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Draft

Impervious Cover Assessment for Woodbridge Township, Middlesex County, New Jersey

Prepared for Woodbridge Township by the Rutgers Cooperative Extension Water Resources Program

February 2, 2015

Introduction

Pervious and impervious are terms that are used to describe the ability or inability of water to flow through a surface. When rainfall hits a surface, it can soak into the surface or flow off the surface. Pervious surfaces are those which allow stormwater to readily soak into the soil and recharge groundwater. When rainfall drains from a surface, it is called "stormwater" runoff (Figure 1). An impervious surface can be any material that has been placed over soil that prevents water from soaking into the ground. Impervious surfaces include paved roadways, parking lots, sidewalks, and rooftops. As impervious areas increase, so does the volume of stormwater runoff.

Figure 1: Stormwater draining from a parking lot

New Jersey has many problems due to stormwater runoff, including:

- Pollution: According to the 2010 New Jersey Water Quality Assessment Report, 90% of the assessed waters in New Jersey are impaired, with urban-related stormwater runoff listed as the most probable source of impairment (USEPA, 2013). As stormwater flows over the ground, it picks up pollutants including animal waste, excess fertilizers, pesticides, and other toxic substances. These pollutants are then able to enter waterways.

- Flooding: Over the past decade, the state has seen an increase in flooding. Communities around the state have been affected by these floods. The amount of damage caused also has increased greatly with this trend, costing billions of dollars over this time span.

- Erosion: Increased stormwater runoff causes an increase in the velocity of flows in our waterways. The increased velocity after storm events erodes stream banks and shorelines, degrading water quality. This erosion can damage local roads and bridges and cause harm to wildlife.

The primary cause of the pollution, flooding, and erosion problems is the quantity of impervious surfaces draining directly to local waterways. New Jersey is one of the most developed states in the country. Currently, the state has the highest percent of impervious cover in the country at 12.1% of its total area (Nowak & Greenfield, 2012). Many of these impervious surfaces are directly connected to local waterways (i.e., every drop of rain that lands on these impervious surfaces ends up in a local river, lake, or bay without any chance of being treated or soaking into the ground). To repair our waterways, reduce flooding, and stop erosion, stormwater runoff from impervious surfaces has to be better managed. Surfaces need to be disconnected with green infrastructure to prevent stormwater runoff from flowing directly into New Jersey's waterways. Disconnection redirects runoff from paving and rooftops to pervious areas in the landscape.

Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure projects capture, filter, absorb, and reuse stormwater to maintain or mimic natural systems and to treat runoff as a resource. As a general principal, green infrastructure practices use soil and vegetation to recycle stormwater runoff through infiltration and evapotranspiration. When used as components of a stormwater management system, green infrastructure practices such as bioretention, green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits (USEPA, 2013).

The first step to reducing the impacts from impervious surfaces is to conduct an impervious cover assessment. This assessment can be completed on different scales: individual lot, municipality, or watershed. Impervious surfaces need to be identified for stormwater management. Once impervious surfaces have been identified, there are three steps to better manage these surfaces.

1. ***Eliminate surfaces that are not necessary.*** For example, a paved courtyard at a public school could be converted to a grassed area.

2. ***Reduce or convert impervious surfaces.*** There may be surfaces that are required to be hardened, such as roadways or parking lots, but could be made smaller and still be functional. A parking lot that has two-way car ways could be converted to one-way car ways. There also are permeable paving materials such as porous asphalt, pervious concrete, or permeable paving stones that could be substituted for impermeable paving materials (Figure 2).

3. ***Disconnect impervious surfaces from flowing directly to local waterways.*** There are many ways to capture, treat, and infiltrate stormwater runoff from impervious surfaces. Opportunities may exist to reuse this captured water.

Figure 2: Rapid infiltration of water through porous pavement is demonstrated at the USEPA Edison New Jersey test site

Woodbridge Township Impervious Cover Analysis

Located in Middlesex County in central New Jersey, Woodbridge Township covers approximately 24.0 square miles west of Arthur Kill, a tidal strait separating Staten Island, New York City from New Jersey. Figures 3 and 4 illustrate that Woodbridge Township is dominated by urban land uses. A total of 79.2% of the municipality's land use is classified as urban. Of the urban land in Woodbridge Township, medium and high density residential are the dominant land uses (Figure 5).

The literature suggests a link between impervious cover and stream ecosystem impairment starting at approximately 10% impervious surface cover (Schueler, 1994; Arnold and Gibbons, 1996; May et al., 1997). Impervious cover may be linked to the quality of lakes, reservoirs, estuaries, and aquifers (Caraco et al., 1998), and the amount of impervious cover in a watershed can be used to project the current and future quality of streams. Based on the scientific literature, Caraco et al. (1998) classified urbanizing streams into the following three categories: sensitive streams, impacted streams, and non-supporting streams. Sensitive steams typically have a watershed impervious surface cover from 0 – 10%. Impacted streams have a watershed impervious cover ranging from 11-25% and typically show clear signs of degradation from urbanization. Non-supporting streams have a watershed impervious cover of greater than 25%; at this high level of impervious cover, streams are simply conduits for stormwater flow and no longer support a diverse stream community.

The New Jersey Department of Environmental Protection's (NJDEP) 2007 land use/land cover geographical information system (GIS) data layer categorizes Woodbridge Township into many unique land use areas, assigning a percent impervious cover for each delineated area. These impervious cover values were used to estimate the impervious coverage for Woodbridge Township. Based upon the 2007 NJDEP land use/land cover data, approximately 38.7% of Woodbridge Township has impervious cover. This level of impervious cover suggests that the streams in Woodbridge Township are likely non-supporting streams.

