A REGIONAL STORMWATER MANAGEMENT PLAN FOR THE PLEASANT RUN AND HOLLAND BROOK WATERSHEDS READINGTON TOWNSHIP, HUNTERDON COUNTY, NJ

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TABLE OF CONTENTS

PLEASANT RUN AND HOLLAND BROOK WATERSHEDS REGIONAL STORMWATER MANAGEMENT PLAN

EXECUTIVE SUMMARY –

The following report represents the culmination of an extensively detailed analysis of the factors responsible for stormwater related impacts to the Pleasant Run and Holland Brook ecosystems. Pleasant Run and Holland Brook are tributaries of the South Branch Raritan River. The watersheds of both stream systems are adjacent to each other and encompass parts of three municipalities (Clinton Township, Readington Township, and Branchburg Township). The Pleasant Run Watershed encompasses approximately 6,919 acres (10.8 square miles), while the Holland Brook watershed encompasses a total of approximately 7,966 acres (12.4 square miles). Thus, the combined Pleasant Run/Holland Brook (PR/HB) Watershed study area comprises approximately 14,884 acres (23.3 square miles).

This study, which was commissioned by Readington Township, the project's Lead Planning Agency (LPA), was implemented due to concern regarding the existing state of these two streams and the importance of these streams to the health and well-being of the residents of Readington Township. The goal of this project, as stated in the proposal submitted to the NJDEP for 319 funding consideration, was the preparation of a regional stormwater management plan (RSWMP) for both streams for the purpose of correcting past stormwater impacts and averting future stormwater perturbations. While they are in themselves recognized as important lentic ecosystems, Pleasant Run and Holland Brook are additionally important given that they are two of the major tributaries of the South Branch Raritan River, a source of drinking water for residents of central New Jersey. Additionally both streams provide a wide array of passive and recreational opportunities for the residents of the Township. It has been recognized for some time that the water quality and overall ecology of both streams were being impacted by inadequately managed stormwater runoff. The data and information compiled in the Pleasant Run and Holland Brook Characterization and Assessment (Milestone 4 Report) element of the RSWMP clearly documented a variety of impacts including elevated pathogen concentrations, elevated nutrient concentrations, impaired macroinvertebrate communities, and extensive occurrences of stream bank erosion. Pleasant Run is designated on the NJDEP 303(d) 2004 List of Impaired Waters as impaired for general aquatic life (macroinvertebrates) and recreational uses (elevated pathogens). Holland Brook is designated on the NJDEP 303(d) 2004 List of Impaired Waters as impaired for general aquatic life (macroinvertebrates). Overall, Holland Brook exhibited more impacts than Pleasant Run. The majority of the problems affecting both streams can be traced to improperly managed stormwater runoff originating from both agricultural and residentially developed areas.

Owing to the nature of the documented stormwater problems, to improve the water quality and ecological functions of both streams it is imperative that runoff be managed in the future using a regionally-scoped approach. A RSWMP provides the best means by which this can be accomplished. With the development and implementation of the RSWMP it will be possible to address NJDEP's NPS Category of Pollution 1000, 1050, 1350, 1410, 1420, 2100, 2200, 3200,

4500, 4600, 7100, 7550, all of which are a function of land clearing, agricultural activities and residential development.

Due to the magnitude and widespread nature of stormwater related problems, it was concluded, as based on the data developed over the course of this project, that the restorative and mitigative work needed for both streams must encompass the following:

1. Stabilization of eroded stream channels;
2. Control of the influx of pollutants, including pathogens using stormwater management solutions that correct, replace and/or retrofit the existing stormwater management infrastructure;
3. Implementation of stormwater recharge practices at new development and existing sites to help moderate base flows, decrease storm surges and flooding, and lessen the opportunity for streambed and bank scouring;
4. Improvements in stormwater infrastructure to correct localized stormwater flooding problems;
5. Improvements in runoff management from agriculture and livestock farms located within the watershed to reduce pathogen loading and erosion;
6. Control and subsequent elimination of exotic invasive species within the riparian areas of the streams and their tributaries, and where possible and practical the replacement of these invasive species with native vegetation; and
7. Decrease in the frequency and magnitude of algae blooms occurring in the streams as well as in ponds and impoundments draining to these streams.

Within this RSWMP specific Best Management Practices (BMPs) are identified. These include practices and measures intended not only to better control and treat stormwater runoff, but practices and measures intended to raise public awareness. Many of the stormwater management improvements and related BMPs identified and discussed in the RSWMP report reflect recommendations previously made in Master Plan reports and the municipal stormwater plan.

Based on the water quality and use impairments identified above and detailed in this report, the BMPs needed for Pleasant Run and Holland Brook and their watersheds must encompass both proactive as well as restorative measures.

In terms of the former, this means strong planning and protective measures that prevent or ameliorate the watershed's potential future impairment problems, whether these are due to nutrients, sediments, pathogens, or flooding. This is best achieved through source control measures; the regulatory requirements and performance and design standards mandated by ordinances and regulations. These are the keystone to the long-term success of the RSWMP. In fact, the lack of sufficient source control measures is the direct cause for the majority of the problems that currently impact the streams and their watersheds. A well developed RSWMP is inherent to creating the regulatory framework that the stakeholders and users need for the implementation of source control measures.

In terms of stream and watershed restoration initiatives, well designed and properly located BMP measures are needed to remediate scoured and eroded streams segments caused by past watershed-wide development and agriculture practices. To be truly successful and result in sustainable improvements and/or protections, the implementation of these BMPs must proceed following a well orchestrated manner. This again is only possible within the framework of a RSWMP. Without a regionalized approach to the management of stormwater it will be difficult to mitigate the impacts created now and in the future by inadequately controlled or treated stormwater runoff. The systematic biorestoration of these streams begins with improved public education, the protection of remaining riparian buffers, restoration of damaged stream corridors, and the implementation of stormwater BMPs and stormwater retrofits.

Hand in hand with any proactive management and remedial stormwater management are the actions needed to restore stream segments damaged by improperly managed stormwater runoff. The bed and bank load of sediment resulting from the erosion of the main stem and feeder streams of both Pleasant Run and Holland Brook represents a significant amount of the sediment load transported to the South Branch Raritan River. Correction of these problems is ultimately linked to BMPs that can decrease the volume of runoff. Again, the implementation of the measures needed to properly control runoff, facilitate stormwater recharge and systematically restore damaged stream segments is best accomplished within the framework of a RSWMP due to the integrated nature of the required restoration and mitigation projects.

It should be stressed that although the RSWMP identifies specific project sites, these are by far not the only locations where stormwater management related work is needed. In addition, although the Characterization and Assessment Report and Milestone 4 Report detailed the causes, impacts and proposed remedies for the existing state of stormwater management, more detailed studies will be required in the future to further identify or design the needed BMP solutions. As such, although the RSWMP as presented herein and detailed in past milestone project reports, the restoration of Pleasant Run and Holland Brook and their watersheds is a constantly evolving process. Again, the RSWMP will provide the legal framework needed to support the future management and restoration of the watershed. Without such a framework in place neither the stakeholders nor the NJDEP will be successful in meeting the watershed's TMDL or in achieving the goals of the Clean Water Act of making these watersheds consistently swimmable and fishable. But even more important, the RSWMP is critical to the achieving the vision of the LPA and all the local stakeholders of once again elevating these streams to their rightful stature and ecological balance.

1.0 INTRODUCTION / DESCRIPTION OF THE STUDY AREA

1.1 Regional Importance of the Pleasant Run and Holland Brook Watershed

The Pleasant Run and Holland Brook Watersheds encompass parts of three municipalities. The headwaters and much of the main stem of the Pleasant Run and Holland Brook Watersheds are located in Clinton and Readington Townships, Hunterdon County. The downstream portions of both streams and their confluence with the South Branch of the Raritan River are located in Branchburg Township, Somerset County. The Pleasant Run watershed covers approximately 6,919 acres (10.8 square miles), while the Holland Brook watershed includes a total of approximately 7,966 acres (12.4 square miles). Thus, the entire Pleasant Run/Holland Brook (PR/HB) Watershed study area comprises approximately 14,884 acres (23.3 square miles) as a whole.[1] These watersheds are located within Watershed Management Area (WMA) 8 of the Raritan River. An aerial photograph depicting the municipal boundaries of the PR/HB Watershed is provided in Appendix A (Map A).

Readington Township in Hunterdon County includes the headwaters of both streams and comprises most of the watershed (11,249 acres, or over 75%), while Branchburg Township in Somerset County contains the streams' confluences with the South Branch Raritan River and makes up just over 23% of the total watershed area (3,485 acres). The remaining municipality, Clinton Township, lies at the northeastern tip of the watershed and comprises only about 1% of the total watershed area (150 acres), the majority of which is forest (63%) and farmland (32%). (Because of its relatively insignificant watershed area, Clinton Township's involvement in the RSWMP planning process was minimal.) Table 1 describes the breakdown of the PR/HB Watershed by municipality.

Table 1.1 Municipalities Within The PR/HB Watershed

Municipality	County	Acres within the PR/HB Watershed	Percentage of total watershed area
Readington Township	Hunterdon	11,249	76%
Branchburg Township	Somerset	3,485	23%
Clinton Township	Hunterdon	150	1%
TOTAL WATERSHED	**--**	**14,884**	**100%**

[1] Note: the narrative text and data tables within this report include acreages, pollutant load estimates and other data that have been rounded to the nearest 0.01, 0.1 or whole number. Rounding has been utilized to clearly illustrate a variety of data comparisons and simplify the reporting of detailed calculations and data summaries. Minor discrepancies in data totals and percentages are an unavoidable result of this rounding process but do not affect the validity of the results and conclusions reported. Copies of the comprehensive GIS database and detailed spreadsheets related to data calculations discussed herein are also available for review.

The Mapping and Data tables from the Pleasant Run and Holland Brook Watersheds Characterization Report are provided in Appendix A and B.

The Pleasant Run and Holland Brook watersheds can be best characterized as a rural community dominated by 39% low density residential houses and limited commercial properties, 28% agriculture uses, 27% forest, and 6% wetlands.

Table 1.2: PR/HB Watershed Land Use and Land Cover (NJDEP GIS data 2002)

Land Use / Land Cover Designation	Area in Acres	Percent of Total
Agriculture	4,095.80	28%
Barren Land	127.80	1%
Forest	3,946.50	27%
Urban	5,870.30	39%
Water	14.30	0%
Wetlands	829.70	6%
Total Acres	14,884.40	100%

The total area of the PR/HB Watershed is approximately 14,885 acres. Based on the typical precipitation of 49.3 inches annually as recorded in Flemington, the total precipitation for the Pleasant Run/Holland Brook watershed is 75,000,000 cubic meters annually. Ground water recharge and stormwater runoff are affected by topography, soil hydrology characteristics, and land use and land cover. Groundwater recharge was calculated using GSR-32, which was estimated to be approximately 16,000,000 cubic meters for these watersheds. Stormwater runoff was calculated utilizing the Rational Method that estimate that up to 55,000,000 cubic meters of total precipitation are discharged as surface runoff from this watershed.

1.2 Pleasant Run and Holland Brook Watershed Stakeholders and Project History

Readington Township recognized that existing development and nonpoint source (NPS) pollution in the Pleasant Run and Holland Brook watershed was degrading water quality and eroded stream beds and banks. Readington Township applied for and was awarded a grant through NJDEP's 319(h) Nonpoint Source Pollution Control and Management program in 2004 to develop a Regional Stormwater Management Plan (RSWMP) for the Pleasant Run and Holland Brook Watersheds. The two watersheds are separate, but share parallel geographic, political and land cover characteristics, and the decision was made to consider them as a single, unified study area and to create the RSWMP that would address the entire area as a whole (referred to herein as the "PR/HB Watershed").

The purpose of the grant was to develop a RSWMP to obtain additional data needed to properly guide NPS management and mitigation measures, and to address the regional water quality problems affecting Pleasant Run and Holland Brook, through the implementation of watershed-based management and mitigation measures. With the development of a comprehensive RSWMP, it will be possible to more effectively reduce the influx of pathogens, nutrients, control sedimentation and erosion in the watershed's tributary streams, and other stormwater-related pollutants throughout the Pleasant Run and Holland Brook Watershed.

Readington Township is the grantee and was also the appointed Lead Planning Agency (LPA) for the RSWMP development process. Consistent with guidance in NJAC 7:8-3.2(b), in September 2004, Readington invited 26 municipalities, agencies and other organizations with an interest in the watershed, to participate in the Pleasant Run and Holland Brook Watersheds RSWMP Committee Table 1.3.

Table 1.3: List of Active RSWMP Committee Members and Public Participants

Name	Affiliation
Julia Allen	Readington Township, Township Committee
Cheryl Filler	Readington Township, Planning Board, Environmental Commission
Marygrace Flynn	Readington Township Planning Board
Jim Hutzelman	Readington Township
H. Clay McEldowney	Readington Township Engineer
Kathy Tilton	Raritan-Lebanon Sewerage Authority
Chris Erd	Branchburg Environmental Commission
Doug Pollock	Branchburg Environmental Commission
Dave Gromach	Clinton Township Environmental Commission
Joseph S. Kosinski	Clinton Township Engineer
Caroline Armstrong	Hunterdon County Planning Board
Ed Kopp	Hunterdon County Engineering
Tadgh Rainey	Hunterdon County Health Department
Chris Testa	Hunterdon County Soil Conservation District
Paul McCall	Somerset County Planning Department
Julie Potter	Somerset County Planning Division
Amy Shallcross	New Jersey Water Supply Authority
Bob Colburn	North and South Branch Raritan Watershed Management Area
Bill Kibler	South Branch Watershed Association
Jim Hess	Regional Planning Partnership

A follow-up memo was sent on October 11 to representatives of nine municipalities, agencies and other organizations who failed to respond to the initial invitation. A third letter (with a summary of the September 21 kickoff meeting) was sent on November 1, and a follow-up certified mailing was sent on February 22, 2005 to the remaining five entities which did not respond to any of the initial three invitations. Readington Township continued to encourage broad participation in the RSWMPC, and representatives participated from the Branchburg and Clinton Township Environmental Commissions, Hunterdon and Somerset County, the New Jersey Water Supply Authority, the South Branch Watershed Association, and the Regional Planning Partnership. The list of participants is summarized in Table 1.3. Included in Appendix C is the extensive the list of participants who were repeatedly invited to participate in the RSWMP process. A Regional Stormwater Management Plan Committee (RSWMPC) was formally recognized by NJDEP, Division of Watershed Management (the Division) in February 2005.

The NJDEP guidance for the creation of a RSWMP includes several "milestones":

- Milestone 1 included the formation and submission for recognition by the NJDEP of the Regional Stormwater Management Plan Committee (RSWMPC), which was approved by the NJDEP in February 2005.
- Milestone 2 included the NJDEP approval of a Characterization and Assessment of the Pleasant Run and Holland Brook Watershed submitted in March 2006 to the NJDEP. The Characterization and Assessment summarized relevant data to characterize the watershed and the study streams, including the initial results of the pollutant loading analyses, hydrologic analyses, and water quality and biological monitoring.
- Milestone 3, the drainage area-specific water quality, groundwater recharge and water quantity objectives were accepted by the Regional Stormwater Management Plan Committee in December 2007.
- Milestone 4A, the Regulatory Standards for the Pleasant Run and Holland Brook Watershed Regional Stormwater Management Plan were accepted by the Regional Stormwater Management Plan Committee in November 2007.
- Milestone 4B, the Voluntary Measures for the Pleasant Run and Holland Brook Watershed Regional Stormwater Management Plan were accepted by the Regional Stormwater Management Plan Committee in November 2007.
- The Milestone 4A and 4B submissions were subsequently approved with comments by the NJDEP in June 2008.

Milestone 5: Submission of the Completed RSWMP

Milestone 6: Revisions to the RSWMP pending receipt of NJDEP comments on the Milestone 5 report.

Milestone 7: Proposal of the RSWMP Amendment to the Areawide WQMP is dependent on the NJDEP and is outside of the scope of this project.

With the submission of this report and its recommendations Milestones 1-5 are completed in full.

1.3 Authority of Regional Stormwater Management Plan (RSWMP)

In accordance with the stormwater regulations (N.J.A.C. 7:8-3.4 to 3.6) a Regional Stormwater Management Plan must assess the study area and prepare drainage area specific objectives and performance standards for water quality, groundwater recharge and water quantity. The RSWMP must also select stormwater management measures and strategies for their implementation, identify schedules, responsible partners, cost estimates and methods to evaluate the effectiveness of the RSWMP strategies (N.J.A.C. 7:8-3.7 and 3.8).

Once a RSWMP is approved by the NJDEP, and adopted as an amendment to the area wide Water Quality Management Plan Rules (N.J.A.C. 7:15), in accordance with N.J.A.C. 7:8-3.9 and 3.10 the Department, as well as the local municipal planning boards, will rely upon the adopted RSWMP when reviewing stormwater management aspects of development projects or related activities. The Department would utilize the RSWMP as part of any stormwater review conducted under the following regulatory analysis: coastal permitting, freshwater wetlands, CAFRA, stream encroachment, NJPDES, and Dam Safety. The Residential Site Improvement Standards (N.J.A.C. 5:21-7) also acknowledge that all future residential developments must conform to a RSWMP approved by the Department. As such, for the Pleasant Run and Holland Brook municipalities, the RSWMP would serve as the primary review tool, establishing the required performance and design standards utilized by the local planning boards as part of any development review occurring within the boundaries of the Pleasant Run and Holland Brook watershed.

Guidance concerning the WQMP amendment procedure as it applies to a regional stormwater management plan is discussed in Section 7.0 and outlined within the WQMP Rules (N.J.A.C. 7:15-3.4 and 7:15-3.4(b)5i-iv). Upon approval by the NJDEP, each municipality within the regional stormwater management study area would be required to amend their stormwater management plans and ordinances to incorporate the applicable provisions from the RSWMP. In May 2008, the Department adopted amendments to the WQMP rules which require each County to assume the role of the WQMP Designated Planning Agency (DPA) to create and adopt amendments to the County WQMPs. Highlights regarding the authorities and recommendations of the proposed Pleasant Run and Holland Brook RWSMP are outlined below:

- Recommendations and Design Criteria and Performance Standards outlined in a RSWMP will be legally mandatory, and would supersede the Municipal Stormwater Management Plans and Ordinances that have recently been adopted by the watershed communities.
- Similar to a Watershed Protection Plan, the RSWMP outlines certain recommendations that can be implemented on a voluntary basis and communities can consider implementing these measures at their own pace, and as funding is available
- The RSMWP is primarily focused on new construction; however, recommendations are provided that address concerns from existing development and agricultural practices, and potential re-development projects. Redevelopment related projects are important in the combined study watershed given the intersection of the study area by major county and state roadways, COAH (Commission for Affordable Housing) related issues, recent patterns of land use, and the prevailing economic environment.
- The NJDEP should ensure that implementation of these recommendations and access to funding opportunities for the recommendations incorporated in this RSWMP are not

delayed or lost due to the protracted adoption process of the RSWMP as an amendment to the County WQMP.

1.4 Other Relevant Regulatory Programs

During the preparation of the Pleasant Run and Holland Brook RSWMP, each municipality was required to also comply with the NJDEP stormwater regulations and develop and submit individual Municipal Stormwater Management Plans and Ordinances in accordance with N.J.A.C. 7:8. In addition, the Department adopted or proposed significant changes to various regulatory programs in order to protect and enhance water resources. For example, the NJDEP adopted amendments to the Water Quality Management Plans N.J.A.C. 7:15 (May 2008) and the Flood Hazard regulations N.J.A.C. 7:13 (Nov 2007). These regulations and amendments have been reviewed and incorporated as appropriate within the Pleasant Run and Holland Brook RSWMP recommendations to address water resources concerns and better manage the subwatersheds. For example, the Flood Hazard Rules established a riparian zone of 50 feet for all freshwater streams throughout New Jersey.

In addition, each municipality within the regional study area has been actively involved in updating their Master Plans, ordinances and zoning amendments; pursued open space and preservation; and has engaged in the planning efforts of the NJ Department of Community Affairs (DCA). Some of these plans and ordinances provide recommendations and strategies beyond the NJDEP stormwater basic requirements and guidance for best management practices. These actions have also been reviewed and incorporated as appropriate within the RSWMP recommendations to address water resources concerns in the Pleasant Run and Holland Brook subwatersheds.

2.0 NJDEP WATER RESOURCE DESIGNATIONS

Pleasant Run and Holland Brook are tributaries of the South Branch of the Raritan River. The two streams flow from their headwaters in Readington and Clinton Townships (Hunterdon County) southeast through a mix of farms, forested areas and small residential communities, to their confluences with the South Branch in Branchburg (Somerset County) near the border of Hillsborough Township. Both streams are comparable in length, at a total of 21.58 miles (113,977 linear feet) for Pleasant Run and 24.87 miles (131,309 linear feet) for Holland Brook. The HUC 14 watershed unit designation for Pleasant Run is 02030105040020 and that of Holland Brook is 02030105040030. Both streams lie within NJ's Watershed Management Area (WMA) 8 for the Raritan River.

Both Pleasant Run and Holland Brook are characterized by incised stream channels, turbid conditions and loss of canopy cover within the riparian zone. Both streams receive runoff from a combination of agricultural, residential and commercial development sources. Biological assessment data collected by NJDEP indicates that the water quality of both streams is deficient for aquatic life, as designated in the 2006 iteration of the NJ Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2006). However, little data exists regarding specific chemical or bacterial water quality parameters on either stream.

2.1 Streams and Surface Water Classification

Pleasant Run and Holland Brook, together with their tributary streams, are classified as "FW2-NT" waters under NJ's State Surface Water Quality Standards (SWQS), N.J.A.C. 7:9B (NJDEP, 2006). This designation means that PR/HB Watershed streams have a general surface water classification of freshwater (FW2. The "Non-Trout" (NT) designation under the SWQS means that these streams have been determined to be unable to support "trout production" or "trout maintenance." Neither stream has been designated "Category One," the highest level of water quality protection under State regulations. Thus, the Pleasant Run and Holland Brook are regulated as FW2-NT streams under the existing SWQS.

2.2 AMNET Biological Data

The NJDEP biological assessment data indicates that the water quality of both Pleasant Run and Holland Brook is deficient for aquatic life as measured at the downstream AMNET stations in Branchburg (NJDEP, 2004). However, biological data collected at the upstream AMNET stations in Readington indicates no aquatic life impairment (NJDEP, 2004). This disparity suggests that pollutant concentrations within the stream increase as it flows downstream through the residential and agricultural developments that characterize much of the downstream portions of the watershed. A map showing the locations of the NJDEP AMNET biological sampling stations and the four biological sampling stations monitored by Princeton Hydro as part of the project are depicted on Map F, Appendix A.

The NJDEP reports AMNET sampling results for three stations on both Pleasant Run and Holland Brook and the confluences with the South Branch of the Raritan River. In addition, Princeton Hydro monitored macroinvertebrates at two stations on each stream, at an upstream and downstream location. These data are summarized in Table 2.1

For Pleasant Run, the overall trends of the NJDEP AMNET results indicate that the stream is generally not impaired for macroinvertebrates, and the station near the confluence with the South Branch of the Raritan River was also not impaired. However, Princeton Hydro collected macroinvertebrate data, and the sample station PH #3 indicated that the upstream headwater of Pleasant Run was moderately impaired in June 2005.

For Holland Brook, the overall macroinvertebrate results are varied. The NJDEP AMNET results for Station AN0342 indicate the upstream segment of Holland Brook was not impaired from 1994 to 2004. However, the Princeton Hydro station #4 just upstream of this point indicated macroinvertebrate impairments here in June 2005. The NJDEP AMNET results for the Station AN0343 in Branchburg indicate that the downstream segment of Holland Brook was moderately impaired in 1999 and 2004. In addition, the Raritan River Station at AN0341 near the stream confluence indicates that the River was moderately impaired for macroinvertebrates in 2004.

Table 2.1 : Macroinvertebrate AMNET Data

Site ID	Water Body	Location	Municipality	1994	1999	2004
PH St 3	Pleasant Run	Pleasant Run Rd	Readington			MODERATE*
AN0339	Pleasant Run	Pleasant Run Rd	Readington	MODERATE	NONE	NONE
PH St 2	Pleasant Run	Pleasant Run Rd	Readington			NONE*
AN0340	Pleasant Run	So Branch Rd	Branchburg	NONE	MODERATE	NONE
AN0338	Raritan R S Br	Elm St	Hillsborough	NONE	NONE	NONE
PH St 4	Holland Brook	Holland Bk Rd	Readington			MODERATE*
AN0342	Holland Brook	Holland Bk Rd	Readington	NONE	NONE	NONE+
PH St 1	Holland Brook	Holland Bk Rd	Readington			NONE*
AN0343	Holland Brook	So Branch Rd	Branchburg	NONE	MODERATE	MODERATE
AN0341	Raritan R S Br	Studdiford Dr	Branchburg	MODERATE	NONE	MODERATE

Macroinvertebrate AMNET Data reported by the NJDEP for the Raritan River, Round 1 (1994), Round 2 (1999), and Round 3 Data (2004).

* Macroinvertebrate results reported NJDEP were for the 2004 timeframe, and Princeton Hydro collected samples in June 2005. MODERATE refers to a Moderate Impairment for macroinvertebrate diversity
+ NJDEP reported the 2004 data utilizing the new High Gradient Benthic Index (HGMI) and reported station AN0342, an upstream station as an "Excellent" macroinvertebrate community

It should be noted that starting with the 2008 Integrated Report, the Department now uses three new biological indices based upon genus level taxonomy. Specifically a High Gradient

Macroinvertebrate Index (HGMI) is applied to streams of northern ecoregions where assessment results are based on the newly developed metrics are available, they will override those based upon family level metrics when assessing aquatic life use attainment of the entire assessment unit.

The NJDEP Integrated Report concludes that the Statewide AMNET data does show a correlation between benthic macroinvertebrate community impairments and different physiographic land types, land uses and other anthropogenic factors. The NJDEP reports that Statewide, an increase in impervious surfaces was related to a negative response in the aquatic invertebrate community. Conversely, the same data analysis also demonstrated that the more forests and wetlands in a stream's drainage basin, the more protection there is for the macroinvertebrate community health. The NJDEP provided the following general conclusions based on recent statewide data analysis:
http://www.state.nj.us/dep/wms/bwqsa/draft_2008_integrated_report.pdf

1) Fish and invertebrate communities were commonly impaired in urban streams;
2) Invertebrate community impairment was related to developed urban land and wastewater flow upstream of a site;
3) Changes in aquatic community structure were statistically related to environmental variables.

2.3 Fish Index of Biotic Integrity for the Raritan River

In the summer 2000 the NJDEP began to use a Fish Index of Biotic Integrity (FIBI) to measure the health of stream-based fish communities and fish habitat, as well as multiple attributes such as fish species type, abundance, fish tolerance to stress, and the presence of diseases. The NJDEP Fish Index of Biotic Integrity Monitoring Network sample locations for the years 2000 to 2005 are available on the NJDEP GIS data layers. Each site sampled is scored based on its deviation from reference conditions (i.e., what would be found in a non-impacted stream) and classified as "poor", "fair", "good" or "excellent". The NJDEP fish biotic indices for Pleasant Run and the South Branch of the Raritan River indicate an improvement from Fair to Good occurred in recent years. The results for the NJDEP Fish Index of Biotic Integrity are summarized in Table 2.2 below. http://www.state.nj.us/dep/wms/bfbm/downloads.html#top

Table 2.2: NJDEP Fish Index of Biotic Integrity (FIBI)

Station	Stream	Round 1	Round 2 (2005)
FIBI018- Stanton Station (upstream)	So Branch Raritan River	Fair	Good
FIBI017 –Locust Rd	Pleasant Run	Fair	Good
FIBI 0192– Hillcrest Rd	Holland Brook	Fair	
FIBI031 – Rte 28 (downstream)	So Branch Raritan River	Good	

2.4 Water Quality Analytical Data

The NJDEP Draft Integrated Water Quality Report for 2008 reported that, of the statewide streams assessed for general aquatic life (benthic macroinvertebrates) only 27% were listed as not impaired, and 73% were impaired. Of the waterways assessed for trout aquatic life only 25% supported trout. Over 70% of the water bodies assessed for drinking water supply use attained this designation. Approximately 30% of the water bodies statewide assessed for recreational use (swimming or wading) were suitable for this use. The top fifteen (15) pollutants detected in New Jersey waters causing statewide impairments were identified as mercury, PCBs, arsenic, phosphorous, DDx (pesticide), dissolved oxygen, pH, pathogens, chlordane (pesticide), temperature, dioxin (pesticide), and total suspended soils (TSS).

