THE LOWER RARITAN WATERSHED: A RESIDENT'S GUIDE TO STEWARDSHIP

By

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And approved by

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ABSTRACT OF THE THESIS

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My approach to this thesis is a three-chapter guidebook. Chapter 1 will introduce the watershed, demonstrate residential land use and its impact on waterways, and discuss the Environmental Education Continuum created by the Environmental Protection Agency. This diagram is a trajectory from the awareness level to action and can be used to understand the structure of this thesis. Chapter 2 will focus on an analysis of personal field work, conducted from September to November 2018. This chapter is a discussion of materials and methods used, results found, and an analysis. The final chapter is a stewardship guide for resident's living in the Lower Raritan Watershed, but is also applicable to nearly everyone. This thesis will provide readers with adequate knowledge of the watershed and impacts of anthropogenic activity in order to become residential stewards of the Lower Raritan Watershed in New Jersey.

Acknowledgements

This thesis is dedicated to my grandma. She has been my guiding light throughout this journey and has taught me to never stop fighting. I love you a bushel and a peck…

I could not have done this without the other two special woman in my life, you know who you are.

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Chapter 1: An Introduction to the Lower Raritan Watershed

1-1: Watersheds

The most fundamental definition of a watershed is an area of land that drains water, sediment, and dissolved material to a common body of water. Watersheds in fact, are complicated systems. The entirety of the United States is broken into watersheds, with larger watersheds breaking up into thousands of smaller subwatersheds in some cases (Dzurik, Kulkarni & Boland, 2019). The watershed is an ecosystem that provides a wide range of ecological services to the humans, animals and plants that live there. An ecosystem is a, "functioning natural unit with interacting biotic and abiotic components in a system whose boundaries are determined by the cycles and flux of energy, materials and organisms," as described by the Environmental Protection Agency (O'Keefe, Elliott & Naiman, n.d.). So, one can study the watershed as an ecosystem in order to assess interactions between its biotic and abiotic parts.

Watersheds provide many natural processes that deliver beneficial services when the system is properly functioning. But disturbance and development of a watershed can also have disastrous consequences if these processes are misunderstood or disrupted. The watershed beneficial services include transport and storage of water, energy, organisms, sediments and other materials, the cycling of carbon and energy, and the transformation of compounds such as gaseous nitrogen to nitrite or ammonia (O'Keefe, Elliott & Naiman, n.d.). Having a basic understanding of the watershed is critical for people who plan to make changes or decisions that may affect its structure or function.

Waterways are harmed when there is excess impervious surface within the watershed caused by urban development (Environmental Protection Agency, 2018). Stormwater runoff is unable to absorb into the ground, and pollutes waterways while it collects sediment, motor oil, fertilizers, pesticides, pet waste, yard waste and more. When this happens, waterways become blocked causing flooding, erosion, vulnerable wildlife, and algal blooms. Urban land use is a sole factor in determining the way water moves throughout the watershed. Figure 1.1 demonstrates how increasing impervious surface from urban development impacts evapotranspiration, runoff, and infiltration. As impervious surface increases, there is less natural ground cover, causing the rate of evapotranspiration and infiltration to decrease, and runoff to increase.

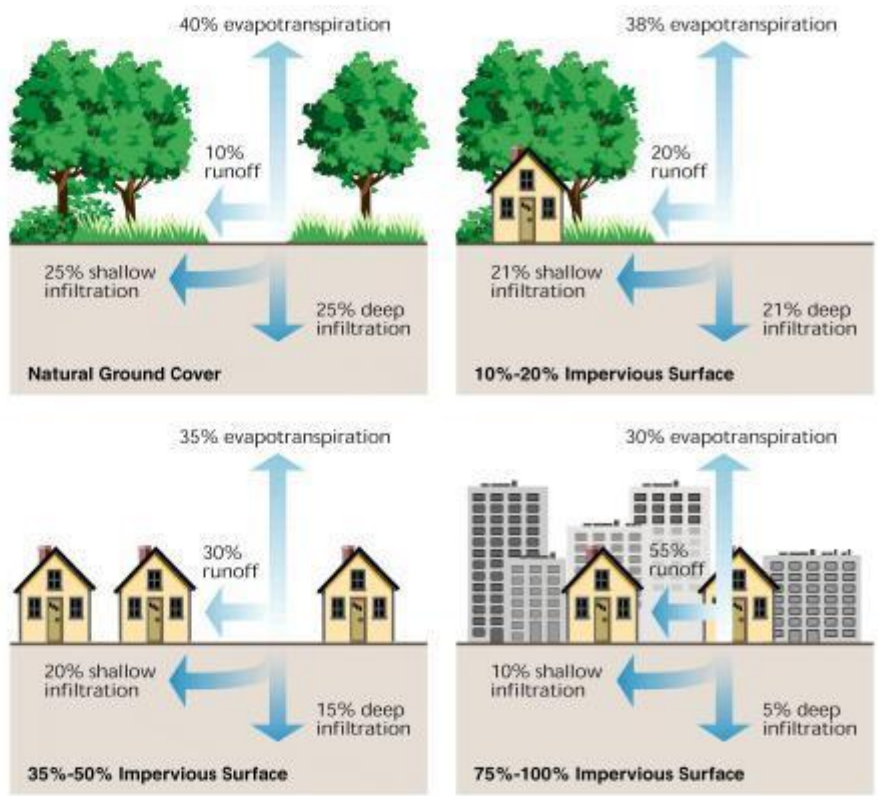


Figure 1.1: How evapotranspiration, runoff, and infiltration are impacted by impervious surface

Image credit: https://www.ncpedia.org/media/stream-runoff-diagram

Streams are an essential part of the watershed because they are tributaries that lead into rivers, which ultimately feed into larger bodies of water. Surrounding a stream on both sides is a zone called the riparian buffer, which is a natural defense for the waterway and its banks. Riparian buffers help protect the stream from contamination, provide ecological habitat, and take part in water and nutrient cycling and hydrologic function (United States Department of Agriculture, 1996). They are defined by their unique vegetation and soil. Water levels affect the type of plants that will grow in the riparian area, and soil in these zones consist of stratified sediments of varying textures subject to intermittent flooding and fluctuating water tables.

There are three designations of waterways given by the Department of Environmental Protection under The Surface Water Quality Standards (SWQS) at N.J.A.C. 7:9B (Division of Water Monitoring & Standards, NJ, 2012). Protection levels depend on the antidegradation category of the waterbody. Antidegradation policies ensure that existing uses for a waterbody are maintained and protected, as well as regulate what changes can be made to that waterway, and what developments can occur in and around these waterways. The categories are: Outstanding National Resource Waters (ONRW), which is the highest level of protection given to surface waters; Category One (C1) Waters, which are of exceptional ecological, recreational, water supply significance, or fishery resources and therefore protected from measurable changes in water quality; and Category Two (C2) waters, which are all surface waters not designated as ONRW or C1 waters. The water quality must be maintained similarly to C1 waters, but the quality standards are lowered to allow for social and economic development in C2 waters.

Depending on a waterway's designation, a riparian buffer is mandatory to the protection of the water (New Jersey Department of Environmental Protection, Division of Watershed Management, 2008). Category One (C1) Waters and higher require a 300 foot riparian buffer. 150 feet is the requirement for waters not designated as C1, but have special circumstances due to trout production, soil type, and endangered species. Category Two (C2) Waters are required to maintain a riparian buffer zone is that is at least 50 feet. Anything occurring in the riparian buffer is considered a regulated activity. Regulated activities include: 1. The alteration of topography through excavation, grading and/or placement of fill; 2. The clearing, cutting and/or removal of vegetation in a riparian zone; 3. The creation of impervious surface; 4. The storage of unsecured material; 5. The construction, reconstruction and/or enlargement of a structure; and 6. The conversion of a building into a private residence or a public building. These activities are determined by N.J.A.C. 7:13 Flood Hazard Area Control Act Rules (N.J.A.C. 7:13, 2015). Figure 1.2 demonstrates ideal conditions with a lush riparian buffer protecting a healthy stream, in close proximity to residential and agricultural land use.

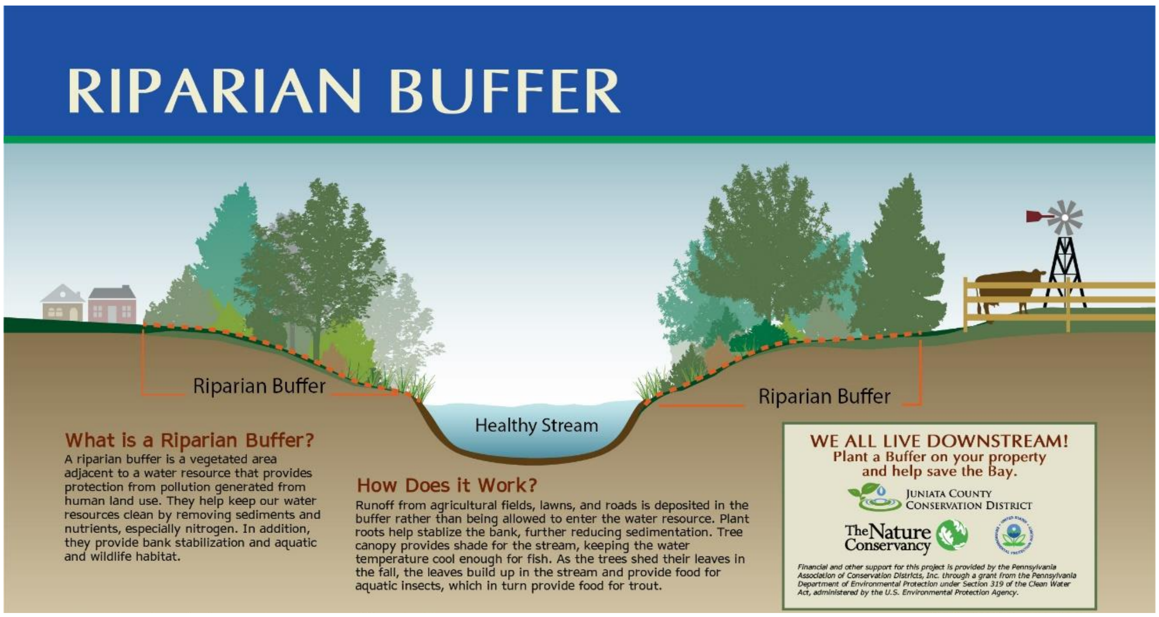


Figure 1.2: A section demonstrating the riparian buffers on each side of a stream

https://www.pacd.org/wp-content/uploads/2009/08/Juniata-Riparian-Buffer-signrevised3-6-13.jpg

The Environmental Education Continuum (EEC), as seen in Figure 1.3, was created by the Environmental Protection Agency, and it considers an individual's environmental education as a trajectory from initial awareness to action. The EEC can be used as a tool to connect environmental information and outreach and environmental education (Environmental Protection Agency, 2009). In connection to this thesis, Chapter

1 can be thought of as the “Awareness” and “Knowledge Stage” in that it provides the scientific knowledge of the watershed ecosystem to become aware of the problem. Chapter 2 is the “Critical Thinking” and “Problem Solving” phase, where a case study is presented which demonstrates residential land use and its impact on waterways. Finally, Chapter 3 is the “Decision Making” and “Action” section, leading residents to become environmental stewards.

