2. Executive Summary

2.1. Background

The Neshanic River Watershed is located in Hunterdon County and encompasses Raritan, Delaware and East Amwell Townships and Flemington Borough and is a headwater watershed of the Raritan River Basin in Central New Jersey. The watershed includes Walnut Brook, First, Second and Third Neshanic Rivers, and the Neshanic River main branch. Water quality impairments in Neshanic streams have been a constant subject in various reports and among the watershed management professionals in the region. According to the U.S. Geological Survey (USGS), the Neshanic River is one of the water bodies with the worst overall water quality in the Raritan River Basin (Reiser, 2004). The Neshanic River was listed in the 2008 New Jersey Integrated Water Quality Monitoring and Assessment Report as impaired for aquatic life and nonpoint source pollution (NPS) from bacteria, phosphorus and total suspended solids (NJDEP, 2008). It is generally recognized that agriculture, rapid urban development and wildlife cause water quality contamination in the watershed. In addition to the water quality problems, there is a concern about increasing occurrence of no/low streamflow in the Neshanic River in late summer (Reiser, 2004).

In the Spring of 2005, a group of water resource professionals from various agencies, namely the New Jersey Institute of Technology (NJIT), the New Jersey Water Supply Authority (NJWSA), the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA), the North Jersey Resource Conservation and Development Council (RC&D), the Rutgers Cooperative Extension (RCE), the South Branch Watershed Association (SBWA) and the Hunterdon County Soil Conservation District (HCSCD) assembled to discuss conducting a systematic study of water quality problems and developing a roadmap for restoring water quality in the Neshanic River Watershed. A proposal for a Neshanic River Watershed Restoration Plan was developed after a series of discussions with NJIT as the lead and all other agencies as collaborators. The proposal was submitted to the Clean Water Act Section 319 (h) program administered by the former Division of Watershed Management at the New Jersey Department of Environmental Protection (NJDEP). In 2006, the NJDEP awarded a grant to NJIT and its collaborators (RP06-068) to develop the Neshanic River Watershed Restoration Plan (Plan).

The Plan details the management measures needed to achieve the desired reduction in bacteria and attain water quality standards for total phosphorus (TP) and total suspended solids (TSS), and to reduce aquatic life impairments to a non-impaired level and outline the actions needed to restore the base flow of the Neshanic River. Because a similar effort was conducted in the lower part of the Neshanic River Watershed, including the Back Brook and its drainage area, the Neshanic River Watershed Restoration Plan focuses on the 31 square mile upper part of the Neshanic River Watershed, which includes Walnut Brook, First, Second and Third Neshanic Rivers and the Neshanic River main branch immediately above the Back Brook confluence with the Neshanic River.

2.2. Sources and Root Causes

Water quality and quantity issues in the Neshanic River Watershed are the result of substantial land use changes in the watershed. According to the historical land use data developed and maintained by NJDEP, land use changes in the watershed include increases in urban land uses and decreases in agricultural lands due to rapid suburbanization during the last two decades. The percentage of urban land in the watershed increased from 16.6 percent in 1986 to 25 percent in 1995, and was 31.2 percent in 2002 and 35.1 percent in 2007. The increases in urban land resulted primarily from the loss in agricultural land in the watershed. Agricultural lands in the watershed decreased from 51.4 percent in 1986 to 43 percent in 1995, and rose to 36.4 percent in 2002 and 35 percent in 2007. Other land uses were relatively steady with forest around 20-21 percent, wetlands at 10-11 percent, water at 0.2-0.5 percent and barren at 0.3-1.6 percent.

Land use changes dramatically alter watershed hydrology. As urban land increases, the impervious surfaces, such as rooftops, driveways, additional roads, and parking lots, increase whereas pervious surfaces, such as traditional agricultural lands decrease. Such land use changes usually decrease infiltration and groundwater recharge and increase surface runoff. Urban and suburban development requires additional roads and stormwater infrastructure, such as drainage pipes and ditches. The latter are designed to convey stormwater away from individual properties as quickly as possible. Tile drainage and swale infrastructure in agricultural lands quickly disperse agricultural runoff from agricultural fields. In general, agricultural and urban development lead to flashy watershed hydrology in which high-velocity flowing runoff reaches the streams quickly resulting in stream bank erosion, unstable channel conditions, and further sedimentation of streams and degradation of stream habitat.

Water quality and quantity are affected by not only quantitative changes in land use, but also the nature of the land use changes and where those changes occur on the landscape. Many intensive land uses, such as agriculture and urban development, took place in hydrologically sensitive areas, hydric soils and riparian areas of the streams, which intensifies the water quality and quantity issues in the watershed. Other sources of water quality degradation include: intensive uses of fertilizer and pesticides in agricultural production and lawn management; livestock production, such as cattle and horses; failing on-site wastewater treatment systems, such as on-site sewage disposal systems (OSDSs); animal manure mismanagement; and deposition of excrement of wildlife, such as deer and geese. The SWAT watershed model was used to improve understanding of how various sources of water quality degradation affect water quality in the watershed. SWAT is a continuous, daily time-step, spatially distributed hydrological river basin scale model that simulates water, sediment, nutrient, chemical and bacteria transport in a watershed resulting from the interaction of weather, soil, stream channel, vegetation and crop growth, and land management practices, and calculates various pollutant loads from landscape and point sources (Arnold et al., 1994; Neitsch et al., 2005). SWAT divides a watershed into hydrologic response units (HRUs) that consist of specific land use, soil and slope characteristics that represent spatial heterogeneity in terms of land cover, soil type and slope class within a watershed. The model estimates relevant hydrologic responses, such as evapotranspiration, surface runoff, peak rate of runoff, groundwater flow, sediment and pollutant loads from each HRU to streams due to the changing climate and land use conditions. Based on the SWAT modeling results, the sources and root causes of water quality degradation are discussed in detail for three categories of water pollutants: sediment; nutrients; and pathogens.

