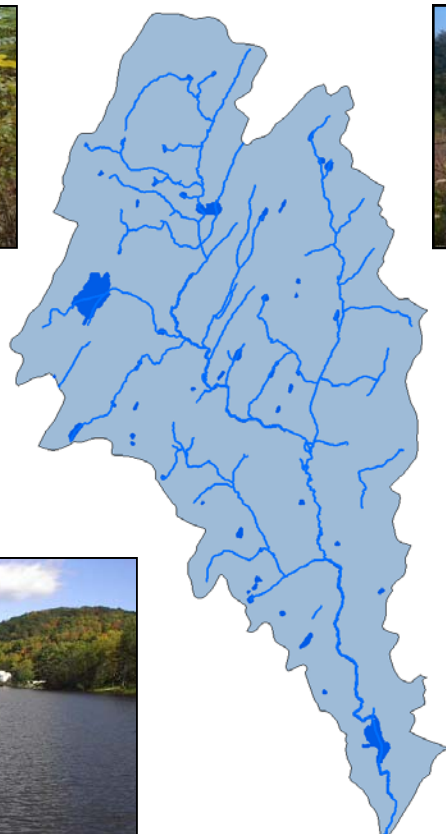
WALLKILL RIVER WATERSHED MANAGEMENT GROUP

Clove Acres Lake / Clove Brook Watershed Restoration Plan NJDEP Project RP05-090



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- Chris Mikolajczyk and Dr. Fred Lubnow of Princeton Hydro, LLC
- Dana Cartwright, Kim Cenno, and Marco Al-Ebus of the New Jersey Department of Environmental Protection (NJDEP)
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Funding was provided by a Grant from the NJDEP and extensive in-kind services and support from the Sussex County Municipal Utilities Authority (SCMUA) and the SCMUA Board of Commissioners.

Profile of the Wallkill River Watershed Management Group (WRWMG)

In 1994, the Sussex County Board of Chosen Freeholders designated SCMUA as the lead agency to develop a Wallkill River Watershed Management Plan. As a result, in March 2000, the NJDEP awarded a contract to the SCMUA to facilitate the Wallkill River Watershed Management Project and bring together local stakeholders to work in partnership to develop a plan to insure the restoration, maintenance and enhancement of the waterways within the Watershed. Over the past eight years, unique stakeholder partnerships have been established and a strong sense of stewardship towards the watershed has been generated. Most importantly, the stakeholders have formed the WRWMG. The key roles of the WRWMG are to:

1. Raise watershed awareness and promote environmental stewardship
2. Generate stakeholder participation in watershed management initiatives
3. Conduct water quality monitoring of local watershed surface waters
4. Drive efforts for potential “on the ground” watershed restoration projects
5. Serve as a Watershed management and water quality liaison for the public residents, municipal officials, and county government organizations

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Executive Summary

A Restoration Plan is presented that addresses the Clove Brook sub-basin (subwatershed) that contains Clove Acres Lake / Lakeshed. The Clove Brook is an impaired waterway, designated as such for non-attainment of total phosphorus (TP). The Clove Brook sub-basin is one of seven HUC 14 sub-basins (02020007020060) that comprise the Papakating Creek Watershed. The Clove Brook sub-basin comprises approximately 12,841 acres or 20.1 square miles of total area and is 47.9% forested, 21.9% agricultural, 16.9% wetlands, 11.2% urban, 1.3% water, and 0.7% barren. The sub-basin encompasses all or portions of the following municipalities: Wantage Township, Sussex Borough, and a small section of Montague Township (essentially all forested). A separate Restoration Plan for the other six HUC 14 sub-basins of the Papakating Creek Watershed has been developed and is being released concurrently with the release of the Clove Brook Restoration Plan.

Clove Brook, Wantage Township

Clove Acres Lake, Sussex Borough

The Papakating Creek Watershed is one of five U.S. Geological Survey (USGS) HUC 11 Watersheds that comprise the Wallkill River Watershed, located in Sussex County, New Jersey. The Papakating Creek Watershed includes approximately 38,798 acres or 60.6 square miles of total area. The Watershed encompasses all or portions of the following municipalities: Frankford Township, Lafayette Township, Wantage Township, Sussex Borough, and a small section of Montague Township (essentially all forested).

In years 2003 and 2004, the NJDEP approved seven Total Maximum Daily Loads (TMDLs) to address the identified pollutant impairments.

Restoration Plan Goals: The total phosphorus (TP) reduction goals developed by the NJDEP, which were later modified by the WRWMG and approved by NJDEP, resulted in the following established Restoration Plan goals:

- Clove Brook sub-basin (the seventh sub-basin comprising the Papakating Creek Watershed): reduction of 2,620 pounds/year of TP, which is a 44.5% reduction in the estimated 2004 total TP loading of 5,887 pounds/year (2,676 kilograms/year)

- Papakating Creek Watershed (six HUC 14 sub-basins): a reduction of 6,841 pounds/ year of TP, which is a 43% reduction in the estimated 2004 total TP loading of 15,909 pounds/year (7,231 kilograms/year)

- Papakating Creek Watershed (all seven HUC 14 sub-basins): in combination with the Clove Brook Restoration Plan, a reduction of 9,459.5 pounds/year, which is a 43.4% reduction in the estimated 2004 total TP loading of 21,795 pounds/year (9,907 kilograms/year)

In accordance with an approved NJDEP Quality Assurance / Quality Control Project Plan, the WRWMG collected additional chemical data to augment data previously collected by NJDEP and United States Geological Survey (USGS). Efforts by the WRWMG were supplemented by professional services provided by Princeton Hydro, LLC, HydroQual, Inc. and Garden State Laboratories. Findings confirmed that the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin are impaired with respect to total phosphorus (TP). Total phosphorus exceedances were slightly to significantly above NJDEP Surface Water Quality Standards (SWQS): TP exceedance values ranged from 0.11 mg/l to 0.29 mg/l relative to the SWQS of 0.10 mg/l for streams.

As part of the Restoration plan development process, the WRWMG conducted an extensive pollutant source-tracking survey to identify potential sources and causes for the TP impairment. Within the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin, nonpoint pollution is the predominate issue of concern versus point source (end of pipeline). The key nonpoint sources of TP were identified as streambank erosion, agricultural land erosion and drainage, undeveloped land erosion and drainage, improper / overuse of both agricultural and residential fertilizer applications, stormwater runoff from developed and undeveloped lands and roads, typical urban area sources (one specific area) and, to a lesser extent, septic systems. In addition, major storm events (rainfall exceeding two to three inches/day) have been observed to be a key factor in the transport of TP to the Clove Acres Lake and the Clove Brook

Streambank Erosion

Agricultural Runoff

Stormwater Road Runoff

An independent assessment of Clove Acres Lake was performed by Princeton Hydro, LLC in accordance with the NJDEP Lake Characterization Protocol and encompassed the following: lake characterization, a variety of in-lake studies (e.g., in-situ water quality data, a bathymetric survey, plankton sampling, aquatic macrophyte studies, and a fisheries survey), collection of relevant watershed data, the quantification of the lake's annual hydrologic and pollutant budgets, and development of a Restoration Plan for the Lake and the Clove Brook sub-basin.

Key conclusions of the assessment by Chris Mikolajczyk and Fred Lubnow of Princeton Hydro, LLC are:

- *"Clove Acres Lake is eutrophic to hypereutrophic"*

- *The Clove Brook is a significant contributor of total phosphorus loading to the Papakating Creek*

- "*Long-term management of the lake should concentrate on managing the lake as a eutrophic waterbody, reduce phosphorus and solid loadings entering the lake, and also consider measures to enhance the lake's recreational fishery potential and control / eradication of the invasive species Eurasian watermilfoil*."

- *Based on existing conditions within the lake, the measured and predicted TP concentrations, and the other factors related to implementation, it is recommended that the percent reduction in TP should be reduced from 75% to 30% as stated in the TMDL.*

Recommendations offered by Princeton Hydro, LCC

- *Based on the observed and modeled conditions of Clove Acres Lake, Princeton Hydro recommends that the targeted TP concentration for this waterbody be 0.04 mg/L and not 0.02 mg/L. A targeted concentration of 0.02 mg/L would be achieved if all residential / agricultural land is converted into forested / wetlands.*

- *Such a scenario of reducing the in-lake TP concentration to 0.02 mg/L is unlikely; therefore the proposed targeted TP concentration for Clove Acres Lake is 0.04 mg/L. Such a TP concentration is 20% below the State's Total Phosphorus Water Quality Criteria of 0.05 mg/L (N.J.A.C. 7:9B-1.14(c)). Such a targeted TP concentration for Clove Acres Lake would require a 30% reduction in the existing annual TP load. With an existing TP load of 2,479 kg and a targeted TP load of 1,712 kg, the annual load would need to be reduced by 767 kg (1,690 lbs) in order to comply with this proposed modification to the TMDL.*

- Proceed with identified implementation projects that address reduction of nonpoint sources of total phosphorous (specific projects noted below and in the Princeton Hydro, LLC Report). Note: Further discussions are in progress between the WRWMG and Princeton Hydro, LLC regarding the modest difference between Princeton's recommendation for a 30% reduction at a design TP lake concentration of 0.04 mg/l versus a reduction of 43% as proposed by the WRWMG, assuming a design lake TP concentration of 0.02 mg/l as stated in the TMDL.

Development of a holistic Management Plan addressing the stated pollutant sources, mitigation of the impacts identified, and achievement of the desired goals is a complex and challenging undertaking that will require many years of concerted, targeted effort by the entire Watershed community. To begin the long-term journey to protect the Watershed's critical natural resources (e.g., stream water quality), proposed reduction strategies and implementation measures are developed to cover five identified 2009 implementation projects as well as subsequent efforts addressing pollution reduction stream-related projects, in-lake treatment approaches, Watershed-wide projects / controls, urban projects / controls, and suggested municipal actions. As noted below, one of the five key implementation projects proposed for 2009 is the establishment of the WRWMG as a Watershed project-management-oriented entity to not only manage the identified implementation projects but also to provide a coordination and integration role addressing the necessary and critical Watershed project implementation efforts required by WRWMG's partners. Experiences have shown that unless an entity is assigned to drive and track pollutant reduction pound by pound, month by month, one key farmer and/or community member at a time within a given large Watershed area, ultimate success of achieving TMDL goals may prove elusive.

The Plan was developed with the following leadership behaviors in mind:

- Awareness of the entire Watershed community (recognizing that the farming community is a significant part of the local economy)
- Teamwork (working with the **right** organizations, interacting at the **right** time with the **right** projects (strong focus on implementation-type projects) and with the **right** working processes)
- Speed (demonstrating a sense of urgency)
- Innovation (striving for continuous improvement)
- Performance (setting, measuring, and achieving ambitious goals)
- Adaptive management style (dealing with challenges, change, successes, failures, and annual funding / resource limitations)

A summary of key recommendations and proposed actions is presented:

Proposed Implementation Projects for 2009 - 2012

Project A:
Design phase for streambank stabilization and riparian restoration along the Clove Brook near Brookside Park in Sussex Borough and Wantage Township (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, and a budget and timeline for project implementation)

Design Phase of Project to be completed within 12 months at a budget of $86,400

Full Project Implementation to be completed within 36 months at an estimated budget of $337,400 (includes design phase costs). Budget for full implementation subject to a re-estimate following design completion.

Project B:
Installation of stormwater treatment devices into six catch basins on Lakeshore Drive with direct discharge to Clove Acres Lake (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, budget and timeline for project implementation)

Full Project Implementation to be completed within 12 months at a budget of $41,125

Project C:
Lakeside riparian restoration and stabilization along the Route 23 border of Clove Acres Lake (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, field installation including full implementation of the restoration and stabilization project; installation of sediment catch basins to take place as part of full project implementation at a future date)

Initial Project Implementation to be completed within 24 months at a budget of $143,00

Full Project Implementation to be completed within 30 months at an estimated budget of $157,000 (Includes initial project implementation costs).

Project D:
Facilitate the development and/or updating of agricultural Conservation Plans by NRCS for 300 acres of active farmland that straddles the Clove Brook in Wantage Township with focus on identifying riparian restoration, manure management, and stream fencing field projects with local farm operators (deliverables to include updated Conservation Plans by NRCS, specific field implementation project work scopes, reconfirmation of project benefits, identified funding sources, and integration of potential pollutant reductions to be achieved by others into a comprehensive pollutant reduction summary balance for the entire Watershed under study)

Project to be completed within 28 months at a budget of $62,800

Full Project Implementation schedule and budget to be determined based upon selected management practices and projects, funding for which will be sought from external sources and funding programs

Project E:
Establishment of the WRWMG as a project management-oriented entity to not only manage the identified implementation projects being executed by the WRWMG but also to provide coordination, technical guidance, and an integration role addressing the necessary and critical Watershed project implementation efforts required by WRWMG's partners and Watershed community members. Technical guidance to cover a broad range of topics (e.g., pollutant source tracking, water resource protection, development of implementation projects, pollutant transport paths, post-monitoring to verify achievement of estimated pollutant reductions). These services are not available from any other organizations within Sussex County and the actions proposed for the WRWMG are in congruence with the resource protection goals of the NJDEP as well as the recently promulgated Program Activity Measures (PAMs) established by the U.S. Environmental Protection Agency (EPA).

Project to be continuously implemented over 40 months at a budget of $80,000

Projects A, B, C, D, and E are designed to be completely implemented over the course of forty (40) months for an estimated total budget cost of $644,325. (Includes an estimated in-kind contribution of $ 30,000, dispersed throughout all five projects.)

Note: The five proposed projects noted above, if implemented together, are estimated to reduce the Watershed TP loading by 100 to 150 pounds/year.

Proposed Long-term Watershed Restoration Strategies: 2009 - 2025

Watershed-Wide (WRWMG / NJDEP as Lead Partners and with potential NJDEP Funding)

- Part of the WRWMG Implementation Entity Role: Monitor, track, and report on the efforts of the USDA Natural Resource Conservation Service (NRCS) and Rutgers Extension Cooperative in the development and updating of approximately 14 agricultural Conservation Plans (to address agricultural farms and commercial / large hobby horse operations); foster relationships with local farmers to encourage them to actively seek the available services from NRCS (overcoming reluctance of some members to seek active support); provide guidance and monitoring of efforts to implement the developed Conservation Plans
- Identification, coordination, and implementation of streambank and riparian restoration projects
- Provide local oversight, coordination and support during implementation of identified streambank restoration projects
- Integration and coordination of the Restoration Plans developed for the Papakating Creek by the WRWMG, the Restoration Plan developed for Clove Acres Lake / Lakeshed by Princeton Hydro, LLC and the Restoration Plan developed by the WRWMG for the Clove Brook sub-basin (a HUC 14 that falls within the Papakating Creek Watershed)
- Stream flow monitoring (relates to pollutant transport balances, flooding, etc.)
- Implementation of a Post-Monitoring Plan as presented in the Restoration Plan.

Watershed-Wide (WRWMG / Municipalities / Other Local Organizations as Lead Partners and Potential Sources of Funding)

- Assessment / evaluation / recommendation of open space land candidates for purchase by Federal, State, County, government agencies, municipalities, and various Land Trust organizations
- Work with Sussex County Engineering in the review and enhancement of stream-related bridge / road design standards to incorporate Best Engineering Practices relating to streambank erosion, sediment, stream disturbances, and road runoff control in order to minimize pollutant transport and adverse impacts on stream water quality
- Implementation of a communication plan to advise / inform / drive water quality improvements through reduction of pollutant sources; establishment of Restoration Plan metrics for monitoring of Plan progress
- Coordination of Watershed-wide efforts with County and Municipal departments (Town Councils, Planning Boards, Departments of Public Works, Open Space Committees, Environmental Commissions, etc.)
- Sponsorship of a winter road-maintenance seminar to address usage of de-icers, grits, etc. and Best Management applications / equipment maintenance practices
- Sponsorship of a stormwater seminar to address effectiveness / noneffectiveness of present practices and foster consideration / acceptance of voluntary adoption of several Tier A guidelines by Tier B municipalities (all participating municipalities within the Papakating Creek Watershed fall within the Tier B category; Tier A guidelines are more extensive / restrictive than Tier B guidelines). (Note: Coordination of this action with NJDEP is recommended)

- Address the need for new ordinances in support of the Restoration Plan goals
- Assessment and implementation of lake restoration projects to protect water quality both within and downstream from Clove Acres Lake and Lake Neepaulin
- Monitor the upgrade of the High Point High School Wastewater Treatment Facility planned for 2010 by the Board of Education (results in a decrease of TP loading to the downstream tributary)
- Sussex Borough is addressed as an Urban Area within a rural setting. The impervious coverage of Sussex Borough is approximately 26% as compared to less than 5% for the surrounding municipalities. The quality of the Clove Brook stream within Sussex Borough is typically classified as Impacted bordering Non-Supporting by use of the Impervious Cover Model (Reference: Urban Subwatershed Restoration Manual #4). This fact is to be considered in the design and implementation of restoration projects specific to Sussex Borough. All proposed projects for Sussex Borough to be reviewed, supported, and approved by the Sussex Borough Town Council and Department of Public Works.
- Development of an invasive species identification and control plan
- Development and implementation of various educational campaigns and programs to raise watershed awareness and solicit stakeholder / volunteer participation in watershed plan implementation initiatives

Recommended Implementation Projects Within 0 - 40 Months From Approval of NJDEP Funding

Five implementation projects noted above (see Projects A, B, C, D, and E) as well the distribution, communication, and discussion of the developed Restoration and Protection Plans by the WRWMG and Princeton Hydro, LLC to entire watershed community included within the project area.

Funding for the implementation of the Restoration Plan will be sought from the following sources:

- NJDEP SFY 2009 319(h) Implementation Grants
- Development of Conservation Plans (in-kind services from USDA - NRCS and Rutgers Cooperative Extension)
- Implementation of Conservation Plans: USDA and other sources (e.g., CREP, CRP, EQIP, WHIP, ICM, etc. Some funding / in-kind services from individual farmers / landowners may be required.
- In-kind services (e.g., County, municipalities, Sussex County Municipal Utilities Authority, Municipal Boards and Committees, etc.)
- Other sources to be identified / investigated (e.g., Dodge Foundation, private corporations, US Fish & Wildlife Service)

Overall Schedule: Initial Implementation Projects for 2009 - 2012 (Initial Phase of an overall timeline of 10 to 15 years with annual planned projects and pollutant reductions)

	Months	4	8	12	16	20	24	28	32	36	40
		2									
Task	**Description**										
Mobilization											
Project A	**Brookside Park Streambank Restoration**										
Project B	**Clove Acres Lake Stormwater Treatment Devices**										
Project C	**Clove Acres Lake / Route 23 Streambank Restoration**										
Project D	**Facilitate Updating of Farm Conservation Plans**										
Project E	**Establish Project Management Oriented Entity**										
Title Block Implementation of the Clove Brook Restoration Plan			**Activity**								

Post-Monitoring Plan:

Considering that the Restoration Plan is to be implemented over a period of 10 to 15 years (primarily impacted by restricted annual funding levels), a Plan is presented that considers objectives, monitoring elements, management policies, monitoring metrics, resource needs, a communication plan, and management strategies best suited for overall management of long-term projects. The use of an adaptive management approach is strongly recommended in pursuing a cost-effective and efficient journey to achieve the desired goals of restoring and protecting the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin with respect to TP. Basically, the implementer is continuously testing assumptions, evaluating the effectiveness of prior decisions / actions, adapting and reacting to new information, and altering future plans based on the totality of current knowledge.

Contributing Plan Success Factors:

- Continued operation and maintenance of the USGS real-time monitoring flow station at Pelletown Road (USGS #01367800)
- Sufficient resources of the Natural Resource Conservation Service, Rutgers Extension Cooperative, and the Soil Conservation District to support the Plan in a timely manner
- Availability of required program / project funding levels to match Plan requirements

- Monitor research findings relating to effective placement of Best Management Practices on agricultural properties and within the Watershed
- Receptivity and support of the Plan by the Watershed community

The goals of the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin Restoration Plan are consistent with the vision established in the Sussex County Strategic Growth Plan and the aims and goals of the Sussex County Agriculture Development Board:

Sussex County Strategic Growth Plan

- Protect and preserve environmentally sensitive areas
- Maintain and enhance surface and groundwater quality / water quantity
- Protect open space
- Encourage farmland preservation
- Protect the Papakating Creek flood plain
- Protect and maintain the quality of life within the Papakating Creek Watershed

Sussex County Agriculture Development Board

- Preserve both farmland and farmers
- Conservation of natural resources on farms
- Ensure clean and plentiful water
- Implement waste management and recycling
- Encourage farmland preservation
- Support and protect the Right-To-Farm Act (ordinances in place by all the participating municipalities within the Papakating Creek Watershed)

A FY 2005 319(h) Nonpoint Source Pollution Control and Management Implementation Grant provided funding for the development of the Restoration Plan from the New Jersey Department of Environmental Protection and significant in-kind services from the Sussex County Municipal Utilities Authority (SCMUA) and the SCMUA Board of Commissioners

Project Description

Introduction

The *New Jersey 2002, 2004, and 2006 Integrated Water Quality Monitoring and Assessment Reports* [1] identified Clove Acres Lake and the Clove Brook as impaired waterways for non-attainment of total phosphorus. In years 2003 and 2004, the New Jersey Department of Environmental Protection (NJDEP) proposed and U.S. Environmental Protection Agency (USEPA) approved a Total Maximum Daily Load (TMDL) [2] to address total phosphorus (TP) in the Clove Brook sub-basin, which contains Clove Acres Lake and the Clove Brook Streamshed.

As part of the administrative process, NJDEP promulgated and submitted to the U. S. Environmental Protection Agency (USEPA) a request for approval of certain amendments to the Sussex County Water Quality Management Plan (SCWQMP) [2] relating to the issued TMDL. In response to the NJDEP and USEPA actions, the Wallkill River Watershed Management Group (WRWMG) submitted and received approval for a fiscal year 2005 319(h) Grant [3] to address the development of a Restoration and Protection Plan for Clove Acres Lake / Lakeshed and the Clove Book Streamshed.

The approved TMDL was to serve as the basis for the development of a Restoration and Protection Plan aimed at identifying the sources of total phosphorus, setting goals for pollutant annual load reductions, and implementation of private and community measures, i.e., application of Best Management Practices (BMPs) in order to attain the applicable Surface Water Quality Standards (SWQS) [4] and a Post-Monitoring Plan to measure the achieved progress.

For reference, a TMDL [5, 6] quantifies the assimilative (carrying) capacity of a stream or lake, taking into consideration point and nonpoint sources of pollutants of concern (in this case, total phosphorus), without exceeding the limits established by the SWQS. Within the WMA02 Watershed, the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin, nonpoint sources of total phosphorus are the predominant pollutant sources of concern versus point sources (end of pipeline discharge). The TMDL also takes into consideration nonpoint sources in the form of load allocations (LAs) and, as applicable, reserve capacity and a margin of safety. Usually, a TMDL also considers point sources in the form of wasteload allocations (WLAs), but this is not necessary due to the minor nature of the point source annual loadings as identified within the Clove Brook sub-basin.

Background

The Clove Acres Lake / Lakeshed and the Clove Brook Streamshed comprise one of seven sub-basins (HUC 14 areas) of the Papakating Creek Watershed. The Papakating Creek Watershed is one of five U.S. Geological Survey HUC 11 Watersheds that comprise the entire Wallkill River Watershed in New Jersey. The Clove Acres Lake / Lakeshed is largely an urban center while the remainder of the Clove Brook sub-basin is largely rural, agricultural, and forested. Both areas are located within Wantage Township and Sussex Borough of Sussex County. Clove Acres Lake is located on the southern end of the Clove Brook, just prior to the confluence of the Clove Brook with the Papakating Creek. The Clove Brook is the primary surface waterbody within the drainage sub-basin, covering approximately 48.9 stream miles. The *New Jersey 2002 and 2004 Integrated Water Quality Monitoring and Assessment Reports* identified Clove Acres Lake and the Clove Brook as impaired waterways and placed them on Sublist 5 for non-attainment of total phosphorus. In April 2004, NJDEP issued a TMDL to address total phosphorus in the Clove Acres Lake / Lakeshed and the Clove Brook Streamshed.

Refer to *Figure 1* showing the location and orientation of the Papakating Creek Watershed with respect to the Wallkill River Watershed (WMA 02) and Sussex County.

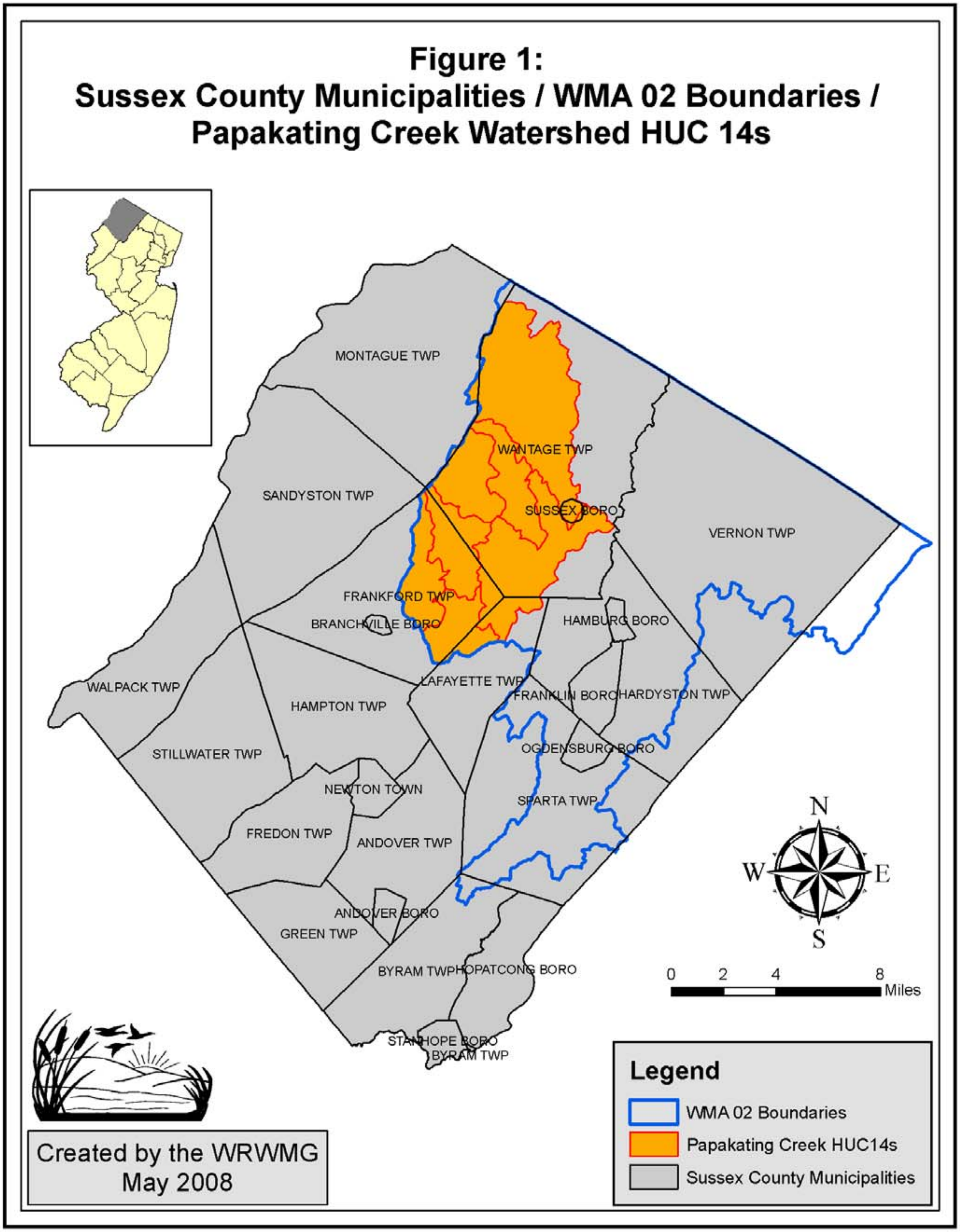

Figure 1:
Sussex County Municipalities / WMA 02 Boundaries / Papakating Creek Watershed HUC 14s

In March 2004, the Wallkill River Watershed Management Group (WRWMG), under the guidance of the Division of Watershed Management of NJDEP, received a $25,000 Priority Stream Segment Grant to address the mainstem of the Papakating Creek. The Priority Stream Grant was in response to the seven TMDLs released by NJDEP [2,3]. The Grant was intended to later serve as a basis for submittal of 319(h) Grant projects for the development of Restoration and Protection Plans for the Papakating Creek and Clove Acres Lake / Clove Brook subwatersheds. Three Tasks were undertaken as components of the Priority Stream assessment:

Task 1: Characterization / assessment of the Papakating Creek Watershed

Task 2: Identification of key data gaps including conducting limited sampling

Task 3: Development of overall work plans, calculation methodologies, identification of potential pollutant sources, approaches for identifying management strategies and practices for reducing pollutant sources, and the identification of potential funding sources


Wallkill River Watershed
Management Group
Papakating Creek Watershed
Stream Priority Assessment Project
NJDEP Grant Document PO No. 5783731 – Task 1
Characterization and Assessment Report
July 2004
Prepared By:
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Watershed Ambassador

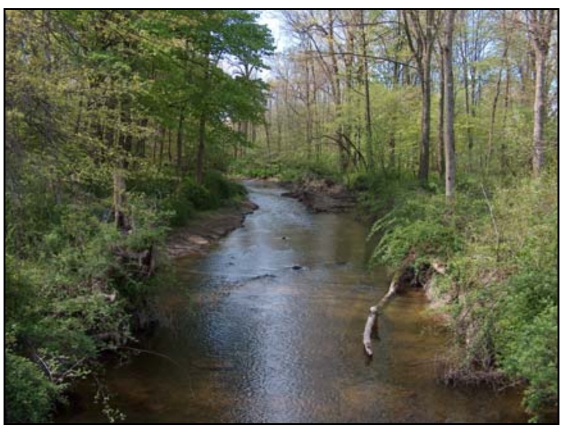
The Task 1 Report [6] was released in July 2004. Upon issuance, WRWMG was authorized to initiate Tasks 2 and 3. Task 2, which covered limited sampling to address key data gaps, was undertaken shortly thereafter. Field sampling was conducted for the balance of 2004 and continued throughout 2005. Sampling data collected under the $25,000 Grant was augmented by data collected as part of the WRWMG third-year contract. All field-sampling events were conducted in accordance with an approved NJDEP Quality Assurance Project Plan (QAPP).

Task 2 findings confirmed the NJDEP-assessed Papakating Creek and Clove Acres Lake / Lakeshed and the Clove Brook Streamshed impairments with respect to total phosphorus. Some evidence was found indicating that total phosphorus may be correlated with annual farming / agricultural field operations as well as with storm events and typical nonpoint pollutant sources. Both parameters show seasonality effects, which indicate the need for appropriate field sampling throughout the year.

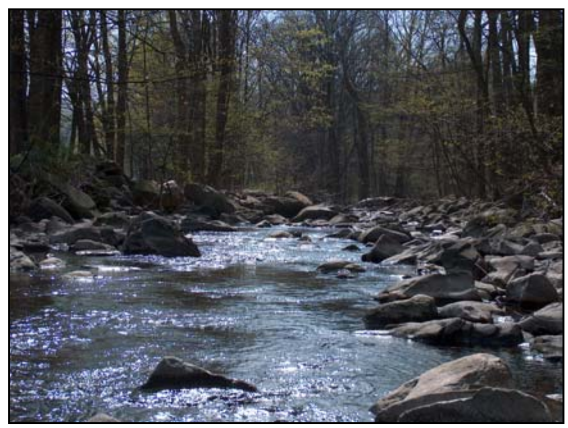
Shortly thereafter, the Wallkill River Watershed Management Group (WRWMG) submitted two Grant Proposals [7] as follows:

- Development of a Watershed Restoration and Protection Plan for the Papakating Creek covering six HUC 14 subwatersheds. The Grant proposal was budgeted at $168,850 and outlined a 36-month project timeline to develop an overall Restoration and Protection Plan. Measurement of flow rates relating to the field-sampling plan conducted by the WRWMG was subcontracted to HydroQual, Inc.

- Development of a Watershed Restoration and Protection Plan for the Clove Acres Lake / Lakeshed (the seventh HUC 14 subwatershed of the Papakating Creek Watershed). The Grant Proposal was budgeted at $138,050 and outlined a 30-month project timeline to develop an overall Restoration and Protection Plan. The WRWMG engaged Princeton Hydro, LLC to conduct a detailed Clove Acres Lake characterization assessment using the NJDEP-approved methodology. The Clove Acres Lake / Lakeshed / Clove Brook Streamshed Restoration Plan will be issued separately from this Report.



Papakating Creek
Frankford Township



Clove Brook
Wantage Township

Project / Watershed Goals

The total phosphorus TMDL reduction goals developed by the NJDEP and later modified by studies conducted by the WRWMG resulted in the following established Restoration Plan reduction goal:

- NJDEP 319(h) Clove Acres Lake / Lakeshed and Clove Brook Streamshed Watershed Grant (NJDEP Contract RP05-090): The Restoration Plan for the Clove Acres Lake / Lakeshed (the seventh HUC 14 area of the Papakating Creek Watershed), when implemented, is to result in the achievement of an overall 77% reduction in the estimated total phosphorus loading of 2,676.1 kilograms/year (5,887 pounds/year).

- NJDEP 319(h) Papakating Creek Watershed Grant (NJDEP Contract RP05-088): The Restoration Plan for the Papakating Creek Streamshed (six of seven HUC 14s), when implemented, is to result in the achievement of an overall 31% reduction in the estimated total phosphorus loading of 7,231.3 kilograms/year (15,909 pounds/year).

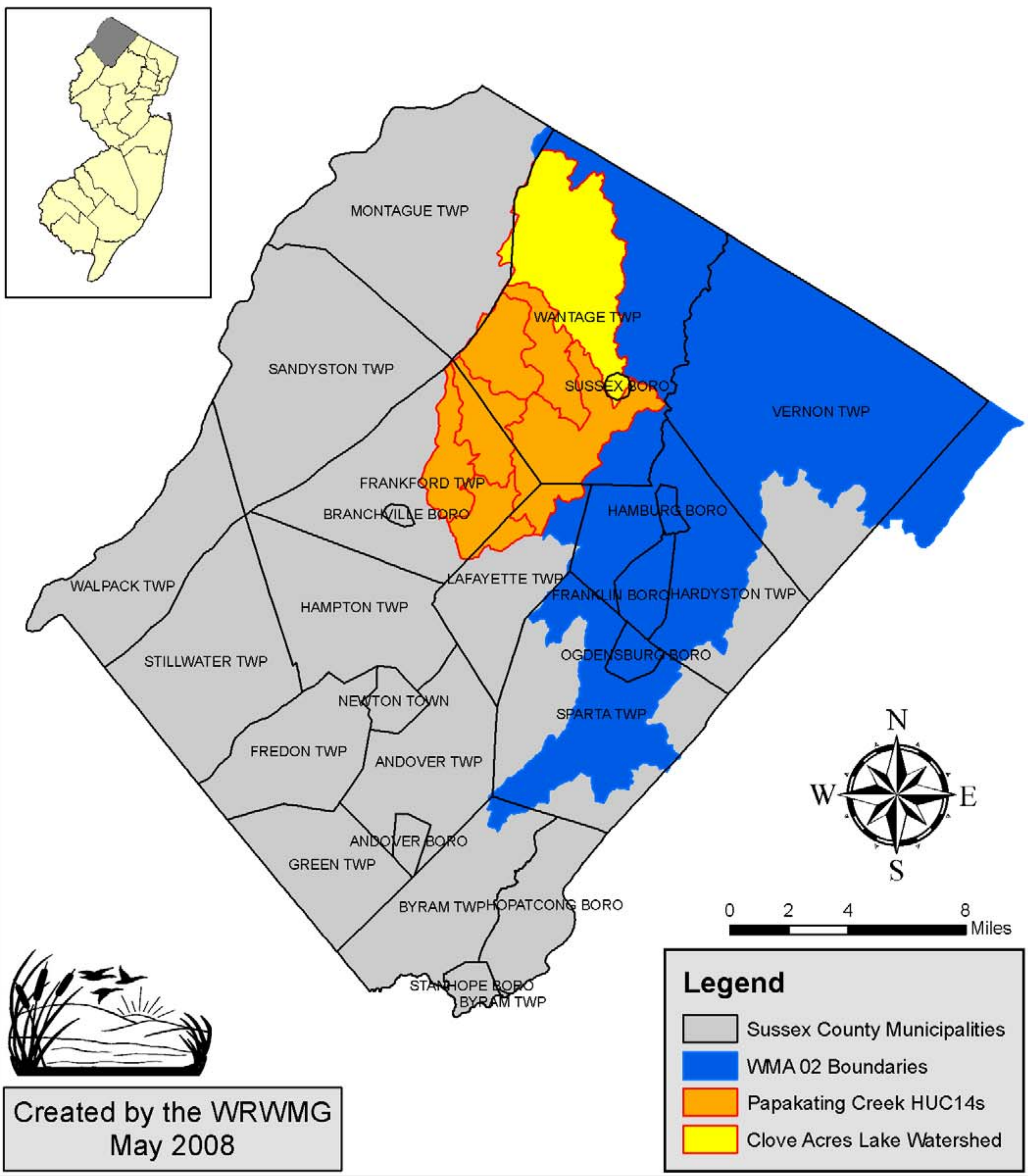
Overall Summary: The Clove Acres Lake / Lakeshed and Clove Brook streamshed Grant plus the Papakating Creek Grant, taken together, are to achieve a 43.4% reduction in a total phosphorus annual loading of 21,796 pounds/year for the entire Papakating Creek Watershed (seven HUC 14 drainage areas).