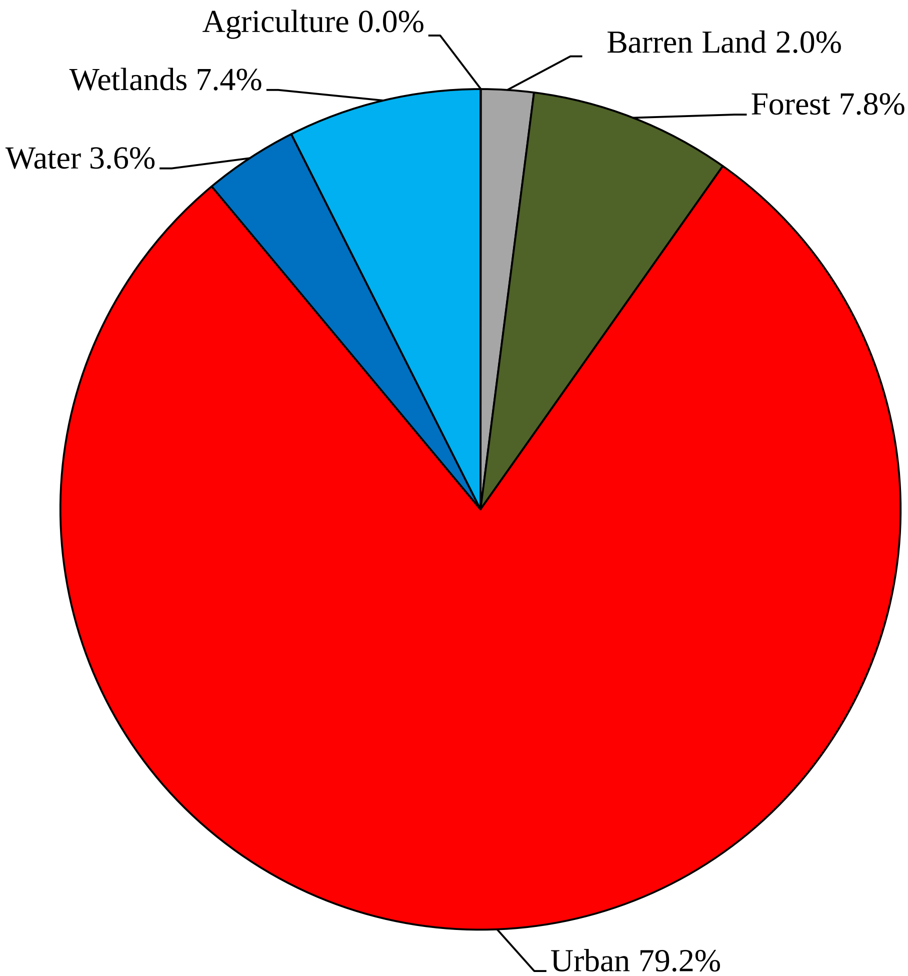


Figure 3: Pie chart illustrating the land use in Woodbridge Township

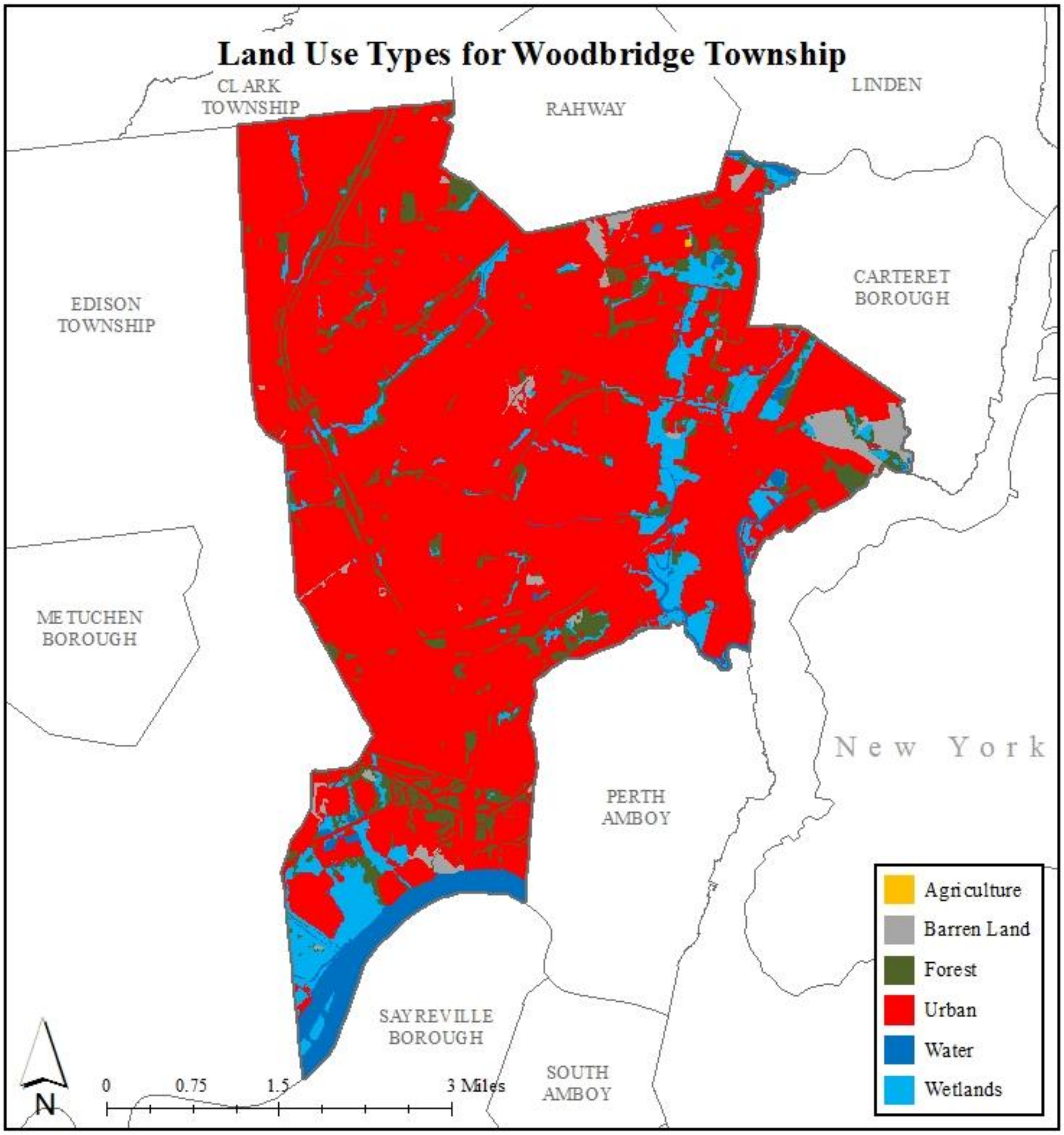


Figure 4: Map illustrating the land use in Woodbridge Township

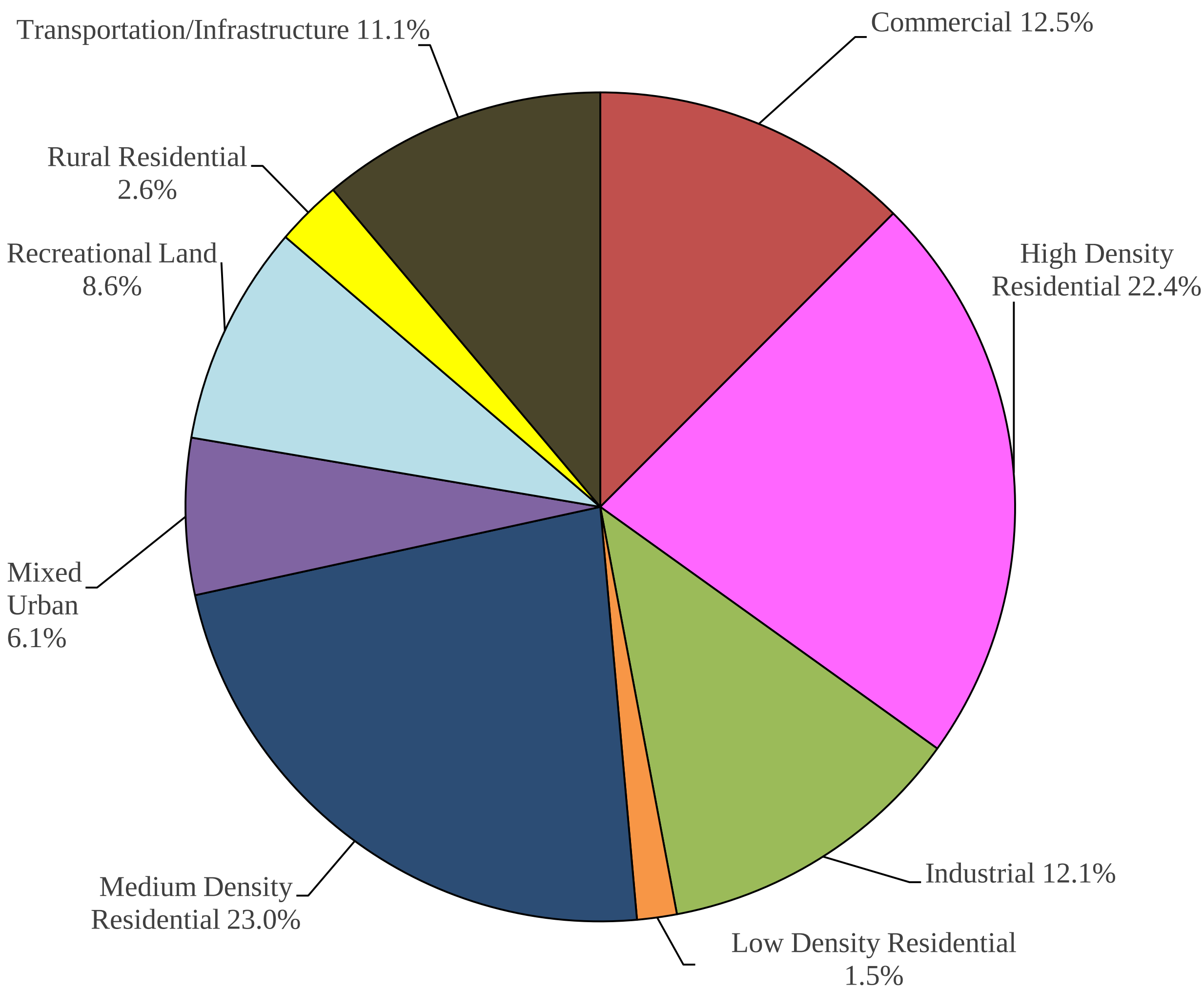


Figure 5: Pie chart illustrating the various types of urban land use in Woodbridge Township

Water resources are typically managed on a watershed/subwatershed basis; therefore an impervious cover analysis was performed for each Raritan River subwatershed within Woodbridge Township (Table 1 and Figure 6). On a subwatershed basis, impervious cover ranges from 28.6% in the Arthur Kill Waterfront subwatershed to 46.6% in the Lower Raritan River subwatershed. Evaluating impervious cover on a subwatershed basis allows the municipality to focus impervious cover reduction or disconnection efforts in the subwatersheds where frequent flooding occurs.

In developed landscapes, stormwater runoff from parking lots, driveways, sidewalks, and rooftops flows to drainage pipes that feed the sewer system. The cumulative effect of these impervious surfaces and thousands of connected downspouts reduces the amount of water that can infiltrate into soils and greatly increases the volume and rate of runoff that flows to waterways. Stormwater runoff volumes (specific to Woodbridge Township, Middlesex County) associated with impervious surfaces were calculated for the following storms: the New Jersey water quality design storm of 1.25 inches of rain, an annual rainfall of 44 inches, the 2-year design storm (3.3 inches of rain), the 10-year design storm (5.1 inches of rain), and the 100-year design storm (8.6 inches of rain). These runoff volumes are summarized in Table 2. A substantial amount of rainwater drains from impervious surfaces in Woodbridge Township. For example, if the stormwater runoff from one water quality storm (1.25 inches of rain) in the Rahway River subwatershed was harvested and purified, it could supply water to 574 homes for one year[1].

[1] Assuming 300 gallons per day per home

Table 1: Impervious cover analysis by subwatershed for Woodbridge Township

Subwatershed	Total Area		Land Use Area		Water Area		Impervious Cover		
	(ac)	(mi^2)	(ac)	(mi^2)	(ac)	(mi^2)	(ac)	(mi^2)	(%)
Arthur Kill Waterfront	1,155.0	1.80	1,113.2	1.74	41.8	0.07	318.6	0.50	28.6%
Mill Brook/ Martins Creek	42.5	0.07	42.5	0.07	0.00	0.00	15.9	0.02	37.3%
Rahway River	4,939.6	7.72	4,900.0	7.66	39.6	0.06	1,851.1	2.89	37.8%
Lower Raritan River	1,566.6	2.45	1,197.3	1.87	369.3	0.58	522.2	0.82	46.6%
Red Root Creek	1,185.0	1.85	1,149.5	1.80	35.6	0.06	377.6	0.59	32.8%
Robinsons Brook	1,307.9	2.04	1,303.3	2.04	4.61	0.01	450.8	0.70	34.6%
Woodbridge Creek	5,171.3	8.08	5,106.5	7.98	64.7	0.10	2,189.3	3.42	42.9%
Total	15,368.0	24.0	14,812.4	23.1	555.6	0.87	5,725.4	8.95	38.7%

