# GREEN INFRASTRUCTURE STRATEGIC PLAN

## MADISON BOROUGH

*JULY 1, 2024*


RUTGERS
New Jersey Agricultural Experiment Station

Chatham

# ACKNOWLEDGEMENTS

This document has been prepared by the Rutgers Cooperative Extension Water Resources Program, with funding and direction from Sustainable Jersey and the New Jersey Agricultural Experiment Station, to highlight green infrastructure opportunities within Madison Borough.  We would like to thank the New Jersey Agricultural Experiment Station and Madison Borough for their input and support in creating this document.




RUTGERS
New Jersey Agricultural
Experiment Station

# TABLE OF CONTENTS

# GLOSSARY OF GREEN INFRASTRUCTURE TERMINOLOGY

1 **BEST MANAGEMENT PRACTICE (BMP)**

Activities or structural improvements that help reduce the quantity and improve the quality of stormwater runoff

2 **CONNECTED IMPERVIOUS SURFACE**

When stormwater runoff flows directly from an impervious surface to a local waterway or a sewer system, the impervious surface is considered "connected" or "directly connected."



3 **DISCONNECTED IMPERVIOUS SURFACE**

When stormwater runoff flows from an impervious surface onto a pervious surface or into a green infrastructure practice prior to entering a local waterway or a sewer system, the impervious surface is considered "disconnected."

4 **GREEN INFRASTRUCTURE PRACTICE**

A stormwater management practice that captures, filters, absorbs, and/or reuses stormwater to help restore the natural water cycle by reducing stormwater runoff, promoting infiltration, and/or enhancing

5 **IMPERVIOUS COVER ASSESSMENT (ICA)**

Readily available land use/land cover data from the New Jersey geographic information system (GIS) database are used to determine the percentage of impervious cover in municipalities by subwatershed. The ICA includes calculations of stormwater runoff volumes associated with impervious surfaces.

6 **GREEN INFRASTRUCTURE ACTION PLAN**

A plan that identifies opportunities to retrofit specific sites with green infrastructure practices to reduce the impacts of stormwater runoff from impervious surfaces. A companion document to the green infrastructure strategic plan.

7 **IMPERVIOUS SURFACE**

Any surface that has been covered with a layer of material so that it is highly resistant to infiltration by water (e.g., paved roadways, paved parking areas, and building roofs)

8 **LOW IMPACT DEVELOPMENT (LID)**

A land planning and engineering design approach that emphasizes conservation and use of on-site natural features to manage stormwater runoff and protect water quality

9 **MUNICIPAL SEPARATE STORM SEWER**

A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that transports stormwater runoff to local waterways or stormwater facilities such

10 **NONPOINT SOURCE (NPS) POLLUTION**

"Nonpoint source pollution" is also called "people pollution." It is the pollution that comes from our everyday lives. It is the fertilizers that wash off farms and lawns. It is the pet waste that washes into streams. It is the sediment (or soil) that erodes from the land into local waterways. It is the oil and grease that comes from parking lots. Finally, it is the pollutants such as nitrogen, phosphorus, and heavy metals that settle out of the atmosphere onto roads and rooftops. When it rains, stormwater runoff carries nonpoint source pollution and may ultimately wash it into waterways.

11 **PERVIOUS SURFACE**

Any surface that allows water to pass through it (e.g., lawn area)



12 **STORMWATER RUNOFF**

The water from rain or melting snows that can become "runoff" flowing over the ground surface and returning to lakes and streams

13 **WATERSHED IMPROVEMENT PLAN**

A plan that the New Jersey Municipal Separate Storm Sewer System (MS4) Permit requires each municipality to prepare that includes a watershed inventory and watershed assessment. The purpose of the plan is to identify watershed improvement projects that will improve the health of local waterways and reduce flooding.

# INTRODUCTION

By using cost-effective green infrastructure practices, Madison Borough can begin to reduce the negative impacts of stormwater runoff and decrease the pressure on local infrastructure and waterways. For Madison Borough, potential green infrastructure projects have been identified in the Green Infrastructure Action Plan for Madison Borough, New Jersey, dated February 9, 2024. In the Action Plan, each project has been classified as a mitigation opportunity for recharge potential, total suspended solids removal, and stormwater peak reduction. For each proposed green infrastructure practice, detailed green infrastructure information sheets provide an estimate of gallons of stormwater captured and treated per year. Additionally, artistic renderings for three of the potential green infrastructure projects have been included in the Action Plan. These artistic renderings provide an aerial photograph of the site and details of the proposed green infrastructure practices.

This Green Infrastructure Strategic Plan is intended to build upon the Green Infrastructure Action Plan by providing a holistic examination of Madison Borough to help the community identify additional green infrastructure opportunities that go beyond the Action Plan. The Strategic Plan links site suitability criteria with impervious cover and green space criteria to examine tax-exempt parcels of land in the community as well as municipally owned roadside green space for possible stormwater management opportunities. The Strategic Plan presents long-term goals for impervious cover management to couple the short-term goals that are contained in the Action Plan. The Strategic Plan is to be used as a guide for the community of Madison Borough to continue its long-term commitment to improving water quality and reducing flooding by recognizing green infrastructure opportunities throughout the municipality and ultimately implementing green infrastructure practices that demonstrate to residents and local leaders the benefits of and opportunities for better managing stormwater runoff. Additionally, concept designs for the potential green infrastructure projects have been developed. These concept designs provide an aerial photograph of the site and details of the proposed green infrastructure practices. Lastly, Appendix A of this document offers information about community engagement opportunities related to green infrastructure, while Appendix B provides maintenance guidelines for green infrastructure practices.

Rutgers University professor, Tobiah Horton, reviews a rain garden design with a homeowner.


A community garden that harvests and recycles rainwater


Rain barrel workshop participants

# WHAT IS GREEN INFRASTRUCTURE?



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 principle, 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).


A rain garden after planting

# WHAT IS STORMWATER?

When rainfall hits the ground, it can soak into the ground or flow across the surface. When rainfall flows across a surface, it is called "stormwater" runoff. Pervious surfaces allow stormwater to readily soak into the soil and recharge groundwater. 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 amount of stormwater runoff. New Jersey has many problems due to stormwater runoff from impervious surfaces, including:

- POLLUTION: According to the 2020 New Jersey Water Quality Assessment Report, 95% of the assessed waters in New Jersey are impaired. Urban-related stormwater runoff is 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 carried to 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 has increased greatly with this trend, costing billions of dollars over this time span.
- EROSION: Increased stormwater runoff causes an increase in stream velocity. 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.


Stormwater catch basin


Purple cone flower


Pervious pavers

To protect and repair our waterways, reduce flooding, and stop erosion, stormwater runoff has to be better managed. Impervious 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.

# WHY ARE IMPERVIOUS SURFACES IMPORTANT?

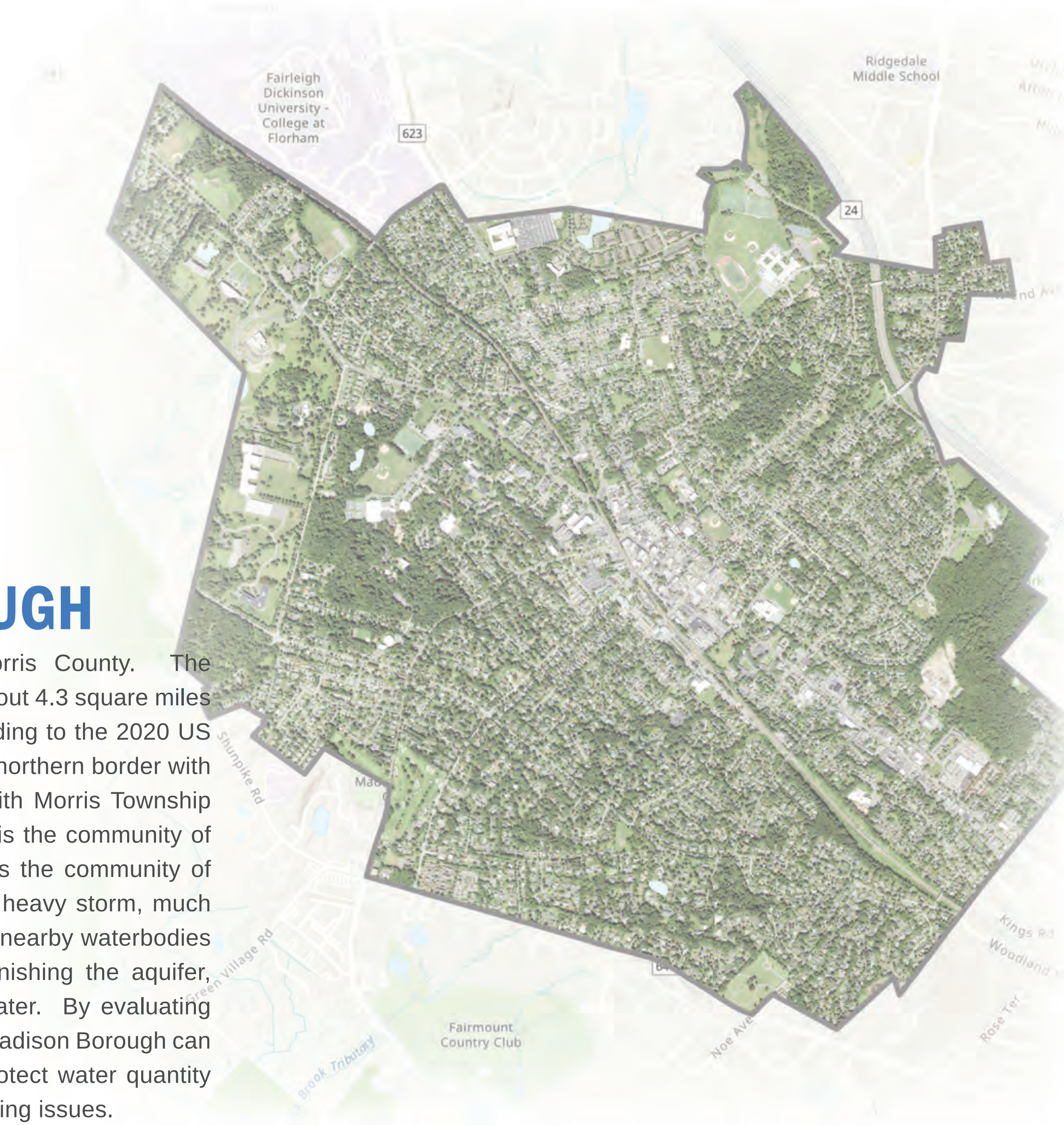
The primary cause of the pollution, flooding, and erosion problems is the quantity of impervious surfaces draining directly to local waterways. New Jersey is one of the most developed states in the country. Currently, the state has the highest percent of impervious cover in the country at 12.1% of its 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 where pollutants can be removed naturally during the infiltration process). Additionally, impervious surfaces prevent groundwater recharge which is important in Madison since their water supply is 100% groundwater from the Buried Valley Sole Source Aquifer.

According to Schueler (1994), Arnold and Gibbons (1996), and May et al. (1997), there is a significant link between impervious cover and stream ecosystem impairment. Impervious cover is directly 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.



Urbanizing streams can be classified into three categories (Schueler, 1994 and 2004): Sensitive — Sensitive streams typically have a watershed impervious surface cover from 0-10%, Impacted — Impacted streams have a watershed impervious cover ranging from 11-25% and typically show clear signs of degradation from urbanization, Non-supporting — 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.

Schueler et al. (2009) reformulated the impervious cover model, and this new analysis determined that stream degradation was first detected between 2 to 15% impervious cover. The updated impervious cover model recognizes the wide variability of stream degradation at impervious cover below 10%. The updated model also moves away from having a fixed line between stream quality classifications. For example, 5 to 10% impervious cover is included for the transition from sensitive to impacted, 20 to 25% impervious cover for the transition from impacted to non-supporting, and 60 to 70% impervious cover for the transition from non-supporting to urban drainage.

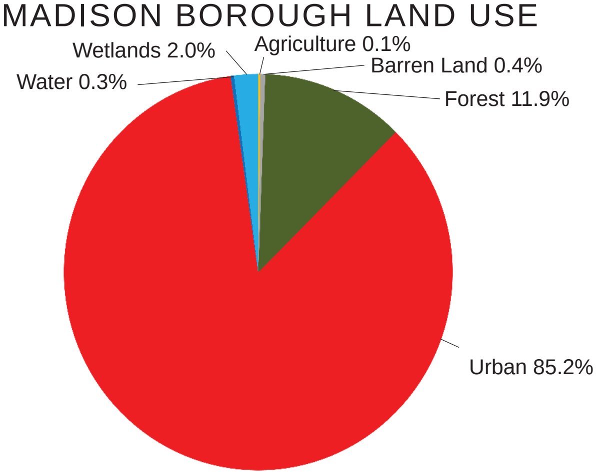


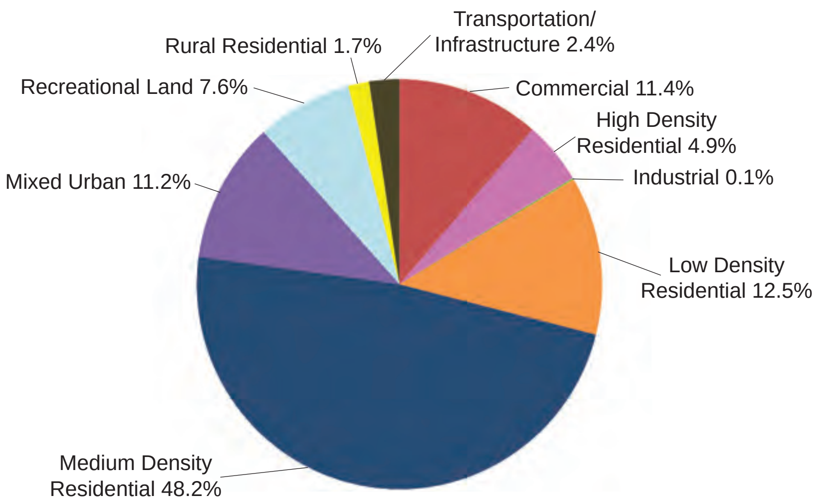

# MADISON BOROUGH

Madison Borough is located in Morris County. The municipality covers an area totaling about 4.3 square miles and has a population of 16,937 according to the 2020 US Census. Madison Borough shares its northern border with Florham Park and western border with Morris Township and Harding Township. To the south is the community of Chatham Township, and to the east is the community of Chatham Borough. In the event of a heavy storm, much of the municipality's runoff travels into nearby waterbodies untreated and prevents it from replenishing the aquifer, which provides the town's drinking water. By evaluating the feasibility of green infrastructure, Madison Borough can identify cost-effective ways to help protect water quantity as well as water quality and local flooding issues.