Some existing water quality data is available through the NJDEP (NJDEP 2008). For Holland Brook (AN0342) the data show acceptable (attaining NJ SWQS) levels for phosphorus, temperature, dissolved oxygen, pH, nitrate, total dissolved solids, total suspended solids and unionized ammonia in 2004 (Table 2.3). For Pleasant Run, the data include reported elevated fecal coliform/ E coli (i.e., fecal coliform) levels (Table 2.3).

Pathogens (bacteria) are generally associated with wastewater and fecal matter and can affect public health by causing various infections of the intestine or ear/nose /throat. The USEPA and NJDEP sets State Water Quality Standards (SWQS) for recreational use of waters (swimming or wading) based on levels of pathogens to minimize the public health risks. Previously the NJDEP SWQS for safe recreational use was based on fecal coliform levels of less than 200 CFU/100ml. Based on guidance from the USEPA, the NJDEP modified the SWQS reference from fecal coliform to referencing E coli bacteria. The E coli standard is more representative of the bacteria that can cause health issues for humans. The current NJDEP SWQS for recreational use is based on E coli levels less than the geometric mean of 126 CFU/100ml or a single maximum level of 235 CFU/100ml.

Table 2.3: NJDEP Water Quality Results

Stream	HUC 14	Results	Data Source
Pleasant Brook	02030105040020-01	Fecal coliform /E coli Not Attaining Recreational Use > SWQS of 200/ 100 ml E coli	NJDEP 2008 Integrated Report – 303(d) List of Impaired Waters -high ranking
Holland Brook	02030105040030-01	Station AN0342 Attaining NJ SWQS levels for phosphorus, temperature, dissolved oxygen, pH, nitrate, total dissolved solids, total suspended solids and unionized ammonia	NJDEP 2004 Integrated Report (AN0342)

As part of this report, bacteria monitoring was conducted in the summer of 2005 and elevated concentrations of fecal coliform were detected in both streams as noted in the summary Table 2.4. Overall the fecal coliform levels in both Pleasant Run and Holland Brook generally exceeded the former fecal coliform SWSQ during most of the monitoring events in 2005. During storm events the fecal coliform levels in both streams significantly exceeded the SWQS of 200 CFU/100ml. During base flow events (or dry days) Pleasant Run exceeded the pathogen standard during 50% of the monitoring events. During base flow events the upstream segment of Holland Brook exceeded the SWQS during 25% of the sampling events. However, downstream stream segment of Holland Brook exceeded the SWQS during 50% of the sampling events. Based on the 2005 data, pathogens are impairing water quality and recreational uses of these streams. Pathogens levels in waterways may be attributed to improperly treated wastewater, failing septic systems, pet waste, livestock, wildlife (deer), and/or geese.

Table 2.4 PR/HB Stream Water Quality Data for Fecal Coliform, 2005

2005 fecal coliform concentrations	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
Pleasant Run								
ST-3	540	>1600	130	240	>1600	130	140	1600
ST-2	130	>1600	540	240	1600	110	220	>1600
Holland Brook								
ST-4	170	>1600	350	170	>1600	540	130	540
ST-1	240	1600	1600	350	1600	110	33	920

NOTE: Blue columns indicate sampling conducted during a storm event as defined in project QAPP.
Former NJDEP SWQS for fecal coliform was < 200 CFU/100 ml

2.5 Total Maximum Daily Load (TMDL) for the South Branch of the Raritan River

The NJDEP has not established TMDLs for either Pleasant Run or Holland Brook. The NJDEP has designated the entire length of the South Branch of the Raritan River as pathogen impaired (fecal coliform), and has established TMDL for pathogen (fecal coliform) reduction along the entire length of the South Branch of the Raritan River (Table 2.5A and 2.5B, Exhibit 2.6). Pollutants in runoff from both Pleasant Run and Holland Brook are suspected to contribute to the pathogen exceedances reported for the South Branch of the Raritan River.

Table 2.5A – NJDEP Stream Impairments in the Pleasant Run and Holland Brook Watershed
Draft New Jersey Integrated Water Quality Monitoring and Assessment Report, 2008

Waterbody	Aquatic Life	Trout	Recrea-tion	Drinking Water Supply	Agricultural Water Supply	Fish Consump	TMDL
Pleasant Run 02030105040020-01	**Sublist 5**	**NA**	**Sublist 5**	**Sublist 2**	**Sublist 2**	**Sublist 3**	**NO**
Hollow Brook 02030105040030-01	**Sublist 5**	**NA**	**Sublist 3**	**Sublist 2**	**Sublist 2**	**Sublist 3**	**NO**

Sublist 5: Non Attainment - Impaired
Sublist 3: Insufficient Data
Sublist 2: Indicates full attainment but other designated uses are not assessed.

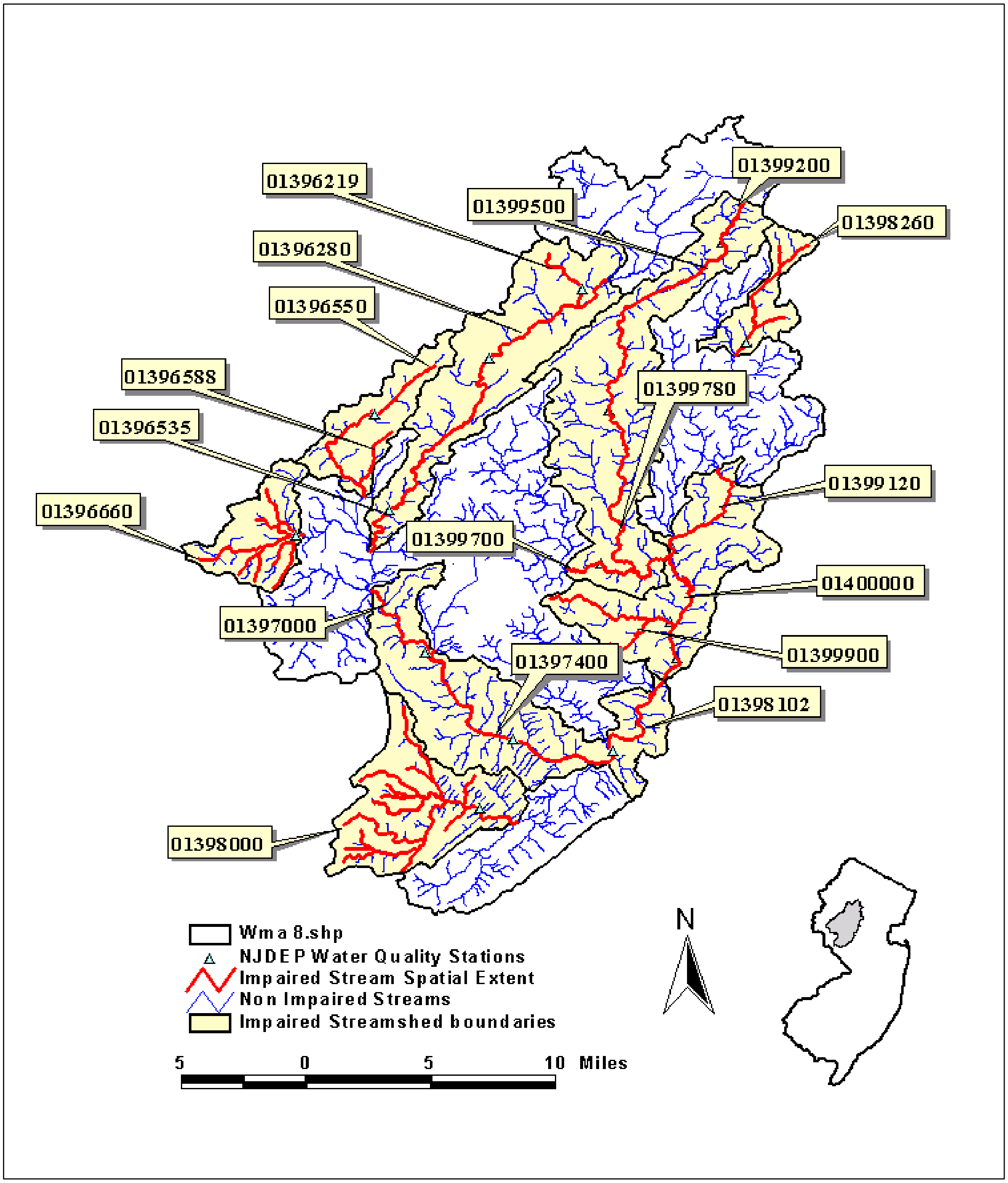
Table 2.5B – NJDEP Stream Impairments in the Pleasant Run and Holland Brook Watershed
Draft New Jersey Integrated Water Quality Monitoring and Assessment Report,2004 and 2008

Pleasant Run HUC 14 02030105040020					
2004	Fecal Coliform	E.Coli	Phosphorus	Biological	Cause Unknown
2008					
		Sublist 5			Sublist 5

Holland Brook HUC 14 02030105040030					
2004	Fecal Coliform	E. Coli	Phosphorus	Biological	Cause Unknown
2008					
		Sublist 3			Sublist 5

Sublist 5: Non Attainment - Impaired
Sublist 3: Insufficient Data
Sublist 2: Indicates full attainment but other designated uses are not assessed.

Exhibit 2.6: NJDEP Designated Impaired Stream Segments and TMDLs in the South Branch and North Branch of the Raritan River, NJDEP
2003http://www.nj.gov/dep/watershedmgt/DOCS/TMDL/june2006/Raritan%20FC.pdf



3.0 PLEASANT RUN AND HOLLAND BROOK CHARACTERIZATION AND ASSESSMENT

The data and information presented in Section 3 of this RSWMP report have been presented in the past to the NJDEP as part of the approved Characterization and Assessment report (Milestone 3 Report). This included a detailed assessment of both the socioeconomic and environmental attributes of the Pleasant Run and Holland Brook watersheds. The water quality and pollutant modeling data quantified existing water quality problems of both streams and served largely as the basis for the actions and recommendations set forth in this RSWMP.

3.1 Demographics

Hunterdon County as a whole grew in population by over 20% between 1990 and 2004 (from 107,776 to 129,746 people), while Somerset County grew by almost 32% (from 240,279 to 316,750) during the same time period. When compared to the rate of growth in the state as a whole during this time period—less than 13%—it is clear that the western-central region of the state in which the PR/HB watershed lies has experienced a relatively high rate of growth and development over the past two decades (US Census Bureau, 2004).

Though it comprises a relatively small portion of the watershed (23%), Branchburg Township had the most rapid rise in population of any of the watershed municipalities, with an increase of 4,055 residents (37% of the 1990 population) between 1990 and 2004, the most recent year for which Census data exists (US Census Bureau, 2004). Readington Township was not far behind with an increase of 3,001 (22%) during the same time period (US Census Bureau, 2004). Although these population estimates reflect the total population of each municipality, rather than the population within the study area, the numbers illustrate the development pressures that continue to be felt throughout this region. They also underscore the urgency of mitigating the water quality impacts associated with increased development (e.g., increases in stormwater runoff due to higher impervious surface coverage). Table 3.1 shows the population change between 1990 and 2004 for each of the PR/HB Watershed municipalities.

Table 3.1. Municipal Populations of PR/HB Watersheds [2]

Municipality	Acres within the PR/HB Watershed	Percentage of total watershed area	Current (2004) population	1990 population	Change in population from 1990 to 2004
Readington Twp	11,249.4	75.6%	16,401	13,400	+3,001 (+22%)
Branchburg Twp	3,485.3	23.4%	14,943	10,888	+4,055 (+37%)
Clinton Twp	150	1%	13,862	10,816	+3,046 (+28%)

3.2 Topography, Geology and Soils

Details of the following aspects of the topographic, geologic and soil characteristics and features of the project study area were detailed in the **Milestone 2: Characterization and Assessment Report**. The following information is a summary of that data.

Readington Township is located within the Piedmont Physiographic Province or the Triassic Lowlands. This province constitutes approximately 20% or 1,500 square miles in New Jersey. The Raritan Valley Lowland Element of the Piedmont Physiographic Province contains low rolling plains with southeasterly sloping topography. The Piedmont is flat in areas with slightly rolling, predominantly gentle slopes.

3.2.1 Topography/Steep Slopes

Appendix A of the Milestone 5 Report includes a map illustrating the topography of the PR/HB watershed. This is based on the slopes and topography depicted on the USGS 7.5 Minute Series Quadrangle maps for Flemington & Raritan, NJ. Although the terrain throughout most of study area ranges in slope from 0-8%, there are several areas characterized by contiguous tracts of steep (10-15%) and very steep (15%-25%) sloped land. The steepest slopes (8-25%) occur east of Round Valley Reservoir along the Readington and Clinton Township borders, in what comprises the headwater areas of both Pleasant Run and Holland Brook. The topography of lands immediately adjacent to Holland Brook and Pleasant Run can vary greatly and be as much as eight to twenty five percent. Some of this is a function of stream down cutting that has occurred over time due to clearing and water related bank erosion resulting in incised stream banks that exceed 25%. Such steeply sloped stream banks occur quite frequently along the length of both streams (from the headwaters to their confluence with the South Branch Raritan River). These steeply sloped areas also occur in the more valley-like sections of the watersheds, and as such are not solely restricted to the transition areas from Round Valley Reservoir and Round Valley Mountain.

[2] Source: US Census Bureau, American FactFinder website (http://factfinder.census.gov). Population counts reflect the total population of each watershed municipality, rather than the portion of the population actually residing within the watershed boundary.

3.2.2 Geology

The project study area lies within the Triassic basin and is underlain primarily by shales of the Brunswick formation, with Stockton sandstone, volcanic basalt, and diabase formations also fairly prevalent. The geologic features of the area have interacted over time with the physical, biological and chemical attributes of the study area. These interactions are often most obvious with respect to background water chemistry characteristics such as pH, conductivity, hardness and alkalinity, which are discussed below in Section 3.7. The area's geology also influences the prevailing native vegetation and the wildlife associated with vegetation, as the relief, drainage, soil and underlying rock formations act in concert to affect floral and faunal succession and diversity.

3.2.3 Soils

The soils within the study area are derived largely from the weathering of the underlying Brunswick shale. These soil formation processes, coupled with various soil qualities such as texture (e.g., sand, silt, clay), water-holding capacity, and nutrient content, are active factors in determining the resident biological community. Likewise, plants, microorganisms, soil invertebrates (e.g., earthworms), and other animal life living in and on soils are active factors in soil formation. The interaction of these physical and biological processes determines, in large part, the living natural resources that persist and sustain themselves in a given locale.

As per the *Soil Survey of Hunterdon County, New Jersey* (Jablonski, 1988), twenty six (26) soil series are mapped within the PR/HB watershed. The predominant soils within the central portion of the watershed (largely defined by the municipal boundaries of Readington Township) are the Penn soils. The lower portion of the watershed (largely defined by the western municipal boundary of Branchburg Township and the South Branch Raritan River) are the Bucks soils. According to the USDA, both the Penn and Buck soils are considered to have moderate to severe erosion potential, with the potential increasing with increasing slope. Soil erosion potential, or erosion hazard, is the potential of a soil to erode itself naturally if not adequately protected. It is unrelated to historical erosional tendencies. The major factors that determine erosion potential are soil texture, organic matter content, structure, hydraulic conductivity, and to a lesser extent, slope.

Many of the soils occurring within the study area are characterized by a high seasonal water table and a shallow depth to bedrock. Those soils occurring within the PR/HB study area having shallow depth to groundwater are the:

- Abbotstown,
- Chalfont,
- Reaville,
- Readington,

- Raritan,
- Rowland, and
- Mt. Lucas series.

Neither the Penn nor the Bucks soils are characterized by shallow depth to groundwater.

Soils having a shallow depth to bedrock include the Klinesville, Penn and Reaville soils. Depth to seasonal high water level is the distance between the surface and the highest level reached in most years by ground water or water perched over a fragipan (hard impermeable layer). Depth to bedrock is the distance between the surface of the soil and the upper surface of the rock layer. These characteristics, along with slope, stoniness and permeability, largely determine the suitability of most soils for septic systems and building foundations.

Prime agricultural soils are those exhibiting adequate natural rainfall, temperatures conducive to farming, lack of excessive moisture, proper pH, adequate permeability, soils deep enough to store adequate moisture storage and aid root growth, and a lack of gravel, cobbles or stones. The Hunterdon County Soil Conservation District lists thirty-two prime farmland soils in Hunterdon County. Readington Township contains ten prime agricultural soils, as listed below:

- **Atb** - Athol gravelly loam, 2-6 percent slopes
- **BdA** - Birdsboro silt loam, 0 to 2 percent slopes
- **BdB** - Birdsboro silt loam, 2 to 6 percent slopes
- **BuB** - Bucks silt loam, 2 to 6 percent slopes
- **MoB** - Mount Lucas silt loam, 0 to 6 percent slopes
- **NoB** - Norton loam, 2 to 6 percent slopes
- **PeB** - Penn shaly silt loam, 2 to 6 percent slopes
- **RbA** - Raritan silt loam, 0 to 2 percent slopes
- **RbB** - Raritan silt loam, 2 to 6 percent slopes
- **TuB** - Turbotville loam, 2 to 6 percent slopes

Soils of Statewide Importance are those prime agricultural lands suited to the production of regional crops. Soil suitability for this category includes adequate water, season, temperature, steepness, aspect, or other attributes required for regionally significant crops. The Hunterdon County Soil Conservation District lists thirty-six (36) soils of statewide importance in the County. Those Soils of Statewide Importance occurring within the PR/HR watershed are as follows:

- Abbotstown,
- Annandale/Edneyville,
- Athol,
- Bucks,
- Chalfont,
- Lansdowne,
- Legore,

- Lehigh,
- Neshaminy,
- Penn, Norton,
- Penn-Bucks,
- Readington, and
- Reaville.

3.3 Land Use and Land Cover (LU/LC)

The watershed analyses based on land use and land cover (LU/LC) relationships was accomplished for the PR/HB watershed by overlaying the LU/LC data onto the 2002 aerial photograph of the project area and superimposing on that the most recent parcel data obtained from the towns or the county planning departments. The RSWMPC and the LPA then conducted a detailed cross-reference of the composite map, identifying and rectifying changes in the LU/LC database that arose as a result of recent land development activities. Low-density/rural residential development is the dominant land use in the watershed, covering 4,748 acres or nearly 32% of the total watershed area. Typically, lands with this classification are single-unit residences on lots of at least 0.5 acres and larger, with associated impervious surfaces comprising 15-25% or less of the total area (Anderson et al., 1976). Farmland and forests respectively account for 28% and 20% of all lands within the PR/HB watershed. Field/brush shrub land covers almost 6% of the watershed, while wetlands comprise an additional 4%. Recreational lands (e.g., parks and athletic fields) make up just over 1%. Industrial and commercial development covers less than 1% of the watershed area, even when their respective acreages (53 acres and 30 acres) are added together. Table 3.2 provides a breakdown of existing LU/LC categories (based on the refined 1995/97 NJDEP database) and their relative proportions within the PR/HB Watershed, while Table 3.3 provides a breakdown of the same LU/LC categories by municipality. A map depicting these LU/LC categories within the watershed is provided in Appendix A (Map E).

Table 3.2. General Existing Land Use/Land Cover Categories in the PR/HB Watershed.[3]

LU/LC Category	Acres within PR/HB Watershed	Percentage of total watershed area
Low Density/Rural Residential	4,748.4	31.9%
Agricultural	4,262.1	28.6%
Forest	3,062.4	20.6%
Field/Brush/Shrubland	884.2	5.9%
Urban/Mixed Urban/Other Urban	870	5.8%
Wetlands	646.9	4.3%
Recreational Lands	158.6	1.1%
Barren/Transitional Areas	127.9	0.9%
Industrial	52.7	0.4%
Commercial	29.5	0.2%
High/Medium Density Residential	28	0.2%
Lakes	14.3	0.1%
Streams	< 0.00	< 0.00
TOTAL WATERSHED AREA	**14,884.7**	**100%**

[3] LU/LC categories are based on Anderson et al., 1976.

Table 3.3. General Land Use/Land Cover Categories by Municipality.[4]

LU/LC Category	Acres within PR/HB Watershed	Percentage of total municipal watershed area
READINGTON TOWNSHIP		
Low Density/Rural Residential	3,709.87	32.98%
Agricultural	2,989.36	26.57%
Forest	2,638.06	23.45%
Field/Brush/Shrubland	705.61	6.27%
Urban/Mixed Urban/Other Urban	480.78	4.27%
Wetlands	474.08	4.21%
Recreational Lands	156.51	1.39%
Barren/Transitional Areas	63.61	0.57%
Commercial	14.78	0.13%
Lakes	10.25	0.09%
Industrial	1.76	0.02%
High/Medium Density Residential	4.68	0.04%
Streams	<0.01	<0.01%
TOTAL READINGTON	**11,249.35**	**100%**
BRANCHBURG TOWNSHIP		
Agricultural	1,224.47	35.13%
Low Density/Rural Residential	1,031.86	29.61%
Urban/Mixed Urban/Other Urban	389.16	11.17%
Forest	330.13	9.47%
Field/Brush/Shrubland	177.62	5.10%
Wetlands	164.09	4.71%
Barren/Transitional Areas	72.94	2.10%
Industrial	50.91	1.46%
High/Med Density Residential	23.26	0.67%

[4] LU/LC categories are based on Anderson et al. 1976.

Table 3.3. General Land Use/Land Cover Categories by Municipality.[4]

LU/LC Category	Acres within PR/HB Watershed	Percentage of total municipal watershed area
Commercial	14.71	0.42%
Lakes	4.07	0.12%
Recreational Lands	2.04	0.06%
Streams	<0.01	<0.01%
TOTAL BRANCHBURG	**3,485.26**	**100%**
CLINTON TOWNSHIP		
Forest	94.14	62.76%
Agricultural	48.28	32.18%
Low Density/Rural Residential	6.61	4.40%
Field/Brush/Shrubland	0.96	0.64%
Wetlands	0.03	0.02%
Urban/Mixed Urban/Other Urban	<0.01	<0.01%
Recreational Lands	<0.01	<0.01%
Barren/Transitional/Disturbed Areas	<0.01	<0.01%
Industrial	<0.01	<0.01%
Commercial	<0.01	<0.01%
High/Medium Density Residential	<0.01	<0.01%
Lakes	<0.01	<0.01%
Streams	<0.01	<0.01%
TOTAL CLINTON	**150.02**	**100%**
TOTAL WATERSHED AREA	**14,884.7**	**--**

3.4 Hydrology

Hydrologic modeling was an important component in characterizing the PR/HB watershed. The resulting data enabled a quantitative estimate of important components of the regional hydrology, especially overland stormwater runoff and groundwater recharge, to be computed. The details of the hydrologic modeling are provided in the Characterization and Assessment report but are summarized herein. All hydrologic modeling was conducted on subwatershed-specific basis, utilizing GIS databases published by NJDEP, including LU/LC, Political Boundaries, and NRCS Soils Data. ArcGIS was used to export these datasets into spreadsheet files that were subsequently used to conduct the modeling.

The total area of the PR/HB Watershed is approximately 14,885 acres. The largest subwatershed, Subwatershed 2 or "Pleasant Run Central", accounted for 22% of the total area (3,288 acres) of the entire study watershed. Readington Township was the largest contributing municipality, accounting for 76% of the total area (11,249 acres). At the other end of the scale, the smallest subwatershed, Subwatershed 3 ("Pleasant Run North") accounted for just under 10% of the total study area (1,454 acres), while Clinton Township was the smallest contributing municipality, accounting for just 1% of the total area (150 acres).

Overall, precipitation for the Pleasant Run/Holland Brook region, as measured at Flemington, averages 49.3 inches annually which amounts to a total volume of 75 x 10^6 m^3. May through September is the wettest period of the year, while the least amount of rainfall occurs on average between October and December.

Runoff, as calculated by the Rational Method, is closely related to the area of the defined catchment, as other factors affecting the calculation of the Rational Method (including soil hydrology characteristics, LU/LC, and precipitation) are constant or similar between watersheds. Subwatersheds 2 (Pleasant Run Central), 5 (Pleasant Run South), and 6 (Holland Brook South) all contribute disproportionately more runoff than percentage of watershed land area. Similarly, Branchburg Township also contributes slightly more runoff per area than the other municipalities. In total, the Rational Method calculations estimate that up to 55 x 10^6 m^3 of total precipitation is discharged as surface runoff.

3.5 Groundwater Recharge

Map G (Appendix A) depicts groundwater recharge rates throughout the PR/HB watershed, as interpreted by NJDEP and the New Jersey Geological Survey (NJGS) on the basis of GSR-32. As defined in the GSR-32 user's guide, groundwater recharge is "that water which infiltrates vertically downward from the land surface to below the unsaturated zone. This water may then move laterally to discharge in streams or to enter an aquifer" (Hoffman, 2002). The depicted recharge rates are based on the predicted permeability rates of the soils that dominate each individual GIS polygon, with adjustments made by NJGS for slope. They reflect the total amount of precipitation expected to infiltrate beyond the root zone over the course of a one-year period, based on average rainfall and soil moisture index properties. The depicted rates are not refined or altered to account for existing land disturbance or any impervious areas. Thus, the data presented on Map G is best thought of as the total anticipated recharge in inches per year. The GSR-32 methodology has been converted to a simplified, user-friendly Excel spreadsheet available through NJGS or via NJDEP's stormwater management website (www.NJStormwater.org). Given that the recharge data presented in Map G are based on the input of soils data as interpreted from the soil survey, as discussed above, a direct relationship exists between the soils map and the groundwater recharge map. The groundwater recharge map shows the best recharge areas that exist in the study watershed. Some of the lowest recharge areas occur adjacent to stream corridors and in areas characterized by wetlands and hydric soils. Of particular interest is the fact that some of the largest contiguous areas characterized by exceptionally high groundwater recharge occur in the northwestern perimeter of the PR/HB watershed.

Groundwater recharge, as calculated by the GSR-32 model, is more variable than runoff totals between the catchments due to a greater diversity of soils and greater relative differences in recharge capacity between different LU/LC and soil groups. Groundwater recharge as calculated using GSR-32 is therefore less closely correlated with land area. Subwatersheds 2 (Pleasant Run Central), 5 (Pleasant Run South), and 6 (Holland Brook South) all contribute disproportionately smaller amounts of groundwater recharge per surface area unit than the other subwatersheds. This was also true of Branchburg Township as compared to the other watershed municipalities. Total groundwater recharge was estimated to be approximately 16 x 10^6 m^3.

The Posten Method estimate of interflow is directly correlated with land area, so there is no proportional difference between subwatersheds or municipalities. In total, the Posten Method calculated a total interflow of 17 x 10^6 m^3, a result greater than total groundwater recharge. This may indicate a condition of poor aquifer recharge existing throughout the region.