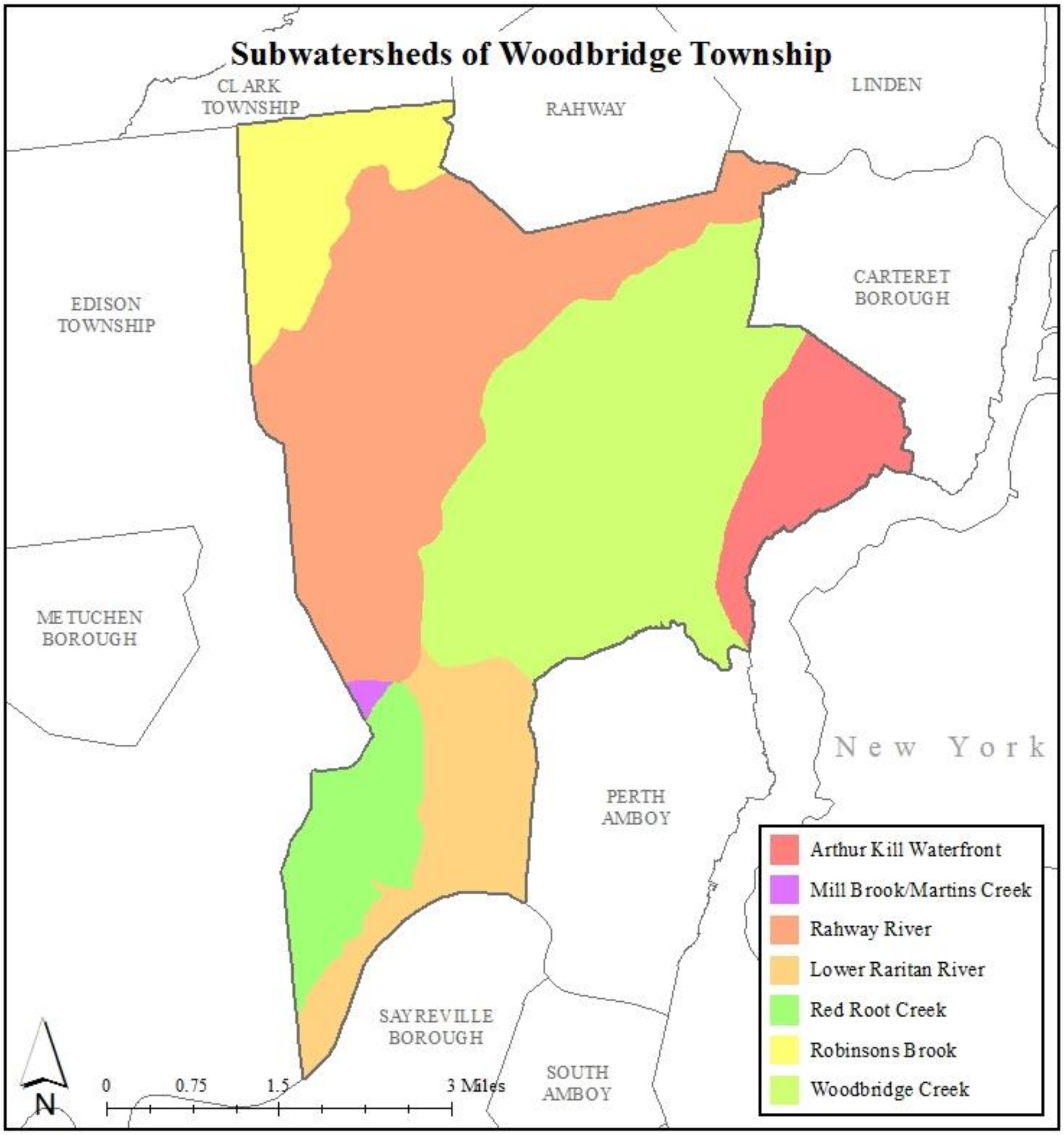


Figure 6: Map of the subwatersheds in Woodbridge Township

Table 2: Stormwater runoff volumes from impervious surfaces by subwatershed in Woodbridge Township

Subwatershed	**Total Runoff Volume for the 1.25" NJ Water Quality Storm (MGal)**	**Total Runoff Volume for the NJ Annual Rainfall of 44" (MGal)**	**Total Runoff Volume for the 2-Year Design Storm (3.3") (MGal)**	**Total Runoff Volume for the 10-Year Design Storm (5.1") (MGal)**	**Total Runoff Volume for the 100-Year Design Storm (8.6") (MGal)**
Arthur Kill Waterfront	10.8	380.6	28.5	44.1	74.4
Mill Brook/ Martins Creek	0.5	19.0	1.4	2.2	3.7
Rahway River	62.8	2,211.5	165.9	256.3	432.3
Lower Raritan River	17.7	623.8	46.8	72.3	121.9
Red Root Creek	12.8	451.1	33.8	52.3	88.2
Robinsons Brook	15.3	538.6	40.4	62.4	105.3
Woodbridge Creek	74.3	2,615.5	196.2	303.2	511.2
Total	194.3	6,840.1	513.0	792.8	1,337.0

The next step is to set a reduction goal for impervious area in each watershed. Based upon the Rutgers Cooperative Extension (RCE) Water Resources Program's experience, a 10% reduction would be a reasonably achievable reduction for these watersheds in Woodbridge Township. While it may be difficult to eliminate paved areas or replace paved areas with permeable pavement, it is relatively easy to identify impervious surfaces that can be disconnected using green infrastructure practices. For all practical purposes, disconnecting an impervious surface from a storm sewer system or a water body is an "impervious area reduction." The RCE Water Resources Program recommends that all green infrastructure practices that are installed to disconnect impervious surfaces should be designed for the 2-year design storm (3.3 inches of rain over 24-hours). Although this results in management practices that are slightly over-designed by NJDEP standards, which require systems to be designed for the New Jersey water quality storm (1.25 inches of rain over 2-hours), these systems will be able to handle the increase in storm intensities that are expected to occur due to climate change. By designing these management practices for the 2-year design storm, these practices will be able to manage 95% of the annual rainfall volume. The recommended annual reductions in runoff volumes are shown in Table 3.

As previously mentioned, once impervious surfaces have been identified, the next steps for managing impervious surfaces are to 1) eliminate surfaces that are not necessary, 2) reduce or convert impervious surfaces to pervious surfaces, and 3) disconnect impervious surfaces from flowing directly to local waterways.

Elimination of Impervious Surfaces

One method to reduce impervious cover is to "depave." Depaving is the act of removing paved impervious surfaces and replacing them with pervious soil and vegetation that will allow for the infiltration of rainwater. Depaving leads to the re-creation of natural space that will help reduce flooding, increase wildlife habitat, and positively enhance water quality as well as beautify neighborhoods. Depaving also can bring communities together around a shared vision to work together to reconnect their neighborhood to the natural environment.

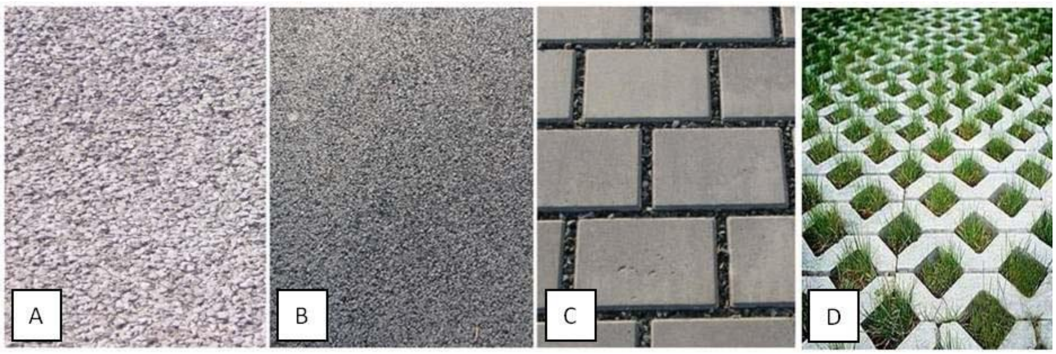
Table 3: Impervious cover reductions by subwatershed in Woodbridge Township

Subwatershed	Recommended Impervious Area Reduction (10%) (ac)	Annual Runoff Volume Reduction (MGal)
Arthur Kill Waterfront	31.9	36.2
Mill Brook/ Martins Creek	1.6	1.8
Rahway River	185.1	210.1
Lower Raritan River	52.2	59.3
Red Root Creek	37.8	42.9
Robinsons Brook	45.1	51.2
Woodbridge Creek	218.9	248.5
Total	572.5	649.8

Pervious Pavement

There are four different types of permeable pavement systems that are commonly being used throughout the country to reduce the environmental impacts from impervious surfaces. These surfaces include pervious concrete, porous asphalt, interlocking concrete pavers, and grid pavers.

> "*Permeable pavement is a stormwater drainage system that allows rainwater and runoff to move through the pavement's surface to a storage layer below, with the water eventually seeping into the underlying soil. Permeable pavement is beneficial to the environment because it can reduce stormwater volume, treat stormwater water quality, replenish the groundwater supply, and lower air temperatures on hot days (Rowe, 2012).*"



Permeable surfaces: (A) pervious concrete, (B) porous asphalt, (C) interlocking concrete pavers, (D) grid pavers (Rowe, 2012)

Pervious concrete and porous asphalt are the most common of the permeable surfaces. They are similar to regular concrete and asphalt but without the fine materials. This allows water to quickly pass through the material into an underlying layered system of stone that holds the water allowing it to infiltrate into the underlying uncompacted soil.

Impervious Cover Disconnection Practices

By redirecting runoff from paving and rooftops to pervious areas in the landscape, the amount of directly connected impervious area in a drainage area can be greatly reduced. There are many cost-effective ways to disconnect impervious surfaces from local waterways.

- Simple Disconnection: This is the easiest and least costly method to reduce stormwater runoff for smaller storm events. Instead of piping rooftop runoff to the street where it enters the catch basin and is piped to the river, the rooftop runoff is released onto a grassed area to allow the water to be filtered by the grass and soak into the ground. A healthy lawn typically can absorb the first one to two inches of stormwater runoff from a rooftop. Simple disconnection also can be used to manage stormwater runoff from paved areas. Designing a parking lot or driveway to drain onto a grassed area, instead of the street, can dramatically reduce pollution and runoff volumes.

- Rain Gardens: Stormwater can be diverted into shallow landscaped depressed areas (i.e., rain gardens) where the vegetation filters the water, and it is allowed to soak into the ground. Rain gardens, also known as bioretention systems, come in all shapes and sizes and can be designed to disconnect a variety of impervious surfaces (Figure 7).