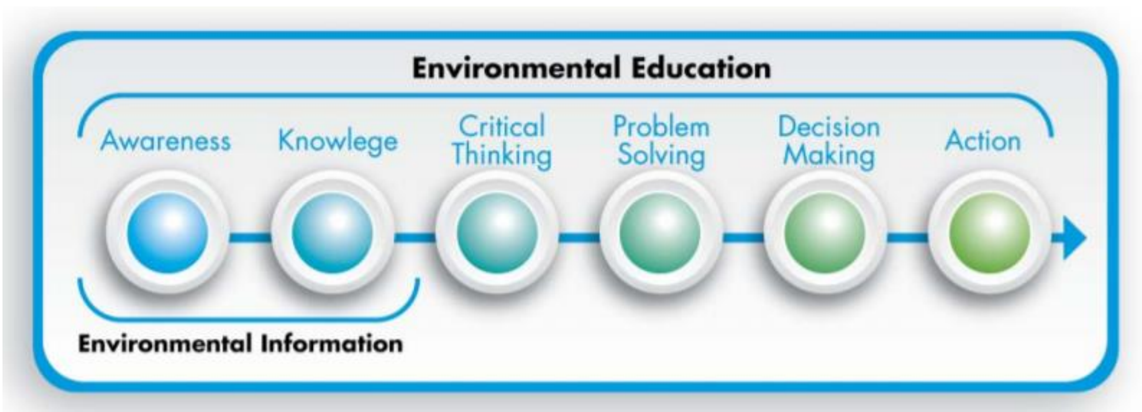


Figure 1.3: Environmental Education Continuum

Image credit: https://www.epa.gov/sites/production/files/documents/2009_eehighlights.pdf

1-2: The Raritan River

The Raritan River system is entirely contained to the state of New Jersey, covering over 1,100 square miles and crossing boundaries of seven counties including Morris, Hunterdon, Somerset, Union, Middlesex, Mercer, and Monmouth (Rutgers, The State University of New Jersey, n.d.). The Raritan River watershed is home to approximately 1.5 million people. These residents rely on the water from the Raritan for drinking, as well as for recreational purposes. According to Rutgers University, the U.S.

Clean Water Act and New Jersey Department of Environmental Protection have enforced regulations to control development along the river, as well as its usage, but centuries of anthropogenic activity have done damage which has been difficult to remedy.

The first recorded instance of human activity along the Raritan River was due to settlers known as the Naraticongs, a branch of the Lenape who were part of the Iroquois Nation (The Borough of Raritan, (n.d.). These natives hunted, fished and were the first to take part in agricultural practices, planting corn in the fertile soil. By 1683, the Dutch and English bought land from the Naraticongs. The area was named Raritan, after the Naraticongs, meaning “forked river” or “where the stream overflows” depending on differing historical accounts. These various groups of settlers found the Raritan River appealing for similar reasons: its fertile soil and the possibility as a navigable trade route. These early European settlers were the first examples of human caused disturbance to the watershed ecosystem, a concept that would not be studied for centuries later. Historically, the Raritan has been relied on as a source for human prosperity and existence. Today, communities such as Princeton, Bound Brook and New Brunswick rely on the Raritan as a source of drinking water (New Jersey Water Supply Authority, n.d.). There are two purification centers, both located in Hunterdon County, called the Spruce Run and Round Valley Reservoirs. Combined, they hold 66 billion gallons of water.

Water is essential to life, and it is obvious that the Raritan River has played a vital role in shaping communities adjacent to its banks. Unfortunately, population growth has negatively affected water quality due to human reliance on the river for recreation, drinking, waste processing, agriculture, industry, and more. As these uses increase, the quality of the water decreases.

Within the Raritan Watershed (Raritan Basin), there are three Watershed Management Areas (WMA), with WMA 9, or The Lower Raritan Watershed being the area of focus for this report. Its counterparts are known as the Upper Raritan Watershed, and the Millstone Watershed.

The Lower Raritan Watershed is the most densely populated Watershed Management Area out of the three within the Raritan Basin, as seen in Figure 1.4. The total population of the Lower Raritan Watershed was 819,136 in 2010, increasing almost 20 percent in a 20-year span (1990 to 2010) (Giri, Krasnuk, Lathrop, Malone & Herb, 2016). The total number of housing units in 2010 was 291,772. The projected population in 2034 is estimated to be 959,641

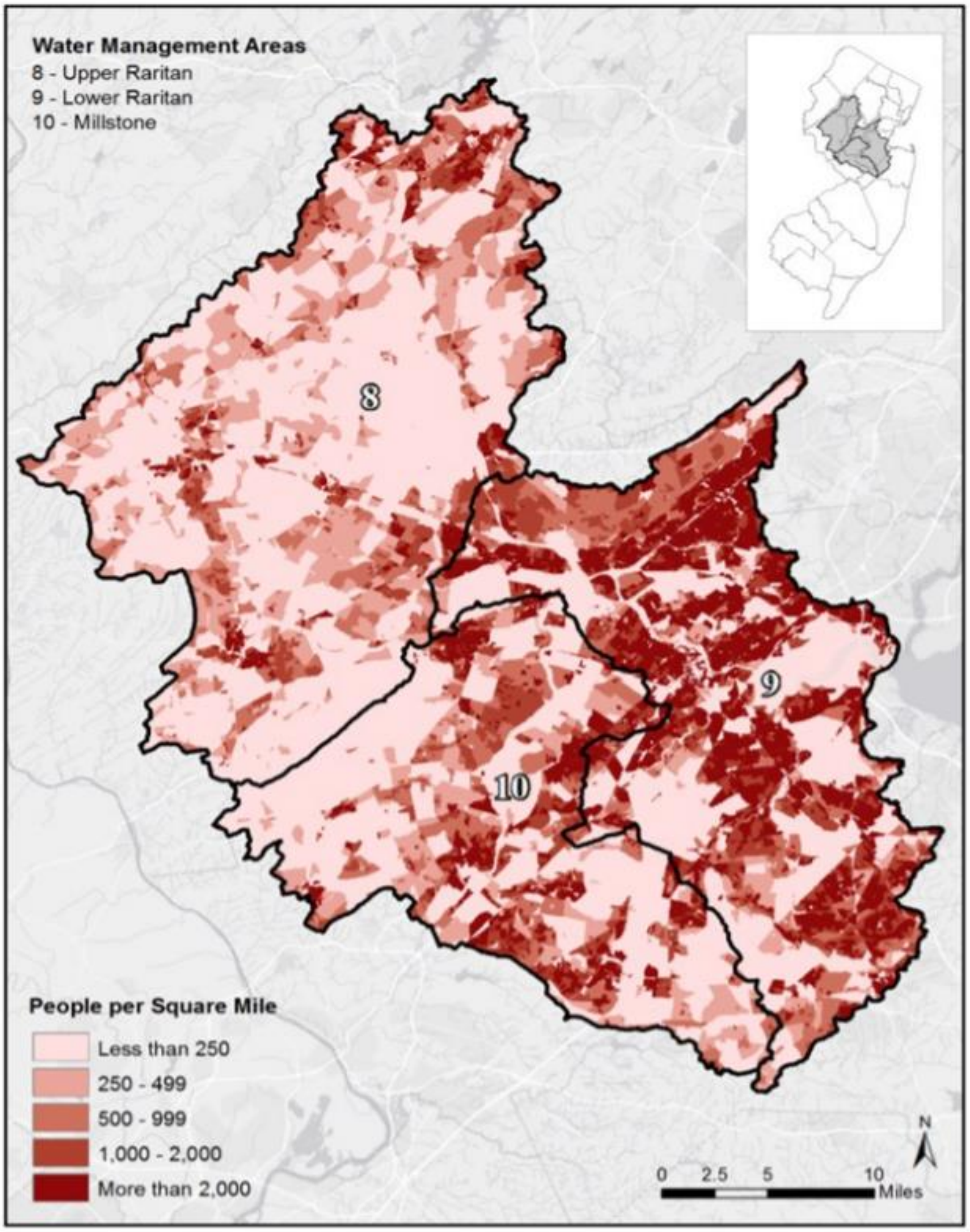


Figure 1.4: People per square mile in the 3 Watershed Management Areas within the Raritan Basin

Image credit: http://raritan.rutgers.edu/wp-content/uploads/2017/01/SOR-Final-2017-01-30.pdf

Analysis of land use types, patterns, and trends is routine in watershed management. These patterns and the structure of the landscape are often the result of anthropogenic activity (O'Keefe, Elliott & Naiman, n.d.). Residential land use has a dramatic impact on the watershed and its waterways. As of 2012, The Lower Raritan Watershed was 22.4 percent impervious surface, the highest of its neighbors, the Millstone and Upper Raritan (Giri, Krasnuk, Lathrop, Malone & Herb, 2016). In Figure 1.5, land use by category is displayed by percentage, and demonstrates that one third of the total land use in WMA 9 is residential. This indicates that those living in the watershed can have one of the largest positive impacts on the watershed by making small changes to their routines. Those who live in direct vicinity of the stream have an even greater job when it comes to stewardship. Figure 1.6 shows residential land use falling within the 300 foot riparian buffer, which makes up 17 percent of the total buffer. The Lower Raritan Watershed is a densely populated area comprised of many households which are potentially burdening waterways.

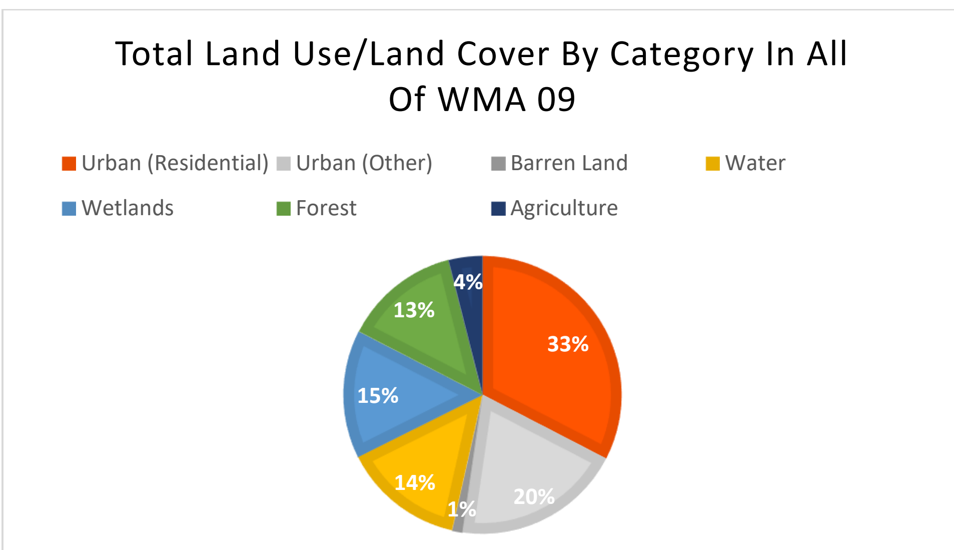


Figure 1.5: Total land use/land cover broken into category in all of WMA 09

Image credit: Jillian Dorsey, (Data source NJDEP 2012 Land Use).