2.2.1. Pathogens

Both fecal coliform and *Escheria coli* (E. coli) in water are indicators of pathogen contamination. In general, human and animal wastes are sources of pathogens in Neshanic streams. Failing OSDSs, which are the largest source of pathogens in the watershed, contribute 46 percent of the pathogen loads in the Neshanic streams. The second largest source is manure that is applied to the field for row-crop production, which accounts for 31 percent of the annual load of pathogens in the Neshanic streams. Livestock in the watershed is a significant contributor of pathogens to streams, including animals grazed on pasture and/or animals that enter streams. Livestock account for 19 percent of annual pathogen loads in the watershed, which make it the third largest contributor to pathogen loads. Another minor contributor is wildlife, such as geese and deer.

2.2.2. Nutrients

Nutrients include total nitrogen (TN) and TP. Water quality monitoring efforts by USGS, NJDEP and the project team indicate that TP is a significant source and TN is an insignificant source of water pollution in the watershed. The SWAT assessment shows that 229,119 pounds of TN and 12,282 pounds of TP leave the watershed through streamflow each year. The primary source of nutrients in the Neshanic River Watershed is agricultural land that is used for row-crop production, pasture and hay, accounting for 76 percent of the TN and 60 percent of the TP loads in the watershed. Fertilizers on urban lands are the second largest sources of nutrients, contributing 11 percent of the TN load and 29 percent of the TP load.

2.2.3. Sediment

Sediment in streamflow is measured by TSS. Results of the SWAT model indicate that, each year, streamflow carries 1,715 tons of sediment out of the watershed. Streams are the primary source of sediments and contribute 1,021 tons of sediment per year, which accounts for 60 percent of the total annual sediment load. The source of sediments from the streams is soil eroded from the streambanks and resurfaced from the deposited sediments in the stream bed due to the high energy streamflow. The remaining 40 percent of sediments, roughly 694 tons, come from various land uses in the watershed, including row-crop agriculture (i.e., corn, soybean, wheat and rye production), which accounts for almost 57 percent of the sediment, urban land (27 percent) and other agricultural lands, such as pasture and hay (15 percent).

2.3. **Required Load Reductions**

The NJDEP (2010a) designated the Neshanic River and its tributaries as FW2-NT. According to this designation from the New Jersey Surface Water Quality Standards (NJAC 7:9B) amended January 4, 2010 (42 N.J.R. 68a), the following surface water quality standards are applicable to the pollutants of concern in the Neshanic River and its tributaries:

- *E. coli* shall not exceed a geometric mean of 126 counts per 100 milliliter (mL) or a single sample maximum of 235 counts per 100 mL;

- Fecal coliform shall not exceed a geometric average of 200 counts per 100 mL, nor shall more than 10 percent of the total samples taken during any 30-day period exceed 400 counts per 100 mL;
- TP shall not exceed 0.1 mg/L;
- TSS shall be less than 40 mg/L; and
- TN shall be below 10 mg/L.

For all impaired streams, the U.S. Environmental Protection Agency (EPA) requires the development of Total Maximum Daily Loads (TMDLs) for the pollutants of concern. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

The NJDEP approved and adopted a TMDL for fecal coliform for the Neshanic River, which requires a 87 percent reduction in fecal coliform from medium/high density residential, low density/rural residential, commercial, industrial, mixed urban/other urban, forest, and agricultural lands (NJDEP, 2003). A nutrient TMDL for the Raritan Basin was developed and is still under review by NJDEP. However, the adopted fecal coliform TMDL and the nutrient TMDL are based on the water quality monitoring data at the USGS Reaville Gage Station, and therefore cover only the upper portion of the Neshanic River Watershed. The project team developed its own load reduction targets for the pollutants of concern that enable the streams in the Neshanic River Watershed to meet the water quality standards for their designated uses. This project uses a more robust load duration curve method for setting TMDL targets. A duration curve is a graph representing the percentage of time during which the value of a given parameter (e.g. flow, load) is equaled or exceeded.

The load reduction target for the Neshanic River Watershed is defined as the total pollutant load reductions that are required to satisfy the water quality standards for the non-trout FW2 streams in the watershed as defined by NJDEP. A 10 percent margin of safety (MOS) and less than 10 percent exceedance threshold were adopted to determine the pollutant load reduction targets. The 10 percent MOS indicates the more stringent water quality targets at the 90 percent of the regulatory water quality standards. For example, the TN target is 9 mg/L instead of 10 mg/L when considering the MOS. Given the stochastic nature of water contamination, it is not practical to require the water quality standard to be achieved daily. The less than 10 percent exceedance threshold requires a frequency of violating the water quality standards and their MOS of less than 10 percent.

