TECHNICAL MEMORANDUM

TO: Project Steering Committee
Wood-Pawcatuck Watershed Flood Resiliency Management Plan

FROM: William Guenther, Scientist
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DATE: October 12, 2016

RE: Green Infrastructure Assessment
Wood-Pawcatuck Watershed Flood Resiliency Management Plan

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1. Introduction

Fuss and O'Neill performed a screening-level assessment of potential green infrastructure (GI) retrofit sites throughout the Wood-Pawcatuck watershed. The goal of this assessment is to identify opportunities and develop concepts for site-specific green infrastructure retrofits that achieve dual objectives – increase flood resiliency by reducing runoff volumes and peak flows and improve or protect water quality by reducing pollutant loads to receiving waters.

Green infrastructure refers to systems and practices that reduce surface water runoff through the use vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). Green infrastructure includes a variety of stormwater management practices, such as bioretention, engineered wetland systems, permeable pavement, green roofs, green streets, infiltration planters, tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of drainage systems and receiving waters.

Sites were selected and analyzed using Geographic Information System (GIS) mapping and associated geospatial data. GIS allows for rapid evaluation of specific land-based attributes that are important for assessing the feasibility of green infrastructure practices. In addition to selection and analysis of specific sites, streets within developed areas were also reviewed for their potential to support the use of green infrastructure within the public right-of-way, an approach which is referred to as "green streets." Green streets retrofits can range from simple roadside water quality or bioswales to more comprehensive streetscape retrofits including enhanced landscape design, bicycle and pedestrian access, and traffic-calming measures.

In addition to reducing polluted runoff and improving water quality, green infrastructure can improve flow conditions in streams and rivers by infiltrating water into the ground, thereby reducing peak flows during wet weather and sustaining or increasing stream base flow during dry periods, which can be important for aquatic habitat and fisheries. When applied throughout a watershed, green infrastructure can help mitigate flood risk and increase flood resiliency. At a smaller scale, green infrastructure can also reduce erosive velocities and streambank erosion.

Finally, green infrastructure has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change. For these reasons, many communities are exploring the use of and are adopting green infrastructure within their municipal infrastructure programs.

2. Assessment Methods and Findings

The overall green infrastructure assessment consists of three major tasks:

1. Screening-level assessment to quickly identify areas of the watershed with the greatest feasibility for and potential benefits from green infrastructure retrofits,
2. Field inventories of the most promising green infrastructure retrofit opportunities in the watershed identified from the screening step,
3. Green infrastructure concept designs for selected retrofit sites.

The technical memorandum documents the methods and findings of the screening-level assessment, as well as field inventories and green infrastructure concept designs for selected retrofit sites.

Site Screening Evaluation

A screening evaluation was conducted using publicly-available GIS data for Rhode Island and Connecticut to quickly identify specific sites within the watershed where green infrastructure retrofits can be implemented that would provide water quantity (i.e., runoff reduction) and water quality (i.e., pollutant reduction) benefits. The types of site or parcel-based green infrastructure retrofits with potential applicability in the watershed include:

- Permeable pavement
- Bioretention/bioswales
- Infiltration/filtration systems
- Wet vegetated treatment systems
- Tree boxes and tree planting
- Water harvesting and reuse.

The assessment used the following site evaluation criteria[1] and data sources. Slight variations in the evaluation criteria were required for sites in Rhode Island and Connecticut due to differences in information available from both states.

[1] Other site-specific factors such as land area, impervious area, drainage area, subsurface utilities, subsurface contamination, and storm drainage system capacity are also important considerations for green infrastructure retrofits.

1. Land Ownership – Publicly-owned (e.g., municipal) sites are most favorable because they avoid the cost of land acquisition and provide direct control over green infrastructure construction, maintenance, and monitoring by the municipality. Other publicly-owned sites such as schools, universities, state facilities, and federal facilities are also potential green infrastructure candidates. Certain types of private parcels (e.g., private schools and churches) may be suitable and were also included in the analysis.