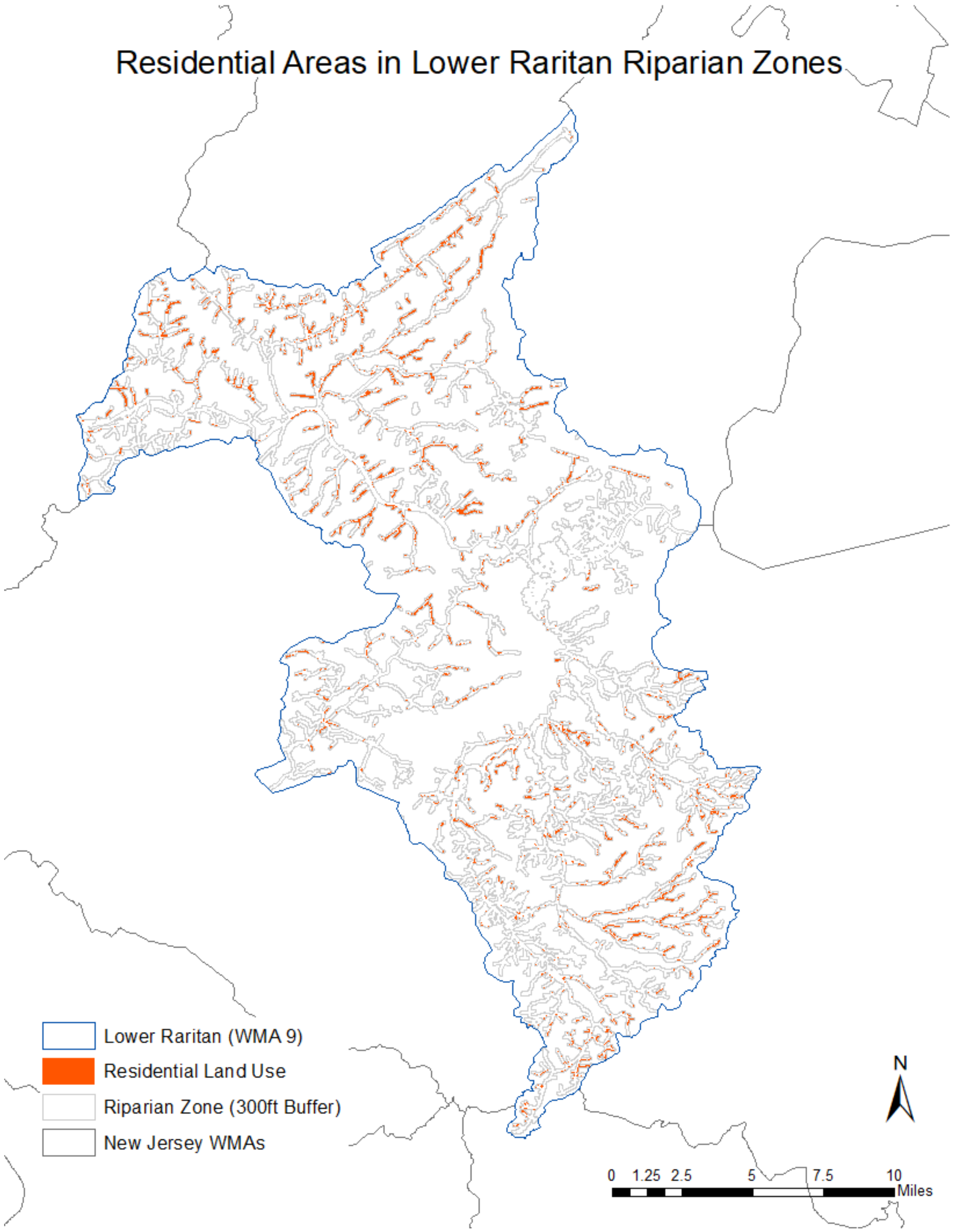


Figure 1.6: Percent of residential land use within the 300 foot riparian buffer zone

Image credit: Jillian Dorsey and Colin Marx, (Data source NJDEP 2012 Land Use).

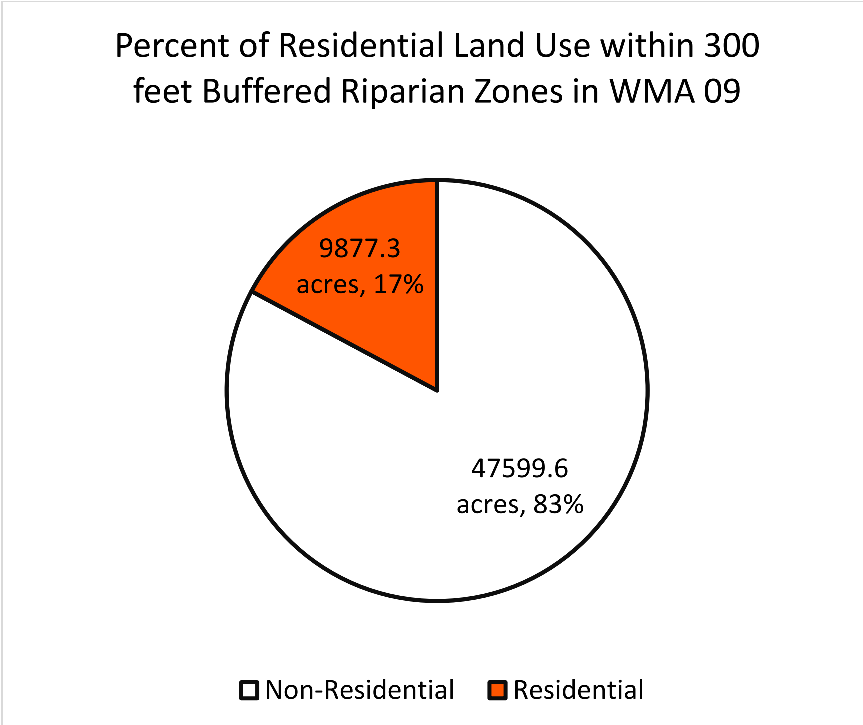


Figure 1.7: 17 percent of land within the 300 foot riparian buffer in WMA 09 is residential land

Image credit: Jillian Dorsey and Colin Marx, (Data source NJDEP 2012 Land Use).

1-3 A Guide to Chapters 2 and 3

The following document should be used as a guide towards watershed stewardship for residents of the Lower Raritan Watershed. Chapter 2 is an extensive summary of the field work conducted along the Mill Brook Stream while Chapter 3 is a resident's guide for protecting the watershed and its waterways. The Mill Brook stream assessment in Chapter 2 included a visual analysis of the stream and its banks in order to understand how residents living in direct vicinity of the stream impacted the water. Guidelines from the New Jersey Department of Environmental Protection were used to measure stream health, as well as instances of anthropogenic activity. The Mill Brook

Stream received marginal scores according to these guidelines and signs of pollution, human intervention, and ecological disruption were evident from photographs taken.

Based on this information, it can be concluded that insufficient action is being taken to protect our waterways. Chapter 3's guide to stewardship is focused towards all Lower Raritan Watershed residents and is not limited to those only with streams in their backyards. Taking what is known about watershed ecosystems, it can be deduced that all residents of the watershed have a responsibility towards fostering stewardship. Since the beginning of settlement along the river, humans have been responsible for the increase in development, impervious surface, pollutants, and eroding banks ultimately taking its toll on this vital resource, known as the Raritan.

Chapter 2: Mill Brook Stream Assessment

2-1: Abstract

Beginning in September 2018, data was collected and analyzed from the Mill Brook Stream, in Watershed Management Area 9 (The Lower Raritan Watershed). Visual assessments were conducted at 17 points along two branches of the Mill Brook in Highland Park Borough and Edison Township, New Jersey. These visual assessments were done in order to measure the health of the stream based on signs of anthropogenic activity. Results showed that the stream's overall health scored a marginal rating for both Branches 1 and 2. Photo documentation confirmed a high percentage of anthropogenic activity occurring along the stream. The goal of this research is to: 1) document the occurrence of residential land within the 300-foot riparian buffer in the Lower Raritan Watershed, WMA9; 2) Present a case study of the detrimental impacts of residential/anthropological impacts on stream health, taking the case of Mill Brook; and 3) build from the data collected and analyzed to create a resident's guide to stewardship in the watershed.

2-2: Introduction

In order to create a resident's guide to stewardship, the frequency of residential land use was assessed in the Lower Raritan Watershed, and a case study of the Mill Brook Stream was conducted. The residents who live adjacent to the stream are only a small fraction of the Lower Raritan Watershed residents; anthropogenic activity throughout the whole watershed impacts the waterways. The question asked before the

Mill Brook Stream Assessment was conducted was as follows: how have instances of anthropogenic activity impacted the Mill Brook Stream? This question was answered from various results including, scores of the Habitat Assessment for Low Gradient Streams provided by the New Jersey Department of Environmental Protection, scores from a rating system based on instances of anthropogenic activity, scores from a rating system based on native versus nonnative plant activity, and finally, photo documentation.

2-3: Materials and Methods

a. Site Location and Description

From late September to early November, research was conducted along a tributary of the Raritan River called the Mill Brook, which is located between Highland Park and the west end of Edison Township, as seen in Figure 2.1. The area of study falls within a single HUC 14 (02030105120170), which is within the larger HUC 11 (02030105120), part of the subwatershed called Lawrence Brook to Mile Run. On a larger scale, this area is in Watershed Management Area 9 (WMA 09) within the Lower Raritan Watershed, in the Raritan Basin as seen in Figure 2.2. A close up of the Mill Brook Stream and its tributaries can be seen in Figure 2.3.