The historical analysis comparing current development conditions with the historical pre-developed state sheds light on the effect of development and land use patterns on certain portions of the water budget. The analysis clearly shows that an increase in land development results in an increase in runoff, but a decrease in recharge. In total, watershed development to date appears to have increased the volume of runoff by 13%. This is primarily a function of the increase in impervious surfaces and the increase runoff potential associated with agricultural lands. This pattern is most evident in Subwatershed 5 (Pleasant Run South) and Subwatershed 6 (Holland Brook South), but it is observed in all subwatersheds and municipalities, particularly Branchburg Township.

The same pattern was observed in reverse regarding recharge potential. In total, there is an estimated 21% decrease in recharge associated with development in the Pleasant Run/Holland Brook region. As with runoff, the main causes affecting decreased groundwater recharge include an increase in impervious surface (associated with all urban development), an alteration of vegetation, and increase in widespread agriculture. This was most evident in Subwatersheds 2 (Pleasant Run Central), 5 (Pleasant Run South), and 6 (Holland Brook South), as well as Branchburg Township. In general, under developed watershed conditions, the water budgets of both streams are substantially changed with increased runoff and decreased groundwater recharge through the watershed.

The results of the GSR-32 data and the accompanying map should not be confused with well yield data. In contrast to the ability to provide or sustain water from the perspective of a potable water aquifer, the recharge data reflects those areas where interflow (the lateral movement of groundwater from soil storage reservoirs) into streams and wetlands is likely to be maximal. As such, it is possible and plausible that an area designated as having high recharge capability can at the same time have poor well yields.

3.6 Critical Habitat Areas (Landscape Project Mapping)

GIS data from the NJ Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP) were integrated with the project database to evaluate the amount and type of critical wildlife habitat present within the PR/HB Watershed. Through an effort known as the Landscape Project, ENSP has compiled an extensive database that combines information about the locations of threatened and endangered and "priority" species with land-use/land-cover data in order to identify and map areas of critical habitat for these species within broad land areas called "landscape regions" (Niles et al., 2004).[5]

The Landscape Project has identified five major habitat types in New Jersey: forest, forested wetland, emergent wetland, grassland and beach. All of these, with the exception of beach habitat, have been identified with the PR/HB Watershed. In addition, the Landscape Project has identified areas of critical importance for three specific Threatened and Endangered species: bald eagle foraging area, urban peregrine falcon nest and wood turtle. Of these, only wood turtle habitat has been identified in the watershed (concentrated in the northwestern corner of the study area in Readington Township). The Landscape Project also assigns a priority ranking to each land area identified as a critical habitat, ranging from Rank 1 (land that meets habitat-specific suitability requirements, but where no confirmed species occurrences have been documented) to Rank 5 (land where one or more occurrences of one or more Federal Endangered and/or Threatened species has been documented). Nearly 29% (a total of approximately 9,232 acres) of the land in the PR/HB Watershed has been identified as critical habitat through analysis of the Landscape Project data. The majority of this area is split about evenly between forested habitat (3,947 acres) and grassland habitat (3,965 acres). Just under 5% of the watershed, or approximately 1,502 acres, is Rank 1 habitat. Table 6 provides a listing of the critical habitat areas and rankings identified in the PR/HB Watershed and their respective acreages.

[5] The NJDEP Division of Fish & Wildlife defines "Endangered Species" as "those whose prospects for survival in NJ are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination." Assistance is needed to prevent future extinction in the state. "Threatened Species" are "those who may become endangered if conditions surrounding them begin to or continue to deteriorate." The term "Species of Special Concern" applies to those that "warrant special attention because of some evidence of decline, inherent vulnerability to environmental deterioration, or habitat modification that would result in their becoming a Threatened species. See www.nj.gov/dep/fgw/spclspp.htm. "Priority species" are nongame wildlife considered by NJDEP to be species of special concern as determined by a panel of experts (Niles et al., 2004).

Table 3.4 Critical Habitat Areas in the PR/HB Watershed

Critical Habitat Area	Rank	Acreage within the PR/HB Watershed	Percent of total watershed area
Emergent Wetland	1	270.4	**0.8%**
Forested	2	2,700.0	**8.4%**
Forested	3	258.9	**0.8%**
Forested	5	987.9	**3.1%**
Forested Wetlands	1	517.8	**1.6%**
Forested Wetlands	2	17.7	**0.1%**
Grassland	1	714.1	**2.2%**
Grassland	2	2,383.4	**7.4%**
Grassland	3	760.3	**2.4%**
Grassland	5	107.2	**0.3%**
Wood Turtle Habitat	3	514.0	**1.6%**
Total Critical Habitats Area	--	9,231.7	**28.7%**
TOTAL WATERSHED AREA	**--**	**32,186.8**	**100%**

Rank 5 – one or more occurrences of at least one Federal Endangered or Threatened wildlife species.
Rank 4 – one or more occurrences of at least one State Endangered wildlife species.
Rank 3 – one or more occurrences of at least one State Threatened species.
Rank 2 – one or more occurrences of at least one non-listed State priority species.
Rank 1 – meets habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species. (Niles et al., 2004)

3.7 Results of Stream Monitoring

3.7.1 Existing Water Quality

A water quality monitoring program was conducted as part of the RSWMP project. The details of this effort are contained in the Milestone 2 Characterization and Assessment Report. The sampling program essentially involved the collection of water chemistry, flow and biological data at four sampling stations in the study area (two on the Pleasant Run and two on the Holland Brook). All sampling was conducted in accordance with an NJDEP-approved Quality Assurance Project Plan (QAPP). Sampling was conducted between June 2005 and September 2005 under both baseflow (four sampling events) and storm event (four sampling events) conditions (table 3.5). During this time period, measurements were made of the following parameters:

Chemical (eight sampling events at four stations)
- Temperature (in situ)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (in situ)
- pH (in situ)
- Total Phosphorus (TP)
- Soluble Reactive Phosphorus (SRP)
- Total Suspended Solids (TSS)
- Nitrate-Nitrogen (NO^3-N)

Bacterial (eight sampling events at four stations)
- Fecal coliform (FC)
- Fecal streptococcus (FS)

Biological (one sampling event at four stations)
- Benthic macroinvertebrates

Table 3.5 Water Quality Sampling Stations and Parameters

Station #	Sampled Parameters	Stream	Subwatershed
1	chemical, bacterial, biological	Holland Brook	1 (Holland Brook – Central)
2	chemical, bacterial, biological	Pleasant Run	2 (Pleasant Run –Central)
3	chemical, bacterial, biological	Holland Brook	3 (Pleasant Run – North)
4	chemical, bacterial, biological	Pleasant Run	4 (Holland Brook – North)

Station 1 (ST-1) is the downstream sampling station on Holland Brook, located off Brookview Road in Readington Township. Station 2 (ST-2) is the downstream Pleasant Run station, located between Route 202 and Old York Road in Readington Township (Centerville). Station 3 (ST-3) is the upstream sampling station on Pleasant Run. It is located in Readington Township, off Route 629/Stanton Road at the corner of Route 523/Flemington-Whitehouse Road. The final station, ST-4, is located on the upstream portion of Holland Brook, off Holland Brook Road just northwest of the intersection with Cole Road, in the Whitehouse Station section of Readington Township. The locations of the four sampling stations were fixed using GPS and have been mapped as part of the RSWMP GIS data base. The water quality results of the stream sampling program are presented in Tables 3.6, 3.7, and 3.8, with the data displayed for each stream under baseflow and storm flow conditions.

Table 3.6 presents the results of the *in-situ* measured parameters. Overall, the *in-situ* measured parameters (dissolved oxygen (DO), temperature, pH and conductivity) showed no significant deviation from the standard range expected for streams in Hunterdon County. As shown in

Table 3.6, DO concentrations were typically well above the State standard of 5.0 mg/L, but depressed DO concentrations were observed at a number of the stations during the August baseline and storm event sampling events, and again during the September storm sampling event. Most of the lower DO readings were only slightly depressed, yet still acceptable (in the range of 5 to 6 mg/L). However, at ST-2 during the August and September storm events, the DO concentration dropped well below the State standard.

The pH measured at all four stations tended to be well within the range established by the State for streams, varying over the course of the entire project from a high of 7.9 to a low of 6.04. At all four stations, the pH values were within the neutral range (7.0-7.9) on all but two sampling dates.

Conductivity readings were generally in the 0.200 to 0.300 mmhos/cm range. These values are about typical for most Hunterdon County streams. On a relative scale, the conductivity measurements recorded for ST-2 (downstream Pleasant Run) tended to be higher on each sampling date than those measured at the other sampling stations. A comparison of the conductivity levels measured in June, July and August under either baseflow or storm conditions showed very little intra-station variation (i.e., regardless of wet or dry conditions, the conductivity readings were relatively similar). However, at ST-3 in September the storm conductivity reading was significantly greater than that measured under baseflow conditions. It should be noted that elevated conductivity readings are expected to occur more frequently in the winter and spring due to road runoff containing deicing products (e.g., salt and brine solutions).

Analysis of the bacterial data collected at each stream showed significant bacterial contamination throughout the PR/HB Watershed. The data displayed in Table 3.7 show frequent occurrences of elevated fecal coliform (FC) concentrations, with the measured concentrations at times greatly in excess of the State standard. These elevated readings occurred during both dry and wet weather conditions. The station displaying the greatest frequency of elevated FC was ST-1. Although not entirely consistent in terms of peak FC concentrations, the fecal streptococcus (FS) data collected in concert with the FC data shows similarly elevated conditions. ST-2, the lower Pleasant Run station, had some of the greatest and most consistently elevated FC:FS ratios. Overall, the FC:FS ratio exceeded 5:1 during only one sampling event (ST-1, July 6 – second storm event). Although the FC:FS ratio is only a moderately accurate indicator metric, the data suggest that animals, rather than humans, are the source of the majority of the measured bacterial contamination.[6]

[6] Some sources suggest that a fecal coliform: fecal streptococci ratio >4.0 is an indicator of human sources of fecal contamination; however, USEPA does not currently recommend this as a reliable test. <www.epa.gov/volunteer/stream/vms511.html>

Table 3.6 2005 Stream Water Quality Monitoring Data by Parameter (*In-Situ*)

2005 pH measurements (units)	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	7.77	7.71	7.90	7.15	**6.48**	7.90	7.54	7.02
ST-2	7.78	7.27	7.71	**6.04**	**6.45**	7.41	7.48	6.97
ST-3	7.78	7.38	7.76	7.47	**6.13**	7.44	7.45	7.02
ST-4	7.91	7.67	8.29	8.07	6.60	7.99	7.90	7.21
2005 specific conductivity measurements (mmhos/cm)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	0.236	0.254	0.260	0.273	0.271	0.247	0.250	0.242
ST-2	0.315	0.388	0.347	0.412	0.560	0.491	0.608	0.644
ST-3	0.172	0.186	0.219	0.224	0.236	0.231	0.268	0.719
ST-4	0.251	0.271	0.270	0.309	0.295	0.288	0.307	0.296
2005 dissolved oxygen measurements (mg/L)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	8.62	7.88	8.97	5.81	6.71	8.49	8.70	6.35
ST-2	9.28	6.43	7.93	**0.97**	6.07	7.00	8.34	4.06
ST-3	8.01	7.40	7.40	6.24	5.77	6.39	6.78	6.13
ST-4	8.44	7.93	9.35	7.80	7.15	9.28	11.26	8.54
2005 temperature measurements (degrees Celsius)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	18.00	22.96	22.76	22.90	22.25	21.97	17.51	20.84
ST-2	19.80	22.31	22.85	18.92	22.12	23.93	16.60	20.69
ST-3	18.70	21.93	21.09	23.41	21.55	22.33	17.58	20.96
ST-4	17.60	19.56	19.76	20.57	18.62	18.86	14.98	17.76

NOTE: ND = nondetect (SRP <0.003, Nitrate-N <0.02, TSS <3); blue text indicates storm event.

Table 3.7 2005 Stream Water Quality Monitoring Data by Parameter (Bacterial)

2005 fecal coliform concentrations	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	240	1600	1600	350	1600	110	33	920
ST-2	130	>1600	540	240	1600	110	220	>1600
ST-3	540	>1600	130	240	>1600	130	140	1600
ST-4	170	>1600	350	170	>1600	540	130	540

2005 fecal streptococci concentrations	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	49	>1600	70	540	>1600	240	540	920
ST-2	540	>1600	920	540	1600	920	540	>1600
ST-3	110	>1600	240	170	>1600	240	540	>1600
ST-4	>1600	>1600	350	130	>1600	130	220	920

2005 FC:FS ratios	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	**4.90**	1.00	**22.86**	0.65	1.00	0.46	0.06	1.00
ST-2	0.24	-	0.59	0.44	1.00	0.12	0.41	-
ST-3	**4.91**	-	0.54	1.41	-	0.54	0.26	<1.0
ST-4	<0.11	-	1.00	1.31	-	**4.15**	0.59	0.59

NOTE: blue text indicates storm event.

With regard to the monitored nutrients, Total Phosphorus (TP) and Nitrate-Nitrogen (NO_3-N), the sampling data show relatively elevated in-stream concentrations under both baseline and storm conditions (Table 3.8). Specifically, TP concentrations under both baseflow and storm conditions were consistently above 0.05 mg/L. The State standard for FW2 streams, 0.1 mg/L, was routinely exceeded at most of the sampling stations, ST-3 and ST-4 in particular, under storm conditions. The exception to this was the baseflow sampling conducted in June, when the TP concentration contravened the State standard at ST-2 (lower Pleasant Run) and ST-4 (upper Holland Brook).

Regardless of weather conditions, the soluble reactive phosphorus (SRP) component of the measured TP was at least 50% on each sampling date. This indicates that a large portion of the measured phosphorus is in a reactive, easily assimilated form. This is significant in that the SRP component is readily available for algal, phytoplankton and periphyton assimilation, suggesting that these streams are prone to eutrophication.

Although nitrate (NO_3-N) concentrations did not exceed the State standard of 10.0 mg/L during any sampling event, the measured concentrations tended to show some degree of nutrient impairment. Specifically, the measured concentrations were typically above 0.2 mg/L. The higher nitrate concentrations were measured during wet weather events, with the September event generating the highest measured concentration (1.9 mg/L) at ST-4. Overall, this station, the upper Holland Brook, had the highest measured nitrate concentrations, regardless of whether the sampling was conducted under dry or wet weather conditions.

The measured Total Suspended Solids (TSS) concentrations never exceeded the State standard, regardless of whether the sampling occurred under baseflow or storm conditions. Given the visible cloudiness of the streams often observed immediately following a storm event, it was anticipated that the wet weather sampling events would generate TSS levels at or greater than the State standard of 40 mg/L. However, as demonstrated by the data, on all but one sampling date (27 June), and at only one stream (ST-1), the TSS concentrations measured under storm and base flow conditions were less than 20 mg/L, and for the most part less than 5 mg/L. This may mean that much of the observable turbidity in either stream is dominated by larger particle-sized sediments that settle out of solution fairly rapidly. It may also be a function of the time lag between the beginning of each storm event and the initiation of sampling, although this is very unlikely as all storm event sampling was conducted within 6 to 12 hours of the beginning of each rainfall event. Overall, the results of the TSS sampling and analyses raise some questions. The measured concentrations do not seem to coincide with observed conditions in the stream, specifically the ease at which noticeable turbidity is created even under moderate storm flows or through the disturbance of the stream bottom.

In summary, the results of the 2005 water quality monitoring program indicate that the Pleasant Run and Holland Brook are impacted by fecal coliform (most likely of non-human origin). Both streams are also characterized by elevated phosphorus and nitrate concentrations that are indicative of a eutrophic ecosystem.

Table 3.8 2005 Stream Water Quality Monitoring Data by Parameter (Lab)

2005 TP concentrations (mg/L)	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	0.09	**0.18**	0.07	0.06	0.07	0.06	0.04	0.06
ST-2	**0.13**	**0.16**	0.09	0.05	**0.14**	0.08	0.06	**0.12**
ST-3	0.09	**0.26**	**0.11**	0.09	**0.94**	0.09	0.09	**1.20**
ST-4	**0.13**	**0.15**	**0.11**	0.08	0.09	0.07	0.06	0.06
2005 SRP concentrations (mg/L)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	0.045	0.040	0.043	0.035	0.046	0.040	0.029	0.043
ST-2	0.052	0.073	0.049	0.010	0.064	0.063	0.039	0.048
ST-3	0.058	0.090	ND	0.044	0.760	0.070	0.066	1.100
ST-4	0.075	0.096	0.058	0.048	0.067	0.062	0.044	0.058
2005 NO_3-N concentrations (mg/L)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	0.59	0.46	0.61	0.14	0.14	0.17	0.19	0.42
ST-2	0.25	0.39	1.10	0.15	0.18	0.17	0.11	0.45
ST-3	0.62	0.67	0.72	0.12	0.73	0.22	0.15	0.87
ST-4	1.20	1.40	1.50	1.50	0.87	1.30	1.80	1.90
2005 TSS concentrations (mg/L)	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	4	24	5	6	ND	4	ND	ND
ST-2	ND	6	4	4	12	4	3	ND
ST-3	3	17	ND	ND	5	3	ND	ND
ST-4	ND	ND	ND	ND	7	ND	3	ND

NOTE: ND = nondetect (SRP <0.003, Nitrate-N <0.02, TSS <3); blue text indicates storm event.

3.7.2 Macroinvertebrate Sampling Results

The upper reaches of both streams harbored organisms such as the larvae of the stone fly (Plecoptera), mayfly (Ephemeroptera) and caddisfly (Tricoptera) that are sensitive to water quality impairment and/or habitat modification,. The lower stream segments; however, were populated by a relatively greater number of stress-tolerant species, and showed evidence of impairments associated with eutrophication, sedimentation and habitat degradation. Overall the results of the macroinvertebrate surveys of the streams confirmed that although both Pleasant Run and Holland Brook support a wide and diverse array of macroinvertebrates, the macroinvertebrate communities show distinct evidence of ecological impairment.

3.8 Unit Area Loading Modeling (Pollutant Loading Analysis)

Five pollutants of concern were modeled for the PR/HB watershed: Total Phosphorus (TP), Total Nitrogen (TN), Total Suspended Solids (TSS), Lead (Pb) and Zinc (Zn). This was accomplished by integrating a Unit Area Loading (UAL) model (Uttormark et al., 1974; USEPA, 1980, 1990) with the GIS database. The resulting pollutant loads were expressed on an annual scale for the watershed under both existing development and buildout scenarios. The selected pollutant export coefficients were those contained in Uttormark et al. (1974), Reckhow et al. (1980), USEPA (1980) and Schueler (1986), but refined to better reflect local conditions of slope, soils, vegetation and land cover. The details of these analyses are provided in the Milestone 2 Characterization and Assessment Report.

3.8.1 Existing Land Use

The existing pollutant loads for the five pollutants of concern noted above were calculated for each subwatershed (Table 3.9). Predictably, the subwatersheds with the highest attributed pollutant load were those with the largest area, with Subwatershed 2, which comprises the largest portion of the watershed area (22% or 3,287.5 acres) generating 24% (7,848.88 lbs/year) of the total TN load, 22% (452.23 lbs/year) of the total TP load, approximately 20% of the total TSS (771,657.61 lbs/year), Pb (695.14 lbs/year) and Zn (677.65 lbs/year) loads. A relatively large proportion of this subwatershed is classified as agricultural (approximately 1,004 acres or 34% of the total subwatershed area). Agricultural land is associated with high nutrient inputs such as nitrogen fertilizers, which is reflected in the related pollutant export coefficients.

Table 3.9 PR/HB Watershed Existing TN, TP and TSS Loads (Lbs/Yr)

Sub-watershed	Total Acreage	% of watershed	TN	% of TN load	TP	% TP load	TSS	% TSS load
1 (HB-Central)	2,946.3	**19.79**	6,654.9	**20.68**	374.1	**17.96**	695,707	**17.95**
2 (PR-Central)	3,287.5	**22.09**	7,848.8	**24.39**	452.2	**21.72**	771,657	**19.91**
3 (PR-North)	1,454.4	**9.77**	2,919.2	**9.07**	181.8	**8.73**	369,212	**9.53**
4 (HB-North)	2,268.2	**15.24**	4,128.1	**12.83**	278.3	**13.36**	536,215	**13.83**
5 (PR-South)	2,177.1	**14.63**	5,023.3	**15.61**	354.0	**17.00**	700,042	**18.06**
6 (HB-South)	2,751.1	**18.48**	5,612.5	**17.44**	442.2	**21.23**	803,381	**20.73**
TOTAL WATERSHED	**14,884.7**	**100**	**32,186.8**	**100**	**2,082.6**	**100**	**3,876,216**	**100**

Table 3.10 PR/HB Watershed Existing Lead and Zinc Loads (Lbs/Yr)						
Sub-watershed	**Total Acreage**	**% of total watershed**	**Pb**	**% Pb load**	**Zn**	**% Zn load**
1 (HB-Central)	2,946.3	**19.79**	518.36	**14.76**	514.11	**14.98**
2 (PR-Central)	3,287.5	**22.09**	695.14	**19.79**	677.65	**19.75**
3 (PR-North)	1,454.4	**9.77**	280.65	**7.99**	280.05	**8.16**
4 (HB-North)	2,268.2	**15.24**	547.82	**15.59**	541.56	**15.78**
5 (PR-South)	2,177.1	**14.63**	493.89	**14.06**	469.24	**13.68**
6 (HB-South)	2,751.1	**18.48**	977.19	**27.82**	948.52	**27.64**
TOTAL WATERSHED	**14,884.7**	**100**	3,513.05	**100**	3,431.13	**100**

As presented in Tables 3.9 and 3.10, the subwatersheds with the largest attributed portion of the PR/HB Watershed TN loads are Subwatershed 2 (24%) and Subwatershed 1 (21%). However, the highest modeled TP loads are associated with Subwatersheds 2 and 6, with almost 22% of the total watershed TP load attributed to each. Regarding TSS, Pb and Zn loads, Subwatershed 6 is responsible for the largest portion (over 20%) of the estimated total pollutant load in the watershed area, despite comprising less than 20% of the watershed's total acreage. The basis for this disproportion is the relatively high percentage of residential land in this subwatershed; at nearly 46% residential development, Subwatershed 6 is the most urbanized section of the PR/HB Watershed in terms of residential development.

Overall, the results of the UAL analysis highlight three important factors that must be addressed as part of any strategy that will evolve through the RSWMP. First, the more developed sub-watersheds generate greater amounts, on a per-unit basis, of phosphorus, heavy metals and sediments than do the more forested or even the agriculture-dominated areas of the watershed. Although one could conclude that this is an obvious result, there are important underlying reasons for this relationship that must be transferred into the development of the RSWMP. More development leads to more impervious cover, greater opportunity for the compaction of soil, and the substitution of native plants with suburban vegetation and landscaping. These conditions increase the volume of runoff generated during every storm and decrease the opportunity for the infiltration of precipitation. Second, increases in impervious cover also increase the rate and velocity of runoff, contributing to the more efficient mobilization and transport of pollutants and the scour and disruption of the receiving streams. Finally, independently targeted yet integrated measures are needed to control and reduce pollutant loading from the residential, commercial and agricultural areas of the watershed. These measures must begin with strategies designed to control the sources and overall generation of pollutants (source reduction), but include appropriately designed BMPs (structural and non-structural) to control runoff volumes, rates and pollutant loads. These must include stream buffers and conservation areas, as well as low-impact development techniques, and stormwater infrastructure retrofits in currently developed areas where appropriate.

It is also recognized that although a sub-watershed or a land use / land cover may be generating a significant amount of pollutant loading, some of this may be "unmanageable".

Table 3.11 Existing Unmanageable (Forest, Water, Wetlands) Pollutant Load

Municipality	Total Acreage	% of watershed area	Estimated Unmanageable Pollutant Loading (lbs/yr)			Total Unmanageable Acres
			TN	TP	TSS	
Branchburg	3,485.27	23.4%	771.58	28.07	1,094,322.98	688.59
Readington	11,249.35	75.6%	4,299.11	233.16	398,200.47	3,836.33
Clinton	150.02	1%	87.39	6.90	8,754.65	95.13
TOTAL	14,884.64	100%	5,158.08	268.13	1,501,278.10	4,620.05

Table 3.12 Existing Manageable (Developed Land) Pollutant Load

Municipality	Total Acreage	% of watershed area	Estimated Manageable Pollutant Loading (lbs/yr)			Total Manageable Acres
			TN	TP	TSS	
Branchburg	3,485.27	23.4%	6,916.01	577.60	66,779.87	2,796.68
Readington	11,249.35	75.6%	19,969.93	1,097.33	2,289,521.88	7,413.02
Clinton	150.02	1%	142.63	8.44	18,620.09	54.89
TOTAL	14,884.64	100%	27,028.57	1,683.37	2,374,921.884	10,264.59

3.8.2 Projected Future Land Use (Buildout)

The UAL analysis was conducted for LU/LC conditions under a projected development scenario. To estimate future development, a review of current municipal zoning regulations and maps was performed. After compiling the necessary GIS and regulatory data, the restrictions and requirements (i.e., minimum lot size, maximum percent impervious coverage, development type) governing development within each zone in each of the three watershed municipalities were assessed in order to determine the future LU/LC category of each zone assuming "full buildout" under current zoning regulations.

Next, the GIS database for the watershed was queried to identify any lands with characteristics, such as steep slopes (≥15%), wetlands, FEMA floodplain areas, mines and quarries, and permanently preserved parcels (i.e., county, municipal and Green Acres open space parcels and lands preserved under the NJ Department of Agriculture – State Agriculture Development Committee's Farmland Preservation program), that render that land unsuitable and/or unavailable for development. These lands were considered "undevelopable", and as such were assigned LU/LC categories identical to their existing categories. In contrast, lands without development constraints such as those described above were considered "developable", and were reclassified according to the land uses each would have if built out fully to the most intensive state possible under current zoning.

Based on this methodology, it was determined that a total of 11,134.83 acres in the PRHB Watershed is available for development. The remaining 3,749.84 acres was considered "undevelopable," either because these lands are part of a permanently protected open space or farmland preservation parcel, or because steep slopes, wetlands or other unsuitable conditions preclude development. A breakdown of these developable and undevelopable lands by subwatershed is provided in Table 14. Map J depicts LU/LC categories in the PR/HB watershed under projected buildout conditions and is provided in Appendix A.

Table 3.13 Developable Lands in the PR/HB Watershed, by Subwatershed.

Sub-watershed	Total Acreage	Developable Acres	Percent Developable	Protected/ Undevelopable Acres	Percent Undevelopable
1 (HB-Central)	2,946.3	2,140.7	**73**	805.6	**27**
2 (PR-Central)	3,287.5	2,404.2	**73**	883.3	**27**
3 (PR-North)	1,454.4	1,081.7	**7**	372.7	**26**
4 (HB-North)	2,268.2	1,733.6	**76**	534.7	**24**
5 (PR-South)	2,177.1	1,443.8	**66**	733.3	**34**
6 (HB-South)	2,751.1	2,330.9	**85**	420.2	**15**
TOTAL WATERSHED	**14,884.6**	**11,134.9**	**75**	**3,749.8**	**25**

Based on this analysis of projected development in the PR/HB watershed, a UAL analysis was then conducted to estimate future pollutant loads, assuming full buildout under current municipal zoning. To account for variations in specific future land development, several assumptions were made in assigning pollutant loading values to projected future land uses. For lands currently zoned for agricultural uses (other than those identified as protected under a farmland preservation program), future pollutant loading coefficients for TP, TN and TSS were calculated as an average of all agricultural coefficients. In contrast, future pollutant loading for <u>protected</u> farmland was estimated using the coefficients assigned to the existing LU/LC codes. Similarly, for lands identified as permanently protected and those with steep slopes (≥15%), wetlands, FEMA floodplain areas, mines and quarries, future pollutant loads were calculated according to the existing LU/LC codes assigned to those lands.