Figure 7: Rain garden outside the RCE of Gloucester County office which was designed to disconnect rooftop runoff from the local storm sewer system

- Rainwater Harvesting: Rainwater harvesting includes the use of rain barrels and cisterns (Figures 8a and 8b). These can be placed below downspouts to collect rooftop runoff. The collected water has a variety of uses including watering plants and washing cars. This practice also helps cut down on the use of potable water for nondrinking purposes. It is important to divert the overflow from the rainwater harvesting system to a pervious area.

Figure 8a: Rain barrel used to disconnect a downspout with the overflow going to a flower bed

Figure 8b: A 5,000 gallon cistern used to disconnect the rooftop of the Department of Public Works in Clark Township to harvest rainwater for nonprofit car wash events

Examples of Opportunities in Woodbridge Township

To address the impact of stormwater runoff from impervious surfaces, the next step is to identify opportunities in the municipality for eliminating, reducing, or disconnecting directly connected impervious surfaces. To accomplish this task, an impervious cover reduction action plan should be prepared. Aerial photographs are used to identify sites with impervious surfaces in the municipality that may be suitable for inclusion in the action plan. After sites are identified, site visits are conducted to photo-document all opportunities and evaluate the feasibility of eliminating, reducing or disconnecting directly connected impervious surfaces. A brief description of each site discussing the existing conditions and recommendations for treatment of the impervious surfaces is developed. After a number of sites have been selected for inclusion in the action plan, concept plans and detailed green infrastructure information sheets are prepared for a selection of representative sites.

For Woodbridge Township, three sites have been included in this assessment. Examples of concept plans and detailed green infrastructure information sheets are provided in Appendix A. The detailed green infrastructure information sheets describe existing conditions and issues, proposed solutions, anticipated benefits, possible funding sources, potential partners and stakeholders, and estimated costs. Additionally, each project has been classified as a mitigation opportunity for recharge potential, total suspended solids removal, and stormwater peak reduction. Finally, these detailed green infrastructure information sheets provide an estimate of gallons of stormwater captured and treated per year by each proposed green infrastructure practice. The concept plans provide an aerial photograph of the site and details of the proposed green infrastructure practices.

Conclusions

Woodbridge Township can reduce flooding and improve its waterways by better managing stormwater runoff from impervious surfaces. This impervious cover assessment is the first step toward better managing stormwater runoff. The next step is to develop an action plan to eliminate, reduce, or disconnect impervious surfaces where possible and practical. Many of the highly effective disconnection practices are inexpensive. The entire community can be engaged in implementing these disconnection practices.

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Appendix A

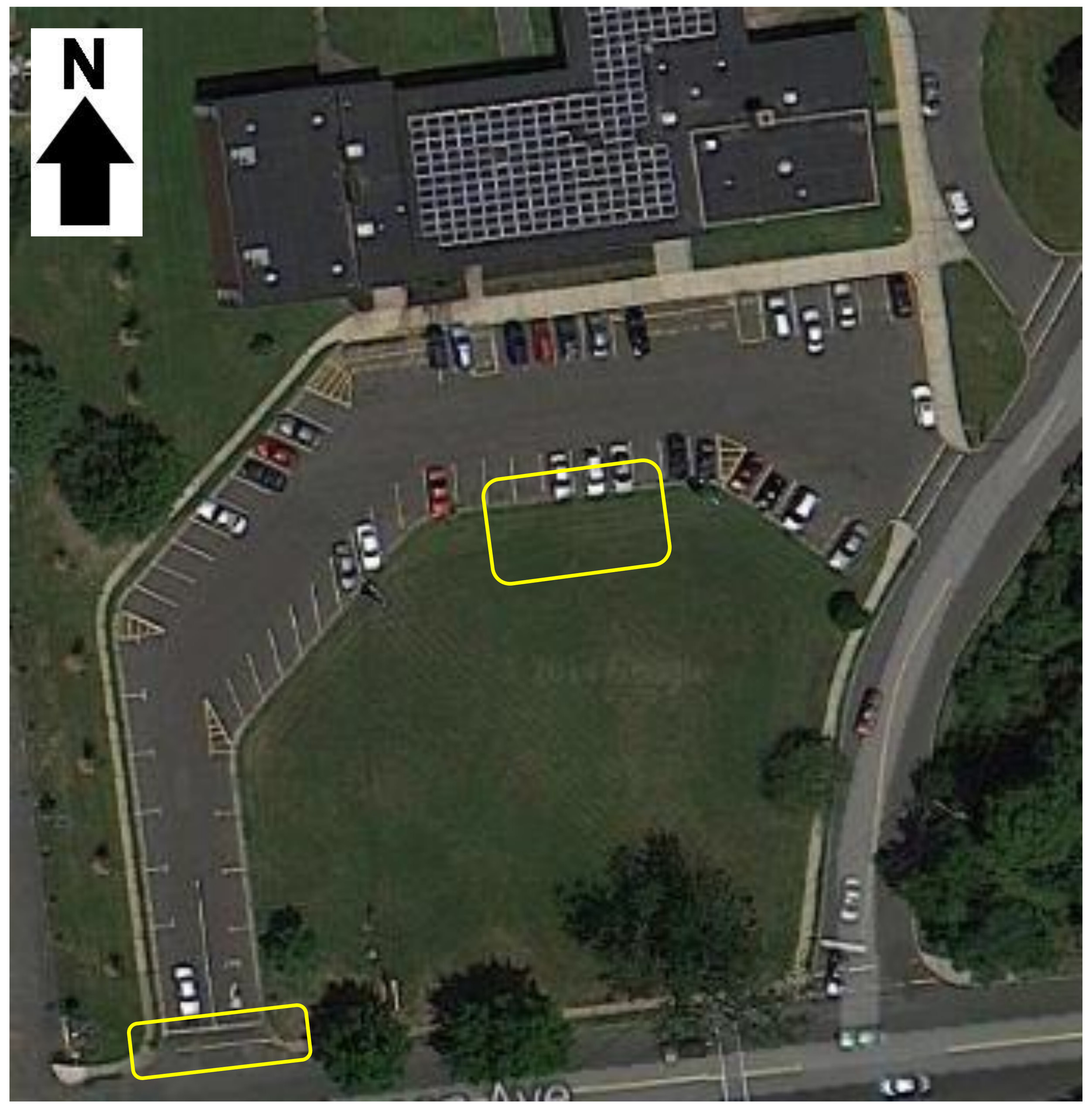
Examples of Impervious Cover Reduction Action Plan Projects

Concept Plans and Detailed Green Infrastructure Information Sheets

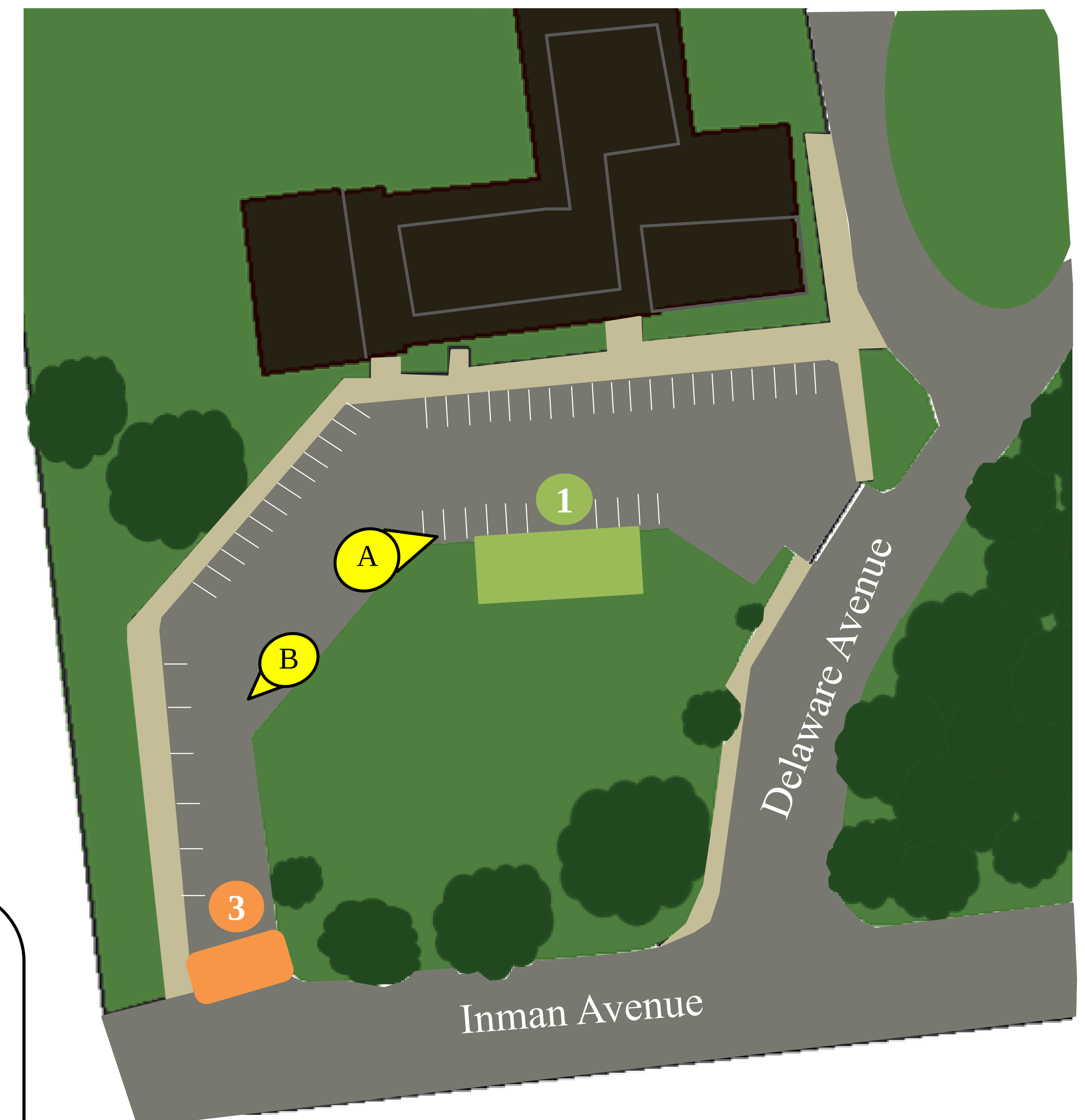
Woodbridge Township
Impervious Cover Assessment
Woodbridge Township Evergreen Senior Center, 400 Inman Avenue

