Rutgers
New Jersey Agricultural
Experiment Station

Impervious Cover Assessment
for
South Brunswick Township, Middlesex County, New Jersey

Prepared for South Brunswick Township by the
Rutgers Cooperative Extension Water Resources Program

November 23, 2014

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

South Brunswick Township Impervious Cover Analysis

Located in Middlesex County in central New Jersey, South Brunswick Township covers approximately 41 square miles east of Raritan. Figures 3 and 4 illustrate that South Brunswick Township is dominated by urban land uses. A total of 41.6% of the municipality's land use is classified as urban. Of the urban land in South Brunswick Township, medium density residential is the dominant land use (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 South Brunswick 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 South Brunswick Township. Based upon the 2007 NJDEP land use/land cover data, approximately 16.1% of South Brunswick Township has impervious cover. This level of impervious cover suggests that the streams in South Brunswick Township are likely impacted.

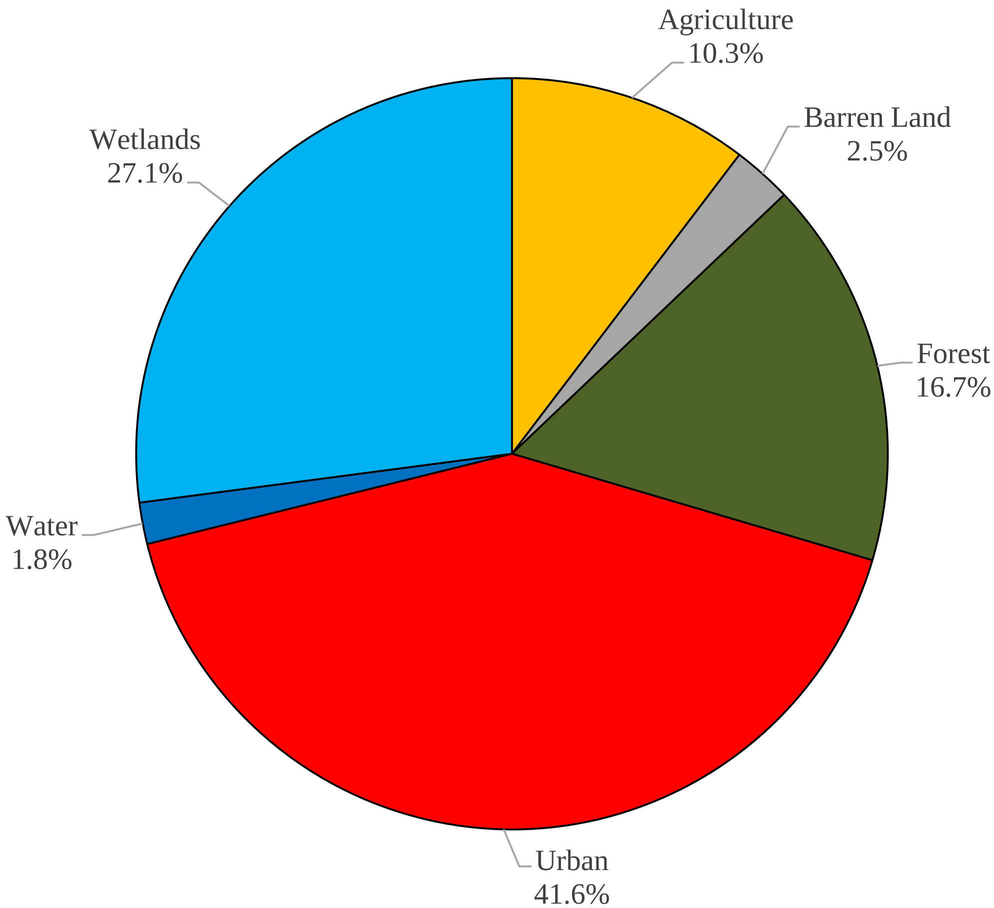


Figure 3: Pie chart illustrating the land use in South Brunswick Township

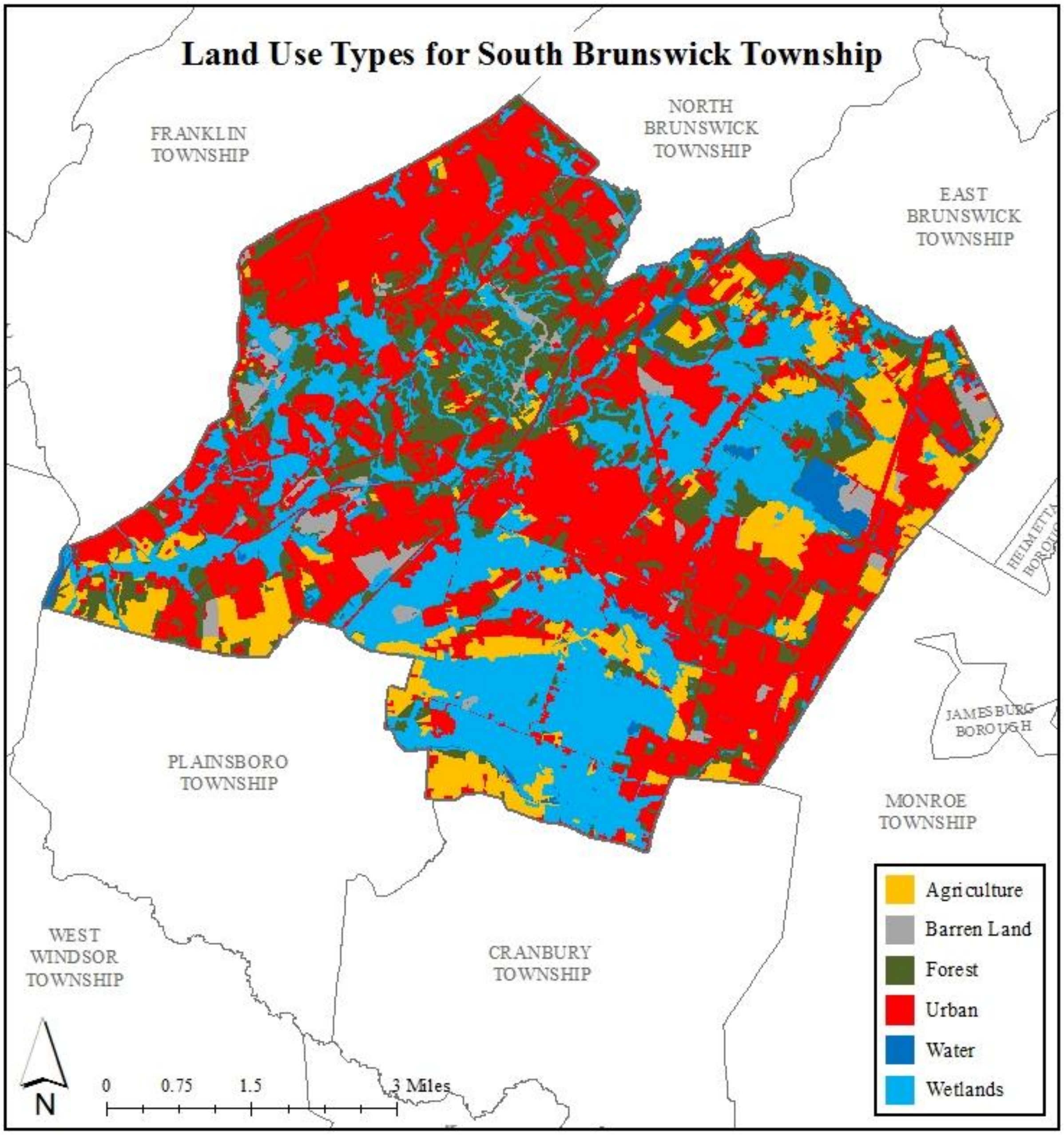


Figure 4: Map illustrating the land use in South Brunswick Township

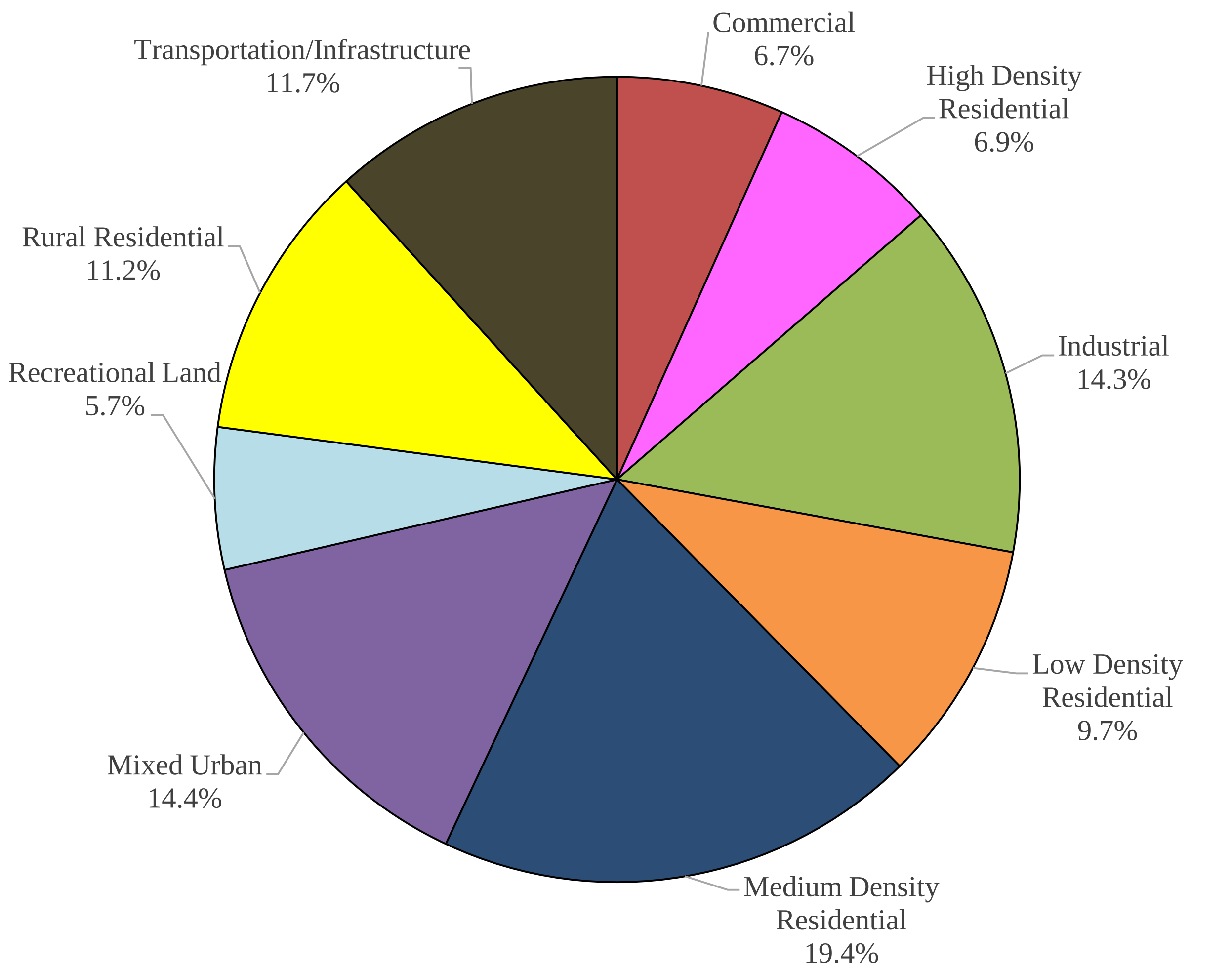


Figure 5: Pie chart illustrating the various types of urban land use in South Brunswick Township

Water resources are typically managed on a watershed/subwatershed basis; therefore an impervious cover analysis was performed for each Raritan River subwatershed within South Brunswick Township (Table 1 and Figure 6). On a subwatershed basis, impervious cover ranges from 5.9% in the Cedar Brook subwatershed to 26.3% in the Millstone 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 South Brunswick 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 South Brunswick Township. For example, if the stormwater runoff from one water quality storm (1.25 inches of rain) in the Lawrence Brook Watershed was harvested and purified, it could supply water to 206 homes for one year[1].