Table 3.14 Projected TN, TP and TSS Loads (Lbs/Yr) Under Future Development Conditions

Sub-watershed	Total Acreage	% of Total Area	TN	% TN load	TP	% TP load	TSS	% TSS load
1 (HB-Central)	2,946.3	**19.79**	5,473.22	**18.79**	385.71	**16.43**	630,193.01	**16.06**
2 (PR-Central)	3,287.5	**22.09**	6,481.26	**22.25**	441.33	**18.80**	724,146.99	**18.45**
3 (PR-North)	1,454.4	**9.77**	2,777.03	**9.53**	200.25	**8.53**	326,247.60	**8.31**
4 (HB-North)	2,268.2	**15.24**	3,934.16	**13.50**	298.55	**12.72**	457,631.69	**11.66**
5 (PR-South)	2,177.1	**14.63**	4,301.65	**14.77**	328.81	**14.01**	592,333.17	**15.09**
6 (HB-South)	2,751.1	**18.48**	6,165.07	**21.16**	692.96	**29.52**	1,194,439.50	**30.43**
TOTAL WATERSHED	**14,884.7**	**100**	29,132.38	**100**	2,347.60	**100**	3,924,991.95	**100**

Table 3.15 Projected Lead and Zinc Loads (Lbs/Yr) Under Future Development Conditions

Sub-watershed	Total Acreage	% of Total Area	Pb	% Pb Load	Zn	% Zn load
1 (HB-Central)	2,946.3	**19.79**	1,438.55	**19.89**	1,437.88	**20.05**
2 (PR-Central)	3,287.5	**22.09**	1,608.03	**22.23**	1,606.23	**22.40**
3 (PR-North)	1,454.4	**9.77**	720.88	**9.97**	720.88	**10.05**
4 (HB-North)	2,268.2	**15.24**	1,158.55	**16.01**	1,157.78	**16.15**
5 (PR-South)	2,177.1	**14.63**	958.91	**13.26**	954.71	**13.31**
6 (HB-South)	2,751.1	**18.48**	1,348.22	**18.64**	1,293.19	**18.03**
TOTAL WATERSHED	**14,884.7**	**100**	**7,233.14**	**100**	**7,170.67**	**100**

A comparison was made between estimated current pollutant loading and pollutant loading under future development conditions, given the assumptions described above. The results of this comparison are provided in Tables 3.16 below. In the case of three of the pollutants, loads are estimated to increase by 12% (TP) to over 100% (Pb and Zn). The estimated increase in TSS loads, however, was calculated to be only just over 1%, while TN is expected to actually <u>decrease</u> by approximately 9.5%. The basis for this seemingly counterintuitive prediction is most likely the anticipated transition of a significant portion of watershed lands from agricultural production to residential development, consistent with current municipal zoning regulations. Assuming that much of the current agricultural land will transition to low-density residential development means that intensive use of high-nitrogen fertilizers commonly associated with farm fields, as well as soil erosion due to agricultural activities (including grazing animals), will decrease, resulting in lower or comparable TN and TSS concentrations under buildout conditions. As noted above, however, other pollutants of concern, such as TP, Pb and Zn, are likely to increase under buildout conditions because of their high correlation with urbanized lands.

It must also be stressed that in-stream concentrations of TSS could actually increase, even if the land-based load is decreased. This could occur under a scenario where increased total flows or increased peak flows would contribute to the scour of the stream channel and exacerbate bed and bank erosion of the Pleasant Run and Holland Brook. Although detention basins can mitigate some of these problems, as demonstrated by NJDEP and Hunterdon County (1986) in the nearby South Branch Rockaway Creek drainage, it is also possible for multiple basins to actually worsen the problem. These scenarios underscore the importance of improved management and treatment of stormwater-based NPS pollution in the watershed, particularly in the specific subwatersheds likely to experience the greatest future water quality impacts, to mitigate these anticipated increased pollutant loads. In addition, a desire on the part of the watershed municipalities (especially Readington Township) to maintain the rural/agricultural landscape that largely defines the community may stimulate efforts to protect additional agricultural lands through farmland preservation programs. To reduce the nutrient and TSS loads that go hand-in-hand with these agricultural operations, opportunities to implement and fund agricultural BMPs, such as riparian buffer creation/maintenance, manure management programs and soil-conserving tilling practices, will be identified in the RSWMP.

Table 3.16 Change in Estimated Load (Lbs/Yr)
From Current to Projected Future Development Conditions

Sub-Watershed	Change in TN load	Change in TP load	Change in TSS load	Change in Pb load	Change in Zn load
1 (HB-Central)	-1,181.70	+11.65	-65,514.30	+920.19	+923.77
2 (PR-Central)	-1,367.62	-10.90	-47,510.62	+912.89	+928.58
3 (PR-North)	-142.17	+18.46	-42,964.63	+440.23	+440.83
4 (HB-North)	-193.97	+20.29	-78,583.41	+610.73	+616.22
5 (PR-South)	-721.55	-25.23	-107,709.53	+465.02	+485.47
6 (HB-South)	+552.61	+250.81	+391,058.58	+371.03	+344.67
TOTAL WATERSHED	**-3,054.41**	**+265.07**	**+48,776.08**	**+3,720.09**	**+3,739.54**

4.0 WATERSHED PROBLEM IDENTIFICATION AND ANALYSIS

4.1 Overview of Impacts

Elevated levels of pathogens and nutrients, impaired macroinvertebrates, eroded stream banks and localized flooding were identified by the RSWMPC as indicators of water quality and ecological impacts in Pleasant Run and Holland Brook. Overall, stormwater management throughout the watershed can be characterized as ranging from nonexistent to inadequate. The more recently developed (post-2004) areas of the watershed have improved stormwater management infrastructure, including stormwater management basins, recharge basins and related BMPs that serve to reduce the NPS loading of runoff. Reductions in NPS loading is also being accomplished via street sweeping, the installation of eco-grates, the passage and enforcement of pet waste and yard waste ordinances, and improved review of new development projects.

However, due to the nature, distribution and intensity of development within the Pleasant Run and Holland Brook watersheds, stormwater management and NPS control BMPs need to be expanded and improved if the streams' water quality impairments are to be rectified. Given the rural to suburban setting that characterizes the majority of the Pleasant Run and Holland Brook watersheds, improvements in stormwater management do not necessarily require the implementation of only structural BMPs. Rather, it will take the correct combination of structural and nonstructural BMPs to accomplish the following:

1. Mitigation of storm surges and the control of peak flows (contributing to flooding and stream erosion problems),

2. Compensation within the more intensively developed portions of the watershed for lost recharge or infiltration capacity (contributing to the increased volume of runoff, the magnitude of peak flows and alterations in baseflow conditions), and
3. Reduction of pollutant loading (contributing to problems with the accumulation of floatables in the watershed, the deposition of sediments and the influx of nutrient-laden runoff responsible for the watershed's eutrophication.

Due in part to the long history of agricultural development in the study watersheds, encroachments have occurred into riparian areas, floodplains, and to some extent wetlands and open waters. Impacts or alteration of the services and functions of such natural areas decreases their stormwater mitigation properties adding to stormwater-related impacts. Impaired riparian areas also negatively impact the ecological values of the stream systems. This has contributed to the loss of essential habitat for various species and has increased the opportunity for the establishment and spread of non-native, invasive species.

4.2 Stream Water Quality Monitoring

The results of the stream sampling program were presented and summarized in Section 3. These data cover baseflow and storm flow conditions and include some macroinvertebrate data and visual stream assessment data. As previously discussed, the *in-situ* measured parameters (dissolved oxygen (DO), temperature, pH and conductivity) tended to show no significant deviation from the standard ranges expected for streams in Hunterdon County. As shown in Table 3.6, DO concentrations were typically well above the State standard of 5.0 mg/L, but depressed DO concentrations were observed during the August baseline event. Depressed DO concentrations were also observed during storm event sampling. During the August and September storms DO concentrations dropped at some stations well below the State standard. Based on Princeton Hydro's assessment of seasonal and storm-related DO variations in other northern New Jersey streams it was concluded that two factors were likely responsible for the observed dips in DO. First, as these decreases coincided with storm events, the observed depressions in DO are likely linked to increase loading that exerted a biological oxygen demand. This loading could be of either an external (conveyed with runoff) or internal (resuspension of bed load) source. However, it is not uncommon to observe in streams subject to stormwater loading a temporary depression in DO during or immediately following a storm event.

More troublesome were the results of the bacteriological and nutrient monitoring data. Analysis of the bacterial data collected at each stream showed evidence of significant bacterial contamination throughout the PR/HB Watershed. The data (presented in Section 3, Table 3.7) is also displayed in Table 4.1. The data show frequent occurrences of elevated fecal coliform (FC) concentrations, with the measured concentrations at times greatly exceeding the State standard for contract recreation. Of particular significance is that many of the elevated readings occurred during both dry weather conditions. It should be noted that between the completion of the field studies and the completion of the final report, the NJDEP uses E.coli as the indicator organism for primary contract recreation waterbodies. Although the fecal coliform data cannot be used to judge the streams' consistency with contact recreation water quality standards, the data nonetheless show both streams being subject to loading under baseflow and wet weather conditions that result in elevated bacteria levels.

Table 4.1 2005 Bacteria Stream Water Quality Monitoring Data

2005 fecal coliform concentrations	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	240	1600	1600	350	1600	110	33	920
ST-2	130	>1600	540	240	1600	110	220	>1600
ST-3	540	>1600	130	240	>1600	130	140	1600
ST-4	170	>1600	350	170	>1600	540	130	540
2005 fecal streptococci concentrations	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	49	>1600	70	540	>1600	240	540	920
ST-2	540	>1600	920	540	1600	920	540	>1600
ST-3	110	>1600	240	170	>1600	240	540	>1600
ST-4	>1600	>1600	350	130	>1600	130	220	920
2005 FC:FS ratios	**6/21/05**	**6/27/05**	**7/6/05**	**8/2/05**	**8/8/05**	**8/22/05**	**9/7/05**	**9/15/05**
ST-1	**4.90**	1.00	**22.86**	0.65	1.00	0.46	0.06	1.00
ST-2	0.24	-	0.59	0.44	1.00	0.12	0.41	-
ST-3	**4.91**	-	0.54	1.41	-	0.54	0.26	<1.0
ST-4	<0.11	-	1.00	1.31	-	**4.15**	0.59	0.59

NOTE: blue text indicates storm event.

The station displaying the greatest frequency of elevated FC was ST-1. Although not entirely consistent in terms of peak FC concentrations, the fecal streptococcus (FS) data collected in concert with the FC data shows similarly elevated conditions. Although the FC:FS ratio is only a moderately accurate indicator metric, the data suggest that animals, rather than humans, are the source of the majority of the measured bacterial contamination.[7]

With regard to Total Phosphorus (TP) and Nitrate-Nitrogen (NO_3-N) data, relatively elevated in-stream concentrations were observed under both baseline and storm conditions (Section 3, Table 3.8 and Table 4.2). Specifically, TP concentrations under both baseflow and storm conditions were consistently above 0.05 mg/L, and the State standard for TP in FW2 streams (0.1 mg/L)

[7] Some sources suggest that a fecal coliform: fecal streptococci ratio >4.0 is an indicator of human sources of fecal contamination; however, USEPA does not currently recommend this as a reliable test. <www.epa.gov/volunteer/stream/vms511.html>

was routinely exceeded at most of the sampling stations. Section 3 provides a more details review of the water quality monitoring data. However, it can be concluded that both Pleasant Run and Holland Brook are impacted by fecal coliform, elevated phosphorus levels and nitrate concentrations indicative of a eutrophic ecosystem.

Table 4.2 Phosphorus (TP) Concentrations Measured in PR/HB

2005 TP concentrations (mg/L)	6/21/05	6/27/05	7/6/05	8/2/05	8/8/05	8/22/05	9/7/05	9/15/05
ST-1	0.09	**0.18**	0.07	0.06	0.07	0.06	0.04	0.06
ST-2	**0.13**	**0.16**	0.09	0.05	**0.14**	0.08	0.06	**0.12**
ST-3	0.09	**0.26**	**0.11**	0.09	**0.94**	0.09	0.09	**1.20**
ST-4	**0.13**	**0.15**	**0.11**	0.08	0.09	0.07	0.06	0.06

NOTE: Blue columns = storm event, red text denotes exceedance of State TP standard.

4.3 Pollutant Loading

Again details of the pollutant loading analysis conducted for Pleasant Run and Holland Brook under existing development and projected development scenarios were presented in Section 3 of this report. To summarize, the GIS LU/LC database modeled annual loads for the five pollutants of concern highlight three important factors that must be addressed as part of any strategy that will evolve through the RSWMP. First, the more developed sub-watersheds generate greater amounts, on a per-unit basis, of phosphorus, heavy metals and sediments than do the more forested or even the agriculture-dominated areas of the watershed. Second, increases in impervious cover also increase the rate and velocity of runoff, contributing to the more efficient mobilization and transport of pollutants and the scour and disruption of the receiving streams. Finally, to address and reduce the existing and future loading of pollutants to both streams the RSWMP must include elements aimed at reducing the overall generation of pollutants (source reduction), along with elements aimed at controlling runoff volumes, rates and pollutant loads. The types of measures needed for the proper long-term management of Pleasant Run, Holland Brook and their respective watersheds must therefore include both Source Control and Delivery Control techniques. Source Control techniques are designed to inhibit pollutant generation. These techniques are typically planning or regulatory in nature and include:

- Ordinances and land development regulations geared toward the protection of open space and the minimization of impervious cover.
- Ordinances and land development regulations that protect riparian areas and corridors by creating conservation areas,
- Ordinances that control pollutant sources (e.g., pet waste management, fertilizer use/restrictions, and waterfowl feeding restrictions.
- Encouragement of low-impact development techniques

Those that are deemed Delivery Control are designed to intercept and treat the pollutant load in some capacity thereby reducing the magnitude of the load discharged to the receiving water; in this case either Pleasant Run or Holland Brook. Such techniques include:

- Restoration of impacted and eroding stream banks,
- Homeowner installed rain barrels,
- Rain gardens and other "small foot print" best management practices,
- Bioretention and bioinfiltration basins, swales and similar structures,
- Reclamation and restoration of impacted stream buffers, riparian areas and floodplains,
- Retrofit and improvement of existing stormwater conveyance system , and
- Regional as well as site-specific stormwater infrastructure retrofits in currently developed areas of the watershed.

As such, the goal of the Pleasant Run/Holland Brook RSWMP is comprehensive stormwater management using measures that include source control and delivery control techniques as well as those intended to restore impacted stream and riparian areas.

The pollutant load data show that increased land disturbance and impervious cover are directly related to water quality problems. Therefore, targeting watershed sources directly linked to increased impervious cover and land disturbance is consistent with achieving the RSWMP's goal of improved water quality. As illustrated in the previous tables, pollutant load analysis can become skewed if the total area of the watershed is overlooked, thus potentially leading to an improper allocation of effort and funding. Although the larger sub-watersheds will innately tend to be the largest source of pollutants, focus needs to be directed to that portion of the load that is truly manageable. For example, a large tract of stable, forested land will generate some amount of TN and TP. On a relative scale for a particular subwatershed this could conceivably be the primary source of pollutant loading. However, time spent trying to reduce this load is ill advised and will not yield any high degree of benefit. As such, it is important when making stormwater management decisions to emphasize for the most part the "manageable" sources of pollutant loading, because on a unit-area basis these are the most significant sources and those most in need of control and reduction. Tables 4.3A, 4.3B, 4.4A and 4.4B provide a breakdown of "manageable" and "non-manageable" sources of TN, TP, TSS, Pb and Zn.

Table 4.3A Existing Manageable (Developed Land) Pollutant Loads (Lbs/Yr) by Municipality

Municipality	Total Acreage	% Watershed Area	Existing Manageable Pollutant Loading			Total Manageable Acres
			TN	TP	TSS	
Branchburg	3,485.27	23.4	6,916.01	577.60	66,779.87	2,796.68
Readington	11,249.35	75.6	19,969.93	1,097.33	2,289,521.88	7,413.02
Clinton	150.02	1	142.63	8.44	18,620.09	54.89
TOTAL	14,884.64	100	27,028.57	1,683.37	2,374,921.884	10,264.59

Table 4.3B Existing Unmanageable (Forest, Water, Wetlands) Pollutant Loads (Lbs/Yr) by Municipality						
Municipality	**Total Acreage**	**% Watershed Area**	**Existing Unmanageable Pollutant Load**			**Total Unmanageable Acres**
			TN	**TP**	**TSS**	
Branchburg	3,485.27	23.4	771.58	28.07	1,094,322.98	688.59
Readington	11,249.35	75.6	4,299.11	233.16	398,200.47	3,836.33
Clinton	150.02	1	87.39	6.90	8,754.65	95.13
TOTAL	14,884.64	100	5,158.08	268.13	1,501,278.10	4,620.05

Table 4.4A Existing Manageable (Developed Land) Pollutant Load (Lbs/Yr)By Subwatershed						
Subwatershed	**Total Acreage**	**Total Manageable Acres**	**% of watershed**	**Manageable Pollutant Load**		
				TN	**TP**	**TSS**
1	2,946.31	2,527.39	85.8	5,137.77	375.09	605,235.57
2	3,287.52	2,885.48	87.8	6,244.64	445.55	715,317.51
3	1,454.44	1,097.08	75.4	2,289.96	166.70	271,796.89
4	2,268.24	1,841.91	82.8	3,583.35	275.83	42,6019.02
5	2,177.08	1,877.54	86.3	4,073.49	327.40	580,553.93
6	2,751.08	2,496.28	90.7	6,085.85	695.25	1,192,915.58
TOTAL	14,884.67	12,725.68	85.5	27,415.06	2,285.82	3,791,838.50

Table 4.4B Existing Unmanageable (Forest, Water, Wetlands) Pollutant Load (Lbs/Yr) By Subwatershed						
Subwatershed	**Total Acreage**	**Total Unmanageable Acres**	**% of Subwatershed**	**Estimated Unmanageable Pollutant Load**		
				TN	**TP**	**TSS**
1	2,946.31	418.92	14.2	335.44	10.61	24,957.43
2	3,287.52	402.04	12.2	236.62	-4.22	8,829.48
3	1,454.44	357.36	24.5	487.07	33.55	52,193.50
4	2,268.24	426.33	18.8	350.81	22.72	31,612.66
5	2,177.08	299.54	13.8	228.17	1.41	11,779.24
6	2,751.08	254.80	9.26	79.22	-2.28	1,523.91
TOTAL	14,884.67	2158.99	14.5	1,717.33	61.79	130,896.22

As illustrated particularly in Tables 4.4A and 4.4B, the central and southern portions of both the Pleasant Run and Holland Brook watersheds tend to have the least amount of unmanageable pollutant sources (e.g., forested land, wetlands, etc.). The northern subwatersheds (3 and 4), tend to be the steeper head water areas and publically owned lands that are not developed and will remain so. Thus, although intuitively the case, the RSWMP should be prioritizing projects in subwatershed 1, 2, 6 and especially 5, and most of the contributing pollutant sources are manageable.

4.4 Projected Future Land Use (Buildout)

Similar to the UAL analysis conducted under existing LU/LC conditions in the watershed, annual pollutant loads were also calculated for projected future development conditions. To estimate future development, a review of current municipal zoning regulations and maps was performed. After compiling the necessary GIS and regulatory data, the restrictions and requirements (i.e., minimum lot size, maximum percent impervious coverage, development type) governing development within each zone in each of the three watershed municipalities were assessed in order to determine the future LU/LC category of each zone assuming full buildout under current zoning regulations.

Next, the GIS database for the watershed was queried to identify any lands with characteristics, such as steep slopes (≥15%), wetlands, FEMA floodplain areas, mines and quarries, and permanently preserved parcels (i.e., county, municipal and Green Acres open space parcels and lands preserved under the NJ Department of Agriculture – State Agriculture Development Committee's Farmland Preservation program), that render that land unsuitable and/or unavailable for development. These lands were considered "undevelopable," and as such were assigned LU/LC categories identical to their existing categories.

In contrast, lands without development constraints such as those described above were considered "developable", and were reclassified according to the land uses each would have if built out fully to the most intensive state possible under current zoning. Based on this methodology, it was determined that a total of 11,134.83 acres in the PRHB Watershed is available for development. The remaining 3,749.84 acres were considered "undevelopable", either because these lands are part of a permanently protected open space or farmland preservation parcel, or because steep slopes, wetlands or other unsuitable conditions preclude development. A breakdown of these developable and undevelopable lands by subwatershed is provided in Table 4.5, with details of the respective loads in Tables 4.6 and 4.7.

Table 4.5 Developable Lands in the PR/HB Watershed, by Subwatershed					
Sub-watershed	**Total Acreage**	**Developable Acres**	**Percent Developable**	**Protected/ Undevelopable Acres**	**Percent Undevelopable**
1 (HB-Central)	2,946.3	2,140.7	**73%**	805.6	**27%**
2 (PR-Central)	3,287.5	2,404.2	**73%**	883.3	**27%**
3 (PR-North)	1,454.4	1,081.7	**74%**	372.7	**26%**
4 (HB-North)	2,268.2	1,733.6	**76%**	534.7	**24%**
5 (PR-South)	2,177.1	1,443.8	**66%**	733.3	**34%**
6 (HB-South)	2,751.1	2,330.9	**85%**	420.2	**15%**
TOTAL WATERSHED	**14,884.6**	**11,134.9**	**75%**	**3,749.8**	**25%**

Table 4.6 Projected TN, TP and TSS Loads (Lbs/Yr) Future Development Conditions								
Sub-watershed	**Total Acreage**	**% Total Area**	**Future TN Load**	**% Future TN load**	**Future TP Load**	**% Future TP Load**	**Future TSS Load**	**% Future TSS Load**
1 (HB-Central)	2,946.3	**19.7**	5,473.22	**18.79**	385.71	**16.43**	630,193.01	**16.06**
2 (PR-Central)	3,287.5	**22.09**	6,481.26	**22.25**	441.33	**18.80**	724,146.99	**18.45%**
3 (PR-North)	1,454.4	**9.7**	2,777.03	**9.53**	200.25	**8.53**	326,247.60	**8.31**
4 (HB-North)	2,268.2	**15.24**	3,934.16	**13.50**	298.55	**12.72**	457,631.69	**11.66**
5 (PR-South)	2,177.1	**14.63**	4,301.65	**14.77**	328.81	**14.01**	592,333.17	**15.09**
6 (HB-South)	2,751.1	**18.48**	6,165.07	**21.16**	692.96	**29.52**	1,194,439.50	**30.43**
TOTAL WATERSHED	**14,884.7**	**100**	29,132.38	**100**	2,347.60	**100**	3,924,991.95	**100**

Table 4.7 Projected Lead and Zinc Loads (Lbs/Yr) Future Development Conditions							
Sub-watershed	**Total Acreage**	**% Total Area**	**Future Pb Load**	**% Future Pb Load**	**Future Zn Load**	**% Future Zn Load**
1 (HB-Central)	2,946.3	**19.79**	1,438.55	**19.89**	1,437.88	**20.05**
2 (PR-Central)	3,287.5	**22.09**	1,608.03	**22.23**	1,606.23	**22.40**
3 (PR-North)	1,454.4	**9.77**	720.88	**9.97**	720.88	**10.05**
4 (HB-North)	2,268.2	**15.24**	1,158.55	**16.01**	1,157.78	**16.15**
5 (PR-South)	2,177.1	**14.63**	958.91	**13.26**	954.71	**13.31**
6 (HB-South)	2,751.1	**18.48**	1,348.22	**18.64**	1,293.19	**18.03**
TOTAL WATERSHED	**14,884.7**	**100**	**7,233.14**	**100**	**7,170.67**	**100**

A comparison was made between estimated current pollutant loading and pollutant loading under future development conditions, given the assumptions described above (Table 4.8-4.12). As detailed in Section 3, the results showed an increase by 12% for TP (Table 4.9) to over 100% for lead and zinc (Tables 4.11 and 4.12). The estimated increase in TSS loads, however, was calculated to be only just over 1% (table 4.10), while TN is projected to actually <u>decrease</u> by approximately 9.5% (Table 4.8). The basis for this seemingly counterintuitive prediction was concluded to be the anticipated transition of a significant portion of agricultural lands to residential development. This is both consistent with the history of development in the PR/HB watersheds and is predicted to be the case based on current municipal zoning regulations. Assuming that much of the current agricultural land will transition to low-density residential development means that intensive use of high-nitrogen fertilizers commonly associated with farm fields, as well as soil erosion due to agricultural activities (including grazing animals), will decrease, resulting in lower or comparable TN and TSS concentrations under buildout conditions. As noted above, however, other pollutants of concern, such as TP, Pb and Zn, are likely to increase under buildout conditions because of their high correlation with urbanized lands. It must also be stressed that in-stream concentrations of TSS could actually increase, even if the land-based load is decreased. This could occur under a scenario where increased total flows or increased peak flows would contribute to the scour of the stream channel and exacerbate bed and bank erosion of the Pleasant Run and Holland Brook. Although detention basins can mitigate some of these problems, as demonstrated by NJDEP and Hunterdon County (1986) in the nearby South Branch Rockaway Creek drainage, it is also possible for multiple basins to actually worsen the problem. These scenarios underscore the importance of improved management and treatment of stormwater-based NPS pollution in the watershed, particularly in the specific subwatersheds likely to experience the greatest future water quality impacts, to mitigate these anticipated increased pollutant loads. In addition, a desire on the part of the watershed municipalities (especially Readington Township) to maintain the rural/agricultural landscape that largely defines the community may stimulate efforts to protect additional agricultural lands through farmland preservation programs. To reduce the nutrient and TSS loads that go hand-in-hand with these agricultural operations, opportunities to implement and fund agricultural BMPs, such as riparian buffer creation/maintenance, manure management programs and soil-conserving tilling practices, will be identified in the RSWMP.