Re-estimation of the Required Total Phosphorus Reduction Percentages for the Papakating Creek Watershed and Clove Acres Lake / Lakeshed and Clove Brook Streamshed: As noted above, the total phosphorus TMDL for the Clove Acres Lake / Lakeshed specified a required reduction percentage of 77%. Upon detailed analysis, it was shown that achieving a 77% reduction was equivalent to returning the entire Clove Brook sub-basin to a natural state (100% forest, barren land, and water land cover). Since this state is not a feasible outcome, the WRWMG and NJDEP agreed to reallocate the targeted annual TP reduction loading of 9,459.5 pounds/year (21,796 x 0.434) between the two Watershed Grants: Papakating Creek and the Clove Brook. A methodology was proposed by the WRWMG to keep the approach to theoretical the same for the two Watershed Grants. The analysis resulted in resetting the 31% reduction percentage for the Papakating Creek to 43% and resetting the 77% reduction percentage to 44.5% for the Clove Acres Lake / Lakeshed and Clove Brook Streamshed. For reference, the theoretical minimum loading within the Watershed was estimated as if the entire Watershed was retuned to a natural state (defined as consisting of land cover classifications such as forests, vegetative areas, ravines, water streams, wetlands, and barren lands). The changes made were in accordance with discussions and guidance received from the NJDEP Bureau of Environmental Analysis and Restoration (BEAR).

The theoretical percentage reduction (or maximum feasible percentage reduction) is defined as the estimated annual input loading less the natural state loading divided by the annual input loading times 100. The approach to theoretical is defined as the targeted reduction percentage divided by the theoretical percentage reduction times 100. It is recognized that through chemical-based treatment approaches (chemical processes), loadings less than the estimated natural state loading level can be achieved but these approaches are beyond the realm of applicable cost-effective approaches under consideration as part of the Restoration Plan.

Refer to *Figure 2* showing the breakdown of the six HUC14s comprising the Papakating Creek Watershed Restoration Plan Project Area and the one HUC 14 comprising the Clove Acres Lake / Lakeshed Watershed Restoration Plan Project Area.

Figure 2:
Papakating Creek Watershed & Clove Acres Lakeshed Grant Proposals Project Area Breakdown



Translation of Project / Watershed Goals into Management Objectives

Table 1 summarizes the translation of Watershed goals to proposed management strategies for achieving the targeted Watershed pollutant reductions with respect to total phosphorus.

Table 1: Project Goals Linked to the Causes and Sources of Impacts to Management Objectives

Goals	**Indicators**	**Cause or Source of Impact**	**Management Objectives**	**Indicator and Target Value**
Support designated uses for the Clove Acres Lake / Lakeshed and Clove Brook Streamshed**:** TP nutrient loading reduction of 2,620 pounds/year	Total phosphorus	In-stream channel processes (erosion), surface erosion (sediment transport), agricultural / land use operations, and, to a much lesser extent, septic issues (applies to specific locations)	Pollutant reduction and implementation of conservation plans and BMPs, educational / outreach efforts, and municipal actions	Part of Post-Monitoring Plan that addresses both source control and delivery reduction; target is to achieve a level of 0.1 mg/l of total phosphorus in the Clove Brook and 0.05 mg/l of total phosphorus in Clove Acres Lake . The design target TP concentration for the lake is 0.03 mg/l.
Conduct a sampling program to address data gaps and to augment NJDEP total phosphorus databases	Parameters are identified in the Grant's Quality Assurance Project Plan	Not Applicable	Conduct a one-year sampling program to address data gaps; data to augment NJDEP's database	Monitor against the NJDEP Surface Water Quality Standards

Goals	Indicators	Cause or Source of Impact	Management Objectives	Indicator and Target Value
Conduct a parameter source tracking assessment	Monitor for total phosphorus	Sources to be identified	Estimate annual loadings and compliance against NJDEP's Surface Water Quality Standards (SWQS)	Target values as set by NJDEP's SWQS
Identification of restoration and implementation actions / projects			Identify suitable BMPs, funding sources, and municipal ordinances and community actions	
Identification of implementation funding sources			Coordinate WRWMG actions with funding sources	
Identification / development of monitoring criteria and a Post-Grant Monitoring Plan			Develop a Post-Monitoring Plan (data to be collected to address both pre- and post-sampling results	
Development and implementation of an Education and Outreach Program			Develop and implement an Education and Outreach Program	

Clove Acres Lake / Clove Brook Watershed
Key 2009 - 2012 Implementation Projects

Based on extensive sampling results, pollutant source tracking studies, data analyses by the WRWMG and Princeton Hydro, LLC, and the fact that Clove Acres Lake was accidentally drained in 1988 and reestablished as a lake in 2003, the following projects were identified for the first Phase of designing / constructing implementation projects for the Clove Acres Lake / Clove Brook subwatershed:

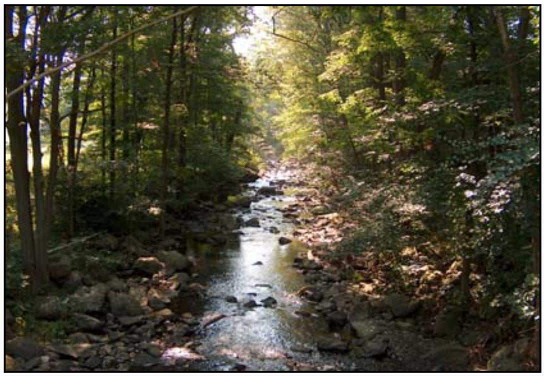
Table 2: Clove Acres Lake / Clove Brook Key Implementation Projects for 2009 - 2012

Project	Land Treated	Targeted Pollutant Reduction	Project Goals	Estimated Cost (Dollars)
Project A: Streambank Stabilization and Riparian Restoration (near Brookside Park)	400 feet (both sides of stream)	Total Phosphorus, Sediment, and Restoration of Streambank (approximately 2 pounds/yr reduction)	1. Achieve Clove Brook Water Quality Standards (TMDL related) 2. Develop Design Drawings and Implementation Budget Costs and Timeline 3. Complete Project Implementation will Reduce Flooding at Newton Ave. and Loomis Ave. Bridges and Local School Playground as well as Reduce Damage to Wastewater Lines Located on Underside of Bridges	**$86,400** (12-month schedule for Design Phase) **$337,400** (36-month schedule for complete project design and implementation)
Project B: Stormwater Treatment Devices for Clove Acres Lake	Small urban area surrounding Clove Acres Lake	Total Phosphorus and Sediment (40 to 60 pounds/yr TP reduction)	1. Clove Acres Lake Water Quality Improvement (TMDL related) 2. Develop Design and Implementation Budget Costs and Timeline 3. Installation of Devices	**$41,125** (12-month schedule)

<u>Project C:</u> **Clove Acres Lakeside Riparian Restoration and Stabilization along Route 23 Border**	Small urban area surrounding Clove Acres Lake (heavy traffic flow on Route 23 on west side of lake)	Total Phosphorus and Sediment (20 to 40 pounds/yr TP reduction)	1. Clove Acres Lake Water Quality Improvement (TMDL related) 2. Develop Design and Implementation Budget Costs and Timeline 3. Complete Project Implementation Will Reduce Stormwater Pollutant Loading to Clove Acres Lake	**$143,000** (24-month schedule for Design Phase) **$157,000** (30-month schedule for complete project design and implementation)
<u>Project D:</u> **Facilitate Development / Updating of 2 to 5 Agricultural Conservation Plans by NRCS, Coordination of Efforts by the WRWMG Partners, and Active Participation in the Scoping / Identification of Agricultural Implementation Projects**	300 Acres of active agricultural land straddling the Clove Brook in Wantage Township	Total Phosphorus, Sediment, Fecal Coliform / *E.coli*, and Elimination of Causes of Streambed and Riparian Buffer Deterioration (target 50 pounds/yr TP reduction)	1. Achieve Clove Brook Water Quality Standards (TMDL related) 2. Clove Brook Headwaters - Identification / Development of Agricultural Conservation Plans and Develop Work Scopes for Identified Farm Onsite Implementation Projects	**$62,800** (28-month schedule)
<u>Project E:</u> **Establishment of WRWMG as a Project Management-Oriented Entity for Identified Implementation Projects Under Management by the WRWMG as well as by the WRWMG's Watershed Partners**	Entire Clove Acres Lake / Clove Brook Subwatershed	(target identification of additional Total Phosphorus reductions for the selected watershed project area	1. Achieve Clove Brook Water Quality Standards (TMDL related) 2. Clove Acres Lake Water Quality Improvement (TMDL related)	**$80,000** (40-month schedule)
<u>Overall Estimate of TP Reduction:</u> **100 to 150 lbs/year after all five projects are implemented; estimated reductions to be refined using EPA Region 5 STEPL Load Estimation Tool during design phases**				

<u>Subwatershed Characteristics</u> (the provided data augments the assessment / characterization information provided in the WRWMG Priority Stream Segment Report [7])

Land Use / Land Cover



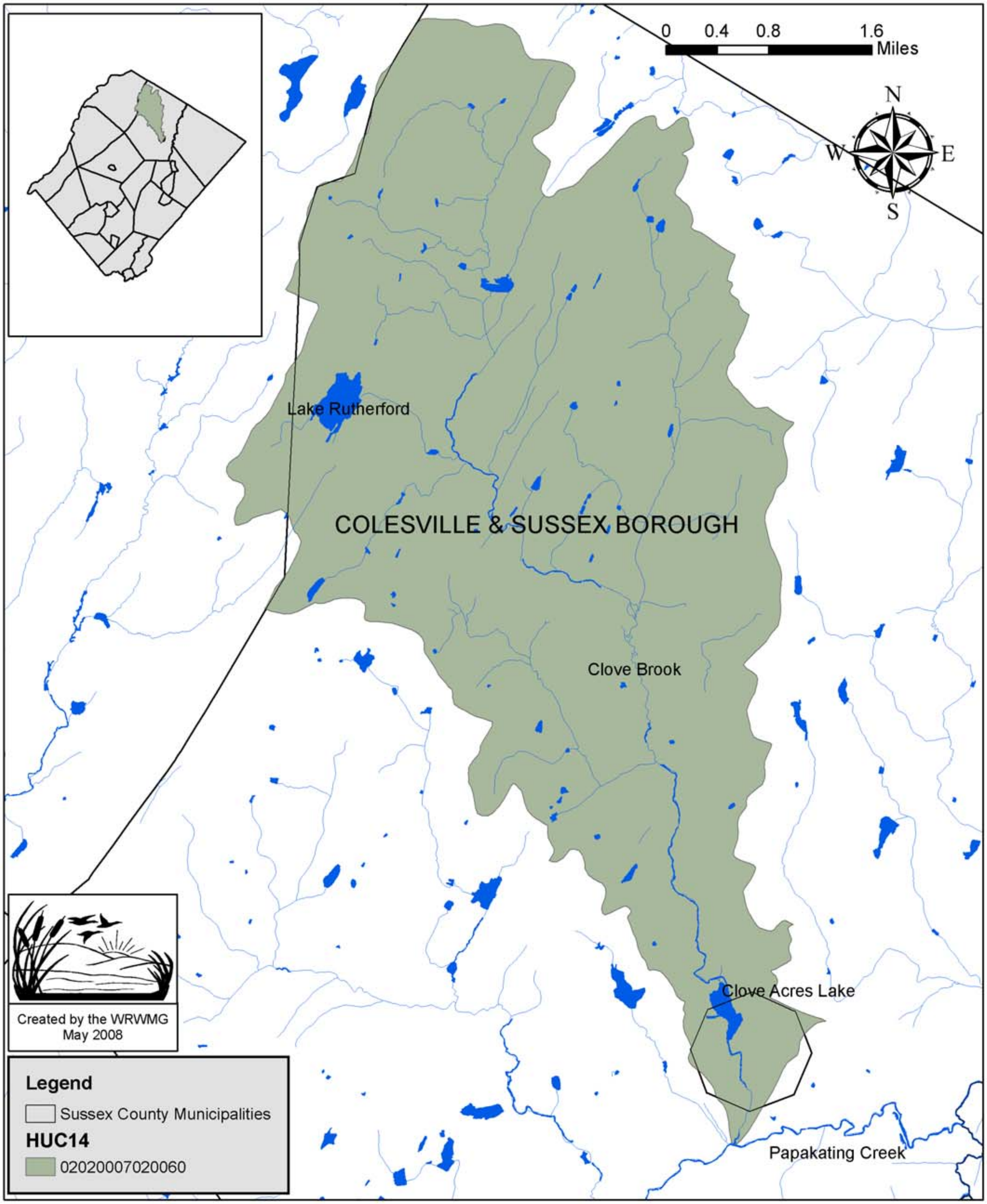
The predominant land uses in the Clove Acres Lake / Lakeshed and the Clove Brook Streamshed include forest and woodland, agriculture, low-, medium- and high-density residential, lake communities (isolated), commercial (Sussex Borough), wetlands, barren lands, and surface waterbodies. The total estimated acreage of the project area is approximately 12,841 acres or 20.1 square miles.

For purposes of report clarity and understanding, a HUC 14 identifier was given to the HUC sub-basin as noted in *Table 3*:

<u>Table 3: HUC 14 Watershed Name Identifier</u>

<u>HUC 14</u>	**<u>Watershed Area Identifiers</u>**
02020007020060	***Colesville and Sussex Borough*** Areas along segments of Routes 23, 651 (Unionville Road), 519 (Greenville Road), Rose Morrow Road, Beemer Road, Clove Road, Medaugh Road, Wantage School Road, Dewit Road, Motown Road, and Skytop Road; Area contains Clove Acres Lake, Clove Cemetery, Van Bunschooten Museum, Pleasants Acres RV Camp, Wantage Township Town Hall, Sussex Borough Town Hall, and Lake Rutherford

Figure 3:
Clove Acres Lake / Lakeshed HUC 14 Identifier



Land Use Classifications and HUC 14 subwatershed areas are summarized in *Table 4:*

Table 4: Papakating Creek Watershed Land Use Classifications / HUC 14 Acres

Based on 2002 NJDEP Land Use Aerial Maps

HUC	Agriculture	Barren	Forest	Urban	Water	Wetlands	Total Acres
02020007 020010	953.7	4.9	1512.7	332.4	14.9	442.8	3261.3
02020007 020020	1315.1	46.3	1301	467.4	29.7	654.4	3813.9
02020007 020030	1345.2	36.4	941.8	384.4	10.2	304.8	3022.8
02020007 020040	1114.6	16.9	1668.2	462.2	23.8	534.2	3819.9
02020007 020050	898.9	19.9	1453.4	645.6	78.1	445.4	3541.3
02020007 020060 (Clove Brook sub-basin)	2815.9	87.8	6151.9	1440.7	168.6	2176.4	12841.3
02020007 020070	2316.6	85.4	3419.6	1087	165.5	1424.2	8498.3
Totals	**10760**	**297.6**	**16448.6**	**4819.7**	**490.8**	**5982.2**	**38798.9 (60.6 sq. mi)**
Percent (includes all seven HUC 14s)	**27.7%**	**0.8%**	**42.4%**	**12.4%**	**1.3%**	**15.4%**	**100%**
Percent (includes only HUC 02020007 020060 (Clove Acres Lake/ Lake-shed) and Clove Brook Stream-shed	**21. 9%**	**0.7%**	**47.9%**	**11.2%**	**1.3%**	**17.0%**	**100%**

Reference: NJDEP Data Source -‘*Total Maximum Daily Load to Address Phosphorus in the Clove Acres Lake and Papakating Creek Northwest Water Region,”* April 19, 2004

Portion of Each Municipality's Acreage Within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed as a Percent of the Municipality's Total Acreage

Table 5 quantifies the percent of each municipality's total acreage that lies within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed. Sussex Borough is noted as 100% within the Watershed, although actual data would show approximately 99+%.

Table 5: Percentage of Each Municipality's Land Area That Falls Within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed (as defined by one HUC 14 area)

Land Area	Wantage Township (acres)	Sussex Borough (acres)
Municipality Acres within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed	**12,438.15**	**403.15**
Total Municipality Acres	**43,039.15**	**403.15**
Area Percentage within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed	**28.9%**	**100% (actually 99+%)**

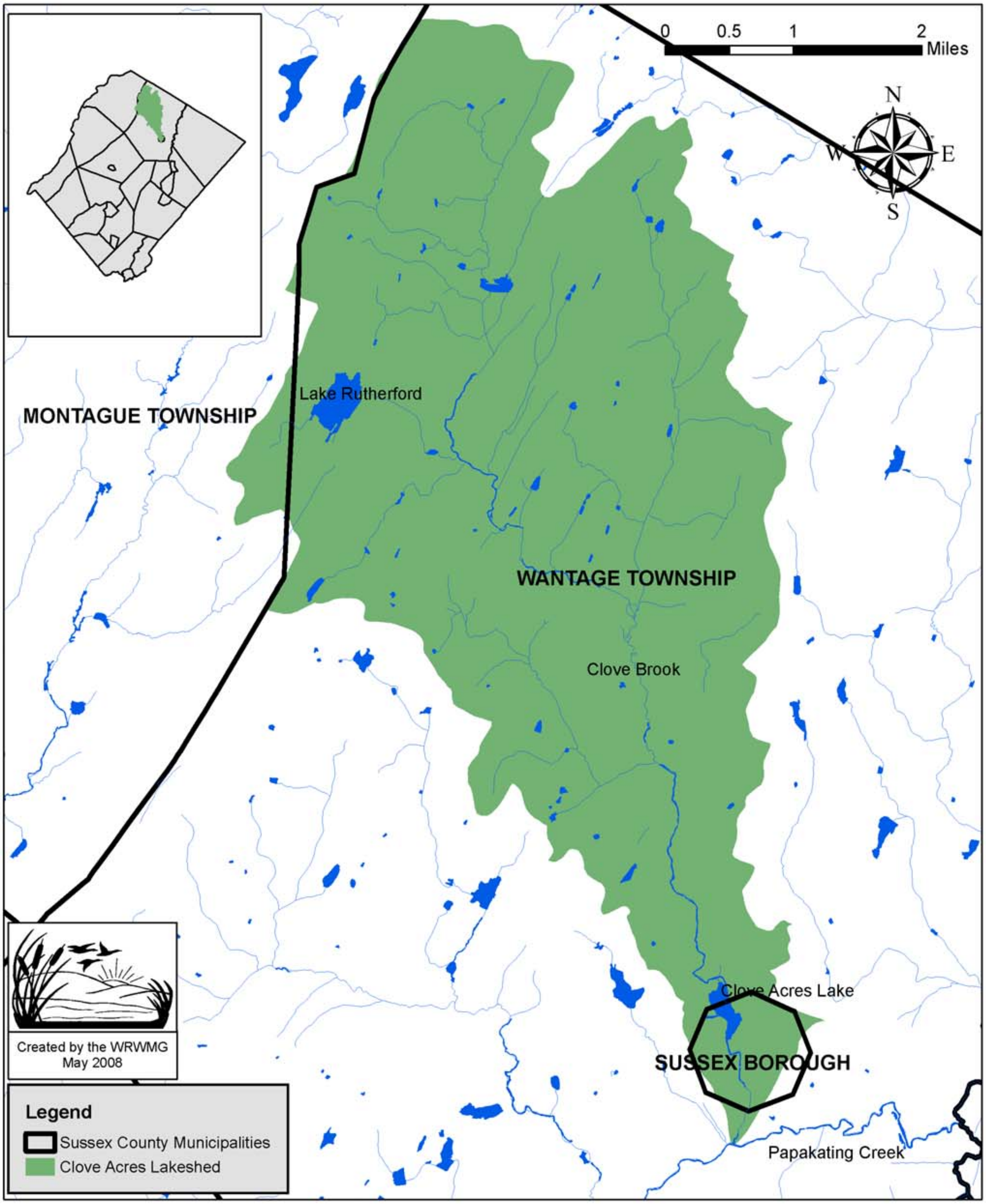
Portion of Each Municipality's Acreage Within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed as a percent of the Total Subwatershed Acreage

Table 6 quantifies the distribution of Clove Acres Lake / Lakeshed and Clove Brook Subwatershed acreage that fall within each municipality as a percent of the total subwatershed acreage.

Table 6: Percentage of Each Municipality's Land Area That Falls Within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed as a Percent of the Subwatershed Acreage (as defined by one HUC 14 area)

Land Area	Wantage Township (acres)	Sussex Borough (acres)
Municipality Acres within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed	**12,438.15**	**403.15**
Total Subwatershed Acreage	**12,841.3**	**12,841.3**
Area Percentage within the Clove Acres Lake / Lakeshed and Clove Brook Subwatershed	**96.86%**	**3.14%**

Figure 4:
Municipalities Within the Clove Acres Lakeshed



Land Parcels Bordering Clove Acres Lake and the Clove Brook

As part of the source-tracking assessment, an analysis was conducted to identify the approximate number and size of lots bordering the Clove Brook. The intent was to prioritize those lots that may have the highest potential to directly contribute to pollutant loadings or potentially serve as buffers and/or candidates for open space acquisition. Results of the analysis are noted in *Table 7*:

Table 7: Size Distribution of Parcels Bordering Clove Acres Lake and the Clove Brook Waterways

Stream	Clove Acres Lake and the Clove Brook	Percentage
Lots ≤ 10 Acres	1,615	89.4%
Lots > 10 to 25 Acres	73	4.0%
Lots > 25 to 50 Acres	54	3.0%
Lots > 50 to 75 Acres	37	2.1%
Lots > 75 to100 Acres	18	1.0%
Lots > 100 to 125 Acres	8	0.4%
Lots > 125 to 250 Acres	1	0.1%
Total Lots	1,806	100%

Chart 1: Lot Sizes Bordering Clove Acres Lake / Clove Brook (Sussex Borough) and the Clove Brook (Wantage Township)

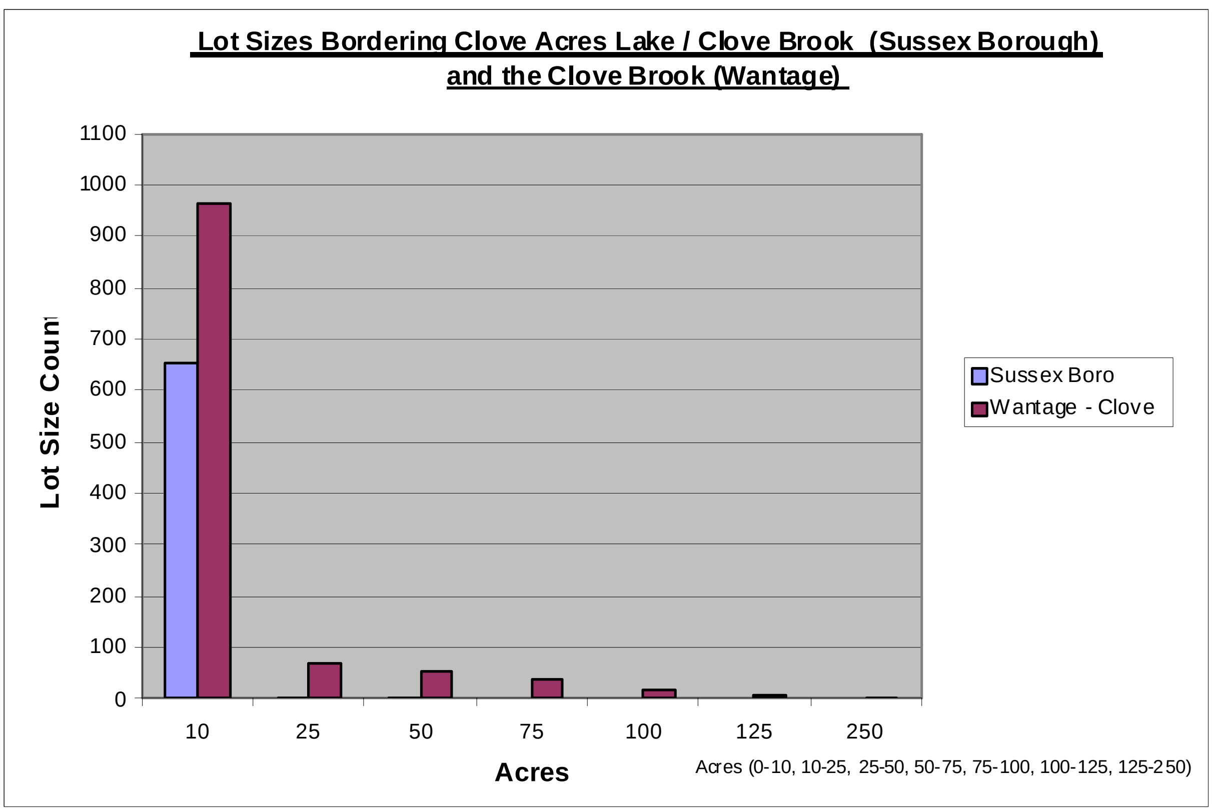
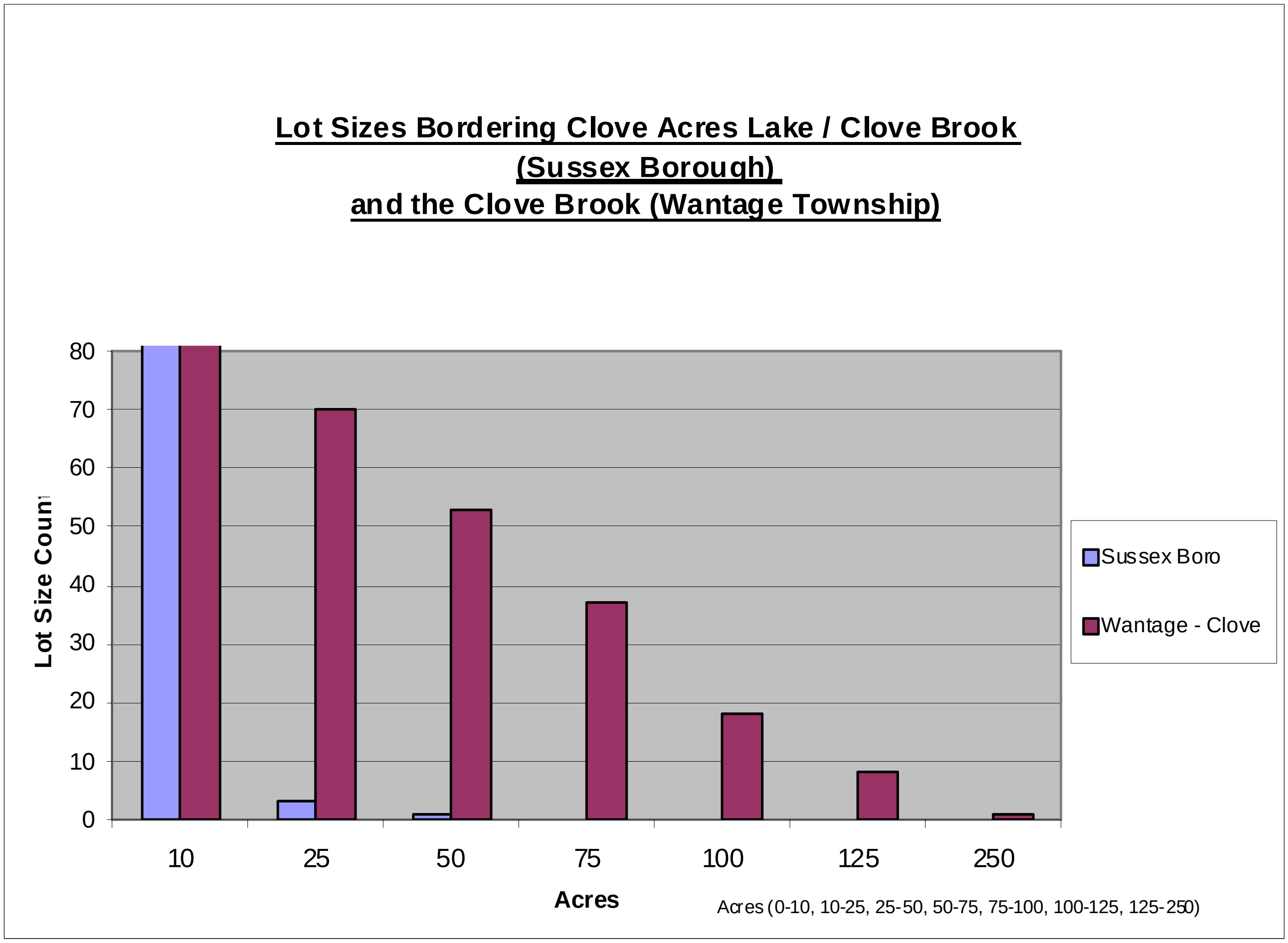


Chart 2: *Lot Sizes Bordering Clove Acres Lake / Clove Brook (Sussex Borough) and Clove Brook (Wantage Township) (data rescaled to show comparison of acres greater than 10 acres)*



Recognizing that the Restoration Plan will be directed to all residents and land owners within the project area, the initial Education and Outreach Program could be directed along the following communication channels: 1) communicate first with approximately 191 lot owners [lot sizes greater than 25 acres], 2) followed by 1,615 lot owners [lots greater than 0 to 10 acres], and 3) all remaining lot owners and stakeholders within the Watershed.

The results of the above analysis were also used to prioritize those sites identified for initial visual studies as part of the source-tracking survey. The data further show that the majority of lots (89.4%) bordering the waterways are 10 acres in size or less and that the preponderance of lot sizes greater than 10 acres ranged from 10 to 75 acres.

In addition to the above-stated purpose, the developed lot-size data were intended to support ongoing efforts to identify critical source areas that significantly contribute to phosphorus transport from adjacent lands to nearby water streams. This work will be further addressed in ongoing discussions with Dr. Zeyuan Qiu of the New Jersey Institute of Technology and Grace Messinger from North Jersey Resource Conservation and Development.

Important Project Information Regarding Clove Acres Lake


Clove Acres Lake: 1988 - 2002

Clove Acres Lake was accidentally drained in 1988 and reestablished as a lake in 2003. Prior to refilling, a significant portion of the lake bottom was dredged and the dredged material was removed. As stated in the TMDL, the impairment status of Clove Acres Lake was established using data collected prior to draining of the lake. In order to assess the current water quality, aquatic plant status, and fishery status of Clove Acres Lake, a full lake characterization / assessment study, as defined by NJDEP, was sub-contracted to Princeton Hydro, LLC in 2005. Key results and findings from their study are reported elsewhere in this Report. Their full Clove Acres Lake / Lakeshed Characterization / Assessment Report will be issued concurrently with the release of the WRWMG's Clove Acres Lake / Lakeshed and Clove Brook Streamshed Restoration Plan.


Clove Acres Lake: Present Day

Waterways / Streams / Restoration Plan Impaired Sections

Using NJDEP-available GIS information, the stream length for the Clove Brook, plus its tributaries within the Clove Brook Streamshed was calculated as:

Table 8: Stream Lengths Within the Clove Brook Sub-basin HUC 14

HUC 14	**Watershed Area Identifiers**	**Stream Length**
		(miles)
02020007020060	Clove Brook including Clove Acres Lake	48.86

Specific impaired stream lengths as reported in the NJDEP Total TMDLs are summarized in *Table 9*. Based on NJDEP's 303(d) Integrated Lists for 2002, 2004, and 2006, NJDEP's Total Phosphorus TMDL for Clove Acres Lake / Lakeshed, and the WRWMG and Princeton Hydro, LLC chemical sampling data, the entire Clove Acres Lake / Clove Book watershed is concluded to be impaired with respect to Total Phosphorus. As such, and as depicted in *Figure 5*, the 2006 Integrated List identifies the Clove Brook HUC 14, as well as the adjacent Papakating Creek HUC 14 # 020200070270, as Sublist 4A subwatersheds, indicating that a TMDL for Total Phosphorus has been established. The 2006 Integrated List also identified the Clove Brook subwatershed as an impaired HUC 14 for pathogens (E.coli) (See *Figure 6*). As a result, the NJDEP's Bureau of Environmental Analysis & Restoration (BEAR) has scheduled development of an *E.coli*-based TMDL for the Clove Brook Watershed within the next two years.

Table 9: 2002 / 2004 / 2006 Integrated Lists
Clove Brook Watershed Waterbodies / Impairments

Waterbody	**Station Name**	**Site ID**	**Impaired River Miles / Lake Area**
2002 / 2004 / 2006 Integrated Lists - Total Phosphorus Impairments			
Clove Acres Lake (see Notes 1 and 2)	Clove Acres Lake	Clove Lake - 02	Approx. 34 acres (the spatial extent defined for the Clove Acres Lake / Clove Brook Streamshed is the entire length of the Clove Brook); Entire stream length for TP and E.coli

Note 1: Listed on Sublist 5 of the *2004 Integrated List* (Microsoft Excel document; dated June 1, 2005) (List refers to TMDLs already prepared and approved by NJDEP and EPA)

Note 2: Listed in Appendix A-2 of the *2006 Integrated Water Quality Monitoring & Assessment Methods Document*, dated December 2006

Figure 5:
HUC 14#s 020200070260 / 70 - 2006 Integrated List Sublist 4A
TMDL Established for Total Phosphorus

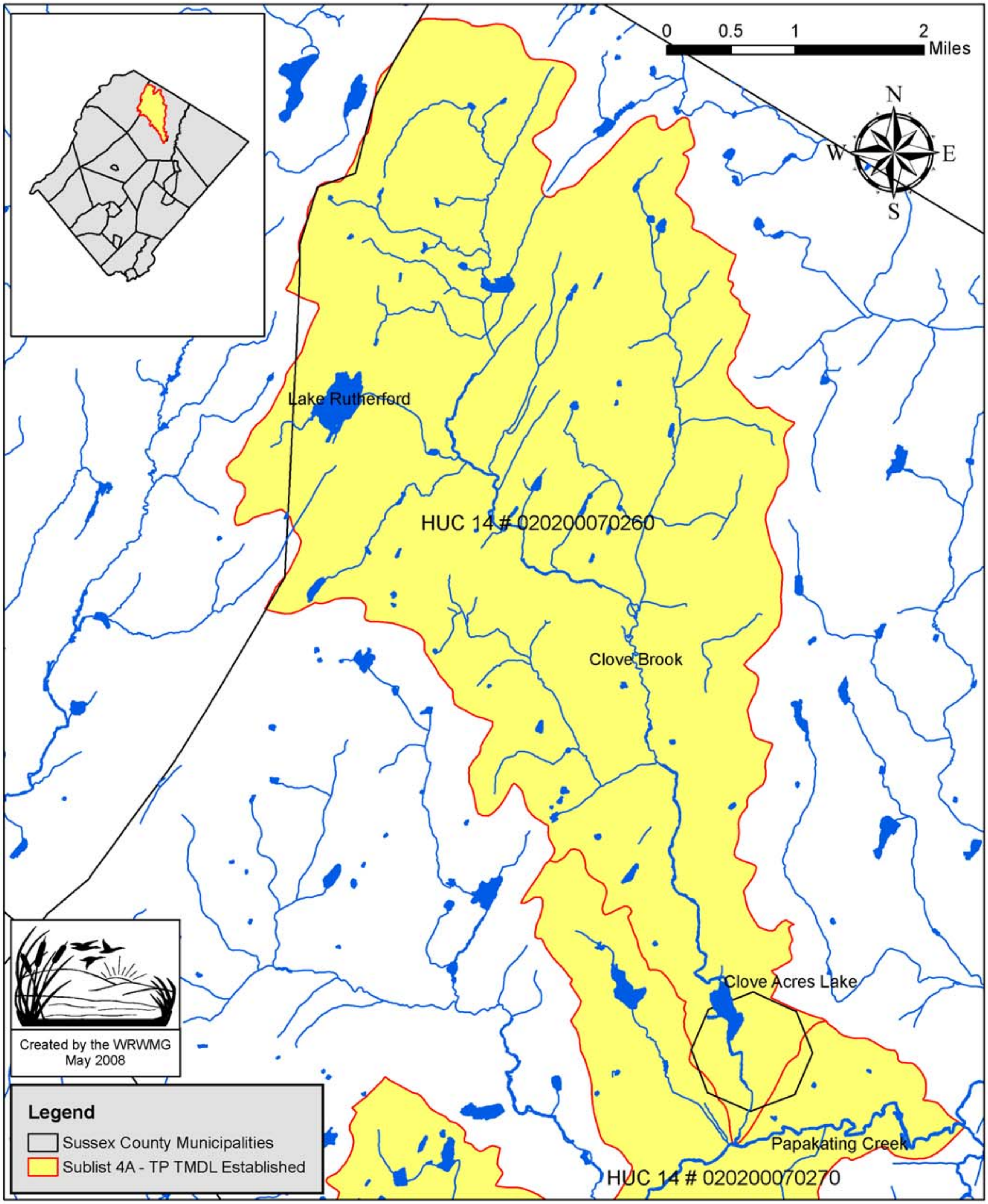
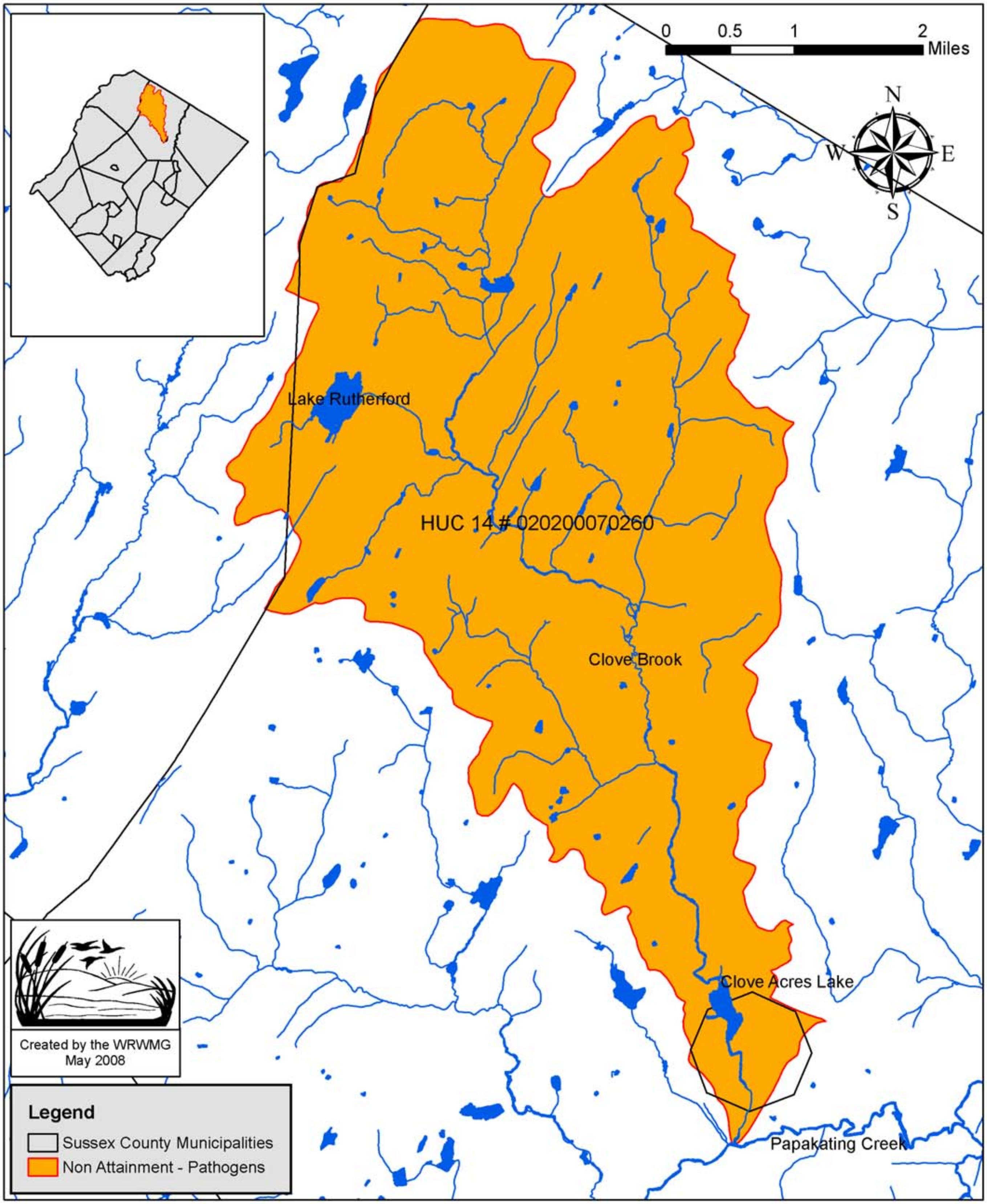


Figure 6:
HUC 14# 020200070260 - 2006 Integrated List Sublist 5
Non Attainment for Pathogens



Soils

Three key aspects of soil characteristics are covered below:

1. Phosphorus content of sediments emanating from the Watershed during stormwater events
2. Septic suitability criteria
3. General soil types within the watershed

Sediment Phosphorus Analysis / Annual Loading - Sussex County soil data for 2002 was requested from the Rutgers Soil Testing Laboratory for farm, commercial, lawn, ornamental, and vegetable garden samples submitted for measurement of total pounds of phosphorus / acre. Collected data are summarized in *Table 10.*

Table 10: Analysis of Sussex County Soil Samples [8, 9] (ppm = parts/million)

Parameter	**Farm/Commercial**	**Lawn / Ornamental / Vegetable Garden**	**Comments**
Number of Samples	41	57	
Maximum Value	710 ppm	1243 ppm	
Minimum Value	5 ppm	10 ppm	
Average Value	208 ppm	265 ppm (as a general rule, values approaching 500 ppm are typically cited in the technical community)	Values over 130 ppm are defined as "very high" by the Rutgers Soil Testing Laboratory
Potential Annual Phosphorus Loading Contribution (pounds/year)	For the entire Watershed, using the sediment areal coefficients from the BMP manual, potential annual phosphorus loadings of 720 pounds (corresponding to 265 ppm) and 1200 pounds (corresponding to 500 ppm) were estimated Note: Estimated phosphorus loadings are assumed to be part of the phosphorus loadings estimated using the phosphorus areal loading coefficients as reported elsewhere in this Report		Further validates the need to reduce the sediment (soil) phosphorus content, as well as the annual generation loss rate of sediments to the various Watershed streams

Watershed Soil Types: *Table 11* summarizes the soils, including their pertinent properties, found within the Papakating Creek Watershed (seven HUC 14s). The noted information was obtained from the Natural Resources Conservation Service's *(NRCS) Soils Searcher* mapping program distributed by the Sussex County Soils Conservation District. The *Soils Searcher* is a digital soil data viewer, delivered on a CD-ROM, containing a certified *Soil Survey Geographic Database* (SSURGO).