# LAND USE IN MADISON BOROUGH

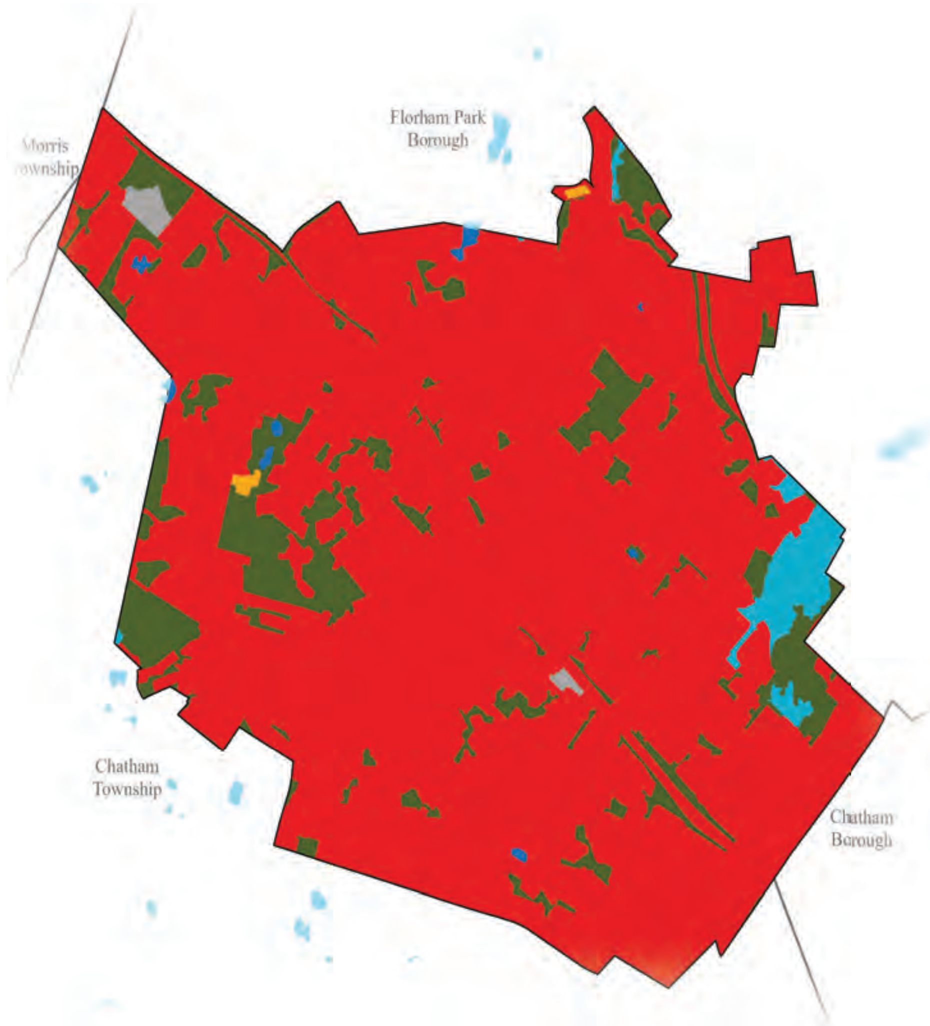
Madison Borough is dominated by urban land uses. A total of 85.2% of the municipality's land use is classified as urban. Of the urban land in Madison Borough, medium density residential is the dominant land use. Urban land uses tend to have a high percentage of impervious surfaces.



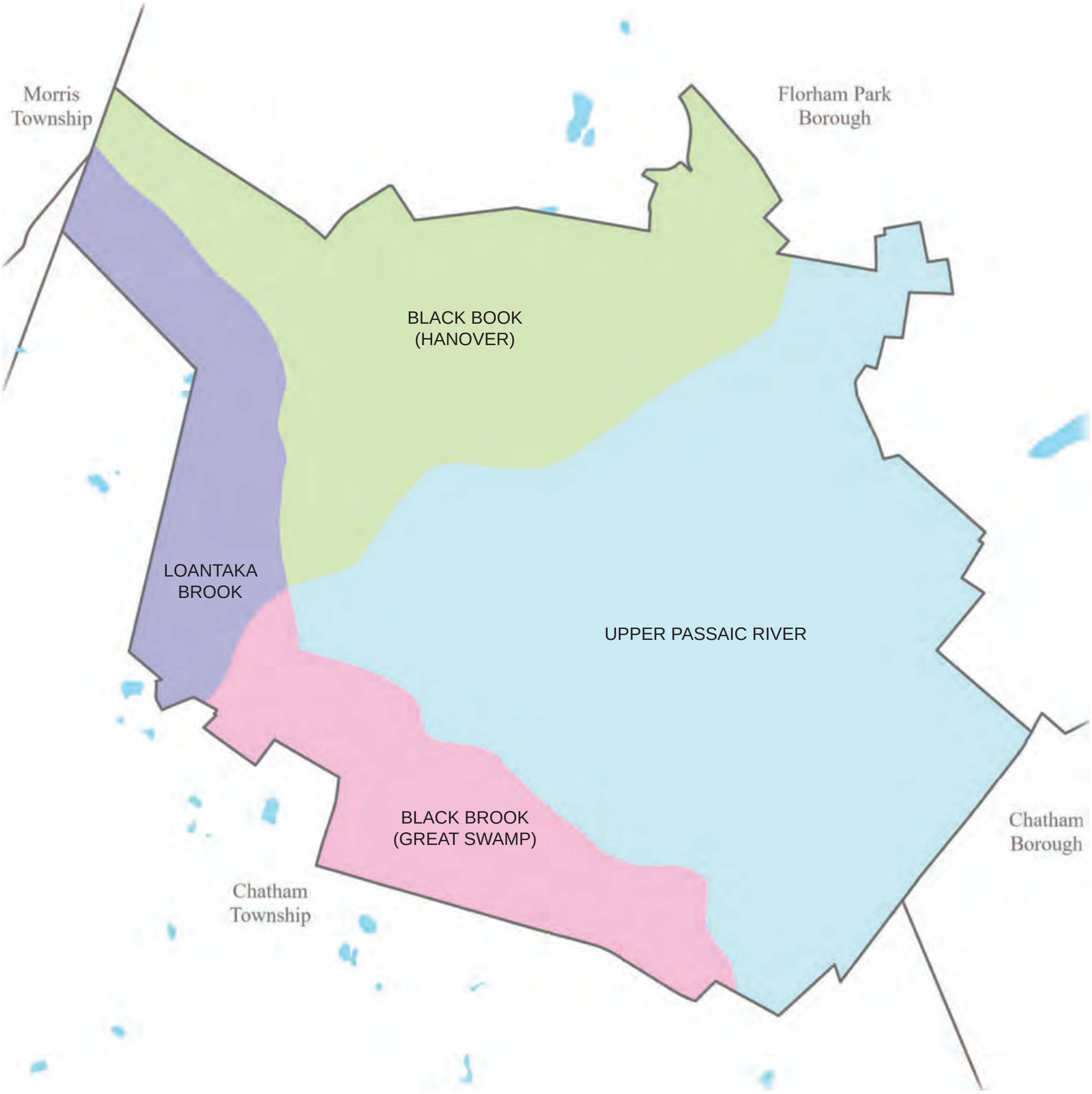






MADISON BOROUGH LAND USE



# MADISON BOROUGH SUBWATERSHEDS



# IMPERVIOUS COVER ANALYSIS

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.

The New Jersey Department of Environmental Protection (NJDEP) open data impervious surface geographic information system (GIS) data layer depicts surfaces throughout Madison Borough that have been covered with materials that are highly resistant to infiltration by water, rendering them impervious. This dataset was used to estimate the impervious coverage for Madison Borough. Based upon the 2015 NJDEP impervious cover data, approximately 34.6% of Madison Borough has impervious cover.

Water resources are typically managed on a watershed/subwatershed basis; therefore, an impervious cover analysis has been performed for each subwatershed within Madison Borough (Table 1). On a subwatershed basis, impervious cover ranges from 17.2% in the Loantaka Brook subwatershed to 38.3% in the Upper Passaic 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 and groundwater recharge has been limited.

Connected downspout


Reservoir

TABLE 1. IMPERVIOUS COVER ANALYSIS BY SUBWATERSHED FOR MADISON BOROUGH

| Subwatershed | Total Area | Land Use Area | Water Area | Impervious Cover | |
|---|---|---|---|---|---|
| | (ac) | (ac) | (ac) | (ac) | (%) |
| Black Brook (Great Swamp) | 355.9 | 355.0 | 0.9 | 106.7 | 30.1% |
| Black Brook (Hanover) | 730.7 | 726.0 | 4.7 | 265.3 | 36.5% |
| Loantaka Brook | 279.2 | 277.2 | 2.0 | 47.6 | 17.2% |
| Upper Passaic River | 1,401.6 | 1,401.2 | 0.4 | 536.1 | 38.3% |
| **Total** | **2,767.4** | **2,759.34** | **8.0** | **955.69** | **34.6%** |

TABLE 2. STORMWATER RUNOFF VOLUMES FROM IMPERVIOUS SURFACES BY SUBWATERSHED IN MADISON BOROUGH

| Subwatershed | Total Runoff Volume for the 1.25" NJ Water Quality Storm (Mgal) | Total Runoff Volume for the NJ Annual Rainfall of 50" (Mgal) | Total Runoff Volume for the 2-year Design Storm (3.58") (Mgal) | Total Runoff Volume for the 10-year Design Storm (5.40") (Mgal) | Total Runoff Volume for the 100 Year Design Storm(8.85") (Mgal) |
|---|---|---|---|---|---|
| Black Brook (Great Swamp) | 3.6 | 144.9 | 10.4 | 15.6 | 25.6 |
| Black Brook (Hanover) | 9.0 | 360.1 | 25.8 | 38.9 | 63.7 |
| Loantaka Brook | 1.6 | 64.7 | 4.6 | 7.0 | 11.4 |
| Upper Passaic River | 18.2 | 727.8 | 52.1 | 78.6 | 128.8 |
| **Total** | **32.4** | **1,297.5** | **92.9** | **140.1** | **229.7** |

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 Madison Borough, Morris County) associated with impervious surfaces have been calculated for the following storms: the New Jersey water quality design storm of 1.25 inches of rain, an annual rainfall of 50 inches, the 2-year design storm (3.58 inches of rain), the 10-year design storm (5.40 inches of rain), and the 100-year design storm (8.85 inches of rain). These values are based on current rainfall values. These runoff volumes are summarized in Table 2. A substantial amount of rainwater drains from impervious surfaces in Madison Borough. For example, if the stormwater runoff from one water quality storm (1.25 inches of rain) in the Upper Passaic River subwatershed was harvested and purified, it could supply water to 166 homes for a year (assuming 300 gallons per day per home).

# WHAT CAN WE DO ABOUT IMPERVIOUS SURFACES?

Once impervious surfaces have been identified, there are three steps to better manage these surfaces through green infrastructure practices.

1 Eliminate surfaces that are not necessary. 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 areas that will help reduce flooding, increase wildlife habitat, and positively enhance water quality as well as beautify neighborhoods.



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 cart ways could be converted to one-way cart 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.

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 also exist to harvest rainwater for non-potable uses such as watering gardens.


RAIN GARDEN


116

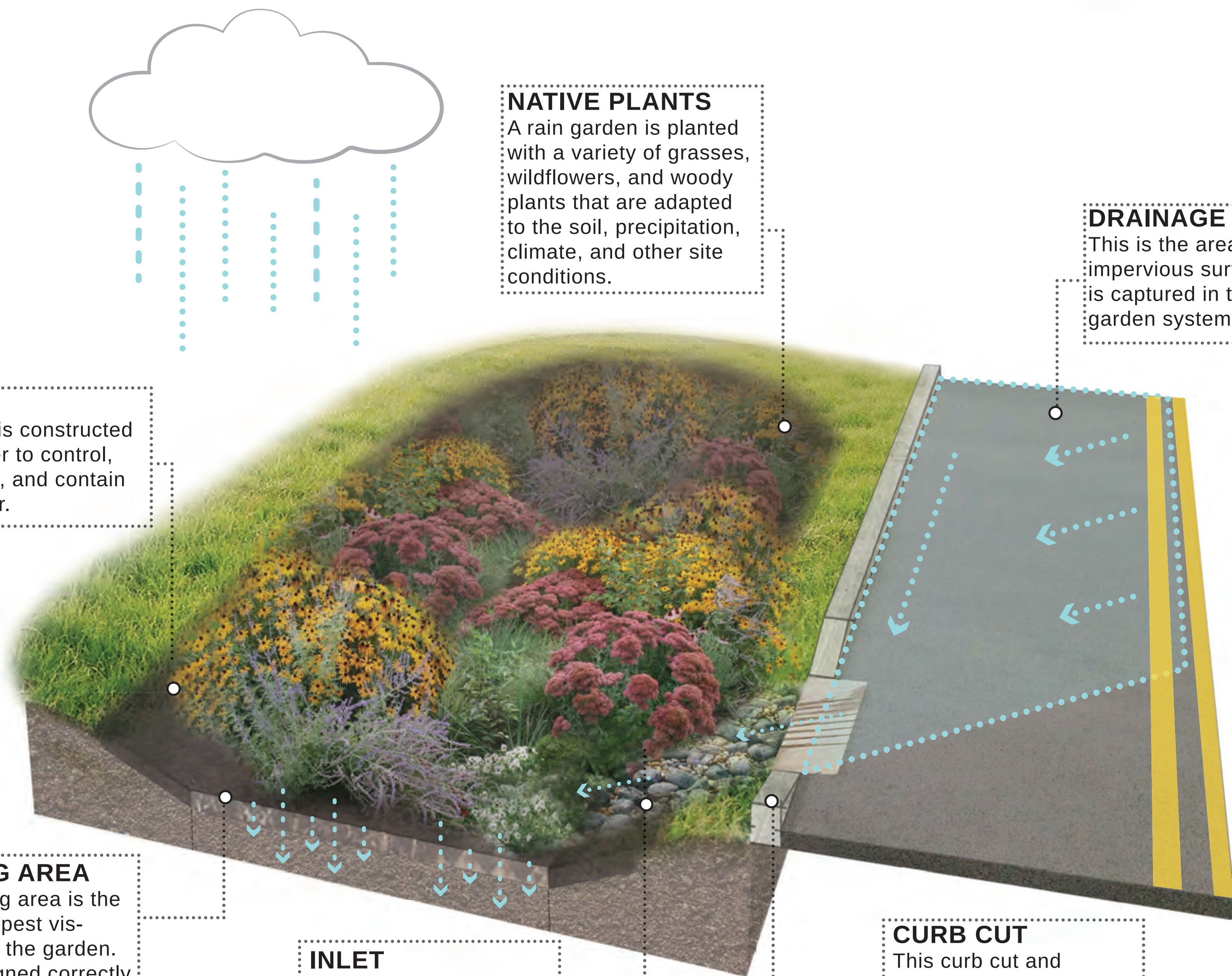
# GREEN INFRASTRUCTURE PRACTICES

# BIORETENTION SYSTEMS

A rain garden, or bioretention system, is a landscaped, shallow depression that captures, filters, and infiltrates stormwater runoff. The rain garden removes nonpoint source pollutants from stormwater runoff while recharging groundwater. A rain garden serves as a functional system to capture, filter, and infiltrate stormwater runoff at the source while being aesthetically pleasing. Rain gardens are an important tool for communities and neighborhoods to create diverse, attractive landscapes while protecting the health of the natural environment. By incorporating an underdrain, rain gardens can also be installed in areas that do not infiltrate.