Table 4.8 Change in TN Loading (Lbs/Yr) Existing to Future Development Conditions

Sub-watershed	Total Acreage	Existing TN Load	Future TN Load	Change In TN Load	Percent Change
1 (HB-Central)	2,946.3	6,654.92	5,473.22	**-1,181.70**	-17.76
2 (PR-Central)	3,287.5	7,848.88	6,481.26	**-1,367.62**	-17.42
3 (PR-North)	1,454.4	2,919.20	2,777.03	**-142.17**	-4.87
4 (HB-North)	2,268.2	4,128.13	3,934.16	**-193.97**	-4.70
5 (PR-South)	2,177.1	5,023.20	4,301.65	**-721.55**	-14.36
6 (HB-South)	2,751.1	5,612.46	6,165.07	**+552.61**	+9.85
TOTAL WATERSHED	**14,884.7**	**32,186.79**	**29,132.38**	**-3,054.41**	**-9.49**

Table 4.9 Change in TP Loading (Lbs/Yr) Existing to Future Development Conditions

Sub-watershed	Total Acreage	Existing TP Load	Future TP Load	Change in TP Load	Percent Change
1 (HB-Central)	2,946.3	374.06	385.71	**+11.65**	+3.11
2 (PR-Central)	3,287.5	452.23	441.33	**-10.90**	-2.41
3 (PR-North)	1,454.4	181.79	200.25	**+18.46**	+10.15
4 (HB-North)	2,268.2	278.26	298.55	**+20.29**	+7.29%
5 (PR-South)	2,177.1	354.04	328.81	**-25.23**	-7.13
6 (HB-South)	2,751.1	442.15	692.96	**+250.81**	+56.73
TOTAL WATERSHED	**14,884.7**	**2,082.53**	**2,347.60**	**+265.07**	**+12.73**

Table 4.10 Change in TSS Loading (Lbs/Yr) Existing to Future Development Conditions					
Sub-watershed	**Total Acreage**	**Existing TSS Load**	**Future TSS Load**	**Change in TSS Load**	**Percent Change**
1 (HB-Central)	2,946.3	695,707.31	630,193.01	**-65,514.30**	-9.42
2 (PR-Central)	3,287.5	771,657.61	724,146.99	**-47,510.62**	-6.16
3 (PR-North)	1,454.4	369,212.23	326,247.60	**-42,964.63**	-11.64
4 (HB-North)	2,268.2	536,215.10	457,631.69	**-78,583.41**	-14.66
5 (PR-South)	2,177.1	700,042.70	592,333.17	**-107,709.53**	-15.39
6 (HB-South)	2,751.1	803,380.92	1,194,439.50	**+391,058.58**	+48.68
TOTAL WATERSHED	**14,884.7**	**3,876,215.87**	**3,924,991.95**	**+48,776.08**	**+1.26**

Table 4.11 Change in Pb Loading (Lbs/Yr) Existing to Future Development Conditions					
Sub-watershed	**Total Acreage**	**Existing Pb Load**	**Future Pb Load**	**Change in Pb Load**	**Percent Change**
1 (HB-Central)	2,946.3	518.36	1,438.55	**+920.19**	**+177.52**
2 (PR-Central)	3,287.5	695.14	1,608.03	**+912.89**	**+131.32**
3 (PR-North)	1,454.4	280.65	720.88	**+440.23**	**+156.86**
4 (HB-North)	2,268.2	547.82	1,158.55	**+610.73**	**+111.48**
5 (PR-South)	2,177.1	493.89	958.91	**+465.02**	**+94.15**
6 (HB-South)	2,751.1	977.19	1,348.22	**+371.03**	**+37.97**
TOTAL WATERSHED	**14,884.7**	**3,513.05**	**7,233.14**	**+3,720.09**	**+105.89**

Table 4.12 Change in Zinc Loading from Existing to Future Development Conditions					
Sub-watershed	**Total Acreage**	**Existing Zn Load**	**Future Zn Load**	**Change in Zn Load**	**Percent Change**
1 (HB-Central)	2,946.3	514.11	1,437.88	**+923.77**	**+179.68**
2 (PR-Central)	3,287.5	677.65	1,606.23	**+928.58**	**+137.03**
3 (PR-North)	1,454.4	280.05	720.88	**+440.83**	**+157.41**
4 (HB-North)	2,268.2	541.56	1,157.78	**+616.22**	**+113.79**
5 (PR-South)	2,177.1	469.24	954.71	**+485.47**	**+103.46**
6 (HB-South)	2,751.1	948.52	1,293.19	**+344.67**	**+36.34**
TOTAL WATERSHED	**14,884.7**	3,431.13	**7,170.67**	**+3,739.54**	**+108.99**

5.0 PLEASANT RUN AND HOLLAND BROOK RSWMP OBJECTIVES

Within this section of the RSWMP report "drainage area-specific water quality, groundwater recharge and water quantity objectives" are identified and discussed, as required by N.J.A.C. 7:8-3.5 and N.J.A.C. 7:8-2.2. Specifically the objectives of the Pleasant Run and Holland Brook RSWMP focus on "the elimination, reduction, and minimization of stormwater related impacts associated with new and existing land uses". Factors concerning environmental, social, and economic factors of the Pleasant Run/Holland Brook (PR/HB) watersheds were taken into consideration in the development of this RSWMP. Furthermore in developing the objectives and related recommendations of the plan, the Design and Performance Standards for Stormwater Management Measures as outlined in N.J.A.C. 7:8-5 were consulted and used as guidance.

Although the water quality of both streams, as documented in Sections 3 and 4, is impacted and the biota of the streams have been compromised, the NJDEP has not yet developed TMDLs for any contaminant detected in Pleasant Run or Holland Brook, including fecal coliform and total phosphorus. As noted in Section 2, both waterbodies do appear on the NJDEP 2006 303(d) List of Impaired Waterbodies related to pathogens and general aquatic life impairments (pollutants unknown) (NJDEP 2006). The drainage area objectives presented herein as a minimum specifically address pathogens, phosphorus, TSS, and other common pollutants that threaten and impair the water quality of these streams and impact their ability to consistently meet State water quality standards. The following provides an outline of the Water Quality Objectives and the means by which these objectives are to be satisfied. The objectives in general call for a reduction in nutrient, sediment and bacteria inputs to the streams.

5.1 Water Quality Objectives

1. **Objective**: **Address nutrient loading in watersheds**
   a. Goal: Reduce nutrient loading and meet water quality standards for nutrients
   b. Measures:
      i. Outreach and education: manure management, septic management, and proper landscaping techniques
      ii. NRCS programs
      iii. Riparian buffer improvements
      iv. Stormwater retrofits
   c. Sites:
      i. Riparian buffer improvements along the PR and HB (main stem and tributaries)
      ii. Stormwater retrofits of basins and outfalls that discharge along the PR and HB (main stem and tributaries)

2. **Objective**: **Address sediment loading to streams**
   a. Goal: Reduce transport of sediment, litter and debris

b. Measures:
   i. Install NJCAT-certified manufactured treatment devices (MTDs) and retrofits of outfalls that discharge to PR or HB
   ii. Streambank stabilization
   iii. Require, enforce and improve vegetated buffers (minimum 100ft width)
   iv. NRCS farmer-friendly programs

c. Sites:
   i. Stormwater retrofits of basins and outfalls that discharge to the PR and HB
   ii. Streambank stabilization projects along PR and HB

3. Objective: Address pathogen impairments in the watershed

a. Goal: Reduce bacterial loading to streams and meet water quality standards for pathogens

b. Measures:
   i. Manure management education
   ii. Septic management education
   iii. NRCS programs
   iv. Riparian buffer improvements

c. Sites:
   i. Watershed-wide
   ii. Riparian buffer improvements along the PR and HB (main stem and tributaries)

4. Objective: **Address conditions for aquatic life**

a. Goal: Meet water quality standards for sediment, nutrients, dissolved oxygen and maintain suitable temperatures for aquatic life

b. Measure:
   i. Outreach and education: septic, livestock and manure management
   ii. Reduction of chloride contaminants
   iii. Stream buffer improvements
   iv. Stream restoration projects
   v. Stormwater infrastructure retrofits

c. Sites:
   i. Watershed wide
   ii. Retrofits of basins and outfalls that discharge to the PR and HB

5. Objective: **Raise awareness of watershed municipalities and residents**

a. Goal: Prepare education and outreach materials and engage residents

b. Measure:
   i. Press releases and mailings
   ii. Encourage backyard retrofits (low fertilizers, rain gardens, native vegetation, etc.)

iii. Public workshops and seminars on septic, livestock and manure management

c. Sites: watershed wide

5.2 Water Quantity Objectives

The objective of the water quality management deals directly with the elimination of chronic areas of flooding within the PR/HB watershed. These are mostly road crossings where the runoff conveyance capacity of the existing drainage system is routinely exceeded leading to flooding problems that create public safety and welfare problems (Table 5.1). However, flood control is not the only goal of these objectives. These objectives also deal with decreasing the volume of runoff. This benefits a wide array of stormwater management goals including reduction in pollutant loading, reduction in stream scour and erosion and mitigation or compensation for historic alterations in the base flow regimes of both Pleasant Run and Holland Brook.

1. Objective: **Address flooding issues**

a. Goal: Reduce flood levels

b. Measures:

i. Require during the redevelopment of any pre-developed site that the recharge volume standard be 110% of pre-existing (pre-developed) conditions

ii. In depth hydraulic/hydrologic analysis of PR and HB

iii. Develop reference sites or benchmarks on both PR and HB in order to develop long term data gathering such as stream flow and channel analysis for hydrology studies

iv. Disconnect and minimize impervious surfaces through LID

b. Sites:

i. All development sites

ii. Sites with flooding issues (see Appendix A)

5.3 Groundwater Recharge Objectives

As is the case with the flood control objectives, the primary purpose and goal of the groundwater recharge objectives is to reduce the volume of runoff. In the case of these objectives, the focus is placed on minimizing runoff by increasing the opportunity for groundwater recharge. The primary positive impact that this has on the PR/HB ecosystem is stabilization of baseflow and maintenance of the hydrologic attributes of the streams' riparian and wetland systems. Again, a reduction in runoff will benefit water quality by reducing the amount of pollutants mobilized and transported into the streams and reducing scour potential by reducing the volume of water in the streams' channels during storm events.

1. **Objective**: **Address groundwater recharge**

a. Goal: Increase groundwater recharge potential

b. Measure:

i. Groundwater- well head protection ordinance
ii. Groundwater recharge education
iii. Groundwater recharge outreach: backyard retrofits (rain gardens, landscaping, etc.)
iv. Require during the redevelopment of any pre-developed site that the recharge volume standard be 110% of pre-existing (pre-developed) conditions

c. Sites:
i. Watershed wide
ii. All development sites

Sections 6 and 7 which follow provide details of the measures and projects activities proposed for implementation that will satisfy the management and restoration objectives outlined above.

Table 5.1 Flood-Prone Sites Within the Pleasant Run/Holland Brook Watershed

ID #	Location	Identified Problem	Municipality	Source of info
1	CR 629 - from the Hillcrest Road intersection to mail box #105	flooding	Readington	Hunterdon County Engineering Dept.
2	CR 629 - Barley Sheaf Road intersection	flooding	Readington	Hunterdon County Engineering
3	CR 629 - 100 yds west of the Cole Road intersection	flooding	Readington	Hunterdon County Engineering
4	CR 629 - 200 yds east of the County Route 523 intersection extending 1240 feet to mail box #15	flooding	Readington	Hunterdon County Engineering
5	CR 629 - 200 yds east of State Highway 202	flooding	Readington	Hunterdon County Engineering
6	Between State Highway 202 and Craig Road	undersized cross-drain	Readington	Hunterdon County Engineering
7	CR 620 - near the Readington Reformed Church	Runoff from church onto road; 1100 feet east of the church, westbound lane, swale drains to basin, overflows roadway	Readington	Hunterdon County Engineering
8	CR 620 - Hillcrest Road intersection	flooding	Readington	Hunterdon County Engineering
9	CR 620 - crossing at the Readington Post office	flooding	Readington	Hunterdon County Engineering

10	CR 620 - Holland Brook Road intersection	flooding	Readington	Hunterdon County Engineering
11	CR 629 – intersection with Cole Rd and west	flooding	Readington	Readington DPW
12	CR 629 – along Springtown Road, north from intersection	flooding	Readington	Readington DPW
13	Rockafellow's Mill Road, south from intersection with River Ave.	flooding	Readington	Readington DPW
14	Along Holland Brook Road between Kosciuszko Road and Pine Bank Road	flooding	Readington	Readington DPW
15	Along Stanton Station Road, west of intersection with Lilac Drive	flooding (note: "We put barricades on our side; Raritan puts out on their side."	Readington	Readington DPW
16	Along Mountain Road, just north of intersection with Weather Hill Ct.	flooding	Readington	Readington DPW
17	State Rt 22 between Green Gate Rd and Far Knoll Lane	flooding (note: "Westbound only usually; NJDOT detours usually."	Readington	Readington DPW
18	Along Mill Road, north from intersection with Mill End Road	flooding	Readington	Readington DPW
19	Along Lamington Road where it crosses Rockaway Creek (north of intersection with Ryland Road)	flooding	Readington	Readington DPW
20	Along Island Road where it crosses Rockaway Creek	flooding	Readington	Readington DPW

6.0 SOURCE CONTROL TECHNIQUES (PERFORMANCE STANDARDS, PLANNING STRATEGIES ORDINANCES/REGULATIONS AND PUBLIC AWARENESS)

With the adoption of the RSWMP the review of site development, re-development and site disturbance projects occurring within the watershed will incur greater scrutiny to ensure compliance with the N.J.A.C. 7:8-5, Design and Performance Standards for Stormwater Management Measures, or in the cases of non-compliance, the implementation of suitable mitigation measures.

6.1 Stormwater Design Performance Standards

This section presents the regulatory standards that will be mandated by law under NJAC 7:8-3.6 upon NJDEP adoption of the Pleasant Run - Holland Brook Watersheds Regional Stormwater Management Plan. Both the Pleasant Run (PR) and Holland Brook (HB) appear on the 2006-2008 New Jersey State 303(d) List for Water impairments to general aquatic life (macroinvertebrates) from unknown pollutants. As discussed previously in Section 2.0 these impairments may be caused by sediment loading, nutrients, and/ or pathogens as well as hydrology variations. The standards outlined below are based on the NJDEP Stormwater Best Management Practices (BMP) Manual for bioretention systems.

- Nutrients - Nutrient loading will be addressed by mandating a standard removal rate of 60% (or greater) for total phosphorus and 30% (or greater) for total nitrogen.
- Groundwater Recharge - Another main concern is the varying surface water flow that has been observed in the past decade as development has increased; flooding and loss of base flow has become increasingly common. Because of this “flashiness”, stream bank erosion and loss of aquatic habitat is a concern in the watershed. A 110% recharge standard will be required for all development.
- Total Suspended Solids - Sediment transport and impairment will be addressed by mandating a total suspended solids removal rate of 90% (or greater) from stormwater runoff for all development, including redevelopment.
- Pathogens - It is noted that Pleasant Run appears on the 2006 New Jersey State 303(d) List for pathogen impairments. In addition, elevated levels of pathogens were detected in both streams in 2005. Reducing pathogen concentrations will be addressed in both Section 6.0 (regulatory) and 7.0 (voluntary) of this RSWMP. Emphasis on pathogen removal will be made in Section 7.0 so that 319(h) funding can be used to install structural BMPs and implement educational measures that can be used to abate bacterial loading to the streams. For instance, pathogen sources can be addressed by pursuing farming initiatives such as NRCS incentive programs and the North Jersey Resource Conservation and Redevelopment (NJRC&D) River Friendly Farming Programs that address livestock and manure management or promote riparian buffer planting. These types of projects will protect water quality and preserve the agricultural resources and character of the watersheds.

6.2 Recommended Ordinances

6.2.1 Groundwater-Wellhead Protection Ordinance

Rationale

Groundwater is a critical natural and economic resource for New Jersey. It is the state's most frequently used source of drinking water; in addition to being an integral part of the hydrologic system and contributing source to stream base flow, groundwater is vitally important for fish, wildlife, and recreation. The purpose of this section is to note the connection between groundwater, drinking water supplies, base flow of streams and flooding. Groundwater discharges to surface waters, making significant contributions to stream base flow. Impervious surfaces, such as roads, sidewalks, rooftops and even large expanses of turf grass typical of golf courses, disrupts the natural hydrologic cycle and impedes precipitation from infiltrating into the ground; the result of which is a reduction in groundwater and aquifer recharge and supply to surface waters. During storms, impervious surfaces deliver precipitation directly to streams as either sheet flow or via stormwater outfalls. The runoff enters the stream without treatment and, as a result, is a source of water pollution. Furthermore, the increase in impervious surfaces in otherwise forested or wetland areas has increased the amount of stormwater runoff and is a reason why the communities of New Jersey have been witnessing an increase in localized flooding in residential areas.

In recent years, residents of Readington Township have expressed concern over the loss of baseflow of the Pleasant Run and Holland Brook and the increased frequency of flooding in these same stretches of stream. Long time residents report that flooding and loss of baseflow was not as common an occurrence as it has recently become. Groundwater protection is needed to safeguard water supplies and preserve baseflow in the Pleasant Run and Holland Brook watersheds. In addition, a wellhead protection ordinance will help to safeguard groundwater resources that serve as drinking water supplies from becoming contaminated by metals, pesticides and other dangerous chemicals.

Localized flooding commonly occurs on residential streets directly downstream of the Stanton Ridge Golf Course in headwaters sections of both the PR and HB. Conversely, these areas commonly dry up under baseflow conditions. It may be that the golf course and housing development is, in fact, compromising the groundwater resources of the watersheds. This "flashiness" in stream flow, depreciated stream levels under baseflow conditions and elevated stream levels under storm conditions, is deteriorating the health of the watershed, threatening human safety and jeopardizing infrastructure like bridges and stormwater outfalls. The Hunterdon County Engineering Department and Readington Township Department of Public Works have listed several locations of flooding in the watershed; this list is included in Table 5.1.

The purpose of a wellhead protection ordinance is to protect a community's groundwater drinking supply from threats of contamination from commercial, industrial, residential, agricultural and municipal land uses. Wellhead protection ensures a supply of safe and pure drinking water; it preserves both the quality and quantity of drinking water. A wellhead protection area is the area of land surrounding each public community water supply well, public non-community water supply well, or cluster of domestic wells. Because contaminants can migrate through the ground, areas that store drinking water supplies need to be delineated and mapped as to ensure that potential sources of contamination will not be located in these areas. Land use, physical facilities and other activities that are located in the delineated wellhead area need to be regulated to reduce the potential for groundwater contamination.

The Groundwater-Wellhead Protection Ordinance that is recommended as a model for this RSWMP is from the Hunterdon County Environmental Toolbox, see Appendix E. The model ordinances of the Hunterdon County Environmental Toolbox are science-based and have been created to ensure environmentally sound development within the County. Though the model ordinance specifies the protection of wellhead areas, it also states that the protection of groundwater is integral to the quality and quantity of surface flow. Therefore, this model is an adequate means of addressing groundwater both as a water resource and as a drinking water resource through one concerted ordinance for the PR and HB watersheds.

In addition to adopting a groundwater-wellhead protection ordinance, proper planning should be implemented in the watershed communities. Groundwater protection should be explained and promoted in the master plan of each municipality. Site plan review should promote low impact development (LID) that uses infiltration and recharge technologies and reduces and disconnects areas of impervious surfaces. Municipalities should comply with the New Jersey State Basic Requirements (SBR) for solids and floatable controls, maintenance yard operations and employee training in order to prevent the contamination of groundwater supplies.

Implementation Strategy

An ordinance that outlines groundwater and wellhead protection should be implemented by the watershed municipalities within 12 months of NJDEP adoption of the RSWMP. The model ordinance drafted by Hunterdon County Planning Board is an appropriate model that can be adopted by watershed municipalities. However, it should be revised to address the importance of groundwater protection and aptly re-titled.

6.2.2 Improper Disposal of Waste Ordinance

Rationale

This RSWMP strongly recommends that the watershed municipalities comply with the SBRs (Appendix D) for addressing improper disposal of waste as related to sources of bacterial contamination. Readington has addressed these elements of the SBR by adopting a Stormwater Pollution Prevention Plan that includes ordinances prohibiting wildlife feeding, detecting and eliminating illicit connections to the municipality's MS4 and requiring owners and keepers of pets to dispose of their pet's waste properly. A related set of ordinances or similar pollution prevention plan adopted by all watershed municipalities is strongly encouraged to address and abate the pathogen contamination of the PR and HB.

Prohibiting wildlife feeding discourages certain target species such as Canada geese and other waterfowl from congregating and overwintering. It is well documented that waterfowl, Canada geese especially, are a significant source of fecal contamination in New Jersey's streams, lakes and ponds. Illicit connection detection and elimination will also help address and remediate a pathogen contamination in the watershed. Since these connections are hooked up directly with a stormwater conveyance system that discharges directly to a stream without treatment, human sewage may be directly entering the PR and HB. And finally, disposing pet wastes properly will reduce the chances of it washing away with rain and directly into a nearby stream or through a stormwater drain without treatment.

Implementation Strategy

Ordinances that address improper disposal of waste such as illicit connection detection and elimination, wildlife feeding and pet waste will be adopted by municipalities within 6 months of RSWMP adoption.

6.3 Reduction of Chloride-Related Contaminants

Rationale

The most commonly used and effective means of keeping road conditions safe under icy and snowy conditions involves the application of sodium chloride (NaCl or salt). This deicing agent is readily available and inexpensive. However, road salt is released into the environment as it runs off impervious surfaces into adjacent soils and nearby waterbodies or percolates into the groundwater. There is no natural removal mechanism for NaCl in fresh surface waters. Additionally numerous studies have documented that over time residual road salt accumulates in the soils of drainage ditches or in the discharge swales of stormwater catch basins. These salts in turn may leach out into the groundwater over time or during periods of heavy rains. Salt is also released into the environment from other sources the most notable salt storage piles, salt loading areas, car and truck washing areas, and sites where large amounts of snow is stock piled over the winter. Studies completed by various groups including New York State Department of Transportation, USEPA, Environment Canada, and Minnesota have shown that chloride containing compounds negatively impact soils, vegetation, aquatic biota, water quality (both surface and groundwater), and drinking water supplies in addition to causing corrosion to vehicles, bridges and other infrastructure.

Though NaCl is inexpensive and efficient in melting and preventing ice and snow accumulation on roads, its impacts to the environment and infrastructure (though corrosion) can be significant. There are alternatives to traditional road salt; however, the alternatives tend to be much more expensive and would cause municipalities to cover additional costs to address modified storage, handling, equipment and spreading operations. Some alternatives appear to be viable options; however, a greater understanding of the extent of the environmental and infrastructure impacts of NaCl alternatives still needs to be investigated.

Roadway deicing and salt management reduction will be addressed through this RSWMP in order to minimize potential impacts to the natural resources of the PR and HB watersheds. Watershed municipalities will adhere to the SBRs (see Appendix D) for de-icing material storage. In addition, all catch basins located along treated roadways that run parallel to or cross the PR and HB and their tributaries should be surveyed and evaluated for potential inlet retrofits that filter out salts and sediment. Watershed municipalities should adopt a Best Management Practice (BMP) protocol for storage and application of road salt. Included in Appendix F is a document for salt use created for Minnesota (2006) that details various BMP practices for salt applications and storage. This document recommends deicing BMPs that incorporate the following principles:

1. Right Material- will depend on the conditions being treated: when pavement temperature is very cold, materials with low working temperature or mixtures of materials may be more appropriate.
2. Right Amount- of materials also depends on conditions, such as the amount of residual chemical on the pavement surface, the expected pavement temperature and the amount of precipitation expected.
3. Right Place- placement of materials is important in doing the job and not wasting product. This requires the right equipment and trained operators.
4. Right Time- timing is important to minimize waste and maximize effectiveness. If temperature pavement is above freezing, salt may be ineffective and should not be applied.

The incorporation of salt brines within the deicing protocols is recommended in the Minnesota report, and has been recommended in workshops sponsored by the NJWSA and implemented by local communities, such as Princeton Township. Studies indicate that less salt is used in the brine format than if municipalities rely on solid forms of salt. Several other items should be noted in deicing application, some examples include: (1) the use of proper equipment like a pavement temperature sensor; (2) an instrument that controls the rate of salt application; (3) storm and weather tracking to provide guidance and assist in making snow and ice control decisions by officials and operators; and (4) taking special precautions near systems such as wetlands and streams, which are sensitive to salt. Communication between municipal employees and officials is key. Figure 6.1 illustrates an appropriate procedure and decision making tree for the application deicing products.

Exhibit 6.1. De-icing application procedure schematic

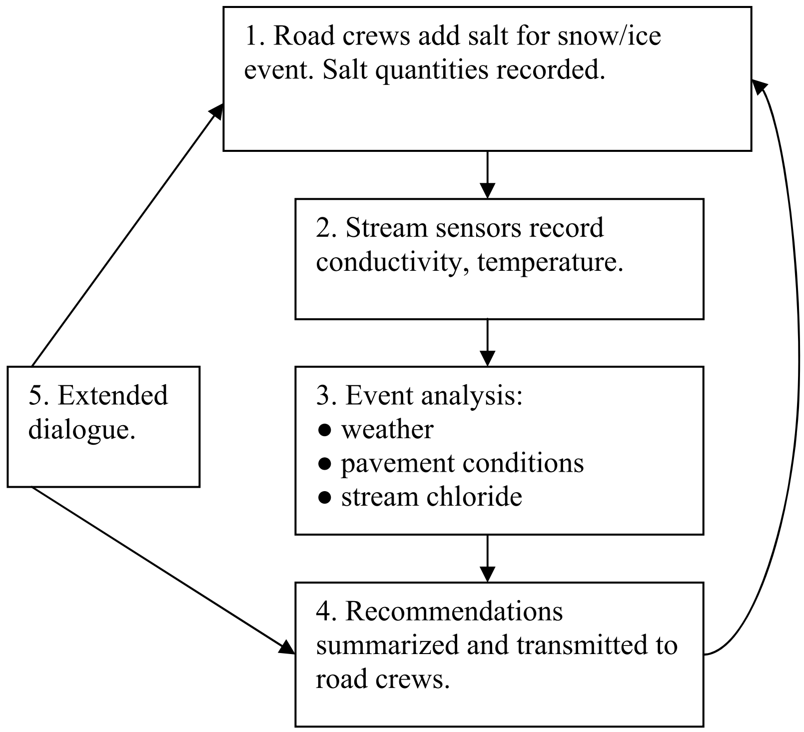


Figure from Baker 2007.

Implementation Strategy

Watershed municipalities will adopt and will implement a BMP document for deicing material storage and application within 12 months of NJDEP approval of this RSWMP. The BMP document should outline protocols that protect sensitive areas, supervising and training staff and maintaining equipment. Appendix F also contains a winter salt management plan used by Minnesota Department of Environmental Quality that provides good information for municipalities to use as a resource.

6.4 BPU/PSE&G Utility Line Maintenance

Rationale

For the past several years, PSE&G power line maintenance has resulted in a number of environmental impacts at stream and wetland crossing. Utility lines traverse forest, wetlands, grasslands, stream corridors and open space tracts within the PR and HB watersheds. The clearing of vegetation in the manner often implemented as part of this maintenance results in increased runoff and sediment loading; both of which are inconsistent with the overall goals of the PR/HB RSWMP. Improper clearing of these lands can degrade water quality by removing riparian vegetation and disturbing soil. The clearing also alters and degrades the habitat value and attributes of the affected streams, wetlands and riparian areas by decreasing shading, increasing sediment deposition and increasing the opportunity for the colonization of invasive species. This has raised the concerns of many residents and representatives of the region's municipalities, including Readington Township.

It is necessary for representatives of PSE&G and NJ BPU to meet with watershed municipalities to discuss details of maintenance and clearing practices. Current regulations call for clearing all vegetation within 90 feet from the center line on both sides of the power line. This means that a total width of 180 feet of vegetation from the ground up will be disturbed and cleared during utility line maintenance. Municipalities should be given proper notification of maintenance dates prior to initiation of related activities.

Though PSE&G has been willing to meet with municipal representatives in the past to identify certain locations within Readington Township to avoid, the need for cooperation is still urged, especially in regard to sensitive areas like riparian corridors and wetlands. Furthermore, it is evident that current clearing employs tree-topping- a practice that does not invoke any aesthetic value and is a questionable maintenance practice in terms of tree health. If tree topping continues in stream corridors, water temperature can increase due to loss of canopy cover. The loss of cover to waterbodies is an unquestionable threat to aquatic health and deterioration of riparian habitat. Appropriate pruning practices need to be utilized by maintenance personnel to prevent detrimental damage to vegetation and the surrounding system. Soil erosion due to utility line maintenance needs to be avoided. The outright removal of vegetation undoubtedly disturbs soil and causes erosion in environmentally sensitive areas such as stream corridors.

Implementation Strategy

Formal, public meetings between utility and municipal representatives should take place prior to any maintenance occurs. Utility maintenance plans should be shared with municipalities who can then discuss with local and county planning boards for review and comment. Specific sites such as stream corridors and wetlands should be left uncompromised. In addition, it is recommended that the formation of a county-wide subcommittee comprised of municipal representatives, county employees and other pertinent groups be initiated. This committee should be formed within 9 months of adoption of this RSWMP. All municipalities in the region should be invited to join and participate. By involving the municipalities of the region, then tactics and contacts can be shared.