[1] Assuming 300 gallons per day per home

Table 1: Impervious cover analysis by subwatershed for South Brunswick Township

Subwatershed	**Total Area**		**Land Use Area**		**Water Area**		**Impervious Cover**		
	(ac)	**(mi^2)**	**(ac)**	**(mi^2)**	**(ac)**	**(mi^2)**	**(ac)**	**(mi^2)**	**(%)**
Cedar Brook	80.4	0.13	80.4	0.13	0.0	0	4.8	0.01	5.9%
Devils Brook	3,635.0	5.68	3,604.5	5.63	30.5	0.05	499.8	0.78	13.9%
Great Ditch	4,696.7	7.34	4,438.8	6.94	257.8	0.4	839.4	1.31	18.9%
Heathcote Brook	4,764.9	7.45	4,740.0	7.41	24.9	0.04	730.6	1.14	15.4%
Ireland Brook	802.8	1.25	796.1	1.24	6.7	0.01	69.3	0.11	8.7%
Lawrence Brook	5,293.0	8.27	5,228.0	8.17	65.0	0.1	666.9	1.04	12.8%
Manalapan Brook	435.0	0.68	426.6	0.67	8.4	0.01	98.4	0.15	23.1%
Millstone River	1,009.8	1.58	980.5	1.53	29.2	0.05	258.2	0.4	26.3%
Oakeys Brook	2,261.6	3.53	2,251.0	3.52	10.6	0.02	482.0	0.75	21.4%
Shallow Brook	2,667.0	4.17	2,632.3	4.11	34.7	0.05	369.9	0.58	14.1%
Six Mile Run	596.9	0.93	596.3	0.93	0.5	0	137.7	0.22	23.1%
Total	26,243.0	41.0	25,774.5	40.3	468.4	0.73	4,156.9	6.49	16.1%

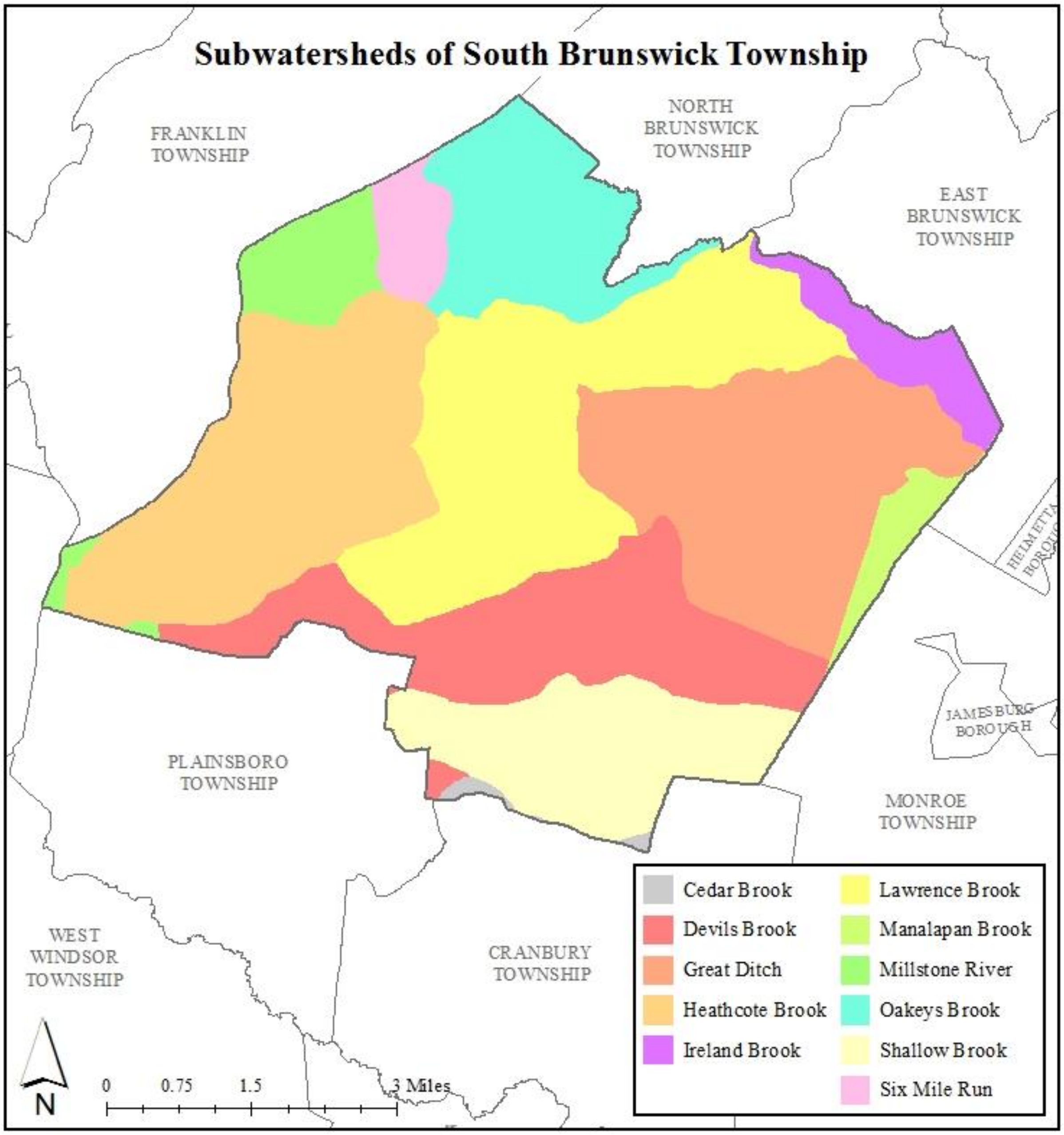


Figure 6: Map of the subwatersheds in South Brunswick Township

Table 2: Stormwater runoff volumes from impervious surfaces by subwatershed in South Brunswick 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)
Cedar Brook	0.2	5.7	0.4	0.7	1.1
Devils Brook	17.0	597.1	44.8	69.2	116.7
Great Ditch	28.5	1,002.8	75.2	116.2	196.0
Heathcote Brook	24.8	872.9	65.5	101.2	170.6
Ireland Brook	2.4	82.8	6.2	9.6	16.2
Lawrence Brook	22.6	796.8	59.8	92.4	155.7
Manalapan Brook	3.3	117.6	8.8	13.6	23.0
Millstone River	8.8	308.5	23.1	35.8	60.3
Oakeys Brook	16.4	575.8	43.2	66.7	112.5
Shallow Brook	12.6	441.9	33.1	51.2	86.4
Six Mile Run	4.7	164.5	12.3	19.1	32.1
Total	141.1	4,966.2	372.5	575.6	970.7