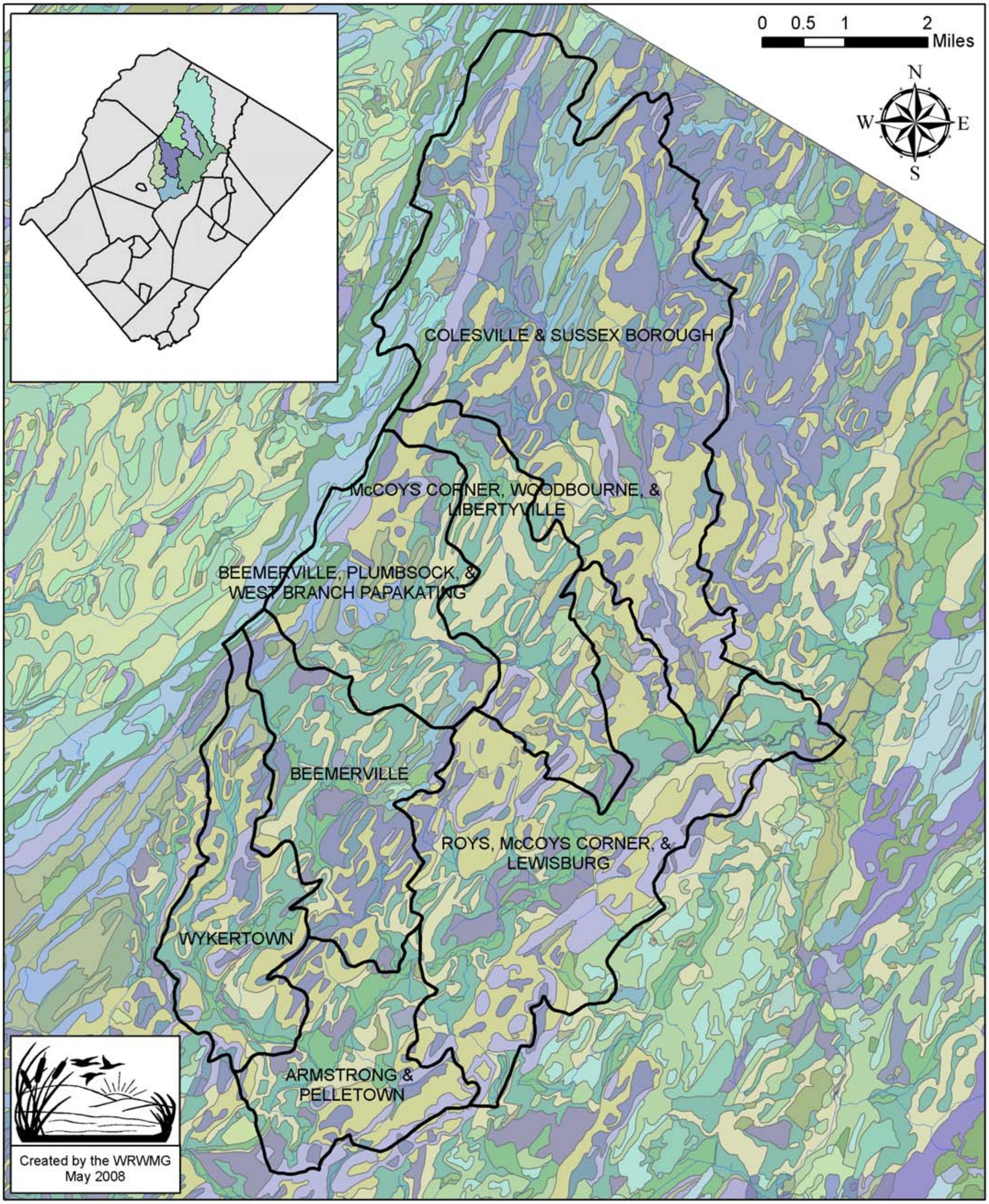
A second source for soil information used is from NRCS's *Web Soil Survey*, which can be found at http://websoilsurvey.nrcs.usda.gov.

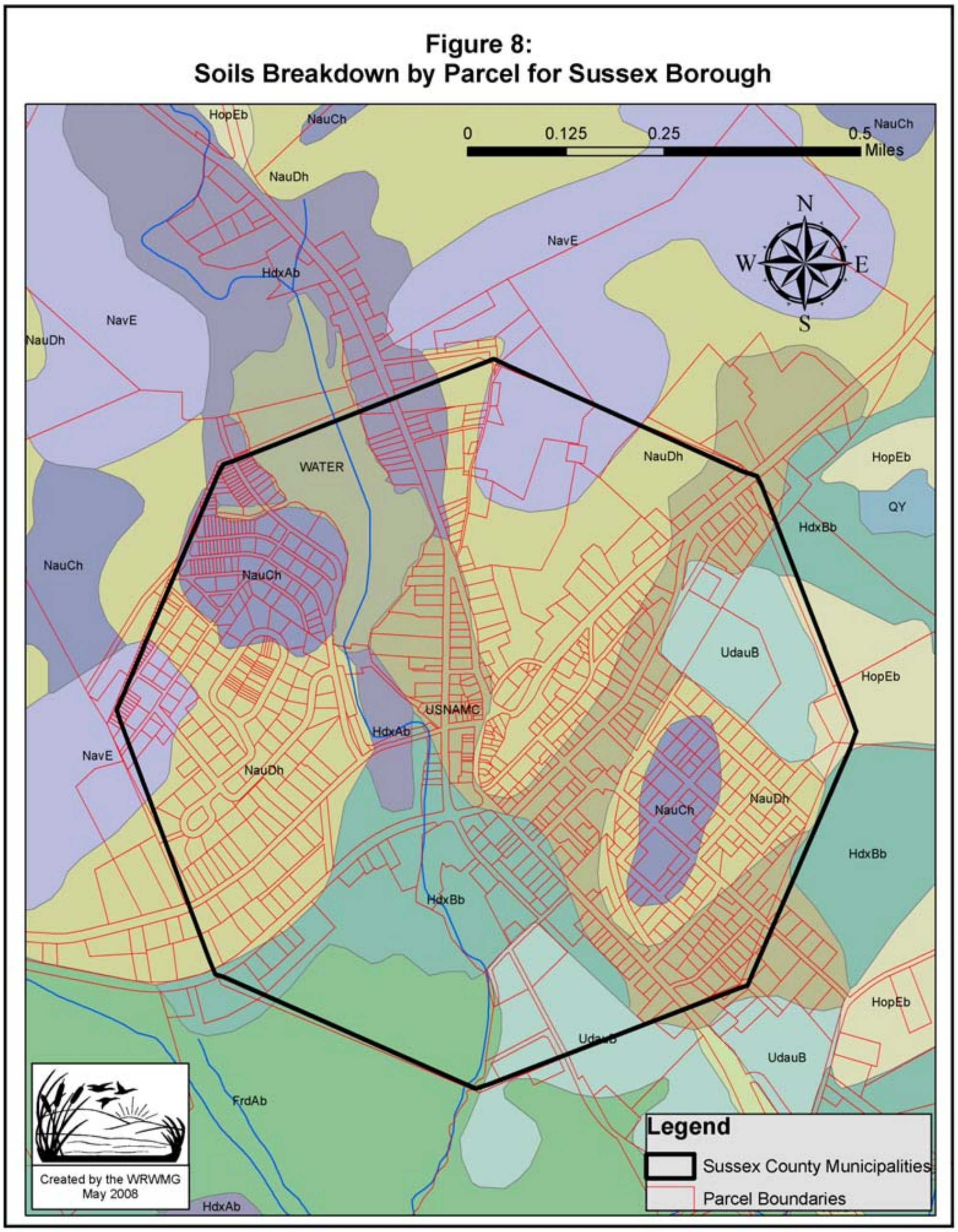
Specific parcel soil properties can be defined by the application of GIS tools using the NRCS soil maps overlayed with area parcel maps. Refer to *Figure 7* for a GIS soil map for the entire Clove Acres Lake and Clove Brook Watershed and *Figure 8* for a GIS Soil Map developed for Sussex Borough (a portion of HUC 14 - 02020007020060).

Table 11: Types & Characteristics of Soils Found Within the Papakating Creek Watershed

HUC Number	**HUC Identifier**	**Soil Types**	**Applicable Characteristics / Properties**		
		Major Coverage	**Texture**	**Depth to Water Table**	**Septic Suitability**
02020007020010	Wykertown	Nassau-Manlius, Hazen-Hoosic, Fredon-Halsey, Hoosic-Otisville, Venango, Wurtsboro-Swartswood, etc. Generally, the first four soil types comprise approx. 80% of the soil series (these soil types are further described as very rocky or very stony)	Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Rated
02020007020020	Beemerville		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Rated
02020007020030	Armstrong and Pelletown		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Very Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Limited
020200070200-40	Beemerville and Plumbsock		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Very Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Rated
02020007020050	McCoys Corner, Woodbourne, & Libertyville		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Rated
02020007020060	Clove Acres Lake / Lakeshed and Clove Brook Streamshed		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments)	Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Limited
02020007020070	Roys (Roys Road), McCoys Corner, & Lewisburg		Loam, Silt, and Silt Loam (with thin and flat limestone, sandstone, or schist fragments	Very Deep (majority of area) to very shallow	Very Limited (majority of area) to Not Limited

Figure 7:
Papakating Creek Watershed Soils Breakdown





Soil Abbreviations:	
FrdAb: Fredon-Halsey complex, 0-3% slopes	**NavE: Nassau-Rock outcrop complex, 35-60 % slopes**
HdxAb: Hazen-Hoosic complex, 0-3% slopes	**QY: Quarry**
HopEb: Hoosic-Otisville complex, 25-60% slopes	**UdauB: Udorthents-Urban land complex, 0-8%**
NauCh: Nassau-Manlius complex, 8-15 % slopes	**USNAMC: Urban land-Nassau-Manlius complex, 8-15 % slopes**
NauDh: Nassau-Malius complex, 15-35 % slopes	

Additional Notes: Septic Suitability Criteria **-** Most of the sub-basin is served by onsite septic systems, with the exception of Sussex Borough, which sends their wastewater to the Sussex County Municipal Utilities Authority via a pump station located adjacent to Brookside Park. Except for Sussex Borough and several small subdivisions, existing residential lots typically range from one/half to one acre, 1 to 3 acres, and up to 3 to 10 acres. Where soil suitability / high water table elevation may rule out conventional septic designs, alternative systems may need to be considered (raised mounds, peat systems, drip irrigation, spray irrigation, advanced designs, etc). Soil suitability must meet the New Jersey Department of Environmental Protection Requirements defined in N.J.A.C. 7:9A-4 and 5.

Topography [8]

The topography of the Papakating Creek Watershed ranges from gently rolling terrain in the east to strongly sloping terrain in the west, up to elevations approaching 1,200 to 1,500 feet above sea level. At High Point, the elevation peaks at 1,803 feet, the highest point in New Jersey. Both High Point State Park and Stokes State Forest are located within the Kittatinny Mountain Ridge. Steep slopes are encountered scattered throughout the Watershed with areas of significant steep slopes around the Clove Brook, and the western portion of the Watershed. Minor slopes are generally classified 0% - 10%, moderate / precautionary slopes of 10% to < 20%, and steep slopes of ≥ 20%. For reference, a two-foot rise over a 10-foot horizontal run constitutes a 20 % slope.

Overlooking the Papakating Creek Watershed from Sunrise Mountain, which is part of the Kittatinny Mountain Ridge

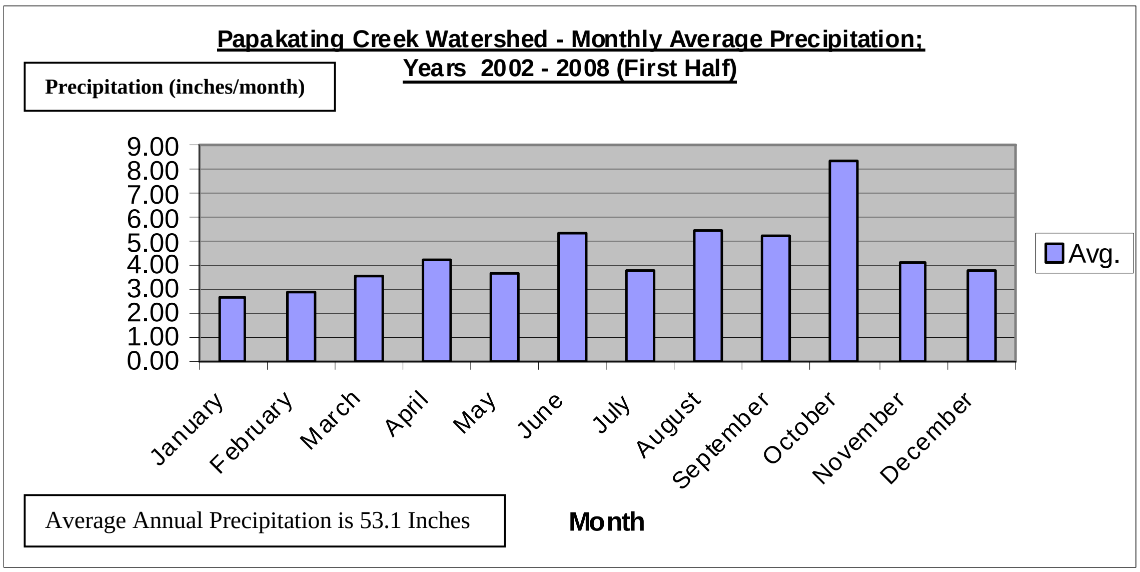
Threatened and Endangered Species [8]

The Papakating Creek Watershed's diverse topography and land use patterns provide excellent habitat for many animal and plant species. There are two state-maintained databases that highlight important habitat for threatened and endangered species: 1) the Natural Heritage Database and 2) the Landscape Project Database. Both can be accessed from either the NJDEP's Office of Land Management or Division of Fish and Wildlife websites. Classifications cover State Endangered Species (SE), State Threatened Species (ST), Breeding Population Only (Br), and Non-breeding Population Only (NB). Within the Watershed (an area contained within the Kittatinny Valley region), the databases list the following species: Wood turtle (SE), Bog turtle (SE), Bobcat (SE), Great blue heron (ST), Red-shouldered hawk (SE, Br), Barred owl (ST), Northern harrier (SE, Br), Timber rattlesnake (SE), Cooper's hawk (ST), Northern goshawk (SE, Br), Bobolink (ST), Savannah sparrow (ST), Vesper sparrow (ST, NB), Red-headed woodpecker (ST), and Grasshopper sparrow (ST, Br).

Papakating Creek Watershed Precipitation:
Years 2002 - 2008 (first half)

The WRWMG obtained daily precipitation recordings taken at the Sussex County Municipal Utilities Authority's Recycling Facility located in Lafayette Township. Although this location is just outside the boundaries of Papakating Creek Watershed, the data are considered representative of actual daily precipitation events occurring within the Watershed. The obtained data were transformed into an Excel format as presented in *Chart 3.*

Chart 3: Watershed Precipitation: Years 2002 - 2008 (first half)
(Data Source: SCMUA / WRWMG Records)



Restoration Plan Drivers

NJDEP-Related TMDLs and 2002, 2004, 2006 Integrated Lists [1,10]

In accordance with Section 305(b) of the Federal Clean Water Act, the NJDEP established in April 2004 a TMDL for total phosphorus in the Clove Acres Lake / Lakeshed and the Papakating Creek Watershed within Watershed Management Area (WMA) 02. The intent of the TMDL is to identify all the contributors to surface water quality impacts and to set goals for load reductions for total phosphorus as necessary to meet the Surface Water Quality Standards. Management control strategies were to be developed based on accurate source assessments, matching reduction strategies with sources, selecting responsible community entities and aligning financial resources to effect implementation.

NJDEP Surface Waters Quality Standards [4]

- Phosphorus, Total (mg/l):

  Lakes: Phosphorus as total phosphorus (TP) shall not exceed 0.05 mg/l in any lake, pond, or a tributary at the point where it enters such bodies of water, except where site-specific criteria are developed pursuant N.J.A.C. 7:9B-1.5(g) 3.

  Streams: Except as necessary to satisfy the more stringent criteria noted above where site-specific criteria are developed pursuant to N.J.A.C. 7:9B1.5(g)3, phosphorus as total phosphorus (TP) shall not exceed 0.1 mg/l in any stream, unless it can be demonstrated that TP is not a limiting nutrient and will not otherwise render the waters unsuitable for the designed uses.

Papakating Creek Watershed: 2007 Proposed / 2008 Adopted C1 Waterbodies [11]

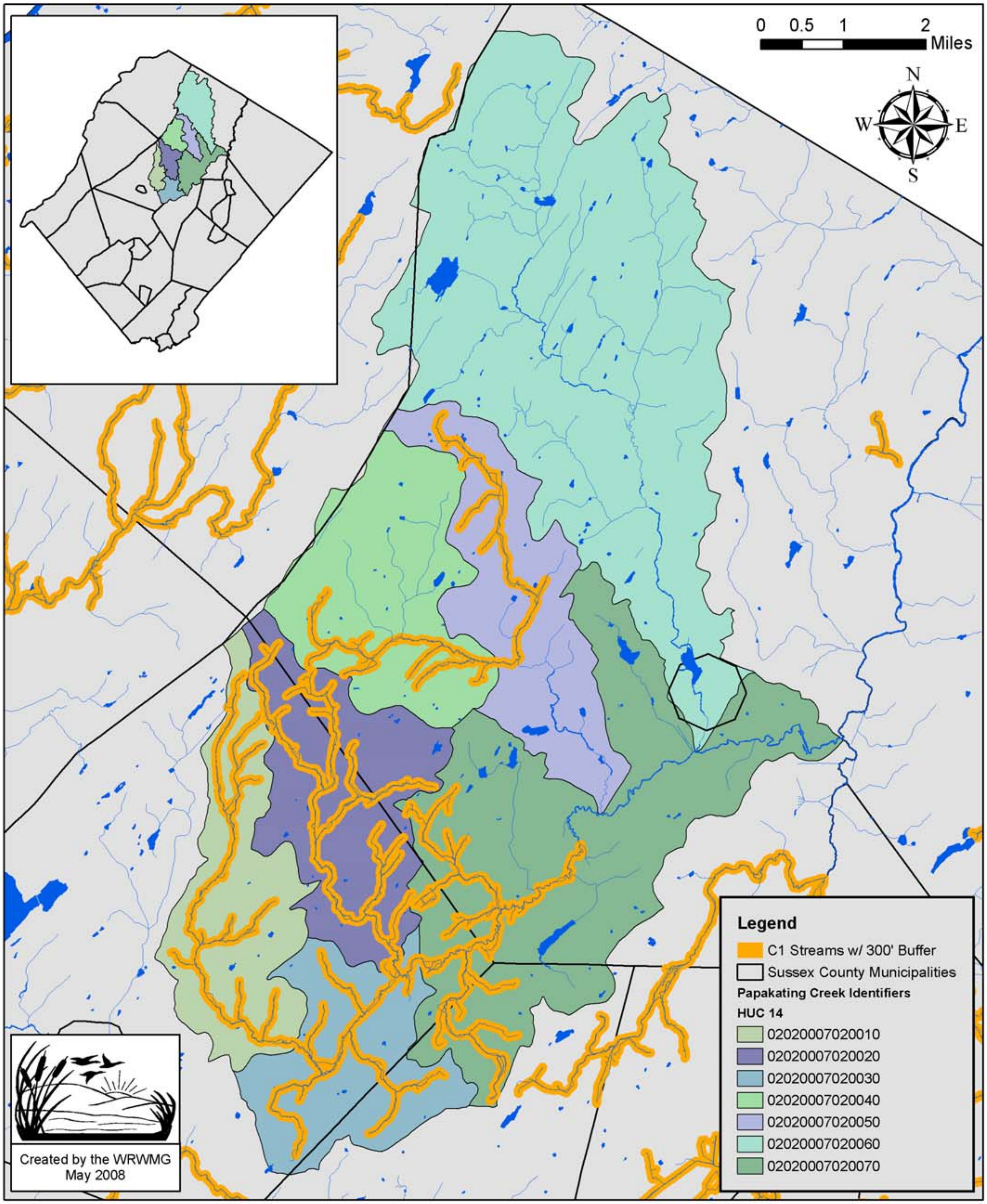
On June 16, 2008 the NJDEP adopted amendments to the Surface Water Quality Standards (SWQS) at N.J.A.C. 7:9B that changed the designation of a significant number of streams within the Papakating Creek Watershed from Category C2 to Category C1 Classification. Category C1 waterways are those waters designated for protection from measurable changes in water quality based on exceptional ecological significance, exceptional water supply significance, exceptional fisheries resource(s), and present surface water quality. A Category C1 Classification mandates a 300-foot buffer adjacent to waterways to provide protection of water quality in accordance with the Stormwater Rules (N.J.A.C. 7:8) and the Flood Hazard Area Control Rules (FHACA at N.J.A.C. 7:13). In regard to the Papakating Creek Watershed, the following Papakating Creek segments have been changed from Category C2 to Category C1 Classification:

- Headwaters and mainstem within Frankford Township including all tributaries emanating from Wantage Township
- All tributaries within Lafayette Township
- Papakating Creek west of Roy's
- Mainstem north of Roy's to the Lehigh and New England Railroad crossing in Wantage Township (downstream from confluence with Lake Windsor Tributary)
- Some headwater segments of the Papakating Creek West Branch mainstem
- Libertyville tributary

Notes:
1. Although included in the proposed amendments on May 31, 2007, the Clove Brook and Clove Acres Lake were not reclassified from C2 to C1 in the adopted amendments published in the June 16, 2008 *New Jersey Register (pages 3713 - 3714)*.
2. For specific details, refer to the NJDEP website and/or in the *New Jersey Register*, dated June 16, 2008.

See *Figure 9* for a map of the Category 1 stream segments found within the Papakating Creek Watershed. For specific details, refer to the official version of the C1 amendments on the NJDEP website and / or the *New Jersey Register*, dated June 16, 2008.

Figure 9:
Papakating Creek Watershed Category 1 Stream Segments



Chemical Databases: NJDEP / USGS / WRWMG / HydroQual, Inc. / Princeton Hydro, LLC [12, 13]



Quality Assurance Project Plan All project and field sampling work tasks were in accordance with the QA/QC document prepared by HydroQual, Inc, dated March 4, 2002 for the WMA 02 Phase I Contract Task B Program and as amended in May 2003, December 2004, September 2005, and November 2005. The November 2005 Amendment Work Plan revisions reflect supplementary monitoring for approved 2005 SFY 319(h) TMDLs / Restoration Plan Projects for the Papakating Creek and Clove Acres Lake / Lakeshed and Clove Brook streamshed. Refer to *Appendix VI* for a copy of the approved QAPP

The scope of supplementary monitoring covered chemical sampling at five WRWMG sites on the Clove Brook and two sites on the Papakating Creek:

- Sites "I" &"J" - quarterly
- New Sites "O," "P," and "Q"- monthly
- Sites "K" & "L" (Papakating Creek) - quarterly

See *Figure 10* for a map displaying the location of the WRWMG's chemical sampling sites for the Clove Acres Lake / Lakeshed and Clove Brook Streamshed.

Augmented Sampling: Selection of Water Quality Parameters

Nine specific parameters plus related stream physicals considered to be important indicators of water quality within the Papakating Creek subwatersheds were selected for assessment. The parameters / physicals selected were as follows:

Ammonia: an essential compound in biological processes

Un-ionized Ammonia: excessive concentrations lead to fish toxicity; concentrations were calculated from total ammonia, water pH, and water temperature

Total Kjeldahl Nitrogen (TKN): a measurement of organic nitrogen plus any ammonia-nitrogen in the stream sample; TKN is important because organic nitrogen represents oxygen demand in the stream

Total Phosphorus: a measure of all phosphorus forms found in a water sample; concentrations are important to stream health; it is a primary nutrient for algae and aquatic plants and can stimulate excessive growth

Ortho-Phosphates: the dissolved inorganic phosphorus form found in aquatic environments; form used by photosynthesizing organisms; also defined as the "algal available" or "bioavailable phosphorus"

Nitrate + Nitrite: represents the oxidized forms of nitrogen in the stream

Conductance: a measure of the total amount of ions in an aqueous sample; lakes and streams with a high quantity of dissolved materials that act as charged particles will have a high conductivity

Total Dissolved Solids (TDS): high values can impact the taste of water, as well as stream ecosystems

Total Suspended Solids (TSS): the health of stream ecosystems are effected by concentrations of TSS; level impacted by storm runoff and streambank erosion

pH: the water standard for pH is > 6.5 and < 8.5; values less than 7 are considered acidic and values greater than 7 are considered basic; this parameter directly influences the types of plants and animals that can live in a lake or stream

Dissolved Oxygen: a measurement of oxygen dissolved in water; a measure of the overall quality of the stream water; the concentration depends on the physical, chemical, and biological characteristics of the stream water; desired instantaneous levels are > 4 mg/l in nontrout waters, > 5 mg/l in waters classified as trout maintenance, and > 7 mg/l in waters classified as trout production

Oxygen Saturation: a measure of how much oxygen is present as a percentage of the maximum it could contain

Water Temperature: influences the chemical and biological processes in a stream; warmer waters hold less oxygen than cooler waters

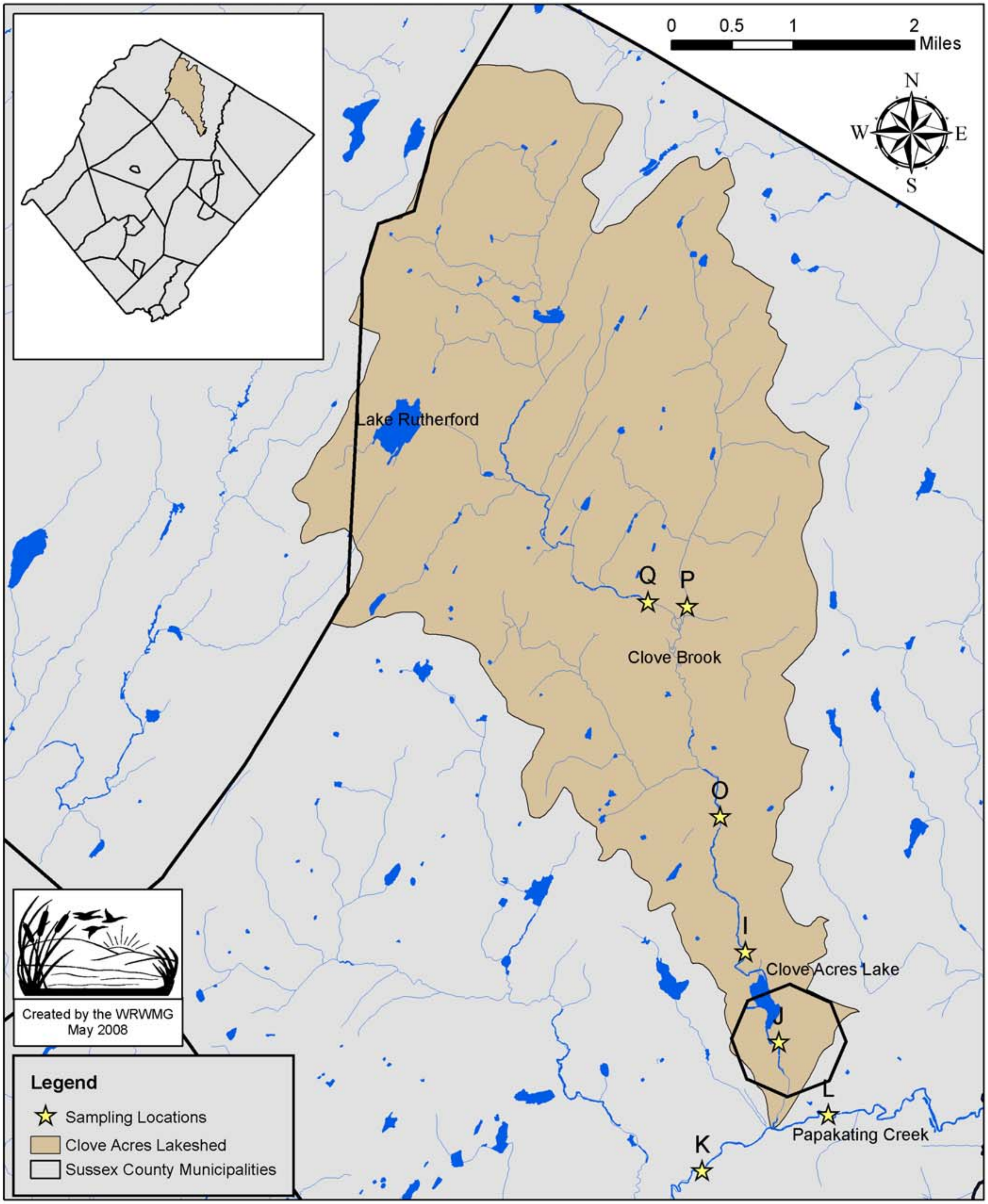
Ambient Temperature: a measure of the local air temperature

Stream Flow: a measure of the amount of water passing per unit of time (generally expressed as cubic feet/second (cfs)

Precipitation: a measure of rainfall in inches/day

All stream samples were collected by the WRWMG and analyzed by Garden State Laboratories under an approved NJDEP Quality Assurance Project Plan (QAPP). Flow measurements were taken by HydroQual, Inc. All reported analytical data were reviewed by Garden State Laboratories, as well as the WRWMG. Only total phosphorus was found to exceed NJDEP's Surface Water Quality Standards (SWQS). All collected data were incorporated into a project database that is available from the WRWMG upon request. Copies were issued to NJDEP as part of the developed project deliverables as well as for the development of the New Jersey 2008 Water Quality Limited Segment Integrated List.

Figure 10: WRWMG Clove Acres Lakeshed / Clove Brook Watershed Chemical Sampling Locations



Total Phosphorus Database Sources

Database Source: NJDEP

Refer to Appendix F, page 66, of NJDEP's *"TMDL to Address Phosphorus in the Clove Acres Lake and Papakating Creek Northwest Region,"* dated April 19, 2004.

Stream water data for total phosphorus are provided for Papakating Creek at Sussex (Station 01367910), Papakating Creek at Sussex (Station 01367909), and WRWMG's Sampling Site "L' at Sussex, as well as from flow data collected from February 1994 to January 2004.

Database Source: WRWMG / HydroQual, Inc.[12, 13]

WRWMG sampling and HydroQual, Inc. flow data for 5 sites within the Clove Brook sub-basin for the January 2004 through June 2007 time period are summarized in *References 11 and 12.*

Database Source: USGS

USGS real-time flow station data (01367800) for Site "R" (Papakating Creek at Pelletown) are listed in the WRWMG database, dated 2004 through June 2007.

Additional USGS parameter data are available from their website:
http://waterdata.usgs.gov/nj/nwis/uv?cb_00065=on&cb_00060=on7cb-00021=on&format

USGS Gage Station located on the Papakating Creek
Pelletown Road, Frankford Township, NJ

Database Source: Princeton Hydro, LLC [14, 15]

This subject is covered in the Clove Acres Lake Characterization and Restoration Plan [19] developed by Princeton Hydro, LLC dated August 2008, and the Clove Brook Restoration Plan prepared by the WRWMG, dated August 2008. The referenced Report by Princeton Hydro, LLC is attached as *Appendix VII*. The assessment of Clove Acres Lake performed by Princeton Hydro, LLC in accordance with the NJDEP Lake Characterization Protocol encompassed the following: lake characterization, a variety of in-lake studies (e.g., in-situ water quality data, a bathymetric survey, plankton sampling, aquatic macrophyte studies, and a fisheries survey), relevant watershed data, the quantification of the lake's annual hydrologic and pollutant budgets, and development of a Restoration Plan for the Lake and the Clove Brook sub-basin. Key recommendations developed by Chris Mikolajczyk and Fred Lubnow of Princeton Hydro, LLC that are relevant to both the development of the Papakating Creek Restoration Plan and the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin are:

- *"Clove Acres Lake is a eutrophic to hypereutrophic waterbody that has the potential, and periodically does, experience nuisance water quality conditions (e.g., algal mats, excessive densities of rooted aquatic plants, etc.), particularly during the mid-summer season."*

- *The Clove Brook is a significant contributor of total phosphorus loading to the Papakating Creek*

- "*Long-term management of the lake should concentrate on managing the lake as a eutrophic waterbody, reduce phosphorus and solid loadings entering the lake, and also consider measures to enhance the lake's recreational fishery potential and control / eradication of the invasive species Eurasian watermilfoil*."