6.5 Education

Rationale

6.5.1 Groundwater Recharge

Each municipality has been issued an MS4 permit that requiring the distribution of educational materials on stormwater management. Another MS4 permit requirement is that each municipality must host an annual event to promote stormwater management education. Awareness of role of groundwater recharge in stormwater management is an element of this RSWMP that would strongly benefit from additional education and outreach efforts. It is encouraged that municipalities implement and promote unique, user-friendly strategies such as disconnecting impervious surfaces, landscaping techniques and installing BMPs such as bioretention cells or infiltration devices like rain gardens in suitable areas.

It is recommended that municipal employees, officials and watershed residents learn why groundwater recharge is important and how groundwater supplies can become contaminated. Appropriate outreach materials for both municipal representatives and residents should be distributed; workshops should be held to further train municipal employees to aid in their education and train residents in landscaping techniques. The non-profit group, The Groundwater Foundation, has a searchable website (http://www.groundwater.org/) that provides toolkits, brochures and other educational materials that could be distributed or used as a model for township action. This group also offers community opportunities for local involvement; a program called the Groundwater Guardian could be an appropriate type of tool used as a stepping stone to addressing groundwater recharge education in the watershed municipalities. Appendix G provides an example of an applicable brochure that educates the public about groundwater issues.

6.5.2 Regional Stormwater Forum

The field of stormwater management is ever-changing: new technologies to treat stormwater and advances in infiltration techniques are being developed and need to be communicated within the field. Stormwater regulations are another topic that requires professionals and officials in which to keep current. Other issues like enforcement may challenge some municipal and county officials in implementing stormwater measures. These topics can be discussed in a cooperative forum between municipal and county officials, engineers, as well as volunteer groups, technical consultants and others. Through this RSWMP, it is strongly encouraged that a Regional Stormwater Forum be formed in order to create a committee that discusses advances in technologies, changes in regulations, avenues for public involvement and other topics that face the communities of the region. Opportunities and ideas for workshops and conferences that offer continuing education for municipal employees are other priority issues that can be incorporated into the mission of such a forum. The focus of the Regional Stormwater Forum should include enhancing opportunities for stormwater management measures by improving communication among organizations, promoting partnerships, identifying financial resources, and broadening awareness of stormwater pollution throughout the region's environmental community.

Implementation Strategy

Groundwater Education

- A groundwater education program should be outlined by watershed municipalities in a groundwater education plan. This plan should be drafted within 12 months of RSWMP adoption. Implementation of the education plan should begin 18 months following RSWMP adoption.

Regional Stormwater Forum

- Work towards forming a Regional Stormwater Forum should be initiated immediately following the adoption of the RSWMP by NJDEP and, subsequently, the first meeting should take place no later than three months afterward.

6.6 Redevelopment using LEED and LID

Rationale

Cities across the nation including Seattle and Portland, Oregon and communities in Maryland are "going green" and installing LEED (Leadership in Energy and Environmental Design) and LID (Low Impact Development) techniques to reduce water consumption and manage stormwater runoff. The NJ Stormwater Rules require LID for new major developments. These approaches are designed to utilize soils and vegetation as the primary vehicles for infiltration, evapo-transpiration and stormwater reuse, thus preserving the hydrologic cycle, rather than utilizing the traditional collection, conveyance and storage structures. Watershed municipalities are encouraged to advocate, promote and provide incentives for developers, businesses and homeowners to pursue green alternative techniques in the design of their development or <u>re-development</u> projects. Options that address water quantity and stormwater source controls that can be incorporated into development designs include installing low flow toilets and water fixtures, water re-use strategies such as rain barrels, rain gardens, green roofs, porous pavement, streetscaping, and direct injection into groundwater. The combination of source controls through alternatives like LID and end of pipe controls like installing MTDs in outfalls that discharge to streams will be a long term, viable solution to protecting water quality, controlling water quantity, and recharging groundwater supplies. In addition, green approaches to stormwater management essentially functions to preserve base flows, moderate temperature impacts and protect hydrologic stability.

Implementation Strategy

The 2004 New Jersey Stormwater Rules require the implementation of Low Impact Development (LID) and Non-Structural Stormwater Management techniques for new major developments; however, this requirement does not apply to re-development projects. It is the intention of the Pleasant Run and Holland Brook RSWMP that all new development projects incorporate to the fullest extent practical both the NJDEP promoted nonstructural stormwater management and LID site development techniques for new construction and redevelopment projects. It is the intention of the RSWMP through these design provisions to proactively reduce stormwater runoff and potential pollutant loadings. As each development and re-development project is unique and is affected by unique zoning, site condition and resource attributes that create constraints to the full application of an LID design or may dictate the extent to which non-structural stormwater BMPs can be used, this element of the RSWMP is deemed at this time voluntary. The LID and non-structural BMP strategies which the RSWMP would seek to be incorporate into the design of all new development and redevelopment projects are outlined below. Additional information for LID and non-structural stormwater BMPs measures is provided in Subchapter 5 of the NJDEP Stormwater Management Rules.

- Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss.
- Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces.
- Maximize the protection of natural drainage features and vegetation.
- Minimize the decrease in the pre-construction “time of concentration.”
- Minimize land disturbance including clearing and grading.
- Minimize soil compaction.
- Provide low maintenance landscaping that encourages retention and planting of native vegetation and minimizes the use of lawns, fertilizers, and pesticides.
- Provide vegetated open-channel conveyance systems that discharge into and through stable vegetated areas.
- Provide preventative source controls.
- Encourage the disconnection of downspouts and disconnection of impervious cover.

It should be noted that the combination of structural and nonstructural measures, the end of pipe retrofit and pollution control at the source, have the potential of alleviating the water quality, quantity and recharge problems of Pleasant Run and Holland Brook watershed. Therefore, these techniques should be used in a complementary fashion to control the amount of runoff entering the watershed, manage stormwater before it enters a waterbody and lessen the effects of development and impervious surfaces in the Pleasant Run and Holland Brook watershed.

7.0 DELIVERY CONTROL TECHNIQUES (STORMWATER MANAGEMENT STRATEGIES AND RESOURCE RESTORATION)

The goal of the Pleasant Run and Holland Brook RSWMP project is the reduction of sediment, pathogens, and phosphorous to the watershed using replicable, easy to maintain BMPs that are consistent with the NJDEP's overall stormwater management approach and the NJDEP Stormwater Best Management Manual. The objectives of the project are:

- Demonstrate that effective and measureable reduction of sediment, pathogens and phosphorous can be achieved using cost-efficient, easy to install and maintain stormwater retrofits, small footprint bioretention systems, regional created bioretention basins, and stream bank restoration projects.
- Use the project's results as a model for the control of NPS loading from other sections of the PR/HB watershed and drainage area for the South Branch of the Raritan River to reduce pathogens and phosphorus in accordance with the TMDL established for the Raritan River.
- Through public outreach utilize the results of the project to demonstrate to municipal government, DPWs and local residents that the proposed stormwater retrofits, bioretention basins, and stream bank restoration work can be conducted in a cost-effective manner, and represent easily maintained solutions for the reduction of existing NPS loading to Pleasant Run and Holland Brook.
- Provide a framework of projects that can be replicated in other locations to control loads from newly developing or redeveloping areas of the PR/HB watershed.

The following section outlines various stormwater management measures and strategies for the Pleasant Run and Holland Brook watershed. The municipalities within the watershed, as well as other watershed and community stakeholder groups, are encouraged to pursue NJDEP 319(h), NRCS grants and other grant funding opportunities to implement these voluntary projects. The types of projects which could remedy stormwater-related problems throughout the watershed include:

1. Watershed Restoration
2. Structural Stormwater Management
3. Non-Structural Stormwater Management
4. Education
5. Other

It should be noted that some of the specific sites identified herein under the water shed restoration heading can also be incorporated into the municipal Stormwater Mitigation Plan as potential Stormwater Mitigation Projects. The NJDEP recognized that situations may arise in which the design and performance standards of the Stormwater Rules may be impossible to meet for a proposed development because of potential site constraints. Therefore, the Stormwater Management rules (N.J.A.C. 7:8-4) allow a municipality to develop a Stormwater Mitigation Plan in order to grant a variance or exemption for these special cases. Municipalities may identify a pool of specific

Stormwater Mitigation Projects that could be selected by an applicant to offset the effect of a requested waiver/exemption or to address an existing stormwater problem. The municipality may also provide a process through which an applicant has the flexibility and responsibility to identify an appropriate mitigation project and a location to implement the mitigation project to offset the deficit that would be created by the grant of a waiver/exemption or to address a stormwater based impairment. Municipalities can offer both options. Each year the municipality must submit the annual report form to the NJDEP and identify whether any variances or exemptions from stormwater management standards have been granted, and summarize the proposed mitigation projects that have been implemented. Additional details for the Stormwater Mitigation Plan are provided at: http://www.state.nj.us/dep/stormwater/docs/munimitipplan030706.pdf

7.1. Watershed Restoration Projects

Rationale

The Pleasant Run and Holland Brook Watershed Characterization and Assessment Report identified that approximately 60% of the watershed area is comprised of forest, wetland, and agricultural lands. Such areas tend to associated with the portions of the watershed that has experienced the least amount of residential or commercial development. As such, these portions of the PR/HB watershed tend to characterized by a low percentage of impervious cover; whether that be in the form of paved surfaces, road ways or roof tops. The remainder of the watershed area, approximately 40%, is characterized as developed urban land. The suburban nature of the watershed means that given areas, such as the central sub-watershed of the study area are characterized by large lot sub-divisions. Nonetheless, even these areas have suffered from land clearing, loss of native land cover, and encroachment or impact of riparian areas, wetlands and stream corridors. The measures outlined in this plan have been crafted cognizant of the existing character of the PR/HB watershed. As such emphasis is given to:

- Retrofitting or upgrading the existing stormwater collection system and existing stormwater BMPs,
- Anticipating the stormwater management needs and opportunities associated with redevelopment projects (e.g., along Routes 202 and 22),
- Preserving the agricultural element of the watershed,
- Protecting and improving stream corridors, and
- Promoting farm and landowner-friendly initiatives to help sustain the natural resources of their property.

In addition, although several stream bank restoration projects have been identified, each site should be evaluated independently and site-specific considerations taken into account when developing actual design plans for the repair and enhancement of these areas. Any restoration or repair work conducted on these impaired sections of stream must be based on sound technical data, which at a minimum should include detailed hydrologic and hydraulic studies of the system, a comprehensive assessment of the ecology and ecosystem dynamics impacted stream, and solutions based on geomorphological interpretation of the stream dynamics under an array of flow conditions.

Specific Elements:

This section of the RSWMP outlines the types of projects that are deemed necessary to remedy stormwater problems in the watershed; specific sites have been identified by members of the LPA and RSWMPC.

- Create a long-term watershed monitoring database
- Complete an inventory and survey of stormwater conveyance system including a map of sanitary sewer lines (to address fecal contamination) in the subwatershed area
  - Restoration techniques
  - Streambank stabilization
  - Riparian Buffer improvements
  - Structural Stormwater Management

In order to remediate the problems caused by changes in the hydraulic regime of the study area, the following types of implementation projects should be outlined in a restoration plan: (1) stream bank stabilization and restorations, (2) riparian buffer improvements, and (3) other structural retrofits to existing stormwater infrastructure.

7.1.1 Watershed Monitoring Database

Long term data collection at permanent, reference sites (such as the sampling stations established under the water quality monitoring program for this RSWMP) creates a useful database that can be applied to a variety of contexts. Data can provide information on the baseline conditions for channel, chemical, biological and physical parameters. Baseline data can also be used to: determine trends in geomorphic conditions; quantify environmental impacts; assess responses to management; track effects for an entire drainage basin; allow valid comparisons based on stream type; and contribute to regional databases. Developing a database created on sound scientific principles will aid in protecting watershed health by providing information against which anti-degradation standards can be measured and regulations enforced. Through this RSWMP, it is recommended that a database of stream flow and including other common parameters be initiated.

It is recommended that collection of stream data be initiated at reference sites along the PR and HB for long term monitoring. A database should be established that includes results for baseline and storm event conditions. This should be a long term project that could employ the same sampling stations as identified as part of the RSWMP sampling (maps included in Milestone 2) or could expand and include additional sampling stations. At each site, a staff gauge should be installed; stream depth should be recorded and flow measurements should be taken on a monthly to quarterly basis at a minimum. Measurements could be taken by municipal employees, volunteer groups or contracted personnel. The purpose of collecting such data will serve as a long term stream study that will create a record of hydrologic attributes of the Pleasant Run and Holland Brook. The raw data should be used to re-run hydrologic models every few years to track the changes of the hydrology of the watershed.

7.1.2 Stormwater Infrastructure Survey and Retrofit Recommendations

Stormwater management entails controlling stormwater runoff in order to reduce downstream erosion, water quality degradation, and flooding. The application of stormwater management strategies is generally employed as a means of mitigating the negative effects of land use change and development in a watershed. The stormwater management measures recommended within this RSWMP are commonly referred to as Best Management Practices (BMPs). For the most part the stormwater management recommendations presented herein build upon the stormwater ordinance requirements of the municipalities participating in this RSWMP, the requirements of N.J.A.C. 7:8 and design guidance provided in the NJDEP Stormwater BMP Manual. Watershed municipalities and other groups are encouraged to pursue 319(h) funding to install BMPs in the watershed to correct water quality impairments.

The MS4 outfall mapping is a State Basic Requirement (SBR) for all Tier A municipalities. It is recommended that a database of outfall and stormwater infrastructure locations be created using Global Positioning Systems (GPS) and mapped using Geographical Information Systems (GIS) software, which could be considered Phase I. Phase II of a stormwater infrastructure survey is to identify structures that are deteriorating, transporting large amounts of floatables and sediment, causing stream bank erosion, or have other problems that need attention. The mapped survey locations will be a necessary tool in the infrastructure survey to help focus and prioritize locations and retrofit opportunities. Therefore, the following tasks are recommended to be implemented:

- A survey of all stormwater infrastructures within the project area, an inventory of degraded sites,
- Identify outfalls that transport large amounts of sediment and/or have drainage areas with a high potential for NPS loadings such as pasture land, parking lots, and roadways
- Identify potential candidate sites for retrofitting with a manufactured treatment device (MTD) that is efficient in capturing sediments, metals, hydrocarbons, and other stormwater pollutants
- Identify property ownership and identify potential parties responsible for the long-term maintenance of the outfalls, stormwater systems and any proposed MTD operation

Standard catch basins are merely intended to collect and transport storm water to receiving waterbodies as quickly as possible to avoid localized flooding. As such, they offer little positive impact on storm water quality. In contrast, water quality inlets along with manufactured treatment devices will also collect and convey stormwater, yet their design provides some degree of pollutant removal and load reduction. These measures should be considered for the more densely developed neighborhoods and locales of the Pleasant Run and Holland Brook watershed study area to decrease pollutant loadings to the Pleasant Run and Holland Brook's tributaries. For example, these structures would tend to be feasible for the commercial corridors along Routes 22 and 202 and the established Whitehouse Station neighborhood of Readington Township.

Although there are different designs, for the most part water quality inlets are catch basins with an outlet invert pipe rise approximately 0.6 m (2 ft) from the bottom. The raised outlet pipe creates a retention sump within the basin. This sump helps to trap sediments by slowing storm surges and reducing the velocity of the inflowing runoff. Slowing stormwater flow allows for the settling of coarse and medium-sized sediment particles.

In addition to trapping sediments, water quality inlets may have the added effect of removing other pollutants such as heavy metals, petroleum hydrocarbons and, to a lesser extent, nutrients. These pollutants are removed because of their affinity towards binding with sediment particles. Removal of the sediments results in the removal of the adsorbed pollutants. The installation of an elbow hood or baffle to the sump basin further aids in oil and grease separation and the trapping and containment of floatables (paper, leaves and trash). This modification also minimizes the re-suspension of settled sediment particles trapped within the basin. Water quality inlets are unobtrusive and are compatible with standard storm drain networks. They can be easily accessed for maintenance and are capable of reducing pollutant loading from vehicular traffic, especially petroleum hydrocarbons. Disadvantages of water quality inlets include their limited stormwater and pollutant removal capabilities and the need for the frequent clean-out of accumulated sediments. The normal cleaning is done at least twice a year; once in the late autumn after leaf fall, and following the spring thaw once all deicing/snow clearing activities have ceased. Proper maintenance enhances pollutant removal and helps prevent re-suspension of trapped sediment particles

Manufactured treatment devices can be used with, or as a supplement to, an existing stormwater collection system. These devices are particularly well suited for the retrofit and/or upgrade of stormwater collection systems from impervious areas. The pollutant removal capabilities of these structures are limited largely to the removal of total suspended solids and floatables, and to some extent, particulate pollutants, including particulate phosphorus and the heavy metals and petroleum hydrocarbons that adhere to sediments. There is a variety of manufactured stormwater treatment devices recognized and approved by the NJDEP.

Rationale

Proper stormwater management will help alleviate pollutant loading to the streams and watersheds of the Pleasant Run and Holland Brook watershed. The installation of BMPs certified by NJ Corporation for Advanced Technology (NJCAT) are those structural devices recognized by NJDEP to adequately remove total suspended solids (TSS). Referred to as manufactured treatment devices (MTDs), have been tested and their removal efficiencies confirmed by NJCAT (Table 7.1). The confirmation certification conducted through the NJCAT program focuses only in sediment. These, and other MTDs and related structural devices, may also be capable of removing phosphorus, bacteria and other pollutants from stormwater. Although the devices in Table 7.1 are the only devices currently certified by NJCAT, for Pleasant Run and Holland Brook other devices should be considered when the removal of such pollutants as bacteria and phosphorus need to be considered. Table 7.2 highlights three patented, structural devices that remove bacteria, phosphorus and other pollutants.

Table 7.1 NJCAT-verified Manufactured Treatment Devices (MTDs)

Company	MTD Name	TSS Removal (NJCAT Verification)
CONTECH Stormwater Solutions, Inc.	Stormwater Management StormFilter®	79% (2007)
	Vortechs® Stormwater Treatment System	64% (2004)
	CDS- High Efficiency Unit	68.5-88% (2003)
	VortSentry® System	69% (2005)
	CDS- Filtration System	82.7% (2006)
Stormceptor® Group of Companies	Stormceptor® System	75% (2004)
Hydro International	Downstream Defender®	70% (2005)
AquaShield, Inc.	Aqua-Swirl™ Concentrator	60% (2005)
	AquaFilter™ Filtration Chamber	80.5% (2005)
Terre Hill Concrete Products	Terre Kleen Stormwater Device	78% (2007)

Table 7.2 Structural BMPs that Address Bacteria and Phosphorus

Company	Name	Pollutant Targets
AbTech Industries	Smart Sponge® Technology	**Bacteria**, Hydrocarbons, and Floatables
	Case Study: Installed at a public bathing beach in RI to capture bacteria in catch basins before entering waterbody. Catch basin inserts installed in Norwalk, CT helped abate an oil spill of 1200 gallons in an effort to protect the Long Island Sound.	
EcoSense™ International	EcoSense™ Stormwater Filtration System	**Bacteria**, Hydrocarbons, Floatables, Heavy Metals, **Sediment, Phosphorus**, Nitrogen
Fabco Industries	Fabco StormX Products	**Bacteria**, Hydrocarbons, Floatables, Heavy Metals, **Sediment, Phosphorus**, Nitrogen
Source: http://www.epa.gov/ne/assistance/ceitts/stormwater/techs.html		

Implementation

The installation of Stormwater BMPs or MTDs to upgrade or retrofit existing catch basins could be considered for the more densely developed commercial and residential areas of the watershed. The RSWMPC should evaluate the stormwater infrastructure data from recent surveys to identify and prioritize key replacement sites, especially along Route 202, Route 22 and even some of the major County roads such as Route 523. Existing catch basins, located in the major development nodes of the watershed, that discharge directly into the streams should be prioritized for update and upgrade.

7.1.3 Stormwater Flooding Concerns

The Hunterdon County Planning Department and the Readington Township Engineer have identified several road crossings and outfalls where routine and significant flooding occurs in the watershed. These areas of flooding are identified in Table 7.3. Flooding can be a result of inadequate stormwater controls, and also road crossing culverts that are undersized to handle the volume of stormwater runoff discharged from the increase in impervious developed lands. Future development will be responsible to implement measures to maximize the infiltration/ recharge of stormwater runoff; however, these requirements will not sufficiently address the existing flooding concerns. Additional voluntary measures are recommended for the NJDOT, Hunterdon County and Townships to retrofit the existing stormwater drainage swales and culverts to better manage stormwater runoff in the watershed. For example, small scale bioretention stormwater swales or check dams could be constructed to reduce flooding, increase recharge and improve stormwater quality. The RSWMPC should continue to work with the NJDOT, Hunterdon County and Townships to seek funding to implement improved stormwater BMP measures.

7.1.4 BMP Improvements on Township Property

Municipally-owned properties are good candidate sites for the installation of stormwater BMP retrofits, rain gardens, or to demonstrate unique stormwater management techniques. Suitable areas include municipal yards, lots, parks and playgrounds. Other properties, such as those owned by municipal school boards may be suitable for these types of projects as well. Public lands offer the following benefits: no associated costs of purchasing land; publicly accessible; common space offers good opportunists for demonstration BMP models; and interpretive signs could be designed and installed to educate visitors.

Additionally, wide streets and rights- of- ways can present opportunities for a number of retrofit strategies from creating bioretention swales in road medians or on the sides of roads, to increasing tree plantings and employing streetscaping techniques that create small vegetated areas used to passively treat runoff and infiltrate precipitation. The ideal conditions for street retrofits include: wider streets that serve large lots; wide street right- of- ways that provide room for stormwater treatment options; streets where utilities are located underneath the pavement or on only one side of the street; neighborhoods that are receptive to streetscaping projects or modifications to drainage; and neighborhoods that request traffic calming devices. Some examples of such structures that can be used in a retrofit application are the Filterra biotreatment systems (http://www.filterra.com/).

7.1.5 Residential Rain Gardens

This initiative will focus on educating and encouraging homeowner associations or landowners that live in the large lot developments and even interested commercial properties with a "campus" type setting, to install rain gardens on their property. The goal of this initiative is to raise awareness about stormwater, natural landscaping, and actions a landowner can take in order to decrease the amount of runoff flowing from their property to the storm sewers in their neighborhood by implementing small scale stormwater management projects on private property. The initiative should aim to deliver outreach materials to residents, and design and install several rain gardens on private property. Appendix J provides background information and fact sheets about rain gardens.

Potential structural stormwater strategies are highlighted in the Table 7.3, which were extracted from the 2005 USEPA Handbook for Watershed Restoration. This USEPA matrix rates bioretention basins, infiltration trenches, stormwater wetlands or wet ponds with a good or a high capability to reduce fecal bacteria and nutrients, which are a concern in this watershed. These methods would also help to infiltrate, recharge and/or retain stormwater in the subwatershed areas, which are also priority objectives identified for this watershed. Conventional dry detention or extended dry detention would not satisfy the current NJDEP requirements for 80% TSS reduction or satisfy the NJDEP recharge requirements. Bioretention, infiltration trenches, and wet ponds should be evaluated as appropriate structural strategies that can be selected for site specific areas within the Pleasant Run and Holland Brook Watershed.

Implementation

The installation of Stormwater BMPs or stormwater retrofit to existing catch basins could be considered for the more densely developed commercial and residential areas of the watershed. The RSWMPC should evaluate the stormwater infrastructure data from recent surveys to identify and prioritize key replacement sites, especially public lands. Basins that discharge directly into the watershed and are documented sites of elevated levels of sediment, fecal coliform and phosphorus should be prioritized. Priority should be provided for mitigation projects on public lands that will help remediate downstream flooding and improve water quality concerns.

Table 7.3 Best Management Practice Screening Matrix (EPA 2005).

Structural Management Practice	Hydrologic Factor				Pollutant Factor				
	Interception	Infiltration	Evaporation	Reduced Peak Flow	Total Suspended Solids	Nutrients	Fecal Coliform Bacteria	Metals	Temperature
Bioretention	●	ɵ	ɵ	ɵ	●	●	●	●	●
Conventional dry detention	○	○	ɵ	●	○	○	●	ɵ	ɵ
Extended dry detention	○	○	ɵ	●	ɵ	ɵ	●	ɵ	○
Grass swale	ɵ	ɵ	○	○	ɵ	○	○	●	ɵ
Green roof	●	○	●	ɵ	○	○	○	○	●
Infiltration trench	○	●	○	ɵ	●	●	●	●	●
Parking lot underground storage	ɵ	ɵ	○	●	●	●	ɵ	●	●
Permeable pavement	ɵ	ɵ	ɵ	ɵ	ɵ	○	ɵ	○	ɵ
Sand filter	○	○	○	○	●	●	ɵ	●	●
Stormwater wetland	●	○	ɵ	●	●	●	●	●	ɵ
Water quality swale	ɵ	ɵ	ɵ	ɵ	●	●	○	●	●
Wet pond	○	○	●	●	●	●	●	●	○

Table key: ○ Poor, Low or No Influence, ɵ Moderate Influence, ● Good, High Influence[8]

7.1.6 Streambank Stabilization Plan

Stabilizing stream banks can prove to be an effective strategy to conserve and improve aquatic systems. Restoration entails transforming a degraded stream ecosystem into one that is ecologically viable. The goals of any given restoration project should be clearly defined prior to work and outlined within the context of the current conditions and disturbances that make restoration practices necessary. Streambank stabilization projects perform the following tasks: (1) prevent the loss of land or damage to vegetation, utilities, roads, buildings or other infrastructure adjacent to a

[8] The recommendations in Table 7.4 were based primarily on the following references: USEPA National Management Measures to Control Nonpoint Source Pollution from Urban Areas, NJDEP Stormwater BMP Manual, NYDEC Stormwater Manual on Structural BMPs, and the Connecticut Stormwater Manual.

waterbody; (2) reduce sediment loads to streams; (3) maintain the structure of the stream channel; and (4) improve the stream for recreational use or as habitat for fish and wildlife. It is important to understand the attributes of a stream corridor prior to commencing any restoration practices and to identify the source of the impact in the system that is causing the stream to degrade. Written maintenance and monitoring plans should be included as part of a restoration plan. These types of projects could serve as a basis for improving water quality-related impairments in the watershed and improve habitat for aquatic species. Specific Project sites are identified in Table 7.4 and 7.5 below, and photographs and cost estimates of these potential restoration sites are included in Appendix H.