   Publicly-owned properties in the watershed were identified and mapped using the 2011 Land Use/ Land Cover (LULC) dataset from RIGIS and the State/Municipal Parks and Open Space layer available from UCONN MAGIC. The following RIGIS land use categories were included in the selection process: institutional, developed recreation, cemeteries, and airports. The following facility point data was also included in the analysis: colleges and universities (University of Rhode Island), fire stations, schools (public and private), hospitals, libraries, and State Comprehensive Outdoor Recreation Plan (SCORP) sites.

2. Development – Sites within developed areas typically have greater potential for green infrastructure retrofits. Developed areas are more at-risk for flood damages and typically generate greater runoff volumes than undeveloped or lightly-developed areas. The site screening criteria included the following categories from the 2011 Land Use/ Land Cover data: low density development, medium density development, and high density development.

3. Subsurface Conditions – Subsurface conditions are key considerations for infiltration-based green infrastructure retrofits. Soil infiltration capacity, depth to groundwater, depth to restrictive layers (bedrock, dense till), soil bulk density, and inundation of soils due to flooding are important soil-based characteristics that can affect the feasibility of infiltration-based green infrastructure retrofits.[2] For the purposes of this screening evaluation, Natural Resources Conservation Services (NRCS) soil classifications and the Soil Survey Geographic (SSURGO) database were used to assess the feasibility of infiltration practices at a given site. The following describes the soils criteria used in the evaluation:

   o <u>Hydrologic Soil Group</u> – Hydrologic Soil Groups (HSGs) mapped by the NRCS provide an initial estimate of infiltration rate and storage capacity of soils on a site. Group A soils have the lowest runoff potential (highest infiltration rates) and Group D soils have the highest runoff potential (lowest infiltration rates) when thoroughly wet. Soils with higher infiltration capacities are generally better suited for green infrastructure. HSG mapping provides an initial estimate of infiltration potential; field investigations are necessary to verify soil conditions for final feasibility determinations and design purposes.

   o <u>Seasonal High Water Table</u> – Depth to the groundwater table is an important consideration for green infrastructure practices that rely on infiltration or water storage, such as constructed wetlands and stormwater basins. Infiltration practices typically require at least 3 feet of separation between the bottom of the infiltration system and seasonal high groundwater. A deep groundwater table also allows for water storage capacity in the upper part of the soils horizon and can indicate areas where stormwater basin construction is feasible.

4. Impaired Waters – In order to locate green infrastructure where it will have the greatest benefit to water quality, sites were selected that are in close proximity to impaired waters, which are surface waters that do not meet current water quality standards for specific uses such as recreation and aquatic life. For this screening-level analysis, sites within 1/2 mile of mapped water quality impairment were assumed to discharge to the impaired water body.

5. Impervious Cover – Water quality impacts are known to occur in surface waters within drainage basins that have a high degree of impervious cover due to changes in watershed hydrology and pollutant sources that result from development of the landscape with hard surfaces. Sites with higher amounts of impervious cover generate more runoff and have greater potential for runoff reduction through the use of green infrastructure retrofits. Areas with a high degree of development and impervious surfaces are generally considered high priority for green infrastructure implementation. Selection criteria included site impervious coverage of over 30% or at least 1 acre of total impervious cover on a given site.

Application of Site Screening Criteria

Attachment 1 depicts an example of the screening methodology applied to the portion of the watershed within the Town of Westerly, Rhode Island. The example is provided to demonstrate the screening methodology and results at a smaller, more readable scale since the methodology and results cannot be easily visualized (in a report format) at the scale of the overall Wood-Pawcatuck watershed. A watershed-wide map at a larger scale was prepared for field investigations.

The site screening process described above was performed by applying each of the screening criteria in succession, thereby reducing the number of selected sites with each successive screening criterion. The results of the site screening process are summarized below and in the example maps in *Attachment 1* for the Westerly portion of the watershed.