- *Based on existing conditions within the lake, the measured and predicted TP concentrations, and the other factors related to implementation, it is recommended that the percent reduction in TP should be lowered from 75% as stated in the TMDL to 30%. The following provides a series of points to support this recommendation.*

  1. *Clove Acres Lake should be managed as a small artificial impoundment and not as a natural lake.*

2. *The targeted TP concentration under the TMDL is 0.02 mg/L. Based on this study's analysis, if the entire Clove Acres Lake watershed was completely forested and no one lived in the watershed, the TP concentration would be 0.021 mg/L. Thus, under the TMDL's existing targeted TP concentration scenario, the entire watershed would need to be completely re-forested. Again, this is largely a reflection of the fact that Clove Acres Lake is an artificial impoundment of Clove Brook; such watersheds have larger pollutant loads on an aerial basis, relative to natural lakes.*

3. *The dominant water quality problems impacting the recreational and ecological value of Clove Acres Lake is the presence of the nuisance exotic submerged macrophyte Eurasian watermilfoil. This nuisance plant negatively impacts the lake's fishery and recreational potential as well as facilitates the growth of filamentous mat algae along the water's surface. In contrast, planktonic algal blooms do not persist long in Clove Acres Lake due to the lake's high flushing rate; the lake flushes slightly less than 200 times per year. Given these conditions, the focus on Clove Acres Lake should be placed on the eradication of the invasive species, coupled with some watershed management.*

Recommended Water Quality Goals for Clove Acres Lake as Proposed by Princeton Hydro, LLC

Based on the observed and modeled conditions of Clove Acres Lake, Princeton Hydro recommends that the targeted TP concentration for this waterbody be 0.04 mg/L and not 0.02 mg/L. A targeted concentration of 0.02 mg/L would be achieved if all residential / agricultural land is converted into forested / wetlands. If pre-development conditions are the goal for the Clove Acres Lake watershed, then the dam should be breeched to restore Clove Brook to its original condition. However, since the lake is a valuable ecological and recreational resource for the local stakeholders, such an action is unlikely and the TMDL and associated Restoration Plan need to focus on managing the lake.

Such a scenario of reducing the in-lake TP concentration to 0.02 mg/L is unlikely; therefore the proposed targeted TP concentration for Clove Acres Lake is 0.04 mg/L. Such a TP concentration is 20% below the State's Total Phosphorus Water Quality Criteria of 0.05 mg/L (N.J.A.C. 7:9B-1.14(c)). Such a targeted TP concentration for Clove Acres Lake would require a 30% reduction in the existing annual TP load. With an existing TP load of 2,479 kg and a targeted TP load of 1,712 kg, the annual load would need to be reduced by 767 kg (1,690 lbs) in order to comply with this proposed modification to the TMDL.

The report by Princeton Hydro, LLC addresses in great detail all the data, assessments, and studies noted above as well as specific recommendations applicable for the restoration and protection of Clove Acres Lake / Lakeshed. In summary, Princeton Hydro, LLC recommends:

- Watershed-based nonpoint reduction measures for nutrient control and management

- The eradication of Eurasian watermilfoil using a contact systemic herbicide such as Sonar^{R}, which has fluridone as its active ingredient. Sonar^{R} is used at other recreational lakes within Sussex County with great success. Other approaches considered are: contact herbicides, biological approaches using sterile grass carp or aquatic weevils, and mechanical weed harvesting.

- Implementation of a biomanipulation program (structuring the aquatic food web to favor the growth of non-scum forming algae and minimizing the density of blue-green algae) after major reduction of Eurasian watermilfoil and the aerial cover of submerged vegetation is between 30% - 40%; program addresses management of Clove Acres Lake as a largemouth bass fishery for enhancement of the lake's recreational value

Further discussions are in progress between the WRWMG and Princeton Hydro, LLC regarding the modest difference between Princeton's recommendation for a 30% reduction at a design TP lake concentration of 0.04 mg/l versus a reduction of 43% as proposed by the WRWMG, assuming a design lake TP concentration of 0.02 mg/l as stated in the TMDL.

Assessment of Chemical Sampling/Findings: Clove Acres Lake and Clove Brook [13, 16, 17, 18]

Overall Findings

The analytical and field measurement results for the sites sampled on the Clove Brook, within the TMDL-defined HUC14 area, showed all parameters sampled to be in compliance except for total phosphorus and ortho phosphate. Specifically, results show 100% compliance with the Surface Water Quality Standards (SWQS) for each of the following parameters measured: total ammonia, nitrate, nitrite, un-ionized ammonia, Total Kjeldahl Nitrogen (TKN), conductance, dissolved solids, water temperature (for nontrout waters), dissolved oxygen (for trout maintenance waters), and pH. In accordance with NJDEP guidelines, a water stream is not impaired with respect to a specific parameter if ≥ 90% of the samples meet SWQS requirements.

Exceedances Found with Respect to Total Phosphorus (refer to *Charts 4 and 5*)

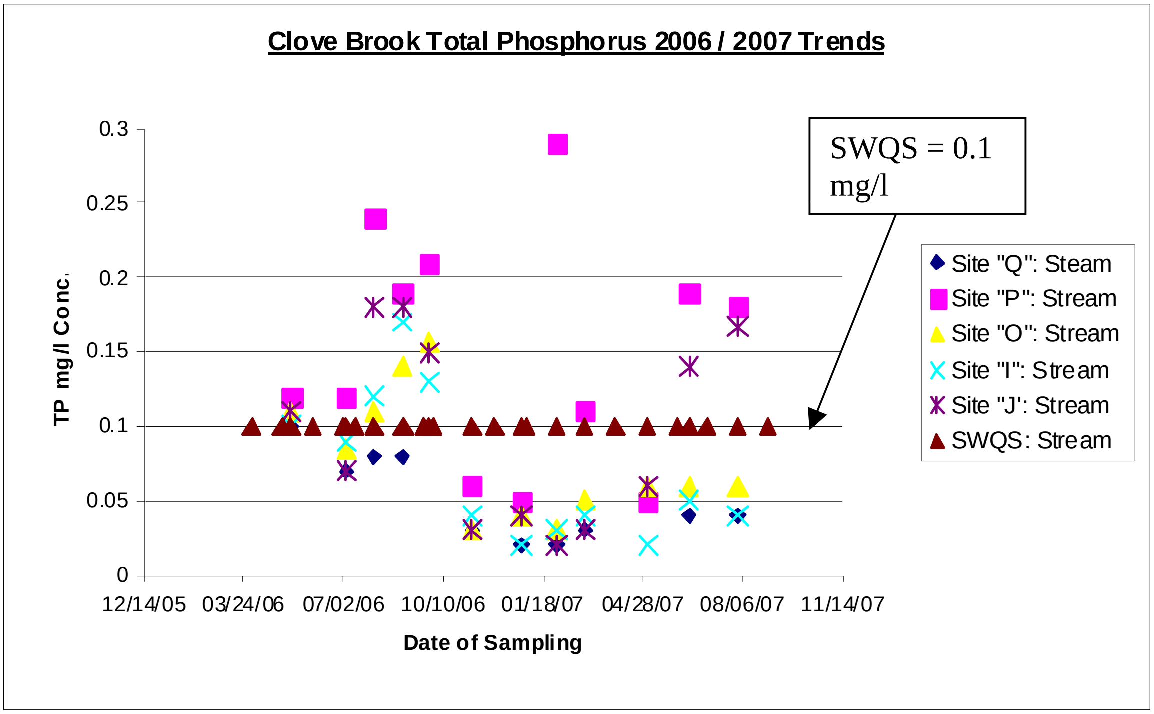
Total Phosphorous (TP):

> Four out of five sites sampled for TP had data sets exhibiting greater than 10% exceedances relative to the SWQS of 0.1 mg/l TP (implies impairment). Range of TP compliances were 33% to 100% (Site "Q"). Refer to *Charts 4 and 5* and Table 12 for findings relating to sampling results and the impact of precipitation and local annual farming practices on TP loadings.

Table 12: Data Trend Observations

Chemical Parameter	**Time Periods When Monthly Results Trended Higher**	**Likely Independent Variables**
Total Phosphorus	July - September 2006 February 2007 June - August 2007	1. Precipitation (results in increased streambank erosion and sediment land erosion transport) Observed abnormal precipitation periods (strong correlation with months when higher TP trends were observed): August - October 2006 (17 inches of rain over three months) June - August 2007 (18 inches of rain over three months) Base Reference: Typical monthly rainfall averages 3.8 inches/month and 45 to 48 inches/year for the Papakating Creek Watershed. Within the last six years, annual precipitation averaged 52.5 inches/year. 2. Farming Practices - seasonality factors 3. NJPDES Dischargers - not an issue in this Watershed

***Chart 4: Augmented Sampling Program for Total Phosphorus (Clove Brook*) (Data Source: WRWMG)**



TP stream concentration spikes (above 0.1 mg/l but below 0.25 mg/l) were observed at Sites "P" and "J" on the June and August sampling days of 2006 and 2007. Similar results were found for Site "I" on the June and August sampling days of 2006. Site "P" is upstream from Site "I" and Site "I" is upstream from Site "J". The relatively elevated stream concentrations found during these time periods are believed to be strongly influenced by adjacent farming / agricultural field operations concurrent with frequent significant storm events. The sampling data set (58 values) used for *Chart 4* also shows 62% compliance with the SWQS for streams.

As indicated in NJDEP's TP TMDL, Site "L" (Papakating Creek at Sussex) serves as the integrator site for the Papakating Creek and Clove Brook waterbodies. Preliminary studies addressing annualized TP and stream flow rates around the confluence of the Papakating Creek and the Clove Brook and Site "L" (just downstream) show that the TP load allocation at Site "L" is estimated at 15% - 20% from the Clove Brook and 85% - 80% from the Papakating Creek.

The data sets for each of the sampling sites were further analyzed using box and whisker diagrams [19, 20, 21] (term used interchangeably with box plots) to visually show the dispersion of data within and among the various data sets. For background, a box plot provides a graphical summary of a set of data based on the quartiles of that data set: quartiles are used to split the data set into four groups - Q1 (25th percentile), Q2 (50th percentile; same as the medium value), and Q3 (75th percentile). Each whisker (vertical line) represents 25% of the data measurements and the extremities of these whiskers are the minimum and maximum values of the data. As an example, the data developed for Site "J" were as shown in *Table 13*:

Table 13: WRWMG Site "J" Box Plot Statistics
(Discharge stream from the Clove Acres Lake, downstream from the Dam)

Parameter	**Value**
Data set	**12 values**
Water quality parameter	Total Phosphorus (TP)
Maximum value	0.18 mg/l
75th Percentile	0.143 mg/l (Q3)
Mean	0.06 mg/l
50th Percentile (median)	0.06 mg/l (Q2)
25th Percentile	0.04 mg/l (Q1)
Minimum value	0.02 mg/l
Interquartile range	Q3 - Q1 = 0.143 - 0.04 = 0.103 mg/l
NJDEP Surface Water Quality Standard (SWQS)	Concentration. not to exceed 0.1 mg/l
Remarks Sampling Site is Impaired - more than 10% of the values exceed 0.1 mg/l TP (SWQS); since Q2 and the mean are essentially the same value, the data set appears to be normally distributed; Reference Article: Box Plots - Wikipedia	

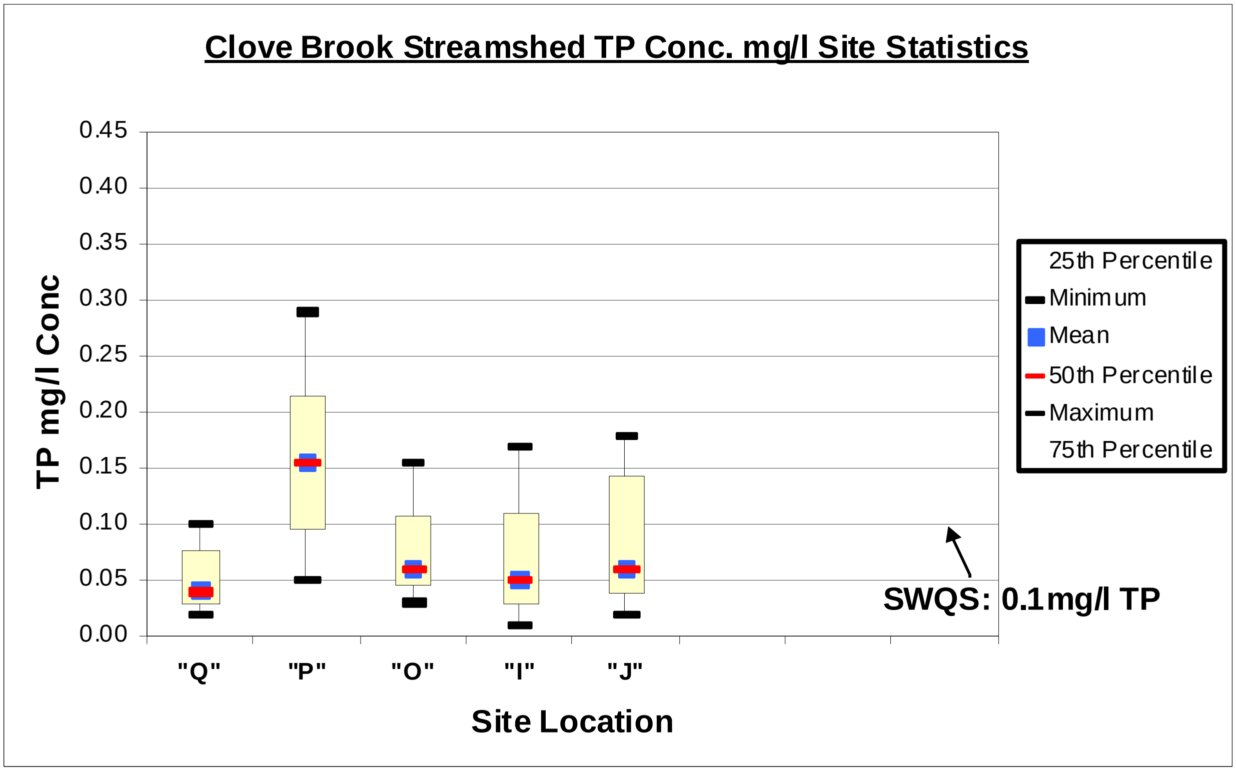
Chart 5 shows developed box plots (called parallel box plots) for the sampling sites on the Clove Brook. Key points and observations are:

- Data sets were comprised of 12 individual values per sampling site data set. A data set of 12 values is considered relatively small but adequate to make some definitive statements about the data distribution including symmetry.
- All sampling sites show total phosphorus impairment except Site "Q"
- All sites except Site "P" show the data sets are skewed to the right (greater height difference of the 50th percentile to the 75^{th} percentile relative to the height difference of the 25^{th} percentile to the 50^{th} percentile). The top whisker is much longer than the bottom whisker and the 50th percentile line is trending to the bottom of the box.
- The simplicity of the box plot renders it ideal as a means of comparing many sampling site data sets at once. Obvious differences are immediately apparent by visually comparing the constructed parallel box plots.
- The developed box plots will serve as a baseline for monitoring stream quality improvements during implementation of the developed Restoration and Protection Plan.



Upstream and Downstream Views of Clove Brook Site "J"
Newton Avenue, Sussex Borough

Chart 5:
Clove Brook Augmented Sampling Site Statistics for Total Phosphorus
(Parallel Box Plots)



Concurrent with the above approach to identify potential total phosphorus nonpoint sources, research studies by others [22, 23, 24] are underway to identify "critical area sources" within a watershed where both total phosphorus land concentration and local transport factors are assessed together for the purpose of identifying "risk areas" that may be responsible for significant total phosphorus loadings to nearby streams. The benefit of this approach allows a more focused effort on those parcels classified as "critical source areas," rather than addressing all lands along a stream or within the entire Watershed. Research progress and potential application of this evolving methodology will be monitored and, if found useful, the findings will be incorporated in the proposed Implementation Plan and/or Post-Monitoring Plan at a later date.

Project Plan Pollutant Assessments and Goals

Total Phosphorus Pollutant Budget

As previously stated (page 6), the present annual estimated total phosphorus load leaving the Papakating Creek Watershed including the Clove Brook sub-basin [contribution: 5,887 pounds/year], is 21,796 pounds / year. The TMDL goal is to reduce this loading by 43.4%, an overall reduction of 9,459.5 pounds / year.

Tracking Effectiveness of Implementation Projects Towards Achievement of Targeted Reduction Goals

Chart 6 (Papakating Creek) and *Chart 7* (Clove Acres Lake / Clove Brook) were developed to show:

1. Estimated total phosphorus loadings (TP TMDL)
2. Estimated total phosphorus loadings plus the contribution of buildout (full buildout to occur over 30 years based upon present zoning regulations)
3. Targeted loadings after achieving specified reduction percentage
4. Theoretical loadings assuming the entire Watershed is returned to a natural state (forest, barren land, and water land covers)
5. A hypothetical (theoretical) example showing the tracking of achieved results following completion of successive implementation projects (to be further discussed under the subject of Post-Monitoring Plans)

Chart 6: Papakating Creek (six HUC 14s) Total Phosphorus Annual Load, Target Reduction Goal, and Forecast Reduction Trend

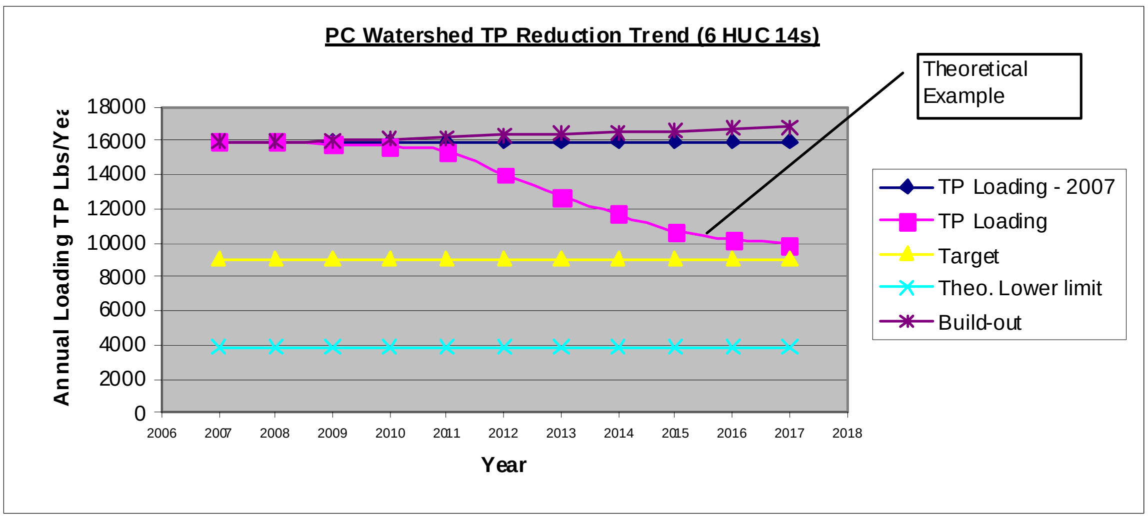
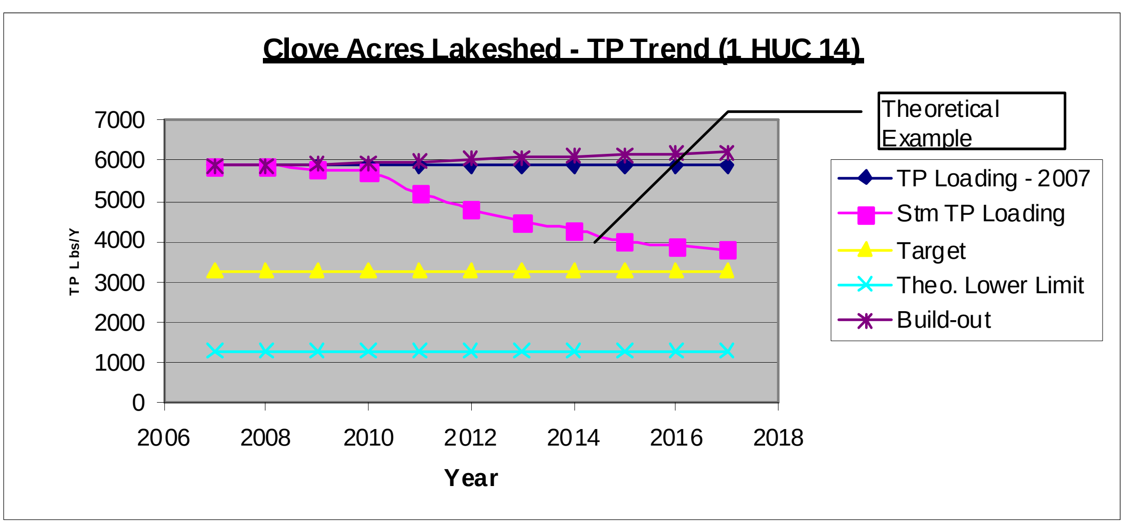


Chart 7: Clove Acres Lake / Lakeshed / Clove Brook Sub-basin Total Phosphorus Annual Load, Target Reduction Goal, and Forecast Reduction Trend



Restoration Control Measures

Background

Agricultural land use within the Clove Brook sub-basin accounts for approximately 22% of the total sub-basin area. Therefore, particular focus was devoted to the assessment of current agricultural operations consisting of dairy, non-dairy cattle, crop, pastureland, nurseries, floriculture, and equestrian, as well as residential properties in the process of being placed in farmland assessment status. Based on limited information, the majority of farmers having larger dairy operations appear to have already implemented a number of Best Management Practices (Conservation Plan, Comprehensive Nutrient Management, rooftop rain water isolation / drainage, filtering of rain water from animal holding stalls, collection and recycle closed systems for waste waters, use of concrete slabs in selected places, although they are in many cases, natural stream buffer strips are in place, although limited in many areas. From a priority setting viewpoint, attention to non-dairy, crop, and commercial / hobby equestrian operations likely offers the best short-term opportunities for effecting TP pollutant reduction.

In addition, information searches [25, 26] were conducted to collect available agricultural crop information, as well as results of research studies addressing alternatives in farming practices that can be considered in controlling / limiting annual total phosphorus loadings to a watershed. The more significant variables identified by the researchers were:

- Tillage practices (conventional, mulch, and no-till)
- Crop farming (no practices, contour, stripcropping, and terraces)
- Phosphorus loss with waterborne sediment
- Phosphorus dissolved in surface water runoff
- Type(s) of crop(s) grown
- Type and application rate of fertilizer(s)
- Soil characteristics
- Weather conditions

The above list clearly shows that the annual rate of TP losses (lbs/year) from a given parcel of land in an agricultural land-use application is a function of many controllable and uncontrollable variables / practices. Preliminary experimental results showed a potential of reducing TP losses by 13% for “mulch / no-till” versus “conventional” and 28% for “contour / stripcropping / terraces” versus “no practices.” In addition, significant pollutant reductions approaching 32% were found in the direct deposition of fecal phosphorus through pasture management and streambank fencing. The pollutant - reduction percentages found can be used as first-pass estimates of expected benefits to be derived for implementation projects relating to adaptations made on farming properties. Reduction efficiencies for other practice changes will be further researched and incorporated into the Post-Monitoring Plan database. Studies by the same authors point out that significant variations are typically found even within a localized area. Considering both the complexity and lack of specific agricultural onsite information, a major component of the Restoration Plan will deal with the development / updating of Conservation Plans and development of a pollutant reduction efficiency database. The primary focus is to be on engaging farmers / equine owners in areas that have been determined to be priority areas for implementation projects, working towards the achievement of TMDL and Surface Water Quality Standards.

Of equal importance, significant attention to the local equine community is recommended. Results from an equine survey, conducted within the last three years by the Orange County Horse Council / NY Horse Council / Orange and Ulster Soil & Water Conservation Districts for an adjacent watershed in New York, is available to jump start a similar effort recommended for the Clove Brook sub-basin.

Recommended Management Plan

Executive Summary

A Restoration Plan is presented that addresses the Clove Brook sub-basin (subwatershed) that contains Clove Acres Lake / Lakeshed. The Clove Brook is an impaired waterway, designated as such for non-attainment of total phosphorus (TP). The Clove Brook sub-basin is one of seven HUC 14 sub-basins that comprise the Papakating Creek Watershed.

An extensive pollutant source-tracking survey to identify potential sources and causes for the TP impairment. Within the Clove Acres Lake / Lakeshed and the Clove Brook sub-basin, nonpoint pollution is the predominate issue of concern versus point source (end of pipeline). The key nonpoint sources of TP were identified as streambank erosion, agricultural land erosion and drainage, undeveloped land erosion and drainage, improper / overuse of both agricultural and residential fertilizer applications, stormwater runoff from developed and undeveloped lands and roads, typical urban area sources (one specific area) and, to a lesser extent, septic systems. In addition, major storm events (rainfall exceeding two to three inches/day) have been observed to be a key factor in the transport of TP to the Clove Acres Lake and the Clove Brook

An independent assessment of Clove Acres Lake was performed by Princeton Hydro, LLC in accordance with the NJDEP Lake Characterization Protocol and encompassed the following: lake characterization, a variety of in-lake studies (e.g., in-situ water quality data, a bathymetric survey, plankton sampling, aquatic macrophyte studies, and a fisheries survey), collection of relevant watershed data, the quantification of the lake's annual hydrologic and pollutant budgets, and development of a Restoration Plan for the Lake and the Clove Brook sub-basin.

Key conclusions of the assessment by Chris Mikolajczyk and Fred Lubnow of Princeton Hydro, LLC are:

- *"Clove Acres Lake is eutrophic to hypereutrophic"*

- *The Clove Brook is a significant contributor of total phosphorus loading to the Papakating Creek*

- "*Long-term management of the lake should concentrate on managing the lake as a eutrophic waterbody, reduce phosphorus and solid loadings entering the lake, and also consider measures to enhance the lake's recreational fishery potential and control / eradication of the invasive species Eurasian watermilfoil*."

- *Based on existing conditions within the lake, the measured and predicted TP concentrations, and the other factors related to implementation, it is recommended that the percent reduction in TP should be reduced from 75% to 30% as stated in the TMDL.*

Recommendations offered by Princeton Hydro, LCC

- *Based on the observed and modeled conditions of Clove Acres Lake, Princeton Hydro recommends that the targeted TP concentration for this waterbody be 0.04 mg/L and not 0.02 mg/L. A targeted concentration of 0.02 mg/L would be achieved if all residential / agricultural land is converted into forested / wetlands.*

- *Such a scenario of reducing the in-lake TP concentration to 0.02 mg/L is unlikely; therefore the proposed targeted TP concentration for Clove Acres Lake is 0.04 mg/L. Such a TP concentration is 20% below the State's Total Phosphorus Water Quality Criteria of 0.05 mg/L (N.J.A.C. 7:9B-1.14(c)). Such a targeted TP concentration for Clove Acres Lake would require a 30% reduction in the existing annual TP load. With an existing TP load of 2,479 kg and a targeted TP load of 1,712 kg, the annual load would need to be reduced by 767 kg (1,690 lbs) in order to comply with this proposed modification to the TMDL.*

- Proceed with identified implementation projects that address reduction of nonpoint sources of total phosphorous (specific projects noted below and in the Princeton Hydro, LLC Report). Note: Further discussions are in progress between the WRWMG and Princeton Hydro, LLC regarding the modest difference between Princeton's recommendation for a 30% reduction at a design TP lake concentration of 0.04 mg/l versus a reduction of 43% as proposed by the WRWMG, assuming a design lake TP concentration of 0.02 mg/l as stated in the TMDL.

Development of a holistic Management Plan addressing the stated pollutant sources, mitigation of the impacts identified, and achievement of the desired goals is a complex and challenging undertaking that will require many years of concerted, targeted effort by the entire Watershed community. To begin the long-term journey to protect the Watershed's critical natural resources (e.g., stream water quality), proposed reduction strategies and implementation measures are developed to cover five identified 2009 implementation projects as well as subsequent efforts addressing pollution reduction stream-related projects, in-lake treatment approaches, Watershed-wide projects / controls, urban projects / controls, and suggested municipal actions. As noted below, one of the five key implementation projects proposed for 2009 is the establishment of the WRWMG as a Watershed project-management-oriented entity to not only manage the identified implementation projects but also to provide a coordination and integration role addressing the necessary and critical Watershed project implementation efforts required by WRWMG's partners. Experiences have shown that unless an entity is assigned to drive and track pollutant reduction pound by pound, month by month, one key farmer and/or community member at a time within a given large Watershed area, ultimate success of achieving TMDL goals may prove elusive.

A summary of key recommendations and proposed actions is presented:

Proposed Implementation Projects for 2009 - 2012

Project A:
Design phase for streambank stabilization and riparian restoration along the Clove Brook near Brookside Park in Sussex Borough and Wantage Township (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, and a budget and timeline for project implementation)

Design Phase of Project to be completed within 12 months at a budget of $86,400

Full Project Implementation to be completed within 36 months at an estimated budget of $337,400 (includes design phase costs). Budget for full implementation subject to a re-estimate following design completion.

Project B:
Installation of stormwater treatment devices into six catch basins on Lakeshore Drive with direct discharge to Clove Acres Lake (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, budget and timeline for project implementation)

Full Project Implementation to be completed within 12 months at a budget of $41,125

Project C:
Lakeside riparian restoration and stabilization along the Route 23 border of Clove Acres Lake (deliverables to include project details, design drawings and specifications, reconfirmation of project benefits, field installation including full implementation of the restoration and stabilization project; installation of sediment catch basins to take place as part of full project implementation at a future date)

Initial Project Implementation to be completed within 24 months at a budget of $143,000

Full Project Implementation to be completed within 30 months at an estimated budget of 157,000 (Includes initial project implementation costs).

Project D:
Facilitate the development and/or updating of agricultural Conservation Plans by NRCS for 300 acres of active farmland that straddles the Clove Brook in Wantage Township with focus on identifying riparian restoration, manure management, and stream fencing field projects with local farm operators (deliverables to include updated Conservation Plans by NRCS, specific field implementation project work scopes, reconfirmation of project benefits, identified funding sources, and integration of potential pollutant reductions to be achieved by others into a comprehensive pollutant reduction summary balance for the entire Watershed under study)

Project to be completed within 28 months at a budget of $62,800

Full Project Implementation schedule and budget to be determined based upon selected management practices and projects, funding for which will be sought from external sources and funding programs

Project E:
Establishment of the WRWMG as a project management-oriented entity to not only manage the identified implementation projects being executed by the WRWMG but also to provide coordination, technical guidance, and an integration role addressing the necessary and critical Watershed project implementation efforts required by WRWMG's partners and Watershed community members. Technical guidance to cover a broad range of topics (e.g., pollutant source tracking, water resource protection, development of implementation projects, pollutant transport paths, post-monitoring to verify achievement of estimated pollutant reductions). These services are not available from any other organizations within Sussex County and the actions proposed for the WRWMG are in congruence with the resource protection goals of the NJDEP as well as the recently promulgated Program Activity Measures (PAMs) established by the U.S. Environmental Protection Agency (EPA).

Project to be continuously implemented over 40 months at a budget of $80,000

Projects A, B, C, D, and E are designed to be completely implemented over the course of forty (40) months for an estimated total budget cost of $664,325. (Includes an estimated in-kind contribution of $ 30,000, dispersed throughout all five projects.)

Note: The five proposed projects noted above, if implemented together, are estimated to reduce the Watershed TP loading by 100 to 150 pounds/year.

Proposed Long-term Watershed Restoration Strategies: 2009 - 2025

Watershed-Wide (WRWMG / NJDEP as Lead Partners and with potential NJDEP Funding)

- Part of the WRWMG Implementation Entity Role: Monitor, track, and report on the efforts of the USDA Natural Resource Conservation Service (NRCS) and Rutgers Extension Cooperative in the development and updating of approximately 14 agricultural Conservation Plans (to address agricultural farms and commercial / large hobby horse operations); foster relationships with local farmers to encourage them to actively seek the available services from NRCS (overcoming reluctance of some members to seek active support); provide guidance and monitoring of efforts to implement the developed Conservation Plans
- Identification, coordination, and implementation of streambank and riparian restoration projects
- Provide local oversight, coordination and support during implementation of identified streambank restoration projects
- Integration and coordination of the Restoration Plans developed for the Papakating Creek by the WRWMG, the Restoration Plan developed for Clove Acres Lake / Lakeshed by Princeton Hydro, LLC and the Restoration Plan developed by the WRWMG for the Clove Brook sub-basin (a HUC 14 that falls within the Papakating Creek Watershed)
- Stream flow monitoring (relates to pollutant transport balances, flooding, etc.)
- Implementation of a Post-Monitoring Plan as presented in the Restoration Plan.

Watershed-Wide (WRWMG / Municipalities / Other Local Organizations as Lead Partners and Potential Sources of Funding)

- Assessment / evaluation / recommendation of open space land candidates for purchase by Federal, State, County, government agencies, municipalities, and various Land Trust organizations
- Work with Sussex County Engineering in the review and enhancement of stream-related bridge / road design standards to incorporate Best Engineering Practices relating to streambank erosion, sediment, stream disturbances, and road runoff control in order to minimize pollutant transport and adverse impacts on stream water quality
- Implementation of a communication plan to advise / inform / drive water quality improvements through reduction of pollutant sources; establishment of Restoration Plan metrics for monitoring of Plan progress
- Coordination of Watershed-wide efforts with County and Municipal departments (Town Councils, Planning Boards, Departments of Public Works, Open Space Committees, Environmental Commissions, etc.)
- Sponsorship of a winter road-maintenance seminar to address usage of de-icers, grits, etc. and Best Management applications / equipment maintenance practices
- Sponsorship of a stormwater seminar to address effectiveness / noneffectiveness of present practices and foster consideration / acceptance of voluntary adoption of several Tier A guidelines by Tier B municipalities (all participating municipalities within the Papakating Creek Watershed fall within the Tier B category; Tier A guidelines are more extensive restrictive than Tier B guidelines). (Note: Coordination of this action with NJDEP is recommended)

- Address the need for new ordinances in support of the Restoration Plan goals
- Assessment and implementation of lake restoration projects to protect water quality both within and downstream from Clove Acres Lake and Lake Neepaulin
- Monitor the upgrade of the High Point High School Wastewater Treatment Facility planned for 2010 by the Board of Education (results in a decrease of TP loading to the downstream tributary)
- Sussex Borough is addressed as an Urban Area within a rural setting. The impervious coverage of Sussex Borough is approximately 26% as compared to less than 5% for the surrounding municipalities. The quality of the Clove Brook stream within Sussex Borough is typically classified as Impacted bordering Non-Supporting by use of the Impervious Cover Model (Reference: Urban Subwatershed Restoration Manual #4). This fact is to be considered in the design and implementation of restoration projects specific to Sussex Borough. All proposed projects for Sussex Borough to be reviewed, supported, and approved by the Sussex Borough Town Council and Department of Public Works.
- Development of an invasive species identification and control plan
- Development and implementation of various educational campaigns and programs to raise watershed awareness and solicit stakeholder / volunteer participation in watershed plan implementation initiatives

Recommended Implementation Projects Within 0 - 40 Months From Approval of NJDEP Funding

Five implementation projects noted above (see Projects A, B, C, D, and E) as well the distribution, communication, and discussion of the developed Restoration and Protection Plans by the WRWMG and Princeton Hydro, LLC to entire watershed community included within the project area.

Funding for the implementation of the Restoration Plan will be sought from the following sources:

- NJDEP SFY 2009 319(h) Implementation Grants
- Development of Conservation Plans (in-kind services from USDA - NRCS and Rutgers Cooperative Extension)
- Implementation of Conservation Plans: USDA and other sources (e.g., CREP, CRP, EQIP, WHIP, ICM, etc. Some funding / in-kind services from individual farmers / landowners may be required.
- In-kind services (e.g., County, municipalities, Sussex County Municipal Utilities Authority, Municipal Boards and Committees, etc.
- Other sources to be identified / investigated (e.g., Dodge Foundation, private corporations, US Fish & Wildlife Service)

Key Field Findings by the WRWMG Regarding Nonpoint Sources of Total Phosphorus

Total Phosphorus (TP): Sediment from streambank erosion, improper / overuse of fertilizers including animal waste products on agricultural and residential lands, agricultural and residential soils subject to erosion, TP dissolved in surface water runoff, TP dissolved in leachate and carried through the soil profile, undeveloped land erosion and drainage, stormwater runoff from developed and undeveloped lands and roads, typical urban area sources (one specific area) and, to a lesser extent, septic systems.

The identified pollutant sources generally have varying negative impacts on the environment, including but not limited to:

- Exceedances of NJDEP Water Quality Standards for total phosphorus and ortho phosphate
- Sediment loadings resulting in the transport of pollutants to streams, settling of soil particles causing sediment bars in streams (alteration of stream hydrology), smothering of habitat required by fish and other aquatic organisms, increase in water turbidity causing a murky, muddy condition of the water and increased stress on fish within the stream
- Alteration of water temperature and stream hydrology
- Depletion of oxygen content of the stream
- Creation of algae blooms (visual field observations did not show this impact as being significant)
- Degradation of stream riparian buffers due to disturbance of streambanks
- Acceleration of the rate of lake eutrophication. It is well known and documented [27, 28] that lakes within urban watersheds are sensitive to urbanization (from fertilizers, septic systems, high-density zoning, etc.) and stormwater discharges since lake water quality is critically linked to the quality of the incoming water from the watershed. Human-induced disturbances in the watershed dramatically increase nutrient, fecal coliform / *E.coli*, and soil / organic loads into the lake that can accelerate the rate of eutrophication.
- Stormwater runoff - adverse impacts to the environment, including stream ecosystems, due to residential and commercial development that predominately took place prior to the adoption of the NJDEP Stormwater Management Rules [29, 30] and publication of a Stormwater Best Management Practice Manual in February of 2004. Focus is now on the application of nonstructural versus structural approaches to stormwater management (e.g., the use of vegetated swales instead of routing stormwater through storm sewer pipes).
- Stormwater road and parking lot runoff - transport of pollutants, alteration of stream hydrology, intensification of area flooding issues, etc.