RUTGERS
New Jersey Agricultural Experiment Station

PROJECT LOCATION:



SITE PLAN:



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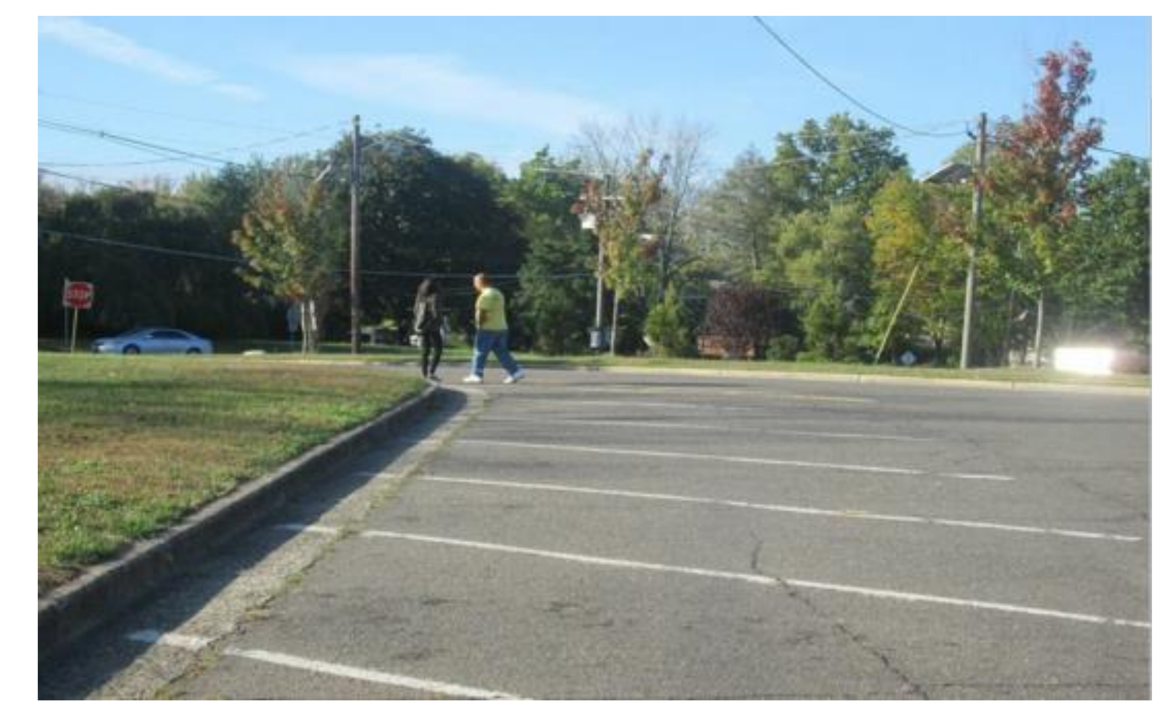
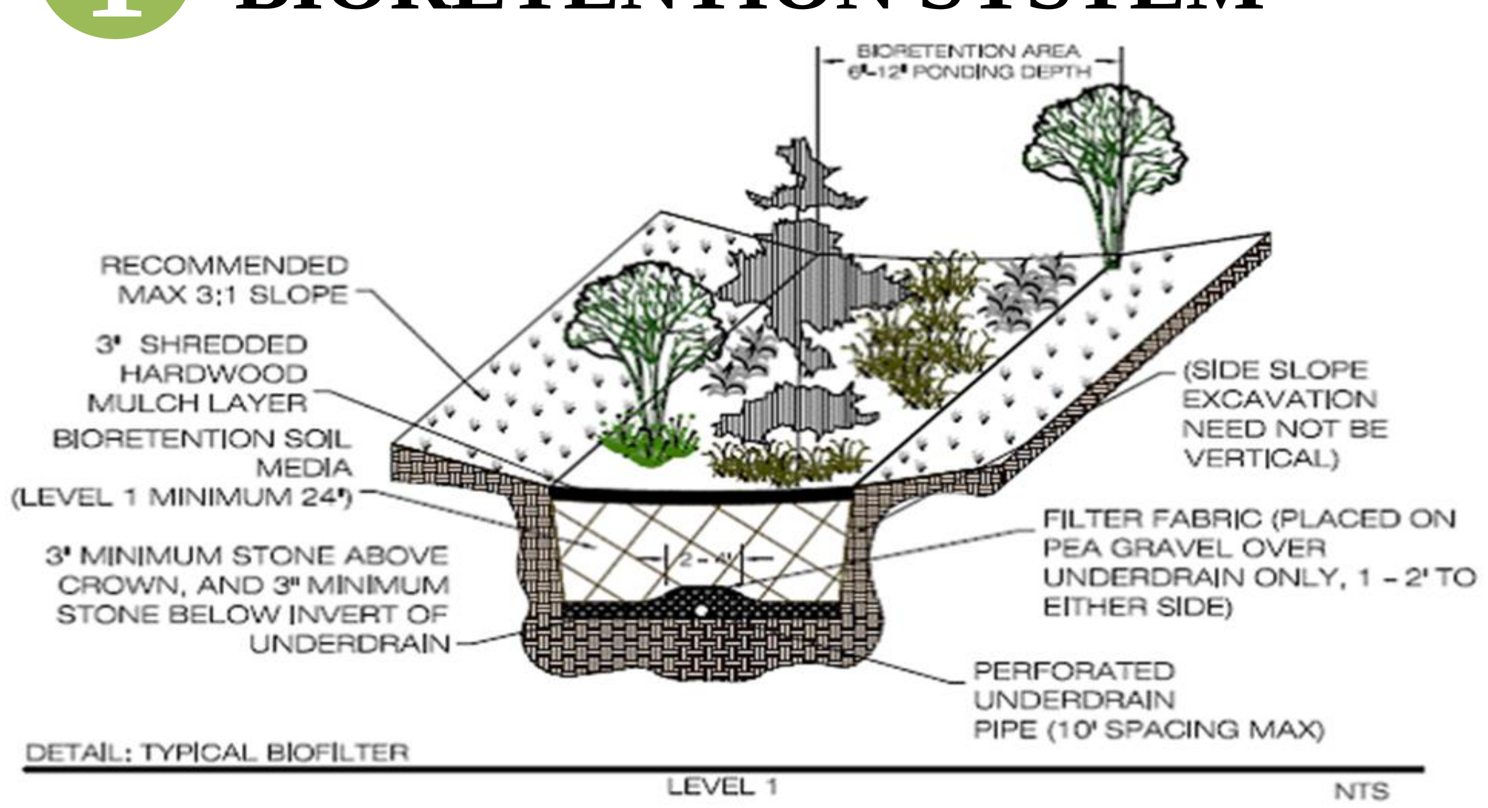


1 **BIORETENTION SYSTEM:** A bioretention system could be installed across from the front entrance of the building, next to the main parking lot. A bioretention system will reduce runoff and allow stormwater infiltration, decreasing the amount of pollutants that reach the stream.

CURB CUTS: Curb cuts should be installed to allow the flow of runoff into the bioretention system.

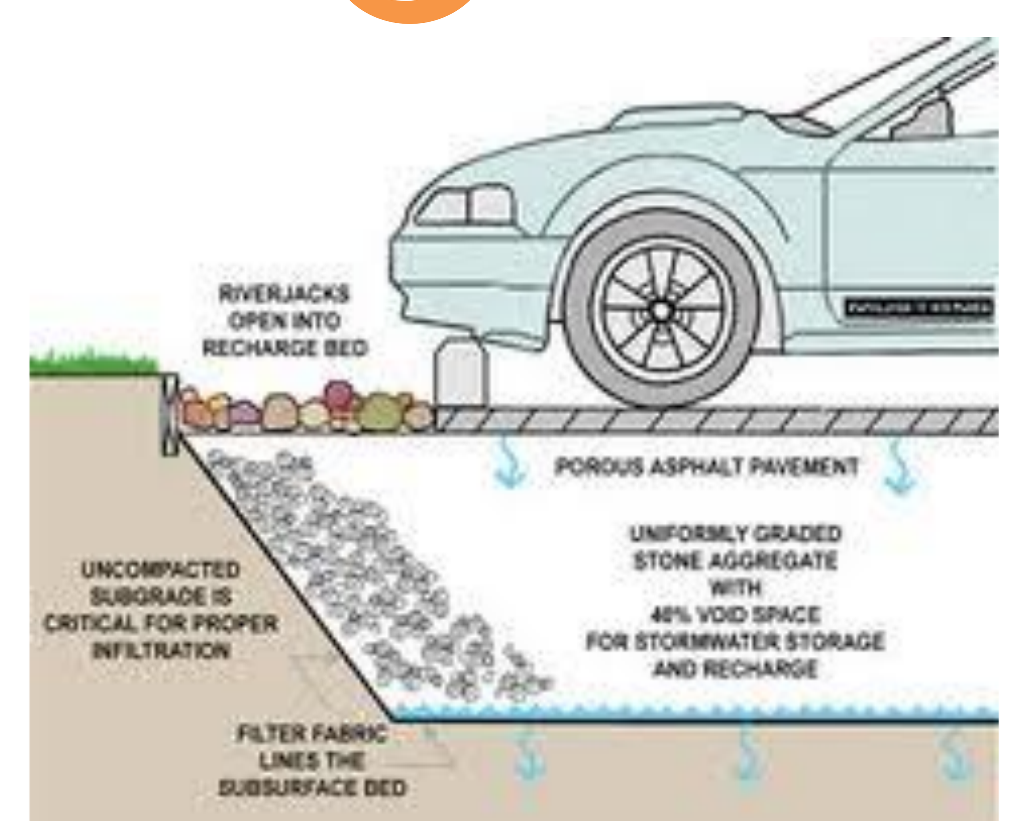
3 **POROUS PAVEMENT:** Porous pavement promotes groundwater recharge and filters stormwater. Porous pavement can be installed at the exit of the school's driveway.