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 South Brunswick 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 South Brunswick Township

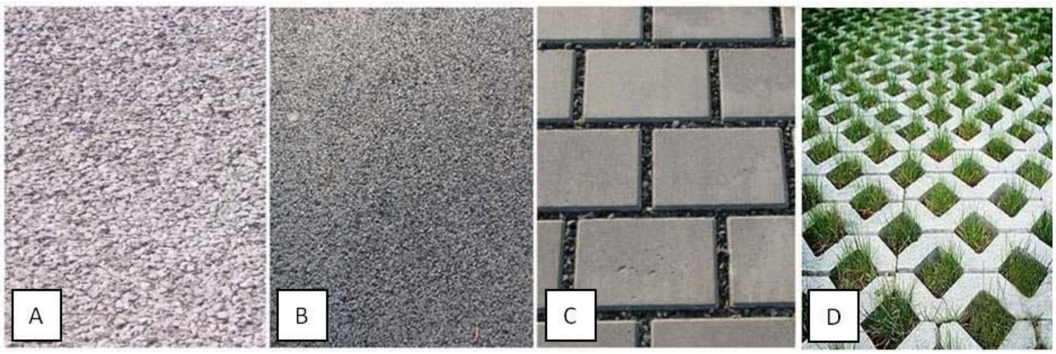
Subwatershed	**Recommended Impervious Area Reduction (10%) (ac)**	**Annual Runoff Volume Reduction [2] (MGal)**
Cedar Brook	0.5	0.5
Devils Brook	50.0	56.7
Great Ditch	83.9	95.3
Heathcote Brook	73.1	82.9
Ireland Brook	6.9	7.9
Lawrence Brook	66.7	75.7
Manalapan Brook	9.8	11.2
Millstone River	25.8	29.3
Oakeys Brook	48.2	54.7
Shallow Brook	37.0	42.0
Six Mile Run	13.8	15.6
Total	415.7	471.8

[2] Annual Runoff Volume Reduction =
Acres of impervious cover x 43,560 ft^2/ac x 44 in x (1 ft/12 in) x 0.95 x (7.48 gal/ft^3) x (1 MGal/1,000,000 gal)
All green infrastructure should be designed to capture the first 3.3 inches of rain from each storm. This would allow the green infrastructure to capture 95% of the annual rainfall of 44 inches.

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 South Brunswick 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 South Brunswick 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

South Brunswick 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.

References

Arnold, C.L. Jr. and C.J. Gibbons. 1996. Impervious Surface Coverage The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association* 62(2): 243-258.

Caraco, D., R. Claytor, P. Hinkle, H. Kwon, T. Schueler, C. Swann, S. Vysotsky, and J. Zielinski. 1998. Rapid Watershed Planning Handbook. A Comprehensive Guide for Managing Urbanizing Watersheds. Prepared by Center For Watershed Protection, Ellicott City, MD. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds and Region V. October 1998.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, E.G. Welch. 1997. Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion. *Watershed Protection Techniques* 2(4): 483-493.

Nowak, D. J., and E. J. Greenfield, 2012. Trees and Impervious Cover in the United States. *Landscape and Urban Planning* 107 (2012): 21-30. http://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_nowak_002.pdf

Rowe, A., 2012. Green Infrastructure Practices: An Introduction to Permeable Pavement. Rutgers NJAES Cooperative Extension, FS1177, pp. 4. http://njaes.rutgers.edu/pubs/publication.asp?pid=FS1177

Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques*1(3): 100-111.

United States Environmental Protection Agency (USEPA), 2013. Watershed Assessment, Tracking, and Environmental Results, New Jersey Water Quality Assessment Report. http://ofmpub.epa.gov/waters10/attains_state.control?p_state=NJ

Appendix A

Examples of Impervious Cover Reduction Action Plan Projects

Concept Plans and Detailed Green Infrastructure Information Sheets

South Brunswick Township
Impervious Cover Assessment

Grace Presbyterian Church, 57 Sand Hills Road

RUTGERS
New Jersey Agricultural Experiment Station

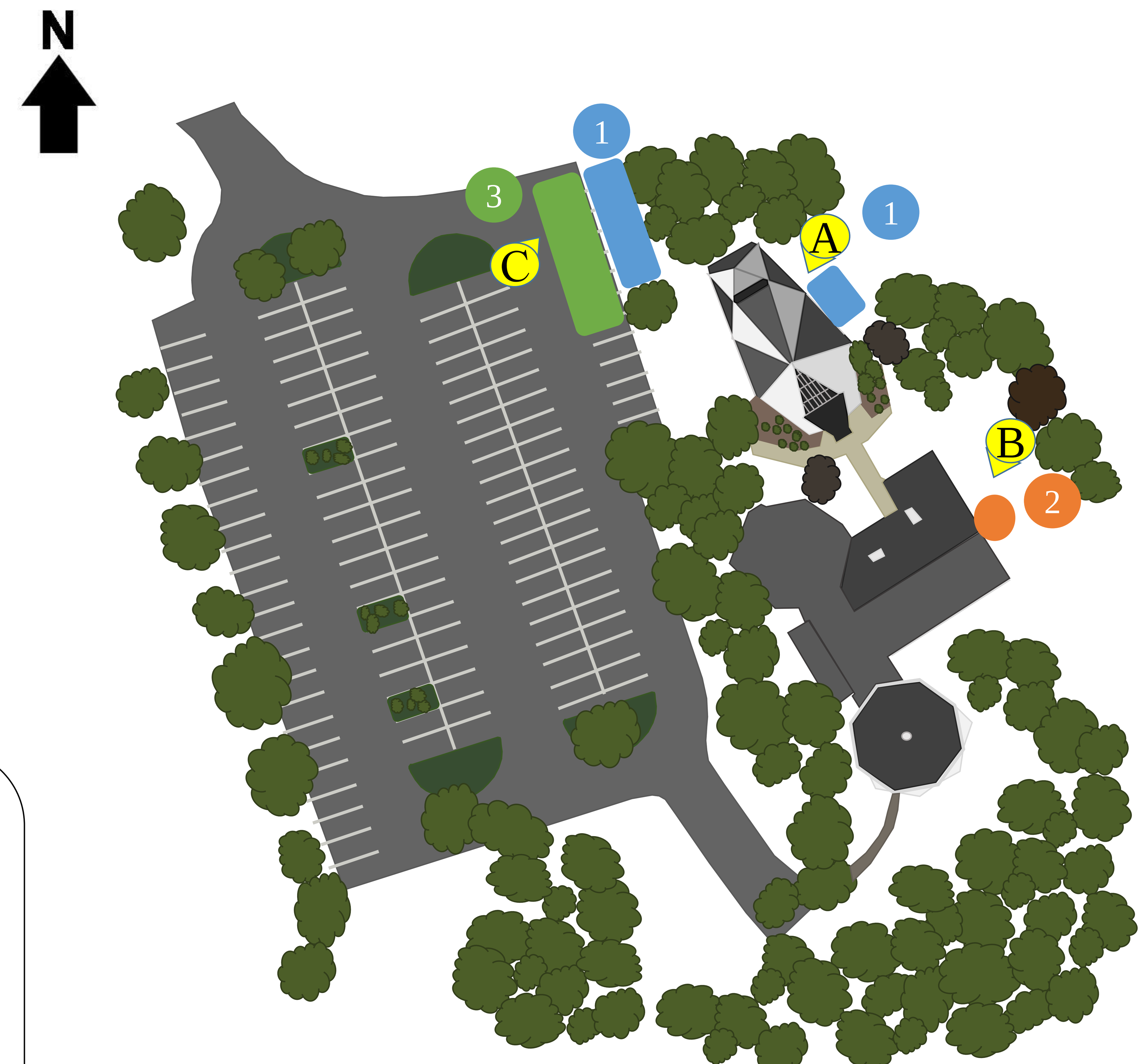
PROJECT LOCATION:

1 **BIORETENTION SYSTEM:** A bioretention system could be installed near the northeast side of the parking lot and along the northeast side of the building where an inlet exists and can act as an overflow. A bioretention system will reduce runoff and allow stormwater infiltration, decreasing the amount of contaminants that reach catch basins.

2 **CISTERN:** A cistern will decrease the volume of stormwater runoff reaching catch basins by capturing and storing stormwater runoff for use in watering the existing vegetable garden.

3 **POROUS ASPHALT:** Porous asphalt promotes groundwater recharge and filters stormwater.