Project Ranking and Prioritization

Pending further working sessions with project partners, the following draft ranking / prioritization methodology was established:

Ranking Categories:

A - High Priority (implementation 0 to 3 years)
B - Moderate Priority (implementation 2 to 5 years)
C - Low Priority (implementation 3 to 7 years)
D - Supportive (reassess / quantify potential value to meet plan objectives)
E - Task proceeding independently of the Restoration Plan

Prioritization: Relates to prioritization of projects within each Ranking Category (projects listed in decreasing order of perceived value, availability of technical resources, and timing with respect to funding sources; "1" being the highest; "2" being of next highest priority, etc.)

Value is defined in terms of pollutant reduction potential / unit of funding expended. The objective is to implement those projects that can bring the greatest value / benefit per unit of funding and / or unit of elapsed timing.

Summary Table - Recommended Priorities for the Watershed Community

(focused projects that lead to reduction of priority pollutants (total phosphorus, fecal coliform and *E.coli*, sediment) and potential attainment of TMDL goals and stream SWQS)

Table 14: Summary of Watershed Restoration and Protection Plan Projects

IMPLEMENTATION PROJECTS AND THEMES				
(Many identified tasks to be concurrently addressed with the implementation of the Papakating Creek Watershed Restoration Plan)				
WATERSHED-WIDE				
Project / Task / Initiative	**Ranking Category - Priority Within Ranking Category**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
1. Serve as a Watershed Liaison / Coordination-type Organization Within Sussex County for the Implementation of the Papakating Creek and Clove Brook Restoration Plans			**I - 5**	
a. Education and Outreach relating to the implementation of the Restoration Plan (general public, agricultural, and municipal and county organizations and Boards, etc.) (efforts to augment / supplement individual implementation plans)	**A - 1**	**Meeting Rooms**	**I - 11**	

b. Development of three advisory panels addressing: • General Restoration Plan Implementation • Agricultural Interests • Participating Municipalities - Dept. of Public Works, Open Space, etc. (Note: all with specific roles with minimum overlap of responsibilities)	**A - 2**	**Meeting Rooms**		
Project / Task / Initiative	**Ranking Category - Priority Within Ranking Category**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
2. Facilitate Development of Agricultural Conservation Plans				
a. Update 15 prioritized agricultural conservation plans for maximum water quality improvement. Plans selected are chosen based on proximity to water course and estimated severity of current pollutant loading through GIS analysis of aerial imagery and augmented sampling program. Ultimate Goal - to assist NRCS in the identification of priority areas for NRCS to develop and/or update approximately 50 Conservation Plans addressing agricultural, horse, and tree farms)	**A - 2**	**Meeting Rooms & Field**	**I - 4**	
b. Build working partnerships with individual farmers to further assess priority source areas	**A - 1**	**Field**		
c. Stream-fencing projects (focus area for NRCS / farm community)	**A - 3**	**Field**	**I - 7**	
d. Manure-management programs (focus area for NRCS / farm community)	**A - 4**	**Field**		
e. Water-quality monitoring on farm properties (focus activity for priority source tracking)	**A - 5**	**Field**		
f. Install riparian buffers on agricultural properties that have been prioritized for maximum benefit to water quality (CREP, WHIP, etc.)	**A – 6**	**Field**		

Project / Task / Initiative	Ranking Category - Priority Within Ranking Category	Project Location - Field or Meeting Rooms	Further Details - Refer to Appendix	Other Comments
3. Coordinate / Complete Streambank Restoration Projects				
a. Clove Brook @ Brookside Park	**A - 1**	**Field**	**I - 1**	
b. Clove Brook at the VFW Hall on Route 23; site is between a working farm and a cemetery	**B - 1**	**Field**		
c. TBD - Stakeholder Identified Locations	**TBD**	**Field**		
d. Multiple locations - removal of stream debris to protect stream habitat and for flood control	**A - 3**	**Field**	**I - 8**	
4. Sponsor Municipal Outreach Programs (focus area for municipalities)				
a. Arrange / sponsor a winter road maintenance workshop, develop guidelines and support shared service arrangements for winter road issues (use of road de-icers, maintenance of spreaders, etc.); intended for municipalities within and outside the project area	**A - 1**	**Meeting Rooms**		
b. Support / encourage road maintenance shared- service agreements	**A - 2**	**Meeting Rooms**		
c. Provide guidance / advise regarding multiple road drainage issues (for reduction of pollutants to streams; e.g., consideration of catch basins at selected sites and addressing runoff pipes from roads that directly drain to nearby streams and lakes)	**A - 3**	**Meeting Rooms & Field**		
d. New Ordinances	**A - 4**	**Meeting Rooms**		
e. Low Impact Development (LID) guidelines (recommend for consideration and incorporation into subdivision approvals and Planning Board guidelines; relates to water quality issues	**B - 1**	**Meeting Rooms**		

Project / Task / Initiative	**Ranking Category - Priority Within Ranking Category**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
5. Recommended Areas for Open Space Preservation				
a. Papakating Preserve along Lewisburg Road - Wantage Township	**A - 2**	**Field**	**I - 9**	
b. Historic rail trails / current gas pipelines - Frankford and Wantage Townships	**B - 2**	**Field**	**I - 9**	
6. Monitor Regulatory Programs				
a. Flood Hazard Control Act - address / advise implementation implications	**A - 1**	**Meeting Rooms & Field**		
7. General Education and Outreach (E&O) Efforts (Supplementary Programs)				
a. Coordinate / Facilitate Key E&O Initiatives • Manure management • Septic management (partner with County Health Department) • Storm drain stenciling • Watershed clean-ups • Website management • Newsletters • Internet mapping services • Auto-Tour guides • Outreach Presentations • Restoration Site ID / Educational Information Signs	**A**	**Meeting Rooms & Field**		
b. Provide Information to Target Groups • County and municipal officials • Local lake associations • Non-profit organizations • Community groups, clubs, and general public • Schools / educational institutions • Sussex County MUA - Board of Commissioners • Sussex County Agricultural Board • Sussex County Soil Conservation District • Sussex County Engineering, Planning, and GIS Depts. • Sussex County Chamber of Commerce • US Fish and Wildlife Service	**A**	**Meeting Rooms & Field**		

Project / Task / Initiative	Ranking Category - Priority Ranking	Project Location - Field or Meeting Rooms	Further Details - Refer to Appendix	Other Comments
8. Longer Range Efforts				
a. Lusscroft Farm - establish a Watershed Education Center (Wantage)	**C - 1**	**Field**		
b. Provide assistance and watershed expertise regarding the National Wildlife Refuge's Comprehensive Conservation Plan (CCP) to seek authorization for increasing the land acreage of the Refuge by purchasing an additional 9,500 acres from willing sellers (approx. 90% of the acres are within the Papakating Creek Watershed)	**A - 1**	**Meeting Rooms & Field**		
c. Equine-industry Education and Outreach materials	**B - 1**	**Field**		
d. Cross-sharing Watershed information with the Orange County Land Trust (Middletown, NY);	**A - 2**	**Meeting Rooms & Field**		
e. Maintenance water-quality monitoring (downstream from each HUC 14 identified in the plans to show trends and watershed-wide improvement to meet EPA strategic goals)	**C**	**Field**		
f. Recreational / public use trails along the Papakating Creek (Utilize already existing railbed trails / gas pipeline trails)	**B - 3**	**Field**		
g. Installation of stream and tributary identification signs on watershed roadways	**A - 1**	**Field**		
h. Develop an Auto-Tour program for the Papakating Creek Watershed	**B - 2**	**Field**		
i. Work with County Engineering in the review and enhancement of bridge / road design standards to incorporate Best Engineering Practices relating to sediment and road runoff control in order to minimize adverse impacts on stream water quality as well as to identify ongoing / existing problem areas	**B - 4**	**Meeting Rooms & Field**		

Project / Task / Initiative	**Ranking Category - Priority Ranking**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
9. Post Implementation Plan Activities				
a. Development of a Post-Monitoring Plan (to include pre- and post- monitoring data and trends); coordinate with monitoring plans incorporated within individual implementation projects; propose to monitor and track near project sites as well as quarterly to track trends	**A**	**Meeting Rooms**		
b. NJDEP / WRWMG communications	**A**	**Meeting Rooms**		
c. Continuing discussions with key partners / contacts • Ag-Choice Inc. (horse manure reprocessing / upgrading within Sussex County) • • Dr. Tammie Veith (USDA at Penn State University) • Dave Derrick (US Army Research Center - streambank restoration technical guidance)	**A**	**Meeting Rooms**		

Municipality-Specific (many proposed projects in this section to require focused municipality / county leadership and funding)

Project / Task / Initiative	**Ranking Category - Priority Ranking**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
<u>Sussex Borough:</u> (Recommendations listed here as well in the Papakating Creek Watershed Restoration Plan)				
a. Clove Brook Streambank Restoration Project near Brookside Park (site is located approximately 1 mile downstream of Clove Acres Lake and 1 mile upstream from the confluence of the Clove Brook and the Papakating Creek)	**A - 2**	**Field**		

b. Clove Brook Streambank Restoration Project at Newton Ave.	**C - 1**	**Field**		
c. Elimination of wastewater overflows to the Clove Brook during major storm events (the site subject to overflows is just north of Brookside Park); propose documentation of current efforts, including project milestones, and identification of additional steps / funding required to accelerate the program	**E**	**Field**		
d. Continue search for illicit connections to the Clove Brook (currently an active program by the Sussex Borough DPW Department)	**E**	**Field**		
e. Summary of Princeton Hydro's recommended Restoration Plan for Clove Acres Lake / Lakeshed and the Clove Brook sub-basin:	**B - 1**	**Field**	**I - 10**	
• Watershed-based nonpoint measures for nutrient control and management (e.g., catch basin filters)	**A - 1**	**Field**		
• Eradication of Eurasian watermilfoil	**A - 1**	**Field**		
• Management of native macrophytes; attempt to maintain an aerial cover of macrophytes over the lake bottom of approximately 30%	**A - 1**	**Field**		
• Implementation of biomanipulation program at a later time frame; implement management of Clove Acres Lake as a largemouth bass fishery	**A - 1**	**Field**		
Note: Above four projects relate to the restoration of Clove Acres Lake and the enhancement of water quality				
f. Institute a long term riparian protection program (particularly needed for the Clove Brook section that is downstream from Clove Acres Lake to Newton Avenue to just north of Brookside Park)	**B - 1**	**Field**		

Project / Task / Initiative	Ranking Category - Priority Ranking	Project Location - Field or Meeting Rooms	Further Details - Refer to Appendix	Other Comments
Wantage Township:				
a. High Point Regional High School wastewater system upgrade - NJPDES Permit No. NJ0031585; upgrade planned for 2010 by the local School Board of Education; focus on monitoring to determine water quality gains for reporting to NJDEP and EPA regarding strategic water quality goals	**E**	**Meeting Rooms & Field**		
b. Lake Neepaulin - multiple projects (the outlet from the lake contributes TP to the Papakating Creek, downstream from the confluence of the Clove Brook and the Papakating Creek	**E**	**Field**		
• Dam upgrade - in planning / funding phase by Lake Neepaulin, the Township, and other partners (stated for reference only; no involvement by the WRWMG)	**E**	**Field**		
• Installation of storm water sedimentation basins (one is very critical to address a total phosphorus water quality issue; expected pollutant reduction quantity to be determined as part of initial scoping study by others)	**B - 4**	**Field**		
• Address multiple stormwater drainage issues from nearby roads to the lake and to the Neepaulakating Creek (the tributary from Lake Neepaulin to the Papakating Creek); BMPs to be considered are catch basin filters, sedimentation basins, vegetated swales, etc.,	**B - 6**	**Field**		
• Initiate a minor dredging project to remove a sediment bar at the inlet area of lake (a water quality issue)	**B - 5**	**Field**		
• Institute a total phosphorus management system (low phosphorus fertilizers, septic pumping ordinance, etc. to control a recurring lake weed problem)	**B - 3**	**Field**		
• Address an apparent anoxic condition near / at bottom of lake (dissolved oxygen less than 1mg/l)	**B - 4**	**Field**		

• Implement a stormwater drain stenciling project (work commenced by local lake volunteers and the watershed ambassador in the spring / summer of 2008; work to continue in 2009) • Provide Education and Outreach to the Friends of Lake Neepaulin (FOLN) regarding total phosphorus management for the lake • Initiate a consistent / long-term lake water-quality monitoring program (by local lake organization) • Consider the practicality and feasibility of constructing recreational trails along the Neepaulakating Creek (by agencies other than NJDEP)	**B - 1** **B - 1** **B - 2** **D**	**Field** **Field** **Field** **Field**		
<u>Project / Task / Initiative</u>	**<u>Ranking Category - Priority Ranking</u>**	**<u>Project Location - Field or Meeting Rooms</u>**	**<u>Further Details - Refer to Appendix</u>**	**<u>Other Comments</u>**
<u>Sussex Borough and Wantage Township:</u>				
a. Princeton Hydro, LLC to identify multiple projects for the restoration and protection of Clove Acres Lake / Lakeshed	**A - 1**	**Field**		
b. Road run-off issues along Route 23 (many sites identified for stormwater related BMPs)	**B**	**Field**		
c. Clove Acres Lake Riparian Restoration Project (approximately 100 feet of Borough lakeside property to be vegetated with native trees / shrubs - planned for spring 2008; work and funding by others))	**E**	**Field**		
d. Address geese control at Clove Acres Lake	**A - 3**	**Field**		
e. Conduct clean-ups along the Clove Brook	**B - 1**	**Field**		
f. Establishment of a lake / local community group to manage and implement projects for the protection of Clove Acres Lake waters	**B - 2**	**Field**		

g. To further protect the potable water supply of Sussex Borough, recommend and support C1 nomination for Lake Rutherford (located high on Kittatinny Ridge), the tributary from Lake Rutherford to the Colesville Reservoir, and the Colesville Reservoir **h.** To minimize loss of Lake Rutherford's holding volume, consider installation of sedimentation basins to filter stormwater flows into the lake. Reference a study conducted in 2006 by Princeton Hydro, LLC the lake has lost 22% of its volume within the last 70+ years; propose follow-up discussions with Sussex Borough) **i.** Discuss / participate in the Inflow / Infiltration Project (I&I) underway by an outside engineering firm for Sussex Borough. Project relates to addressing excessive flow into the sanitary sewer system with overflow to the Clove Brook under severe storm events. Considering the significant impact this situation has on the water quality of the Clove Brook, additional funding will be necessary / sought from agencies other than NJDEP to fund the project. All efforts / services to be offered by the WRWMG to be advisory and related to water quality issues and TP / *E.coli* pollutant reductions .	**A - 2** **C - 1** **A - 1**	**Meeting Room & Field** **Meeting Rooms & Field** **Meeting Rooms & Field**		
Project / Task / Initiative	**Ranking Category - Priority Ranking**	**Project Location - Field or Meeting Rooms**	**Further Details - Refer to Appendix**	**Other Comments**
Montague Township: (responsibility of municipality) **a.** The only activity of note relates to forest protection and maintenance **b.** Participation on a municipal road winter maintenance panel **c.** Education and Outreach	 **A - 1** **A - 2** **A - 1**	 **Field** **Meeting Rooms** **Meeting Rooms & Field**		

Leading Management Strategies for Addressing Non-point Pollutant Sources [31, 32, 33, 34, 35, 66,37,38,39]

Future Funding of the Wallkill River Watershed Management Group for Implementation of Specific Papakating Creek and Clove Acres Lake Pollutant Reduction Projects, Dissemination of the Watershed Restoration Plans, Centralized Leadership, Address Plan Revisions and Amendments, and Provide Overall Monitoring and Data Trending of all Watershed-wide Efforts to Achieve Both NJDEP and EPA Water Quality and Strategic Goals

Key Project Partners:

- NJDEP Division of Watershed Management
- Wallkill River Watershed Management Group
- Sussex County Municipal Utilities Authority

Proposed Project Concept: Identifying / Selecting the WRWMG as a Watershed Restoration Plan Implementation Entity

The Wallkill River Watershed Management Group (WRWMG) has become known, not only throughout the Wallkill River Watershed but also, throughout all of Sussex County as the primary local resource for area stakeholders in matters relating to water quality and water resource management. Through the successful completion of several Section 319 (h) and CBT Grant funded projects, the reputation of the WRWMG has progressed such that they have become an indispensable resource for the New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management (DWM) in implementing Total Maximum Daily Loads (TMDL's) and attaining water quality goals in the Wallkill River Watershed. The WRWMG has evolved to serve a critical role as the liaison between the Department and the general public of Sussex County, allowing for the Department to hear and address the concerns of the stakeholders within the county to a much more intimate degree than would normally be afforded a state agency.

Through the development of two separate, but intertwined, Watershed Restoration Plans for the Papakating Creek and Clove Acres Lake Watersheds, the WRMWG has successfully fostered crucial stakeholder partnerships, identified viable restoration initiatives, and generated strong momentum towards the successful implementation of these Restoration Plans. In addition, because the WRWMG is the entity that has developed the Restoration Plans for these two contiguous watershed areas, they already have a comprehensive knowledge and understanding of the Watershed, water quality impairments, and restoration needs. As such, the WRWMG is already in perfect position to hit the ground running and effectively implement identified restoration strategies, initiatives, and projects once funding is secured.

Proposed Mission of the WRWMG (efforts to be integrated within approved implementation projects):

Based on watershed-wide accomplishments to date, the WRWMG is the necessary organization needed to serve as the umbrella entity serving the needs of the Watershed community. Besides management of specific implementation projects, the WRWMG proposes to accept the added role of maintaining pollutant reduction records as well as documenting the initiatives undertaken by both the WRWMG through funded grants as well as community organizations and municipalities to show a demonstrable watershed-wide improvement. This effort is congruent with the EPA strategic water quality improvement goals that all states are expected to meet. The WRWMG's unique ability to know all of the activities underway in the watershed as well as inside knowledge of *where* municipalities and local groups should be working to make the largest water quality improvement allows the WRWMG to serve in a similar capacity as the 'County Watershed Agents' that Rutgers has partnered with the NJDEP to fund. In essence, the WRWMG will be the organization responsible for keeping tabs on everything from agricultural projects, stormwater projects, lake community projects, equine programs, etc. that could report *all* of these improvements to the NJDEP and conduct water quality monitoring to show measurable change as these initiatives are undertaken. The WRWMG has a niche role to fill, and is the best group to do so within Sussex County.

For NJDEP Consideration, the WRWMG Offers a Concept That Offers Better Alignment of All Watershed-wide Efforts and Achievement of Earlier Results Than Attainable Through Current Protocols and Business Processes: Establishment of Three Advisory Panels in Support of the Papakating Creek and Clove Brook Restoration Plans

Achievement of the desired Restoration Plan(s) goals is a complex and challenging undertaking that will require many years of concerted, targeted effort by the entire Watershed Community. Implementation projects alone may only capture 20% to 30% of the desired pollutant reductions within the first five NJDEP funding cycles. The WRWMG firmly believes and supports the concept of establishing project leadership teams to lead and guide the overall effort. Considering the network / complexity of interrelated tasks to be undertaken, the WRWMG proposes a concept based on the formation of three leadership advisory panels to address:

- Restoration Plan(s)
- Agricultural Elements
- Municipal Elements

Establishment of a Restoration Plan Leadership / Advisory Panel

Tasks:

- Provide project / program management leadership guidance with strong focus on representing specific entities within the Watershed
- Represent the majority interests of the entire Watershed community
- Provide a consistency / compliance check with ongoing Municipal and County programs, plans, initiatives, and local planning efforts
- Provide guidance and advice, to municipalities with respect to proposed implementation projects (one representative from each major municipality within the project area)
- Provide specific skills / know-how / organizational strengths and capabilities with respect to program direction and overcoming unforeseen program obstacles
- Provide long-range continuity during the multiple-year implementation phases and Post-Monitoring program

Potential Participating Organizations:

Municipalities (Frankford, Wantage, Sussex Borough, Lafayette, and Montague)
Sussex County Planning / Sussex County Office of GIS (SCOGIS)
Sussex County Board of Agriculture
New Jersey Forest Service
Wallkill River Watershed Management Group
Sussex County Municipal Utilities Authority
New Jersey Department of Environmental Protection

Meeting Schedule: Quarterly during the first year; semi-annually during the second year; to be followed as developments dictate thereafter

Establishment of an Agricultural Advisory Panel

Accelerating the adoption of farming Best Management Practices and implementation of Conservation Plans by the farming community is likely to offer the best opportunities for reducing total phosphorus and fecal coliform / *E.coli* pollutant loadings within the Watershed. The effect of wildlife on pollutant loadings is also considered important but will need to await development of suitable microbial source-tracking methods that are expected to be available within the next 0 to 3 years. Considering the criticality and significant role played by the farming community, leadership of such an important effort to reduce pollutant loadings is best accomplished / achieved through establishment of an Advisory Panel that is tasked to:

Tasks:

- Provide technical expertise in the fields of agricultural practices, restoration and protection Best Management Practices (BMPs) including cost-effectiveness and BMP pollutant-reduction efficiencies, GIS applications, and septic / wastewater matters
- Provide ideas and feedback on Grant-related nonpoint pollutant-reduction strategies
- Review the agricultural and farming technical aspects of the developed Restoration and Protection Plans
- Provide guidance and assistance relating to the identification of funding sources for implementation efforts
- Select committee members to serve as contacts with specific agricultural community members for the purpose of developing / updating agricultural Conservation Plans
- Assist in the implementation of the Papakating Creek and Clove Acres Lake / Lakeshed / Clove Brook Restoration Plans
- Participate in various outreach efforts to disseminate information / educational materials
- Provide long-range continuity during the multiple-year implementation phases and Post-Monitoring programs

Potential Participating Organizations:

Municipalities (Frankford, Wantage, Sussex Boro, Lafayette, and Montague)
Sussex County Planning / Sussex County Office of GIS (SCOGIS)
Sussex County Board of Agriculture
Sussex County Agriculture Development Board
Sussex County Soil Conservation District
North Jersey RC&D Council
Natural Resources Conservation Service (NRCS)
New Jersey Forest Service
Rutgers Cooperative Extension of Sussex County
Public Stakeholders
Wallkill River Watershed Management Group
Sussex County Municipal Utilities Authority
New Jersey Department of Environmental Protection

Meeting Schedule: Every two months during the first year; to be followed as developments dictate thereafter

Panel Mission: Agricultural Operations - Development / Updating of Conservation Plans and Implementation of Best Management Practices (bulk of effort to be by NRCS)

Within the Papakating Creek Watershed (seven HUC 14 sub basins), there are more than 100 parcels / tracks where various active, significant agricultural operations are practiced. Based on discussion with several of WRWMG's partners, it was concluded that development / updating of Conservation Plans would be most appropriate to address long-term water quality improvement initiatives within the Papakating Creek Watershed. Overall, the concept of a Conservation Plan encompasses the following efforts, work scope, and potential benefits:

- Partnering with an NRCS natural resource specialist (conservationist) to develop an overall plan that addresses the management of natural resources within the selected agricultural site

- The format of the Plan is not only to address the soil, water, air, plant, and animal resources with respect to appropriate Best Management Practices but also to address the economic improvement of the land operations as practiced by the land operator.

- The Plan also helps to identify appropriate available federal, state and local assistance and cost-share programs.

- The Conservation Plan is essentially cost-free through the efforts of the U.S. Department of Agriculture Natural Resource Conservation Service in cooperation with the local Soil Conservation District.

- Expected outcomes from implementing the Conservation Plan are improvement of water quality within the area (focus to be on total phosphorus, fecal coliform / *E.coli*, and sediment losses), protection of soil properties, productivity enhancements, protection of the productive value of the land, and compliance with applicable environmental regulatory requirements.

- Considerable data and information with respect to the development of Conservation Plans can be obtained from the U.S.D.A. Natural Resources Conservation Service at http://www.nj.nrcs.usda.gov/programs

Establishment of a Municipal Advisory Panel

Literature and experience gained from other Grant studies confirm that participating municipalities within a watershed can play an important role in the identification and implementation of projects to reduce pollutant loadings to streams and waterways. Suggested opportunities are: a) projects directed at stormwater sediment reduction b) reduction of the use of de-icers during winter periods (without sacrificing road safety), c) sharing of winter road maintenance experiences d) erosion control practices along streams and roads, and, possibly, equipment and/or equipment calibration procedures, e) sharing of lessons learned from implemented Stormwater Plans, and all while realizing benefits through shared service arrangements. The role of the Advisory Panel is envisioned as follows:

Tasks:

- Provide technical expertise in the fields of stormwater management practices and lessons learned, winter road practices / maintenance activities relating to the use of road de-icers, guidance on municipal flooding issues, municipal drainage issues, and feedback on stream erosion / sediment control projects

- Provide ideas and feedback on Grant-related nonpoint pollutant-reduction strategies

- Provide guidance and assistance relating to proposed streambank and riparian restoration projects

- Provide guidance and assistance relating to the identification of funding sources for implementation efforts

- Participate in various outreach efforts to disseminate information and educational materials within the departments of each municipality

- Sponsor workshops on topics of winter road maintenance, stormwater, erosion and sediment control, etc.

Potential Participating Organizations:

Municipalities within the Papakating Creek Watershed

The Department of Public Works or Road Department of each municipality

Sussex County Department of Engineering

Public Stakeholders

Wallkill River Watershed Management Group

Sussex County Municipal Utilities Authority

New Jersey Department of Environmental Protection

Meeting Schedule: Quarterly for the first year; to be followed as developments dictate thereafter

Panel Mission: Targeted Actions for Municipalities [30, 37, 38]

The five municipalities falling within the project area are all classified as Tier B with respect to the Municipal Stormwater Rules. Tier B is less restrictive than Tier A, which has been assigned to more urban / developed municipalities (Tier A municipalities within Sussex County are Andover Township, Byram Township, Hopatcong Borough, Town of Newton, Sparta Township, and Stanhope Borough). Considering the ultimate goal of protecting stream water quality, the voluntary adoption of the following Tier A requirements are proposed for consideration by the Tier B municipalities:

- Improper Disposal of Waste: Adopt and enforce ordinances covering pet waste, litter, improper waste disposal, and yard waste

- Municipal Separate Storm Water Systems (MS4) Outfall Pipe Mapping – addresses outlet pipes that discharge to surface waters

- Road Erosion Sediment Controls: Develop a roadside erosion control maintenance program to identify and stabilize roadside erosion

- De-icing Material Storage: Need for a permanent enclosed storage facility and/or equipment for handling liquid brine solution

- Review and enhance Tier B local public education requirements

- Adopt / implement an employee-training program (include a focus on the spreading procedure pertaining to de-icers and spreader maintenance / calibration requirements

Note: Stormwater runoff containing road salts has become a source of contamination of surface and subsurface waterbodies. In addition, the impact of salt runoff on the environment as well as high corrosion rates in relation to highway structures and vehicles is well recognized. To further education regarding how best to minimize the impact of road / de-icing materials, a Sussex County/ Papakating Creek Watershed seminar should be considered to address a broad range of winter road maintenance practices and operations (spreading materials, de-icing chemicals, spreader calibration, salt storage, liquid brine equipment, etc.). Training programs conducted by the New Jersey Local Technical Assistance Program and the New Jersey Water Supply Authority in 2004, 2005, and 2007 in support of the Raritan Basin System Watershed studies [35, 37] could serve as role models for conducting similar workshops within Sussex County. A recommendation is made to form an advisory panel consisting of municipal, County, and WRWMG personnel to initiate, develop, and sponsor a seminar addressing the above training and cooperative effort.

Best Management Practices Tool Box

Table 15 summarizes well-documented Best Management Practices for the reduction and prevention of pollutant loadings to streams, aquifers, roadways, and local lands. The list is not intended to be all inclusive of known practices.

Table 15: Conservation / Farming Protection Choices (Best Management Practices Tool Box)

Erosion & Sediment Control	**Nutrient Management**	**Livestock Barnyard. Manure, and Waste Management**	**Livestock Grazing Management**	**Pest and Pesticide Management**	**Irrigation Management**
Conservation Cover	**Agricultural Composting**	**Combined Waste Facility**	**Alternate Water Supply**	**Appropriate Biological Controls**	**Backflow Prevention**
Conservation Crop Rotation	**Filter Strips**	**Diversion(s)**	**Fencing**	**Appropriate Cultural Controls**	**Efficient Irrigation System**
Contour Farming	**Conservation Crop Rotation**	**Filter Strip**	**Pasture Management**	**Appropriate Physical Controls**	**Irrigation Water Management**
Contour Strip-cropping	**Cover Cropping**	**Heavy Use Area Protection(s)**	**Plan for Proper Grazing**	**Maintain and Calibrate Application Equipment**	**Tailwater Recovery System(s)**
Contour Buffer Strips	**Equipment Calibration**	**Manure Composting**	**Prescribed Grazing**	**Data Collection**	**Water Measuring System(s)**
Cover Cropping	**Fertilizer Storage, Handling, & Containment**	**Manure Storage Facility(s)**	**Riparian Buffer**	**Application Plans and Records**	**Farm Pond**
Critical Area Planting	**Green Manure Cropping**	**Manure Storage Field Stacking Area**	**Stream Crossing**	**Protect and Enhance Natural Controls**	
Diversion(s)	**Intercropping**	**Plan for Manure and Waste Utilization**	**Vegetative Stabilization**	**Safe Storage, Mixing, Loading, and Disposal**	
Field Borders	**Nutrient Budgeting**	**Roof runoff Management**		**Scout for Pests**	
Field Strip-cropping	**Nutrient Record Keeping**	**Silage Leachate Waste Management**		**Special Handling of Sensitive Areas**	
Filter Strip	**Plant Tissue Testing**	**Wastewater Treatment System(s)**			

Erosion & Sediment Control	**Nutrient Management**	**Livestock Barnyard. Manure, and Waste Management**	**Livestock Grazing Management**	**Pest and Pesticide Management**	**Irrigation Management**
Grade Stabilization Structure	**Proper Timing and Application Methods**	**Petroleum Product Storage**			
Grassed Waterway(s)	**Soil Nitrate Testing**	**Hazardous and Household Waste Management**			
Mulching	**Soil Testing**				
Outlet or Lined Waterway(s)	**Yield Data**				
Pasture and Hayland Planting					
Residue Management: No-till, Strip Till, Mulch Till, Ridge Till					
Riparian Buffer					
Sediment Basin(s)					
Stream Channelization Measures					
Tree Planting					
Windbreak					
Brush Management					
Wetlands and Wetlands Enhancement					

References:

a. NRCS Guide, USDA, titled "*Conservation Choices*"
b. Ag-Choice Composting Facility (Manure Management), Sussex County, Andover, New Jersey
c. Farm Bill 2002, titled "*Conservation Practices and Programs for Your Farm*"
d. Division of Agricultural and Natural Resources: Criteria and Standards for Animal Waste Management, Proposed New Rules: N.J.A.C. 2:91
e. Orange and Ulster Soil and Water Conservation Districts, et al, 2007, "*Wallkill River Watershed Conservation and Management Plan*"

Existing Implemented and Relevant Municipal Ordinances

Table 16 briefly summarizes a survey that was conducted with each participating municipality to establish the status of applicable ordinances that are generally considered essential in support of the goals of a Restoration Plan. The information will be used to identify where new ordinances may be required.

Table 16: Summary of Applicable / Status of Municipal Ordinances Within the Clove Brook Sub-basin

Ordinances	**Wantage Township**	**Sussex Borough**	**Montague Township**
Stormwater Tier	**B**	**B**	**B**
Stormwater Management Plan	**In place**	**In place**	**In place**
Formulation of De-icers and Sand Mixtures Used Within the Township	**Sodium chloride / sand - grit mixture**	**Sodium chloride / sand - grit mixture**	**Sodium chloride / sand – grit mixture**
Soil / Sediment Conservation	**Refer to Soil Conservation District Ordinance**	**Refer to Soil Conservation District Ordinance**	**In place by ordinance**
Steep Slope Protection	**In place**	**No need**	**In place**
Stream Buffer/ Riparian Corridor Conservation	**No current ordinance**	**No current ordinance**	**No current ordinance**
Tree Preservation / Removal	**No current ordinance**	**No current ordinance**	**No current ordinance**
Wetlands Protection	**Covered under NJDEP regulations**	**Covered under NJDEP regulations**	**Follow NJDEP requirements**
Septic Management Program	**System designs and inspections covered under the County of Sussex County Health Department (septic tank pump-out program not currently required within Township)**	**98% of Township on central wastewater system (Sussex County Municipal Utilities Authority); 2% of Township on conventional septic systems**	**System designs and inspections covered under the County of Sussex County Health Department**

Ordinances	**Wantage Township**	**Sussex Borough**	**Montague Township**
Fertilizer Application Formulation	**No current ordinance**	**No current ordinance**	**No current ordinance**
Geese Management	**No current ordinance**	**In place but review suggested**	**No current ordinance**
Standard for Dry Well Installation	**No current ordinance**	**No current ordinance**	**No current ordinance**
Limestone / Carbonate Geology	**No current ordinance**	**No need**	**No need**
Impervious Cover Limitations	**Addressed in zoning ordinance**	**Addressed in zoning ordinance**	**Addressed in zoning ordinance**
Wellhead Protection Plan	**Mentioned in the Aquifer Protection and Well Testing Ordinance; Provisions for full wellhead protection is advisable**	**Potable water served from Rutherford Lake (develop-ment of a specific protection ordinance is advisable)**	**No**
Streambank Stabilization Ordinance	**No current ordinance**	**No current ordinance**	**No current ordinance**
Sediment and Erosion Control Plan	**Covered under Soil Conservation District Ordinance**	**Covered under Soil Conservation District Ordinance**	**Covered under Soil Conservation District Ordinance**
Low-impact Development	**No current ordinance**	**No current ordinance**	**No current ordinance**
Right-To-Farm Ordinance	**In place**	**In place**	**In place**
Full / Part Time Enforcement Officer	**Full time**	**Part time (share arrangement with Wantage Township)**	**Part time**

Pollutant Source-Tracking Assessment

Table 17 summarizes typical generic pollutant sources for total phosphorus that were observed during source-tracking field tours conducted within the Watershed. The list can be used to aid in devising / selecting appropriate reduction strategies to achieve the targeted Restoration Plan pollutant-reduction goals.

Potential Total Phosphorus Sources

Table 17: List of Major Total Phosphorus Sources by Municipality

Potential Pollutant Sources	Wantage Township	Sussex Borough
Fertilizers	Applicable	Applicable
Sediment/Erosion	Applicable	Applicable
Loss of Riparian Buffers	Applicable	Applicable
Rural Stormwater	Applicable	
Urban Stormwater		Applicable
Mal-operating Onsite Septic Systems	Unknown	Unknown (98% of Borough on central wastewater system)
Manure-Related Practices	Applicable	
NPJDES- Permitted Facilities	One NPJDES site; not considered a factor; upgrade planned for 2010	

Note: Montague Township within the Clove Brook sub-basin is essentially 100% forested / water bodies

Clove Brook along Route 23, Wantage Township

Overall Summary of Field Findings

The HUC 14 parcel and stream assessments were performed by traveling along local roads, walking portions of rail beds that run parallel to various stream segments, and observations at road crossings, as well as from aerial and GIS-developed maps. Assessments also included photographing of all field findings and observations and holding discussions with various community members. *Table 18* summarizes field assessments covering one (02020007020-060) of seven HUC 14s that comprise the Papakating Creek Watershed. Assessments for the other six HUC 14 sub-basins will be in a separate Report covering the Papakating Creek Watershed.

Table 18: Summary of HUC 14 Project Area Land Users

HUC 14	Sub-basin (Acres)	Farms	Horse Farms	Tree Nurseries	Other (Notes A and B)	Sub-total
02020007020060	12,841.3	10	3	_	8	18
Probable Count (assume 80% was actually observed in the field)		13	4	1	10	28

Notes:
A: Examples - cemetery, VFW Hall (outside, open structure), hamlet, lakes, park, RV camp, etc.
B: Located adjacent to the Clove Brook

HUC 14 - 02020007020060

HUC AREA IDENTIFIER: ***COLESVILLE AND SUSSEX BOROUGH***

Areas along segments of Routes 23, 651 (Unionville Road), 519 (Greenville Road), Rose Morrow, Beemer Road, Clove Road, Medaugh Road, Wantage School Road, Dewit Road, Motown Road, and Skytop Road; Area contains Clove Acres Lake, Clove Cemetery, Van Bunschooten Museum, Pleasant Acres RV Camp, Wantage Township Town Hall, Sussex Borough Town Hall, Lake Rutherford, and Clove Brook headwaters

Key Facts: Percent Impervious Cover: 1.52% overall; Sussex Borough is at 24.59%
HUC Acres: 12,841.3
Predominate Land Cover: rural, very low residential density, both active farms (declining) and old agricultural farm fields, extensive wet lands and highly forested
Stream Miles: Classified as C2 waters
Stream Percent Tree Canopy: ≥ 50%
Stream Buffers: ≥ 50% (varying widths; excludes lakes)
Targeted Pollutant Reductions: Total Phosphorus

Key Field Findings - North of Clove Acres Lake:

Waterways:

Lake Rutherford - source of water for Sussex Borough, overflow forms a tributary to the Clove Brook; the lake is located entirely within High Point State Park boundary and is essentially 100% buffered by dense forest.