Table 7.4 Holland Brook Mitigation Projects

Map ID	Photo ID	Location Block and Lot	Streambank Restorations	Riparian Enhancements/ Other
1	23-33	Rte 523 by bridge	3 to >5 ft eroded banks	
2	48-51	Pinebrook Road Bk 55/ Lot 13.51	3 to >5 ft eroded banks	
3	56-59	Readington Village Bk 68/ Lot 2	4 to >5 ft eroded banks	
4	65-70	Old Farm Rd Bk 68/Lot 3 (may be outside of watershed)	2 to >5 ft eroded banks and eroded tributary	
5	72-75	Holland Brk Rd and Rte 202 Branchburg	3-4 ft eroded bank	
6	74 76-77 78-80	Holland Brk Rd and Hidden Lane Branchburg	>3 ft eroded bank	Reforest Stream corridor
7	31	Stone Arch bridge East of Rte 523		Repair historic footbridge
8	44-45	Pinebrook and Roosevelt Rd		Reforest buffer 2 ft eroded banks
9	12-15	Golf course Bk 45/ Lot 25.29		Allow reforest buffer -no mow Limited bank erosion
10	28	Horse Farm Bk 45/ Lot 10		Allow reforest buffer -no mow Limited bank erosion
11	43	Holland Brk Rd Bk 54/Lot 1.07		Reforest floodplain -no mow
12	81-84	Old York Rd		Reforest Stream corridor and floodplain >2 ft eroded bank

Table 7.5 Pleasant Run Mitigation Projects

Map ID	Photo ID	Location Block /Lot	Stream bank Restoration & Other Mitigations
13		Stanton Rd Intersection	>3 ft eroded banks Streambank restoration
14		Bk 75/ Lot 35.03 Locust Rd	Driveway dam removal/ restoration/ buffer enhancements
15		Pleasant Run Rd & Rte 202 Outfall	Eroded banks
16	14	Golf Course Bk 51/ Lot 21.28	Buffer enhancements
17	21-26	Appletree Rd Bk 65/ Lot 23	Horse farm/ manure 2-3 ft eroded banks
18	27-29 32-35	Briarwood Farm Pleasant Run Rd	Horse farm/manure

The Flood Hazard Control Area (FHA) Regulations were significantly amended and adopted by the NJDEP in November 2007. These Flood Hazard Control Area regulations outline specific requirements for activities within riparian zones and stream channels, including stream bank restorations and stormwater outfall repair and maintenance (N.J.A.C. 7:13 subchapters 9, 10 and 11). Generally, the new rules provide stricter environmental and engineering standards and permitting requirements to protect the public safety, minimize the flood damage, and ensure that flooding does not increase. The new rules also require various new permits for many actions that may disturb riparian zones. Highlights of some relevant FHA Rules regarding outfall retrofitting, stream bank stabilizations, and riparian enhancements are provided in Appendix I.

7.1.7 Riparian Buffer Improvements

Riparian buffers are generally linear strips of vegetated land adjacent to streams and ponds that are designed to intercept pollutants and manage other environmental concerns. Strategically placed buffers in the agricultural landscape can effectively mitigate the movement of sediment, nutrients, and pesticides within and from farm fields. Buffers along roadways can mitigate the movement of related pollutants from vehicles like oil and antifreeze, as well as sediment, litter and road salts. Within the riparian setting, buffers can enhance wildlife habitat and biodiversity in addition to trapping sediment and other pollutants. These types of projects could serve as a basis for improving water quality-related impairments in the watershed and improve habitat for aquatic species. Information regarding potential riparian enhancement projects are included Tables 7.4 and 7.5 and photographs of specific sites are included in Appendix H. Example of potential project sites include: Holland Brook at Readington Road and Hillcrest Road, and Pleasant Run at Pleasant Run Road at various private lands.

7.2. Stormwater Education and Outreach

Rationale

Public Education is required under the New Jersey Stormwater Rule; it is a requirement for watershed planning, and for Regional Stormwater Management Plans. The continued protection and preservation of the Pleasant Run and Holland Brook Watershed is contingent upon an educated audience of county and municipal leaders, residents, land owners, and the business community regarding various matters affecting the health of the watershed and its critical habitat areas, including:

- Improve communication, training and coordination among local, county, state governments, local committees, and environmental organizations for watershed related activities.
- Improve public education and raise awareness to promote stewardship of watershed resources, improve water quality, and reduce non-point source pollutants.
- Improve environmental and land conservation efforts by preserving open space, sensitive environmental areas and habitats by promoting such concepts as riparian buffer stream bank preservation and restoration, reforestation, floodplain preservation,
- Enhance the existing volunteer stream monitoring and restoration programs in this watershed offered for example by the Readington Township EC, the NJWSA and the SBWA .
- Celebrate successes to recognize noteworthy efforts, encourage participation, and continue the implementation of the Pleasant Run and Holland Brook RSWMP at the annual meetings.
- Prepare and disseminate the Watershed information via:
  - Educational Displays and Brochures for community events
  - Demonstration projects
  - Watershed tours or hikes
  - Workshops and staff training seminars
  - Volunteer opportunities for cleanups, plantings, monitoring or stenciling storm drains
  - Local planning or ordinances efforts

The implementation of these actions and success of this plan is greatly dependent upon the continued commitment and coordination among the municipal partners and stakeholders of the RSWMP. These groups can share the costs of these outreach efforts and work to ensure that a specific audience is reached with a targeted message. For example, as per the municipal stormwater permit, Tier A communities are required to periodically conduct educational programs for township employees involved in BMP maintenance and management. This education program of DPW staff, township engineer, and others could be coordinated by a RSWMP watershed-wide Stormwater Committee. The Pleasant Run and Holland Brook communities can rotate the responsibilities for hosting such training and educational events with registration fees used to offset the costs. A RSWMP watershed-wide Stormwater Committee could also be set up to coordinate and conduct round table discussions of stormwater issues once or twice per year. The RSWMP watershed-wide

Stormwater Committee would serve as a forum for brainstorming options for stormwater management techniques, drafting model stormwater ordinances, identifying sites suitable for stormwater improvements and providing related stormwater management outreach to township officials.

Educational efforts stemming from the PR/HB RSWMP will also include elements directly relevant to the general public. In this capacity the RSWMP watershed-wide Stormwater Committee will disseminate information to landowners, schools and residents of the watershed about ways in which they can make a difference in the water quality of Pleasant Run and Holland Brook. Together the municipal officials and staff will work to provide recommendations for ongoing cleanups, plantings, and target watershed areas and deliver educational material and create opportunities to raise awareness about stormwater issues.

Specific Educational Topics

1. Education on Canada goose biology and waterfowl management measures will be communicated to the public using interpretative signs on public land where waterfowl are known to nest and congregate. Education on this topic will extend to advertised presentations by experts in the field of goose control.

2. Information about low phosphorus fertilizers and proper lawn care will be disseminated to the public.
    a. A 'lawn care expo day' for residents will be organized to demonstrate proper lawn care without the use of phosphorus fertilizers. Hand out information and demonstrations to be included.
    b. Outreach to retail businesses to advertise and promote watershed friendly, low phosphorus products.

3. Education on the importance of riparian and wetland buffers, including discussion of invasive species.
    a. Develop a brochure dealing with the importance of riparian and wetland buffers, as well as conservation easements in general, and distribute to the pubic.

4. Education of local DPW employees on the management and maintenance of BMPs
    a. Annual training of DPW employees in the maintenance of bioretention, sand-filter, MTD and other "non-conventional" BMPs.

5. Annual training session for Planning Board, Zoning Board and Township Committee members.
    a. Information and technical transfer presentation to land use board members (as well as elected municipal council members) of the RSWMP and its goals and objectives.

Readington Township presently educates residents during community days and through information posted on the website (http://www.readingtontwp.org/) about various environmental topics. However, education on the following topics will be improved: septic management, manure management, and landscaping for watershed health. Education efforts will therefore target homeowners, landowners and farmers as well as municipal officials and employees.

7.2.1 Septic Management

Portions of all three municipalities located within the Pleasant Run/Holland Brook watershed rely on on-lot wastewater treatment systems (septic systems) to manage wastewater generated from residential and non-residential sources. OF the three municipalities, the relevancy of septic management is most significant for Readington Township. Township lands encompassed by the watershed and relying on septic systems for the management of wastewater represent a large part of the total PR/HB watershed. Additionally, much of this development occurs relatively close to the streams.

Septic management education is needed in the PR-HB watershed, as in the rest of the state, because improperly sited, faulty and/or poorly maintained septic systems can discharge bacteria, viruses, nutrients and toxic chemicals to groundwater and surface water. Since over half of New Jersey's population relies on groundwater for its water supply, improper use and failure of septic systems is a major concern (ANJEC 2002). Septic malfunction can also cause surface water pollution, which can lead to fish advisories, beach closings and contaminated water supplies. On the other hand, properly designed, sited and constructed septic systems provide necessary on-site wastewater treatment and important groundwater recharge that contributes to baseflow in streams. In addition, septic systems are the most inexpensive and efficient means of treating wastewater. A management program that requires proper maintenance of septic systems will help to ensure proper operation of both older and newer systems. Older systems are of particular concern because they may not have been subjected to strict requirements, may be located in inappropriate areas and have minimum design elements. Newer systems also need to be managed to guarantee effective wastewater treatment and longevity.

Properly functioning septic systems are an essential part of residential infrastructure and increase property values. Municipalities should help educate homeowners about proper septic management including proper siting, how to improve the value of their property, how to avoid purchasing property that has expensive septic problems and how to comply with NJDEP regulations. There are several resources that can provide educational tools and ideas to improve current educational approaches, including, but not limited to the following:

Educational Toolkit by the Groundwater Foundation:
  http://www.groundwater.org/pe/lakemac.html
USEPA Handbook on Septic Management
  www.epa.gov/owm/septic/pubs/onsite_handbook.pdf
NJ-Specific Information

http://www.anjec.org/html/waterresources.htm#anjecpubs

7.2.2 Backyard Retrofitting

Homeowners should be encouraged to pursue green strategies to manage stormwater on their property. The Green Values Stormwater Toolbox website (http://greenvalues.cnt.org/), is just one of the many valuable educational tools accessible to the general public. This website provides an online calculator (http://greenvalues.cnt.org/calculator) to allow the user to estimate maintenance savings and groundwater recharge benefit of six different environmentally friendly landscaping techniques by inputting site-specific details. For example by replacing 25% of a 1.5 acre lot with native landscapes can reduce runoff by 20%.

Elements of the Backyard Retrofitting Education campaign should highlight proper landscaping, controls for soil erosion, guidelines for car washing and disposing of car fluids, disposal of pet waste, and other ideas of ways to decrease stormwater discharges from a homeowner's property such as installing rain barrels or disconnecting impervious surfaces. Many outreach materials are available that could be distributed to homeowners in the watershed. The brochure, entitled *Caring for Backyard Buffers,* available at the following website provides links for native landscaping ideas. http://www.thewatershed.org/images/pdf/SBMWA_Backyard_Buffers.pdf

7.2.3 Manure Management

The need to address proper manure management is an important initiative in terms of avoiding negative impacts on water quality. Because the use of manure helps the farmer re-use animal waste and fertilize the soil, it is important that its management be outlined in an agreeable manner that does not jeopardize farm production or stream health.

Manure solids are composted with materials such as leaves and grass clippings, to produce soil nutrient supplements high in organic content. Because manure contains both animal waste products and decaying vegetation, improper management can threaten water quality in terms of fecal and nutrient contamination. Proper manure management is important because it prevents these pollutants from migrating to surface and ground waters. Application of manure to the land at the proper time, using proper management techniques and in proper amounts recycles the nutrients through the soil, reducing the expense of commercial inorganic fertilizers as well as the need to add organic matter. Proper application of manure can improve soil quality, fertility and water-holding capacity.

Since large, commercial farms are regulated by Right to Farm, the manure management initiative proposed as part of this RSWMP would only affect small farms in the watershed. Because small farms are vital to preserving the agricultural character of the watershed and essential in providing services to the community, manure management is recommended as a voluntary measure so as not to financially burden these small scale operations. It is strongly recommended that small farms, that have the financial resources, comply with the NJ Dept of Agriculture (NJDA) Animal Waste Rules (draft). It is encouraged that farmers conform to additional measures that are not required but are highly recommended by NJDA, such as fencing along waterbodies. (http://www.state.nj.us/agriculture/divisions/anr/agriassist/animalwaste.html).

The five general requirements of the NJDA Animal Waste Rules are: 1) No agricultural animal operation shall allow animals in confined areas to have uncontrolled access to waters of the state; 2) Manure storage areas shall be located at least 100 linear feet from waters of the state; 3) The land application of animal waste shall be performed in accordance with the principles of the NJDA BMP Manual; 4) No dead animals and related animal waste resulting from a reportable contagious disease or an act of bio-terrorism shall be disposed of without first contacting the State Veterinarian; and 5) Any person entering a farm to conduct official business related to these rules shall follow bio-security protocol (NJDA 2006, draft).

Various farming BMP practices to minimize discharges of pathogens, nutrients, and pesticides are highlighted in publications funded by the USDA-NRCS in fact sheets provided at the website: http://www.sera17.ext.vt.edu/SERA_17_Publications.htm This supplementary information could be distributed to farmers as education and outreach materials and used as a resource for drafting farm conservation management plans.

7.3. Other Delivery Control Options and Techniques

Watershed municipalities can further their efforts of stormwater management by pursuing non-structural projects that would aid in the conservation of soil, water and habitat of the watershed.

7.3.1 Farming NRCS Incentive Programs

Readington Township has been extremely pro-active and successful in implementing Natural Resource Conservation Service (NRCS) incentive programs, such as the Wildlife Habitat Incentive Program (WHIP), which are voluntary programs for landowners who want to create or improve wildlife habitat on their property. These programs have brought conservation projects to private lands in Readington Township, most of which are agricultural lands and located in the PR and HB watersheds. Each project in Readington has included a conservation plan to focus efforts and improve watershed health; examples of elements of a conservation plan may include: improve riparian forest buffers and nutrient/mowing/pest management. These NRCS projects have been successful in involving landowners, mostly farmers, and the community in the stewardship of private lands and watershed health. This RSWMP strongly encourages all watershed municipalities to pursue NRCS programs in order to involve residents in creating a conservation plan for their property. Various NRCS grant programs for New Jersey farmers are highlighted on the NRCS website, including WHIP, CIG, CREP, CRP, and EQIP. http://www.nj.nrcs.usda.gov/programs/

In addition, the North Jersey Resource Conservation and Development Council (NJRC&DC) also provides assistance to farmers to help develop site specific BMP practices to preserve local resources. Several local farms have become certified *River Friendly Farms* through their program. http://www.raritanbasin.org/RaritanAg/RF_Farm/index.htm

7.3.2 Continued Farmland Preservation and Open Space Acquisition

Readington Township has been successful in preserving lands through the Farmland Preservation Program administered by the NJ State Agriculture Development Committee (NJSADC) and other open space parcels through the NJ DEP Green Acres Program. In addition, the Township's zoning and cluster development regulations have helped to preserve lands in sensitive areas such as stream corridors. It is recommended through this RSWMP that all municipalities continue to preserve sensitive parcels in streams, wetlands, forested areas, and grasslands habitats. Preserving land is fundamental in conserving natural resources and is a necessary tool for effective watershed management.

7.3.4 Open Space Management Plan and Invasive Species Control

Once open space is protected, a management plan will help guide the restoration, preservation, and enhancement of the natural, cultural, recreational and aesthetic values of the preserved site. Drafting management plans for open space parcels presents an opportunity to help guide municipalities in maintaining the function of the parcel for which it was preserved: i.e. active recreation for ball fields or habitat for grassland birds, etc. All open space management plans, regardless of use, should include an element addressing invasive species control, an ever increasing issue in land management. For more information on the impacts of invasive species, see http://www.invasive.org. It is recommended through this RSWMP that municipalities draft open space management plans to include invasive species management for preserved parcels within the project watershed.

8.0 CONCLUSIONS OF THE PLEASANT RUN/HOLLAND BROOK RSWMP

As documented in the RSWMP Characterization and Assessment report, widespread impairments have occurred, and continue to occur, to Pleasant Run and Holland Brook due to the inadequacies of existing stormwater management regulations, planning and infrastructure. The data and information summarized in Sections 3 and 4, and presented in greater detail in the Characterization and Assessment report, clearly show that no improvement in the condition of the watershed and its tributaries will be possible unless a series of measures are put in place to improve the means by which stormwater is addressed and managed. Due to the magnitude and widespread nature of these problems, the corrections must encompass the following:

1. Regional stormwater management solutions that correct, replace and/or retrofit the existing stormwater management infrastructure;
2. Stabilization of the watershed's stream channels;
3. Control of the influx of pollutants, including pathogen loading;
4. Better stormwater management planning and design, with the focus placed on stormwater recharge to help moderate base flows, decrease storm surges and flooding, and lessen the opportunity for streambed and bank scouring;
5. Upgrade and retrofit of the existing stormwater management infrastructure and use of these opportunities to address and correct localized stormwater and pollutant loading problems;
6. Improve runoff management and reduce pathogen loading and erosion from agriculture and livestock farms within the watershed;
7. Decrease in the occurrence of invasive species within the watershed and within the riparian areas of the watershed and its tributaries;
8. Decrease in the frequency and magnitude of algae blooms;

8.1 Prioritizing & Scheduling of BMP Implementations

The lists of management options described in the previous section were developed to meet each of the goals and objectives established for the Pleasant Run and Holland Brook Watershed RSWMP. The implementation of these measures, especially the structural stormwater BMPs, the stormwater retrofits, the installation of MTDs, and the implementation of the regional bioretention facilities described in Sections 6 and 7 are dependent on many factors including but not limited to access to the lands and the acquisition of funding. Prioritizing the implementation of these measures will be conducted based on the following criteria adopted from the *Pennsylvania Growing Greener Watershed Assessments program:*

- Measurable Stream Improvement/Restoration (TMDL Strategies)
- Ecological Benefit

- Community Support
- Land Owner Access and Cooperation
- Upstream to Downstream Prioritization
- Permitting Requirements
- Site Constraints (topography, groundwater, wetland/stream encroachments, etc.)
- Anticipated Costs, Funding Means and Expected Time Frame
- Identify Project Partners for Implementation, Monitoring and Updating Progress

8.2 Funding and Financial Resources

Projected cost estimates have been developed and potential funding sources have been investigated for some of the voluntary stormwater management options (Milestone 4B report findings) recommended for the Pleasant Run and Holland Brook watershed. The identified projects have been selected on the basis of the field and monitoring data compiled through the Characterization and Assessment study, as well as input from the community and stakeholders. The projected costs provided in Table 8.1 are based on these preliminary assessments but are subject in most cases to further refinement.

The exact mix of BMP installations/construction and other types of restoration measures implemented the local stakeholders will likely be determined by the availability of funding. For each project, the potential funding sources are also identified in Table 8.1, which should be investigated or solicited to implement the desired projects.

As illustrated in the above table the RSWMPC will investigate a variety of probable funding sources that include, but are not limited to:

- The NJDEP CWA 319(h) grant funds are available for implementation projects on public lands or lands under a Conservation Easement restriction. This funding limitation may help prioritize demonstration projects on municipal, county or state owned lands such as town hall, school sites, and parklands. This funding is available to assist municipalities in meeting the Phase II Stormwater requirements.
- The New Jersey Environmental Infrastructure Financing Program, which includes New Jersey's State Revolving Fund, provides low interest loans to assist in correction of water quality problems related to stormwater and wastewater management. Grant funding is also available from the NRCS for restoration projects for public and private landowners.
- In other watersheds throughout New Jersey NRCS funding for landowners has been utilized to implement best management practices on private lands and agricultural lands through programs sponsored by the NRCS, in partnership with the Natural Resources Conservation Service, Rutgers Cooperative Extension, the County Soil Conservation Districts, and the NJ Department of Agriculture. Some of these programs are highlighted below.
    - Conservation Reserve Enhancement Program (CREP)
    - Conservation Reserve Program (CRP)
    - Environmental Quality Incentives Program (EQIP)
    - Farm and Ranch Land Protection Program (FRPP)

- Grassland Reserve Program (GRP)
- Wetlands Reserve Program (WRP)
- Wildlife Habitat Incentives Program (WHIP)

Table 8.1 Projected Cost Summary for the Voluntary Projects

BMP Project	Description	Responsible Party	Time frame	Projected Cost	Funding Source(s)
Created Wetland	Create a 1 acre wetland bioretention system	Townships	2-5 years	$165,000	319(h) funding
Bioretention	Construct a bioretention swale	Townships	2-5 years	$80,000	319(h) funding
Stormwater Catch basin MTD	Remove existing catch basin Replace with MTD	Townships	2-5 years	$80,000	319(h) funding
Bioretention Basin	Convert existing stormwater detention basins into bioretention basins.	Townships, property owners	2-5 years	$250,000	319(h), CWP, EPA
Stream Bank Restorations	Identify appropriate areas in need of stabilization and restore eroded stream channels.	Townships and local stakeholder organizations	2-5 years	$300,000 to $1million	NRCS, 319(h), USEPA, Depending on funding availability.
Continued education and outreach, voluntary signage	Develop Pleasant Run and Holland Brook Watershed displays for local events, RSWMP public outreach meetings	Townships local stakeholder organizations	2009 depends on funding.	$3,000 - $5,000 annually	319(h), EPA Env Justice, Dodge Foundation
Monitoring (see 8.3)	Annual monitoring program to track changes in watershed and tributary conditions Resulting from RSWMP implementation	Townships and local stakeholder organizations	depends on funding.	$12,000 - $15,000 annually	319(h)

8.3 Long Term Monitoring Plans

The New Jersey Stormwater Regulations (N.J.A.C. 7:8-3.1) require a long term monitoring program be drafted and implemented in order to provide a technical database used to assess the success of the measures of the RSWMP. Long term monitoring can be used to assess not only water quality improvements realized through the implementation of the voluntary structural BMP mitigation measures, but also compliance and performance with the regulatory design standards measures. The focus of the monitoring plan presented below pertains to evaluating the improvement in the watershed resulting from the installation or implementation of the various BMPs discussed in Section 7. Tracking these improvements in water quality will be an ongoing responsibility of the

RSWMPC that will be conducted as part of a BMP implementation/installation project. A conceptual, cost-effective monitoring program is detailed below.

The monitoring program will involve periodic water quality, benthic invertebrate and flow monitoring at the same four stations sampled as part of this project's Watershed Characterization and Assessment Study (Milestone 3 Report). All sampling will continue to be conducted in accordance with the NJDEP-approved Quality Assurance Project Plan (QAPP) developed as part of the overall RSWMP study. Sampling events will be limited to the "growing season", May through September, as this is when water quality impacts and impairments peak in the watershed and its tributaries. Water quality sampling will be conducted under both baseflow conditions (defined as a condition of 72 continuous hours where less than 0.5 inches of rain has fallen) and storm event conditions as detailed below.

Baseflow Sampling

Baseflow sampling will be conducted on a monthly scale at the in-watershed and stream stations (or as noted below) between May and September.

- Temperature (in situ)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (in situ)
- pH (in situ)
- Flow (in situ, at stream stations only)
- E coli Bacteria
- Benthic macroinvertebrates
- Water Quality Chemistry (by lab analysis)
  - Total Phosphorus (TP)
  - Soluble Reactive Phosphorus (SRP)
  - Total Suspended Solids (TSS)
  - Nitrate-Nitrogen (NO^3-N)

Storm Event Sampling

Annually three (3) storm events will be sampled; one in May, one in July and one in September. The sampled parameters will be as follows:

- Temperature (in situ)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (in situ)
- pH (in situ)
- Flow (in situ)
- Water Quality Chemistry (by lab analysis)
  - Total Phosphorus (TP)
  - Total Suspended Solids (TSS)

- *E coli* Bacteria

Annually the results of the baseflow and storm event sampling efforts will be synthesized in a summary report. The findings will also be summarized with regard to ongoing progress towards the performance and implementation of the measures stated in the RSWMP, whether they be voluntary or required. In addition, local community events will be targeted to disseminate general educational information, update the community on the implementation of specific projects, and to recognize or honor volunteers or stakeholders working on completed project tasks.

8.4 Measureable Milestones for Tracking Implementation and the Effectiveness of RSWMP

8.4.1 Annual Reporting

To measure the success of this Regional Stormwater Management Plan a variety of milestones and measurable criteria are suggested related to five basic strategies: Planning and Agency Coordination, Ordinance Adoption, Mitigation Projects, Monitoring, and Education. It is recommended that the watershed communities track their progress on implementing the various aspects of this RSWMP by summarizing their activities in the Annual Reports submitted to the NJDEP for the Municipal Stormwater Plans. In addition to the requirements of the NJDEP Stormwater Annual Progress Report, the Annual Report can include the following items:

8.4.2 Planning and Policy/Agency Coordination

- Assess participation in both regional and local planning initiatives to implement measure to preserve and protect natural resources, such as: updates to Master Plan reports, ERIs, zoning initiations, environmental protective ordinances, etc.
- Ensure that Master Plans and other municipal documents are updated every six years to incorporate all the recommendations provided in the Pleasant Run and Holland Brook Watershed RSWMP. In addition, ensure partner coordination and community input.
- Assess the adoption of local land use and stormwater ordinances related to stormwater infiltration, impervious cover limits, redevelopment projects, riparian zone protection ordinances, as recommended in the Pleasant Run and Holland Brook Watershed RSWMP.
- Assess acres of preserved open space compared with the acres already preserved in the watershed, and ongoing acquisitions, and the implementation of greenways to protect the Pleasant Run and Holland Brook Watershed.
- Assess the creation of Tree Commissions, Community Forest Plans, Woodland Protection Ordinance and the development of stewardship plans for public lands.

8.4.3 Mitigation, Restoration, Projects and Maintenance

- Assess the obligation of funding and implementation of large and small-scale stormwater demonstration projects; recharge projects, pollutant loading reductions, repair of illicit connections, activities that restore the stream corridors, stream banks, and the surrounding landscape to improve the health of the watershed.
- Assess the obligation of funding and timely implementation of stormwater maintenance projects.
- Assess the implementation of the stormwater BMPs, retrofits, MTD installation, stream bank restorations outlined in Section 6 and 7.
- Assess the linear feet of restored stream bank to ensure that the BMP is functioning effectively or the restoration project has been successful.

8.4.4 Monitoring and Research

- Routinely assess and compare the baseline data for water quality parameters for pathogens, nutrients, and TSS described in the Characterization Report with ongoing monitoring results. (See Section 8.3 above and in Section 8.5 below).
- Assess populations and diversity of macroinvertebrates and fish species.

8.4.5 Education, Outreach and Stewardship

- Assess the training provided to local officials and staff related to stormwater and other watershed concerns.
- Assess the number and public participation in community sponsored workshops, events, and volunteer stewardship opportunities
- Assess the dissemination of the educational materials to municipalities, environmental organizations and landowners regarding litter, yard waste and pet waste controls, water fowl feeding, water conservation, stormwater management, riparian zone protection, and open space preservation.

8.5 Criteria to Determine Water Quality Improvements

The measurable results of this project will be definitive. As documented in the RSWMP and the Characterization and Assessment report, the proposed regulatory and voluntary mitigation projects will address currently unmanaged or inadequately treated major sources of phosphorus, sediment, pathogen, and gross particulate loading to the watershed. These projects will help reduce known sources of non-point source pollutant loading to the watershed, thereby aiding in the watershed's overall water quality enhancement. This is in keeping with the need to improve the watershed's quality and to reduce the watershed's pathogen load as so mandated by the NJDEP fecal coliform TMDL for the South Branch of the Raritan River and identified in the RSWMP. In doing so, the watershed will be able to meet, on a more consistent basis, the State's water quality standards for TP, pathogens and TSS.

For all BMP sites, a water quality monitoring project will be set up prior to installation of the stormwater management device or facility (refer to Section 8.2 for general monitoring of watershed and stream conditions). Baseline data will be collected and assessed prior to the installation of any stormwater management BMP. Post installation monitoring will also occur and the removal rates of the targeted pollutant or the overall improvement in water quality or other metric (e.g., linear feet of restored stream bank) will be calculated to ensure that the BMP is functioning effectively or the restoration project has been successful. Removal rates will be calculated using the EPA Region 5 model, StepL (Spreadsheet Tool for Estimating Pollutant Load). This model is easy to use and is available as a download from the EPA website in Microsoft Excel format. The actual sampling program conducted for each of the BMP installation/implementation projects will be designed specifically so as to generate the data needed to document the effectively of the project. As noted above, in some cases this may involve the measurement of pollutant load reduction while in other cases may involve the improvement in riparian habitat or the restoration of eroded stream channels. As such, the actual monitoring program will differ somewhat depending on the nature of the project.

