chicago Heights
Moline
Galesburg
Kankakee
Peoria
Bloomington
ILLINOIS
OHIO
Quincy
Champaign
Urbana
Danville
SPRINGFIELD
Decatur
INDIANA
Mississippi
Illinois
Granite City
East St. Louis
Belleville
Wabash
MISSOURI
Ohio
Carbondale
KENTUCKY
Cairo

Chicago's "Green Alleys"

- Permeable pavements on the full width of an alley or simply in a center trench.
- Open bottom catch basins to capture water and funnel it into the ground


Alley with impermeable pavement and poor drainage.


Alley incorporating green alley principles.

Resource: http://www.cityofchicago.org/city/en/depts/cdot/provdrs/alley/svcs/green_alleys.html
Photos: http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf

FEDERAL AGENCIES

Stewardship
Safety
Sustainability

GREEN HIGHWAYS PARTNERSHIP

GREEN ROADS, STREETS and TOWNS

Green Highways Partnership

- "…voluntary public-private collaborative that advances environmental stewardship in transportation planning, design, construction, operations and maintenance while balancing economic and social objectives"
- Initiated by the USEPA and the FHWA
- Case Studies
- Watershed Based Stormwater management Group
- Recycle and Beneficial Reuse Group
- Conservation and Ecosystem Protection Group

Resource: http://www.greenhighwayspartnership.org/index.php

GHP Stormwater Technologies

1. Bioretention Swale
2. Pervious Pavement Shoulder
3. Environmentally Friendly Concrete
4. Preserved Forested Buffer
5. Restored & Stormwater Wetlands
6. Stream Restoration
7. Wildlife Crossing
8. Soil Amendments

GHP Innovative BMP Review

Technology	Innovation	Effectiveness	Relevance to Highway Use	Overall Score
Granular Activated Carbon Columns	3	3	2	8
GAC/IX w/ Detention/Sedimentation BMPs	3	3	1	7
GAC Sandwich and Filter Blanket	3	3	2	8
Ion Exchange Column	3	3	2	8
Aeration Systems	1	1	2	4
Bioretention - Filterra	3	3	4	10
Alum Treatment	2	3	2	7
Chitosan Treatment	2	3	2	7
Polyacrylimide Treatment	2	3	2	7
Below Grade Storage	3	1	3	7
Detention Basin - Outlet Improvement	2	1	3	6
Plate and Tube Settlers	3	3	3	9
Biocide Fabrics	3	2	2	7
Hypochlorite Chlorination	2	3	2	7
Ozone Disinfection	2	3	2	7
UV Disinfection	2	3	2	7
Baffle Boxes	2	2	3	7
Baskets/Boxes	2	2	2	6
Drain Inlet Inserts	2	2	3	7
Fabric Drain Inlet Insert	2	2	2	6
Filter Drain Inlet Insert	2	2	4	8
Screen Drain Inlet Insert	2	2	3	7
Trench Drain Insert	2	2	4	8
Filter Trench	2	3	3	8
Cartridge Filtration	3	2	3	8
Catch Basin Filters	2	2	3	7
Disc Filters	3	3	2	8
Pressure Filter	2	3	2	7
Hydrodynamic Separator	2	2	2	6
Below Grade Infiltration	3	4	4	11
Breakaway Bags	3	2	3	8
Porous Surfaces	4	4	3	11
Water Quality Inlet	2	2	3	7
Constructed Wetland	2	3	2	7
Detention Basin - Bladder Valve	4	3	2	9

PDH Q5

- Which of the following Stormwater Management Practices are acceptable to manage Runoff Reduction Volume?
  - Infiltration
  - Bioretention
  - Dry Swale
  - Sponge Bob

SUNY Albany Dry Swale

Latham Business Park Infiltration Basin

Bioretention - Portland, OR

Remember:

If you show that you’ve done the very best you can do, and are truly open to sound suggestions for improvement, people are more willing to work with you through the issues. We’re all working through the kinks together, and together we can help shape improvement.

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