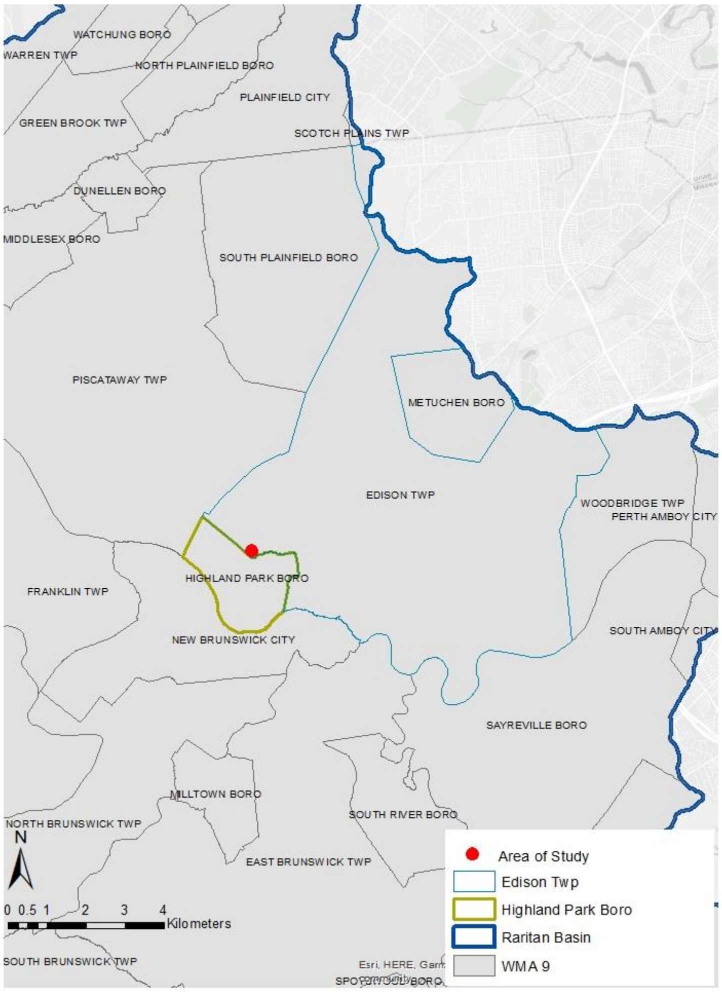


Figure 2.1: Area of study

Image credit: Jillian Dorsey

Figure 2.2 The Lower Raritan Watershed within the Raritan Basin

Image credit: Jillian Dorsey

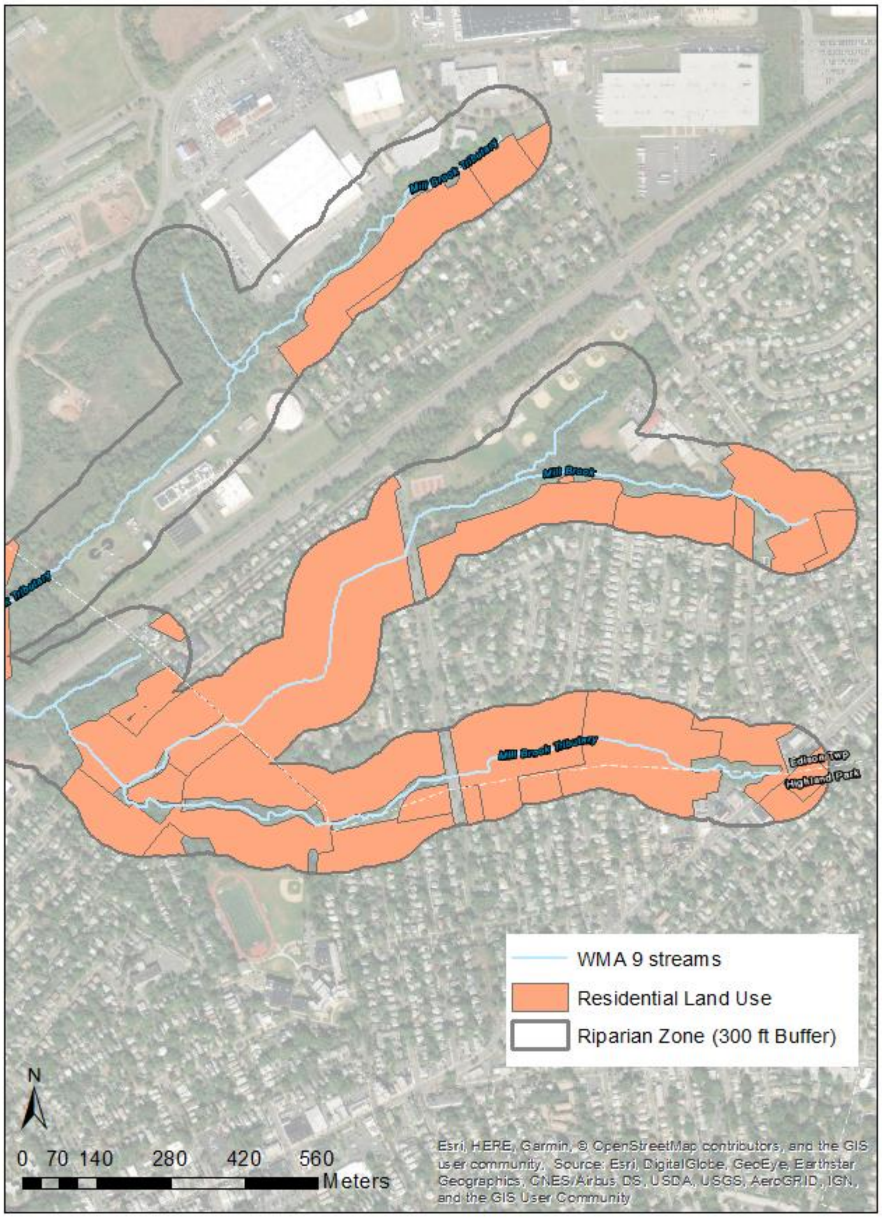


Figure 2.3. Raritan River tributaries

Area of data collection in the streams bordering Highland Park Borough and Edison Township.

Image credit: Jillian Dorsey, (Data source NJDEP 2012 Land Use).

b. Sample Plot Selection

Prior to a visual assessment conducted in the Mill Brook Stream, Geographic Information Systems was used to create a map delineating the 300 foot buffer around the Mill Brook Stream and its north and south tributaries. The Mill Brook Stream was designated as Branch 1, while the south tributary was designated as Branch 2. This choice was due to a higher percentage of residential land cover in these “Branches” compared to the northern tributary. The total length of the stream was measured and divided equally in order to develop nine research plots spaced 200 meters apart with a visual assessment point at the 0 meter mark and 100 meter mark. Any discrepancy in distance between plots was due to logistical constraints, discussed later. Each research plot was broken up into points A (0 meters) and B (100 meters), which can be seen in the detailed map in Figure 2.4.

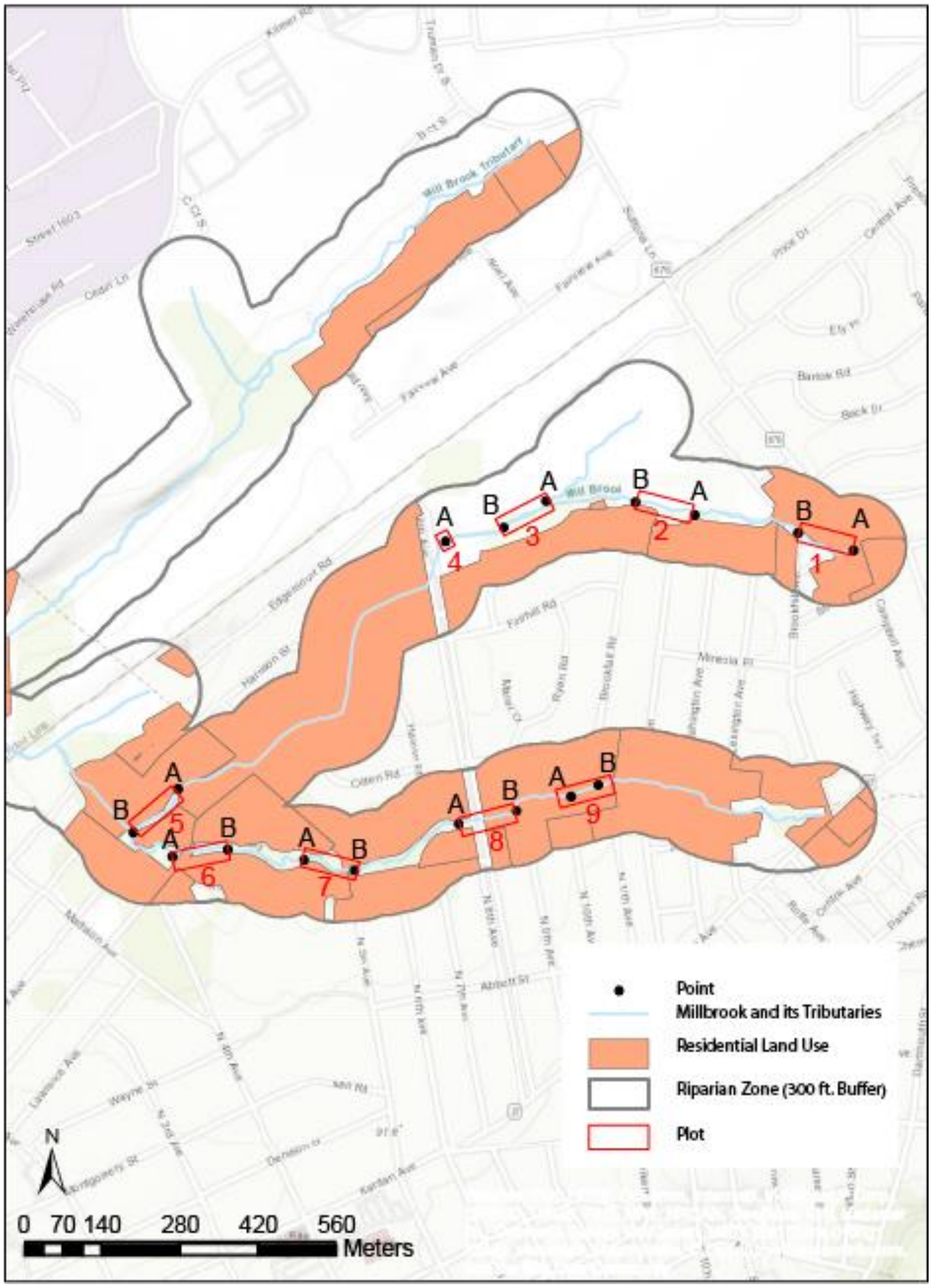


Figure 2.4: Nine study plots

Area of data collection in the Mill Brook Stream and its southern tributary.

Image credit: Jillian Dorsey, (Data source NJDEP 2012 Land Use).

c. Visual Assessment Methods

A visual analysis was conducted at each point using the guidelines from the Habitat Assessment for Low Gradient Streams provided by the New Jersey Department of Environmental Protection (Figure 2.5) for the 9 plots along the Mill Brook Stream. The categories included in the assessment were based on criteria that demonstrate the health of the stream and the 300 foot riparian zone. The first category looks at the structure of the stream and includes evaluations of epifaunal substrate, pool substrate characteristics, pool variability, and sediment deposition. The second category focuses on stream form and includes channel flow status, channel alteration, and channel sinuosity. The third category looks at degree and type of protection along the stream banks and includes bank stability, bank vegetation and riparian vegetative zone. The example of channel sinuosity can be seen in Figure 2.6 below. The more bends in a stream, the higher score it received. This is because a straighter channel generally means the waterway has been channelized through human intervention.

HABITAT ASSESSMENT FOR *LOW* GRADIENT STREAMS

	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate /Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	. 10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE (LB)	Left 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE (LB)	Left 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE (LB)	Left 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORE

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	60 – 109
POOR	< 60

Figure 2.5: Habitat Assessment Sheet for Low Gradient Streams

A survey was conducted at each of the 17 points along the area of study, using this low gradient monitoring sheet.

Image credit: https://www.state.nj.us/dep/wms/bears/docs/Habitat%20assessment%20sheet%20Low%20Gradient%20-%20YR16.pdf

	Optimal	Sub-Optimal	Marginal	Poor
Channel Sinuosity	Bends in stream increase its length 3 to 4 times longer than if it was a in a straight line	Bends in stream increase its length 2 to 3 times longer than if it was a in a straight line	Bends in stream increase its length 1 to 2 times longer than if it was a in a straight line	Channel is straight; waterway has been channelized for a long distance
Score	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

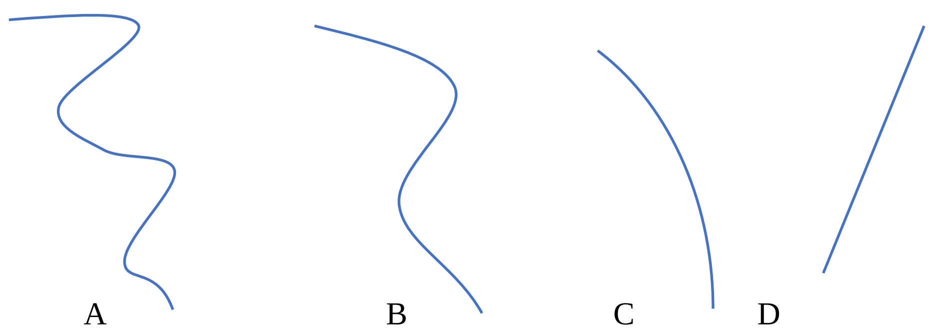


Figure 2.6: Channel Sinuosity, from the Habitat Assessment for Low Gradient Streams

An example of the category, channel sinuosity, from the NJDEP's Habitat Assessment form, seen in Figure 2.6, above. Images A through D represent the sinuosity of the stream channel; image A represents the most sinuous stream, which is the most optimal situation, while image D represents the most channelized stream, the least optimal situation.

Image credit: Jillian Dorsey

Each category was scored from 0 to 20, with 20 being optimal and 0 being a poor rating. Once each category was given a score, the sum of all scores from the ten categories were found. Each value was associated with a habitat score. Possible scores were poor, marginal, sub-optimal, and optimal being the highest rating, as seen in Table 2.1. The values for the Low Gradient Habitat Assessment were recorded for points A and B at each plot, and the average was found and recorded. The values for Branches 1 and 2, which included plots 1 through 5 and 6 through 9, respectively, were kept separate so that the two branches could be compared. Averages were found for both branches by totaling the values from all plots. The average from all 9 plots was calculated as well. The values were then compared to the category table and given a score from the choices seen in Table 2.1.