Three sets of load duration curves were developed for the watershed. Each set contains five load duration curves for TSS, TN, TP, fecal coliform and *E. coli*. The first set of load duration curves is based on observed streamflow and water quality data at the USGS Reaville Gage Station (N1 Station), above which is the upper portion of the watershed. Both TSS and TN satisfy the TMDL water quality goals at the N1 Station. The load reduction targets of 48, 90 and 91 percent for TP, fecal coliform and E. coli, respectively, are required to achieve the specified TMDL goals including MOS and the threshold for the frequency of exceedance at the N1 Station. The second set of load duration curves are based on the streamflow and water quality results simulated by the SWAT watershed model at the N1 station. To satisfy the TMDL requirements, the load reduction targets are 48 percent for TP, 90 percent for fecal coliform and 91 percent for *E. coli*. It is not necessary to reduce TN and TSS at the N1 station. These pollutant load reduction targets are essentially the same as those based on the monitoring data at the same station. Since there is no observed streamflow and water quality data at the watershed outlet, the third set of load duration curves are based on the streamflow and water quality results simulated by the SWAT model. The load reduction targets required to meet the TMDL goals at the watershed outlet are 9 percent for TSS, 49 percent for TP and 89 percent for both fecal coliform and *E. coli*.

2.4. **Management Measures**

Different management measures are recommended to reduce pathogen, nutrients and sediment loads from various sources to the streams and to restore watershed hydrology.

2.4.1. Management Measures to Reduce Pathogenic Loads

The following management measures are recommended to reduce pathogenic loads to the streams:

- OSDS Education and Management – The Plan calls for a comprehensive education campaign on OSDS operation and maintenance, a three-year inspection and certification program, and technical assistance and financial incentive programs to retrofit the failing OSDSs in the watershed.
- Animal Manure Management – In addition to implementing the Criteria and Standards for Animal Waste Management (N.J.A.C. 2:91) adopted by the New Jersey Department of Agriculture (NJDA) in the watershed, the Plan calls for the operation of five small scale regional manure composting and storage facilities and the development and implementation of manure incorporation technology when applying manure as fertilizer in row-crop and hay production.
- Livestock Access Control – The Plan calls for the complete exclusion of livestock from the streams and their immediate riparian areas from pasture and offers technical assistance and financial support as incentives. The exclusion primarily focuses on the streams that pass through pasture and does not apply to temporary stream crossings for livestock.
- Sewer Infrastructure Maintenance in Sewer Service Areas (SSAs) – The Plan calls for periodic assessments of the conditions and capacity of all sewer infrastructures in SSAs and planned updates and/or improvement in the sewer infrastructure in the watershed.
- Wildlife Management – Currently, wildlife is a minor contribution to pathogen contamination in the watershed as compared to other sources. The Plan calls for the active participation in various wildlife management programs implemented at the state and county levels and implementation of various BMPs to disrupt habitats for deer and geese along the streams.
- Detention Basin Retrofitting – The detention basins capture a large amount of stormwater runoff from medium and low density urban development where pathogen sources could exist. There is no existing empirical study indicating how much retrofitting detention basins would reduce pathogen loads. Depending on the final design of the detention basin, a retrofitted detention basin can function like a bio-retention basin or a constructed wetland that removes pathogen loads to the streams.

2.4.2. Management Measures to Reduce Nutrient Loads

The following management measures are recommended to reduce nutrient loads to the streams:

- Integrated Crop Nutrient Management – The amount of fertilizers applied to crops should be based on reasonable crop yield goals and available nutrients in soils as determined by soil testing. Technical assistance for soil test-based integrated crop management (ICM) should be offered to farmers in the watershed.
- Conservation Buffers – Conservation buffers are planned vegetative mixtures of trees, shrubs and grasses placed in landscapes to influence ecological processes and enhance ecosystem goods and services. There are many types of conservation buffers, such as contour buffer strips, field borders, grassed waterways, filter strips and riparian forest buffers. Optimal placement of buffers in the watershed is essential for maximizing their efficiency in reducing nutrient loads.
- Cover Crop – Cover crops are grasses, legumes, forbs or other herbaceous plants established for seasonal cover and other conservation purposes. Cover crops reduce soil erosion, help maintain soil moisture and improve nutrient and organic content of soils. Other potential benefits of cover crops include decreased farm operation costs, reduced tillage, less herbicide use and better overall soil health. Farmers should be offered technical assistance and financial incentives to encourage the use of cover crops on fields that are not farmed for all or part of a year.
- Manure Management – Cropland should not be used as a dumping ground for animal manure. Manure application should be rotated among numerous fields to avoid concentrating manure in a limited area based on an ICM plan or nutrient management plan. To protect water resources and promote crop growth and soil health, manure should be tested for nutrient content and applied according to crop needs.
- Prescribed Grazing – Prescribed grazing is a system that helps agricultural producers to manage grazing and browsing of animals to ensure adequate ground cover and proper livestock nutrition. A prescribed grazing plan can include reducing the number of livestock in a given pasture, more frequent rotation of livestock across pastures, and using temporary fencing to exclude livestock from pastures recovering from past grazing activity. Prescribed grazing helps to maintain healthy and productive pastures. Healthy pastures protect soil from erosion and the resultant phosphorus and fecal runoff. In addition, an actively growing pasture takes up more nutrients, improves water infiltration and reduces runoff and NPS.
- Nutrient Management for Lawn Care – The newly enacted Fertilizer Control Law establishes standards for certain fertilizer applications, requires certification of professional fertilizer applicators and regulates labeling and sale of certain fertilizers. As with agricultural fertilizer application, lawn fertilizer application rates should be based on soil testing in order to promote healthy lawns and reduce nutrient loads to streams.