1 BIORETENTION SYSTEM



CURB CUTS

3 POROUS PAVEMENT



Location: 400 Inman Avenue Colonia, NJ 07067	**Municipality:** Woodbridge Township **Subwatershed:** Robinson's Branch
Green Infrastructure Description: bioretention system (rain garden) curb cuts porous pavement	**Targeted Pollutants:** total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS) in surface runoff
Mitigation Opportunities: recharge potential: yes stormwater peak reduction potential: yes TSS removal potential: yes	**Stormwater Captured and Treated Per Year:** bioretention system: 390,830 gal. porous pavement: 101,955 gal.

Existing Conditions and Issues:

The Evergreen Senior Center has a semicircular parking lot and driveway. The parking lot slopes to the south. The runoff from the parking lot drains to a single catch basin inlet to the storm sewer system. Pollution collected in stormwater runoff, such as oils, grease, metals, coolants from vehicles, and sediment enter the storm sewer system via this inlet, prior to entering local waterways. Runoff from the westernmost portion of the parking lot flows toward Inman Avenue. The existing pavement is in poor condition.

Proposed Solution(s):

A bioretention system could be constructed in the turf grass area across from the entrance to the Evergreen Senior Center. This system would intercept, capture, treat, and infiltrate stormwater runoff from the parking lot and paved driveway. A curb cut should be used to allow stormwater runoff to enter the bioretention system. The existing pavement at the exit of the parking lot can be replaced with porous pavement. The porous pavement system would intercept stormwater runoff that leaves the driveway prior to it discharging onto Inman Avenue and the storm sewer system.

Anticipated Benefits:

Since the bioretention systems would be designed to capture, treat, and infiltrate the entire 2-year design storm (3.3 inches of rain over 24 hours), these systems are estimated to achieve a 95% pollutant load reduction for TN, TP, and TSS. A bioretention system would also provide ancillary benefits such as enhanced wildlife habitat and aesthetic appeal. Porous pavement allows stormwater to penetrate through to soil layers which will promote groundwater recharge as well as intercept and filter stormwater runoff. The system is expected to achieve a 95% pollutant load reduction for TN, TP, and TSS.

Possible Funding Sources:

mitigation funds from local developers
NJDEP grant programs
local social and community groups
Evergreen Senior Center

Partners/Stakeholders:
Woodbridge Township
employees, volunteers, residents
NJ Tree Foundation
students and parents
Rutgers Cooperative Extension

Estimated Cost:
The bioretention system would need to be approximately 3,750 square feet. At $5 per square foot, the estimated cost of the rain garden is $18,750. The porous pavement would need to be approximately 1,500 square feet. At $20 per square foot, the estimated cost of the porous pavement is $30,000. The total cost of the project would be approximately $48,750.

Woodbridge Township
Impervious Cover Assessment
Henry Inman Library, 607 Inman Avenue

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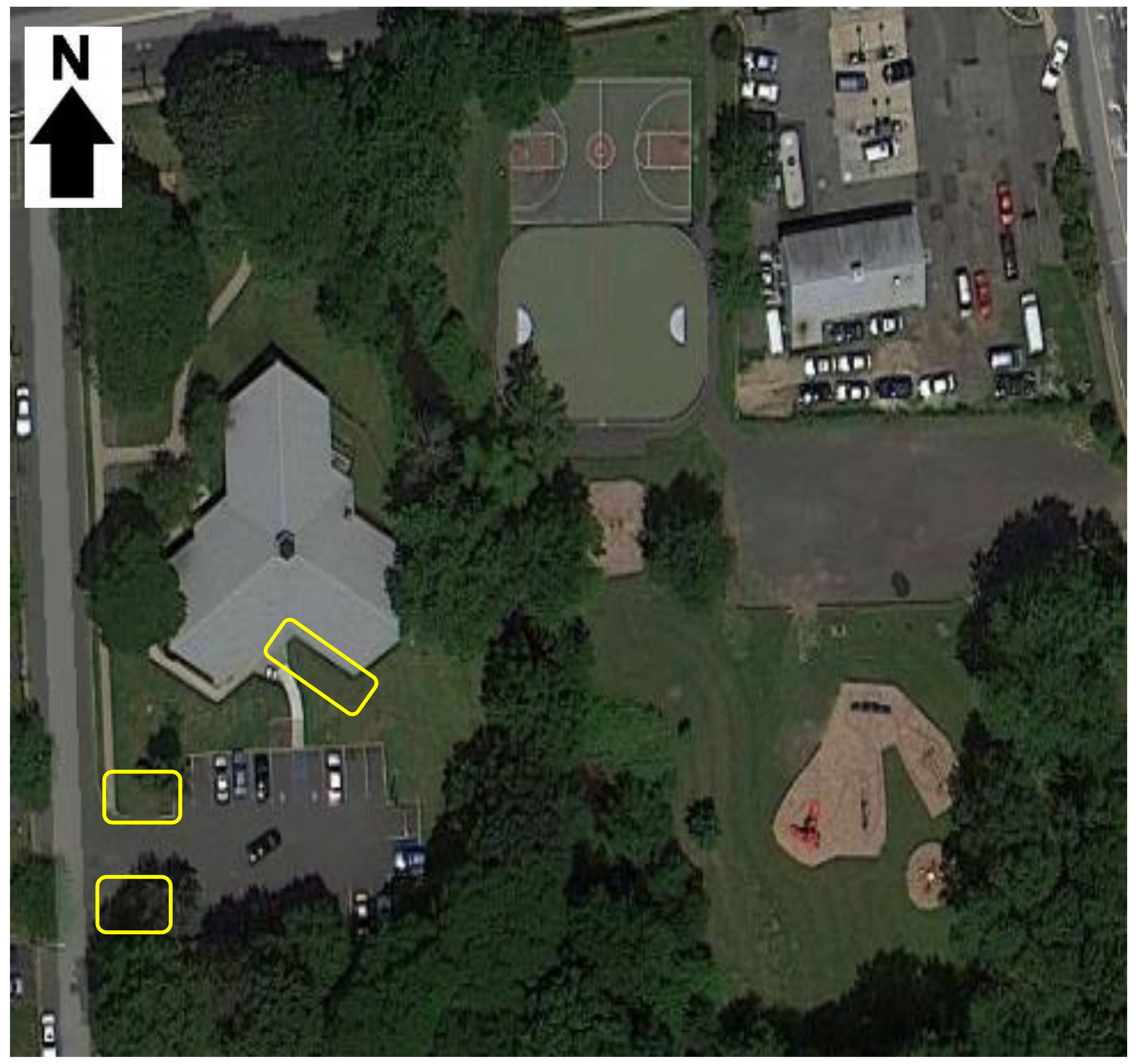
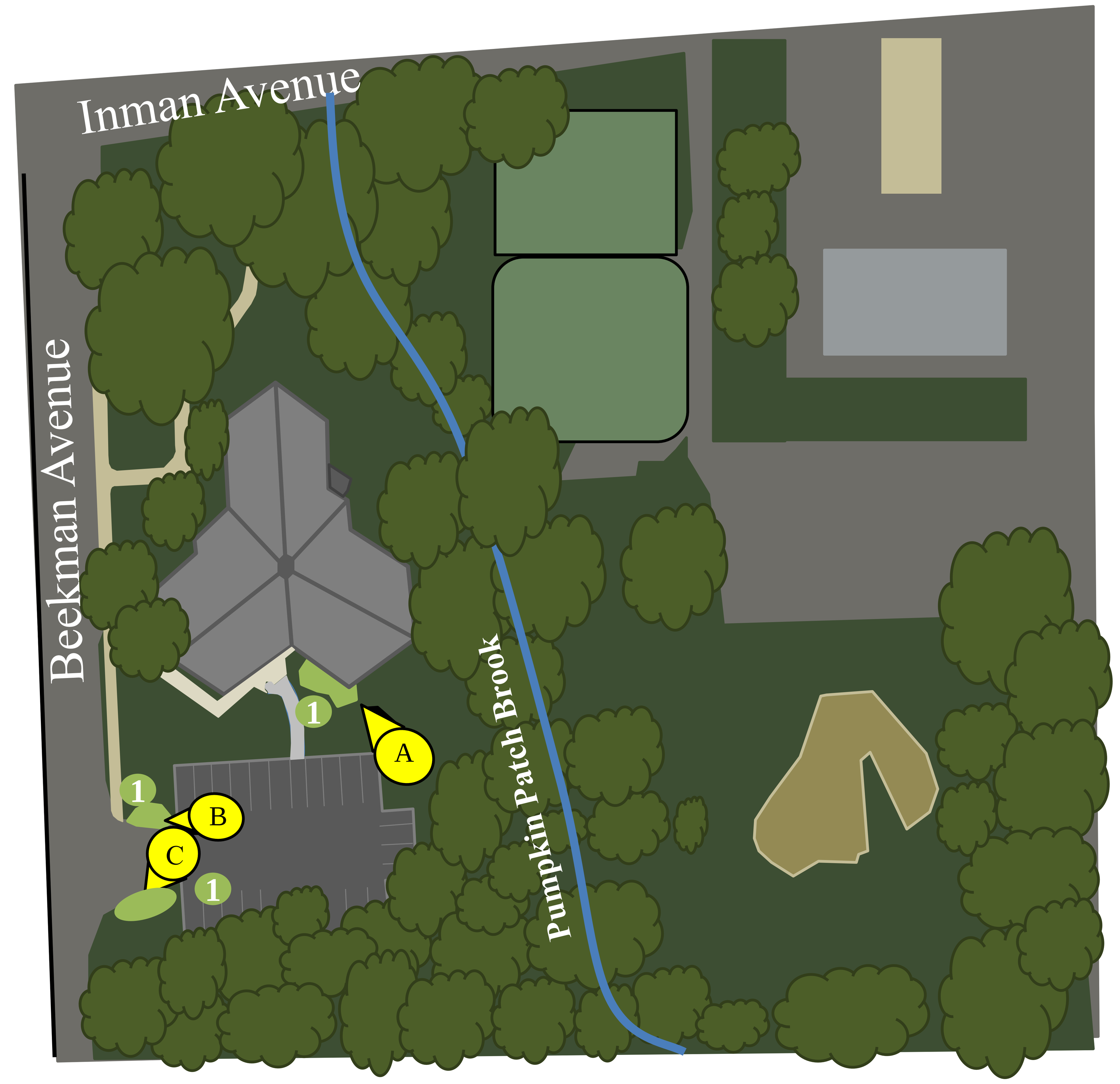
PROJECT LOCATION:



SITE PLAN:



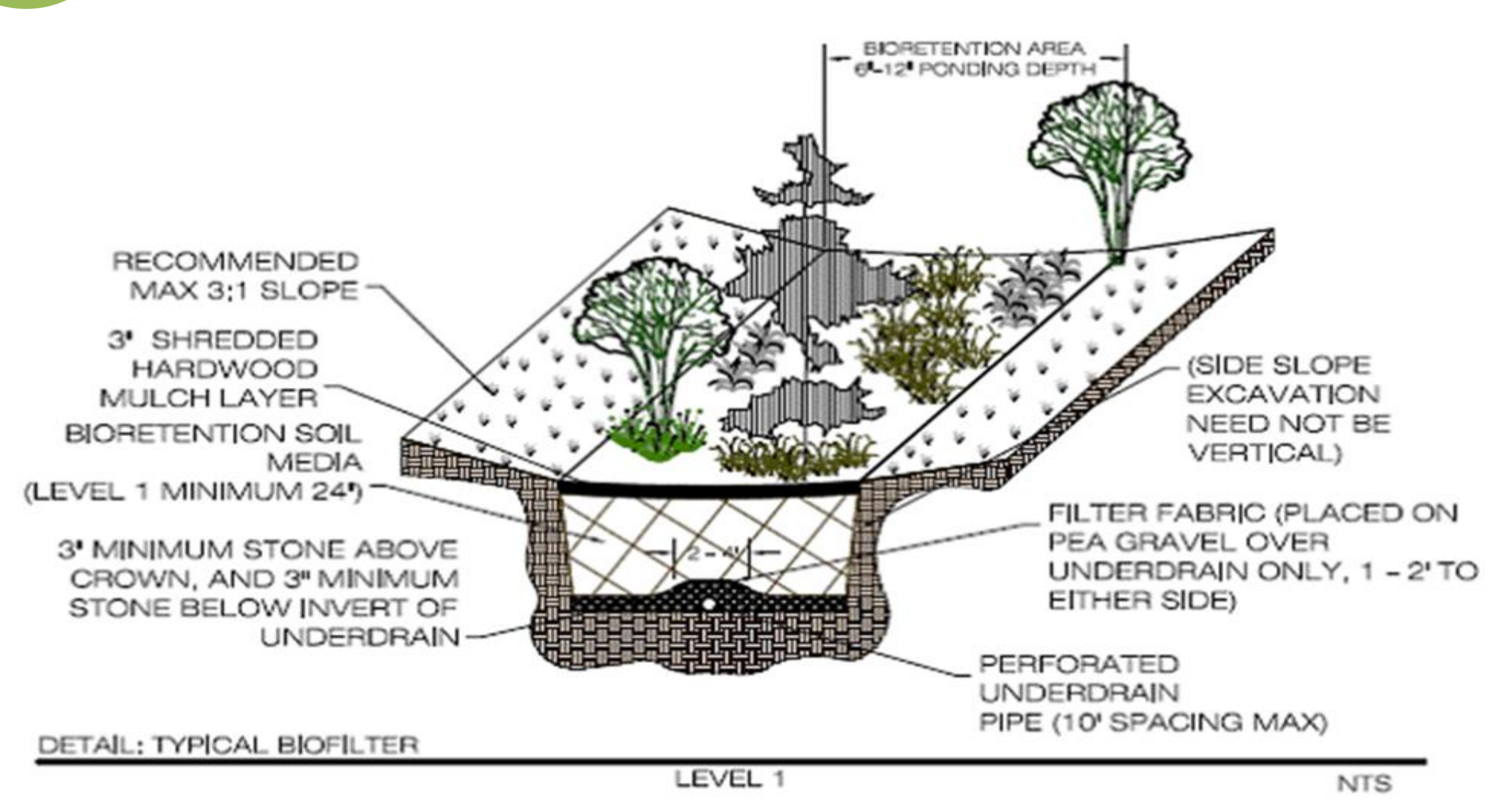
A

B

C

1 **BIORETENTION SYSTEMS:** Downspouts along the side of the building could be disconnected and redirected into a bioretention system. A bioretention system will capture, intercept and treat runoff before it reaches the Pumpkin Patch Brook. Bioretention systems can be used to capture and filter runoff from both sides of the entrance of the parking lot. Curb cuts should be installed to allow the flow of runoff into the bioretention systems.

1 BIORETENTION SYSTEM



Source: http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec9BIORETENTION.html

CURB CUTS

Henry Inman Library
Green Infrastructure Information Sheet

Location: 607 Inman Avenue Colonia NJ 07067	**Municipality:** Woodbridge Township **Subwatershed:** Robinsons River
Green Infrastructure Description: bioretention system (rain gardens) curb cuts	**Targeted Pollutants:** total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS) in surface runoff
Mitigation Opportunities: recharge potential: yes stormwater peak reduction potential: yes TSS removal potential: yes	**Stormwater Captured and Treated Per Year:** bioretention system #1: 62,533 gal. bioretention system #2: 93,799 gal. bioretention system #3: 78,166 gal.

Existing Conditions and Issues:
The Henry Inman Library has impervious surfaces such as parking lots and buildings that contribute to stormwater runoff which carries nonpoint source pollution to local waterways. Along the western side of the Library there is a downspout directly connected and draining to Pumpkin Patch Brook. There is erosion at the entrance of the parking lot at Beekman Avenue.

Proposed Solution(s):
A bioretention system or rain garden could be installed on the southern facing side of the building, along the right side of the Library entrance (bioretention system #1). The runoff from the downspout at this location should be redirected into the bioretention system. Bioretention systems could be installed along the driveway entrance to the site from Beekman Avenue (bioretention system #2 and #3). The existing parking lot slopes west, allowing runoff to be redirected into bioretention system #2 and bioretention system #3. Curb cuts can be installed to optimize stormwater runoff capture from the parking lot and to intercept the runoff before it enters the storm sewer system along Beekman Avenue. All of these bioretention systems would capture, treat, and infiltrate the stormwater runoff, thereby reducing localized flooding and improving water quality.

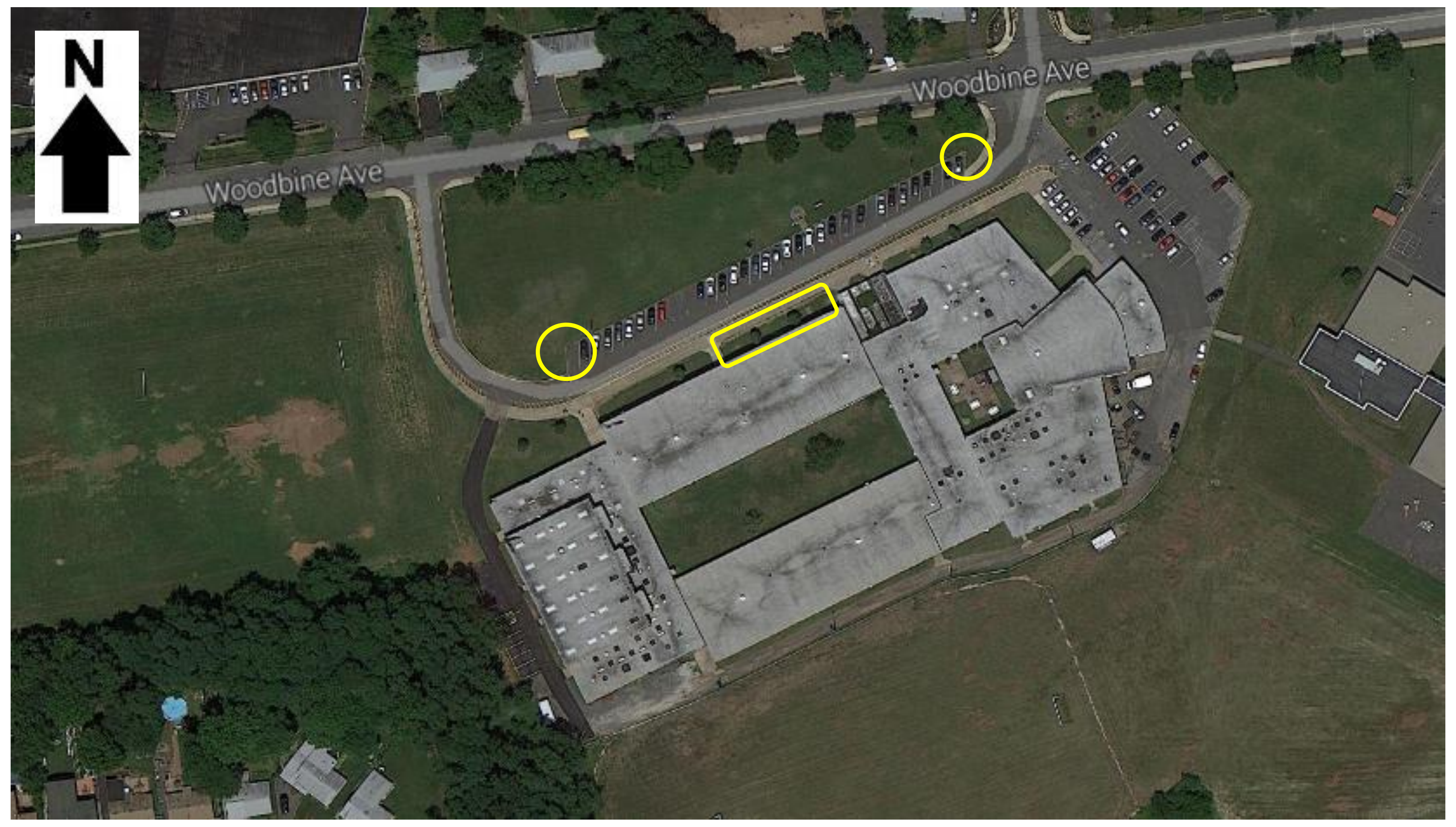
Anticipated Benefits:
Since the bioretention systems would be designed to capture, treat, and infiltrate the entire 2-year design storm (3.3 inches of rain over 24 hours), these systems are estimated to achieve a 95% pollutant load reduction for TN, TP, and TSS. A bioretention system would also provide ancillary benefits such as enhanced wildlife habitat and aesthetic appeal. The bioswale would reduce TN by 30%, TP by 60%, and TSS by 90%.