SITE PLAN:

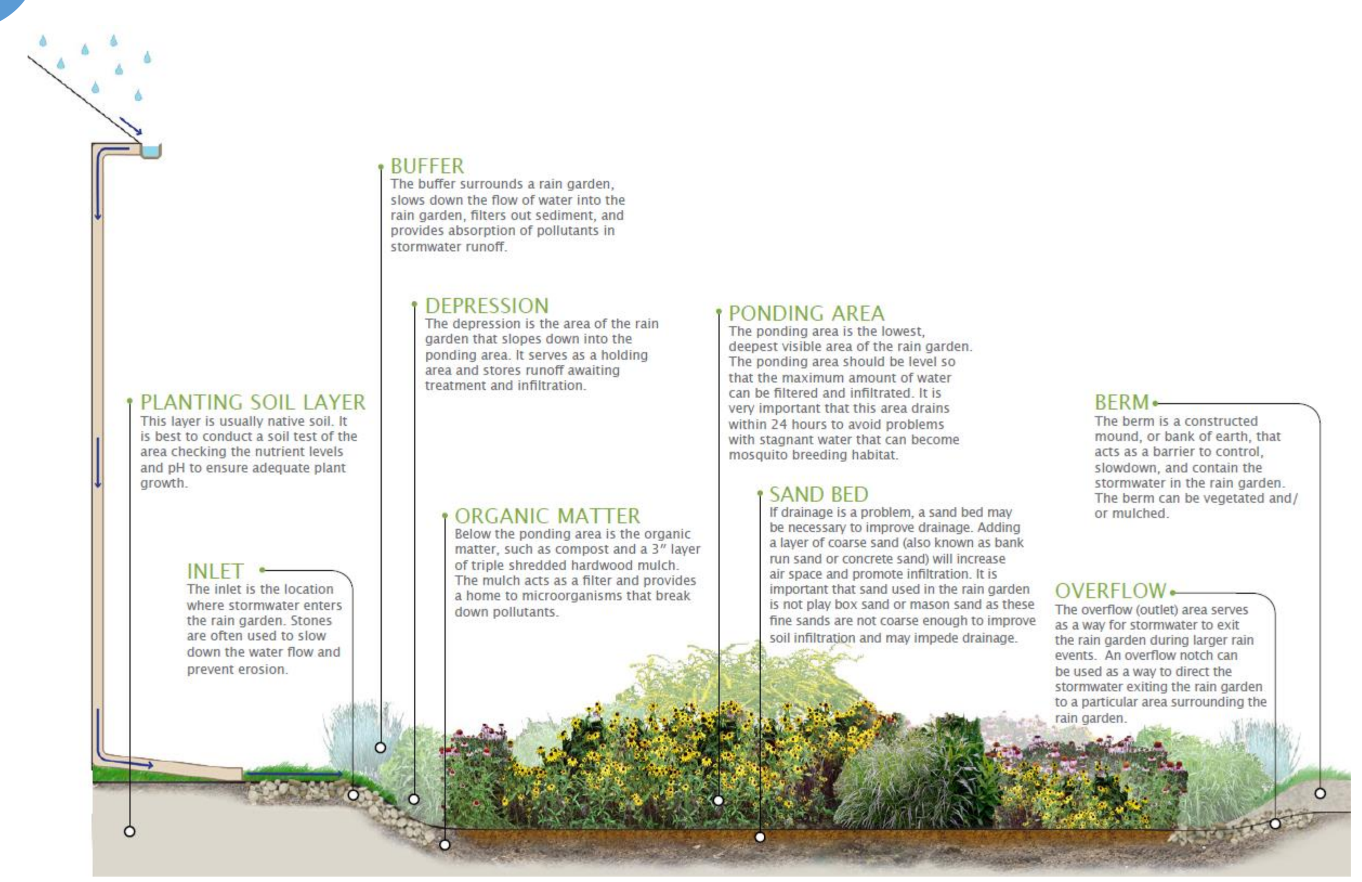


A


B

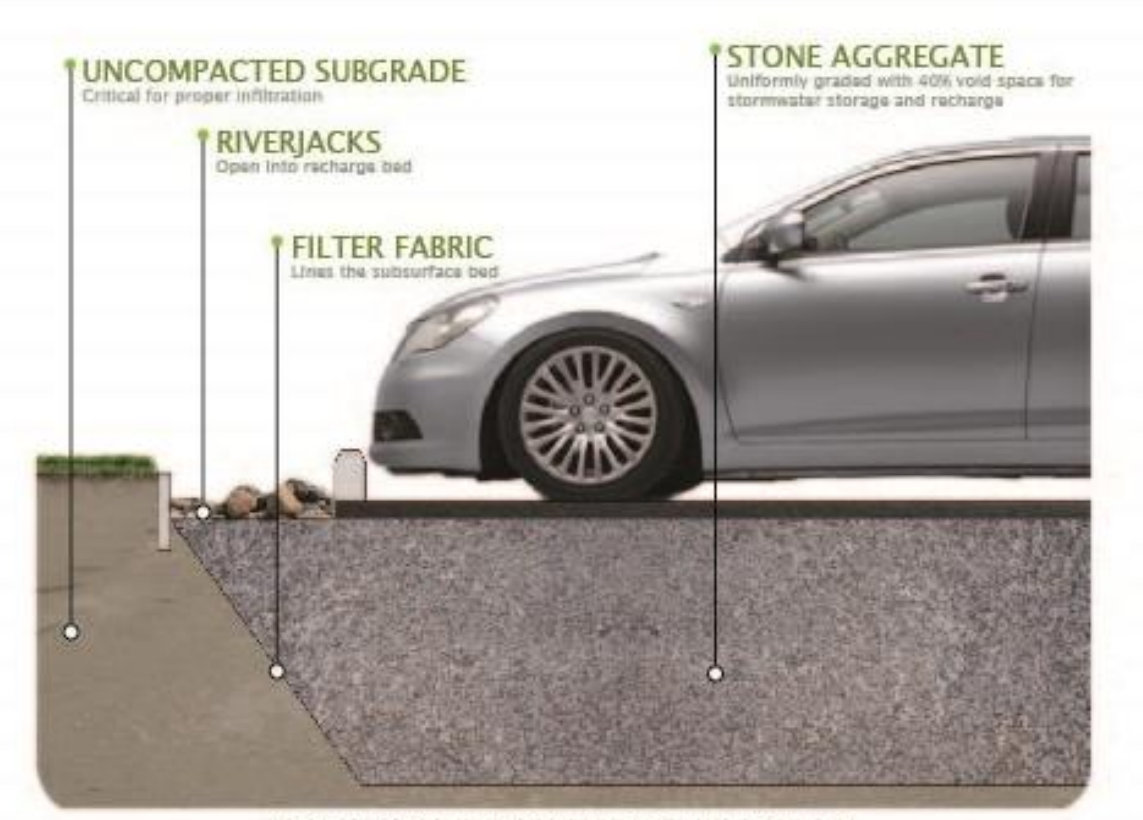

C


1 BIORETENTION SYSTEM



2 CISTERN

3 POROUS ASPHALT



Location: 57 Sand Hills Road Kendall Park NJ 08824	**Municipality:** South Brunswick Township **Subwatershed:** Six Mile Run (Above Middlebush Road)
Green Infrastructure Description: bioretention system cistern 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 systems: building rain garden: 33,507 gal. option 1 - parking lot rain garden: 430,564 gal. cistern: 18,933 gal. option 2 - porous pavement: 423,451 gal.

Existing Conditions and Issues:

This site is off of Sand Hills Road located at the end of Cuyler Road. The site contains a large parking lot and church building. At the northeast portion of the parking lot, there is disintegration of the parking lot with an adjacent turf grass area. At the church's northeast face, there is a fairly large garden and two nearby disconnected downspouts. On the northeast side of the building extension, there is a disconnected downspout flowing into a nearby storm drain.

Proposed Solution(s):

At the northeast portion of the parking lot, the eroding portion could be repaved with porous pavement. A bioretention system could be constructed in the nearby turf grass area to help runoff from the parking lot infiltrate as an alternative or in conjunction with the porous pavement. At the church's northeast face, a cistern could be installed to harvest rainwater for watering the nearby garden. On the northeast side of the building extension, a small rain garden could be installed using the storm drain as an overflow.

Anticipated Benefits:

A bioretention system is estimated to achieve a 30% removal rate for TN and a 60% removal rate for TP (NJDEP BMP Manual). TSS loadings may be reduced by up to 80%. If these bioretention systems are designed to capture and infiltrate stormwater runoff from the 2-year design storm (3.3 inches of rain over 24 hours), these systems will prevent approximately 95% of the TN, TP and TSS from flowing directly into local waterways. A bioretention system would also provide ancillary benefits such as enhanced wildlife and aesthetic appeal to the local residents and members of the congregation of Grace Presbyterian Church. Porous pavement allows stormwater to penetrate through to soil layers which will promote groundwater recharge as well as intercept and filter stormwater runoff. Cisterns can harvest stormwater which can be used for watering plants or other purposes which cuts back on the use of potable water for nondrinking purposes.