Table 2.1: Value associated with habitat scores

Value	<60	60-109	110-159	160-200
Habitat Scores	Poor	marginal	sub-optimal	optimal

In addition to the Habitat Assessment for Low Gradient Streams, a rating system to measure overall anthropogenic activity was created which involved recording all items or instances including but not limited to, mowing, paths, trash, pipes, bricks, concrete, retaining walls, and fences. A rating was also given based on the growth of nonnative versus native plants. Both categories of anthropogenic activity and plants were scored on a 5 to 0 scale, with 5 being most optimal, as seen in Table 2.2. Each time there was evidence of the anthropogenic activity noted, or a nonnative species was seen, the score was reduced by 1 point. Additionally, an inventory of pictures was taken at each plot, as well as between plots at the 200 meter transects, in order to keep track of the type of activity found, and their occurrences.

Table 2.2: Ranking system for anthropogenic activity and invasive species occurrences

Value	0 to 1.5	1.6 to 3.0	3.1 to 4.1	4.2 to 5
Habitat Scores	poor	marginal	sub-optimal	optimal

d. Field Data Collection

The study began at plot 1 by entering where the stream crossed under the road by way of a culvert at Suttons Lane in Edison Township. The number of plots assessed in a day varied, depending on time, weather, and logistical constraints, with the accompaniment of at least one research assistant. Point A (0 m) was the east end of the plot and point B (100 m) was the west end. These points were recorded using a Garmin handheld GPS device. Plots 1 through 5 made up the first branch of the stream. After the completion of a 100 meter transect, 200 meters was measured from point B, to the next plot, which again would begin at point A. The process involved, traveling southwest (towards Highland Park) to the fork in the stream, and redirecting east, to cover the second branch which included plots 6 through 9. Navigating in this direction towards plot 6, point A (0 m) became the west end of the plot, while point B (100 m) became the east. At plot 4, the stream is diverted underground from plots 4 to 5, rendering the stream inaccessible. For this reason, only one score was given at site 4, which was recorded as point A. This method provided for a total of 17 points of visual assessment, with approximately 1500 meters to observe freely in between these visual assessment recordings.

2-4: Results

The average habitat assessment value overall was 94.06, a marginal score. The average value for Branch 1 was 97.4 (Table 2.3), a marginal rating, while the average value for Branch 2 was 78.63 (Table 2.4), also falling within the marginal category. None of the plots received above a sub-optimal score. Plot 8 received the lowest value of 50.8, leaving it in the category of poor. Plot 3 received the highest value of 145.5, placing it in the sub-optimal category. Branch 1 scored 18.77 points higher than Branch 2, but this still qualified them to both fall within the marginal category.

Table 2.3: Habitat assessment scores for Branch 1

The scores for each plot at branch 1 are recorded in the table below, as well as the average score, for plots 1 through 5.

Plot number		**1**	**2**	**3**	**4**	**5**	
Number of replicates		**2**	**2**	**2**	**1**	**2**	**Average**
Epifaunal substrate/available cover		13.5	16	16	5	9.5	**12**
Pool substrate characterization		9	15	16	13	9.5	**12.5**
Pool variability		11	4	16.5	3	6.5	**8.2**
Sediment deposition		8.5	10.5	11.5	13	12.5	**11.2**
Channel flow status		13	12.5	12.5	13	13	**12.8**
Channel alteration		0	15	18	1	4	**7.6**
Channel sinuosity		12.5	9.5	12.5	1	5.5	**8.2**
Bank stability (LB)		5	3	8.5	2	5	**4.7**
Bank stability (RB)		3.5	8	7	2	5	**5.1**
Bank vegetative protection (LB)		5	4.5	6.5	2	1.5	**3.9**
Bank vegetative protection (RB)		3	6	6.5	2	1.5	**3.8**
Riparian vegetative zone width (LB)		3	3	9	3	1	**3.8**
Riparian vegetative zone width (RB)		2.5	6.5	5	3	1	**3.6**
Sum		89.5	113.5	145.5	63	75.5	**97.4**
Category		marginal	sub-optimal	sub-optimal	marginal	marginal	**marginal**

Table 2.4: Habitat assessment scores for Branch 2

The scores for each plot at branch 2 are recorded in the table below, as well as the average score, for plots 6 through 9.

Plot number	**6**	**7**	**8**	**9**	
Number of replicates	**2**	**2**	**2**	**2**	**Average**
Epifaunal substrate/available cover	11.5	12.5	7.5	13.5	**11.25**
Pool substrate characterization	10.5	11	8	14	**10.88**
Pool variability	13.5	7.5	8.5	12	**10.38**
Sediment deposition	13.5	9	8	16.5	**11.75**
Channel flow status	13	12	8	16.5	**12.38**
Channel alteration	8	7.5	0.5	12.5	**7.13**
Channel sinuosity	10	10	3	8	**7.75**
Bank stability (LB)	2	5	3	3	**3.25**
Bank stability (RB)	3.5	6.5	3	5	**4.50**
Bank vegetative protection (LB)	2.5	5	2	2	**2.88**
Bank vegetative protection (RB)	2	4.5	2	2.5	**2.75**
Riparian vegetative zone width (LB)	2	3	2.5	1.5	**2.25**
Riparian vegetative zone width (RB)	2	4.5	2	2.5	**2.75**
Sum	82.5	85.5	50.5	96	**78.63**
category	marginal	marginal	poor	marginal	**marginal**

Table 2.5 shows the results of the anthropogenic activity scores in the Mill Brook. The value totaled to 2.50 out of 5, equating to a marginal score. In the category of nonnative versus native species, the stream scored a 2.39 out a 5 (Table 2.6), also a marginal score. A listing of all nonnative species seen at each plot can be seen in Table 2.7, followed by photos of the most common occurrences (Figure 2.7); Norway Maple, Japanese Knotweed, English Ivy, Burning Bush, and Common Privet. Norway Maple (*Acer platanoides*) was recorded at every research plot.

Table 2.5: Anthropogenic activity scores for Mill Brook

Plot number	1	2	3	4	5	6	7	8	9	
Number of replicates	2	2	2	1	2	2	2	2	2	**Average**
Anthropogenic activity	2.5	3	3.5	2	1.5	2	3.5	1.5	3	**2.5**
category	marginal	marginal	sub-optimal	marginal	poor	marginal	sub-optimal	poor	marginal	**marginal**

Table 2.6: Natives versus nonnatives presence scores for Mill Brook Stream

Plot number	1	2	3	4	5	6	7	8	9	
Number of replicates	2	2	2	1	2	2	2	2	2	**Average**
Natives vs. nonnatives	3	3	3	3	2	2	3	1	1.5	**2.39**
Category	marginal	marginal	marginal	marginal	marginal	marginal	marginal	poor	poor	**marginal**

Table 2.7: Occurrences of nonnative plant species

Nonnative plant species seen at each of the 9 plots.

Scientific Name	**Common Name**		**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Plot 6**	**Plot 7**	**Plot 8**	**Plot 9**	**Total**
Acer platanoides	Norway Maple		2	2	2	1	1	2	2	2	1	15
Reynoutria japonica	Knotweed		0	2	2	0	1	1	1	2	0	9
Hedera helix	English Ivy		0	0	0	0	2	2	2	2	1	9
Euonymus alatus	Burning Bush		0	0	0	0	0	0	1	1	1	3
Ligustrum vulgare	Common Privet		0	0	1	0	1	0	0	0	1	3
Wisteria	Wisteria		0	0	0	0	0	1	1	0	0	2
Rubus phoenicolasius	Wineberry		0	0	0	0	0	1	0	0	1	2
Forsythia	Forsythia		0	1	0	0	1	0	0	0	0	2
Microstegium vimineum	Stilt Grass		1	1	0	0	0	0	0	0	0	2
Bambusoideae	Bamboo		1	0	0	0	0	0	0	0	1	2
Rosa multiflora	Multiflora Rose		0	1	0	0	0	0	0	0	0	1
Pennisetum setaceum	Fountain Grass		0	1	0	0	0	0	0	0	0	1
Phragmites australis	Phragmites		0	0	1	0	0	0	0	0	0	1
Alliaria petiolata	Garlic Mustard		0	0	0	0	1	0	0	0	0	1
Chamaecyparis obtusa	Hinoki Cypress		0	0	0	0	1	0	0	0	0	1
Malus hupehensis	Crab Apple		0	0	0	0	0	1	0	0	0	1
Hibiscus syriacus	Rose of Sharon		0	0	0	0	0	1	0	0	0	1
Zelkova serrata	Japanese zelkova		0	0	0	0	0	1	0	0	0	1
Lonicera	Honey Suckle		0	0	0	0	0	0	0	0	1	1
Morus	Mulberry		0	0	0	0	1	0	0	0	0	1
Catalpa	Catalpa		0	0	0	0	0	0	0	1	0	1
Cornus	Dogwood		0	0	0	0	1	0	0	0	0	1
Viburnum plicatum	Japanese Snowball		0	0	0	0	0	1	0	0	0	1
Duchesnea indica	Mock Strawberry		0	0	0	0	0	0	0	1	0	1
Total			**4**	**8**	**6**	**1**	**9**	**10**	**7**	**8**	**7**	**60**

a. Norway Maple

b. Japanese Knotweed

d. English Ivy

e. Common Privet

f. Burning Bush

Figure 2.7: Common nonnative plants seen during the Mill Brook assessment, labeled a. through f.

Image credit: https://www.fohvos.info/invasive-species-strike-team/info-center/

Table 2.8 below, breaks down the percentage of anthropogenic activity seen each day, based on the instances of anthropogenic activity found in a picture, divided by the number of pictures taken that day. The highest percent of anthropogenic activity seen on a particular day was Saturday, September 29 with 53.85 percent while the lowest percent was on Sunday, October 28 with 14.29 percent. The average instance of anthropogenic activity noted was 36.36 percent. Anthropogenic activity was then broken into the following categories seen in Table 2.9.

Table 2.8: Instances of anthropogenic activity

Percentage of anthropogenic activity noted during each site visit.

Date	**Number of Pictures taken**	**Number of instances of anthropogenic activity**	**Percentage**
Saturday, September 29, 2018	52	28	53.85%
Monday, October 15, 2018	56	19	33.93%
Sunday, October 28, 2018	42	6	14.29%
Monday, October 29, 2018	22	9	40.91%
Saturday, November 3, 2018	125	46	36.80%
Total	**297**	**108**	**36.36%**

Table 2.9. Types of anthropogenic activity.

The different categories of anthropogenic activity occurring on each day of field work, and the number of times they were counted in pictures.