Possible Funding Sources:
mitigation funds from local developers
NJDEP grant programs
Woodbridge Township
Henry Inman Library

local social and community groups
Partners/Stakeholders: Woodbridge Township Henry Inman Library local social and community groups local residents NJ Tree Foundation Rutgers Cooperative Extension
Estimated Cost: Bioretention system #1 would need to be approximately 600 square feet. At $5 per square foot, the estimated cost of the rain garden is $3,000. Bioretention system #2 would need to be approximately 900 square feet. At $5 per square foot, the estimated cost of the rain garden is $4,500. Bioretention system #3 would need to be approximately 750 square feet. At $5 per square foot, the estimated cost of the bioretention system is $3,750. The total cost of the project would be approximately $11,250.

Woodbridge Township
Impervious Cover Assessment
Avenel Middle School, 85 Woodbine Avenue

PROJECT LOCATION:



A

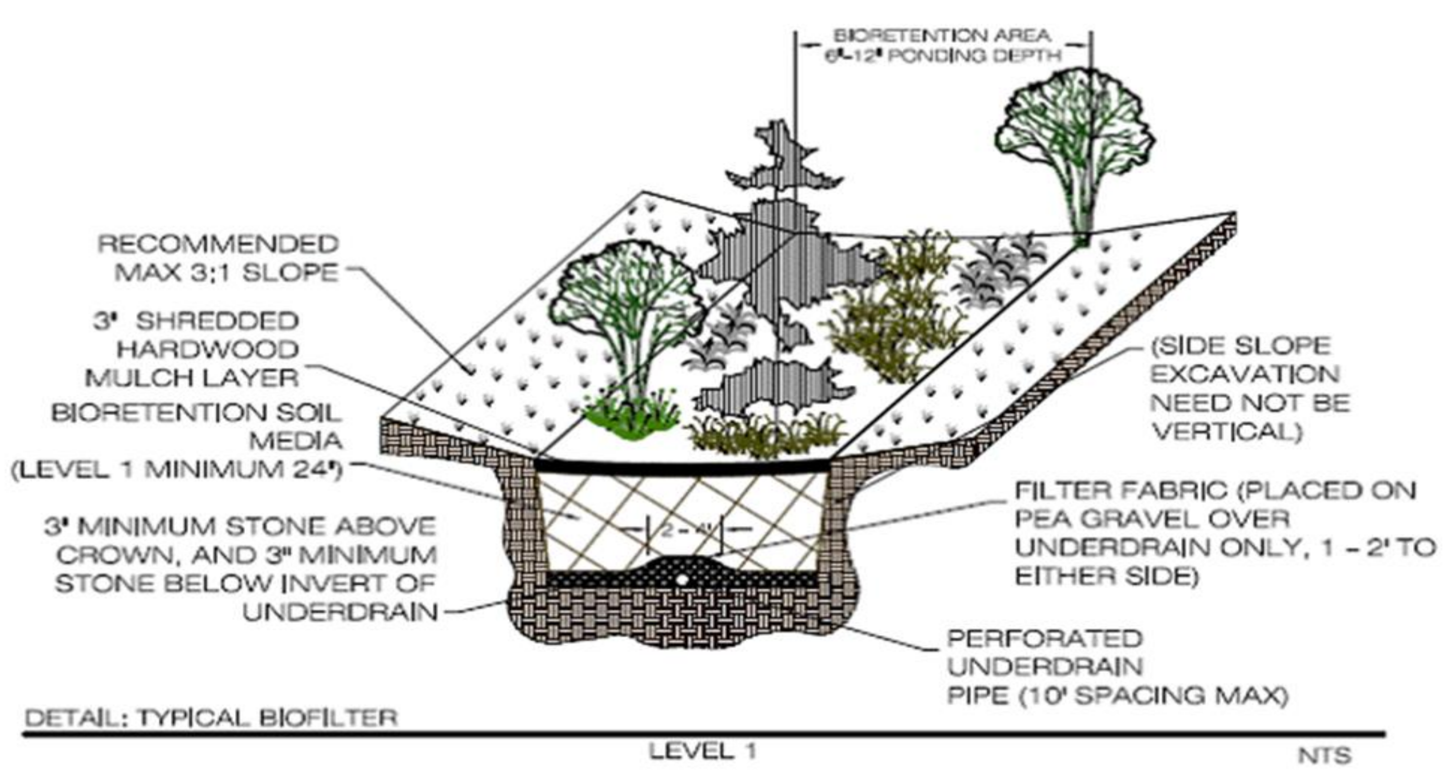
B

SITE PLAN:

1 **BIORETENTION SYSTEMS:** Bioretention systems capture, filter, and infiltrate stormwater runoff. A bioretention system can be installed on the north side of the school near the entrance. The bioretention system will be used to intercept and treat runoff before it enters the storm sewer system. Runoff from the parking lot at the northern edge of the property drains into two storm sewer inlets. A bioretention system can be installed at each of these locations to intercept runoff. Curb cuts should be installed to allow the flow of runoff into the bioretention systems.

EDUCATIONAL PROGRAM: The RCE Water Resources Program's *Stormwater Management in Your Schoolyard* program can be delivered at the Avenel Middle School to educate teachers and students about stormwater management and engage them in the design and construction of the bioretention systems.

1 BIORETENTION SYSTEM



Source: http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec9BIORETENTION.html

EDUCATIONAL PROGRAM

Location: 85 Woodbine Avenue Avenel, NJ 07001	Municipality: Woodbridge Township Subwatershed: Rahway River
Green Infrastructure Description: bioretention system (rain gardens)	**Targeted Pollutants:** total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS) in surface runoff
Mitigation Opportunities: recharge potential: yes stormwater peak reduction potential: yes TSS removal potential: yes	**Stormwater Captured and Treated Per Year:** bioretention system #1: 312,644 gal. bioretention system #2: 312,644 gal. bioretention system #3: 104,221 gal.

Existing Conditions and Issues:
There are impervious surfaces at Avenel Middle School that contribute to stormwater runoff volumes and nonpoint source pollution. Runoff carries nonpoint source pollution such as sediments, nutrients, oil, and grease to local waterways. There are two existing inlets on opposite ends of the single row of parking spaces in front of the school along Woodbine Avenue which capture stormwater runoff from the parking lot. There also is a small roof at the entrance of the school that has five connected downspouts. A storm sewer system inlet exists in the turf grass near the entrance of the school.

Proposed Solution(s):
Bioretention systems could be installed at the ends of the parking lot, adjacent to existing storm sewer inlets. These will be referred to as bioretention systems #1 and #2. These bioretention systems would capture, treat, and infiltrate stormwater runoff from the parking lot and paved entrances. A third bioretention system (bioretention system #3) could be constructed to capture stormwater from the roof downspouts and the sidewalk near the entrance of the school. The existing storm sewer system inlet can be used as an overflow structure for bioretention system #3. Since this is a school, there are educational opportunities for the teachers and students as part of the design and construction of the bioretention systems. The RCE Water Resources Program has a program entitled *Stormwater Management in Your Schoolyard* where Water Resources Program staff provide educational programming about stormwater management and work with the students to actually design and implement bioretention systems.

Anticipated Benefits:
Since the bioretention systems would be designed to capture, treat, and infiltrate the entire 2-year design storm (3.3 inches of rain over 24 hours), these systems are estimated to achieve a 95% pollutant load reduction for TN, TP, and TSS. A bioretention system would also provide ancillary benefits such as enhanced wildlife habitat and aesthetic appeal. Rutgers Cooperative Extension could additionally present the *Stormwater Management in Your Schoolyard* program to teachers and students and include them in the design and construction of the bioretention system. This may

also be used as a demonstration project for the Woodbridge Township Public Works staff to launch educational programming.

Possible Funding Sources:
mitigation funds from local developers
NJDEP grant programs
Woodbridge Township
local social and community groups
home and school association

Partners/Stakeholders:
Avenel Middle School
Woodbridge Township
local community groups
students and parents
home and school association
New Jersey Tree Foundation
Rutgers Cooperative Extension

Estimated Cost:
Bioretention system #1 would need to be approximately 3,000 square feet. At $5 per square foot, the estimated cost of the rain garden is $15,000. Bioretention system #2 would need to be approximately 3,000 square feet in size. At $5 per square foot, the estimated cost of the rain garden is $15,000. Bioretention system #3 would need to be approximately 1,000 square feet in size. At $5 per square foot, the estimated cost of the rain garden is $5,000. The total cost of the project is $35,000.