2.4.3. Management Measures to Reduce Sediment Loads

The following management measures are recommended to reduce sediment loads to the streams:

- Contour Farming – Contour farming uses ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hill slope. Contour farming reduces sediment from gully erosion, surface water runoff, and the transport of phosphorus and other contaminants to streams.
- Conservation Buffers – Conservation buffers have multiple water quality benefits and reduce both sediments and nutrient loads to streams. As runoff flows through a conservation buffer, dense vegetation in the buffer acts as a filter, blocking sediments and sediment-absorbed nutrients, pesticides and pathogens and preventing them from entering streams. To maximize their efficiency in improving water quality, conservation buffers should be placed in the optimal locations in a watershed.
- Livestock Access Control – Livestock access control not only reduces the pathogen loads into streams, but also eliminates livestock disturbances to streambanks and maintains streambank stability. A stable streambank results in less soil erosion and, therefore, less TSS load to the streams in the watershed.
- Cover Crop – Cover crops reduce soil erosion, help maintain soil moisture and improve soil nutrients and organic content. Farmers should be offered technical assistance and financial incentives to encourage the use of cover crops on fields that farmed for all or part of a year.
- Prescribed Grazing – Prescribed grazing helps to maintain healthy and productive pastures. Healthy pastures have lower soil erosion rates, lower phosphorus and fecal matter in runoff, greater absorption of nutrients, and higher water infiltration.
- Roadside Ditch Retrofitting – The roadside ditches in the watershed are actively eroding, thus adding sediment to stormwater that flows through them. Roadside ditch retrofitting can transform ditches into bio-retention systems that are very similar to constructed wetlands.
- Streambank stabilization – Streambank erosion contributes significantly to TSS in streams in this watershed. Streambank stabilization is effective in reducing streambank erosion, improving water quality and enhancing stream ecology. Although streambanks can be temporarily stabilized through various streambank stabilization measures, permanent stabilization can only be achieved by controlling the amount and velocity of stormwater runoff in the watershed. Stabilizing streambanks requires prohibiting any land use activities that disturb the streambank.

2.4.4. Management Measures to Restore Watershed Hydrology and Streamflow

Land use changes and associated stormwater infrastructure have significantly altered the hydrology of the Neshanic River Watershed. Watershed restoration should mitigate the negative impacts of land use changes on watershed hydrology. The following management measures are proposed to restore watershed hydrology and streamflow and improve water quality in the Neshanic River Watershed.

- Bio-retention Systems – Traditional stormwater infrastructure is designed to quickly deliver stormwater from the sources to the streams. Bio-retention systems are BMPs that are designed to retain the stormwater first and then discharge it to the stormwater systems and/or the stream if necessary. These systems are designed to treat the retained stormwater to achieve substantial water quality benefits through various biological processes embedded in the system. The stormwater retained in those systems could also be infiltrated though the soils to recharge groundwater, thus reducing the amount of stormwater entering streams. Bio-retention systems should include a series of bio-retention facilities that are maintained under different situations and include rain gardens in residential and commercial properties and along the roadsides.
- Conservation buffers – Conservation buffers provide both water quantity and quality benefits. They achieve runoff reduction through evapotranspiration by plants and promote groundwater recharge through multiple biological and hydrological processes.
- Conservation Planning and Ordinances – Land use changes, especially suburban development, substantially alter watershed hydrology and cause many water quality problems in the Neshanic River Watershed. As suburban development continues in the watershed, conservation planning and ordinances should be reviewed, developed, implemented, and enforced to alleviate harmful land use activities and protect the water resources in the watershed.
- Farmland and Open Space Preservation – All municipalities in the watershed have active farmland and open space preservation programs. These programs were originally established as urban sprawl control measures to protect important natural and cultural resources from development, retain the amenities of traditional rural communities and improve environmental quality including water quality. Municipal farmland and open space preservation programs in the watershed should continue to be used and expanded to protect critical source areas (CSAs) from intensive land use activities and disturbances and prevent water resources from being degraded at their sources.