8.6 Consistency with Other Plans and Regulations

This Pleasant Run and Holland Brook RSWMP is consistent with the NJDEP regulations for stormwater management (N.J.A.C. 7:8), Regional Stormwater Plans, Residential Site Improvement Standards (RSIS) N.J.A.C. 5:21, NJDEP established TMDLs, State Plan, NJ Wildlife Action Plan (2008), Municipal Land Use Laws (MLUL), Municipal Stormwater Management Plans and Ordinances, local Master Plans, and the Hunterdon County Water Quality Management Plan. In addition, this RSWMP both considered and included provisions from the Flood Hazard Mitigation Rules (N.J.A.C. 7:13) and the Water Quality Management Plan Rules (WQMP -N.J.A.C. 7:15). The RSWMP will also be consistent with the past and current conservation and preservation efforts of the regional stakeholders to protect the surface and groundwater resources, preserve habitat for threatened and endangered species, better manage development within the watershed, prevent loss of baseflow and reduce stormwater pollutant loading, and preserve the rural and agricultural nature of the watershed.

Many of the recommendations in the PR/HB RSWMP support and promote goals and objectives noted in the Readington Township Master Plan and Environmental Resource Inventory. In particular the Readington Township ERI recommends the following measures that are support by the recommendations in this RSWMP:

- Increase education for residents regarding state regulations and local ordinances that restrict encroachments within a 100 foot riparian buffer from the stream and the state wetland buffers areas.

- Best management practices should be required for all development proposals including stormwater quality treatment, increased stormwater recharge, and the elimination of direct stream stormwater discharge.
- Where appropriate require integrated pest management (IPM) programs, drought management plans, buffer zone maintenance plans that include no-mow and no clearing in riparian zones and wetland buffers, except for the maintenance of invasive species.
- Require soil testing programs to minimize unnecessary phosphorus fertilizer applications and pesticide applications.
- Increase restrictions to the amount of impervious surfaces should be considered in light of the established direct and indirect impacts associated with increasing amounts of impervious surface cover. Although, overall the percentage of imperviousness cover throughout the watershed is relatively low (2%) there are areas adjacent to critical resources that are well in excess of 10% impervious and other areas that will likely be subject to a rapid, significant increase in impervious cover. This increase, and the need to manage impervious surfaces results from documented negative impacts on groundwater infiltration and recharge, increases in pollutant loading and increases in the scour, erosion and destabilization of stream and riparian corridors.
- Additional open space set asides should be considered, particularly in vulnerable areas noted in the Clinton, Readington, and Branchburg ERIs.
- Increased capital should be set aside and grants obtained to complete additional analysis and to revise current regulations to be more protective of valuable natural resources. The Township should consider additional development standards to restrict disturbance in all critical/vulnerable areas (e.g., steep slopes, erodible soils, state designated grassland, wetland, and forest critical habitats).
- Develop opportunities to preserve diminishing farmland should continue to be actively pursued. Involvement in county easement purchase program, state fee simple program, and Township easement purchase/option program should continue.
- Reduce the generation of chloride related contaminants and their subsequent impacts to the biota and quality of the streams through the implementation of roadway deicing/salt management reduction.

8.7 Watershed Plan Adoption Process

A number of municipal and county government offices and a number of stakeholder organizations were invited to participate in the creation of the Pleasant Run and Holland Brook Regional Stormwater Management Plan. Readington Township and Hunterdon County representatives routinely participated in the meetings and review process. Based on the findings and recommendations in the RSWMP each municipality will be obliged to modify their stormwater plans or ordinances in order to achieve compliance with the RSWMP.

Readington Township, as the designated Lead Planning Agency, will continue to work in concert with the NJDEP and the two additional municipalities in the implementation of the RSWMP. NJDEP is required to publish the RSWMP in the New Jersey Register and host a public hearing to present the findings and recommendation of the RSWMP, and provide for a minimum 30-day public comment period. Readington Township will work in concert with the NJDEP and Hunterdon

County (the legal entity currently conducting the technical review and approval of all MSWMPs and ordinances) on these hearing proceedings. Following the pubic hearing and comment period, the plan will be officially adopted by the NJDEP. Each municipality within the Pleasant Run and Holland Brook Watershed will be informed and invited to attend the meeting and provide comments. Upon adoption of the RSWMP, the NJDEP is expected to highlight it on the NJDEP Watershed Management website, and NJDEP will provide an additional notice in the New Jersey Register.

8.8 Summary of Compliance with USEPA Nine Required Elements of a Watershed Plan

The following summarizes the consistency of the Pleasant Run and Holland Brook RSWMP in terms of satisfying the nine required elements of a Watershed Protection Plan. These are as follows:

1. Identification of causes and sources of water quality and use impairments– Detailed in the Characterization and Assessment Report submitted and approved by the NJDEP (Milestone 2 Report)
2. Estimation of existing and future pollutant loads and required load reductions – Detailed in the Milestone 2 and 3 Reports submitted and approved by the NJDEP.
3. Description of the NPS management and BMPs needed to realize load reduction goals – Detailed in Milestone 3, 4A and 4B Report submitted and approved by the NJDEP.
4. Estimation of the financial and technical assistance and authorities needed to implement the RSWMP – As discussed in herein in this report (Table 8.1) and in the Milestone 4A and Milestone 4B reports submitted to NJDEP.
5. Description of the educational, outreach and information dissemination measures/techniques that will be put into action to enhance public awareness of the RSWMP – As discussed herein in Sections 6, 7 and 8 and in the Milestone 4A and 4B Reports.
6. Schedule and Authorities for implementation - As detailed in the Milestone 4A and 4B Reports, and discussed herein in Sections 7 and 8.
7. Measurable milestones to determine attainment of RSWMP management measures – As discussed herein within Sections 6, 7 and 8.
8. Description of criteria to determine progress – As discussed herein in Section 8.
9. Implementation of a monitoring element of the RSWMP – As discussed in Milestone 4B Report and herein in Section 8.

Further details are provides below concerning how each of the minimum nine elements were satisfied within each of the above cited Milestone Reports or Sub-Sections of the WPP.

Element 1 Identification of Cause and Sources

In the preparation of the Characterization and Assessment Report (Milestone 2 Report) Princeton Hydro, the LPA and the project stakeholders implemented a detailed biological, chemical and hydrological analysis of Pleasant Run and Holland Brook.

The Pleasant Run watershed covers approximately 6,919 acres (10.8 square miles), and the Holland Brook watershed encompasses approximately 7,966 acres (12.4 square miles). Thus, the entire PR/HB Watershed study area covers approximately 14,884 acres (23.3 square miles). Pleasant Run and Holland Brook, together with their tributary headwater streams, are classified as "FW2-NT" waters under NJ's State Surface Water Quality Standards (SWQS), N.J.A.C. 7:9B (NJDEP, 2005). This designation means that PR/HB Watershed streams have a general surface water classification of Freshwater 2 (FW2), which is applied to fresh waters that lack the additional nondegradation standards of those designated Freshwater 1 (FW1) or Pinelands Waters (PL). The "Nontrout" (NT) label means that these streams have not been designated as "trout production" or "trout maintenance" streams under the SWQS, with the associated elevated water quality protections those designations carry. Neither stream has been designated "Category One," the highest level of water quality protection under State regulations. Biological assessment data collected by NJDEP indicates that the water quality of both streams is deficient for aquatic life, as designated in the 2004, 2006 and 2008 iterations of the NJ Integrated Water Quality Monitoring and Assessment Report, also referred to as the NJDEP's 303D listing.

As per the data contained in the Milestone 2 Report, low-density/rural residential development is the dominant land use in the combined watershed, covering 4,748 acres or nearly 32% of the total watershed area. Typically, lands so classified are developed in the form of single-unit residences set on lots of at least 0.5 acres and larger, with associated impervious surfaces comprising 15-25% or less of the total area (Anderson et al., 1976). Although this is the least intensive category of residential development, it is characterized by larger lot sizes (an indication of "sprawl" type development) and is often associated with specific sources of NPS pollution, such as onsite wastewater disposal systems (i.e., septic systems), lawn fertilizers, garden pesticides and pet waste. Farmland and forests make up the largest portion of the watersheds (28% for PR and 20% for HB). Field/brush/shrubland covers almost 6% of the entire combined watershed, while wetlands comprise an additional 4%. Recreational lands (e.g., parks and athletic fields) make up just over 1%. Industrial and commercial development covers less than 1% of the total watershed area, even when their respective acreages (53 acres and 30 acres) are added together.

As result of stream inspections, sampling and assessments conducted of both waterbodies as part of the Characterization and Assessment element of the project, it was fully documented that both Pleasant Run and Holland Brook have incised stream channels, at times are characterized by turbid conditions and have a history of stream-side canopy loss. In accordance with an NJDEP-approved Quality Assurance Project Plan (QAPP), sampling was conducted of both streams between June 2005 and September 2005 under both baseflow (four sampling events) and storm flow (four sampling events) conditions. The following parameters were measured/analyzed: Temperature (*in-situ*), Conductivity (*in-situ*), Dissolved Oxygen (DO) (*in-situ*), pH (*in-situ*), Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Suspended Solids (TSS), Nitrate-Nitrogen (NO^3-N), Fecal coliform (FC), Fecal streptococcus (FS) and Benthic macroinvertebrates. As evidenced by the results of the baseflow and storm event sampling efforts, both streams receive improperly managed stormwater runoff that results in conditions characterized by elevated nutrient concentrations, elevated pathogen levels and periodic increases in turbidity (TSS). Details of the results of these field assessments are presented in the appendices submitted with the Milestone 2

Report as well as data tables contained within the body of the report. As summarized in that report "the results of the 2005 water quality monitoring program indicate that the Pleasant Run and Holland Brook are impacted by fecal coliform (most likely of non-human origin), elevated phosphorus levels and nitrate concentrations indicative of a eutrophic ecosystem".

Element 2 Estimation of Existing and Future Pollutant Loads and Required Load Reductions

An extensive amount of effort was put into the modeling of the pollutant loads for Pleasant Run and Holland Brook. These data are presented in the Milestone 2 report (See Section 4 - Unit Area Loading Modeling, Pollutant Loading Analysis), and include a detailed explanation of the means of quantification,. Both the existing and "build out" loads for the watershed were computed using a GIS based pollutant load modeling approach. The pollutant export coefficients used in the modeling effort were refined to take into account attributes of the local soils, vegetation, and especially land cover and land use conditions. The resulting data appear in Appendix B of the Milestone 2 Report. Five pollutants of concern for the watershed were modeled under existing and build out conditions: Total Phosphorus (TP), Total Nitrogen (TN), Total Suspended Solids (TSS), Lead (Pb) and Zinc (Zn).

The resulting data fully supported the need for improved management and treatment of stormwater-based NPS pollution in the watershed. This was most evident for the subwatersheds projected to experience the greatest future increase in development and loss of natural land cover. In those subwatersheds, as evidenced by the net increase in pollutant loading, there exists a major need to implement improved stormwater management initiatives in order to mitigate these anticipated increased pollutant loads. In addition, as a result of the municipalities' desire to maintain the rural/agricultural landscape that largely defines the PR/HB watershed, there are efforts in place to protect agricultural lands through farmland preservation programs. Although this is viewed in a positive context with respect to maintaining the character of the community, agricultural land use activities were shown to have a negative impact on the water quality of both streams. Thus, in order to reduce the nutrient and TSS loads that go hand-in-hand with agricultural operations, opportunities to implement and fund agricultural BMPs, such as riparian buffer creation/maintenance, manure management programs and soil-conserving tilling practices, were included as part of the RSWMP and presented in the Milestone 3 report as well as in the Milestone 4A and 4B reports.

In summary, data was provided as a result of the pollutant load modeling effort that documented existing and future pollutant loads to both streams. These data were further refined to identify key subwatershed and key NPS pollutant sources requiring concerted stormwater management controls. As outlined in the Milestone 3 Report and later detailed in the Milestone 4A and 4B reports, specifications were developed using both regulatory and restoration/mitigation based stormwater management tools to address and reduce both existing and the projected increases in stormwater-based pollutant loading.

Element 3 Description of the NPS Management and BMPs Needed To Realize Load Reduction Goals

Details are provided in the Milestone 4A and 4B Reports of the NPS management measures needed to realize load reduction goals and improve the water quality, ecology and environmental functions of Pleasant Run and Holland Brook. This includes details of stream restoration activities and the construction of site-specific BMPs, as well as recommendations associated with various regulatory measures designed to reduce runoff, runoff contaminant loading and the causes behind the streams' ongoing erosion and instability.

The Milestone 4A Report covers the recommended regulatory means of decreasing nutrient loading to the streams. The recommendations presented in the report would require all new development and redevelopment projects to utilize stormwater management BMPs capable of reducing both sediment and nutrients, with mandated minimum performance standards. The mandated standard removal rate for total phosphorus (TP) set in the RSWMP is 60% (or greater), while that for total nitrogen (TN) is set at 30% (or greater). These performance standards are consistent with the NJDEP established TP and TN removal rates for bioretention systems, and as such, are nutrient removal efficiencies achievable using NJDEP approved existing BMP techniques. The objective with this regulation-based element of the RSWMP is to have in place a requirement that the BMPs selected for use in the management of runoff from new developments will be able to achieve a reasonable level of nutrient load reduction. This thus helps protect the streams from the future nutrient load increases as calculated as part of the Characterization and Assessment Study and presented in the Milestone 2 Report.

Also as detailed in the Milestone 4A Report, sediment transport and related impairments caused by the deposition of silt would be addressed in part through the adoption of a higher TSS removal performance standard; specifically 90% (or greater) for all development. This standard would be applied to both new development and redevelopment. It should be noted that Readington Township's existing TSS removal standard is 90%. However, this standard is currently applied only to new development. The 90% removal standard would be an improvement for the portions of the PR and HB watersheds located in Clinton and Branchburg Townships, as both these communities require BMPs to provide only 80% TSS removal and apply the standard only to new development project. It should be noted that the 90% TSS removal standard is consistent with the removal standards established by the NJDEP for bioretention systems as presented in the NJDEP Stormwater Best Management Practices (BMP) Manual. As such, a 90% TSS removal requirement is achievable using a type of commonly employed BMP.

Chronic flooding problems and extensive evidence of stream erosion and scour were documented as part of the Characterization and Assessment Study, both through filed surveys and hydrologic modeling. Increases in peak flows, reductions in base flows and the resulting variation in overall stream flows were all shown in the Milestone 2 Report to be significant causes for the streams' degradation. These impacts were especially evident in the lower reaches of both the PR and HB, particularly near the streams' confluence with the South Branch Raritan River. These impacts were noted to be worsening over the past decade due to the increased development of the watershed. The cumulative impacts of "flashy" flows, stream bank erosion and loss of aquatic habitat presents a concern for these two watersheds that require better management of baseflow. As such within the RSWMP area, another regulation-based element of the RSWMP calls for a 110% recharge standard for all new and redevelopment projects. Recharge volumes would be computed using GSR-32 in accordance with N.J.A.C. 7:8. However, rather than requiring no-net change in recharge, the RSWMP will require 110% recharge, in effect resulting in a decrease in stormwater runoff volume.

Voluntary stormwater management projects for both streams and their watersheds are presented in the Milestone 4B Report. An outline of the recommended voluntary stormwater management projects is as follows:

1. Watershed-Based Restoration Plan
   - Stream studies
   - Stormwater infrastructure survey
   - Stream bank stabilization
   - Improvement of riparian buffers
   - Other restoration techniques
2. Stormwater Management
   - Retrofit catch basins and outfalls that discharge to PR and HB
   - Improvements on Township property
   - Residential rain gardens
3. Education
   - Septic management education
   - Backyard retrofitting
   - Manure management
4. Other options
   - Farmer-friendly/NRCS Incentive Programs
   - Open space management plan and invasive species control
   - Redevelopment using LEED strategies for water reuse and energy conservation
   - Continued farmland preservation and open space acquisition

Of the above, particular detail is provided with respect to the recommended stream bank stabilization and riparian buffer improvement implementation projects. These are detailed, with photos of existing conditions in Appendix A of the Milestone 4B Report. The stream restoration projects promoted in the Milestone 4B Report are:

- Holland Brook- Pinebank Road
- Pleasant Run- Pleasant Run Road- Hanna Farm

The riparian buffer improvement implementation projects promoted in the Milestone 4B Report are:

- Holland Brook – Readington Road and Hillcrest Road
- Pleasant Run- Pleasant Run Road

In summary, mandatory RSWMP driven regulatory measures are presented and discussed in the Milestone 4A Report, while the voluntary stormwater improvement projects are presented and discussed in the Milestone 4B Report. In combination, both reports present actions and implementation projects that when implemented will decrease existing and future pollutant loading to both streams.

Element 4 Estimation of the Financial and Technical Assistance and Authorities Needed To Implement the RSWMP

At the beginning of Section 8 of this report, cost estimates are presented for each of the recommended voluntary mitigation/restoration projects prioritized for both Pleasant Run and Holland Brook (as presented in Section 7 above and in the Milestone 4B Report). Suggested funding sources have been identified for these voluntary stormwater management projects. The projected costs provided in Table 8.1 (reproduced below) are based on these preliminary assessments but are subject in most cases to further refinement.

Projected Cost Summary for the Voluntary Projects					
BMP Project	Description	Responsible Party	Time frame	Projected Cost	Funding Source(s)
Created Wetland	Create a 1 acre wetland bioretention system	Townships	2-5 years	$165,000	319(h) funding
Bioretention	Construct a bioretention swale	Townships	2-5 years	$80,000	319(h) funding
Stormwater Catch basin MTD	Remove existing catch basin Replace with MTD	Townships	2-5 years	$80,000	319(h) funding
Bioretention Basin	Convert existing stormwater detention basins into bioretention basins.	Townships, property owners	2-5 years	$250,000	319(h), CWP, EPA
Stream Bank Restorations	Identify appropriate areas in need of stabilization and restore eroded stream channels.	Townships and local stakeholder organizations	2-5 years	$300,000 to $1million	NRCS, 319(h), USEPA, Depending on funding availability.
Continued education and outreach, voluntary signage	Develop Pleasant Run and Holland Brook Watershed displays for local events, RSWMP public outreach meetings	Townships local stakeholder organizations	2009 depends on funding.	$3,000 - $5,000 annually	319(h), EPA Env Justice, Dodge Foundation
Monitoring (see 8.3)	Annual monitoring program to track changes in watershed and tributary conditions Resulting from RSWMP implementation	Townships and local stakeholder organizations	depends on funding.	$12,000 - $15,000 annually	319(h)

As illustrated above, there are a number of potential funding sources that could provide the money needed to implement the various voluntary stormwater enhancement projects presented and discussed in Milestone Report 4B. Although a majority of the funding needed to implement the mandatory, regulatory driven elements of the RSWMP (Milestone 4A Report) will likely come from the local tax base, it is possible that some of the costs associated with the preparation of new ordinances and the modification of existing ordinances could be covered through grants. Some likely sources of such grant money include the Association of New Jersey Environmental Commissions (ANJEC) as well as money available through foundations such as the Dodge Foundation.

Element 5 Description of RSWMP Educational, Outreach and Information Dissemination Measures/Techniques

Details of the educational and outreach efforts that will be used to achieve public awareness of the RSWMP are presented in Sections 6, 7 and 8 of this report, as well as in the Milestone 4A and 4B Reports. As discussed above two educational initiatives associated with the mandatory, regulatory driven elements of the RSWMP involve outreach and educational programs dealing with Groundwater Recharge and the concept of the Regional Stormwater Forum (see Section 6.5 above). As detailed earlier in Section 7.2 (Stormwater Education and Outreach) some of the educational efforts that could be used to support the voluntary measures include:

- Improve communication, training and coordination among local, county, state governments, local committees, and environmental organizations for watershed related activities.
- Improve public education and raise awareness to promote stewardship of watershed resources, improve water quality, and reduce non-point source pollutants.
- Improve environmental and land conservation efforts by preserving open space, sensitive environmental areas and habitats by promoting such concepts as riparian buffer stream bank preservation and restoration, reforestation, floodplain preservation,
- Enhance the existing volunteer stream monitoring and restoration programs in this watershed offered by the Readington Township EC, the NJWSA and the SBWA.
- Celebrate successes to recognize noteworthy efforts, encourage participation, and continue the implementation of the Pleasant Run and Holland Brook RSWMP at the annual meetings.
- Prepare and disseminate the Watershed information via:
- Educational Displays and Brochures for community events
- Demonstration projects
- Watershed tours or hikes
- Workshops and staff training seminars
- Volunteer opportunities for cleanups, plantings, monitoring or stenciling storm drains
- Local planning or ordinances efforts.

Some of the educational efforts that could be used to support the mandatory, regulatory measures included in the RSWMP (Milestone Report 4A) include:

- The dissemination of information to the public on low phosphorus fertilizers and proper lawn via a 'lawn care expo day' for residents, the publication and distribution of environmentally sound lawn care brochures/flyers and outreach to retail businesses to advertise and promote watershed friendly, low phosphorus products.
- With respect to the protection and maintenance of the streams' riparian and wetland buffers, including their long-term management and control of invasive species, it was recommended that a brochure be developed and distributed to both affected property owners (who can be identified via a tax-parcel indexed GIS buffer map) as well as the general pubic.
- Given the importance of the proper management of stormwater generated from public facilities, conduct annual workshop to educate DPW employees on the maintenance of BMPs, especially the more advanced BMPs such as bioretention basins, bioretention swales, infiltration basins and sand filters. This training/education effort for DPW staff should also include inspection and maintenance activities for manufactured treatment devices (MTDs).
- To keep municipal board member s current on stormwater management regulations and techniques conduct annual training session for Planning Board, Zoning Board and Township Committee members.

Element 6 Schedule and Authorities for Implementation of the RSWMP

Both the Milestone 4A and 4B Reports provide details of the schedule for the implementation of the various components of the RSWMP and identifies the authority responsible for plan implementation. With respect to the mandatory, regulatory elements of the RSWMP, it is projected that once the plan is adopted by the NJDEP, Clinton, Readington and Branchburg would modify their existing MSWMPs to encompass the requirements, performance standards and related aspects of the RSWMP over the following 12 month period. This would include time for the adoption of the various RSWMP supporting ordinances (e.g., groundwater, deicing material storage and application, etc.). With respect to the implementation of the non-mandatory, voluntary restoration projects (Milestone 4B Report), the schedule will be tied directly into the availability of funds for such projects. As such, although the municipalities would once again serve as the authorities under which such efforts would be implemented, the timing of implementation could run over a period of five to ten years depending on the availability and/or receipt of funding from the various sources identified above (NJDEP, NRCS, ANJEC, etc.). Addition discussions related to Schedule and Authorization are contained in Sections 7 and in the earlier portions of Section 8 of this report.

Element 7 Measurable Milestones to Determine Attainment of RSWMP Management Measures

The discussion of the various milestones associated with the Pleasant Run / Holland Brook RSWMP are discussed in the previous sections of this report, specifically Sections 6 and 7. To summarize, the primary milestone that will define the RSWMP as a whole will be its adoption by the NJDEP. At this point, the RSWMP will have sustained review by the affected municipal governments (Readington, Clinton and Branchburg) and the public in general. With the RSWMP's adoption, the means by which stormwater is managed in the PR/HB watershed will be significantly changed. The actual implementation of the RSWMP will in turn be most obviously demonstrated by the milestones associated with the passage of the various supporting municipal ordinances. For example the RSWMP calls for stricter performance standards as outlined below:

- Nutrients - Removal rate of 60% (or greater) for total phosphorus and 30% (or greater) for total nitrogen.
- Groundwater Recharge - 110% recharge standard required for all development.
- Total Suspended Solids – Removal rate of 90% (or greater) for TSS for all development.

A significant milestone will therefore be the adoption of these standards by each Township and their incorporation into the municipality's development ordinance. Additional milestones representative of RSWMP implementation will be the passage of the deicing, groundwater, and similar ordinances discussed in greater detail in Section 6.

Given that the primary objective of the RSWMP is the delisting of both streams from the New Jersey State 303(d) List, a significant milestone representative of RSWMP implementation will be the attainment of improvements in water quality and stream ecology. Much of this will be realized through the completion of the projects identified under the voluntary components of the RSWMP (Milestone 4B Report) and additional projects spurred along by their completion. Related milestones will be associated with the acquisition of the funding needed to implement these projects. The NJDEP 319(h) program, NRCS incentive programs and the North Jersey Resource Conservation and Redevelopment (NJRC&D) River Friendly Farming Programs are all highly competitive funding programs that will likely serve as the source for the money needed to complete the much needed stream rehabilitation and enhancement projects discussed in the Milestone 4B Report. As such, each rewarded grant will be viewed as an important milestone and evidence that the RSWMP is being implemented.

Element 8 Criteria to Determine Progress

For this and any other RSWMP, the two most obvious criteria than can be used to determine progress are 1) a measureable, sustainable improvement in water quality, and 2) the completion of stream restoration projects. Measureable, sustainable improvements in water quality will be quantified via a detailed long-term water quality management program. The program developed for Pleasant Run and Holland Brook is discussed in Element 9 below, but was presented in great detail in an earlier part of Section 8 of this report as well as in the Milestone 4B Report. The criteria associated with quantifying and determining RSWMP progress as it relates to the completion of stream restoration projects are the actual physical improvements of the streams and associated riparian areas.

Additionally as detailed in Section 8.4 of this report, the proposed regulatory and voluntary mitigation projects will address currently unmanaged or inadequately treated major sources of phosphorus, sediment, pathogen, and gross particulate loading to the watershed. As such another criteria that can be used to measure or represent RSWMP implementation is the attainment of the

NJDEP fecal coliform TMDL for the South Branch of the Raritan River as well meeting on a consistent basis, the State's water quality standards for TP and TSS.

For any voluntary projects involving the construction or installation of a BMP, a water quality monitoring program will be developed. The resulting "before and after data" will be used as another criterion to measure or demonstrate the benefits of the RSWMP. Additional supporting data for such BMP projects will be generated using the EPA Region 5 StepL (Spreadsheet Tool for Estimating Pollutant Load) model.

Less quantitative or definitive criterion will be needed to evaluate the progress associated with the outreach and educational elements of the RSWMP; which are more difficult to measure than improvements in water quality or length of repaired streams and buffers. This will likely require the application of non-parametric quantification techniques that could be used to gauge public acceptance and understanding of the regulatory components of the RSWMP.

Element 9 Implementation of a Monitoring Element of the RSWMP

The details of the long-term monitoring element of the RSWMP are presented in Section 8.3. To recap, the monitoring program for Pleasant Run and Holland Brook will involve periodic water quality, benthic invertebrate and flow monitoring at the same four stations sampled as part of this project's Watershed Characterization and Assessment Study (Milestone 3 Report). All sampling will be conducted in accordance with the NJDEP-approved Quality Assurance Project Plan (QAPP). Sampling events will be limited to the "growing season", May through September, and will involve sampling under both baseflow (defined as a condition of 72 continuous hours where less than 0.5 inches of rain has fallen) and storm event conditions. Baseflow sampling will be conducted once monthly and three (3) storms will be sampled during each monitoring year (one in May, one in July and one in September). The parameters of concern will be limited to:

- Temperature (*in-situ*)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (*in-situ*)
- pH (*in-situ*)
- Flow (in situ, at stream stations only)
- E coli Bacteria
- Benthic macroinvertebrates
- Water Quality Chemistry (by lab analysis)
  - Total Phosphorus (TP)
  - Soluble Reactive Phosphorus (SRP)
  - Total Suspended Solids (TSS)
  - Nitrate-Nitrogen (NO^3-N)

Annually the results of the baseflow and storm event sampling efforts will be synthesized in a summary report. The findings will also be summarized with regard to ongoing progress towards the performance and implementation of the measures stated in the RSWMP, whether they be voluntary or required. In addition, local community events will be targeted to disseminate general educational information, update the community on the implementation of specific projects, and to recognize or honor volunteers or stakeholders working on completed project tasks.

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