	9/29/2018	10/15/2018	10/28/2018	10/29/2018	11/3/2018	Total	Percent occurrence
Buildings	6	3	1	2	10	22	20%
Construction materials	3	0	1	0	6	10	9%
Culverts	2	1	0	1	3	7	6%
Fences	4	3	1	0	3	11	10%
Miscellaneous	0	4	0	0	2	6	6%
Mowed lawn	1	0	0	1	0	2	2%
Oil slick	1	1	0	0	0	2	2%
Outlet/ concrete tunnels	1	0	1	0	3	5	5%
Pipe	2	1	1	0	4	8	7%
Retaining walls	2	0	0	3	11	16	15%
Steps	0	0	0	1	0	1	1%
Trash (metal)	1	1	0	0	0	2	2%
Trash (paper)	1	0	0	0	1	2	2%
Trash (plastic)	3	4	1	0	2	10	9%
Yard Waste (grass clippings, leaf litter, branches, mulch)	1	1	0	2	1	5	5%
Total	28	19	6	10	46	109	100%

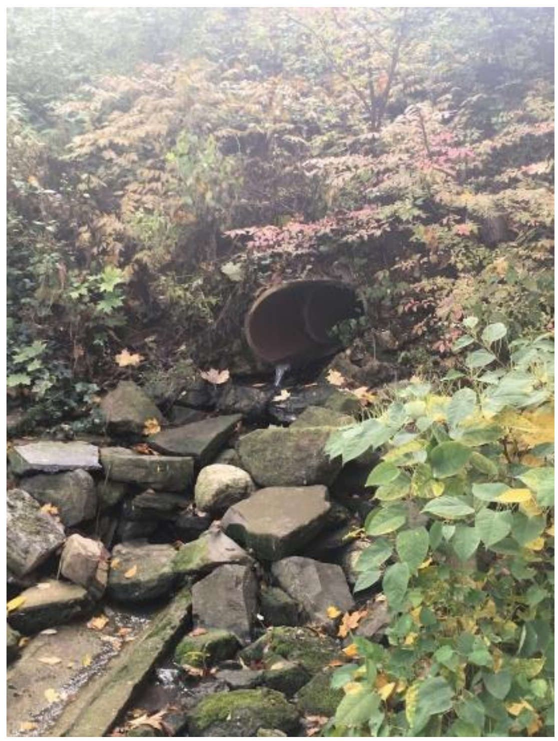
As seen in Table 2.9, the most common type of anthropogenic activity noted in the pictures taken within the five-day study period was buildings, specifically homes seen a total of 22 times. Following buildings on the list are retaining walls, which were seen in many variations, such as gabions, wood, stone, and concrete. Out of all the trash found, plastic was the most common refuse in or near the stream. The miscellaneous group consisted of items that did not necessarily fit into a specific category and consisted of items such as playing balls from a nearby elementary school, hunting posts on trees, a treehouse, and furniture, such as a carpet. The images below show examples of each category from Table 2.9.

a. Buildings

b. Mowed lawns

c. Culverts

d. Outlets/Concrete Tunnels



e. Pipes

f. Fences

g. Retaining walls

h. Trash (metal)

i. Trash (paper)

j. Trash (plastic)

k. Yard Waste

l. Construction Materials

m. Oil

n. Miscellaneous

Figure 2.9: Examples from each category of anthropogenic activity seen during the Mill Brook Assessment, labeled a. through n.

Image credit: Jillian Dorsey

2-3: Discussion

The major finding of this research was the clear indication that The Mill Brook Stream is marginal in terms of ecosystem health. In addition, breaking up the Habitat Assessment scores by branch showed that Branch 2 received a score of almost 20 points lower than Branch 1. This led to the question of, why? It is possible that this is because plots 2, 3 and 4 fell partially within an area of recreational land use, rather than residential. These points within the plots fell along a school yard and open baseball field. This could have led to lesser instances of anthropogenic activity noted along Branch 1, as well as different effects on the stream and riparian zone. Plot 8, falling within Branch 2 received the lowest score while Plot 3, falling within Branch 1, received the highest. Again, this might emphasize the findings that Branch 1 is healthier than Branch 2 due to less residential land use falling within the riparian zone. Yard waste, as noted in Table

2.9, was only counted four times in pictures. It was expected that evidence of grass clippings and leaf dumping would occur more frequently. The lack of evidence could be attributed to error; it is possible yard waste was not visible over the stream bank's slope. The time of year could also account for the lack of yard waste; the majority of field work took place during late fall, when yard work is beginning to slow down until the following spring. The season most likely contributed to the inability to find signs of pesticide and fertilizer use as well.

2-4: Conclusion

The research findings ultimately support the goals of this project. High instances of anthropogenic activity were seen in the Mill Brook Stream through photo documentation and results of the visual assessments for low gradient streams, anthropogenic activity, and nonnative plant species all were marginal. Although considered an urban stream, the health of the Mill Brook can be greatly improved by informing its residents of best practices that will have a positive impact on waterways. The results can be used to take the next steps in compiling methods for best residential landscape practices for homeowners, ultimately reducing the impacts of anthropogenic activities.

Chapter 3: A Resident's Guide to Stewardship

3-1: Introduction

Building on geospatial analysis and field research, the purpose of this chapter is to provide information to residents of the Lower Raritan Watershed about protecting our waterways. Water that flows into the stream from residents' backyards ultimately makes its way into larger water bodies such as the Raritan River and the Atlantic Ocean. Even if they do not have a stream in their yard, the stormwater runoff from each residence makes its way into storm drains and ultimately the waterways on which we rely for many uses. Best landscape practices will be discussed starting with beginner level solutions to advanced level, and readers will understand how these sustainable practices can be incorporated into their property and daily routines. Although some of these solutions pertain to those living in direct proximity to a stream, such as building up the riparian buffer, most suggestions can be followed by all New Jersey homeowners.

3-1-2: Why care for the watershed?

Fishing, boating, hiking, camping, biking and walking alongside the riverbanks are all reasons to care for the watershed. The activities listed are only the recreational opportunities provided by the river; we rely on the river for essential services as well, such as clean drinking water, water for agriculture and manufacturing, and the provision of habitat to an abundance of wild and plant life. The improvement of public access to the Raritan River, specifically the 30-mile stem of the Lower Raritan, is a continuing goal of the Sustainable Raritan River Initiative, established in 2009 at Rutgers University (Public access and recreational use of the river, n.d.). Recently, recreational opportunities in the river as well as fish migration have increased due to dam and obstruction removals. Decisions we make at the watershed scale can dramatically impact the river that we rely on for the services mentioned above. For example, erosion of the river banks caused by human activity can change the structure so it is no longer accessible for use (Yamani, Goorabi & Dowlati, 2011). Overwhelming the waterways with large amounts of debris and waste can cause similar issues. The following subsections will further explain the detrimental impacts that human activities have on the watershed, as well as provide ways to remediate these impacts from small routine changes, to larger-scale interventions.

3-2: Beginner-Level Solutions

a. Clean up after your pets

Although occasionally, a common misconception is that animal waste is good fertilizer for the soil (NJDEP New Jersey Division of Watershed Management, 2018). Potassium, phosphorus, and nitrogen, all found in pet waste, are necessary for the growth of vegetation, but when these levels become high in our waterways, plant growth in lakes and ponds increases, diminishing ecological health and negatively affecting recreational value. It is not uncommon for recreational waterways to close after significant rainstorms due to increased fecal bacteria levels. When pet waste is left on homeowner’s lawns and other properties, nutrients, pathogens, and bacteria can enter waterways by way of stormwater runoff. According to the New Jersey Department of Environmental Protection, “bacteria levels in stormwater runoff appear to be greater in urban and suburban areas than in commercial or industrial zones” (NJDEP New Jersey Division of Watershed Management, 2018). This is most likely due to the presence of pets in residential areas, as it is common for their owners to enjoy walks along waterways and roadways.

If you own a pet, it is important to dispose of their waste in the trash or the toilet. Disposing of the waste down a storm drain will cause it to end up in local waterways (NJDEP New Jersey Division of Watershed Management, 2018). Check with your municipality for ordinances regarding proper disposal of pet waste. In addition, consider talking to your neighborhood Homeowner’s Association about providing “clean up stations” for pet owners, as seen in Figure 3.1.

Figure 3.1: Waste clean up station for pet owners

Image credit: Adobe Stock https://stock.adobe.com/images/dog-waste-station/200605230

b. Properly discard of waste

Another example of a beginner level solution includes properly discarding of yard waste, trash, and construction materials. These were common items found accumulating in the stream during the visual analysis portion of this research. Municipalities generally have information regarding how, when and where to dispose of various kinds of waste. For example, Highland Park has an extensive website regarding their waste and recycling program (Waste and Recycling Information, n.d.). It contains a variety of resources, including a tool called “What Goes where?” Residents can type in the name of an item, directing them where to properly dispose of it.

The accumulation of waste and trash in our waterways is not only visually unappealing but contributes to flooding and excess algae growth (City of Westfield Public Works Department, n.d.). Yard waste, along with inorganic waste like plastics and metals, can overwhelm waterways, clog culverts and storm drains and lead to flooding in our neighborhoods. Grass clippings, leaves and branches are high in nitrogen and phosphorus, acting as a natural fertilizer. When these organic waste items end up in the water, they create algal blooms, depleting the oxygen content in the water and killing aquatic life, ultimately disrupting the water’s ecological habitats.

Figure 3.2: Storm drain leading to local waterways

Image credit: Jillian Dorsey

c. Use more reusable products

One of the most prominent issues seen in the Mill Brook Stream was the accumulation of trash, particularly plastic along the stream and its banks. Consider discontinuing the use of plastic shopping bags for reusable bags instead. The Borough of Highland Park Council passed Ordinance Number 19-1980 “Bring your Own Bag Ordinance” on February 19, 2019 which includes a two-phase implementation beginning in May 2019 (Plastic Bags, n.d.). Shoppers will be charged ten cents for every plastic bag they use and will be provided with complimentary paper bags. Beginning in November 2019, shoppers will be charged 10 cents for paper bags, and plastic bags will no longer be available. According to borough commission, Sustainable Highland Park, it takes approximately 1,000 years for a plastic bag to decompose and only about one percent of all plastic bags used are recycled (Sustainable Highland Park, 2019).

Some other considerations are bringing Tupperware or other reusable containers to restaurants, in order to avoid packing your leftovers in polystyrene, or more commonly known as Styrofoam takeout boxes. Polystyrene, a type of plastic, does not biodegrade in the environment for hundreds of years and resists photo-oxidation, meaning the surface of this material is not broken down by UV rays and oxygen (Bandyopadhyay & Basak, 2013). In addition, animals such as birds often mistake this material for food. The consumption of Styrofoam can be detrimental to wildlife health (Hofer, 2008).

Figure 3.3: Accumulation of trash in the Mill Brook Stream

Image credit: Jillian Dorsey

d. Stop or minimize use of lawn fertilizer

Many resident's do not realize the detrimental effects of improper fertilizer use on our waterways. The main ingredients in lawn fertilizers are nitrogen and phosphorus (Davies, Reed & O'Brien, 2001). Phosphorous is a naturally occurring element in rocks and mineral deposits which is released gradually into the environment, while nitrogen is also naturally present but in soils; both are required for plant growth. Nitrogen is highly soluble and moves quickly in soil, which can cause leaching into groundwater, while phosphorus is slower moving, but can pollute the water if over applied and not integrated with the soil. There are two ways chemicals such as fertilizers enter groundwater. First, is through runoff, and second is leaching, or the downward movement of the substance through the soil. The effects of fertilizer on the water is discussed above, within the passage explaining the importance of properly discarding yard waste.

The results from a study conducted throughout the United States by the University of Florida Center for Landscape Conservation and Ecology showed that many homeowners are not as informed about the fertilizers they use on their lawns as they could be (Khachatryan, Rihn & Dukes, 2014). For example, Twenty percent of homeowners do not know the species of turfgrass their lawn consists of, only 71 percent of participants calculate the amount of fertilizer needed for their yard, 61 percent read the fertilizer labels prior to purchase, and 26 percent of participants conducted soil tests prior to fertilizer use.