1. Site Screening Criterion: Publicly-owned sites within the watershed

    - Rhode Island GIS data layer 2011 Land Use - Land Cover: "Institutional", "Developed Recreation", "Cemeteries", and "Airports"; or
    - Connecticut: GIS State-Municipal Parks and Open Space; or
    - Rhode Island facility point data including colleges and universities, fire stations, schools, hospitals, libraries and State Comprehensive Outdoor Recreation Plan

    Number of sites: 253

2. Site Screening Criterion: Sites with A or B soils and within developed areas

    - Hydrologic Soil Group (HSG) A or B Soils; and
    - Developed Areas

Number of sites: 175/253

3. Site Screening Criterion: Sites with a depth to seasonal high groundwater of at least 6 feet

   - Soils with a seasonal high water at a depth greater than six feet.

     Number of sites: 163/175

4. Site Screening Criterion: Sites within ½ mile of an impaired surface water body

   - Sites within 1/2 mile of an impaired surface water body

   Number of sites: 129/163

5. Site Screening Criterion: Sites with at least 30% impervious, or 1 acre impervious cover.

   Number of sites: 104/129

   (The final example map lists 106 sites. Two sites were combined with nearby sites because they were part of the same complex, under the same ownership.)

Site Screening Results

A total of 104 sites were identified based on the GIS-based screening evaluation. Subsequent to the GIS-based screening, ownership information and aerial photographs were reviewed to verify the suitability of each site for green infrastructure retrofits. Some of the sites were eliminated from further consideration, including sites under private ownership, like golf courses, and sites with relatively small areas of impervious cover that are surrounded by large upland areas, which typically do not generate significant off-site runoff. This final review reduced the number of sites for field level investigation to 82. A few of the sites within the selection are located in the same area. For instance, the University of Rhode Island ("URI") has two separate sites, located at different parts of the campus.

The field investigation included an assessment of the feasibility of green infrastructure retrofits for each site, including specific types of green infrastructure practices, their potential location(s) on the site, expected runoff and pollutant reduction benefits, and other design considerations. Thirty sites were selected from the total of 82 for development of green infrastructure retrofit concepts.

Table 1 lists the geographic distribution of the selected 84 sites within the watershed, which are also shown on the watershed map in Attachment 4.

Table 1. Geographic distribution of potential green infrastructure retrofit sites.

Town	Number of Sites
Charlestown, Rhode Island	6
Exeter, Rhode Island	9
Hopkinton, Rhode Island	18
North Stonington	2
Richmond, Rhode Island	6
South Kingstown, Rhode Island	11
Stonington, Connecticut	3
West Greenwich, Rhode Island	1
Westerly , Rhode Island	26

Sites are generally located in more developed areas of the watershed. Other sites may be considered for field review based on input from the Project Steering Committee, including other publicly-owned sites that are known to contribute to local flooding, sites that are known to contribute to local water quality issues, or sites that may provide significant public education benefit as green infrastructure demonstration sites.

Table 2 is an abbreviated list of all 82 sites from the Excel spreadsheet found in Attachment 2. The spreadsheet includes additional information including acreage, parcel identification numbers, and latitude and longitude locations. Aerial photographs of each site are provided in Attachment 3. Regulatory flood zones are shown on the aerial photographs to avoid siting green infrastructure retrofits within the floodplain.

Table 2. Potential green infrastructure retrofit sites selected for field investigation.

Site Name/Description	Address	Town
Vin Gormley Trailhead Parking	24 Sanctuary Road	Charlestown
Burlingame Management Area	Burlingame State Park Rd	Charlestown
Shannock Baptist Church	1632 Shannock Road	Charlestown
St. Mary's Catholic Church	451-455 Carolina Back Road	Charlestown
Burlingame Management Area	Burlingame State Park Rd	Charlestown
Charlestown Elementary School	363 Carolina Back Road	Charlestown
St. Kateria Tekakwitha Catholic Church	Exeter Rd	Exeter
Exeter Town Animal Shelter	165 S. County Trail	Exeter
Unidentified Building near Animal Shelter	175 S. County Trail	Exeter
Building with Parking Lot	742 Ten Rod Road	Exeter
Exeter Town Hall	675 Ten Rod Road	Exeter
Parking Lot Near Lake	406 Arcadia Road	Exeter
Exeter Job Corps Center	162 Main Street	Exeter
Phoenix House	Gaspee Road and Main Street	Exeter
Exeter Public Library	762 Ten Rod Road	Exeter

Table 2. Potential green infrastructure retrofit sites selected for field investigation.