Rain gardens can be implemented throughout communities to begin the process of re-establishing the natural function of the land. Rain gardens offer one of the quickest and easiest methods to reduce runoff and help protect our water resources. Beyond the aesthetic and ecological benefits, rain gardens encourage environmental stewardship and community pride.



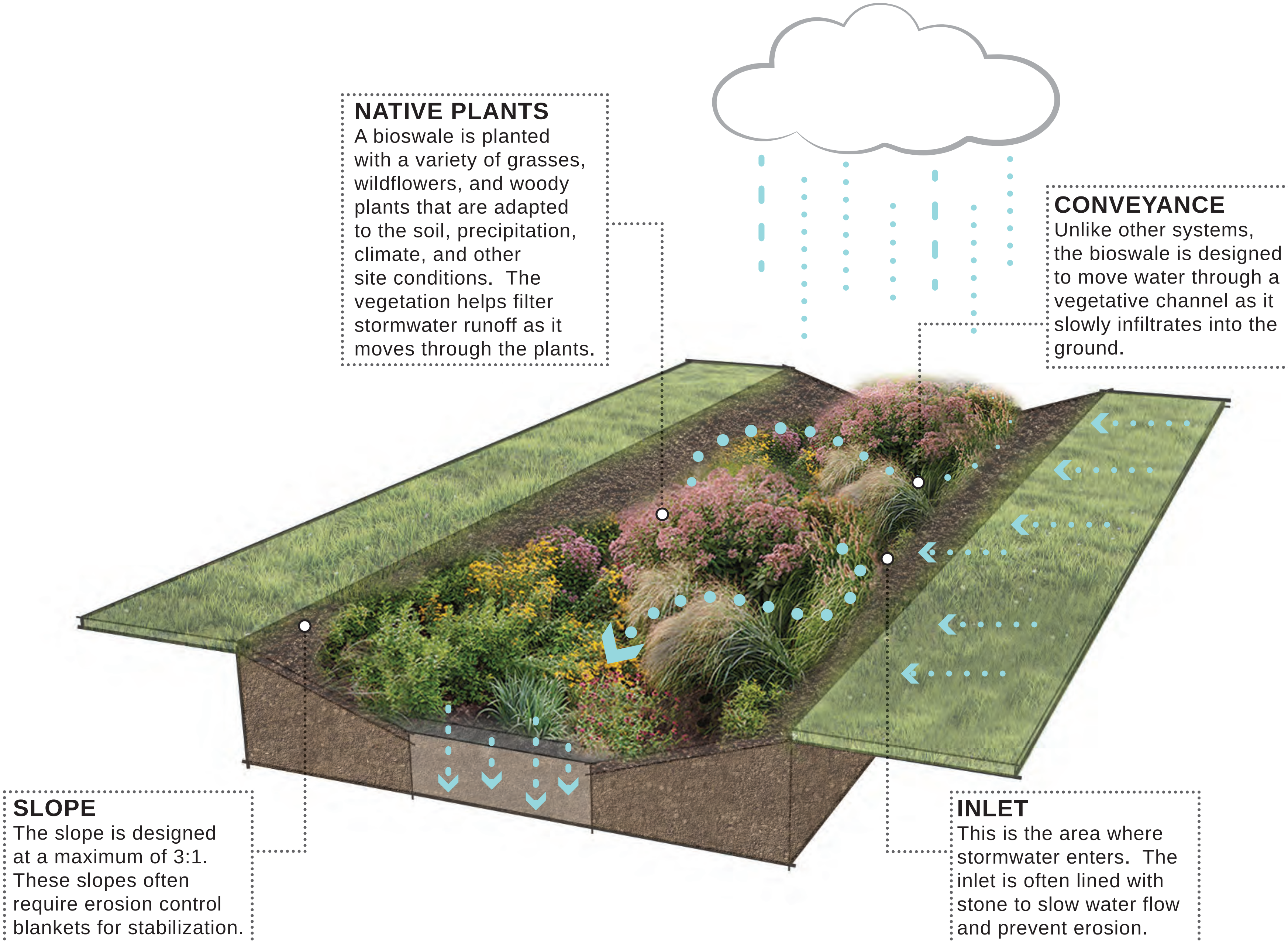

NATIVE PLANTS
A rain garden is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions.
DRAINAGE AREA
This is the area of impervious surface that is captured in the rain garden system.
BERM
The berm is constructed as a barrier to control, slow down, and contain stormwater.
PONDING AREA
The ponding area is the lowest, deepest visible area of the garden. When designed correctly, this area should drain within 24 hours.
INLET
This is the area where stormwater enters. The inlet is often lined with stone to slow water flow and prevent erosion.
CURB CUT
This curb cut and concrete flow pad are designed to help redirect stormwater runoff to the rain garden system and out of the storm drain.

# BIOSWALES

Bioswales are landscape features that convey stormwater from one location to another while removing pollutants and allowing water to infiltrate. Bioswales are often designed for larger scale sites where water needs time to move and slowly infiltrate into the groundwater.

Much like the rain garden systems, bioswales can also be designed with an underdrain pipe that allows excess water to discharge to the nearest catch basin or existing stormwater system.



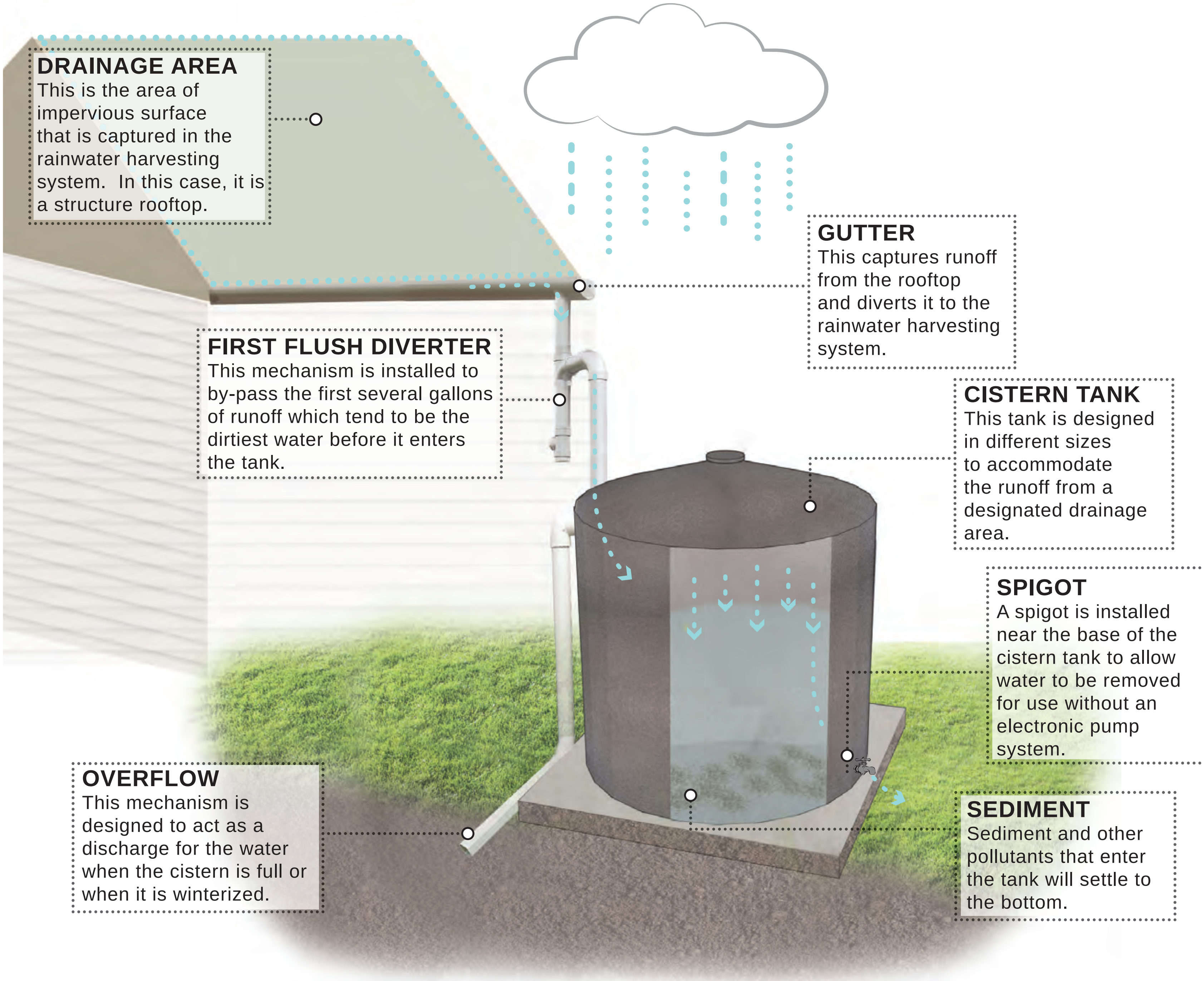

NATIVE PLANTS
A bioswale is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions. The vegetation helps filter stormwater runoff as it moves through the plants.
CONVEYANCE
Unlike other systems, the bioswale is designed to move water through a vegetative channel as it slowly infiltrates into the ground.
SLOPE
The slope is designed at a maximum of 3:1. These slopes often require erosion control blankets for stabilization.
INLET
This is the area where stormwater enters. The inlet is often lined with stone to slow water flow and prevent erosion.

# RAINWATER HARVESTING SYSTEMS

These systems capture rainwater, mainly from rooftops, in cisterns or rain barrels.  The water can then be used for watering gardens, washing vehicles, or for other non-potable uses.

Rainwater harvesting systems come in all shapes and sizes.  These systems are good for harvesting rainwater in the spring, summer, and fall but must be winterized during the colder months.  Cisterns are winterized, and then their water source is redirected from the cistern back to the original discharge area.



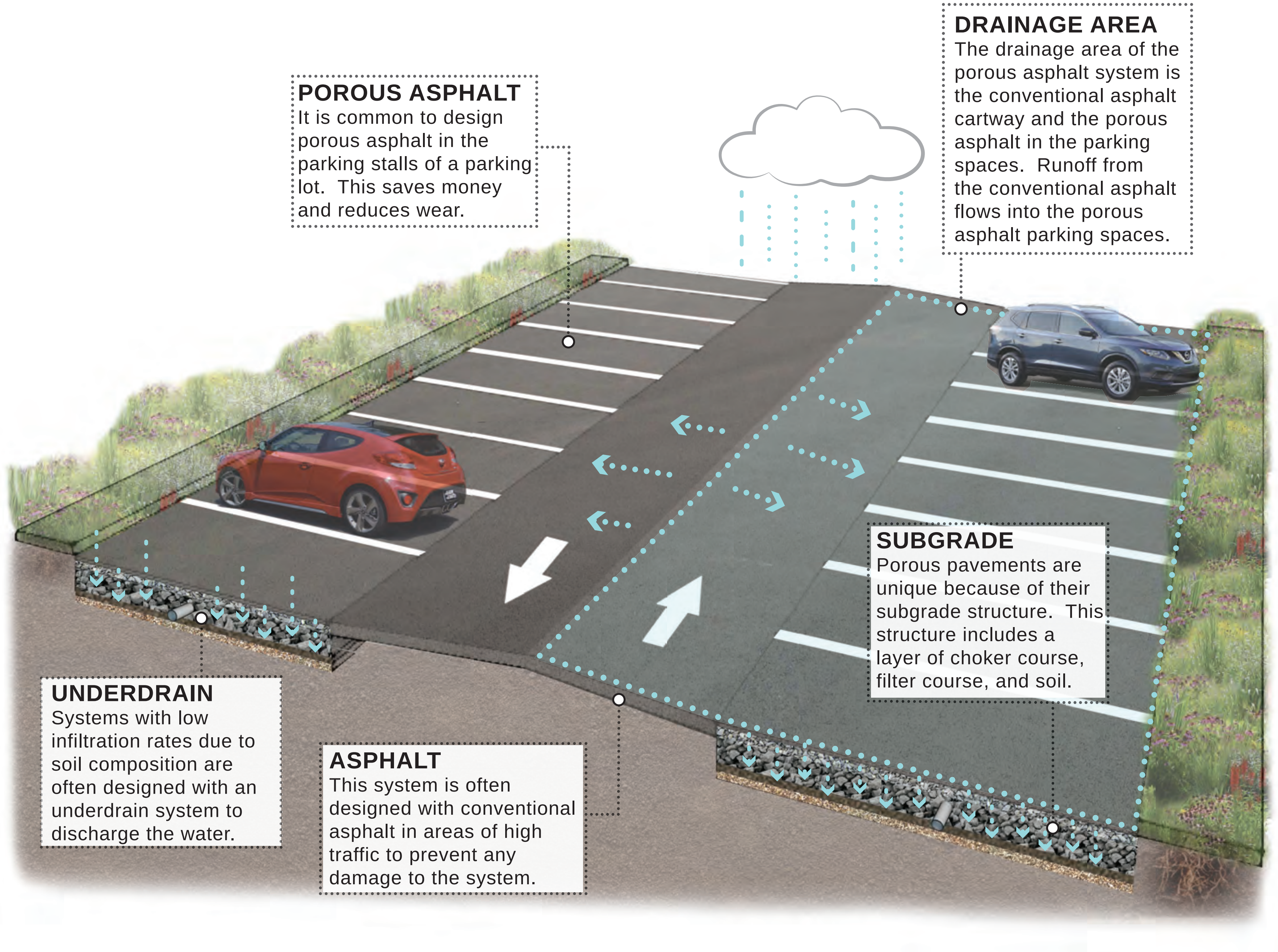

DRAINAGE AREA
This is the area of impervious surface that is captured in the rainwater harvesting system. In this case, it is a structure rooftop.
GUTTER
This captures runoff from the rooftop and diverts it to the rainwater harvesting system.
FIRST FLUSH DIVERTER
This mechanism is installed to by-pass the first several gallons of runoff which tend to be the dirtiest water before it enters the tank.
CISTERN TANK
This tank is designed in different sizes to accommodate the runoff from a designated drainage area.
SPIGOT
A spigot is installed near the base of the cistern tank to allow water to be removed for use without an electronic pump system.
OVERFLOW
This mechanism is designed to act as a discharge for the water when the cistern is full or when it is winterized.
SEDIMENT
Sediment and other pollutants that enter the tank will settle to the bottom.