There are more natural alternatives to using store-bought fertilizer which will keep the lawn looking lush and attractive. Grasscycling is an easy way to naturally fertilize one's lawn and can reduce the need for other fertilizers by up to 25 percent (The

Lawn Institute, n.d.). Leaving the clippings on the grass after mowing the lawn can provide the soil with the appropriate amount of nitrogen, potassium and phosphorus. A special mower, called a mulching mower can be used for this purpose. This mower can reduce your workload, because you will no longer need to bag grass clippings. It will also prevent these clippings from ending up in landfills and streams. Each decade, the percent of yard waste accounting for total municipal solid waste has decreased, due to homeowner participation in grasscycling.

e. Mow your grass higher and less frequently

Consider mowing your grass less frequently and keeping it at a height of three inches to act as a natural buffer for the stream (3 Rivers Wet Weather, n.d.). In addition to this environmental benefit, lawn better resists drought at this height and requires less fertilizer, taking some burden off the homeowner. If you happen to live adjacent to a stream, it is imperative that the area of grass closest to the stream be left untouched as a strong barrier to stormwater runoff. For example, see the images below which demonstrate a neatly manicured lawn up to the edge of the stream in Figure 3.4, and an untamed area of grass in Figure 3.5.

a. Before

b. After

Figure 3.4: Before and after of a stream buffer.

The top image shows a lawn mowed directly up to the edge of the stream, while the bottom shows a stream with a more protective riparian buffer

Image credit: Jillian Dorsey

3-3: Intermediate-Level Solutions

a. Compost

One way to efficiently get rid of yard waste is to recycle it in a compose bin, which can be homemade or store-bought (Forsell, Hlubik, Weidman, & Winokur, 2003). It is important that yard waste is properly disposed of or recycled, so that it does not end up in our waterways causing flooding and disrupting natural ecosystems. Items that can be composted include vegetable food scraps, grass clippings, leaves, weeds, flowers, chopped twigs and branches, sawdust, wood, ash, and coffee grounds with filters. Items that should not be composted include meat, diseased or insect infested plants, seeds, pet feces, food with grease, or soap residue. Reasons to compost other than reducing yard waste from entering waterways include saving money on fertilizer and mulch, reducing waste in landfills, improving soil fertility and plant health in your yard, and saving time from bagging these materials.

Figure 3.6 below demonstrates the factors that contribute to healthy compost. There are two types of compost; slow harvested compost, made by adding layers of waste over several months, is ready in 12 to 18 months, while fast harvest, made by adding equal parts of green and brown materials at once, is ready in 5 to 15 weeks (Forsell, et. al., 2003). Examples of green and brown materials can be seen in Figure 3.7 below. To be used as mulch, one to three inches should be incorporated into vegetable and flower beds before planting to help kill weeds, keep the roots moist and prevent soil erosion. Compost can also benefit as a soil conditioner or be made into potting mix. In Middlesex County, residents can view demonstration compost bins at Davidson's Mill Pond Park in South Brunswick. Tours or demonstrations may be available.

Figure 3.5: Example of a homemade compost bin

Image credit: Lindsay Halladay, https://njaes.rutgers.edu/fs811/

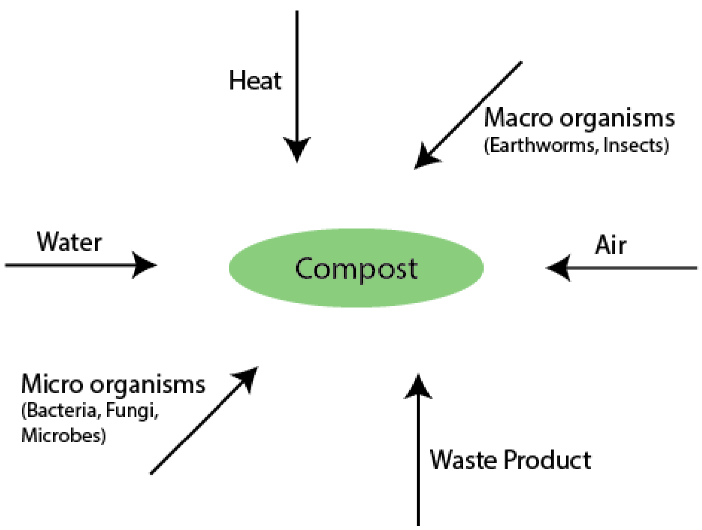


Figure 3.6: Diagram of the biotic and abiotic factors that are components of compost

Image credit: Jillian Dorsey

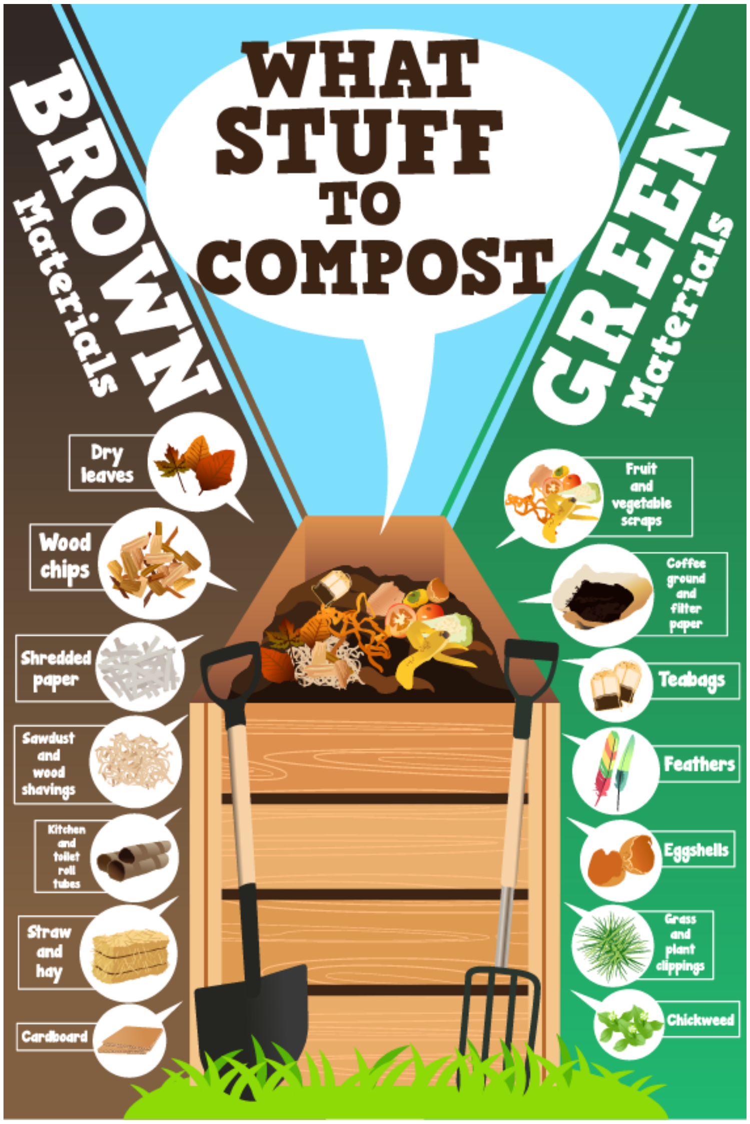


Figure 3.7: Examples of brown and green compost materials

Image credit: Adobe Stock, https://stock.adobe.com/images/what-stuff-to-compost/110770426?prev_url=detail

b. Plant Trees/reduce lawn and replace grass

Typical suburban turf lawns provide little to no ecological value for most animals, pollinators, and other insects. They can even be harmful to animals that eat the grass or pick up seeds and berries that have been contaminated with pesticides. (Talbot, 2016). Although lawn is a better alternative to impervious surfaces such as asphalt and concrete, it still has little biomass compared to larger perennials, shrubs and trees (Missouri Botanical Garden, n.d.). Due to its shallow roots, turf lawn cannot absorb large amounts of water, resulting in stormwater runoff containing pesticides, fertilizers and more. By creating less areas of turf, you are creating less areas to mow, reducing homeowner labor, and eliminating the monoculture created by suburban turf laws. There are specific trees native to the east coast which help with water absorption and can be planted in your yard in an effort to reduce turf (Melendez & Pinto, 2010; Sellmer, Nuss, & Guiser, 2007). Examples of native trees you can plant in your yard which are known for absorbing water and sometimes tolerant of pollution are seen in the planting palette below (Figure 3.8).

Figure 3.8: Planting palette of native tree species appropriate for replacing turf

Image compiled by: Jillian Dorsey

c. Divert or extend your downspout

Diverting your downspout so that the water is not draining directly onto impervious surfaces or into storm drains is a sustainable practice that prevents pollutants from entering waterways. There are different locations that your downspout can be diverted or extended to, such as a rain barrel, a raingarden, or bioswale, all discussed below. First, determine whether a downspout extender or diverter is needed, depending on where the water is being redirected. The following images show what these items look like, and ideas of how to divert or extend your downspout.

Figure 3.9: Downspout diverter
Image credit: Wayfair.com

Figure 3.10: Downspout extender
Image credit: Lowes.com

Figure 3.11: Example of a downspout extended to a rain garden

Image Credit: https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure/important-terms/rain-gardens-bioswales

Figure 3.12: Downspout diverted to a rain barrel

Image credit: Wayfair.com

d. Use a rain barrel

Since most residential property is covered with some impervious surface, one way to reduce runoff is to divert your downspout to a rain barrel (Obropta, 2014). Rain barrels can be hooked up to a hose and used to water your lawn and other plants and shrubs. This is an easy way to save money. Rather than paying to use water from the hose or sink, hundreds of gallons of water can easily be collected each year, for free. The water is safe to use on indoor and outdoor plants, front and backyards, filling a birdbath, or even washing cars. Rain barrels are typically made from 55-gallon food grade plastic drums. Wooden barrels can be used as well, or pre-fabricated rain barrels can be purchased from a retailer. It is important that the barrel is elevated in order to create adequate water pressure. Also, there should always be a screen over the opening to prevent mosquitos from breeding, as well as a mosquito dunk to deter them.

Figure 3.13: A pre-fabricated rain barrel

Image credit: Wayfair.com

3-4: Advanced-Level Solutions

a. Install permeable asphalt and pavers

Most New Jersey homes have a driveway to park their cars. These driveways are often made from the same impervious material: paved asphalt. This allows storm water to pick up pollutants, such as particulates and organic compounds, which ultimately end up in our waterways as runoff. By using a pervious pavement, most of the water will remain where it lands and be infiltrated into the rock and soil layers below. This type of asphalt is an open-graded asphalt course with 14 to 18 percent air voids over an aggregate filter course and an aggregate base reservoir. Since driveways are typically low traffic areas, only two to four inches of the open graded asphalt is needed in application. (Calkins, 2009). An example of a pervious pavement driveway in Figure 3.14 demonstrates how water is absorbed when it hits the surface.

Permeable pavers can also be used to take advantage of the benefits listed above. These hybrid hardscapes are comprised of brick or stone separated by joints, or gaps, where gravel, sand, or a perennial ground cover are laid over aggregate stones (Alliance for the Chesapeake Bay, n.d.). Water can be absorbed into these gaps and is stored underneath the surface, where it can then filter back into the soil. These pavers can be used to create walkways, patios, or driveways. Yearly upkeep is minimal, and less salt is needed during winter months since water no longer collects and freezes on the surface. Figure 3.16 demonstrates each layer of a permeable pavement system.