Site Name/Description	Address	Town
Wood River Health Services	823 Main Street	Hopkinton
Hopkinton Recreation Department	188 Main Street	Hopkinton
Pavillion Steak House	35 Frontier Road	Hopkinton
Chariho Little League	1118 Main Street	Hopkinton
Wyoming Dam Fishing Access	Bridge Street	Hopkinton
Babcock Presbyterian Church	25 Maxson Street	Hopkinton
U.S. Post Office (Ashaway, RI)	131 Main Street	Hopkinton
Seventh Day Baptist Church	8 Church Street	Hopkinton
Ashaway Volunteer Fire Association	213 Main St	Hopkinton
Unidentified Building with Parking Lot	72 High Street	Hopkinton
Trinity Lutheran Church	Rte 216 and Wellstown Rd	Hopkinton
Hope Valley - Wyoming Fire District	996 Main St	Hopkinton
Langworthy Public Library	24 Spring Street	Hopkinton
Abandoned Parking Lot	North of 894 Main Street	Hopkinton
Ashaway Elementary School	12A Hillside Avenue	Hopkinton
Wood River Preschool and Elementary School	1059 Main Street	Hopkinton
Possible DPW facility	51 Bank Street	Hopkinton
Unknown (close to WPWA headquarters)	260 Arcadia Road	Hopkinton
Wheeler High/Middle School	298 Norwich-Westerly Road	N. Stonington
N. Stonington Superintendent and School	313-317 Norwich-Westerly Rd.	N. Stonington
West Vine Street School	25 West Vine Street	Stonington/Pawcatuck
Richmond Carolina Fire District	203 Richmond Town House Rd.	Richmond
Richmond Police Department	1168 Main Street	Richmond
Rhode Island State Police	54 Nooseneck Hill Road	Richmond
Chariho Regional H.S/M.S and Career Center	453 Switch Road	Richmond
Richmond Town Hall	5 Richmond Townhouse	Richmond
Richmond Elementary School	190 Kingstown Road	Richmond
URI, Boss Arena	1 Keaney Road,	South Kingstown
URI, Tennis Courts	Kingstown Road	South Kingstown
Great Swamp Management Area	160-170 Great Neck Road	South Kingstown
West Kingston Fire Department	390 Fairgrounds Road	South Kingstown
West Kingstown Baptist Church	263 Waites Corner Road	South Kingstown
Tuckertown Park	101 Tuckertown Park Drive	South Kingstown
Ryan Center/Meade Stadium	West Alumni Avenue	South Kingstown
West Kingston Services/Center for the Arts	3481 Kingstown Road	South Kingstown
South Kingstown Nursing and Rehab	2115 South County Trail	South Kingstown
West Kingston Elementary School	3119 Ministerial Road	South Kingstown
Unknown	210 Flagg Road	South Kingstown

Table 2. Potential green infrastructure retrofit sites selected for field investigation.

Site Name/Description	Address	Town
West Broad Street School	W. Broad Street	Stonington
West Vine Street School	25 West Vine Street	Stonington
Parking Lot	350 Liberty Street	Stonington
Small Building with Parking Lot	302 Victory Highway	West Greenwich
Watch Hill Fire Department	222 Watch Hill Rd	Westerly
U.S. Post Office	110 Tom Harvey Road	Westerly
Westerly Fire Department	180 Beach Street	Westerly
Unknown Church	45 Elm Street	Westerly
Pilgrim Baptist Church- Central Nursery School	16 Elm Street	Westerly
Grace United Methodist Church	10 Park Ave	Westerly
Immaculate Conception Catholic Church	111 High Street	Westerly
Westerly Town Water Department	68 White Rock Road	Westerly
Bradford School	15 Church Street	Westerly
Westerly Packing	15 Springbrook Road	Westerly
Springbrook Elementary School	39 Springbrook Road	Westerly
Bradford Social Club	2 Bowling Lane	Westerly
Westerly State Airport	62 Airport Road	Westerly
Rotary Park	near 90 Airport Road	Westerly
Public Sports Complex	99 Wilson Street	Westerly
Ocean Community YMCA	77-85 High Street	Westerly
Craig Field Recreation Complex	Mountain Avenue	Westerly
Parking Lot for Football Field	60 Old Hopkinton Road	Westerly
The Westerly Hospital	25 Wells Street	Westerly
Westerly Senior Citizens Center and School	35 State Street	Westerly
St. Pius X School	32 Elm Street	Westerly
Westerly High School	23 Ward Avenue	Westerly
Westerly Town Hall	45 Broad Street	Westerly
93 Tower Street	93 Tower Street	Westerly
Westerly Health Center	280 High Street	Westerly
Bus Depot	8 Springbrook Road	Westerly