# PERMEABLE PAVEMENTS

These surfaces include pervious concrete, porous asphalt, interlocking concrete pavers, and grid pavers. 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 stormwater runoff, allowing it to slowly seep into the underlying uncompacted soil.

By installing an underdrain system, these systems can be used in areas where infiltration is limited. The permeable pavement system will still filter pollutants and provide storage but will not infiltrate the runoff.



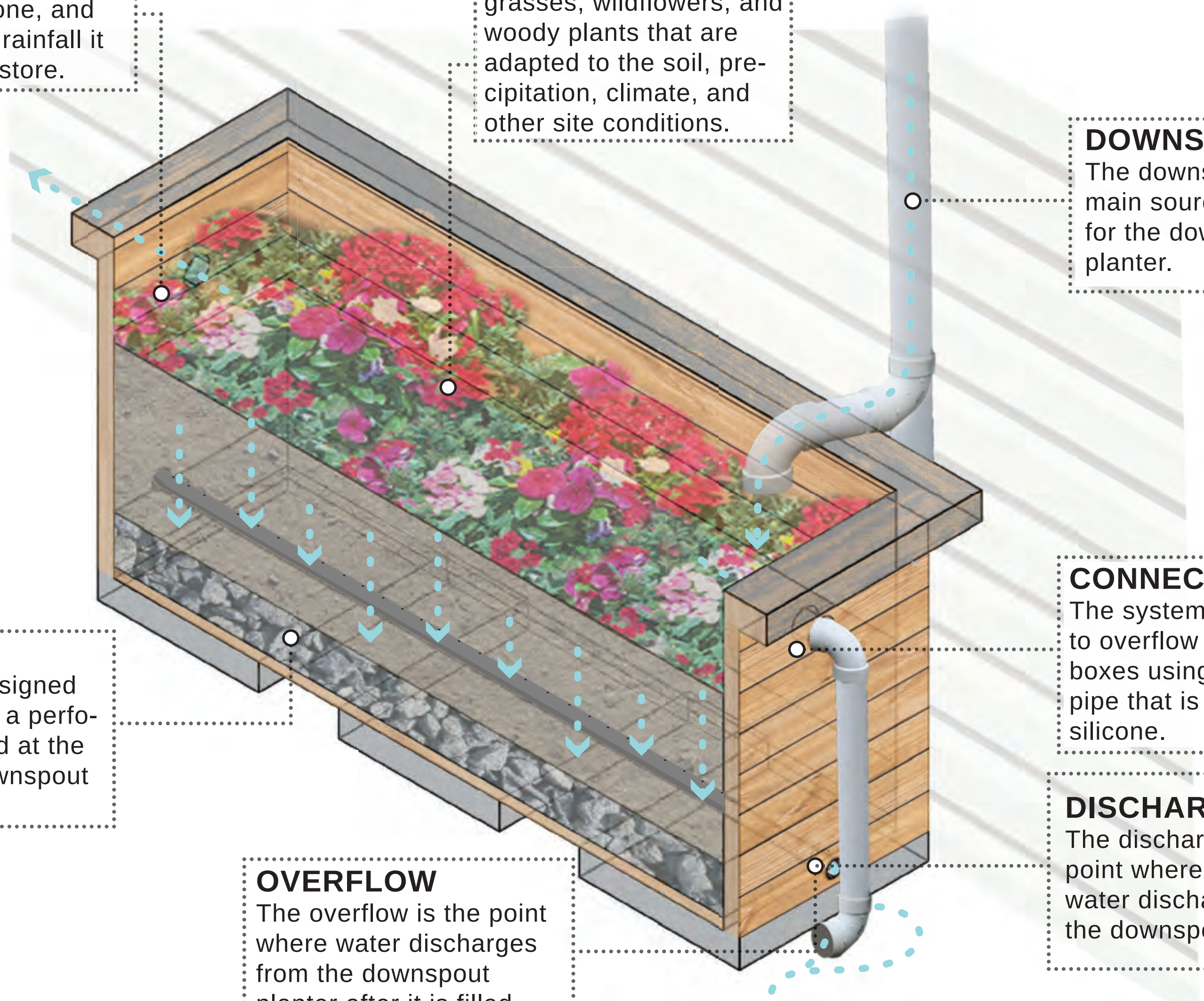

POROUS ASPHALT
It is common to design porous asphalt in the parking stalls of a parking lot. This saves money and reduces wear.
DRAINAGE AREA
The drainage area of the porous asphalt system is the conventional asphalt cartway and the porous asphalt in the parking spaces. Runoff from the conventional asphalt flows into the porous asphalt parking spaces.
SUBGRADE
Porous pavements are unique because of their subgrade structure. This structure includes a layer of choker course, filter course, and soil.
UNDERDRAIN
Systems with low infiltration rates due to soil composition are often designed with an underdrain system to discharge the water.
ASPHALT
This system is often designed with conventional asphalt in areas of high traffic to prevent any damage to the system.

# DOWNSPOUT PLANTER BOXES

Downspout planter boxes are wooden or concrete boxes with plants installed at the base of the downspout that provide an opportunity to beneficially reuse rooftop runoff. Although small, these systems have some capacity to store rooftop runoff during rainfall events and release it slowly back into the storm sewer system through an overflow.

Most often, downspout planter boxes are a reliable green infrastructure practice used to provide some rainfall storage and aesthetic value for property.

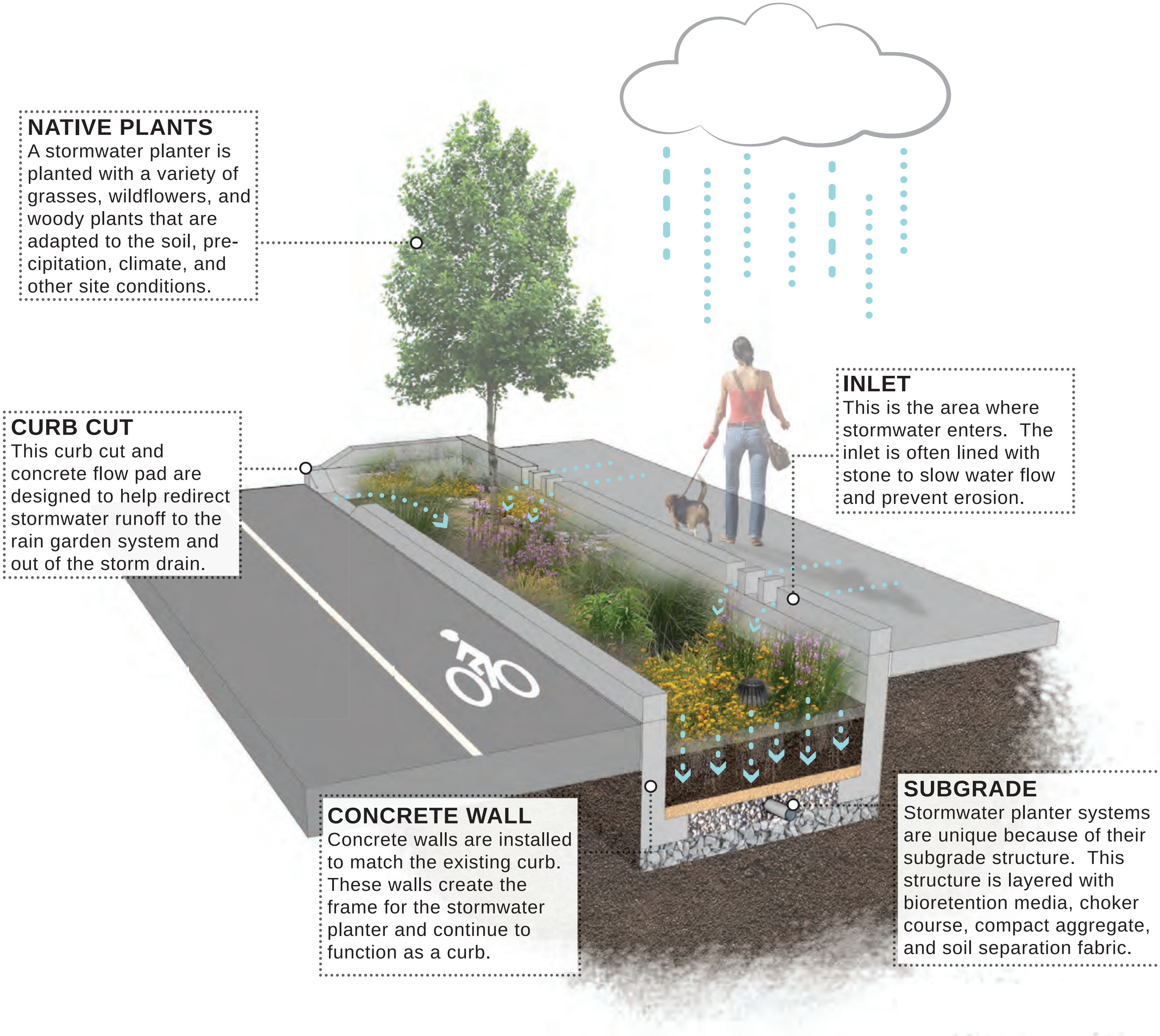



PLANTER BOXES
The downspout planter box can be wooden or concrete. However, all boxes must be reinforced to hold soil, stone, and the quantity of rainfall it is designed to store.
NATIVE PLANTS
A downspout planter is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions.
DOWNSPOUT
The downspout is the main source of water for the downspout planter.
CONNECTION
The system is designed to overflow into adjacent boxes using a connecting pipe that is sealed with silicone.
SUBGRADE
The system is designed to overflow using a perforated pipe located at the bottom of the downspout planter box.
OVERFLOW
The overflow is the point where water discharges from the downspout planter after it is filled.
DISCHARGE
The discharge is the point where treated water discharges from the downspout planter

# STORMWATER PLANTERS

Stormwater planters are vegetated structures that are built into the sidewalk to intercept stormwater runoff from the roadway or sidewalk. Stormwater planters, like rain gardens, are a type of bioretention system. This means many of these planters are designed to allow the water to infiltrate into the ground. However, some are designed simply to filter the water and convey it back into the storm sewer system via an underdrain system.



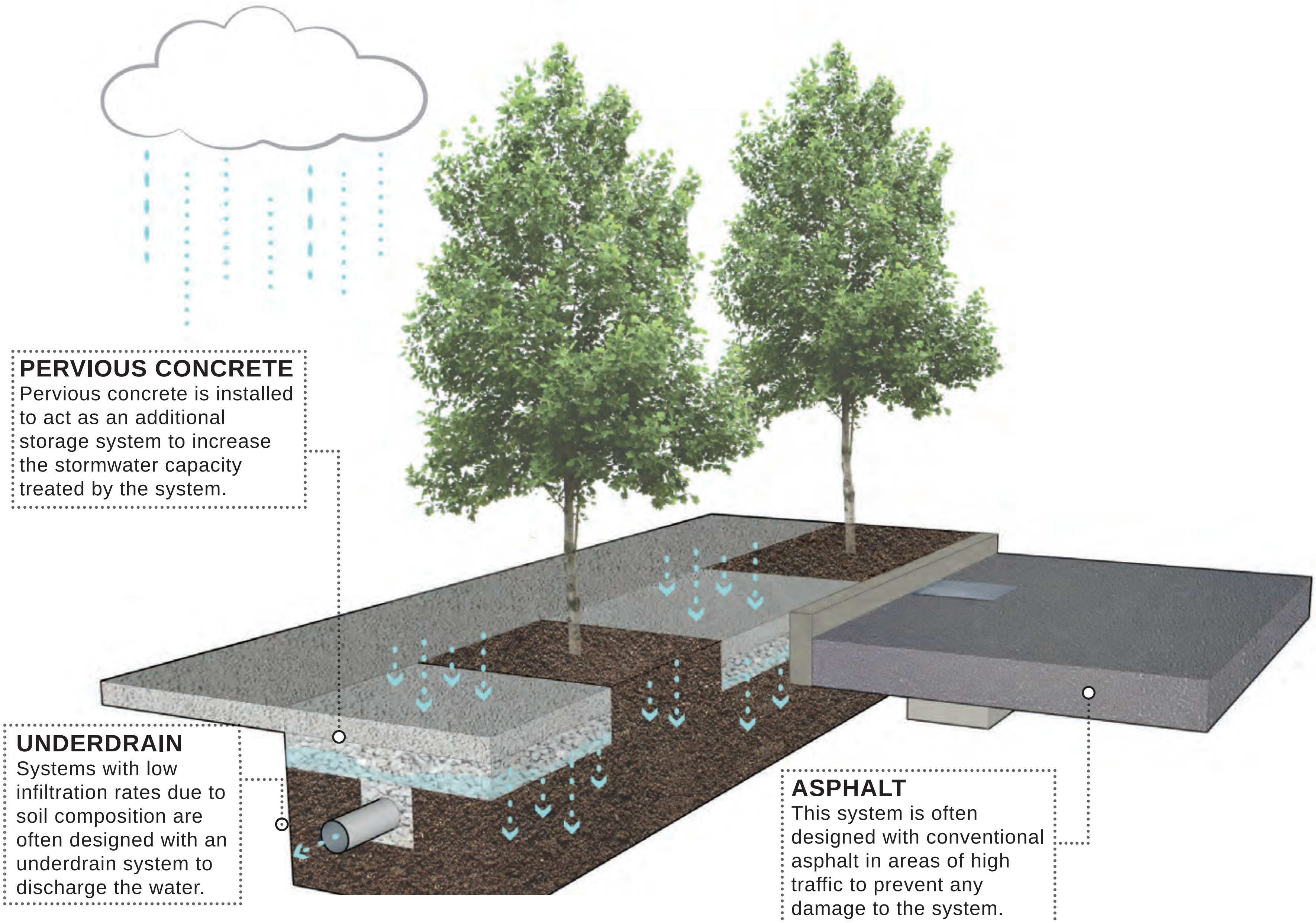

NATIVE PLANTS
A stormwater planter is planted with a variety of grasses, wildflowers, and woody plants that are adapted to the soil, precipitation, climate, and other site conditions.
CURB CUT
This curb cut and concrete flow pad are designed to help redirect stormwater runoff to the rain garden system and out of the storm drain.
INLET
This is the area where stormwater enters. The inlet is often lined with stone to slow water flow and prevent erosion.
CONCRETE WALL
Concrete walls are installed to match the existing curb. These walls create the frame for the stormwater planter and continue to function as a curb.
SUBGRADE
Stormwater planter systems are unique because of their subgrade structure. This structure is layered with bioretention media, choker course, compact aggregate, and soil separation fabric.