Possible Funding Sources:

mitigation funds from local developers
NJDEP grant programs

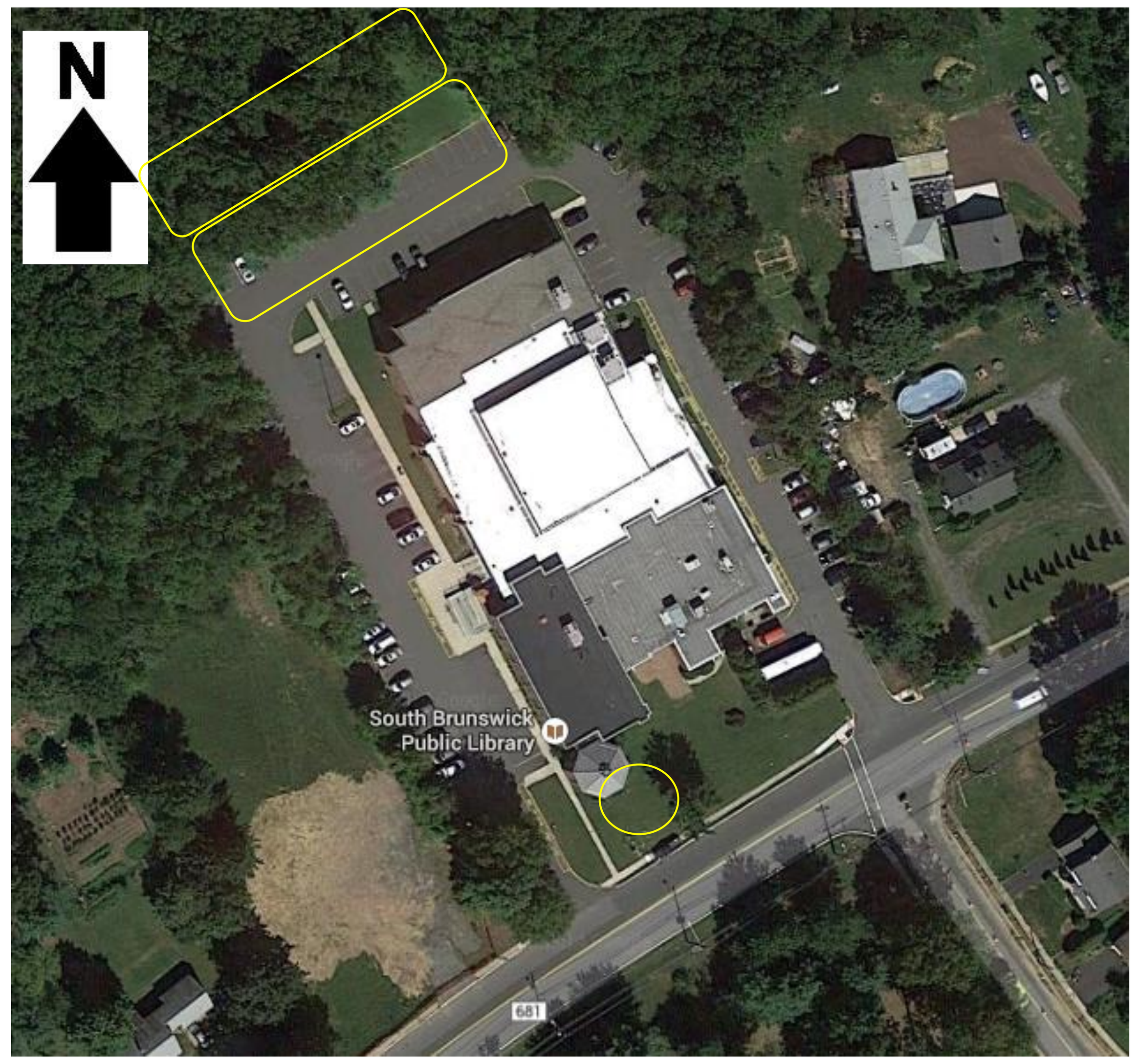
Partners/Stakeholders:
South Brunswick Township
Grace Presbyterian Church
Rutgers Cooperative Extension

Estimated Cost:
Porous pavement or a bioretention system may be used to intercept the runoff from the parking lot. A section of porous pavement which is 2,000 ft^2, with a 3 foot gravel bed, would be required to accommodate the parking lot runoff. At $30/$ft^2$ the estimated cost is $60,000 dollars. If a bioretention system is used a total area of 4,150 ft^2 would be required. At $5/$ft^2$ the estimated cost is $20,750. However, due to the large drainage area and amount of water, a special design of the system may be required. The bioretention system adjacent to the building requires 350 ft^2 and has an estimated cost of $1,750. A 1,500 gallon cistern is required to store the building's runoff. The estimated purchase and install cost is $3,000 dollars. The total cost of Option 1 and Option 2 for this project are $64,750 and $25,500, respectively.

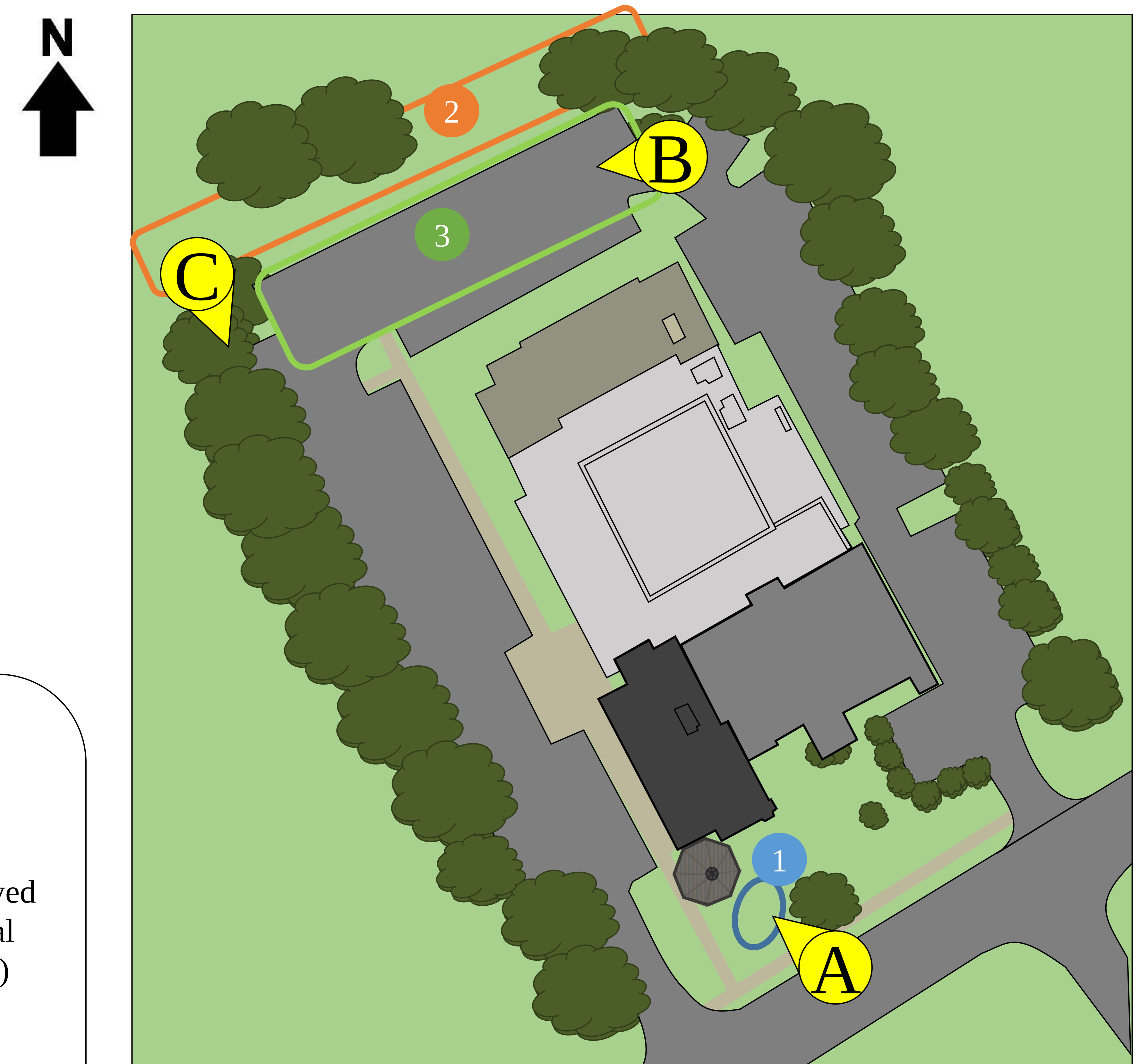
South Brunswick Township
Impervious Cover Assessment
South Brunswick Public Library, 110 Kingston Lane

RUTGERS
New Jersey Agricultural Experiment Station

PROJECT LOCATION:



SITE PLAN:



A

B

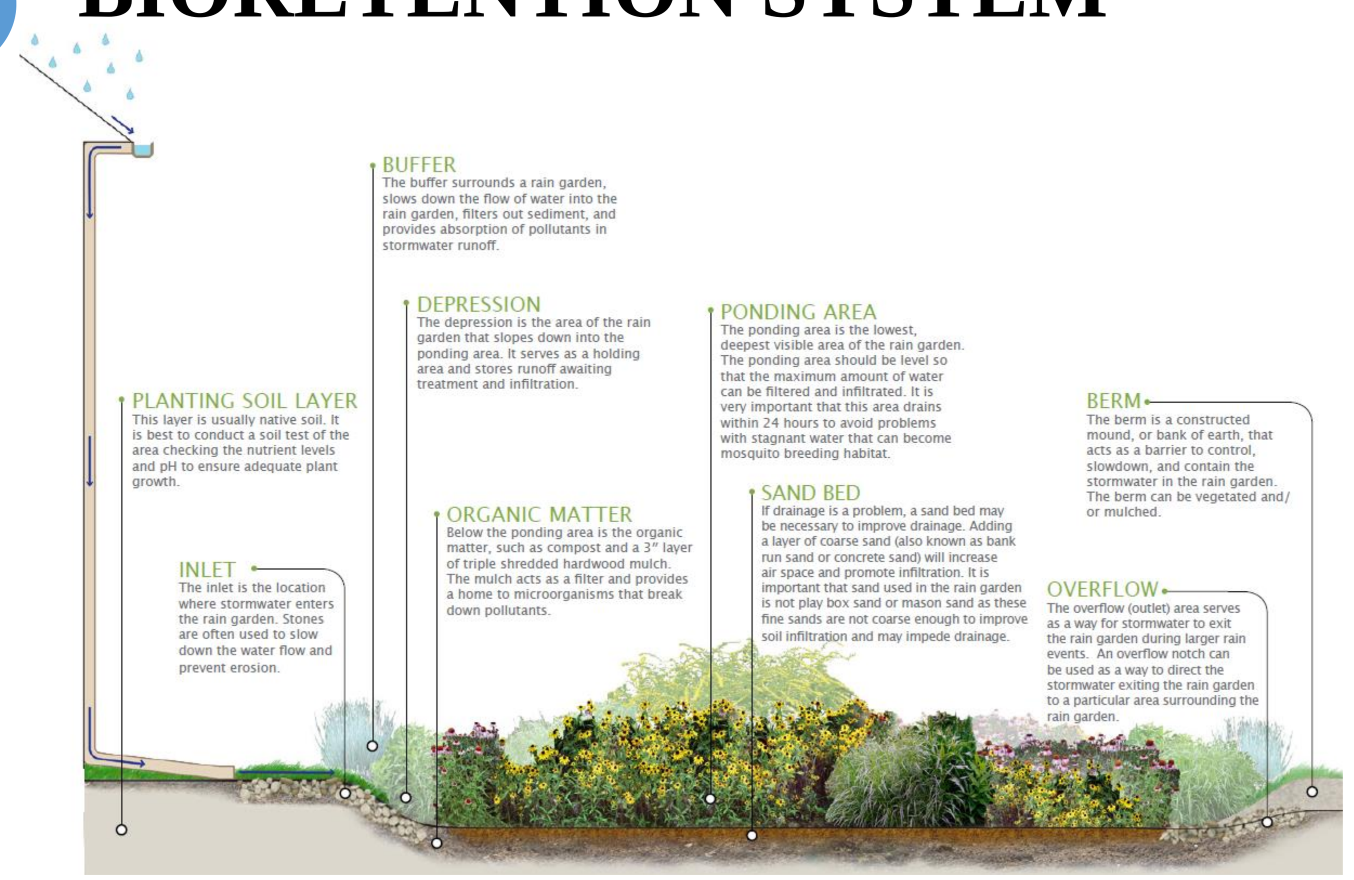
C

1 **BIORETENTION SYSTEM:** A bioretention system will reduce runoff and allow stormwater infiltration, decreasing the amount of water and contaminants transported in the storm sewer to local waterways. A bioretention system can be installed at this site, treating runoff from a portion of the roof.

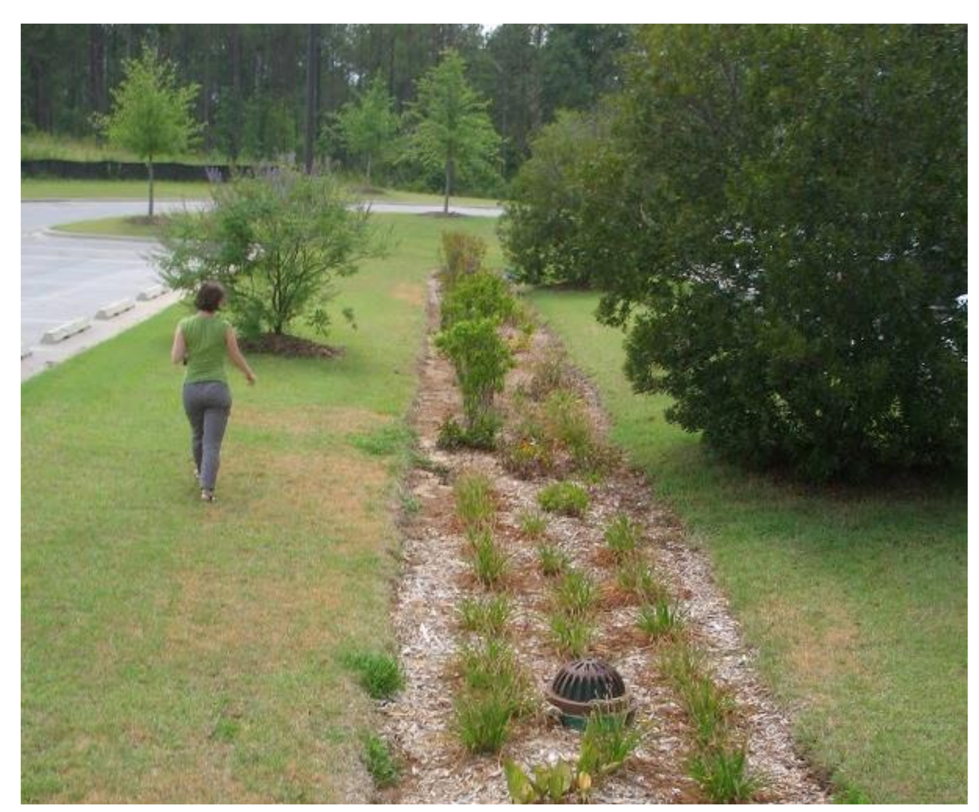
2 **BIOSWALE:** The bioswale will capture, treat, and infiltrate runoff from the parking lot. Water will be conveyed to the swale through a series of curb cuts. The swale will help reduce sediment and nutrient loading to the local waterway while providing beautiful landscaping and habitat for birds, butterflies, and pollinators. (OPTION 1)

3 **POROUS ASPHALT:** Porous asphalt promotes groundwater recharge and filters stormwater. A section of porous asphalt along the northern end of the parking lot will greatly reduce the amount of water reaching the sewer system. (OPTION 2)

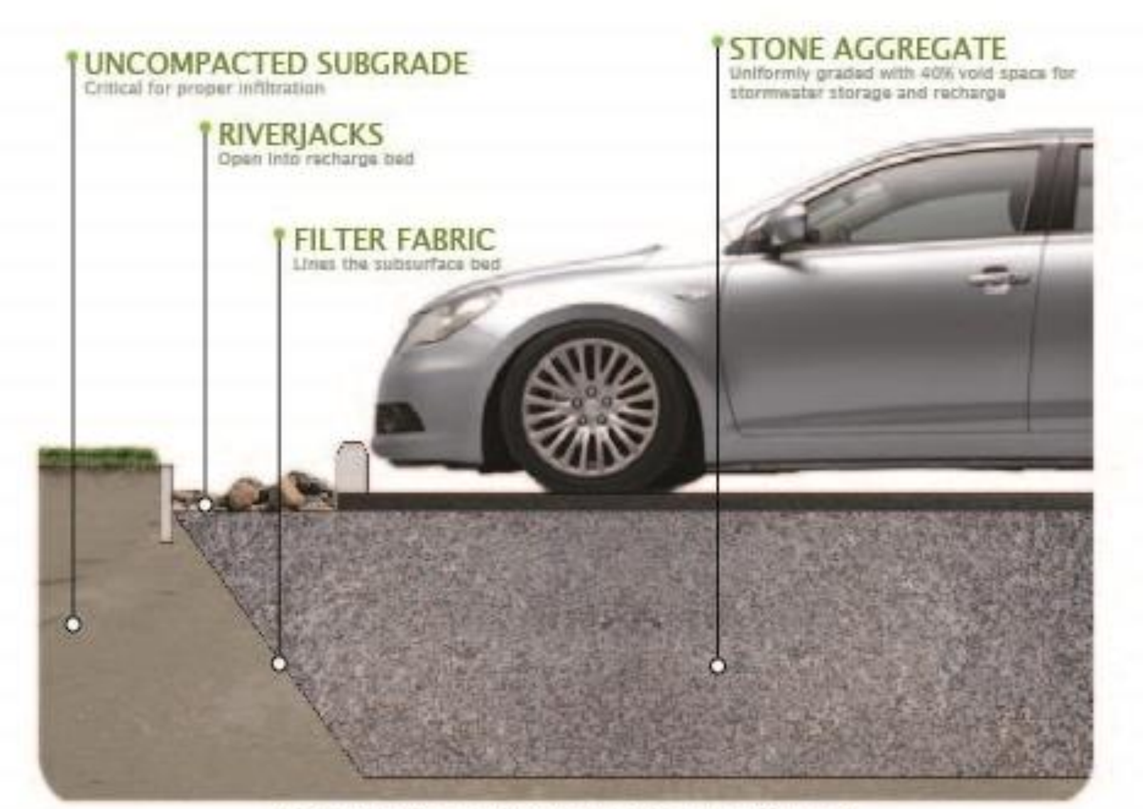
1 BIORETENTION SYSTEM



2 BIOSWALE



3 POROUS ASPHALT



South Brunswick Public Library
Green Infrastructure Information Sheet

Location: 110 Kingston Lane Monmouth Junction, NJ 08852	**Municipality:** South Brunswick Township **Subwatershed:** Lawrence Brook (above Deans Pond dam)
Green Infrastructure Description: curb cuts bioretention system 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 total suspended solids removal potential: yes	**Stormwater Captured and Treated Per Year:** bioretention system:12,298 gal. option 1 bioswale: 845,470 gal. option 2: porous pavement: 845,470 gal.