Streets Screening Evaluation

A GIS-based screening evaluation was also conducted to identify public streets in the watershed that are potential candidates for green infrastructure retrofits, either along the side of the roadway or below the road surface. This approach is also referred to as "green streets." The feasibility of implementing green infrastructure within the public right-of-way depends on several factors including road type, local topography, soils, and depth to groundwater. The types of green streets or right-of-way green infrastructure retrofits with potential applicability in the watershed include:

- Roadside bioswales/linear bioretention
- Water quality swales
- Belowground infiltration systems including infiltrating catch basins (with appropriate pretreatment)
- Permeable pavement (sidewalks, on-street parking spaces, and low-traffic areas)
- Tree boxes and tree planting (primarily streetscape applications).

The assessment used the following evaluation criteria and data sources. Similar to the sites criteria, slight variations in the evaluation criteria were required for streets in Rhode Island and Connecticut due to differences in information available from both states.

1. Road Type – High traffic volumes and high speed limits are not favorable road conditions for siting right-of-way green infrastructure. Therefore, the evaluation only considered roads classified by the Rhode Island Department of Transportation as "minor roads," "arterials," and "collectors" and roads classified as "primary and secondary roads" in Connecticut.

2. Surrounding Development – Streets within developed areas typically have greater potential for green infrastructure retrofits since developed areas are more at-risk for flood damages and typically generate greater runoff volumes than undeveloped or lightly-developed areas. The screening criteria included streets within areas of developed land use based on the 2011 Land Use/ Land Cover dataset.

3. Subsurface Conditions – Similar to the site screening criteria, streets were selected in areas with Hydrologic Soil Group A and B soils and with groundwater at a depth of at least 6 feet based on soil classification. Streets that are located in areas with these subsurface conditions and meet the above criteria are classified as "low priority" retrofit candidates for street or right-of-way green infrastructure retrofits.

4. Proximity to Surface Water Bodies – Streets within areas having the above characteristics and within ½ mile of a main stem river are identified as "medium priority" retrofit candidates. Main-stem rivers are the primary trunks or downstream segments of a river. Right-of-way retrofits and green streets initiatives typically require "buy-in" from the local community. It is often helpful to garner public support for such projects by focusing on areas located close to familiar and recognized water resources, allowing the public to connect the benefits of the project to well-known local resources.

5. Proximity to Impaired Waters – Streets within areas having the above characteristics and within ½ mile of an impaired water body are identified as "high priority" retrofit candidates. Managing and treating stormwater in close proximity to impaired waters will benefit surface waters most in need of improvement.

Streets Screening Results

The maps in Attachment 5 show prioritized street locations in each subwatershed for right-of-way green infrastructure retrofits. Streets in several high priority areas were evaluated based on review of aerial photographs and limited on-site investigation. Several right-of-way green infrastructure concepts were developed as examples of the type of opportunities that exist in the watershed, including roads located in developed and rural settings.

3. Field Inventories, Site Selection, and Conceptual Designs

Field Inventories

Site visits were conducted at the 82 selected priority sites in June and early July, 2016. The sites and adjacent street areas were walked and visually inspected for potential green infrastructure retrofit opportunities (i.e., impervious surfaces connected to the on-site drainage system, available green space to accommodate new green infrastructure practices, site configuration, drainage features that could be enhanced or improved) and physical site characteristics such as site configuration, drainage patterns, current use, slope, landscaping, subsurface utilities, design complexity, and maintenance access considerations. Field notes on potential green infrastructure retrofit sites were recorded using inventory forms developed by the Center for Watershed Protection and photographs were taken at each location (Attachments 6 and 7).