Numerous unnamed, small ponds located in wetland areas - multiple small tributaries to the Clove Brook (generally located within the northwestern area of the Clove Brook HUC 14 sub-basin)

Clove Brook section that is just upstream from the WRWMG Sampling Site ”I” - stream is fairly buffered and forested; adjacent lands are old agricultural fields

Pond - located near Colesville; pond is highly buffered; observed low density housing area

Agricultural Farms:

Large Farm (Route 23) - farm appears well maintained; the farm is situated adjacent to the Clove Brook and is located between the WRWMG sampling Sites “P” and “O”

Farm (Rose Morrow Road, east of Unionville Road [Route 651]) - farm is upstream from the WRWMG sampling Site “P”

Farms - observed three small farms on Beemer Road, north of Rose Morrow Road

Farm (intersection of Clove Road and Unionville Road and south of Wolf pit Road) - suspect possible drainage to the Clove Brook from the farm fields (must be verified)

Farm (west of the intersection of Clove Road and Unionville Road) - observed six cows

Farm / RV Site (Dewitt Road, off Route 23) - observed a small detention pond with the overflow forming a feeder stream to a nearby tributary to the Clove Brook

Farm (opposite the Sussex Borough Water Filtration Plant; the plant is located on Route 23, east of Colesville) - observed sheep grazing

Farm (Brink Road, south of Route 23)

Horse Farm (Brink Road, south of Route 23) - two horses observed

Horse Farm (Midtown Road, north of Route 23) - site is a potential sampling site for determining the water quality of a major headwater tributary to the Clove Brook; the tributary is the composite of at least three feeder streams that combine to form the tributary at this site

Horse Farms (Brown Road) - small horse farm

Other Observations:

Clove Cemetery (Route 23, near the Wantage Town Hall) - the cemetery is situated between the Clove Brook and Route 23

VFW Hall (north side of Route 23, open structure is within 10 to 20 feet from the Clove Brook) - observed approximately 25 cows just north of the VFW Hall (outside of VFW property); the Clove Brook meanders in this vicinity as well as north of this site

Headwaters of the Clove Brook, including all major tributaries and feeder streams - many sections are well buffered with rocky stream bottoms; some portions receive direct runoff of storm waters from Route 23 (e.g., near the former site of the High Point Country Inn); extensive wetlands predominate the area; major portions of the mainstem appear very healthy and free flowing, with rocky bottom, many ripple sections, and buffers on both sides

Colesville Hamlet - observed a cluster of houses and businesses adjacent to the Clove Brook; buildings are within feet of the stream; site is a potential source of various pollutants to the stream

Route 23 (road length within project area) - observed the absence of road catch basins; the result is that a major portion of the stormwater flows to low spots with eventual drainage to the Clove Brook

Bridge (Medaugh Road [Bridge No. X – 57]) - observed severe streambank erosion

Open-Space Candidates:

Land surrounding the stream between Lake Rutherford and the Sussex Borough Water Treatment Plant; these waters serve as the source of potable water to Sussex Borough; stream is located off Route 23 and lies within the hamlet boundary and center of Colesville

Approximately 27 acres of picturesque and scenic sections of the Clove Brook, near the intersection of Route 23 and Ramsey Road; this section of the Clove Brook stream contains at least two significant waterfalls having heights of approximately 20 feet and 60 feet

Key Field Findings - Clove Acres Lake:

Clove Acres Lake - a complete assessment report is to be issued by Princeton Hydro, LLC; the lakeshed is a source of total phosphorus loading and, possibly, fecal coliform / *E.coli*; the lake receives direct stormwater runoff from Route 23 (road has no catch basins) as well as from back yards of residential homes between the lake and Route 23.

<u>Key Field Findings - South of Clove Acres Lake and Prior to the Confluence with the Papakating Creek:</u>

Clove Brook from the Clove Acres Lake Dam to Brookside Park - Extensive streambank alterations due to extreme stream flows (high velocities and stream depths during / following major storm events, particularly observed under the Newton Avenue Bridge (the WRWMG sampling Site "J"). At times, stream depth reaches the underside of the bridge, partially covering a major wastewater transfer pipe running horizontally under the bridge. This site is a candidate for a streambank restoration project.

Park (Brookside Park in Wantage Township, just south of the Borough (leased by Sussex Borough) - park is subject to flooding during major storm events from overflowing of the Clove Brook streambanks and, subject to the intensity of the storm event, from overflow waters from manholes in the vicinity of the Sussex Borough Wastewater Pump Station; the Clove Brook flows parallel to the park and is located within 15 to 20 feet of the park boundary; the stream corridor shows severely eroded streambanks, presence of sediment / point bars (composed of silt, sand, gravel and cobble including the presence of large rocks up to 3 to 6 inches); woody debris (fallen trees), both uniform and non-uniform flow patterns, and several riffle sections in the coarse-grained sections of the stream

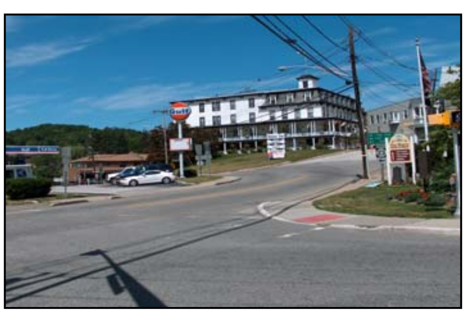
Sussex Borough - In-leakage of stormwater in the subsurface wastewater distribution routing system that is used for the conveyance of wastewaters to the Wastewater Pumping Station; although progress is being made in the identification and correction of pipe failures, including manhole leakage issues, additional funding is required to accelerate and to complete the ongoing engineering and maintenance efforts by the Sussex Borough's Department of Public Works and an outside engineering firm; **until the in-leakage problem is totally resolved, fecal coliform / *E.coli* and other pollutants will continue to flow directly to the Clove Brook under major storm conditions.**

Supplementary Pollutant-Reduction Strategies [38, 39]

In-lake Treatment: (relates to the Clove Brook Restoration Plan; builds on the findings and recommendations from Princeton Hydro, LLC)

Urban Area(s) - Sussex Borough:

Total Phosphorus Sources: urban streets, parking lots, lawns, driveways, leaking wastewater transfer lines, air deposition, internal loading from Clove Acres Lake, etc. Studies have shown that leaves and other organic debris left in the street to be a significant contributor to the urban phosphorus load. Another key source is local soils within the Watershed area that generally contain excess amounts of phosphorus.



Agricultural Related Projects - Funding Source Contacts:

Rutgers Cooperative Extension of Sussex County
Steve Komar, County Agricultural Agent (973-946-3040)

U.S. Natural Resource Conservation Service
Kent Hardmeyer, Ron Phelps, and Janice Reid
(908-852-2576)

Wallkill River Watershed Management Group
Sussex County Municipal Utilities Authority
Nathaniel Sajdak: Watershed Coordinator (973-579-6998 ext. 109)
Ernest Hofer PE: Watershed Specialist (973-579-6998 ext. 111)

Agricultural Related Projects - Project Funding Sources:

Table 19 summarizes available funding programs. Changes are likely following approval by Congress of the pending Farm Bill (late 2008; awaiting final details)

Table 19: Agricultural Conservation Programs / Funding of Best Management Practices

Funding Sources	**Scope / Purpose**	**Typical Terms (may differ in the version presently under consideration by Congress); Cost share refers to potential funding from the indicated Program**
Conservation Reserve Enhancement Program (CREP)	Addresses high-priority conservation issues, such as impacts to water suppliers, loss of critical habitat, and soil erosion; supports practices such as filter strips, forested buffers, and restoration of wetlands; provides farmers with a sound financial package for conserving and enhancing the natural resources of farms	Administered by the U.S. Department of Agriculture (USDA); requires a 10-to-15 year commitment to keep lands out of agricultural production; provides a maintenance incentive payment plus up to 50 % of the eligible costs to install the various conservation practices
USDA Farm Service Agency Outreach Program (FSA)	Administration of farm commodity and conservation programs and makes loans to farmers unable to obtain conventional credit	For more information about FSA programs, visit FSA at **www.fsa.usda.gov**.
Conservation Reserve Program (CRP)	Conversion of highly eroded cropland to a less intensive use; assists with the cost, and establishment of conservation practices; relates to renting lands from farmers for buffers	Cost share up to 50%
Conservation Security Program (CSP)	Provides a security plan to install and / or maintain high levels of conservation practices on working lands; provides rewards and incentives for achieving the desired goals	Cost share up to 50%
The New Jersey Division Of Fish and Wildlife's Endangered and Nongame Species Program (ENSP)	State biologists work with private landowners to protect the habitat of threatened and endangered species	

Funding Sources	**Scope / Purpose**	**Typical Terms (may differ in the version presently under consideration by Congress); Cost share refers to potential funding from the indicated Program**
Environmental Quality Incentives Program (EQIP)	Provides for a broad range of conservation and environmental practices; includes practices relating to soils, water, and grazing lands	Cost share up to 75%
Wildlife Habitat Incentives Program (WHIP)	Prepare and develop a wildlife habitat development program including endangered species	Cost share up to 75%
Forest Land Enhancement program (FLEP)	Provides financial, technical, and educational assistance to forest land owners	Cost share up to 75%
Forest Legacy Program (FLP)	Supports acquisition of properties and easements with the objective of protecting environmentally sensitive forest lands	Cost share up to 75%
Forest Stewardship Program (FSP)	Development of forest- related protection plans	Cost share may be available from other programs
Farm and Ranch Lands Protection Program (FRLPP)	Development of a conservation plan and compliance with the terms of an easement agreement; helps fund purchase of permanent easements	One-time upfront payment for the easement
Grassland Reserve Program (GRP)	Restoration of grasslands and shrublands	Cost share up to 90%
Integrated Crop Management (ICM)	Assistance with both pest management and nutrient management practices	Provides specific dollars / acre for fruit trees, vegetable plantings, and field crops
Landowner Incentive Program (LIP)	State biologists work with private landowners to protect critical habitats	Cost share up to 75%
Wetlands Reserve Program (WRP)	Restoration, protection, and enhancement of wetlands on farm properties; relates to establishment of a conservation easement	Up to 100% reimbursement for restoration costs (10-year restoration agreement)

Funding Sources	**Scope / Purpose**	**Typical Terms (may differ in the version presently under consideration by Congress); Cost share refers to potential funding from the indicated Program**
Conservation Plan (an NRCS service)	Development of a written record of conservation practices, management decisions, and goals; provides engineering and agronomic assistance in applying conservation practices	Assist in identifying cost share assistance programs; Contact source: ***www.nj.nrcs.usda.gov***
Pest Management Assistance		Service available from Rutgers Extension Division; Contact source: ***http://pestmanagement.rutgers.edu***
New Jersey Department of Environmental Protection 319(h) approved Implementation Projects	A broad range of conservation and protection practices	Cost share - up to 100%

Education and Outreach Plan

The ongoing mission of the Wallkill River Watershed Management Group (WRWMG) has always been to raise awareness about the Wallkill River Watershed and generate stakeholder participation in various watershed management initiatives to maintain, restore, and enhance the watershed. From the onset, the key to successfully accomplishing this mission is developing and maintaining an aggressive education and outreach campaign.

The WRWMG has extensive experience with many different approaches, which have successfully generated interest and fostered important stakeholder partnerships.

- Numerous educational watershed newsletters, informational brochures, and a calendar have been produced and distributed
- A WRWMG website has been developed and utilized to effectively reach out to stakeholders via the Internet
- A watershed sign campaign has led to the installation of roadside Wallkill River Watershed and individual stream identification signs
- Educational programs have been presented in the schools and at publicly attended events
- Formal informational outreach presentations have been given at regular county and municipal meetings, special group meetings (rotary clubs, County Chamber of Conference breakfast meetings, League of Municipalities Dinner Meetings, etc.) conferences, and seminars.
- Other successful initiatives include a Watershed Walks Program, Watershed Clean-up Days, and educational demonstrations at the Wallkill River National Wildlife Refuge, the Vernon Earthfest, and the Sussex County Farm and Horse Show / New Jersey State Fair
- Actively working with the Sussex County Office of GIS to develop many Watershed related GIS mapping initiatives, including building an interactive internet mapping service that provides watershed residents with an easy way to access watershed related data and information

It has long since been the stance of the WRWMG that the way to get stakeholders to develop a sense of commitment to the Watershed and a desire to be involved in the efforts to protect it, is to make sure they are continuously aware of the ongoing project efforts and allow them to develop a sound understanding of how they can participate. Throughout the entire development period of the Watershed Restoration Plan for the Clove Acres Lake and the Clove Brook Watershed, the WRWMG has aggressively reached out to and maintained communications with the county officials, the municipalities and the public stakeholders who are a part of this project area to:

- Share collected water quality data and other pertinent project information
- Solicit input and feedback
- Provide Plan development updates
- Encourage active participation in future implementation efforts

Once the Restoration Plan is formally approved by NJDEP, the next step is to begin the design and implementation of the recommended restoration strategies, initiatives, and projects. The long-term success of the plan is largely dependent upon stakeholder buy-in and belief in its overall value. As such, it is recommended that the Education and Outreach (E&O) continue to be a primary focus during the completion of implementation projects as well as municipality, lake community, and county driven initiatives. While the WRWMG will continue to promote the Restoration and Protection Plan, it is recommended that E&O become a critical task of any contracted project.

The following is an outline for an Education and Outreach Plan specific to the Clove Brook Watershed Restoration Plan, geared to obtain and maintain stakeholder buy-in.

TASK 1: Raise awareness about the approved Restoration Plan and distribute throughout the Clove Acres Lake and the Clove Brook Watershed

- Provide summary presentations and distribute copies of Plan at public meetings (County 208 Water Quality PAC, municipal committees, County Board of Agriculture, etc.)
- Issue press announcements to local papers about the Plan and provide information on how to obtain a copy
- Generate informational handouts / posters for distribution at various public locations (county and township buildings, SCMUA, Wallkill River National Wildlife Refuge, public kiosks, etc.)
- Post Plan on the WRWMG website

TASK 2: Develop, Initiate, and Promote hands-on outreach campaigns and projects to share / spread educational information for key topics

- Septic management
- Manure management
- Stormwater management
- Winter road maintenance
- Lake management
- Available public recreational uses within the Watershed

TASK 3: Build a GIS Internet Mapping Service Website designed to track the implementation progress of the Restoration Plan

- Water quality data
- Stream restoration sites
- Watershed clean-up sites
- Stream debris removal sites
- Stream flooding locations
- Public Recreation Locations
- Open Space Properties

TASK 4: Plan and institute a long - term sustainability plan for the continued coordination, implementation, and maintenance of the initiatives, projects, and strategies contained within the Clove Acres Lake and Clove Brook Restoration Plan

- Linkage of the Education and Outreach and Post-Monitoring Plans
- Initiation of a stakeholder recognition program

- Documentation and publication of pollutant reduction project successes achieved both internally and externally by other Watershed Implementation Plan sponsors
- Documentation of project successes both internally and externally to be provided to NJDEP for use in showing attainment of water quality improvement measures to EPA.
- Provide a communication channel between watershed stakeholders and NJDEP, educational institutions, and manufacturing companies in applicable areas relating to non-point pollutant(s) reduction techniques
- Address approaches / considerations that target maintaining the economic viability of the agricultural community within the watershed.

TASK 5: Explore innovative and ongoing outreach programs to generate stakeholder interest in the Clove Acres Lake and the Clove Brook Watershed and encourage general watershed stewardship

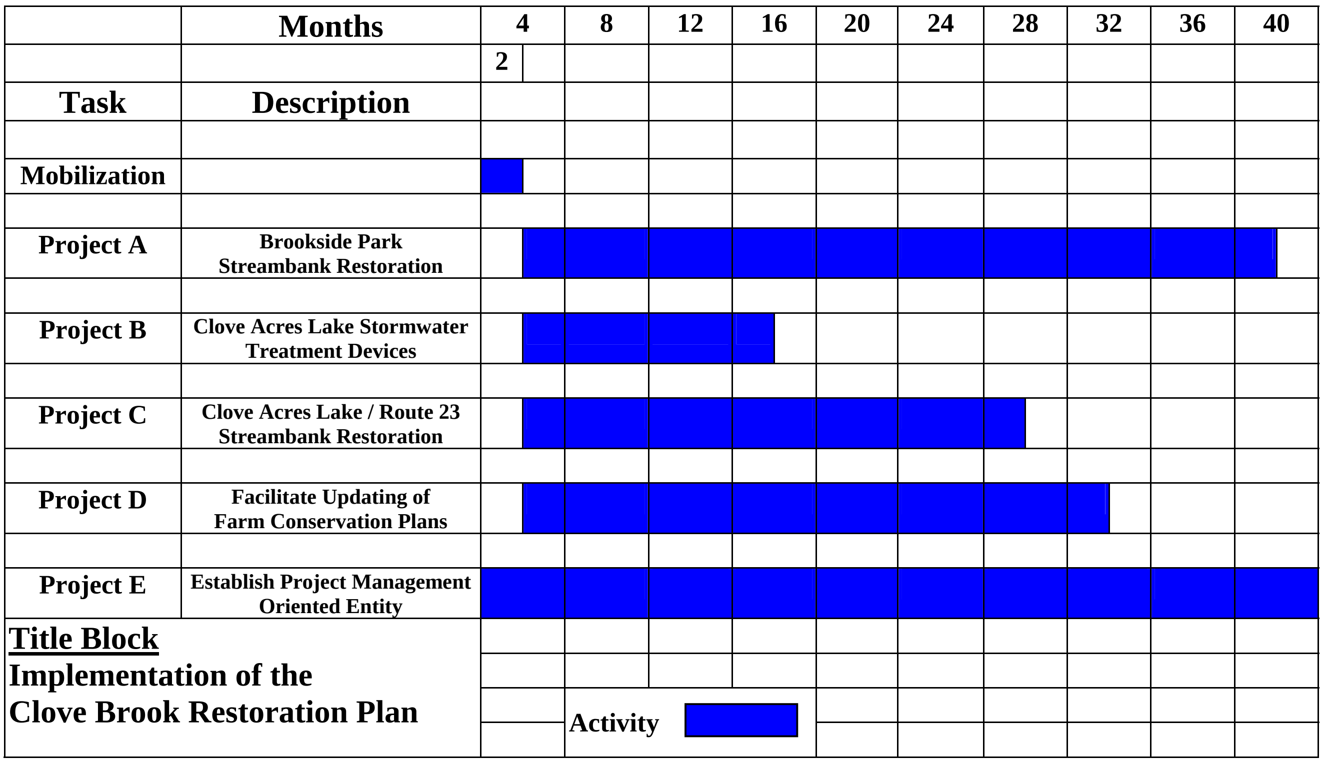
- Seasonal watershed clean-ups program
- Stream identification signs
- Volunteer restoration projects
- Farm tours to promote ongoing water quality activities / practices
- Auto Tour Guides
- Storm drain stenciling
- Sponsor canoe / kayak trips

Ultimately, an education and outreach campaign is a continuously evolving component of any watershed project. As such, there will always be a constant need to monitor and assess the program to ensure that the desired results are being achieved. Although it may not be considered a formal restoration practice or project, a successful outreach campaign is crucial to the long-term successful implementation of any watershed restoration plan, and obtaining the necessary water quality improvements.

Project Schedule:

The following Schedule addresses the proposed Tasks for five implementation projects to be initiated within the first 40-month period of a 15-year program as the foundation of an aggressive program to achieve the targeted pollutant reductions within the Clove Brook subwatershed. The overall goals are to achieve surface water quality levels that are in compliance with the NJDEP SWQS and to restore / protect Clove Acres Lake / Lakeshed / Clove Brook subwatershed.

Overall Schedule: Initial Implementation Projects for 2009 - 2012
(Initial Phase of an overall timeline of 15 years with annual planned projects and pollutant reductions)



Keys for Restoration Plan Success

- Effective integration of science and planning
- Teamwork and partnerships (at all levels)
- Dedication and persistence
- Willingness to learn and improve
- Benchmarking - sharing of experiences, shills, and lessons learned
- Funding availability
- Innovation (use of microbial source tracking tools, application of "critical source areas" within a watershed to identify effective placement of Best Management Practices (BMPs), correlation of BMPs and associated pollutant reduction efficiencies, and use of Geographical Information Systems (GIS) for assessments and information analysis)
- Use of adaptive management techniques for planning both present and future program steps
- Establishing a "living" organizational structure to accomplish the goals targeted over the next 15 years

Post-Monitoring Plan [28, 38, 39, 40]

Considering that the post-Monitoring Plan will extend over a 10 to 15 year time period, the Plan must be carefully designed to be cost-effective. Based on a number of References [38, 40] the following general considerations are offered:

Objectives:

Achieve the NJDEP total phosphorus Surface Water Quality Standards for Clove Acres Lake and the Clove Brook (specific objective)

80% completion / implementation of Conservation Plans for agricultural farms and commercial / hobby horse land operations (specific objective)

Monitor the effectiveness of Implementation Projects with respect to desired pollutant reductions (specific objective)

Procure of necessary funding levels to permit landowners, land operators, and municipalities to implement the desired projects (general objective)

Monitoring Plan Elements:

What to Sample: Clove Acres Lake and Clove Brook surface waters

Where to Sample: WRWMG Sites “O,” “I,” “L,” and “J” (minimum number of sites)

When To Sample: Three year intervals; twice / year (spring / summer periods)

Number of Samples to Collect / Site: One original plus one replicate

How to Sample: In accordance with an approved NJDEP Quality Assurance Project Plan

What to Analyze in Samples: total phosphorus, ortho phosphorus, and dissolved oxygen (the minimum number of parameters to be measured); corresponding stream flow rates would also be beneficial to have for development of mass balances)

Flow Rate Measurements: Augment information from USGS real-time monitoring station 01367800, staff gages at Sites “I,” “J,” and “K” with field measurements at selected locations

Application of Monitoring Data: To develop long-term trend charts for the purposes of a) tracking effectiveness of implemented projects, b) if necessary, to alter the then-current project activities and plans, c) to share with program partners, and d) to show achievement of NJDEP and EPA water quality goals

Plan Management Policy:

The use of an adaptive management approach as defined in a reference by authors Salafsky, Nick, et al [40] is essential in pursuing a cost-effective and efficient journey to achieve the desired goals of restoring and protecting the Clove Brook Watershed over an extended 10- to 15-year time period. Basically, an adaptive management policy is a practice that is based on the integration of analysis, management practices and decisions, full-scale field experimentation, and monitoring to evaluate progress and, if indicated, to alter or adapt new courses of action. Basically, the practitioner is continuously testing assumptions, questioning prior decisions, adapting/ reacting to new information, and learning in order to benefit from one's experiences.

Development of Long-Term Monitoring Metrics - Consider total phosphorus concentrations (mg/l) at specific stream locations, NJDEP stream SWQS for total phosphorus, cumulative funding expended, effectiveness of dollars expended/unit of pollutant reduction, cycle times for implementation of various BMPs, population changes (related to build-out), as well as other metrics as deemed necessary

Charting of Metrics - Develop prior to start of Plan implementation; use the developed metric information to establish the actual impact of management decisions, the level of progress achieved, including the extent of total phosphorus water quality improvements, and the need for Plan alterations

Monitoring of Organizational Structure and Resource Needs - Develop prior to start of Plan implementation

Development of a Long-Term Schedule - Develop prior to start of Plan implementation; identify short-term and long-term milestones

Development of a Long-Term Funding Plan - Develop prior to start of Plan implementation

Conduct Program Reassessments - Conduct a detailed assessment every five years but monitor annually

Development of a Communication Plan - Develop at start of Post-Monitoring Plan implementation (maximize use of electronic formats)

Linkage to the Sussex County Strategic Growth Plan (SGP) [41, 42] and the Sussex County Agriculture Development Board [43]

Sussex County Strategic Growth Plan

The goals of the Clove Brook sub-basin Restoration Plan are consistent with the vision established in the Sussex County Strategic Growth Plan with respect to:

- Protect and preserve environmentally sensitive areas
- Maintain and enhance surface and groundwater quality / water quantity
- Protect open space
- Encourage farmland preservation
- Protect the Clove Acres Lakeshed and Clove Brook Streamshed's flood plain
- Protect and maintain the quality of life within the Clove Brook Streamshed
- Protect endangered and threatened species
- Support cluster development within defined "centers" and protect Sussex County's rural environs

Other aspects of the Restoration Plan are not believed to be in conflict with the overall vision established in the SGP for Sussex County.

Sussex County Agriculture Development Board [42]

The goals of the Clove Brook sub-basin Restoration Plan are consistent with the vision of the Sussex County Agriculture Development Board as presented in the "*Comprehensive Farmland Preservation Plan - Updated November 2007*" as compiled by the Morris Land Conservancy with input from the Sussex County Agriculture Development Board and other local organizations and community groups, to:

- Preserve both farmland and farmers
- Conservation of natural resources on farms
- Ensure clean and plentiful water
- Implement waste management and recycling
- Encourage farmland preservation (Sussex County: 9,458 acres preserved to date with approximately 2,522 acres pending as of November 2007)
- Support and protect the Right-To-Farm Act (ordinances in place by all the municipalities within the Clove Brook sub-basin / Papakating Creek Watershed

With respect to other aspects of the Clove Acres Lake / Lakeshed and Clove Brook sub-basin, efforts will be taken to work in harmony with the agricultural community so as not to adversely impact the future of agriculture within Sussex County and the Clove Brook sub-basin / Papakating Creek Watershed.

Acronyms, Abbreviations, and Definitions

These definitions are not intended to be complete but to aid the reader in understanding the words / terms used within the body of the report.

Accretive - waters increasing by addition or growth; inflows

Adaptive Implementation - periodic assessing and altering, if necessary, a series of sequential tasks that comprise an implementation work plan in to achieve the desired result

Aquifer - a subsurface geological formation or a group of formations that are water bearing; a natural underground layer, often of sand or gravel, that contains water

Antigradation - policies which ensure protection of water quality for a particular water body

AMNET - Ambient Biomonitoring Network

ASMN - Ambient Stream Monitoring Network

Assimilative capacity - the capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water

Base Flow - the sustained low flow of a stream; also defined as streamflow from ground-water seepage into a stream

Best Management Practices (BMPs) - actions that may be implemented that lead to the reduction of pollutants to waterways, such as constructing stream corridor buffers

Box of the Plot - a rectangle that encloses the middle half of the sample, with an end at each quartile

Box Plot - generally presents six sample statistics – the minimum, the lower quartile, the medium, the mean, the upper quartile, and the maximum – in a visual display; various statistical plotting software show the sample statistics including sample values in slightly different formats

C1 - Category One Waters; those waters designated for implementation of antigradation policies

C2 - Category Two Waters; those waters not designated for implementation of antigradation policies

Clean Water Act - Act passed by U.S. Congress in 1972 to control water pollution

Coarse Textured Soil - sand or loamy soil

Coliform - a group of related bacteria whose presence in water may indicate contamination by disease-causing microorganisms

Coliphage - viruses that infect bacteria of the coliform group (e.g. *E.Coli*)

Consumptive - that part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate environment

Depletive - water transfers

Designated Uses - water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act

Dissolution - (also called chemical solution) – the process of chemical weathering of bedrock in which the combination of water and acid slowly removes mineral compounds from solid bedrock and carries them away in liquid solution

Ecosystem - an integrated system of living species, their habitat, and the processes that affect them

EPA - United States Environmental Protection Agency

Erosion - The wearing away of land / streambank surfaces by a stream flow, stormwater runoff, and wind

Eutrophication - The process of nutrient enrichment followed by a rapid increase in nutrient levels creating "algal blooms." On death, bacterial decomposition of the excess algae may seriously deplete oxygen levels. The extremely low oxygen concentrations that result may lead to the death of fish, creating a further "oxygen demand" leading to further deaths

Geometric Mean - the n-th root of the product of n sample values;
Geometric mean = $(\text{Sample Result}_{\#1} \text{ x..x Sample Result}_{\#n})^{1/n}$

GIS - Geographical Information System

Glacial - of or relating to the presence and activities of ice and glaciers

Horse Waste - Manure, urine, bedding, and feed waste products

Hydrograph - presents cumulative stream flow information; developed using the long-term flow database and plotting the points on a frequency table; shows percent of days flow is met or exceeded

Hydrologic Unit Code (HUC) - A classification system devised by the USGS that divide the United States into regions, subregions, accounting units and cataloging units for the purpose of delineating river basins. An example of the numbering system is presented as follows:

02 = region (i.e., Mid-Atlantic Region)
0202 = subregion (i.e., Upper Hudson Basin)
020200 = accounting unit (i.e., Upper Hudson, New Jersey)
02020007 = calculating unit (i.e., Rondout, New Jersey and New York)
02020007010 = watershed (i.e., Wallkill River, New Jersey, Above Route 565)
02020007010010 = subwatershed (i.e., Wallkill River, Lake Mohawk, Above Station Park in Sparta Township)
02020007010010000 = catchment (further breakdown within a subwatershed)

Igneous - rocks transported as molten liquids followed by solidification

Impaired Waterbodies - waterbodies not fully supporting their uses; a waterbody with chronic or recurring monitored violations of the applicable numeric and / or narrative Surface Water Quality Standards

Infiltration - flow of water from the land surface into the subsurface

Invasive Plant - non-indigenous, non-native

Karst - underlain by limestone land forms; a type of topography formed in limestone, gypsum, or other soluble rocks by dissolution, and characterized by closed depressions, sinkholes, caves and underground drainage

Load Duration Curve (LDC) - a visual display of water quality impairment as a function of cumulative stream flow rate, season (spring runoff, summer base flow, winter low); LDC is based upon the hydrograph of the observed stream flows

Loam - soil material that is 7% to 27% clay particles, 28% to 50% silt particles, and less than 52% sand particles

Lower Hinge - 25th percentile (refers to the construction of box plots)

LULC - Land Use / Land Cover

Mean Value - the sum of a list of numbers, divided by the total numbers in the list

Median Value - the middle value of a list of numbers

NAAQS - National Ambient Air Quality Standards

Narrative Criteria - non-numeric, qualitative guidelines that describe a desired water quality goal

NJDEP - New Jersey Department of Environmental Protection

Nonpoint Pollution - The diffuse discharge of pollutants that can occur over extensive areas, such as fertilizers from lawns, dog waste, etc.

Old Fields - Term used in the Land Use / Land Cover Classification System (Reference Line Item 4410) that defines land cover including open spaces that have less than 25 % brush cover

Percent Slope - vertical distance divided by the horizontal distance, then multiplied by 100

pH - values less than 7 are considered acidic and values greater than 7 are considered basic; this parameter directly influences the types of plants and animals that can live in a lake or stream

Point Source Pollution - pollutant loads discharged through a discrete conveyance

Reach - a length of stream that has generally similar physical and biological characteristics

Recharge - water added to an aquifer; sometimes defined as that portion of rainfall that seeps into the ground

Runoff - the precipitation discharged into stream channels from an area

SIC Code - Standard Industrial Classification (SIC) codes are four digit numerical codes assigned by the U.S. government to business establishments to identify the primary business of the establishment

Silt - as a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter)

Sinkhole - a closed, circular or elliptical depression formed either by dissolution of the surface of underlying bedrock or by collapse of underlying caves within bedrock

Steep Slopes - generally defined as slopes greater than 20 percent

Stony - refers to a soil containing stones in numbers and sizes that interfere with or prevent tillage

Stressor - any substance or condition that adversely impacts the aquatic ecosystem

SWQS - Surface Water Quality Standards

TAC - Technical Advisory Committee

TMDL (Total Maximum Daily Load) - quantifies the assimilative (carrying capacity) of a stream or a lake; the sum of the individual wasteload allocation (for an individual pollutant) for point sources, load allocations for nonpoint sources and natural background, and a margin of safety; any pollutant loading above the TMDL results in violation of applicable water quality standards

Upper Hinge - 75th percentile (refers to the construction of Box Plots)

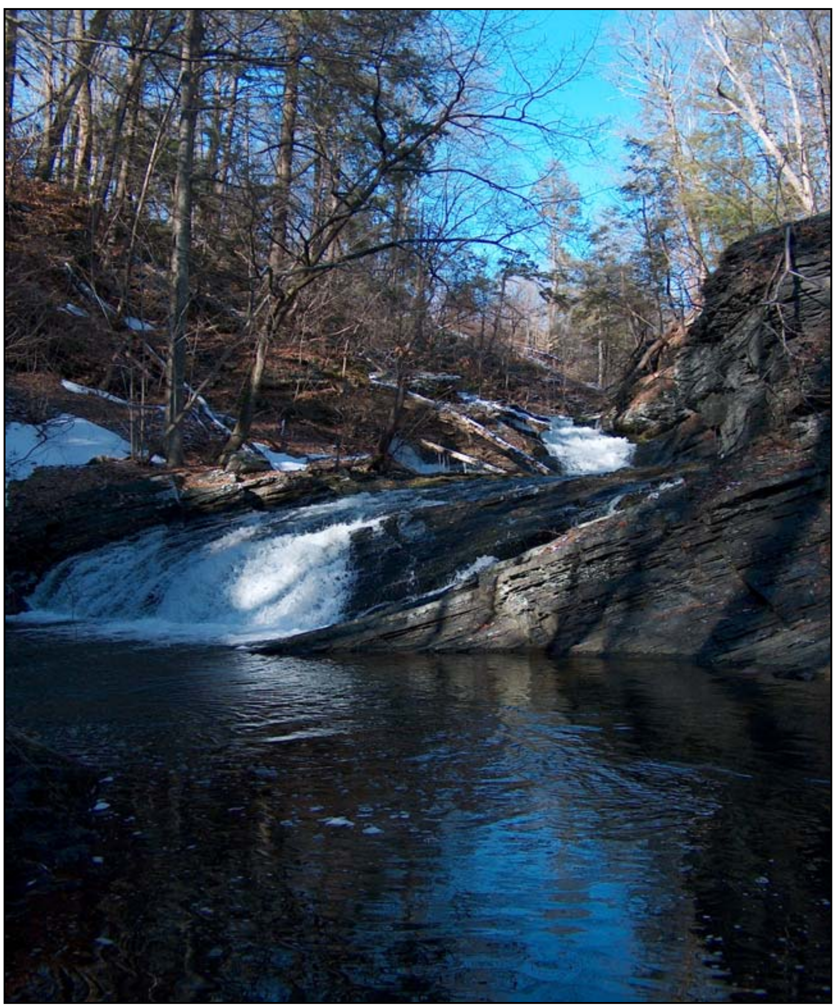
USGS - United States Geological Survey

Water Table - the surface (interface) between the zone of pure saturation (water) and the zone of pure aeration (air) underground

Watershed - a natural region defined by the land area from which precipitation drains into a particular body of water (a river or stream)

Whiskers - vertical lines that end in a horizontal stroke (refers to the construction of Box Plots)

WMA - Watershed Management Area



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APPENDIX: VOLUME I

I. Recommended Implementation Projects (Top Priority)

I - 1: Streambank Stabilization and Restoration Along the Clove Brook Near Brookside Park

I - 2: Installation of Stormwater Treatment Devices into Six Catch Basins on Lakeshore Drive, along Clove Acres Lake

I - 3: Lakeside Riparian Restoration and Stabilization along the Route 23 Border of Clove Acres Lake

I - 4: Development and / or Updating of Agricultural Conservation Plans for Active Farmland along the Clove Brook

I - 5: Establishment of the Wallkill River Watershed Management Group as a Project Management - Oriented Implementation Entity for Sussex County

I - 6: Implementation of Low-cost Riparian Buffer Projects on Agricultural Lands

I - 7: Implementation of Fencing on Agricultural Lands to Minimize Intrusion of Animals into Streams

I - 8: Implementation of Low-cost Projects to Remove Stream Debris

I - 9: Identification of Open Space Land Candidates

I - 10: Clove Acres Lake - Recommendations from Princeton Hydro, LLC Broad Range of Lake / Tributary / Lakeshed Programs

I - 11: Development of an Education and Outreach Program for the Clove Acres Lake / Clove Brook Watershed Restoration Plan

II. GIS Nonpoint Source Pollutant-Modeling by SCOGIS and the WRWMG

III. Preserved Farmland in the Clove Acres Lake / Clove Brook Watershed

IV. Preserved Open Space in the Clove Acres Lake / Clove Brook Watershed

APPENDIX: VOLUME II

PROJECT QUALITY ASSURANCE PROJECT PLANS (QAPPs)

I. SFY 2005 319(h) Grant: Watershed Restoration Plan for Clove Acres Lake and the Surrounding Lakeshed (RP05-090)
Quality Assurance Project Plan

Prepared By: Wallkill River Watershed Management Group

II. Final Quality Assurance Project Plan for Clove Acres Lake, Sussex County New Jersey
Submitted for the Proposed Scope of Work:
The Initiation of a Lake Characterization and Restoration Plan

Prepared By: Princeton Hydro, LLC

APPENDIX: VOLUME III

Characterization Study and Restoration Plan for Clove Acres Lake, Sussex County, New Jersey
September 2008

Prepared For: Wallkill River Watershed Management Group
Prepared By: Princeton Hydro, LLC

APPENDIX I - 1

Proposed d Implementation Projects for 2009 - 2012

PROJECT A:
Streambank Stabilization and Riparian Restoration along the Clove Brook near Brookside Park

Watershed Objective: Achieve surface-water quality standards through the reduction of streambank erosion, and the resultant sediment and total phosphorus loadings to lakes and surface waterways

Project Description: This quarter (1/4) mile section of the Clove Brook, which is approximately three quarters (3/4) of a mile upstream from the confluence with the Papakating Creek, is currently suffering from serve streambank erosion on both sides of the stream. The stream reach is also suffering from major woody debris and litter buildup, which is drastically impacting flow patterns, particularly during high flow periods. These altered flow patterns appear to be a major cause of the observed bank erosion, which in turn is a major source of sediment loading to the Clove Brook, and then the Papakating Creek. The WRWMG wishes to coordinate efforts to clean-up, restore, and enhance this section of the Clove Brook adjacent to Brookside Park by removing the woody debris blockage and all collected litter, stabilizing both sides of the streambanks, and planting native vegetation to improve the health of the riparian buffer. Re-use of the woody debris to be considered in the selection / design of appropriate streambank stabilization treatment techniques.