Existing Conditions and Issues:
This site is located on Kingston Lane and concerns the building and associated parking lots. At the building's street side near the building's southwest corner, there is an octagonal shaped portion with a downspout and a surrounding grassy area. The water in the parking lot flows northwest toward the back of the parking lot where sedimentation has occurred.

Proposed Solution(s):
At the southwest corner, the downspouts could be rerouted into a bioretention system that could be constructed in the large grassy area. At the northeast of the parking lot, curb cuts along with bioretention systems, composed of rain gardens and/or a bioswale, could be installed to absorb runoff from the parking lot before reaching the storm drains. Additionally or alternatively, porous asphalt could be placed along this northeast end to absorb stormwater runoff.

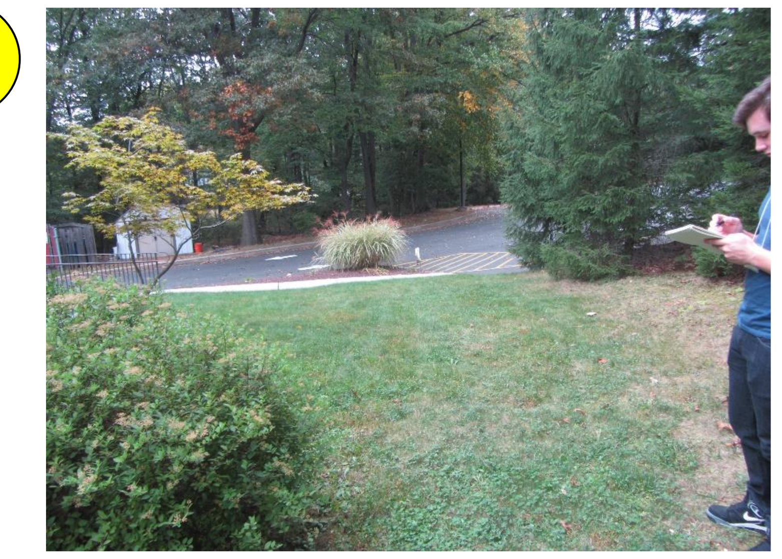
Anticipated Benefits:
A bioretention system is estimated to achieve a 30% removal rate for TN and a 60% removal rate for TP (NJDEP BMP Manual). TSS loadings may be reduced by up to 80%. If these bioretention systems are designed to capture and infiltrate stormwater runoff from the 2-year design storm (3.3 inches of rain over 24 hours), these systems will prevent approximately 95% of the TN, TP and TSS from flowing directly into local waterways. A bioretention system would also provide ancillary benefits, such as enhanced wildlife and aesthetic appeal to the local residents and employees of the South Brunswick Public Library. Curb cuts allow stormwater runoff to flow into the vegetated areas and bioretention systems rather than flow directly into catch basins. Porous asphalt allows stormwater to penetrate through to soil layers which will promote groundwater recharge as well as intercept and filter stormwater runoff.

Possible Funding Sources:
mitigation funds from local developers
NJDEP grant programs

Partners/Stakeholders:
South Brunswick Township
South Brunswick Public Library

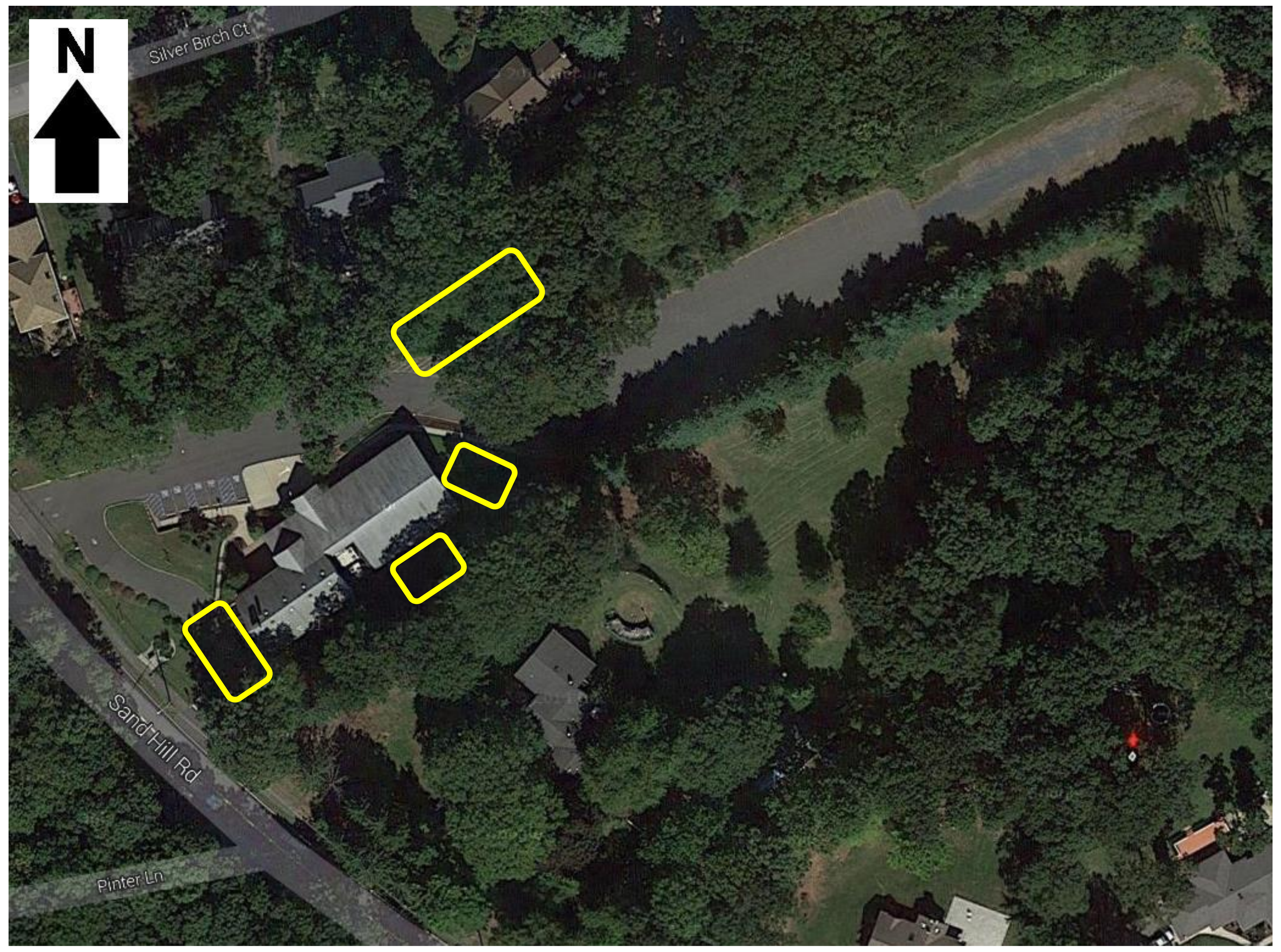
Rutgers Cooperative Extension
Estimated Cost: Option 1 for dealing with the parking lot's runoff is a bioswale. The bioswale proposed for this property is 250 ft long and 35 ft wide (8,750 ft^2). At \$5/ft^2, the estimated cost is \$43,750. The proposed rain garden requires 120 ft^2 for its drainage area. At \$5/ft^2, the estimated cost for the rain garden is \$600. Option 2 is a section of porous asphalt (6,700 ft^2) which will require a 2 ft gravel bed to accommodate the drainage area. At \$25/ft^2, the estimated cost of the porous asphalt is \$167,500. The total estimated cost of this project under Option 1 and Option 2 is \$44,350 and \$167,500, respectively.

South Brunswick Township
Impervious Cover Assessment
St. Barnabas Episcopal Church, 142 Sand Hill Road