2.5. **Recommended Projects**

Table 2.1 summarizes the scope and cost of the BMP projects recommended for achieving the water quality goals established for the watershed. There are eight types of agricultural BMP projects, four types of stormwater BMP projects and two types of OSDS BMP projects. The first column lists the recommended BMPs for various projects. The second column gives the amount of applicable area, length or units to which the BMP could be applied. The third column is the unit application cost of BMPs including installation, maintenance and other costs estimated by the project team based on the best available sources and experiences of implementing those BMPs in the watershed and surrounding regions. The fourth column is the life span for each BMP, which is used to calculate the annual costs of BMP projects. The second to last column is the total cost of the recommended BMP project when it is applied to all applicable units in the watershed, which equals the product of the applicable unit and the unit cost. The last column is the annualized cost, which the total cost divided simply by the life span. The total cost for implementing the eight types of agricultural BMP projects is about $9.5 million of which more than half is for conservation buffers on agricultural lands. The total cost of all stormwater BMP projects is estimated at $39.4 million. Retrofitting roadside swales and ditches in the watershed accounts for half of the total cost of stormwater BMPs. The total cost of establishing the comprehensive OSDS inspection and maintenance programs and eliminating the failing OSDSs in the watershed is $7.6 million. Implementing all recommended BMP projects is expected to achieve and even exceed the load reduction targets for TP, sediment and pathogens as specified in Section 2.3 and restore the watershed hydrology in the Neshanic River Watershed. Total implementation cost is estimated to be $56.5 million.

Table 2.1: Recommended BMP projects for the Neshanic River Watershed

Types of BMP Project	Applicable Unit	Unit Cost ($/unit)	Life span (years)	Total Cost ($)	Annualized Cost ($/year)
1. Cover Crop	4,011 acres	315	3	1,263,180	421,060
2. Prescribed Grazing	892 acres	444	5	396,226	79,245
3. Livestock Access Control	24,663 feet	11.54	10	284,512	28,451
4. Contour Farming	1,846 acres	117	3	215,267	71,756
5. Nutrient Management	9,645 acres	117	3	891,548	297,183
6. Conservation Buffers on Agricultural Lands	988 acres	6,027	15	5,955,005	397,000
7. Regional Animal Waste Storage and composting Structure	5 units	90,000	10	450,000	45,000
8. Manure Application Incorporation Technology	330 acres	156	1	51,480	51,480
A. Subtotal for Agricultural BMP Projects (1-8)				*$9,507,219*	*$1,391,175*
9. Rain Gardens	3,545 units	4,150	15	14,711,750	980,783
10. Roadside Ditch Retrofitting	853 units	23,500	15	20,045,500	1,336,367
11. Detention Basin Retrofitting	153 units	29,500	15	4,513,500	300,900
12. Vegetative Buffers on Developed Lands	27,603 feet	4.84	15	133,657	8,910
B. Subtotal for Stormwater BMP Projects (9-12)				*$39,404,407*	*$2,626,960*
13. OSDS Inspection and Maintenance	1,490 units	600	3	894,000	298,000
14. Failed OSDSs Retrofitting	447 units	15,000	15	6,705,000	447,000
C. Subtotal for OSDS BMP Projects (13-16)				*$7,599,000*	*$633,250*
D. Total (A + B + C)				*$56,510,626*	*$4,763,136*

Although all BMP projects are recommended, they differ in terms of their cost and effectiveness in reducing pollutant loads. Table 2.2 summarizes the priority ranks of all BMP projects according to their cost-effectiveness of BMPs in reducing TP, sediment and pathogen in the Neshanic River Watershed. Cost-effectiveness measures the average reduction in the loading of pollutant achieved by a BMP per dollar spent on implementing that BMP. It equals the annual pollutant load reduction divided by the annual cost of full implementation of the BMP project in the watershed. For example, spending $1,000 on cover crops would reduce TP by 1.86 pounds and spending $1,000 on livestock access control would reduce TP by 32.08 pounds. The BMP with the highest cost-effectiveness has a priority rank of one, which means it should be implemented first. The top five ranked BMPs for reducing TP loads in order of ranking are livestock access control, nutrient management, conservation buffers in agricultural lands, contour farming and prescribed grazing. The top five ranked BMPs for reducing sediment in order of ranking are vegetative buffers in developed lands, livestock access control, contour farming, conservation buffers in agricultural lands and detention basin retrofitting. The top five ranked BMPs for reducing pathogen loads to the streams in order of ranking are livestock access control, livestock waste storage and composting structures, OSDS inspection and maintenance, manure application incorporation technology, and failed OSDS retrofitting.

Table 2.2: Priority ranks for all BMP projects in the Neshanic River Watershed

Type of BMP Project		Priority Rank in Reducing		
		TP	Sediment	Pathogen
1	Cover Crop	8	7	
2	Prescribed Grazing	5	6	6
3	Livestock Access Control	1	2	1
4	Contour Farming	4	3	
5	Nutrient Management	2		9
6	Conservation Buffers in Agricultural Lands	3	4	10
7	Livestock Waste Storage and Composting Structure	12		2
8	Manure Application Incorporation Technology	11		4
9	Rain Garden	10	9	
10	Road Ditches	9	8	11
11	Detention Basin Retrofitting	7	5	7
12	Vegetative Buffers in Developed Lands	6	1	8
13	OSDS Inspection and Maintenance	13		3
14	Failed OSDS Retrofitting	14		5

Note: A shaded area indicates that the impact of the BMP on the reduction of the pollutant is insignificant.