Project A, proposed for implementation in 2009 – 2010, **will be completed within 12 months at a budget of $86,400.** It accounts for the entire design phase of the project, including the development of all project details, design drawings and specifications, reconfirmation of project benefits, and a budget timeline for full implementation. Full Project Implementation can be completed within 36 months at an estimated budget of $337,400 (includes design phase costs).

Project Benefits:

- Stabilization of eroding streambank
- Reduction of sediment pollutant loading to the Clove Brook and Papakating Creek
- Reduction of flooding impacts to Brookside Park and associated athletic fields
- Decrease water temperature, increase dissolved oxygen levels within the stream reach
- Improvement of aquatic habitat and health of macroinvertebrate community
- Improvement of overall stream corridor aesthetics

Necessary Partners:

Sussex Borough
Kuperus Farmside Gardens and Florist
North Jersey Resource Conservation District
Sussex County Municipal Utilities Authority
Wantage Township
Princeton Hydro, LLC
NJDEP
WRWMG

Project Scope:

- Stabilization of stream reach just upstream from Brookside Park, Sussex Borough
- Stream Tasks: stabilize 400 linear feet on both sides of stream; address removal and reuse of stream debris (approximately 10 - 15 fallen / leaning trees; tree sizes up 2' in diameter x 30 to 35 feet long) at three sections, each section is about 75 feet apart; address two stream sediment point bars (75' x 25' and 50' x 20', contains gravel (up to 2.5" in size) and cobbles (stones) up to 7 - 8 inches in size); address streambank stabilization, riparian plantings, and buffer plantings (Bank stability currently ranges from stable to unstable)
- Other comments: height of bank varies from inches to 5 - 7 feet relative to base flow water level; visual assessment of certain bank sections is indicative of severe lateral recession, some mature trees have / will fall into stream following each major storm event, some overhanging vegetation at top of bare bank, numerous slope failures; area subject to frequent flooding; allege major contributor of sediment / total phosphorus / nitrogen loadings to the Clove Brook / Papakating Creek; there is a small holding pond parallel to the stream that drains to the stream in question; stream width varies from about 20' to 40'; stream bed substrate is a composite of sediment, silt, gravel, and cobbles
- Stream accessibility: farm field on one side (possible access point for machinery / trucks); other side is bordered by commercial operations (car dealership, small retail / light commercial building, and several forested parcels; site is also accessible from a foot path originating at Brookside Park

Work Processes:

- Field visits / site design meetings
- Visual assessment reports
- Outreach meetings to participating communities
- Partnership building
- Identification of funding sources

Estimated Funding Requirements for Designe Phase (Project A):

Initial Project Schedule / Timeline: Tweleve (12) Month Program

General Project Budget: $ 86,400

Estimated Funding Requirements (Factor approach) for Full Scale Design & Implemenetation:

Project ex contingency	$317,400	
Permitting Fees	10,000	(allowance; request waiver of NJDEP portion)
Tree(s) Cutting / Removal / Clearing / Equipment Rentals	10,000	
Total	**$337,400**	

Estimate Budget Quality: -20% to + 20%

In Kind Contributions:	**$ 4,300**
Total Project Estimate	**$341,700**

Deliverables:

- Stream bank litter clean-up
- Development of certified engineering design plans for site restoration
- Restoration, stabilization, and re-vitalization of riparian corridor for 400 feet of streambank on each side
- Restoration of natural stream flow conditions
- Coordination of a community volunteer restoration effort to assist with the project
- Educate the community about the benefits of streambank restoration projects

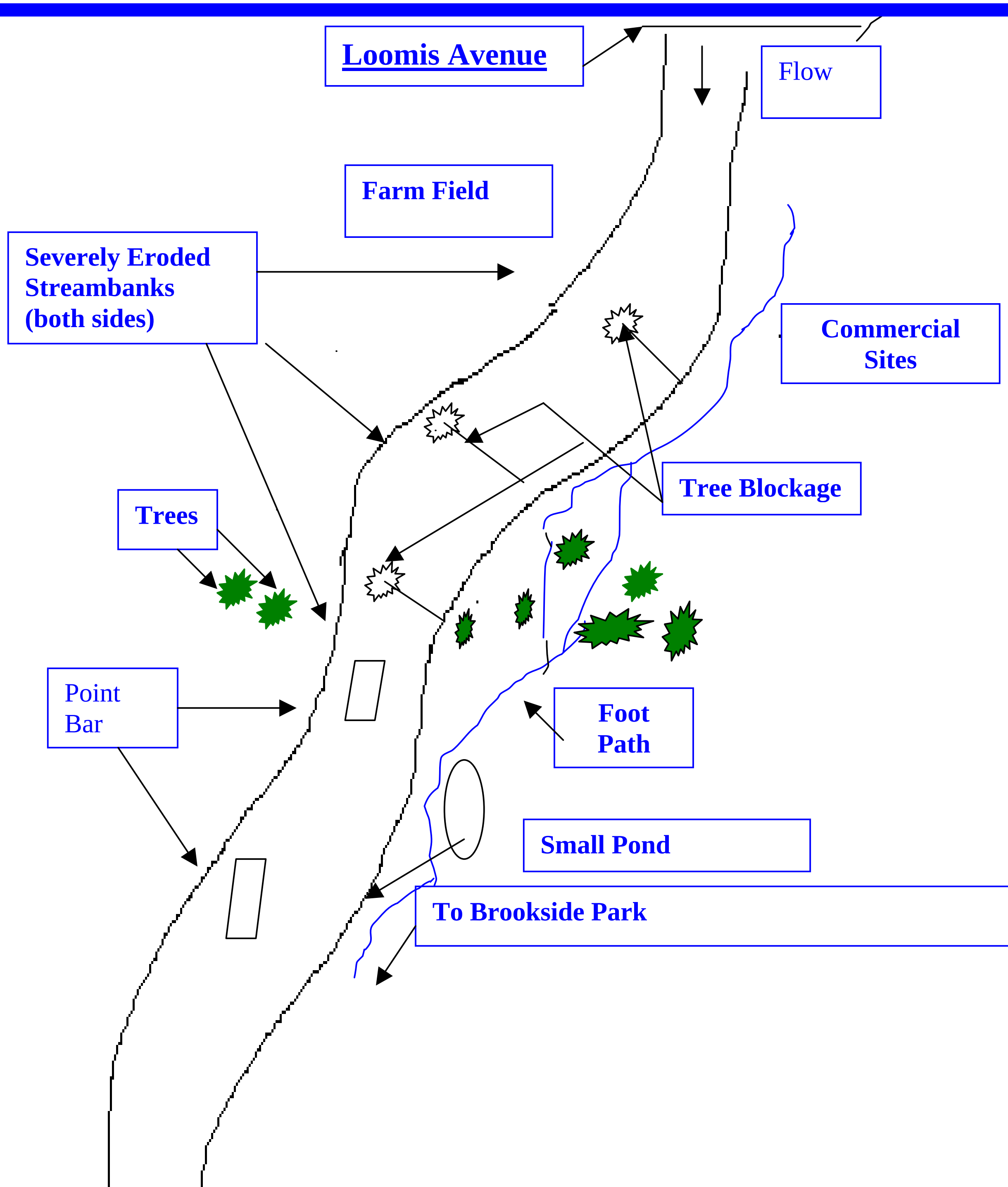
Proposed Project Design Concepts

- Site visits (conceptualize technical work scope / assess project complexity)
- Site meetings with adjacent landowners / commercial businesses / Sussex Borough (build partnerships)
- Identify technical partners (firms with proven experiences and accomplishments; i.e. Princeton Hydro, NRCS, specialized streambank stabilization firms)
- Investigate permitting regulations / requirements
- Establish project goals / benefits / constraints
- Develop implementation strategies / options for economic assessment
- Consider the following likely strategy: [1]
    1. Work with adjacent farmer to conceptualize an initial plan
    2. Princeton Hydro develops concept plan based upon the following considerations: use of debris materials to be removed (tree logs, stumps, etc. for use in streambank stabilization); select appropriate stream repair

practices (revetments, streambank shaping, live stacks, rock and/or “J” vanes, erosion control fabrics, vegetation establishments, scour protection, toe protection, and buffer plantings)

3. Conduct meetings with partners including a representative from Sussex Borough and Wantage Township
4. Develop a budget project cost for funding purposes
5. Arrange / obtain funding
6. Competitive bidding followed by contract award
7. Satisfy NJDEP, Borough, County, and other agency permitting requirements (obtain approval for waiving of NJDEP permitting fees)
8. Complete preparation of final design drawings including specifications
9. Complete balance of required tasks leading to field mobilization, construction, project management activities, project completion and acceptance , and inclusion of project as part of the Papakating Creek / Clove Brook Post-Monitoring Plan

Note 1: Based on discussions with Linda Peterson (NRCS) and Dr Steve Souza (Princeton Hydro, LLC)



Stream Stabilization Length	400'/ side	
Stream Width	20' to 40' (at point bar)	
Buffer Width (farm field side)	2 - 3 rows of trees	
Commercial Sites	Tree Buffer up to 40' - 80' wide	

Notes: Refer to attached photographs of general site conditions, stream views / observations, eroded streambanks, tree blockages (three locations), point bars, farm field, riparian buffers, etc

WALLKILL RIVER WATERSHED MANAGEMENT GROUP
Sussex County Municipal Utilities Authority

APPENDIX I – 2

Proposed Implementation Projects for 2009 - 2012

PROJECT B:

Installation of Stormwater Treatment Devices Into Six (6) Catch Basins on Lakeshore Drive With Direct Discharge to Clove Acres Lake

Watershed Objective:
Achieve surface-water quality standards through reduction of total phosphorus, sediment, and fecal coliform / *E.coli* loadings from stormwater runoff

Project Description:
Consistent with the developed Clove Acres Lake / Clove Brook Restoration Plans by the WRWMG and Princeton Hydro, LLC, **Project B**, proposed for implementation between 2009 – 2012, will provide for the installation of stormwater treatment devices into six catch basins on Lakeshore Drive with direct discharge to Clove Acres Lake. Project deliverables will include project details, design drawings and specifications, reconfirmation of project benefits, as well as a finalized budget and timeline for project implementation. **Full project design and implementation will be completed within 12 months at a budget of $41,125.**

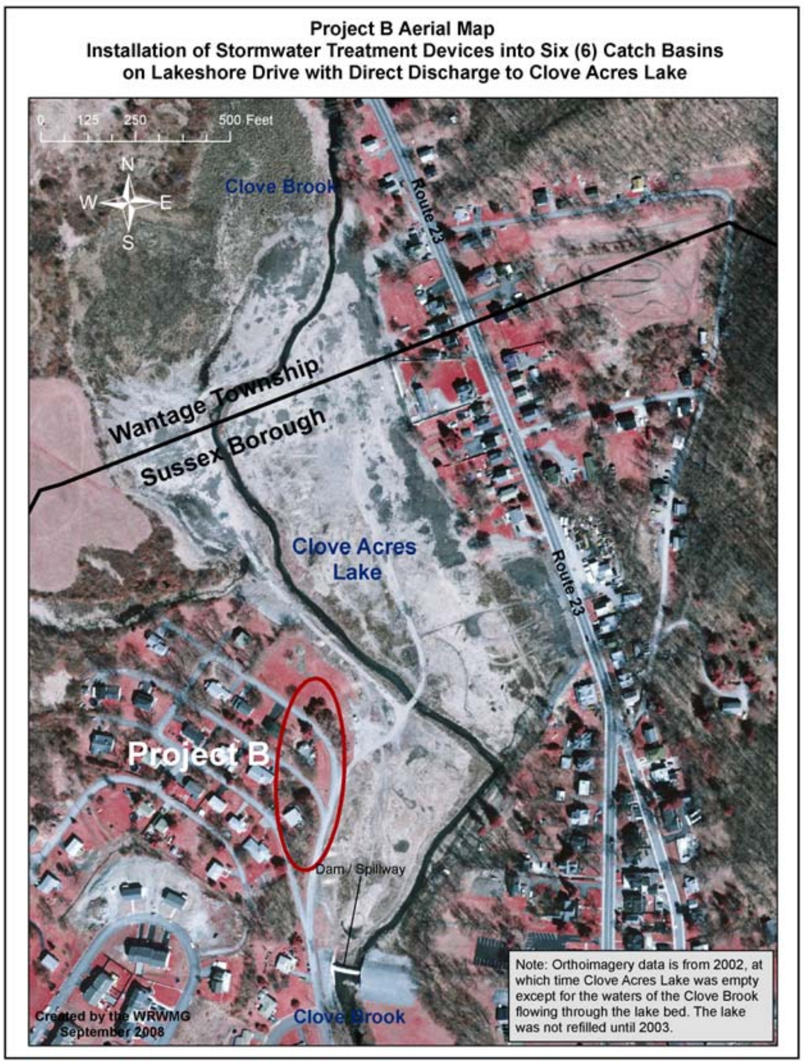
Project Benefits:
Reduction of total phosphorus, sediment, and fecal coliform / E.coli loadings via stormwater into Clove Acres Lake

Project Tasks:

Task 1: Finalize already existing arrangements / partnerships with Sussex Borough
Task 2: Engage design contractor to complete scoping / field / permitting / design efforts
Task 3: Services from Princeton Hydro, LLC.
Task 4: Consultation from Princeton Hydro, LLC to the WRWMG
Task 5: Technical, Project, and Accounting Management Services by the WRWMG

Necessary Partners:

- Sussex Borough
- Princeton Hydro, LLC
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group



APPENDIX I – 3

Proposed Implementation Projects for 2009 - 2012

PROJECT C:
Lakeside Riparian Restoration and Stabilization along the Route 23 Border of Clove Acres Lake

Watershed Objective:
Achieve surface-water quality standards through reduction of total phosphorus, sediment, and fecal coliform / *E.coli* loadings from stormwater runoff

Project Description:
Consistent with the developed Clove Acres Lake / Clove Brook Restoration Plans by the WRWMG and Princeton Hydro, LLC, an open area measured as 300 feet long by 25 feet wide located on the eastern side of Clove Acres Lake has been identified as a suitable site for a riparian restoration project. The designated project area, located within a major urban area and situated between the lake and Route 23, is known as Clove Avenue. This area receives considerable urban runoff from both commercial and residential development in the surrounding area and from high traffic flow along Route 23. Identified pollutants to the lake are stormwater overflow from Route 23, including sediment, road grit, winter deicing chemicals, nutrients, metals, etc., and lake bank erosion due to storm-driven events.

Project C, proposed for implementation between 2009 – 2012, outlines and effort to construct a riparian buffer along the identified stretch of Route 23 in Sussex Borough and to assess / prepare a design for a catch basin retrofit project. **The initial project implementation will be completed within 24 months at a budget of $143,00.** Full project implementation, which includes the installation of sediment catch basins at a future date, can be completed within 30 months at an estimated budget of $157,000 (Includes initial project implementation costs).

Project Goals:

- Improve the surface water quality of Clove Acres Lake / Clove Brook through reduction of nonpoint pollutant sources
- Mitigate the effects of Watershed imperviousness (26% in Sussex Borough; less than 3% in the rural environs)
- Instill / enhance motivation of the Watershed community to support the Clove Acres Lake / Clove Brook Restoration Plan

Project Objectives:

- Install a vegetative filter (planted riparian buffer) along 300 feet of Clove Acres Lake and Route 23(Clove Avenue) in Sussex Borough; prepare a design for a future catch basin retrofit project
- Achieve a 0.5 to 1 pound/year reduction in total phosphorus load to Clove Acres Lake plus a reduction in sediment/related urban runoff pollutants. Future installation of catch basin inserts will give additional reduction.
- Initiate a Post-Monitoring Plan

Specific Tasks:

Task 1: Finalize already existing arrangements / partnerships with Sussex Borough
Task 2: Engage design contractor to complete scoping / field / permitting / design efforts
Task 3: Design services by Princeton Hydro, LLC.
Task 4: Initiation of fieldwork
Task 5: Conduct post-monitoring / verify claimed pollutant reductions
Task 6: Closeout of project

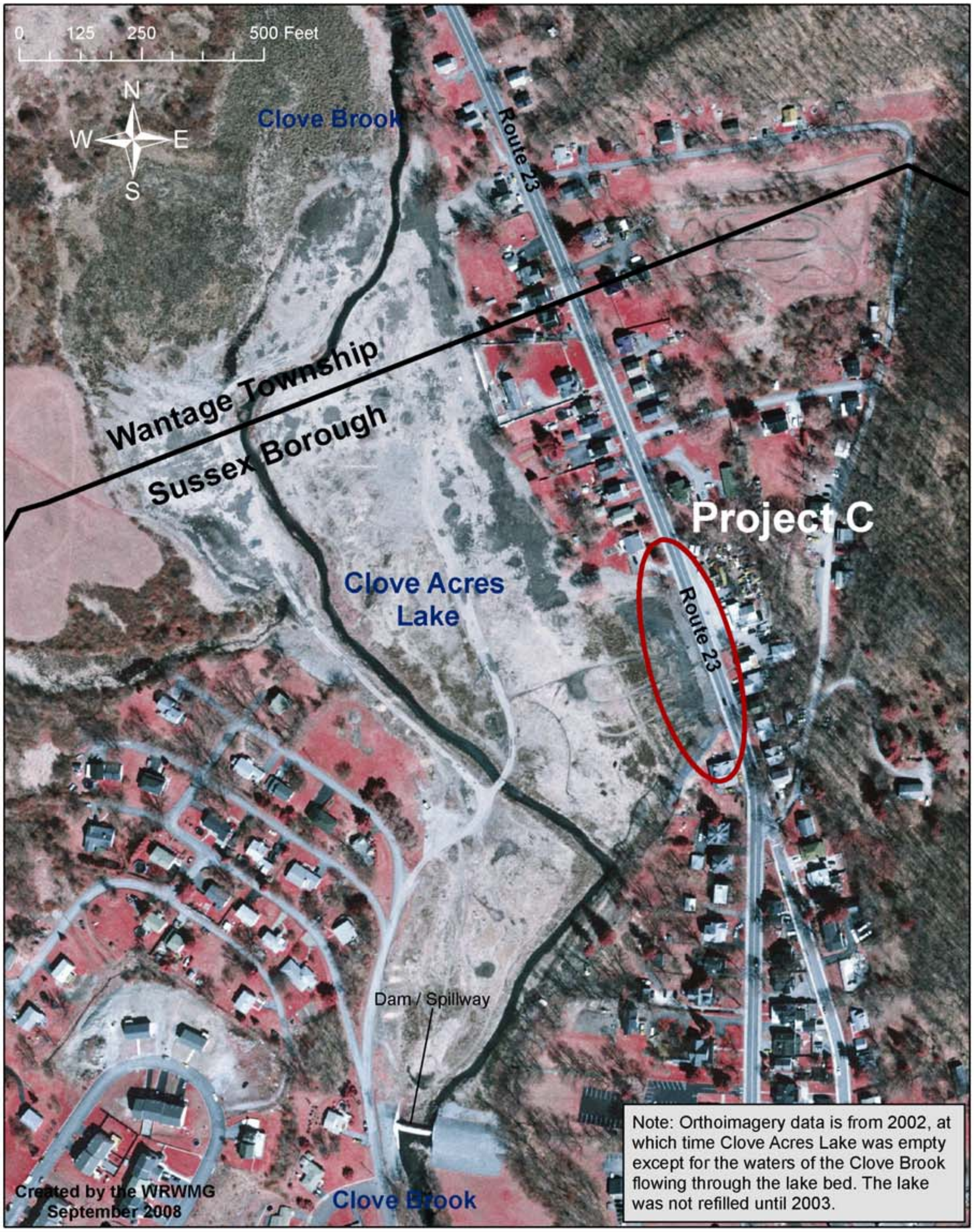
Necessary Partners:

- Sussex Borough
- Wantage Township
- New Jersey Department of Transportation
- Princeton Hydro, LLC
- Natural Resource Conservation Service
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Estimated Funding Requirements:

- Initial Project Implementation to be completed within 24 months at a budget of $143,00
- Full Project Implementation to be completed within 30 months at an estimated budget of $157,000 (Includes initial project implementation costs).

Project C Aerial Map
Lakeside Riparian Restoration and Stabilzation Along the Route 23 Border of Clove Acres Lake



APPENDIX I – 4

Proposed Implementation Projects for 2009 - 2012

<u>PROJECT D:</u>

Working with NRCS, Expedite the Development and/or Updating of Agricultural Conservation Plans for 300 Acres of Active Farmland that Straddles the Clove Brook in Wantage Township

Dairy Farm

Crop Growing

Equine Farm

<u>Watershed Objective</u>:
Achieve surface-water quality standards through reduction of total phosphorus and fecal coliform / *E.coli* loadings from agricultural operations

<u>Project Description</u>:
Field studies [54, 55] have shown that significant pollutant reductions, ranging from 5% to 40% per Best Management Practice implemented, may be achievable on operating agricultural farm sites, particularly in the case of sites adjacent to surface streams. The WRWMG proposes to work with the Natural Resource Conservation Service (NRCS), Rutgers Cooperative Research & Extension Sussex County office, Sussex County Soil Conservation District, Sussex County Agricultural Board, and the farming community to develop / upgrade Conservation Plans. Assistance will be provided to farmers regarding USDA funding sources / programs.

As part of Project D, proposed for implementation in 2009, the WRWMG will facilitate the development and/or updating of agricultural Conservation Plans by NRCS for 300 acres of active farmland that straddles the Clove Brook in Wantage Township with focus on identifying riparian restoration, manure management, and stream fencing field projects with local farm operators (deliverables to include updated Conservation Plans by NRCS, specific field implementation project work scopes, reconfirmation of project benefits, identified funding sources, and integration of potential pollutant reductions to be achieved by others into a comprehensive pollutant reduction summary balance for the entire Watershed under study). **Project D will be completed within 28 months at a budget of $62,800.**

Note: Full Project Implementation schedule and budget to be determined based upon selected management practices and projects, funding for which will be sought from external sources and funding programs.

Project Benefits:
Reduction of total phosphorus and fecal coliform / *E.coli* loadings to the Papakating Creek and Clove Brook

Specific Tasks:

- Conduct meetings with identified partners
- Conduct extensive field visits with project partners and local farmers
- Conduct extensive Education and Outreach efforts to convince farmers of the necessity for and benefits of the proposed program
- Coordinate work tasks with the updating / development of farm Conservation Plans
- With support of project partners, support local farmers in soliciting program funding
- Posting progress reports on the WRWMG website
- Initiation of a modest and conservative farmer Watershed Stewardship recognition

Necessary Partners:

- Local farm community
- Natural Resource Conservation Service
- Rutgers Cooperative Research & Extension Sussex County Office
- USDA funding sources / programs / contacts
- Sussex County Soil Conservation District
- Sussex County Board of Agriculture
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Estimated Funding Requirements:

- Project to be completed within 28 months at a budget of $62,800
- Full Project Implementation schedule and budget to be determined based upon selected management practices and projects, funding for which will be sought from external sources and funding programs

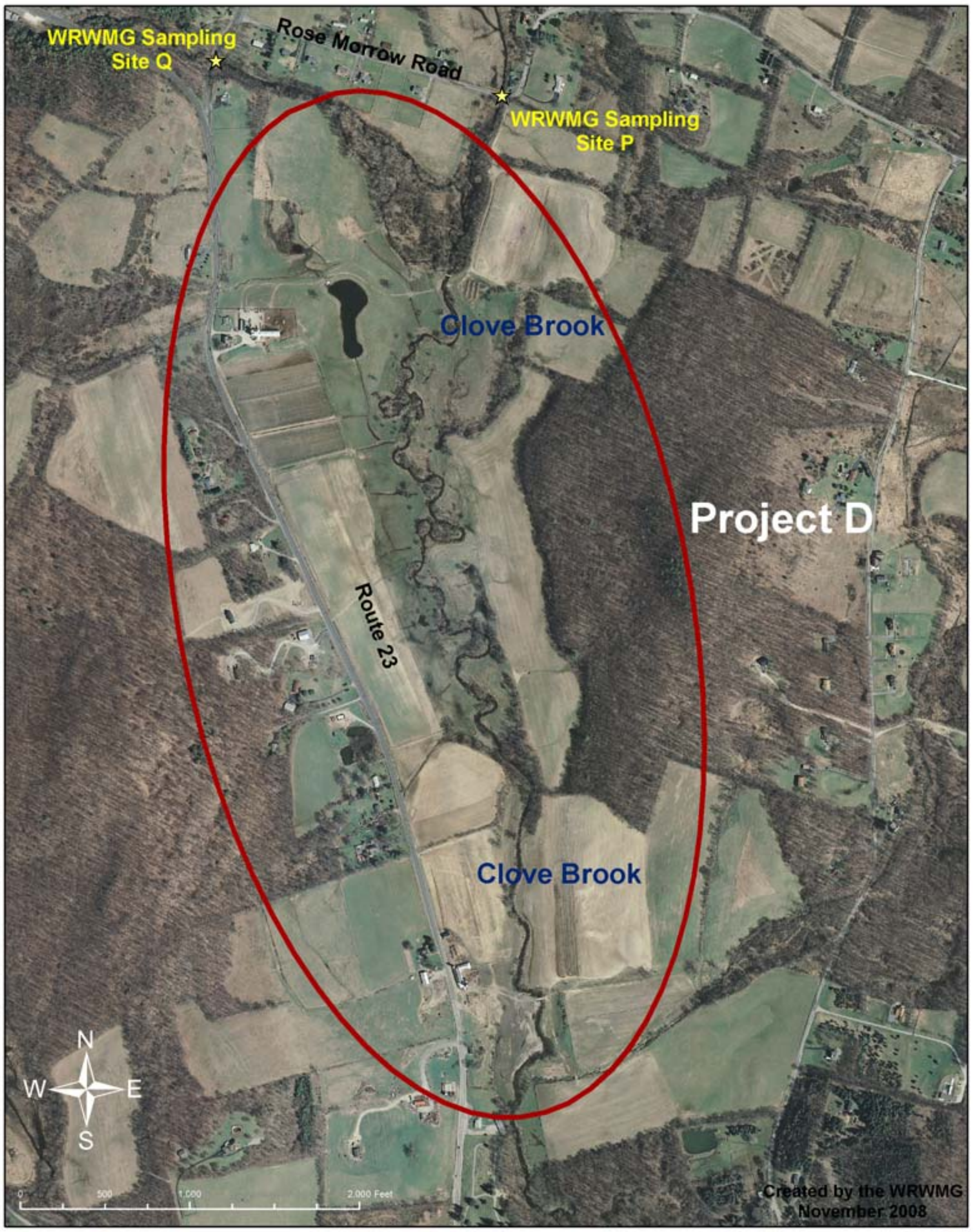
Work Processes:

- Team Building
- Application of Best Management Practices (Conservation Plans; refer to attached generic blank form)
- Field / farmer visits
- Value analysis approaches to show relationship of Watershed stewardship to value to individual farmers
- Concept Plans
- Education & Outreach to the farming community (the most important key task if the program is to be a success)

Deliverables:

- Approximately 15 new / updated Conservation Plans
- Identification of applicable farm sites / implementation projects
- Concept plans (to be developed by project partners)
- Assistance in supporting farmers with funding source applications
- Inclusion of implemented projects within the Restoration Plan Post-Monitoring Plan
- Progress reports to be posted on the WRWMG's Watershed Stewardship website

Project D Aerial Map:
Approximatley 300 Acres of Active Agricultural Lands that Staddle the Clove Brook in Wantage Township

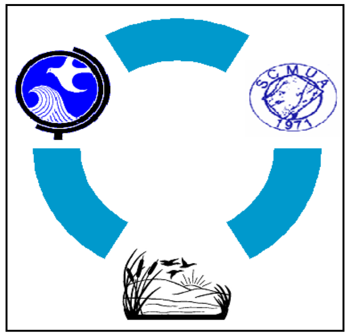


APPENDIX I – 5

Proposed Implementation Projects for 2009 - 2012

<u>PROJECT E:</u>
Establishment of the Wallkill River Watershed Management Group as a Watershed-wide Restoration Plan Implementation Entity

MUNICIPALITIES



WATERSHED STAKEHOLDERS

<u>**Watershed Objective**</u>**:** Achieve surface-water quality standards through a coordinated project leadership approach for the identification / implementation of projects leading to the reduction of total phosphorus and fecal coliform / *E.coli* loadings to surface waterways and lakes.

<u>**Project Description:**</u> The Wallkill River Watershed Management Group (WRWMG) has become known, not only throughout the Wallkill River Watershed but also, throughout all of Sussex County as the primary local resource for area stakeholders in matters relating to water quality and water resource management. **Project E** proposes to establish the WRWMG as a project management-oriented entity to not only manage the identified implementation projects being executed by the WRWMG but also to provide coordination, technical guidance, and an integration role addressing the necessary and critical Watershed project implementation efforts required by WRWMG's partners and Watershed community members. The technical guidance to be provided by the WRWMG will cover a broad range of topics (e.g., pollutant source tracking, water resource protection, development of implementation projects, pollutant transport paths, post-monitoring of initiatives undertaken by both the WRWMG through funded grants, as well as community organizations and municipalities to show demonstratable watershed –wide improvement.

These services are not available from any other organizations within Sussex County and the actions proposed for the WRWMG are in congruence with the resource protection goals of the NJDEP as well as the recently promulgated Program Activity Measures (PAMs) established by the U.S. Environmental Protection Agency (EPA). Formally recognizing the WRWMG as a watershed Restoration Plan implementation entity and providing additional funding resources to the WRWMG to allow for the coordination of an initial implementation phase, will ensure that existing momentum is not lost during the inevitable time gap from plan completion, Department review & approval, and the selection of specific projects for funding.

Project Benefits:

- Serve as a resource for the New Jersey Department of Environmental Protection (NJDEP), Division of Watershed Management (DWM) in implementing projects to attain both TMDL ands water quality goals in the Wallkill River Watershed.

- Extend the current reach of the WRWMG by providing means for the continuation of Watershed surface water quality impairment analysis, "on the ground" Watershed restoration and planning, with prime focus on the NJDEP-approved Papakating Creek and Clove Acres Lake/Clove Brook Watershed Restoration and Protection Plans

- Serve as the liaison between the Department and the general public of Sussex County, allowing for the Department to hear and address the concerns of the stakeholders within the county to a much more intimate degree than would normally be afforded a state agency.

Project Objectives:

- Serve as a communication liaison to the various Watershed entities regarding Restoration Plan implementation opportunities, changing applicable NJDEP Rules, Regulations and Standards, and identification of new implementation projects

- Presentations at county, municipal, and public committee meetings (minimum of 15 presentations)

- Coordination of activities with USDA-NRCS, NJRC&D, USGS, NJGS, Rutgers Cooperative Extension, County Agricultural Board and individual farmers regarding new / revised Conservation Plans / implementation plans

- Initiate conceptual / basic design of water quality structural and nonstructural BMP's

- Conduct literature searches addressing pollutant load reductions for specific BMP's and discussions with research / engineering organizations working in the field

Project Tasks:

1. Work with local stakeholders, county and municipal representatives to design and implement water quality and stormwater structural / nonstructural BMP's to attain water quality goals.

2. Provide oversight and documentation for each BMP selected for implementation and coordinate with the DWM project manager to discuss permit requirements and Land Use Regulation Review for structural / nonstructural measures prior to the award of project funding.

3. Provide report-outs on literature searches that show scientifically proven load reductions for specific BMP's, particularly from nonstructural measures.

4. Work with partners such as USDA - NRCS, Rutgers Cooperative Extension, NJRC&D, USGS, NJGS, and the Sussex County Board of Agriculture to maintain existing working partnerships as well as build new working partnerships with individual farmers and facilitate the review / revision / development of agricultural Conservation Plans to address water quality concerns and impairments.

5. Identification of funding sources that contribute to water quality improvement

6. Assess, evaluate, and recommend open space land candidates for purchase by Federal, State, and County government agencies, municipalities, and various Land Trust organizations

7. Serve as a communication liaison between the local Sussex County residents and officials and the NJDEP DWM on such issues as Category One stream classifications, Flood Hazard Control Act regulations, stormwater policies, existing and future TMDL's, existing and future Integrated Lists / Reports, and Surface Water Quality

Necessary Partners:

1. New Jersey Department of Environmental Protection
2. Sussex County Municipal Utilities Authority
3. Wallkill River Watershed Management Group
4. Sussex County Board of Chosen Freeholders
5. Sussex County Department of Planning
6. Sussex County 208 Water Quality Public Advisory Committee

Estimated Funding Requirements:

Project Schedule / Timeline: Forty (40) Months

General Project Budget: $ 80,000

Note: Includes In-Kind Contribution of $6,500

APPENDIX I - 6

Recommended Implementation Project Within the 0-3 years

Implementation of Low Cost Riparian Buffer Projects on Agricultural Lands

Clove Brook @ Route 23

Papakating Creek @ Route 565 (Looking Downstream)

Watershed Objective:

Achieve surface-water quality standards through the identification / implementation of riparian buffer restoration projects on agricultural lands leading to the reduction of total phosphorus and fecal coliform / *E.coli* loadings to lakes and surface waterways

Project Description:

Several agricultural areas within the watershed have been identified as desirable sites for riparian buffer restoration projects. These locations are currently lacking a viable riparian buffer and as a result are a potential location for pollutant loading to the stream, particularly during major storm events. The WRWMG proposes to work with the Natural Resource Conservation Service, Rutgers Cooperative Research & Extension Sussex County Office, Sussex County Soil Conservation District, Sussex County Agricultural Board, and the farming community to identify farmers who are willing to explore implementing a riparian restoration project on their particular farm. The WRWMG will work to identify and secure funding sources, build partnerships to provide site design, and coordinate overall efforts to implement the projects.

Project Benefits:

- Stabilization of eroding streambanks
- Reduction of fecal coliform / *E.coli* loadings to lakes and surface waterways
- Reduction of sediment pollutant loading to lakes and surface waterways
- Reduction of flooding impacts to streamside fields and properties

- Improvement of riparian corridor health
- Decrease water temperature, increase dissolved oxygen levels in stream reaches
- Improvement of aquatic habitat and health of macroinvertebrate community
- Improvement of overall stream corridor aesthetics

Specific Tasks:

- Conduct meetings with identified partners
- Conduct extensive field visits with project partners and local farmers
- Conduct extensive Education and Outreach efforts to convince farmers of the necessity for and benefits of the proposed projects
- Initiation of a modest and conservative farmer Watershed Stewardship Recognition Program
- Development of implementable riparian buffer site designs

Necessary Partners:

- Local farm community
- Natural Resource Conservation Service
- Rutgers Cooperative Research & Extension Sussex County Office
- USDA funding sources / programs / contacts
- Sussex County Soil Conservation District
- Sussex County Board of Agriculture
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Work Processes:

- Team Building
- Field / farmer visits
- Value analysis approaches to show relationship of Watershed stewardship to value to individual farmers
- Concept Plans
- Education & Outreach to the farming community (the most important key task if the program is to be a success)

Deliverables:

- Identification of applicable farm sites / implementation projects
- Assistance in supporting farmers with funding source applications
- Restoration, stabilization, and re-vitalization of riparian corridor for identified streambank locations
- Educate the community about the benefits of streambank restoration projects

APPENDIX I - 7

Recommended Implementation Project Within 0-3 years

Implementation of Fencing on Agricultural Lands to Minimize Intrusion of Animals into Streams

Potential Candidate Sites:

Papakating Creek at Route 565
WRWMG Sampling Site "K"

Clove Brook at Route 23

Watershed Objective:

Achieve surface-water quality standards through reduction of total phosphorus and fecal coliform / *E.coli* loadings from intrusion of farm animals into adjacent farm streams

Project Description:

Field studies [54, 55] have shown that significant reductions in pollutants in the direct deposition of fecal phosphorus, approaching 32%, were effected through pasture management and streambank fencing. Fencing is a relatively low cost Best Management Practice to implement and results in a rapid and significant pollution reduction opportunity. Suitable farm sites in addition to the above two sites are to be identified. Work to be coordinated with the Natural Resource Conservation Service, Rutgers Cooperative Research & Extension Sussex County Office, and USDA funding sources / programs.