# TREE FILTER BOXES/ENHANCED TREE BEDS

Trees can be incorporated into green infrastructure as filter boxes (pre-manufactured concrete boxes) or enhanced tree beds that contain a special soil mix. Tree filter boxes filter stormwater runoff but provide little storage capacity. They are typically designed to quickly filter stormwater and then discharge it to the local storm sewer system. Enhanced tree beds function more like bioretention systems and are designed to capture and infiltrate stormwater or slowly discharge it with an underdrain.

Often tree filter boxes and enhanced tree beds are incorporated into streetscape systems that include an underlying stormwater system which connects several boxes (as shown on the next page). This is also coupled with pervious concrete or other pervious pavements to increase the storage capacity for rainwater into the system.




PERVIOUS CONCRETE
Pervious concrete is installed to act as an additional storage system to increase the stormwater capacity treated by the system.
UNDERDRAIN
Systems with low infiltration rates due to soil composition are often designed with an underdrain system to discharge the water.
ASPHALT
This system is often designed with conventional asphalt in areas of high traffic to prevent any damage to the system.

# GREEN INFRASTRUCTURE IN MADISON BOROUGH

# SITE SELECTION & METHODOLOGY

TABLE 3. AERIAL LOADING COEFFICIENTS

| Land Cover | Total Phosphorus (TP) [lbs/acre/yr] | Total Nitrogen (TN) [lbs/acre/yr] | Total Suspended Solids (TSS) [lbs/acre/yr] |
|---|---|---|---|
| High, Medium Density Residential | 1.4 | 15 | 140 |
| Low Density, Rural Residential | 0.6 | 5 | 100 |
| Commercial | 2.1 | 22 | 200 |
| Industrial | 1.5 | 16 | 200 |
| Urban, Mixed Urban, Other Urban | 1.0 | 10 | 120 |
| Agriculture | 1.3 | 10 | 300 |
| Forest, Water, Wetlands | 0.1 | 3 | 40 |
| Barrenland/ Transitional Area | 0.5 | 5 | 60 |



**Background on Green Infrastructure Action Plan**

The Green Infrastructure Action Plan was completed in February 2024. For this Plan, municipally owned parcels were evaluated for potential retrofitting with green infrastructure. After conducting thorough inspections of each site, 18 sites were selected and included in the action plan based on site visibility, feasibility, cost effectiveness, and potential partnerships.

For the Action Plan, municipally owned parcels were provided to the RCE Water Resources Program by Madison Borough. Based upon the experience of the RCE Water Resources Program staff, sites were selected for inclusion in the Action Plan. This was accomplished by reviewing the aerial imagery of each site. Field visits were then conducted at each of these potential project sites to determine if a viable option exists to reduce impervious cover or to disconnect impervious surfaces from draining directly to the local waterway or storm sewer system. During the site visit, appropriate green infrastructure practices for the site were determined.

For each potential project site, specific aerial loading coefficients for commercial land use were used to determine the annual runoff loads for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) from impervious surfaces (Table 3). These are the same aerial loading coefficients that NJDEP uses to develop total maximum daily loads (TMDLs) for impaired waterways of the state. The percentage of impervious cover for each site was extracted from the 2015 NJDEP impervious surface layer.

For impervious areas, runoff volumes were determined for the water quality design storm (1.25 inches of rain over two hours) and for the annual rainfall total of 50 inches.

Preliminary soil assessments were conducted for each potential project site identified in Madison Borough using the United States Department of Agriculture Natural Resources Conservation Service Web Soil Survey, which utilizes regional and statewide soil data to predict soil types in an area.

For each potential project site, drainage areas were determined for each of the green infrastructure practices proposed at the site. These green infrastructure practices were designed to manage the 2-year design storm, enabling these practices to capture 95% of the annual rainfall. Runoff volumes were calculated for each proposed green infrastructure practice. The reduction in TSS loading was calculated for each drainage area for each proposed green infrastructure practice using the aerial loading coefficients in Table 3. The maximum volume reduction in stormwater runoff for each green infrastructure practice for a storm was determined by calculating the volume of runoff captured from the 2-year design storm. For each green infrastructure practice, peak discharge reduction potential was determined through hydrologic modeling in HydroCAD. For each green infrastructure practice, an approximate cost estimate is provided. These costs are based upon the square footage of the green infrastructure practice and the estimated cost of green infrastructure practice implementation in New Jersey.

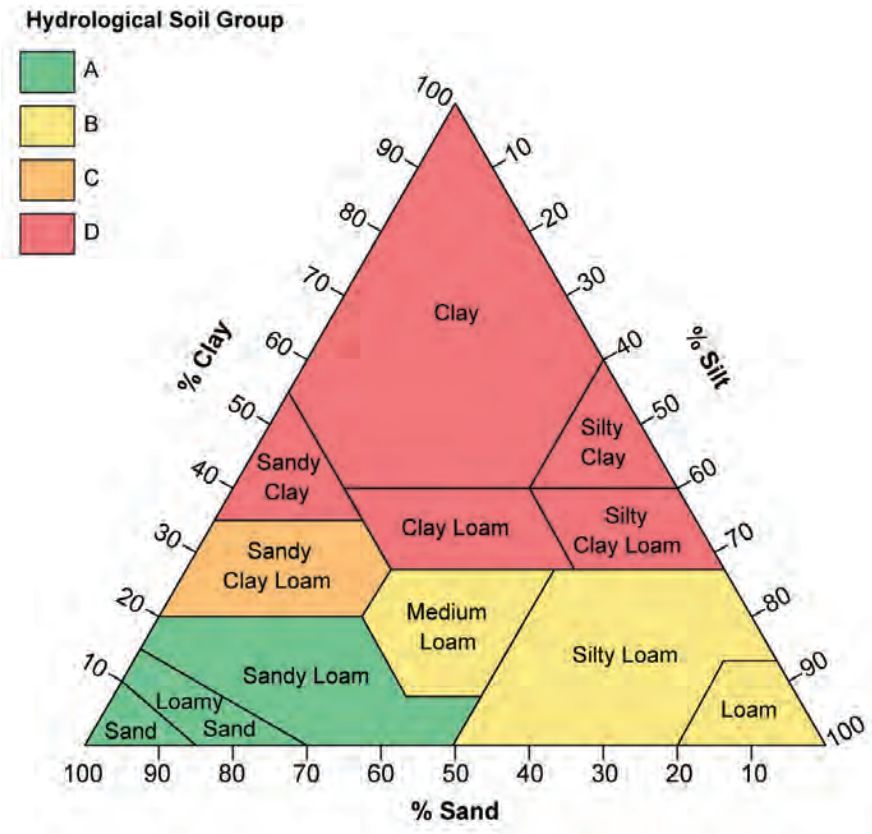
The next step is to examine Madison Borough through various lenses to identify additional areas in the municipality that would be suitable for green infrastructure. The following sections will discuss this effort and examine long-term management goals for Madison Borough.

# ANALYZING SITE SUITABILITY

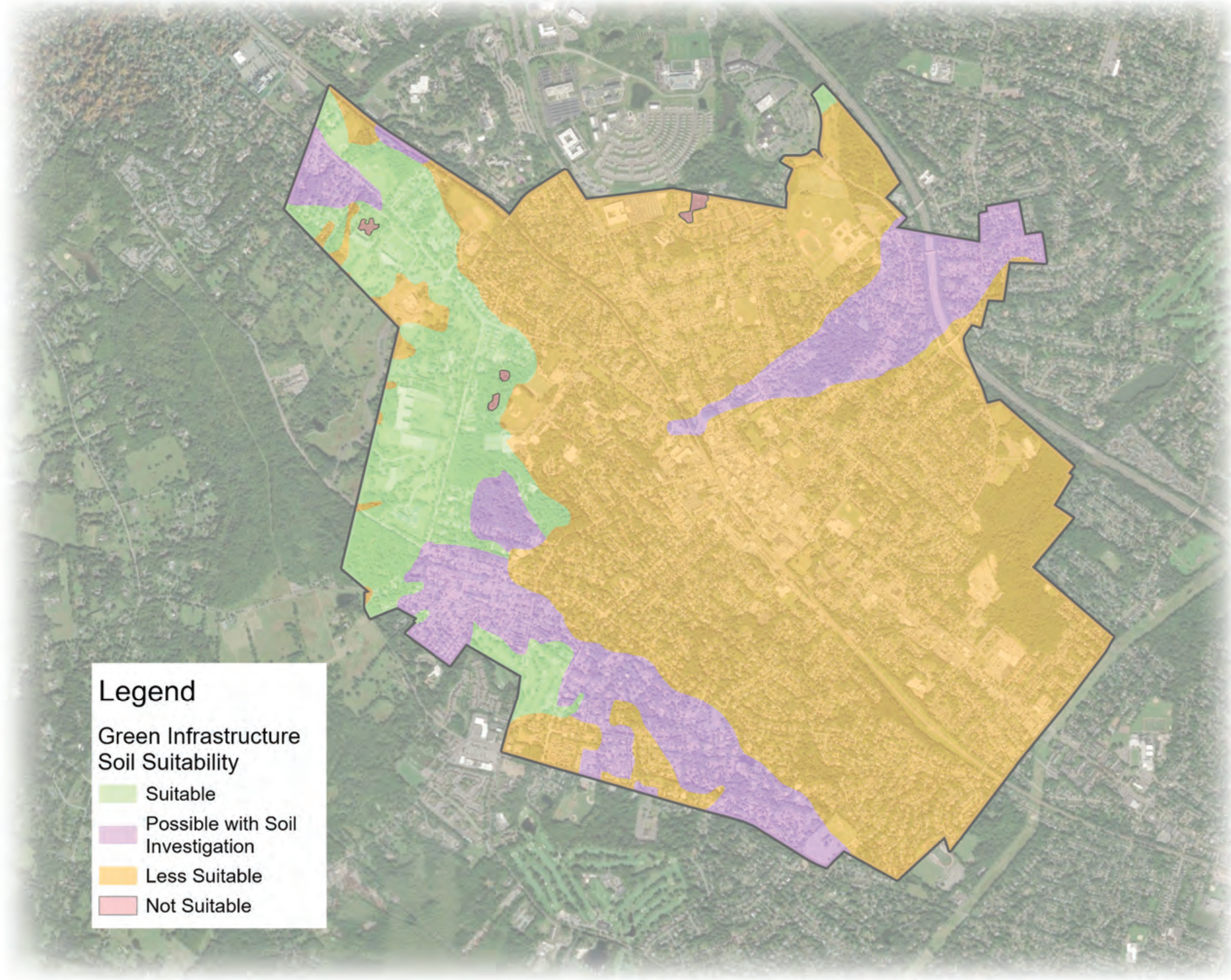
Site suitability can preliminarily be determined by looking at soil data. Ideally, soils will allow high infiltration (hydrologic soil groups A or B) and have greater than 36" to the seasonal high water table or bedrock. Soil data is regional, so site specific conditions may vary. Therefore, even sites claiming high water table may still be suitable, but soil investigation is recommended. Soils that have poor infiltration (hydrologic soil groups C or D) can still be designed with underdrains that will allow filtration of runoff while ensuring adequate drainage. A preliminary desktop soils analysis was conducted for Madison Borough using the United States Department of Agriculture Natural Resources Conservation Service Web Soil Survey, which utilizes regional and statewide soil data to predict soil types in an area. Several key soil parameters were examined (e.g., natural drainage class, saturated hydraulic conductivity of the most limiting soil layer (Ksat), depth to water table, and hydrologic soil group) to evaluate the suitability of each site's soil for green infrastructure practices. Additional soil testing is recommended for all potential project sites to determine suitability for projects and the potential need for underdrain systems.