2.6. Implementation Schedule

Although 14 types of BMP projects are recommended, it is not necessary to implement all BMPs on all applicable lands or at applicable facilities in order to achieve the pollutant reduction targets in the Neshanic River Watershed. There are some practical limits on implementing BMP projects at their applicable units in full scale. Natural resource conditions may restrict the kinds of BMPs that can be implemented on applicable lands. For various reasons, some farmers or landowners may resist implementation of any BMPs on their lands. For example, cover crop is applicable on all 4,011 acres of row-crop fields in the watershed, but it is not realistic to expect all farmers in the watershed to use cover crop on their cropland. An implementation plan should balance the physical restrictions related to natural resource conditions, stakeholders' willingness and ability to act, and financial feasibility. The implementation plan details the types of BMPs being selected for implementation and the scope of how much or how many of the selected BMPs will be implemented in the watershed in terms of implementation acreage and the number of retrofitted stormwater infrastructure that achieve the required pollutant load reduction targets. Table 2.3 presents the implementation targets for all of the recommended BMP projects. Targets are described in terms of the percentage and physical dimensions of the applicable units for the BMP projects (implementation goal) and the amount or reduction achieved (reduction goal). They are based on the cost-effectiveness of those BMPs, the feasibility of implementation and the pollutant reduction requirements. The expected annual load reductions for the implementation plan are 6,632 pounds of TP and 324 tons of sediment, which is sufficient to achieve a 49 percent reduction in TP and greater than 9 percent of reduction in TSS. The expected cost of the implementation plan is $14.6 million. Of this amount, 52 percent is for inspecting and maintaining OSDSs and retrofitting the failing OSDSs in the watershed and 20 percent is for installing conservation buffers on 494 acres of agricultural lands.

Table 2.3: Implementation targets for the recommended BMP projects in the Neshanic River Watershed

Types of BMP Projects		Implementation Goal		Reduction Goal		Implementation Costs	
		%	Unit	TP (lbs)	Sed. (tons)	$	%
1	Cover Crop	50	2,006 acres	392	40	631,590	4.3
2	Prescribed Grazing	50	446 acres	190	8	198,113	1.4
3	Livestock Access Control	100	24,663 feet	913	52	284,512	2.0
4	Contour Farming	75	1,385 acres	380	55	161,451	1.1
5	Nutrient Management	75	5,734 acres	2,608		668,661	4.6
6	Conservation Buffers in Agricultural Lands	50	494 acres	1,850	125	2,977,503	20.5
7	Livestock Waste Storage and Composting Structure	100	5 units			450,000	3.1
8	Manure Application Incorporation Technology	75	248 acres			38,610	0.3
9	Rain Garden	1	35 units			147,118	1.0
10	Road Ditches	1	9 units	2		200,455	1.4
11	Detention Basin Retrofitting	25	39 units	277	35	1,135,750	7.8
12	Vegetative Buffers on Developed Lands	50	13,802 feet	19	10	66,828	0.5
13	OSDS Inspection and Maintenance	100	1,490 units			894,000	6.1
14	Failed OSDS Retrofitting	100	447 units			6,705,000	46.1
Total				6,632	324	$14,559,591	100.0

The estimated reduction in TP is on the conservative side for several reasons. First, almost all BMP projects for reducing pathogen loads also reduce TP loads, but the reductions from some BMPs are difficult to quantify and are not included in the calculation. Second, the implementation of the newly enacted Fertilizer Control Law and the municipal low-phosphorus ordinances for lawn care should substantially reduce TP loads from the urban lands that contribute 28 percent of TP loads to the streams in the watershed. Third, targeting the application of BMP projects in the critical pollution source areas should reduce pollutant loads much more than the average reduction rates used in this estimation in Table 2.3. The quantification of pathogen load reduction is difficult. It is expected that the required 89 percent reduction in pathogen (both fecal coliform and *E. coli*) can be achieved by eliminating the failing OSDSs, improving manure application and completely excluding livestock access to streams in the watershed.

The implementation plan also considers how the BMP projects are implemented in the watershed over space and time. The implementation plan is discussed in terms of a 10-year planning horizon. Table 2.4 presents the implementation schedule within 2, 5 and 10 years in terms of the percentage of the applicable unit and the application unit for each BMP.

In addition to allocating the BMP projects across different timeframes, another important aspect of the implementation plan is the best place in the watershed to implement the BMP projects. In order to maximize the pollutant load reduction potential, especially during the first few years of implementation, BMP projects should be implemented in the high priority areas identified in the project.

Table 2.4: BMP implementation schedule in the Neshanic River Watershed

Types of BMP Projects		In 2 Years		In 5 Years		In 10 Years	
		%	Unit	%	Unit	%	Unit
1	Cover Crop	10	401 acres	25	1,003 acres	50	2,006 acres
2	Prescribed Grazing	10	89 acres	25	223 acres	50	446 acres
3	Livestock Access Control	25	6,166 feet	50	12,332 feet	100	24,663 feet
4	Contour Farming	25	462 acres	50	923 acres	75	1,385 acres
5	Nutrient Management	25	1,911 acres	50	3,823 acres	75	5,734 acres
6	Conservation Buffers in Agricultural Lands	10	99 acres	25	247 acres	50	494 acres
7	Livestock Waste Storage and Composting Structure	20	1 unit	60	3 units	100	5 units
8	Manure Application Incorporation Technology	25	83 acres	50	165 acres	75	248 acres
9	Rain Garden	0.1	4 units	0.5	18 units	1	35 units
10	Road Ditches	0.1	1 unit	0.5	4 units	1	9 units
11	Detention Basin Retrofitting	5	8 units	15	23 units	25	39 units
12	Vegetative Buffers in Developed Lands	10	2,760 feet	25	6,901 feet	50	13,802 feet
13	OSDS Inspection and Maintenance	25	373 units	100	1,490 units	100	1,490 units
14	Failed OSDS Retrofitting	25	112 units	50	224 units	100	447 units