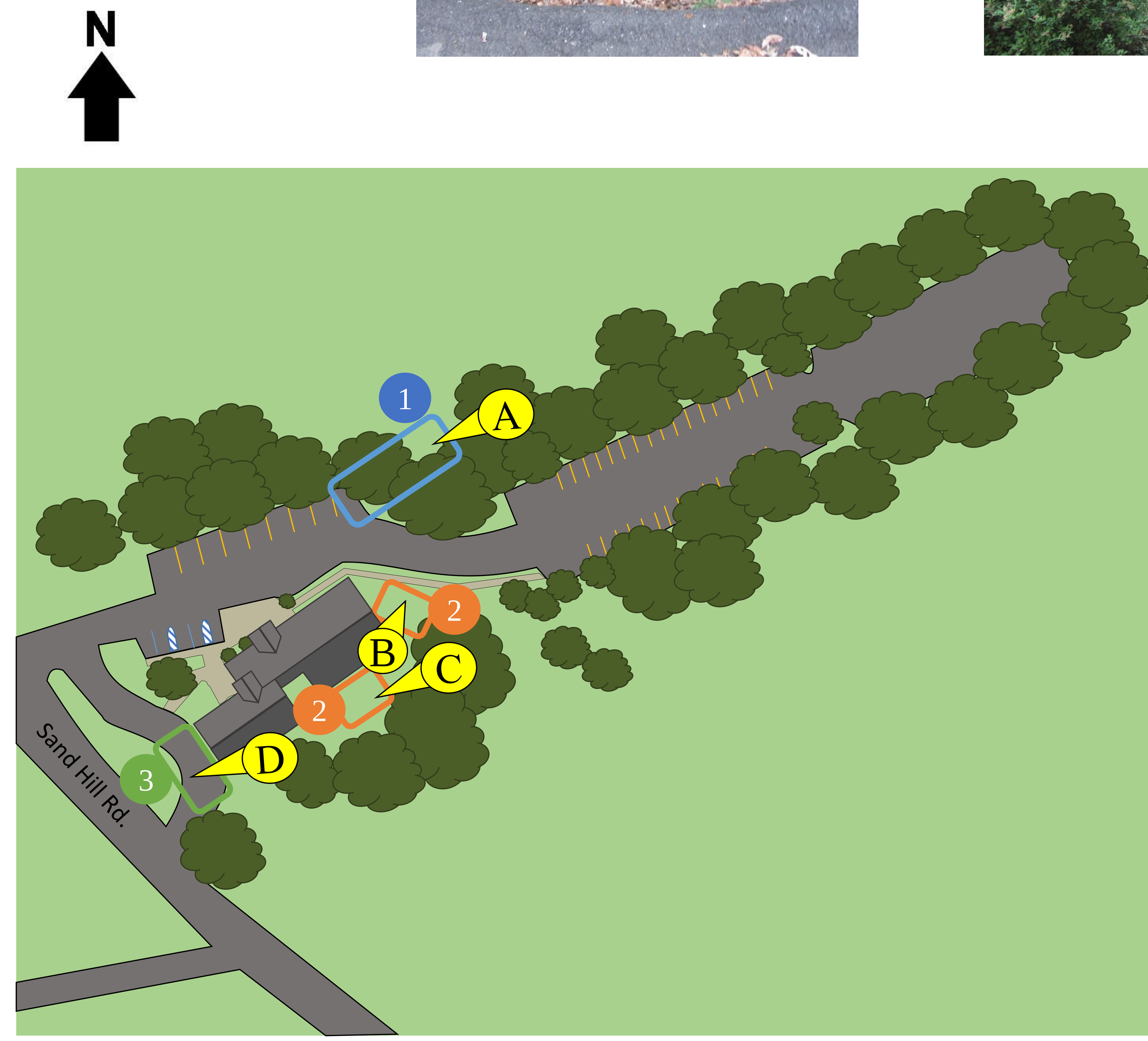


Rutgers New Jersey Agricultural Experiment Station

PROJECT LOCATION:



SITE PLAN:



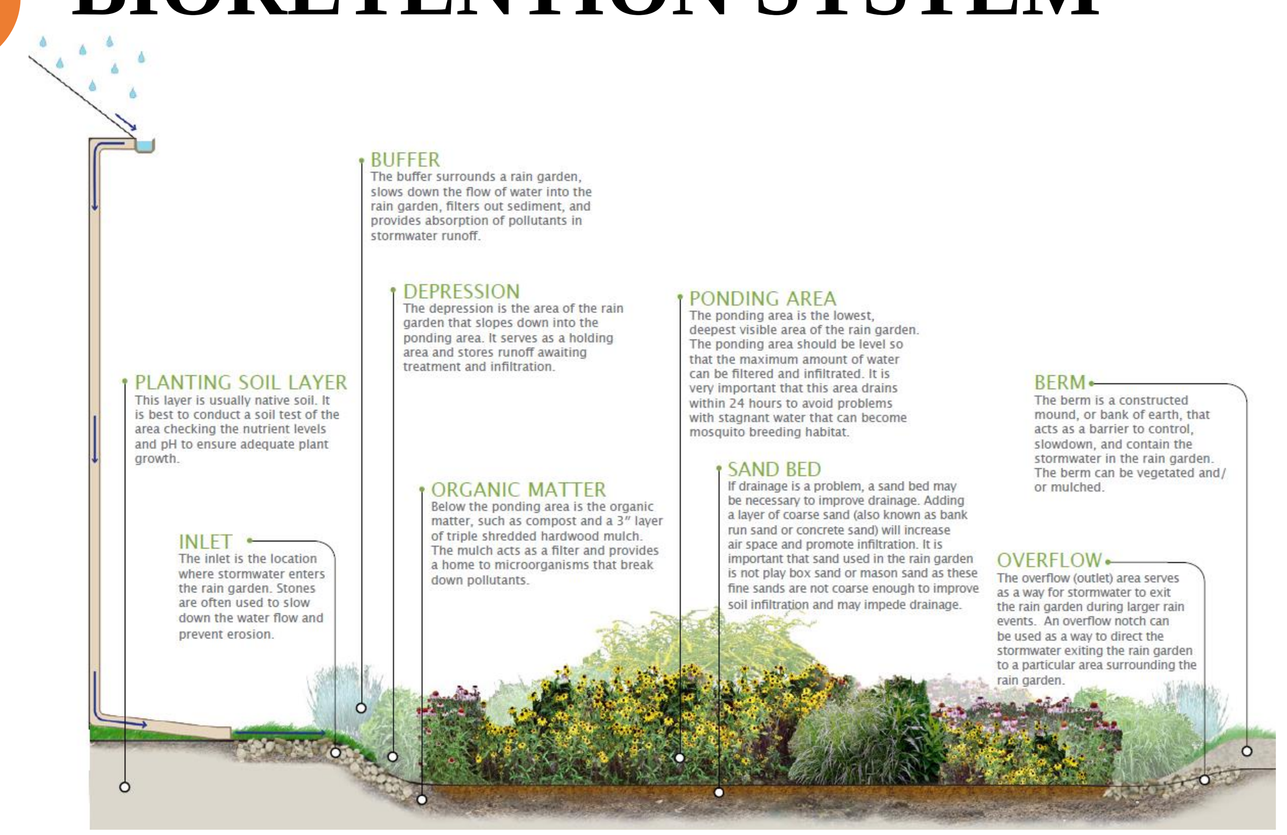
1. **BIOSWALE:** A bioswale will be installed to treat runoff from the upper parking lot. A bioswale is a vegetated system that will lower the levels of sediment and nutrient loading to the local watershed.

2. **BIORETENTION SYSTEMS:** Bioretention systems on this property will reduce the sediment and nutrient loading to the local watershed and will increase groundwater recharge. There are two areas which may be able to accommodate this system and will treat the building's runoff.

3. **POROUS ASPHALT:** Porous asphalt promotes groundwater recharge and filters stormwater.

1 BIOSWALE

2 BIORETENTION SYSTEM



3 POROUS ASPHALT

St. Barnabas Episcopal Church
Green Infrastructure Information Sheet

Location: 142 Sand Hill Road South Brunswick, NJ 08852	**Municipality:** South Brunswick Township **Subwatershed:** Six Mile Run (Above Middlebush Road)
Green Infrastructure Description: bioretention systems 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 systems: rain garden 1: 59,536 gal. rain garden 2:79,469 gal. bioswale: 117,510 gal. porous pavement: 88,927 gal.

Existing Conditions and Issues:
This site is located on Sand Hill Road and contains the building and associated parking lots. At the northern end of the parking lot near the building's northwest corner, there is an area of heavy sediment buildup along the curb. Near the northeast face, there is a large grassy area with a nearby outlet. At the building's middle southeast face, there are several connected downspouts. At the southwest face, there is an area with disconnected downspouts flowing directly into pavement with nearby sedimentation.

Proposed Solution(s):
At the parking lot area, the curb could be removed and a bioswale implemented to absorb the runoff instead. At the northeast face, a rain garden could be installed to absorb runoff before it enters the outlet. At the southeast face, the downspouts could be disconnected and fed into a bioretention system that could be constructed in the large grassy area to absorb stormwater runoff from the roof. At the southwest face, the area could be redone in porous pavement or downspouts rerouted into nearby grassy areas with diffusive pavers or stones.

Anticipated Benefits:
A bioretention system is estimated to achieve a 30% removal rate for TN and a 60% removal rate for TP (NJDEP BMP Manual). TSS loadings may be reduced by up to 80%. If these bioretention systems are designed to capture and infiltrate stormwater runoff from the 2-year design storm (3.3 inches of rain over 24 hours), these systems will prevent approximately 95% of the TN, TP and TSS from flowing directly into local waterways A bioretention system would also provide ancillary benefits, such as enhanced wildlife and aesthetic appeal to the local residents and members of the congregation of St. Barnabas Episcopal Church. Porous pavement allows stormwater to penetrate through to soil layers which will promote groundwater recharge as well as intercept and filter stormwater runoff.

Possible Funding Sources:
mitigation funds from local developers
NJDEP grant programs

Partners/Stakeholders:
South Brunswick Township
St. Barnabas Episcopal Church
Rutgers Cooperative Extension

Estimated Cost:
The bioswale proposed for this property is 100 ft long and 12 ft wide (1,200 ft^2). At $5/$ft^2$, the estimated cost is $6,000. Rain garden 1 and 2 are 600 and 800 ft^2, respectively. At $5/$ft^2$, the estimated cost for the each rain garden is $3,000 and $4,000, respectively. The section of porous pavement will require a 2 ft gravel bed to accommodate the drainage area. At $25/$ft^2$, the estimated cost of the porous pavement is $15,000. The total estimated cost of this project is $28,000.