Green infrastructure suitability is defined using the following parameters:

| | | Depth to Water Table or Bedrock | | | |
|---|---|---|---|---|---|
| | | 0" | 0"-24" | 24"-36" | >36" |
| Hydrologic Soil Group | Unknown | Not suitable | Less Suitable | Possible with investigation | Possible with investigation |
| | A | Not suitable | Less Suitable | Possible with investigation | Suitable |
| | B | Not suitable | Less Suitable | Possible with investigation | Suitable |
| | C | Not suitable | Less Suitable | Possible, underdrained | Suitable, underdrained |
| | D | Not suitable | Less Suitable | Possible, underdrained | Suitable, underdrained |



# MADISON BOROUGH
## GREEN INFRASTRUCTURE SUITABILITY

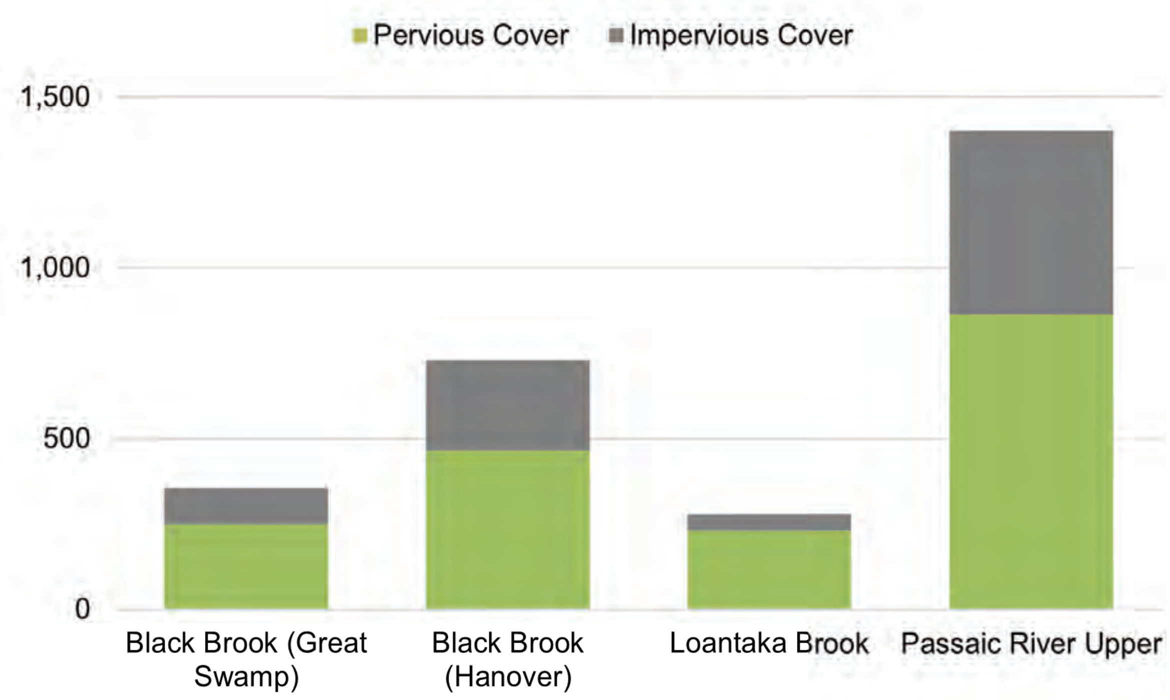


# MADISON BOROUGH
# STORMWATER MANAGEMENT GOALS

With the existing municipal impervious cover at 34.6%, Madison Borough's green infrastructure initiative short-term (i.e., less than five years) impervious cover management goal is to manage stormwater runoff for 20 acres of impervious cover, whereas the long-term goal (i.e., five to twenty years) would be to manage the stormwater from 80 acres of impervious cover. While Madison Borough's Green Infrastructure Action Plan provides several sites to work toward the short-term goal, additional methods of generalized site selection are useful for identifying additional potential project sites to attain these stormwater management goals. The first step to identifying potential project sites to reach these goals is mapping the impervious surfaces throughout Madison Borough.



PERVIOUS AND IMPERVIOUS COVER IN ACRES BY SUBWATERSHED



# MADISON BOROUGH IMPERVIOUS COVER

# MADISON BOROUGH

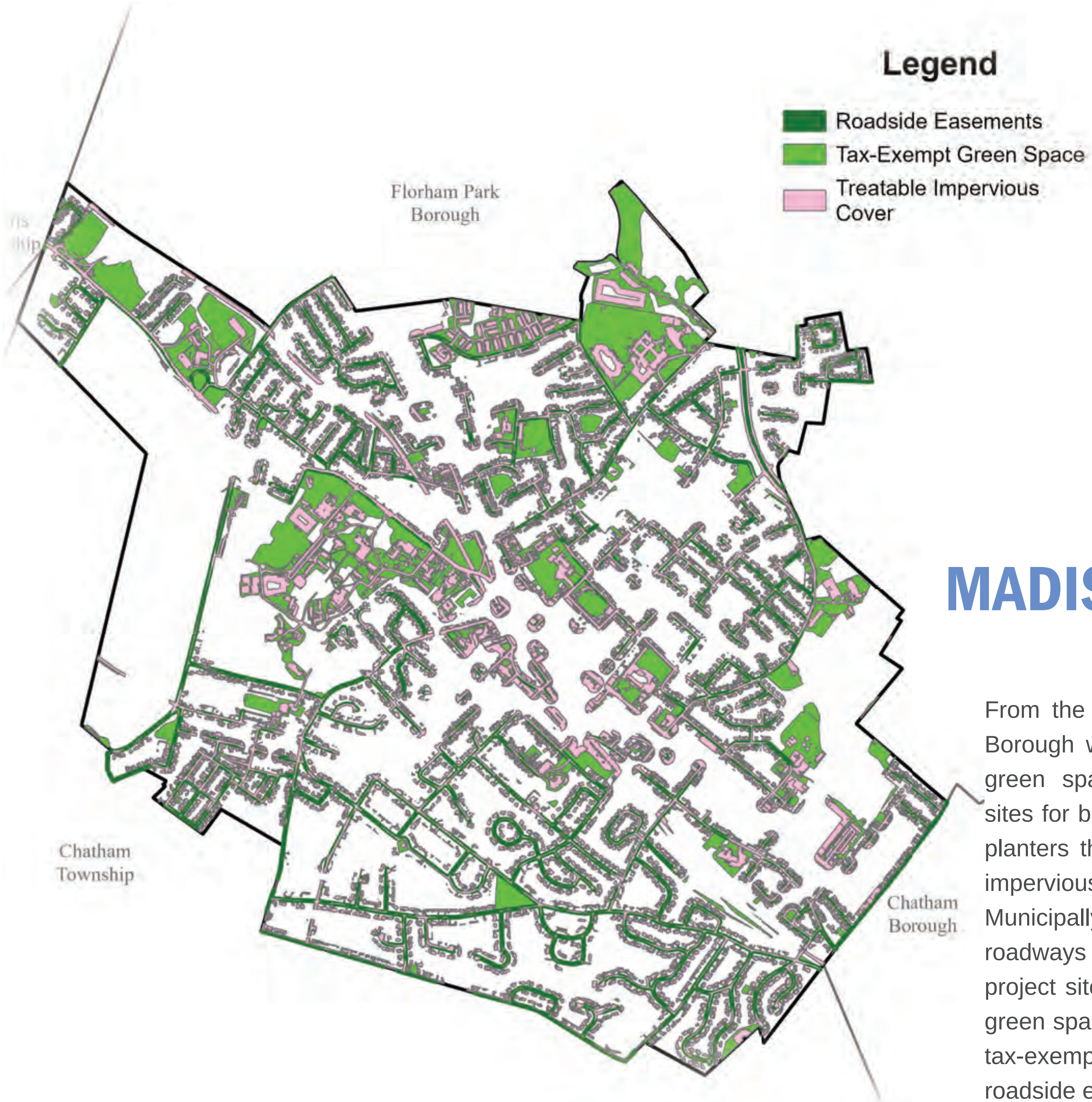
## SITE SELECTION

MADISON BOROUGH TAX-EXEMPT PARCELS AND ROADSIDE EASEMENTS


The strategic placement of green infrastructure projects can foster community engagement and augment the overall impact of these projects. Isolating tax-exempt parcels such as parks, schools, goverment facilities, or churches as potential green infrastructure project locations puts a focus on enhancing public spaces for the benefit of the community as a whole. Prioritizing tax-exempt parcels for green infrastructure projects allows the municipality to demonstrate leadership in sustainability and environmental stewardship with fewer barriers to implementation.

For the purposes of this strategic plan, parcels with the following property classes were isolated (see Appendix C for a list of the isolated parcels):
-Class 15A: Public School Property
-Class 15B: Other School Property
-Class 15C: Public Property
-Class 15D: Church and Charitable Property
-Class 15F: Other Exempt
While property class 15E is also tax-exempt, these parcels are devoted to cemeteries and graveyards, thus are likely ill-suited for the implementation of green infrastructure.

Municipally owned roadside green spaces can also be taken into consideration as potential project sites. The right of way area extends 25 feet on either side from the center of a road. The right of way green space can be isolated by removing impervious surfaces from the layer.




# MADISON BOROUGH GREEN SPACE

From the 134 parcels throughout Madison Borough with tax-exempt property classes, green spaces were isolated as potential sites for bioretention systems or stormwater planters that were close enough to nearby impervious surfaces (within 100 feet). Municipally owned green spaces alongside roadways are also included as potential project sites. A total of 309 acres of viable green space were isolated: 248 acres within tax-exempt parcels and 62 acres within roadside easements.

# MADISON BOROUGH EXISTING CONDITIONS AND MANAGEMENT GOAL

TABLE 4: MADISON BOROUGH EXISTING CONDITIONS

| Impervious Cover | | Existing Loads from Impervious Cover (lbs/yr) | | | Runoff Volume from Impervious Cover (Mgal) | |
|---|---|---|---|---|---|---|
| % | acres | TP | TN | TSS | From the 1.25" Water Quality Storm | For an Annual Rainfall of 50" |
| 34.6 | 2,759 | 2,007.6 | 21,032.1 | 191,200.8 | 32.447 | 1,297.89 |

TABLE 5: MADISON BOROUGH MANAGEMENT GOALS

| Potential Management Area (acres) | Recharge Potential (Mgal/yr) | TSS Removal Potential (lbs/yr) | Maximum Volume Reduction Potential (Mgal/storm) | Peak Discharge Reduction Potential for 2-year storm (3.58") (cu. ft./second) | Estimated Size (acres) | Estimated Cost |
|---|---|---|---|---|---|---|
| Short-Term Management Goal | | | | | | |
| 20 | 25.795 | 3,800 | 1.817 | 68.29 | 5 | $2,178,009 |
| Long-Term Management Goal | | | | | | |
| 80 | 103.180 | 15,200 | 7.269 | 273.14 | 20 | $8,712,035 |



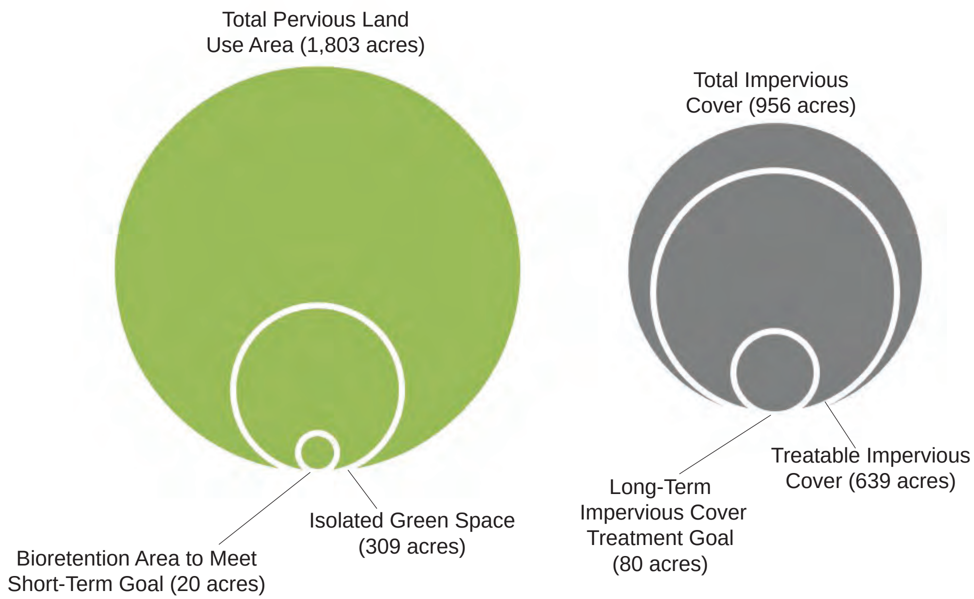
# FEASIBILITY OF MEETING MANAGEMENT GOALS

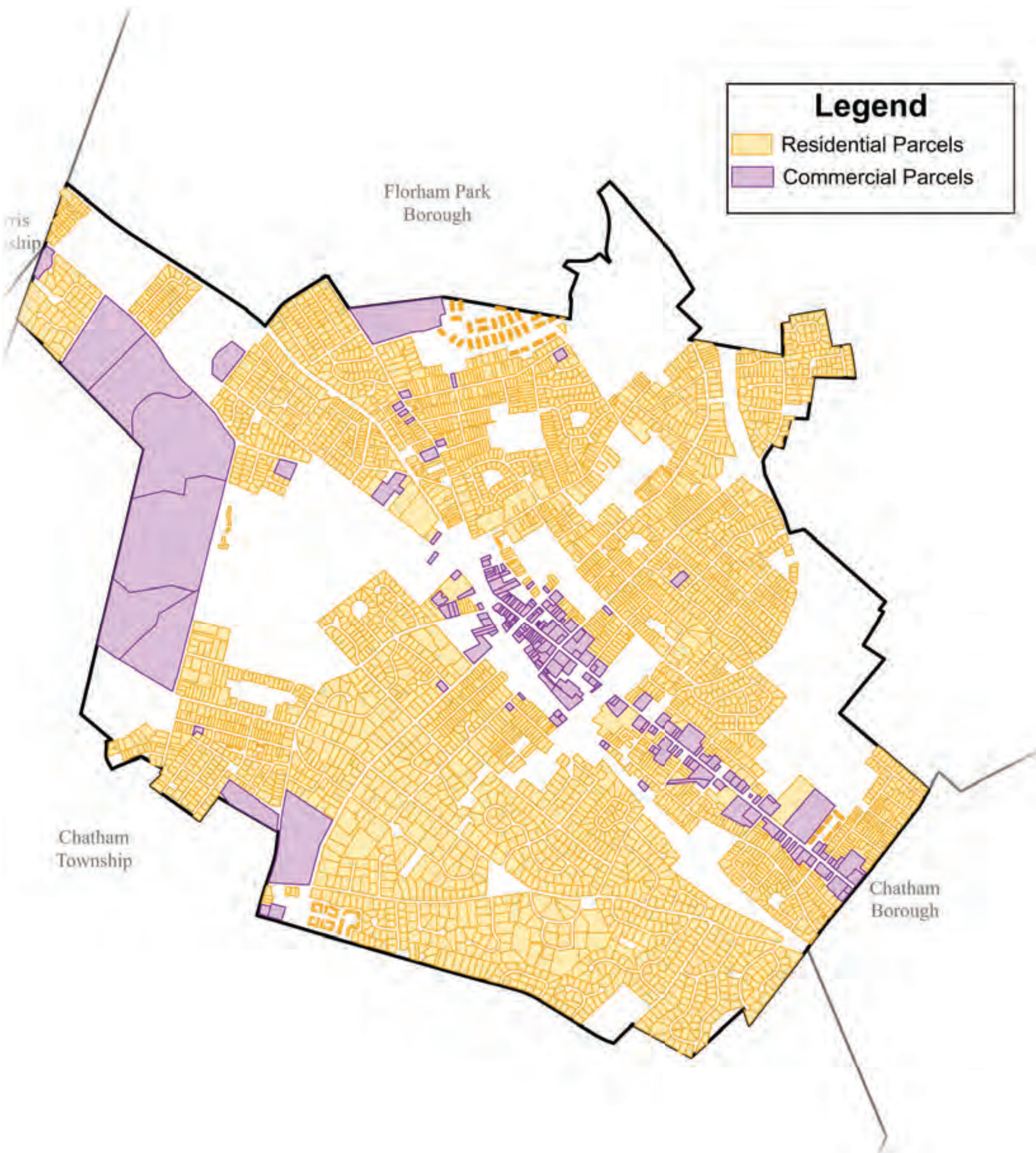
Identifying green spaces is vital to siting projects, but determining the feasibility of meeting Madison Borough's stormwater management goals hinges on the amount of impervious cover that could be treated by utilizing this identified green space. For the purposes of this study, it was assumed that impervious cover within a 100-foot radius of the identified green space could be targeted for treatment. While the treatment radius can vary greately from site to site, setting a defined boundary is important to further define the feasibility of these stormwater management goals.