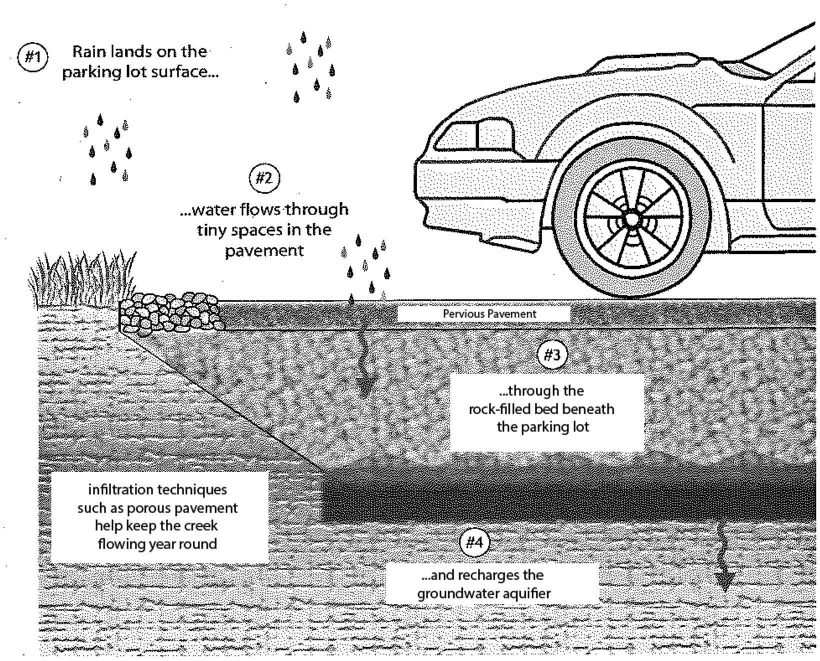


Figure 3.14: Cross section through pervious pavement, demonstrating water infiltration

Image credit: Calkins, 2009, page 225

Figure 3.15: Permeable pavers

Image credit: http://www.stormwater.allianceforthebay.org/take-action/installations/pervious-pavers

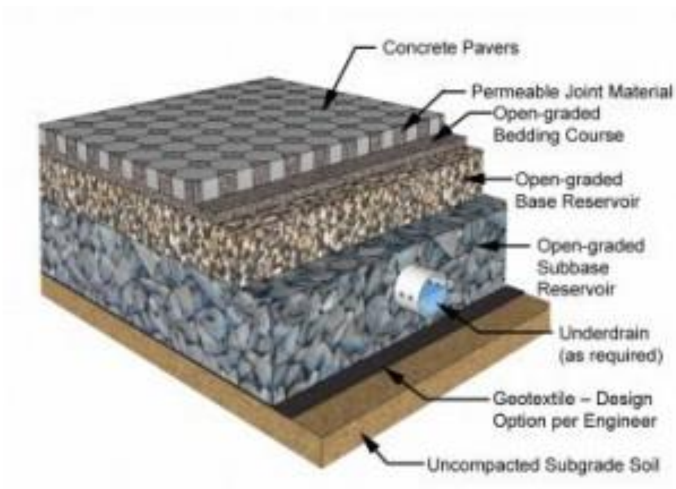


Figure 3.16: Axonometric diagram of permeable paver system

Image credit: http://www.stormwater.allianceforthebay.org/take-action/installations/pervious-pavers

b. Plant rain gardens

The downspout connected to a home can be redirected so that rain is captured in a rain garden. Rain gardens are a beautiful way to help reduce and slow stormwater runoff and prevent erosion by using plants that are highly tolerable to water (Rutgers New Jersey Agricultural Experiment Station, 2017). Typical rain gardens detain storm water allowing approximately 30 percent more water to filter into the ground than regular turf. The plants help remove pollutants as well as mitigate storm water though transpiration. In addition to these benefits, rain gardens are known to attract many species of pollinators such as bumble bees, humming birds, and butterflies. Below are some examples of native plants that can be used in your rain garden (Rain Garden Alliance, 2009):

Figure 3.17: A planting palette of appropriate plants for a rain garden

Image compiled by: Jillian Dorsey

c. Create buffer zones

As discussed in Chapter 1, an expansive and healthy riparian buffer is one of the best protection measures for streams. If your home directly backs a stream, there may only be room for a buffer of 50 feet, but the larger the buffer, the more protection provided to the stream (Connecticut River Joint Commissions INC., 2000). Minimizing the amount of lawn in this expanse is important to protect the stream. The buffer can be thought of in three different zones, as seen in Figure 3.18 below. They are, the streamside, middle, and outer zones. The streamside runs from the water to the top of the bank and should include large shrubs and trees and remain undisturbed for the best protection. The middle zone starts at the top of the bank inland. This area should be planted with trees, shrubs and perennial ground plants in order to protect the water quality and provide habitat. It can be used for minimal recreational use. The outer zone includes the yard, garden or woods between your home and the rest of the riparian buffer. It can be thought of as the first line of defense for the stream and traps initial sediment and pollution. To start creating an adequate buffer in your yard, the Connecticut River Watershed suggests observing the rain flow on your property. Allowing the water to spread out and infiltrate on a flat surface rather than run down a sloped path into the stream all at once is preferred. You can redirect waterflow towards flatter, more permeable areas with stones or landscape timbers, or regrade the land away from the stream if possible.

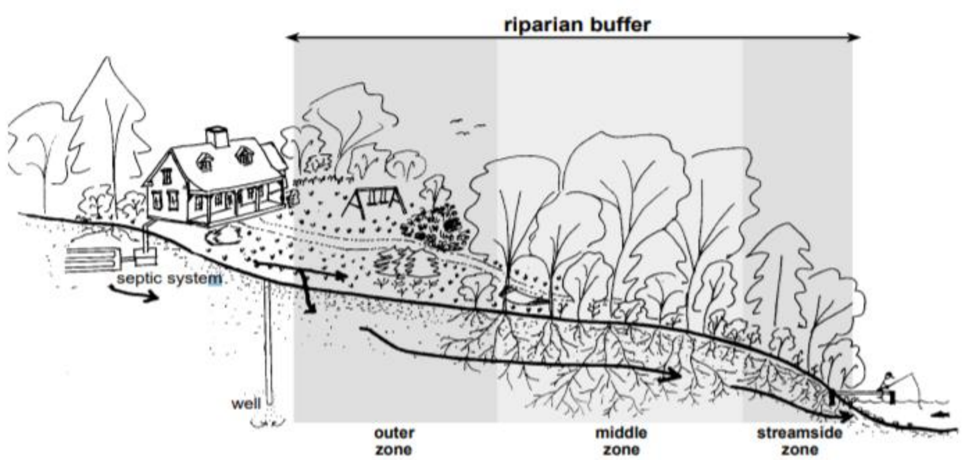


Figure 3.18: Zones of the riparian buffer in a residential yard

Image credit: http://www.crjc.org/buffers/Backyard%20buffers.pdf

d. Build a green roof

A green roof is a unique way to capture storm water but will most likely require the help of professionals. There are two main types of green roofs which can be installed. They are intensive and extensive green roofs. Extensive roofs are more shallow than intensive systems, with soil depths usually less than 6 inches, and are lighter in weight. These systems are more likely to be used for residential purposes on homes, garages, and sheds (Livingroofs Enterprises Ltd., n.d.). The layers of a basic green roof can be seen in Figure 3.19, below. The benefits of a green roof besides stormwater management are the improvement of water quality, the conservation of energy, reduction of temperatures, increased lifespan of the roof, reduction of noise and air pollution, carbon sequestration, and provision of habitat for wildlife. Green roofs can also be aesthetically pleasing and stress reducing for the homeowner and their neighbors (Getter & Rowe, 2006). For expert help, there are companies that specialize in residential green roof installation such as Apex Green Roofs.

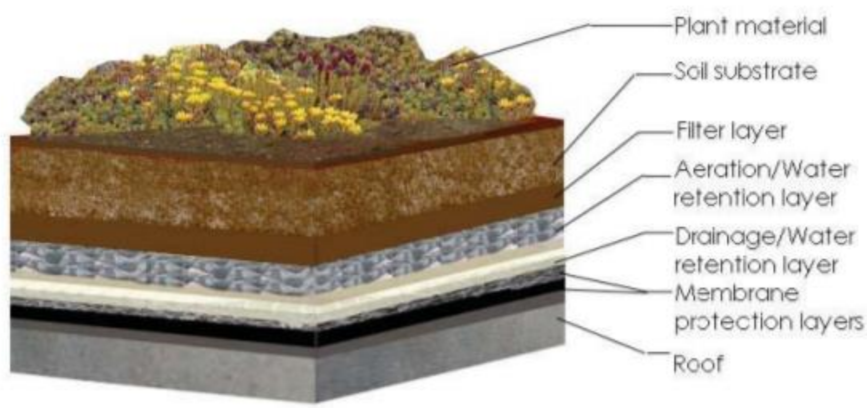


Figure 3.19: Axonometric view of a green roof

Image credit: http://www.nyc.gov/html/ddc/downloads/pdf/cool_green_roof_man.pdf

Figure 3.20: Example of a residential green roof

Image credit: Adobe Stock, https://stock.adobe.com/images/wooden-house-with-extensive-green-living-roof-covered-with-vegetation/190251403?prev_url=detail

e. Install a bioswale

Bioswales are shallow depressions in the soil, typically planted with water tolerant plants which slow and filter storm water (The American Society of Landscape Architects, n.d.). Not only can they decrease stormwater runoff, but they are aesthetically pleasing and provide ecological habitat for many creatures. They can lead into areas such as rain gardens, as mentioned above, or retention/detention basins. Bioswales are often a large-scale project, and it may not be practical for many homeowners to install one due to spatial and logistical constraints. Therefore, the implementation of bioswales can be a community effort lead by homeowner associations and other community groups along with the approval from local government. An example of a successful effort was in Portland, Oregon, where local landscape architect, Kevin Robert Perry, ASLA, designed stormwater curb extensions intended to capture and filter stormwater, preventing it from overwhelming Portland's combined storm/sewage system. Below, is the landscape architect's work, seen in Figure 3.21.

Figure 3.21: A bioswale in a residential neighborhood in Portland, Oregon.

Image credit: https://www.asla.org/bioswales.aspx

3-5: Conclusion

Provided below are a list of resources organized by solution. The links will give supplemental information aimed at guiding residents interested in any of the solutions or projects mentioned in this chapter. With 33 percent of the Lower Raritan Watershed covered by residential land use, it is necessary that all of the watershed's residents begin making strides towards stewardship, no matter the size. Anthropogenic activity impacts waterways in countless ways; whether visible to us or not, a more conscious effort must be made to mitigate the effects humans have had on our precious ecosystems.

Resources:

Beginner Level Solutions:

Sustainable Highland Park:

http://sustainablehighlandpark.org/

What Goes Where?:

http://www.hpboro.com/index.aspx?NID=399

Grasscycling:

https://www.thelawninstitute.org/pages/environment/best-management-practices/mowing-grasscycling/

Intermediate Level Solutions:

Composting:

https://njaes.rutgers.edu/fs811/

Guides to native trees and shrubs:

https://njaes.rutgers.edu/fs1140/

https://extension.psu.edu/trees-shrubs-and-groundcovers-tolerant-of-wet-sites

http://www.missouribotanicalgarden.org/sustainability/sustainability/sustainable-living/at-home/rainscaping-guide/lawn-alternatives.aspx

How to divert your downspout:

https://www.wikihow.com/Redirect-Rainwater-From-a-Downspout

Rain barrels:

https://njaes.rutgers.edu/fs1140/

Advanced Level Solutions:

Rain gardens:

(Rain Garden Manual of New Jersey)
http://water.rutgers.edu/Rain_Gardens/RGWebsite/RainGardenManualofNJ.html

(Rain garden friendly plants)

http://www.raingardenalliance.org/planting/plantlist

Publication on Riverbank Management and Riparian Buffers:

http://www.crjc.org/pubs/riparian-buffers/

Apex Green Roofs:

http://www.apexgreenroofs.com/portfolio-residentialnew

Bioswales

https://www.asla.org/bioswales.aspx

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