Sites Selected for Concept Designs

Based on the findings of the field inventories, green infrastructure retrofit opportunities were identified at most of the sites visited. Table 3 identifies the 30 sites selected for development of concept designs. These sites were selected because they: (1) have the greatest feasibility for green infrastructure retrofits, (2) provide the best opportunities to infiltrate (i.e., reduce) runoff, and (3) are distributed geographically throughout the Wood-Pawcatuck watershed. Many of the sites are also in highly visible, public locations and therefore provide good demonstration value.

Table 3. List of sites selected for conceptual designs

Site No.	Site Drainage Area No.	Site Name	Green Infrastructure BMP Type
21	21a	Vin Gormley Trailhead Parking	Underground Infiltration
21	21b	Vin Gormley Trailhead Parking	Bioretention
41	41	URI Tennis Courts	Rain Gardens
50	50a	Wyoming Dam Fishing Access	Pervious Pavers
50	50b	Wyoming Dam Fishing Access	Articulated Concrete Mat
50	50c	Wyoming Dam Fishing Access	Bioretention

Table 3. List of sites selected for conceptual designs

Site No.	Site Drainage Area No.	Site Name	Green Infrastructure BMP Type
73	73	Exeter Town Animal Shelter	Bioretention
93	93a	US Post Office in Westerly	Bioretention
93	93b	US Post Office in Westerly	Bioretention
93	93c	US Post Office in Westerly	Bioretention
93	93d	US Post Office in Westerly	Bioretention
102	102	United Methodist Church	Bioretention
108	108a	Bradford School	Green Roof
108	108b	Bradford School	Underground Infiltration
114	114a	US Post Office in Ashaway/Hopkinton	Underground Infiltration
114	114b	US Post Office in Ashaway/Hopkinton	Underground Infiltration
125	125a	Trinity Lutheran Church	Rain Gardens
125	125b	Trinity Lutheran Church	Rain Gardens
125	125c	Trinity Lutheran Church	Rain Gardens
125	125d	Trinity Lutheran Church	Bioretention
125	125e	Trinity Lutheran Church	Bioretention
129	129	St Mary's Catholic Church	Bioretention
139	139a	Courthouse Center for the Arts	Bioretention
139	139b	Courthouse Center for the Arts	Bioretention
157	157	Richmond Police Department	Underground Infiltration
159	159	RI State Police	Bioretention
173	173a	Exeter Town Hall	Bioretention
173	173b	Exeter Town Hall	Rain Gardens
185	185a	Wheeler High/Middle School	Bioretention
194	185b	Wheeler High/Middle School (combined with drainage area 194d)	Bioretention
185	185c	Wheeler High/Middle School	Bioretention
185A	185d	Wheeler High/Middle School	Bioretention
185A	185e	Wheeler High/Middle School	Bioretention
191	191a	West Vine Street School	Rain Gardens
191	191b	West Vine Street School	Rain Gardens
194	194a	North Stonington Elementary and Administration Buildings	Bioretention
194	194b	North Stonington Elementary and Administration Buildings	Bioretention
194	194c	North Stonington Elementary and Administration Buildings	Bioretention
194	194d	North Stonington Elementary and Administration Buildings	Bioretention
194	194e	North Stonington Elementary and Administration Buildings	Bioretention
194	194f	North Stonington Elementary and	Bioretention