## MADISON BOROUGH MANAGEMENT GOAL LAND ALLOCATIONS

To reach the short-term goal of treating stormwater from 20 acres of impervious cover, approximately five acres of the total green space (approximately 2%) would have to be converted to bioretention systems. The long-term goal of managing stormwater from 80 acres of impervious cover could be reached by converting approximately 20 acres of the total green space (approximately 8%) to bioretention systems.

The adjacent table highlights the anticipated management numbers and costs for the short- and long-term goals. Costs are highly variable for rain gardens and can vary from $1 to $35 per square foot (SF). A cost of $10/SF was used assuming some projects will be installed with support of the Department of Public Works or local groups, and others would be installed by contractors.






# MADISON BOROUGH
# ADDITIONAL SITES

Residential and commercial areas present additional opportunities to integrate rain gardens to help mitigate flooding, reduce pollution, and promote groundwater recharge. In commercial areas such as office complexes, shopping centers, and industrial parks, rain gardens can be strategically placed to complement existing landscaping and infrastructure. They can be incorporated into entrance landscaping, parking lot islands, and along the perimeters of buildings. Larger commercial developments present opportunities to include rain gardens in public spaces such as plazas, courtyards, and pedestrian walkways. Some areas may already contain stormwater management practices (detention basins, underground infiltration, etc.). These areas should be deprioritized in site selection.

In residential neighborhoods, rain gardens can be scaled to fit individual properties or implemented as a part of community-wide initiatives. They can be integrated into existing landscaping and replace traditional lawns or flower beds, or in underutilized spaces such as side yards between properties, or in multi-family residential developments as community gardens.

Quantitative analysis of implementing rain gardens in residential and commercial areas represents the implementation of 200-square foot bioretention systems for each residential parcel and treatment of 15% of impervious cover on commercial parcels.

# ADDITIONAL GREEN INFRASTRUCTURE SITES

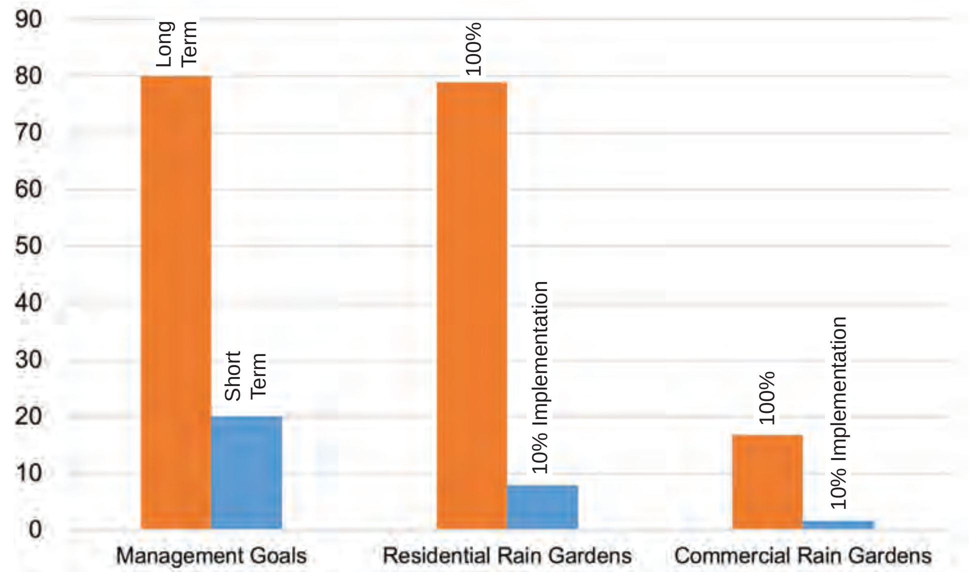
TABLE 6: MADISON BOROUGH ADDITIONAL SITES

| Potential Management Area (acres) | Recharge Potential (Mgal/yr) | TSS Removal Potential (lbs/yr) | Maximum Volume Reduction Potential (gal/storm) | Peak Discharge Reduction Potential for 2-year storm (3.58") (cu. ft./second) | Estimated Size (acres) | Estimated Cost |
|---|---|---|---|---|---|---|
| 100% Implementation of 200-sq ft Rain Gardens per Residential Parcel | | | | | | |
| 78.86 | 101.711 | 14,983 | 7,165,200 | 269.25 | 19.72 | $8,588,000 |
| 10% Implementation of 200-sq ft Rain Gardens per Residential Parcel | | | | | | |
| 7.88 | 10.162 | 1,497 | 715,850 | 26.90 | 1.97 | $858,000 |
| 100% Implementation of Rain Gardens Targeting 15% of Impervious Cover on Every Commercial Parcel | | | | | | |
| 16.74 | 21.591 | 3,181 | 1,521,010 | 57.16 | 4.19 | $1,823,048 |
| 10% Implementation of Rain Gardens Targeting 15% of Impervious Cover on Every Commmercial Parcel | | | | | | |
| 1.67 | 2.159 | 317 | 152,100 | 5.72 | 0.42 | $182,305 |



Other green infrastructure practices such as permeable pavement, stormwater planters, and bioswales can be included in stormwater management plans. Prior sections include guidance on these other practices, which can be used to help site other green infrastructure projects where rain gardens are not feasible. Consider ideas like converting paved areas to pervious pavment, depaving unnecessary paved areas, or installing roadway stormwater planter bump outs. Continuing to prioritize bioretention systems is beneficial for pollutant removal, minimized costs, and ease of installation of implementing green infrastructure to meet stormwater management goals, as well aesthetic and ecological benefits.

IMPERVIOUS COVER TREATMENT GOALS AND POTENTIAL



# SITE ASSESSMENT AND IMPLEMENTATION FACTORS

## BUILT ELEMENTS

**Circulation and Transportation**
Observe movement through, in, and around the site

**Structures and Utilities**
Examine existing infrastructure within the area of the site

**Integration**
Incorporate new infrastructure into the existing surroundings

## NATURAL ELEMENTS

**Water Flow**
Delineate impervious cover management based on drainage

**Existing Vegetation**
Take note of existing trees or invasive species that may conflict

**Soil Suitability**
Test existing soils for infiltration and assess need for underdrains

## IMPLEMENTATION

**Users and Maintenance**
Gather information on who will be using and maintaning the space

**Funding and Available Space**
Consider the scale and limitations of the site and budget

**Project Oversight**
Ensure installation of green infrastructure is overseen by qualified individuals

# GREEN INFRASTRUCTURE IMPLEMENTATION

This report provides a strategic plan to implement green infrastructure to meet long-term managment goals. There is a large amount of underutilized space that can be used to install green infrastructure projects throughout Madison Borough, but a plan is needed to determine how to fund these projects and how to get them implemented in a reasonable timeline.

Funding mechnisms may include seeking local, state and federal grant programs from entities such as NJDEP, National Fish and Wildlife Foundation, US Environmental Protection Agency, Sustainable Jersey, and the Association of NJ Environmental Commissions. The New Jersey Water Bank financing program provides low interest loans for water projects which Madison Borough could use to seek funding for green infrastructure projects. Funding may consider the implementation of a stormwater utility which would assess a fee based on the amount of impervious cover for a given property. This would result in higher fees for businesses with large parking lots and lower fees for typical residential lots. This funding would allow a dedicated stream of funds to support stormwater management projects. Stormwater utilities often provide a reduced utility fee to property owners that have installed green infrastructure or other stormwater management. This would incentivize businesses and other property owners to consider implementing stormwater management projects on their own to avoid such fees. Madison Borough may also pursue a rain garden rebate program to assist property owners with installing rain gardens throughout the municipality. As the green infrastructure initiative moves forward, there will be opportunities to provide additional incentive programs for homeowners and businesses to participate in the effort. There is also potential for incorporating a stormwater management requirement for redevelopment projects in Madison's Stormwater Control Ordinance, which would increase the amount of stormwater runoff being managed in the town.



Members of the Sustainable Madison Advisory Committee will continue to meet regularly with Madison Borough staff and other committees to discuss opportunities for projects and coordinating the implementation of projects. The goal is to install as many projects per year as funding and manpower resources are determined to be available. The Sustainable Madison Advisory Committee will seek funding for this initiative. This strategic plan aims to address the potential for Madison Borough to meet their stormwater management goals through the implementation of green infrastructure projects. These projects can be implemented in collaboration with groups such as Boy Scouts, Girl Scouts, school groups, faith-based groups, social groups, watershed groups, and other community groups. Madison Borough can also allocate annual funding to implement projects and have the Department of Public Works help construct and maintain these projects. The funding sources and incentive programs can make these goals more attainable by overcoming financial and social barriers to implementation of green infrastructure projects.

By establishing and reaching these long-term goals, Madison Borough seeks to move toward a more sustainable future where stormwater is properly managed and streams and waterways are no longer degraded.


New Jersey TREE FOUNDATION
TREE PLANTING

# APPENDIX A: COMMUNITY ENGAGEMENT & EDUCATION

# BUILD A RAIN BARREL WORKSHOP



With the *Build a Rain Barrel* workshop, community members participate in a short presentation on stormwater management and water conservation and then learn how to build their own rain barrel. Workshop participants work with trained experts to convert 55-gallon plastic food-grade drums into rain barrels. They are able to take an active role in recycling rainwater by installing a rain barrel at their home! Harvesting rainwater has many benefits including saving water, saving money, and preventing basement flooding. By collecting rainwater, homeowners are helping to reduce flooding and pollution in local waterways. When rainwater flows across hard surfaces like rooftops, driveways, roadways, parking lots, and compacted lawns, it carries pollution to our local waterways. Harvesting the rainwater in a rain barrel is just one of the ways homeowners can reduce the amount of rainwater draining from their property and help reduce neighborhood flooding problems.

# STORMWATER MANAGEMENT IN YOUR SCHOOLYARD

The *Stormwater Management in Your Schoolyard* program provides educational lectures, hands-on activities, and community-level outreach for students on the topics of water quality issues and stormwater management practices such as rain gardens and rain barrels. Program objectives include the exploration of various aspects of the natural environment on school grounds, the detailed documentation of findings related to these explorations, and the communication of these findings to the school community. As part of this program, several New Jersey State Core Curriculum Content Standards for science (5.1, 5.3, and 5.4), 21st-century life and careers (9.1, 9.3, and 9.4), and social studies (6.3) are addressed. Every school is unique in its need for stormwater management, so each school's *Stormwater Management in Your Schoolyard* program can be delivered in a variety of ways. This program can be tailored for grades K-8 or 9-12 and can be offered to meet a variety of schedules.

# RESIDENTIAL RAIN GARDEN PROGRAM

With the *Residential Rain Garden Program*, community members participate in a short presentation on stormwater management and then learn how to build their own rain garden.  Participants can work with trained experts to help design their own rain gardens.  They are able to take an active role in capturing rainwater by installing a rain garden at their house!  The program could include a rebate for eligible homeowners for installing the rain garden to help fund part of their garden.  By capturing rainwater, homeowners are helping to reduce flooding and pollution in local waterways while beautifying their home and neighborhood. Capturing the rainwater in a rain garden is just one of the ways homeowners can reduce the amount of rainwater draining from their property and help reduce neighborhood flooding problems.  Homeowners can also install pervious pavements when replacing or installing new driveways, walkways, and patio spaces.

# COMMUNITY GROUP RAIN GARDEN PROGRAM


The *Community Group Rain Garden Program* provides educational lectures to empower local community groups to implement their own rain garden project. Groups such as Boy Scouts, Girl Scouts, community service groups, and religious groups would be able to learn about water quality issues and stormwater management practices such as rain gardens and rain barrels. Rain gardens can help bring people together around a single goal to implement these projects together to better their local communities.