The assumption of a 10-year planning horizon does not mean it takes 10 years to achieve the required pollutant load reduction targets. Depending on funding availability and the stakeholders' willingness to act, many recommended BMPs can be implemented at a much faster pace. However, attaining the required pollutant load reduction targets does not guarantee the restoration of water quality and biological integrity of the streams in the watershed because it takes time for reductions in pollutant loads to affect water quality.

2.7. **Measurable Milestones**

During the first two years after the Plan is adopted, the four municipalities in the watershed should:

- Educate the residents, farmers, and businesses on the water quality status of the Neshanic River and responsible stewardship in land use and management;
- Where applicable, establish concrete steps for implementing the New Jersey State Rules for improving water quality and/or preventing water quality from continuous deterioration. These rules includes New Jersey Pollutant Discharge Elimination System Stormwater Regulation Program rules (N.J.A.C. 7:14A), the Stormwater Management Rules (N.J.A.C. 7:8), the Flood Hazard Area Control Act rules (N.J.A.C. 7:13), the Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A), the Criteria and Standards for Animal Waste Management(N.J.A.C. 2:91), and the newly enacted Fertilizer Control Law for commercial and residential lawn care and management.
- Refine their open space and farmland preservation plan for protecting hydrologically sensitive areas from future development.
- Develop the municipal ordinance for OSDS inspection, maintenance and operation that requires a 3-year certification program.
- Work with federal, state, county governmental agencies, universities, non-governmental and non-profit agencies and local environmental consulting firms to apply for and secure the necessary funding and technical assistance and begin implementation of the proposed BMP projects in the watershed.

The implementation of the BMP projects for the first two years as indicated in Table 2.4 are estimated to cost $3.4 million and achieve the following milestones toward the pollutant reduction goals and the attainment of water quality standards:

- Prevent further deterioration in water quality and watershed hydrology;
- Reduce annual TP load by 1,770 pounds, which is close to 30 percent of the required annual load reduction for TP;
- Reduce annual sediment load by 75 tons, which is equivalent to 50 percent of the required annual load reduction for sediment; and
- Reduce annual load of pathogens by 5 percent.

Implementation of the BMP projects during the first five years as indicated in Table 2.4 are estimated to cost $8 million and achieve the following milestones toward the pollutant reduction goals and the attainment of the water quality standards:

- Improve water quality and watershed hydrology;
- Reduce annual TP load by 3,800 pounds, which is equivalent to 60 percent of the required annual load reduction in TP;
- Reduce annual sediment load by 175 tons, which exceeds the required annual load reduction for sediment; and
- Reduce annual load of pathogens by 60 percent.

The completion of the 10-year implementation of the BMP projects as indicated in Table 2.4 is estimated to cost $14.6 million and achieve the following milestones toward the pollutant reduction goals and the attainments of the water quality standards:

- Improve the water quality and restore watershed hydrology;
- Reduce annual TP load by 6,000 pounds, which exceeds the required annual load reduction in TP and attains the water quality standard for TP;
- Reduce annual sediment load by 324 tons, which exceeds the required annual load reduction for sediment and achieves the water quality standard for TSS;
- Achieve an 89 percent annual load reduction for pathogens and attain the water quality standard for pathogens.

2.8. **Funding and Technical Assistance**

As indicated in Table 2.3, the total cost for achieving implementation targets is about $14.5 million. That cost can be broken down into three components: (1) outreach and technical assistance costs for reaching out to stakeholders and designing BMP implementation plans, and obtaining the necessary permits to install the BMPs; (2) BMP installation costs for related materials, labor, equipment and other items; and (3) BMP maintenance costs that ensure proper operation of BMPs. Of the $14.6 million of implementation costs, $1.5 million is for outreach and technical assistance, $10.9 is for installation and $2.2 million is for maintenance.

The funding available for BMP implementation depends on the types of BMPs and the nature of the costs. USDA NRCS and Farm Service Agency (FSA) support installation of agricultural BMPs (1-8) through outreach, technical assistance and cost-sharing of installation costs. There are no consistent funding sources for implementing stormwater BMPs and no public funding sources available to support the OSDS inspection and maintenance and retrofitting because OSDSs are generally viewed as private properties.