Table 3. List of sites selected for conceptual designs

Site No.	Site Drainage Area No.	Site Name	Green Infrastructure BMP Type
		Administration Buildings	
194	194g	North Stonington Elementary and Administration Buildings	Bioretention
206	206a	Browning Mill Pond Parking Access	Forested Buffer
206	206b	Browning Mill Pond Parking Access	Forested Buffer
206	206d	Browning Mill Pond Parking Access	Bioretention
227	227	Hopkinton Recreation Department	Bioretention
229	229	Tuckertown Park	Bioswales
252	252a	Chariho Little League	Rain Gardens
252	252b	Chariho Little League	Rain Gardens
252	252c	Chariho Little League	Rain Gardens
272A	272a	Westerly Senior Center	Bioretention
272	272b	State Street School	Rain Gardens
272	272c	State Street School	Bioretention
274	274	Westerly High School	Underground Infiltration
275	275	Westerly Town Hall	Bioretention
276	276	Tower Street School and Community Center	Bioretention
280	280a	Ashaway Elementary School	Underground Infiltration
280	280b	Ashaway Elementary School	Bioretention
283	283a	West Kingstown Elementary	Underground Infiltration
283	283b	West Kingstown Elementary	Bioretention
284	284	URI Lot at Boss Arena	Underground Infiltration
286	286a	Richmond Elementary School	Bioretention
286	286b	Richmond Elementary School	Bioretention

Concept Designs

Conceptual green infrastructure retrofit designs were prepared for the selected sites. The design concepts reflect opportunities for infiltration and/or water quality treatment at each site. BMPs were sited to capture and infiltrate/treat the 1-inch Water Quality Volume (WQv), where possible. Opportunities were also evaluated to manage additional runoff from on-site and off-site drainage areas.

Preliminary, planning-level costs were estimated for the site-specific concepts based upon unit costs derived from published sources, engineering experience, and the proposed design concepts. Capital (construction, design, permitting, and contingency) and operation and maintenance costs are included in the estimates, and total annualized costs are presented based on the anticipated design life of each green infrastructure practice. A more detailed breakdown of estimated costs is included in Attachment 9.

Pollutant loads were estimated based upon the land uses associated with each drainage area, using published land use pollutant loading factors for Total Phosphorus, Total Nitrogen, Total Suspended Solids and Fecal Coliform Bacteria. Pollutant load reductions were estimated for each individual drainage area based on published pollutant removal efficiencies for various types of BMPS and the sizing of each individual BMP. Pollutant load reduction calculations are provided in Attachment 10.

The retrofit design concepts, including planning-level costs and estimated pollutant removals, are presented on the concept sheets in Attachment 8. Each concept sheet includes a general site description, the proposed retrofit concept, field images with renderings of retrofit opportunities (where available), typical details of recommended BMPs, and estimates of pollutant removal, runoff reduction, and cost.

The green infrastructure retrofit concepts presented in this technical memorandum provide potential on-the-ground projects for future implementation. They also serve as examples of the types of projects that could be implemented at similar sites throughout the watershed. It is important to emphasize that these design concepts are not detailed designs. Individual project proponents (e.g., municipalities, private property owners, developers) are responsible for evaluating the ultimate feasibility of, as well as design and permitting for, these and similar site-specific concepts.

Attachments:
Attachment 1: Example Site Screening Selection – Westerly, Rhode Island
Attachment 2: Spreadsheet of Potential Green Infrastructure Retrofit Sites
Attachment 3: Aerial Photographs of Selected Retrofit Sites
Attachment 4: Watershed Map of Potential Green Infrastructure Retrofit Sites
Attachment 5: Subwatershed Maps with Potential Green Infrastructure Retrofits
Attachment 6: Field Sheets
Attachment 7: Field Photos
Attachment 8: Retrofit Conceptual Designs
Attachment 9: Planning Level Cost Estimates
Attachment 10: Pollutant Loading and Reduction Calculations

Attachment 1

Example Site Screening Selection – Westerly, Rhode Island

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Attachment 2

Spreadsheet of Potential Green Infrastructure Retrofit Sites

Attachment 3

Aerial Photographs of Selected Retrofit Sites

Attachment 4

Watershed Map of Potential Green Infrastructure Retrofit Sites

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Attachment 5

Example Streets Screening Selection – Westerly, Rhode Island

Attachment 6

Field Sheets

Attachment 7

Field Photos

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Attachment 8

Retrofit Conceptual Designs

Attachment 9

Planning Level Cost Estimates

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Attachment 10

Pollutant Loading and Reduction Calculations