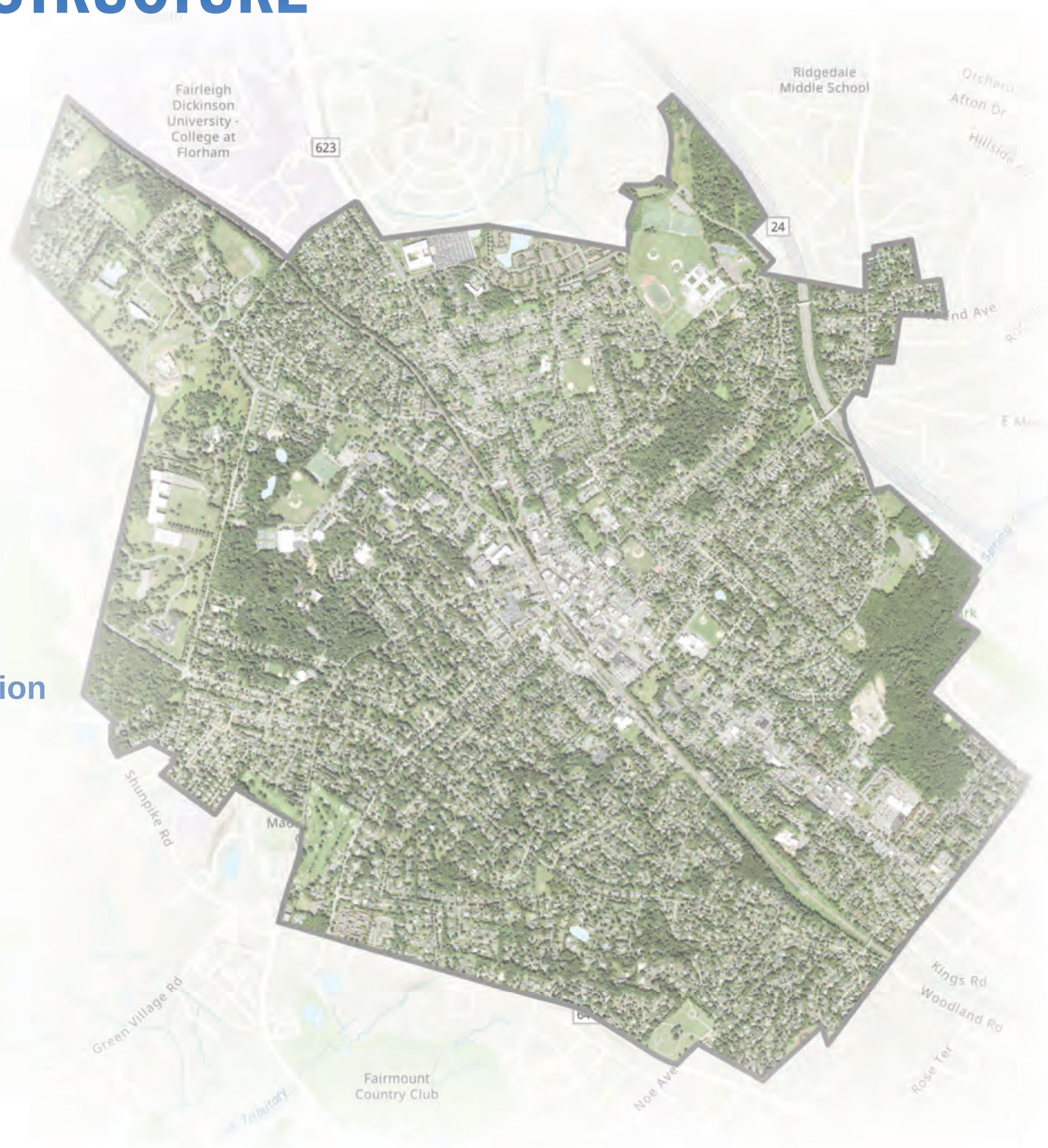
# APPENDIX B:
# MAINTENANCE PROCEDURES

# MAINTAINING MADISON BOROUGH'S GREEN INFRASTRUCTURE SYSTEMS

1. Rain Garden
   Stormwater Planter
   Tree Filter Box

2. Rain Barrel
   Cistern

3. Porous Asphalt
   Underground Detention



## RAIN GARDEN / STORMWATER PLANTER / TREE FILTER BOX

WEEKLY MAINTENANCE

1. Water and weed
2. Inspect for invasive plants, plant health, excessive sediment, and movement of sediment within the rain garden
3. Observe the rain garden during rain events and note any successes (Example of success: stormwater unoff picks up oil and grease from the parking lot, flows through a curb cut, and into a rain garden; the rain garden traps the nonpoint source pollutants before they reach the nearby waterway)

ANNUAL MAINTENANCE

1. Mulch in the spring to retain a 3-inch mulch layer in the garden
2. Prune during dormant season to improve plant health
3. Remove sediment
4. Replant as needed
5. Test the soil (every three years)
6. Harvest plants to use in other parts of the landscape
7. Clean debris from gutters connected to rain garden
8. Replace materials (such as river rock and landscape fabric) where needed

## RAIN BARREL

1. Keep screen on top and a garden hose attached to the overflow to prevent mosquitoes; change screen every two years
2. Remove debris from screen after storms
3. Disconnect the barrel in winter; store inside or outside with a cover
4. Clean out with long brush and water/dilute bleach solution (~3%)



## CISTERN

1. In the fall prepare your cistern for the winter by diverting flow so no water can enter and freeze within the barrel
2. Weekly check: check for leaks, clogs and other obstructions, holes and vent openings where animals, insects, and rodents may enter; repair leaks with sealant; drain the first flush diverter/roof washer after every rainfall event
3. Monthly check: check roof and roof catchments to make sure no debris is entering the gutter and downspout directed into the cistern; keep the roof, gutters, and leader inlets clear of leaves; inspect the first flush filter and all of its attachments, and make any necessary replacements; inspect cistern cover, screen, overflow pipe, sediment trap and other accessories, and make any necessary replacements

## POROUS PAVEMENT

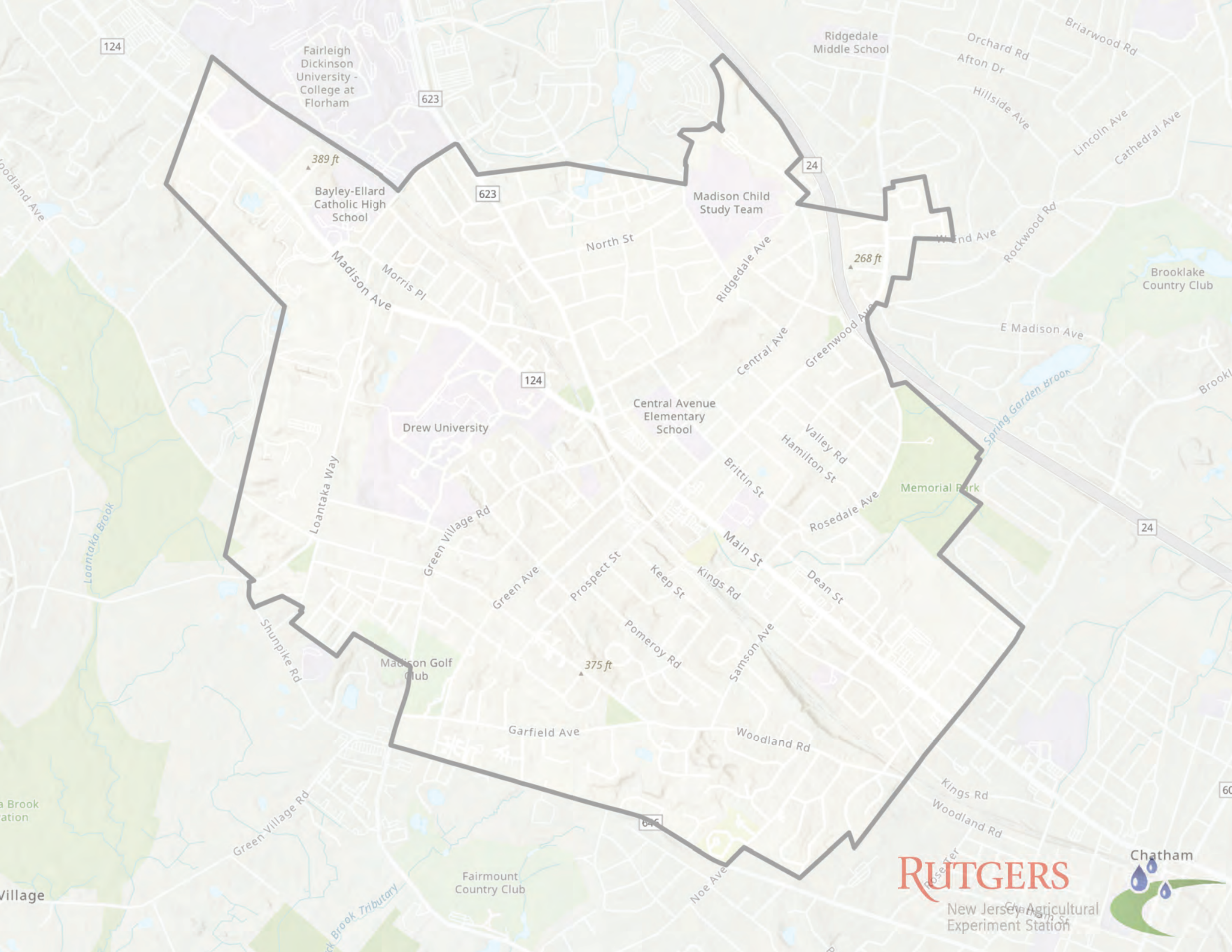
1. Materials cost is ~20-25% more than traditional asphalt
2. Long-term maintenance is required by routine quarterly vacuum sweeping
3. Sweeping cost may be off-set by reduced deicing costs
4. Asphalt repairs can be made with standard asphalt not to exceed 10% of surface area
5. Concrete repairs can be made with standard concrete not to exceed 10% of the surface area

## UNDERGROUND DETENTION

1. Periodic inspections of the inlet and outlet areas to ensure correct operation of system
2. Clean materials trapped on grates protecting catch basins and inlet area monthly
3. Primary maintenance concerns are removal of floatables that become trapped and removal of accumulating sediments within the system; this should be done at least on an annual basis
4. Proprietary traps and filters associated with stormwater storage units should be maintained as recommended by the manufacturer
5. Any structural repairs required to inlet and outlet areas should be addressed in a timely manner on an as needed basis
6. Local authorities may require annual inspection or require that they carry out inspections and maintenance

# APPENDIX C:
# ISOLATED TAX-EXEMPT PARCELS

| BLOCK | LOT | CLASS |
|---|---|---|
| 601 | 1 | 15A |
| 1601 | 1 | 15A |
| 2001 | 16 | 15A |
| 3404 | 33 | 15A |
| 3901 | 12 | 15A |
| 4804 | 31 | 15A |
| 101 | 6 | 15B |
| 101 | 6 | 15B |
| 201 | 1 | 15B |
| 3001 | 1 | 15B |
| 201 | 1.02 | 15C |
| 201 | 2 | 15C |
| 208 | 1 | 15C |
| 208 | 18 | 15C |
| 209 | 5.24 | 15C |
| 209 | 21 | 15C |
| 210 | 1 | 15C |
| 211 | 1 | 15C |
| 306 | 47 | 15C |
| 402 | 1.01 | 15C |
| 402 | 1.02 | 15C |
| 404 | 20 | 15C |
| 404 | 46 | 15C |
| 404 | 47 | 15C |
| 404 | 48 | 15C |
| 504 | 23 | 15C |
| 601 | 1.01 | 15C |
| 903 | 3 | 15C |
| 903 | 3.01 | 15C |
| 1001 | 73 | 15C |
| 1002 | 8 | 15C |
| 1003 | 15 | 15C |
| 1004 | 19 | 15C |
| 1101 | 37 | 15C |
| 1102 | 24 | 15C |
| 1104 | 26 | 15C |
| 1105 | 15 | 15C |
| 1203 | 7 | 15C |
| 1203 | 24 | 15C |
| 1203 | 27 | 15C |
| 1203 | 30 | 15C |
| 1302 | 1 | 15C |
| 1401 | 3 | 15C |
| 1402 | 9 | 15C |
| 1502 | 25 | 15C |
| 1503 | 1 | 15C |
| 1504 | 1 | 15C |
| 1504 | 2 | 15C |
| 1505 | 1 | 15C |
| 1601 | 12 | 15C |
| 1601 | 23 | 15C |
| 1601 | 42 | 15C |
| 1701 | 2 | 15C |
| 1802 | 14 | 15C |
| 2207 | 1 | 15C |
| 2208 | 19 | 15C |
| 2208 | 28 | 15C |
| 2301 | 1 | 15C |
| 2601 | 26 | 15C |
| 2701 | 17 | 15C |
| 2701 | 18 | 15C |
| 2702 | 25 | 15C |
| 2801 | 6 | 15C |
| 2802 | 1 | 15C |
| 2803 | 1 | 15C |
| 2901 | 3 | 15C |
| 3201 | 1 | 15C |
| 3404 | 56 | 15C |
| 3801 | 1.01 | 15C |
| 3802 | 1 | 15C |
| 3803 | 21 | 15C |
| 3803 | 61 | 15C |
| 3901 | 11 | 15C |
| 3903 | 1 | 15C |
| 3904 | 39 | 15C |
| 3904 | 40 | 15C |
| 3904 | 41 | 15C |
| 4103 | 17 | 15C |
| 4303 | 1 | 15C |
| 4402 | 6 | 15C |
| 4503 | 7 | 15C |
| 4807 | 1 | 15C |
| 5001 | 1 | 15C |
| 803 | 13 | 15D |
| 1002 | 1 | 15D |
| 1107 | 8 | 15D |
| 1107 | 9 | 15D |
| 1502 | 11 | 15D |
| 1601 | 16 | 15D |
| 1701 | 1 | 15D |
| 2101 | 7 | 15D |
| 2801 | 7 | 15D |
| 2801 | 8 | 15D |
| 2803 | 3 | 15D |
| 3001 | 2 | 15D |
| 3001 | 3 | 15D |
| 3001 | 5 | 15D |
| 3001 | 6 | 15D |
| 3301 | 25 | 15D |
| 4308 | 4 | 15D |
| 101 | 23 | 15F |
| 401 | 3 | 15F |
| 505 | 7 | 15F |
| 506 | 1 | 15F |
| 706 | 6 | 15F |
| 709 | 11 | 15F |
| 1001 | 65 | 15F |
| 1001 | 83 | 15F |
| 1101 | 13 | 15F |
| 1104 | 12 | 15F |
| 1108 | 4 | 15F |
| 1203 | 17 | 15F |
| 1601 | 7 | 15F |
| 1601 | 9 | 15F |
| 1601 | 30 | 15F |
| 1801 | 9 | 15F |
| 1802 | 6 | 15F |
| 2001 | 17 | 15F |
| 2001 | 24 | 15F |
| 2001 | 25 | 15F |
| 2102 | 8 | 15F |
| 2207 | 15 | 15F |
| 2209 | 3 | 15F |
| 2301 | 2 | 15F |
| 2501 | 6 | 15F |
| 2601 | 10 | 15F |
| 3001 | 1.47 | 15F |
| 3001 | 8.01 | 15F |
| 3001 | 8.02 | 15F |
| 3802 | 23 | 15F |
| 3901 | 25 | 15F |
| 4309 | 9 | 15F |
| 4804 | 26 | 15F |
| 5201 | 11.01 | 15F |


124
Fairleigh Dickinson University - College at Florham
623
389 ft
Bayley-Ellard Catholic High School
623
North St
Madison Child Study Team
Ridgedale Middle School
Orchard Rd
Afton Dr
Briarwood Rd
Hillside Ave
Lincoln Ave
Cathedral Ave
24
Rockwood Rd
268 ft
Brooklake Country Club
E Madison Ave
Madison Ave
Morris Pl
Ridgedale Ave
Central Ave
Greenwood Ave
124
Central Avenue Elementary School
Drew University
Valley Rd
Hamilton St
Brittin St
Memorial Park
Spring Garden Brook
Rosedale Ave
24
Loantaka Way
Loantaka Brook
Green Village Rd
Main St
Green Ave
Prospect St
Keep St
Kings Rd
Dean St
Pomeroy Rd
Samson Ave
Shunpike Rd
Madison Golf Club
375 ft
Garfield Ave
Woodland Rd
Kings Rd
Woodland Rd
Green Village Rd
Fairmount Country Club
Noe Ave
Chatham
RUTGERS
New Jersey Agricultural Experiment Station