The funding and technical assistance for the implementation plan are based on the following recommendations. First, all maintenance costs for installed BMPs should be the responsibility of stakeholders. For example, homeowners should pay for the maintenance cost for installed rain gardens. Local homeowners associations should be responsible for maintaining retrofitted detention basins in their neighborhoods. Residents should be responsible for operating their own OSDSs. Second, 50 percent of the outreach and technical assistance and installation costs for agricultural BMPs (1-8) should be secured through traditional Farm Bill programs, such as the Conservation Reserve Enhancement Program (CREP), Environmental Quality Incentive Program (EQIP) and Wildlife Habitat Incentive Program (WHIP). Third, to jump start the comprehensive OSDS certification and maintenance program and completely eliminate water pollution from the failing OSDSs, the implementation plan should consider funding the OSDS inspection and cost-share the retrofitting cost for failing OSDSs in the watershed.

Table 2.5 summarizes the potential sources of funding for implementation of BMP projects. Stakeholders, such as farmers and residents, could pay $5.4 million of the total implementation costs. Of this amount, 50 percent is for retrofitting failing OSDSs and OSDS inspection and maintenance. The remaining stakeholders' costs are for the time and labor required for maintenance of installed BMPs. The USDA could contribute $2.25 million for agricultural BMPs. An additional $7 million is needed from other sources, of which $6.1 million is for BMP installation and $0.88 million is for outreach and technical assistance.

Table 2.5: Potential sources of funding for implementation of BMP projects

	Types of BMP Projects	Total Cost	Stake-holders	USDA	Other Sources	
					BMP Inst.	Tec. As.
1	Cover Crop	631,590	0	315,795	299,622	16,173
2	Prescribed Grazing	198,113	0	99,057	71,182	27,875
3	Livestock Access Control	284,512	49,326	117,593	70,733	46,860
4	Contour Farming	161,451	0	80,725	62,303	18,423
5	Nutrient Management	668,661	0	334,330	258,031	76,299
6	Conservation Buffers in Agricultural Lands	2,977,503	617,500	1,180,001	751,868	428,133
7	Livestock Waste Storage and Composting Structure	450,000	250,000	100,000	100,000	
8	Manure Application Incorporation Technology	38,610	0	19,305	19,305	
9	Rain Garden	147,118	53,175		58,493	35,450
10	Road Ditches	200,455	63,975		110,890	25,590
11	Detention Basin Retrofitting	1,135,750	288,750		654,500	192,500
12	Vegetative Buffers in Developed Lands	66,828	10,896		45,036	10,896
13	OSDS Inspection and Maintenance	894,000	670,500		223,500	
14	Failed OSDS Retrofitting	6,705,000	3,352,500		3,352,500	
Total		14,559,591	5,356,622	2,246,807	6,077,962	878,200

Other sources of funding for BMP projects include:

- NJDEP: the Clean Water Act 319(h) Nonpoint Source Pollution Control Grants program;
- U.S. Fish and Wildlife Service: the Partners for Fish and Wildlife program and the Bring Back the Natives; and
- U.S. EPA: Five Star Restoration Challenge Grants.

In addition to the standard funding that could be provided by the above agencies, there are alternative funding sources that can be developed for watershed restoration, such as the stormwater mitigation fund implemented in Raritan Township, the stormwater utility and water quality trading being implemented in many other communities in the U.S., and the low-interest or no-interest loan or subsidy for OSDS retrofitting patterned after the New Jersey Clean Energy program.

2.9. **Criteria and Monitoring Program**

Two criteria can be used to evaluate whether watershed restoration is successful. The first criterion relates to changes in land use management practices. This criterion evaluates whether: (1) the proposed BMP projects are implemented in the watershed; (2) stakeholders are more aware of the impacts of their land use and management decisions; and (3) stakeholders continue to practice environmentally friendly BMPs after initial BMP funding ends. The second criterion relates to the outcomes observed in streams and their riparian areas. This criterion evaluates whether such things as: (1) water quality and biological conditions in streams improve over time; and (2) stream channels become stabilized.

Based on these two criteria, a monitoring program can be used to determine the success of watershed restoration efforts. Such a program would involve the following elements:

- Establish a database to document the BMPs being implemented in different locations of the watershed and estimate their water quality impacts using quantitative models and tools, such as Spreadsheet Tool for Estimating Pollutant Load (STEPL) model;
- Continue the comprehensive streamflow, water quality and biological monitoring program at the USGS Reaville Gage Station in the watershed and compare the newly obtained water quality monitoring data to the previous data to determine whether water quality improves;
- Continue the long-term biological monitoring in four biological monitoring stations in the watershed to determine long-term changes in biological conditions in the Neshanic streams; and
- Use volunteers to periodically conduct stream visual assessment using SVAP to assess physical changes in the streams and their riparian zones.

2.10. **Education**

The success of any watershed restoration plan depends on the stakeholders' understanding of the water quality problems in the watershed, and their willingness and ability to take action to solve those problems. Education is the key to enhancing stakeholders' understanding and their willingness and ability to take action. It can take many different forms, such as public media, formal workshops and active participation in community programs offered by various agencies. Examples of such programs are:

- River-Friendly Programs
- Rain Garden Program
- Sustainable Jersey™
- Detention Basin Retrofits
- Agriculture Mini-Grant Program
- Soil Testing Program
- Nonpoint Education for Municipal Officials (NEMO)
- Greening of Department of Public Works (DPWs)

The ultimate goal of education is to improve stakeholders' awareness and promote behavior changes that are beneficial in achieving watershed restoration.