Project Benefits:

Reduction of total phosphorus and fecal coliform / *E.coli* pollutant loadings to the Papakating Creek and Clove Brook

Specific Tasks:

- Conduct meetings with identified partners
- Coordinate work tasks with updating / development of farm Conservation Plans
- Develop concept field plans
- Support local farmers in soliciting program funding

Necessary Partners:

- Natural Resource Conservation Service
- Rutgers Cooperative Research & Extension of Sussex County
- USDA funding sources / programs
- Individual farm partners
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Estimated Funding Requirements:

Included within the estimate developed for establishing the WRWMG as a Watershed entity for the implementation of the Papakating Creek and Clove Brook Restoration Plans (Project E)

Work Processes:

- Team Building
- Application of Best Management Practices (Conservation Plans)
- Field / Farmer Visits
- Concept Plans
- Outreach support to farmers
- Education and Outreach

Deliverables:

- Identification of applicable farm sites
- Concept plans
- Assistance in supporting farmers with funding source applications
- Inclusion of implemented projects within the Papakating Creek Post-Monitoring Plan

WALLKILL RIVER WATERSHED MANAGEMENT GROUP
Sussex County Municipal Utilities Authority

APPENDIX I - 8

Recommended Implementation Project Within 0-3 years

Implementation of Low-Cost Projects to Remove Stream Debris

(Related to Minimization of Streambank Erosion and Reduction of Flooding Intensity)

Potential Candidate Sites:

Clove Brook in Wantage Township

Clove Brook in Sussex Borough

<u>Watershed Objective</u>:

Achieve surface-water quality standards through the removal of woody stream debris at locations throughout the watershed which alter stream flow patterns, exacerbate stream flooding, and increase rates of reduction of streambank erosion, which results in sediment and total phosphorus loadings to lakes and surface waterways. The WRWMG is well aware that woody debris in surface streams (sometimes referred to as a logjam) has both beneficial as well as detrimental impacts. Suitable sites for debris removal will only be selected where flooding is severely impacted as evidence by streambank erosion, land/property damage, and interference with recreational uses of the stream.

<u>Project Description</u>:

Numerous stream reaches throughout the Papakating Creek and Clove Brook Watershed suffer from stream debris conditions as depicted in the photographs above. These debris dams serve to clog normal stream flow patterns, cause litter buildup, and drastically impacting flow patterns, particularly during high flow periods. These altered flow patterns are then a major cause of the streambank erosion, which in turn is a source of sediment loading to the impacted surface waterways. The WRWMG wishes to coordinate efforts to clean-up stream reaches such as these by removing the woody debris dams and all collected litter and return flow patterns to a more normal state. Removed debris materials will be considered for reuse for proposed streambank stabilization projects either at the site of debris removal and/or at nearby sites.

Project Benefits:

- Reduction of streambank erosion
- Reduction of sediment pollutant loading to the watershed surface waters
- Reduction of flooding impacts to adjacent properties
- Increase dissolved oxygen levels in stream reaches
- Improvement of aquatic habitat and health of macroinvertebrate community
- Improvement of overall stream corridor aesthetics

Necessary Partners:

- Municipal Public Works Departments
- Watershed Volunteers
- North Jersey Resource Conservation District
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Estimated Funding Requirements:

These projects are intended to be low cost, volunteer driven efforts, aided by in-kind services from local municipal public works departments, and site location property owners.

Work Processes:

- Field visits
- Visual assessment reports
- Outreach meetings to participating communities
- Partnership building

Deliverables:

- Stream bank litter clean-up
- Restoration of natural stream flow conditions
- Coordination of a community volunteer efforts to assist with the projects
- Educate the community about the benefits of streambank restoration projects

WALLKILL RIVER WATERSHED MANAGEMENT GROUP
Sussex County Municipal Utilities Authority

APPENDIX I – 9

Recommended Implementation Project Within 0-3 years

Identification of Open Space Land Candidates for Potential Preservation Within the Papakating Creek and Clove Brook Watershed

<u>Watershed Objective</u>:

Achieve and / or maintain surface-water quality standards through the protection of open space lands high with water resource value, healthy riparian corridors, or recreational opportunities, or that offer a location for the implementation of an identified non-point source pollutant reduction strategy or best management practice.

<u>Project Description</u>:

The WRWMG will develop and facilitate an identification, assessment, and recommendation process for open space land candidates for purchase by Federal, State, and County government agencies, municipalities, and various Land Trust organizations.

<u>Project Benefits</u>:

The WRWMG is not and does not have the capabilities to be a land acquisition organization. However, the WRWMG has an extensive knowledge of the Papakating Creek Watershed lands as a result of the detailed, parcel by parcel, HUC investigations. This knowledge could be offered to Federal, State, and County government agencies, municipalities, and various Land Trust organizations so that more informed decisions can be made when it comes to selecting parcels for open space preservation.

Necessary Partners:

- Sussex County Open Space Committee
- Municipal Open Space Committees
- Non-profit Land Preservation Organizations (i.e. Natural Lands Trust, Nature Conservancy, etc.)
- Wallkill River National Wildlife Refuge
- New Jersey Department of Environmental Protection
- Sussex County Municipal Utilities Authority
- Wallkill River Watershed Management Group

Estimated Funding Requirements:

Included within the estimate developed for establishing the WRWMG as a Watershed entity for the implementation of the Papakating Creek and Clove Brook Restoration Plans (Project E)

Specific Tasks:

- Field visits / site meetings
- Continued visual assessments / parcel investigations
- GIS mapping / aerial photography review
- Partnership building
- Identification of funding sources
- Facilitate contact / dialogue with non-profit land acquisitions organizations

Deliverables:

- Development of and maintenance of a recommendation list of open space candidates for distribution to Federal, State, and County government agencies, municipalities, and various Land Trust organizations.
- Continuous field investigations to maintain awareness of watershed lands / parcels that enter the real estate market and that could be potential open space candidates
- Work with the U.S. Fish and Wildlife Service, and specifically the Wallkill River National Wildlife Refuge to promote and help encourage the implementation of the Refuge Comprehensive Conservation Plan which includes a proposed expansion of the current refuge boundary to include areas designated along the Papakating Creek corridor. The WRWMG's involvement is based on the assumption that all additional lands will be procured only from willing sellers.

WALLKILL RIVER WATERSHED MANAGEMENT GROUP
Sussex County Municipal Utilities Authority

APPENDIX I - 10

Recommended Implementation Project: 0-3 years

Clove Acres Lake - Recommendations from Princeton Hydro, LLC
Broad Range of Lake / Tributary / Lakeshed / Watershed Programs

Clove Acres Lake - 1988 to 2002

Clove Acres Lake - 2008

<u>Watershed Objective</u>:

Development of a Lake Management Plan that addresses reduction of total phosphorus loadings to and from the lake as well as enhancement of the lake's recreational value. Assist program development, identification of Best Management Practices and in-lake treatment techniques, task prioritization, and the identification of funding sources for implementation of pollutant-reduction projects. The goal of all tasks is the achievement of applicable NJDEP Surface Water Quality Standards (SWQS) and targeted total phosphorus lake and surface water concentrations as established in the applicable NJDEP TP TMDL.

<u>Project Description</u>:

Implementation projects proposed by Princeton Hydro, LLC:

Watershed-based nonpoint reduction measures for nutrient control and management

Examples:

- BMPs (Agricultural, Residential, and Urban)
- Streambank Stabilization (Agricultural, Residential, and Urban Lands)
- Stormwater Conveyance Systems / Manufactured Treatment Devices / MS4 Plans
- Nonstructural BMPs
- Homeowner Practices (e.g., Lawn / Garden Fertilization Management)
- Riparian Buffers
- Additional Watershed Investigations (e.g., failing septics, drainage)
- Canada Geese Control
- Public Education

In-lake Control Projects

Examples:

- Eradication of Eurasian watermilfoil using a contact systemic herbicide such as Sonar^R
- Biomanipulation as an approach to restructure the aquatic food web to favor the growth of non-scum-forming algae and minimize undesirable blue-green algae
- Management of the lake as a largemouth bass fishery for enhancement of the lake's recreational fishery value
- Initiate a consistent / long-term lake water-quality monitoring program

<u>Project Benefits</u>:

- Reduction of total phosphorus to and within Clove Acres Lake and, hence, to the Clove Brook prior to the confluence of the Clove Brook with the Papakating Creek
- Achievement of targeted in-lake total phosphorus levels
- Achievement of Clove Acres Lake / Lakeshed / Clove Brook Watershed targeted total phosphorus reduction goals

<u>Specific Tasks</u>:

- Conduct meetings with identified partners
- Coordinate work tasks with the development of a Lake Management Plan
- Develop concept field plans including budget estimates
- Support the Township and local community members in soliciting program funding

Necessary Partners:

- Clove Acres Lake - residents and local community groups
- Sussex Borough and Wantage Township
- Princeton Hydro, LLC
- Municipal / County departments regarding road / stormwater drainage issues
- County Health Department (beach monitoring)
- NRCS (riparian buffer plantings)
- Wallkill River Watershed Management Group
- Sussex County Municipal Utilities Authority
- New Jersey Department of Environmental Protection

Estimated Funding Requirements:

- See Projects B and C of the Restoration Plan
- Funding for remaining initiatives to be developed by the WRWMG in the next conceptual phase of work

Work Processes:

- Team Building
- Application of Best Management Practices for lakes and surface streams
- Field Visits
- Concept Plans
- Outreach support to lake residents and local community groups
- Support regarding development / identification of funding sources / applications
- Lake management Education and Outreach efforts

Deliverables:

- Quantification of benefits of pollutant-reduction projects
- Assistance in the development of a Lake Management Plan
- Support to Clove Acres lake residents regarding work tasks to be assigned to their lake / water testing / water-treatment consultants, and Township DPW forces
- Concept plans and budget estimates
- Assistance in supporting funding-source applications
- Inclusion of implemented projects within the Papakating Creek / Clove Brook Post-Monitoring Plans

Reference Documents: Clove Acres Lake / Watershed Report Sections from Christopher Mikolajczyk and Dr. Fred Lubnow of Princeton Hydro, LLC (draft sections dated from June to early August 2008; final Report to be released within the next several weeks)

APPENDIX I – 11

Recommended Implementation Project Within the 0-3 years

Development of an Education and Outreach Program for the Clove Acres Lake / Clove Brook Watershed Restoration Plan

Watershed Objective:

The ongoing mission of the Wallkill River Watershed Management Group (WRWMG) has always been to raise awareness about the Wallkill River Watershed and generate stakeholder participation in various watershed management initiatives to maintain, restore, and enhance the watershed. From the onset, the key to successfully accomplishing this mission is developing and maintaining an aggressive education and outreach campaign.

Project Description:

It has long since been the stance of the WRWMG that the way to get stakeholders to develop a sense of commitment to the Watershed and a desire to be involved in the efforts to protect it, is to make sure they are continuously aware of the ongoing project efforts and allow them to develop a sound understanding of how they can participate. As part of implementing the Watershed Restoration Plan for the Clove Acres Lake / Clove Brook Watershed, the WRWMG will aggressively reach out to and maintain communications with the county officials, the municipalities and the public stakeholders who are a part of this project area to:

- Share collected water quality data and other pertinent project information
- Solicit input and feedback
- Provide Plan development updates
- Encourage active participation in future implementation efforts

Project Benefits:

Once the Restoration Plan is formally approved by NJDEP, the next step is to begin the design and implementation of the recommended restoration strategies, initiatives, and projects. As part of this process, there exists a need to bridge the gap between restoration planning and implementation funding cycles, maintain already established momentum, and initiate initial design and implementation of approved restoration initiatives and strategies. The education and outreach program will help to raise awareness about the completed Plan, generate active participation to help implement it, and ultimately generate stakeholder buy-in and belief in its overall value.

Specific Tasks:

The following is an outline for an Education and Outreach Program specific to the Clove Acres Lake / Clove Brook Watershed Restoration Plan, geared to obtain stakeholder buy-in.

Task 1: Raise awareness about the approved Restoration Plan and distribute throughout the Clove Acres Lake / Clove Brook Watershed

- Provide summary presentations and distribute copies of Plan at public meetings (County 208 Water Quality PAC, municipal committees, County Board of Agriculture, etc.)
- Issue press announcements to local papers about the Plan and provide information on how to obtain a copy
- Generate informational handouts / posters for distribution at various public locations (county and township buildings, SCMUA, Wallkill River National Wildlife Refuge, public kiosks, etc.)
- Post Plan on the WRWMG website

Task 2: Develop, Initiate, Promote hands-on outreach campaigns and projects to share / spread educational information for key topics

- Septic management
- Manure management
- Stormwater management
- Winter road maintenance
- Lake management
- Available public recreational uses within the Watershed

Task 3: **Build a GIS Internet Mapping Service Website designed to track the implementation progress of the Restoration Plan**

- Water quality data
- Stream restoration sites
- Watershed clean-up sites
- Stream debris removal sites
- Stream flooding locations
- Public Recreation Loctions
- Open Space Properties

Task 4: **Plan / institute a long - term sustainability plan for the continued coordination, implementation, and maintenance of the initiatives, projects, and strategies contained within the Restoration Plan**

- Linkage of the Education and Outreach and Post-Monitoring Plans
- Initiation of a stakeholder recognition program
- Documentation and publication of pollutant reduction project successes achieved both internally and externally by other Watershed Implementation Plan sponsors
- Provide a communication channel between watershed stakeholders and NJDEP, educational institutions, and manufacturing companies in applicable areas relating to non-point pollutant(s) reduction techniques
- Address approaches / considerations that target maintaining the economic viability of the agricultural community within the watershed.

Task 5: **Explore innovative and ongoing outreach programs to generate stakeholder interest in the Clove Acres Lake / Clove Brook Watershed and encourage general watershed stewardship**

- Seasonal watershed clean-ups program
- Stream identification signs
- Volunteer restoration projects
- Farm tours to promote ongoing water quality activities / practices
- Auto Tour Guides
- Storm drain stenciling
- Sponsor canoe / kayak trips

<u>Deliverable:</u>

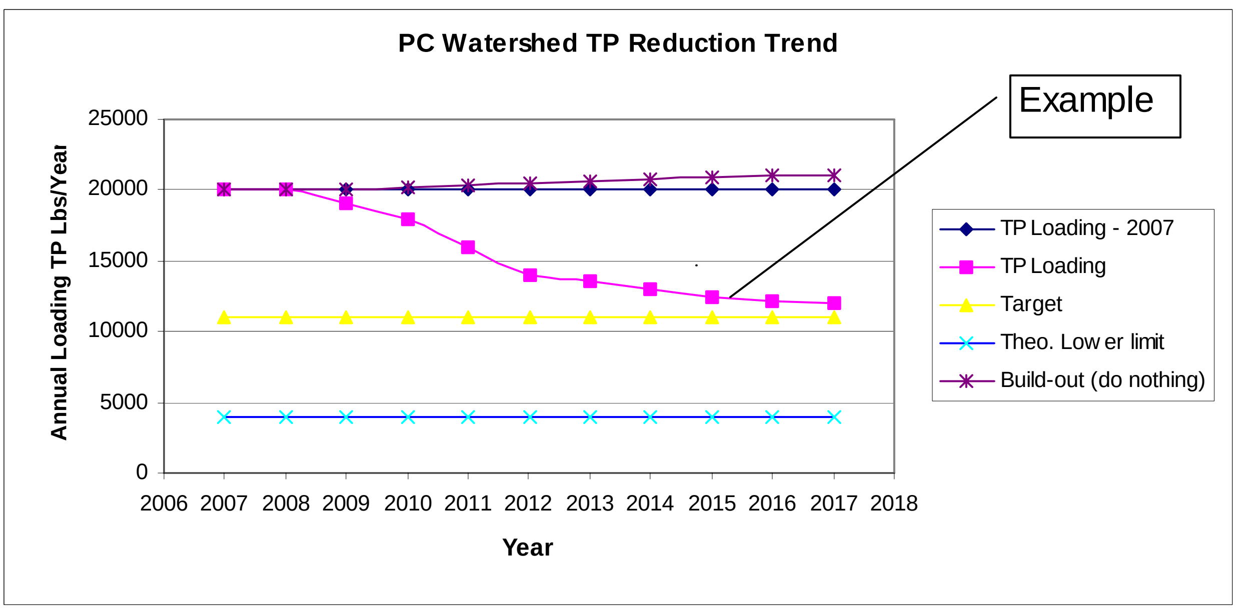
- An outreach campaign that will help facilitate and sponsor the long-term successful implementation of the Watershed Restoration Plan, and obtain the necessary water quality improvements.

Appendix II

Non-Point Source Pollutant GIS Modeling in the Papakating Creek Watershed

Sussex County, New Jersey

As part of the Wallkill River Watershed's Management Groups (WRWMG) efforts to develop Watershed Restoration Plans for both the Papakating Creek and Clove Acres Lake Watersheds, the WRWMG partnered with the Sussex County Office of GIS to develop a GIS-based methodology / model for estimating annual surface water pollutant loads using ESRI's Model Builder and GIS data and tables such as: HUC14 Watersheds, 2002 Land Use / Land Cover (LU/LC), Developable lands from the Sussex County Strategic Growth Plan, Best Management Practice (BMP) loading coefficients, parcel data, and current municipal zoning. The developed methodology can be used for technical calculations addressing the quantification of annual total phosphorus, nitrogen, and sediment loads for a watershed under present, future (100% build-out), future (following implementation projects), and natural state conditions for a single or multiple HUC 14 sub-watershed level within the State of New Jersey. The methodology can also to be used for sensitivity studies typically undertaken to establish theoretical lower limit annual pollutant loads, reality testing of established reduction goals, tracking annual pollutant reductions as a result of completing implementation projects, quantifying future pollutant load contributions from new development projects, assessment of alternative loading coefficients, etc. Charting of results using programs such as Microsoft Excel can then be used to visually display the data for trending analysis.

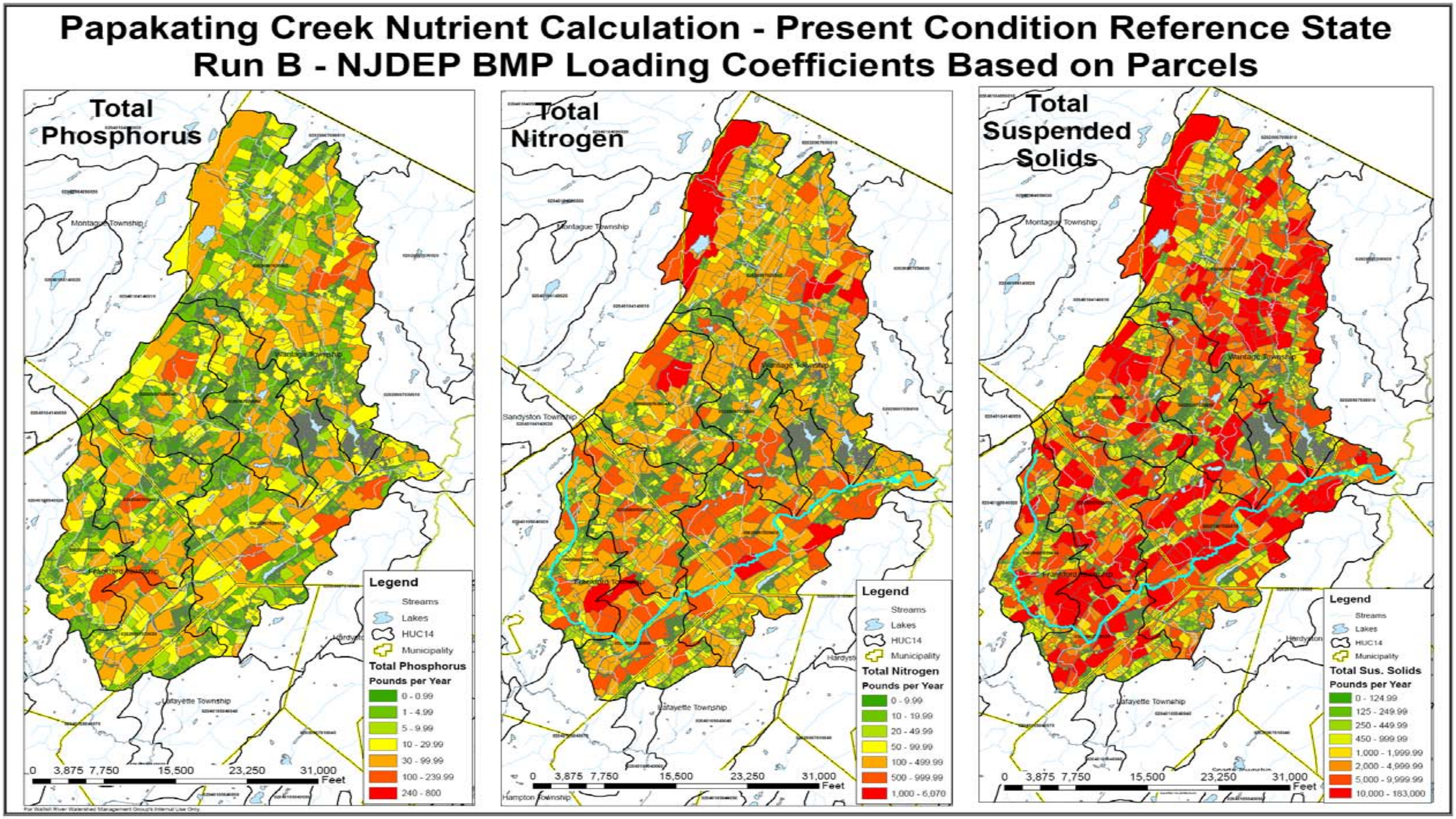


PROJECT TEAM

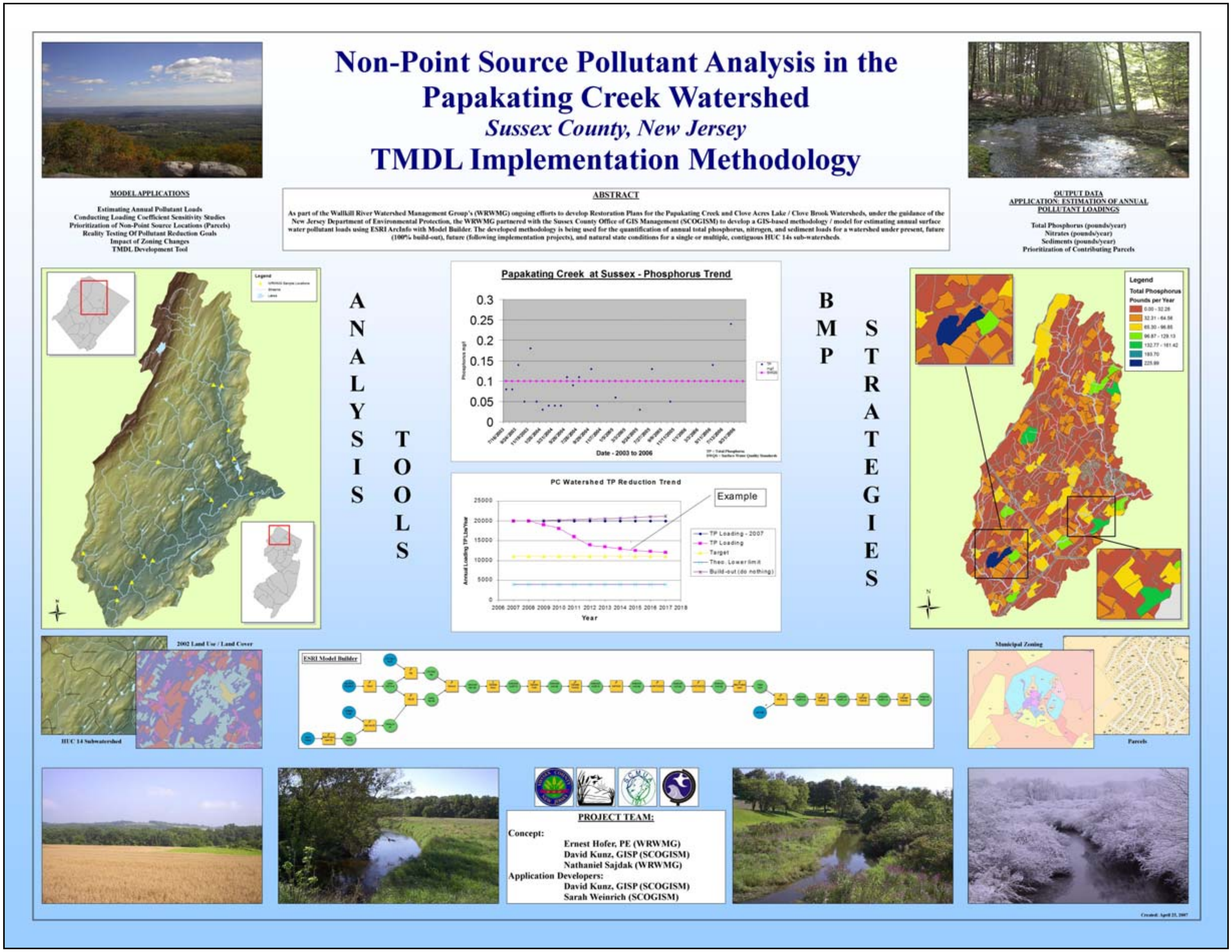
Concept Developers:
Ernest Hofer, PE (WRWMG)
David Kunz, GISP (SCOGISM)
Nathaniel Sajdak (WRWMG)

Application Developers:
David Kunz (SCOGISM)
Sarah Weinrich (SCOGISM)

Appendix II - Continued

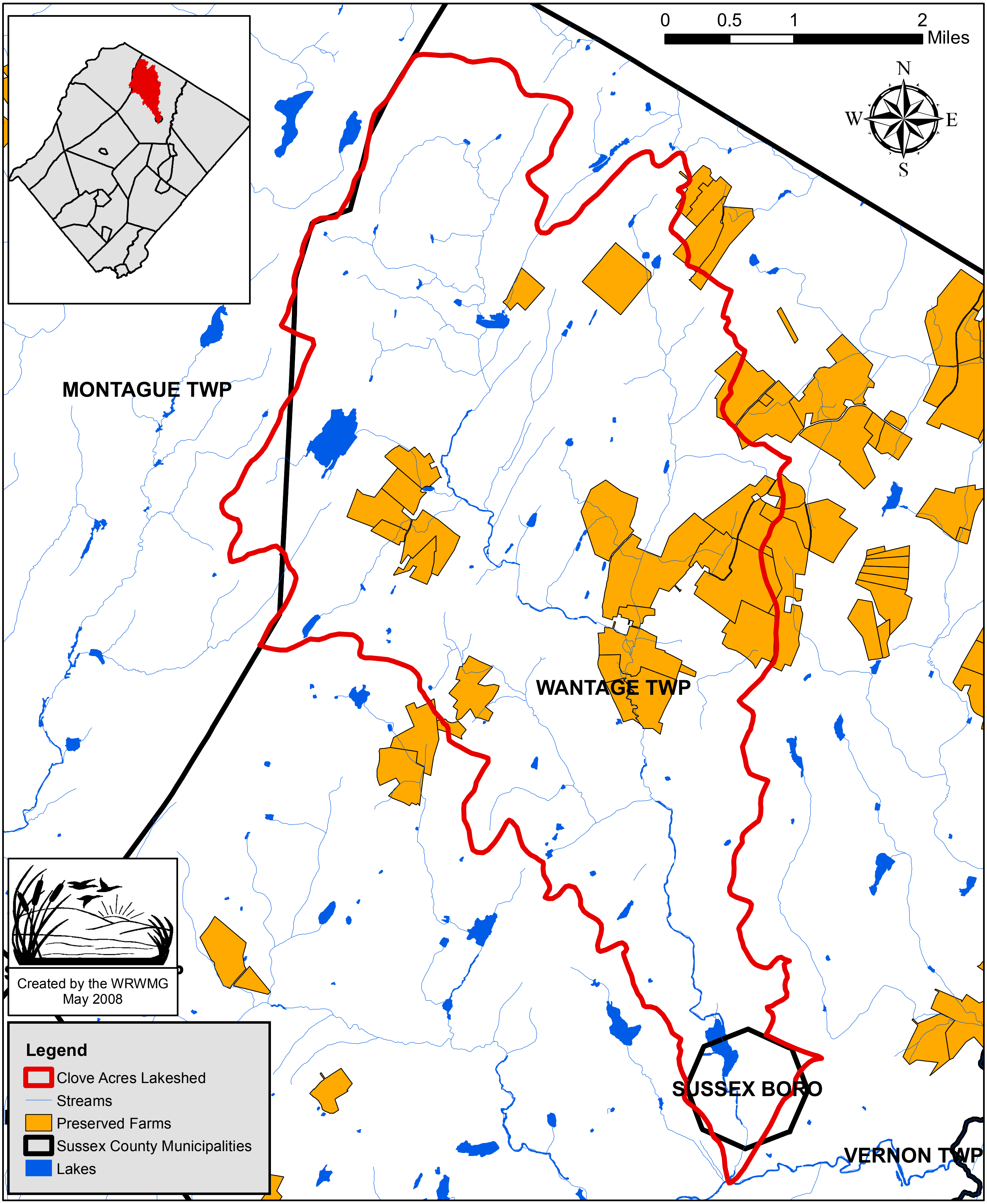


Appendix II – Continued

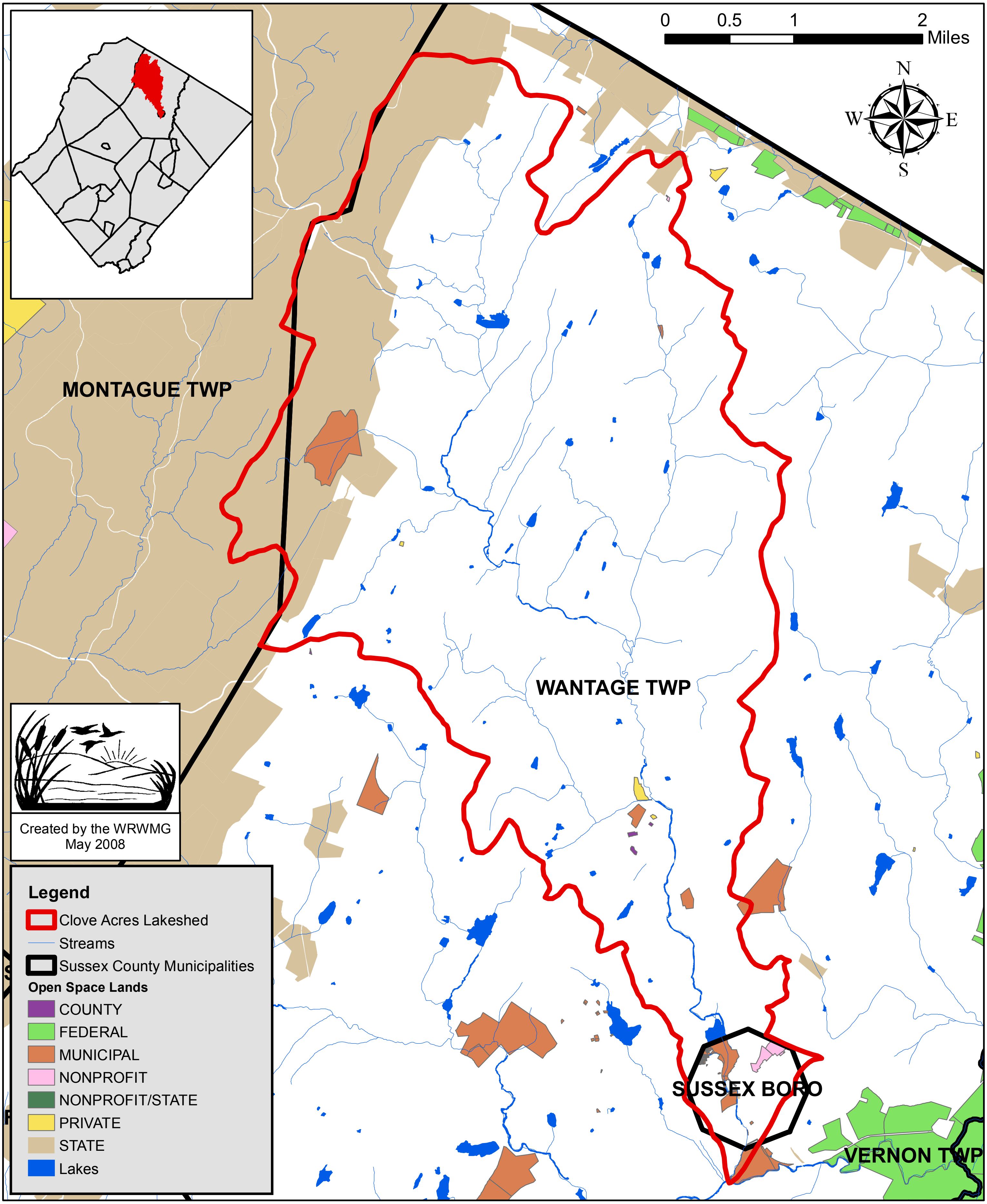


In April 2007, the SCOGISM and the WRWMG participated in the NJDEP's 20th Annual GIS Mapping Competition, with the map displayed above, and placed second in the category of "Best Analytical Presentation". The map was also selected by the New Jersey Academy of the Sciences as "Best Scientific Map" displayed at the competition.

Appendix III:
Preserved Farmland within the Clove Acres Lakeshed



Appendix IV:
Open Space within the Clove Acres Lakeshed



Wallkill River Watershed

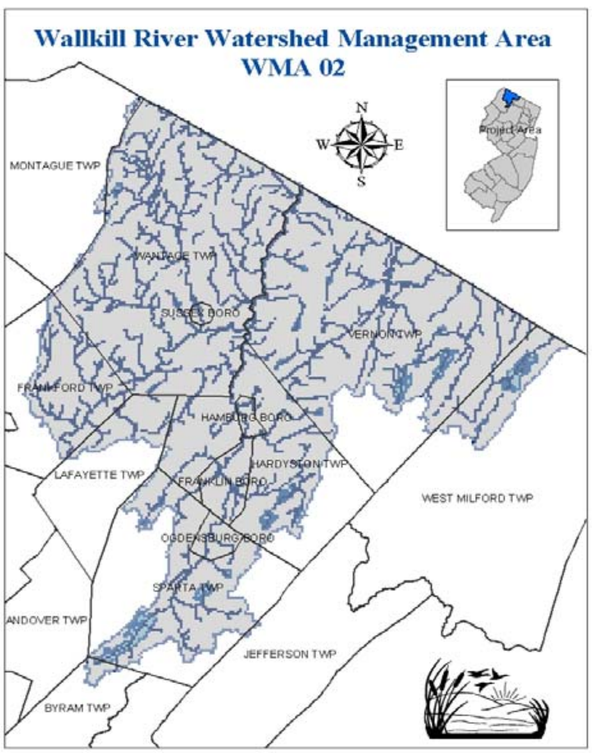
SFY 2005 319(h) Grant: Watershed Restoration Plan for Clove Acres Lake and the Surrounding Lakeshed

Quality Assurance Project Plan (QAPP)

Contract Approved: August 5, 2005
Grant Identifier: RP05-090

(QAPP Final Version – May 10, 2006)

Purpose: To ensure that the sampling tasks will meet the necessary project quality sampling requirements, quality control and assurance procedures, and other project specifications.



Surface Water Quality Database

Date	M_1	M_2	M_3	M_4	M_5	M_6	M_7
Site	**M**	**N**	**O**	**P**	**Q**	**R**	**S**
TP							
OP							
TKN							
TDS		**Sampling / Assessing**					
NH_3		**WMA 02**					
Nitrate		**Surface Waters**					
Nitrite		**Following**					
Cond		**NJDEP / USGS**					
DO		**Guidelines and an**					
T °C		**Approved QAPP**					
pH							
BOD_5							
COD							
TSS							
FC							

Clove Acres Lake and the Surrounding Lakeshed Databases

Ernest Hofer PE
Project Officer
WRWMG / WMA 02

Nathaniel Sajdak
Field Coordinator
WRWMG / WMA 02

Table of Contents

Wallkill River Watershed

SFY 2005 319(h) Grant: Watershed Restoration Plan for Clove Acres Lake and the Surrounding Lakeshed

Contract Approved: August 5, 2005
Grant Identifier: RP05-090

QAPP Final Version – May 10, 2006

Purpose: To ensure that the sampling tasks will meet the necessary project quality sampling requirements, quality control and assurance procedures, and other project specifications.

Ernest Hofer PE
Project Officer (WMA 02)
QAPP Preparer

Nathaniel Sajdak
Field Coordinator (WMA 02)
Watershed Coordinator

<u>**Watershed Management Area 02**</u>
<u>**Surface Water Quality Sampling Program**</u>

<u>**Quality Assurance Project Plan**</u>

<u>**Clove Acres Lake / Lakeshed Grant**</u>

Function	Name	Signature	Date
Reviewed by:			
WMA 02 Lead Agency	John Hatzelis, Administrator Sussex County Municipal Utilities Authority (SCMUA)	______________	__________
Project Officer	Ernest Hofer PE Consultant Watershed Specialist	______________	__________
Field / Program Coordinator	Nathaniel Sajdak Watershed Coordinator WRWMG	______________	__________
Field Measurement / SCMUA Laboratory Coordinator	John Nugent SCMUA Wastewater Superintendent	______________	__________
QA Officers	Thomas Varro PE SCMUA Chief Engineer	______________	__________
Laboratory Director	Harvey Klein Garden State Laboratories, Inc.	______________	__________
NJDEP Project Manager	Dana Emerson Division of Watershed Management	______________	__________
NJDEP Division of Watershed Management	Helen Rancan Statewide NPS Coordinator Bureau of Watershed Planning	______________	__________
NJDEP Division of Watershed Management	Terri Romagna Project Manager	______________	__________
Approved by:			
NJDEP QA Office of Quality Management	Marc Ferko Research Scientist Office of Quality Assurance	______________	__________

Project Management Sections

Introduction

This QAPP is in support of a 30-month project to assess and identify restoration and management techniques, which when implemented, result in achieving an overall 77% reduction in the estimated total phosphorus (TP) Clove Acres Lake / Lakeshed loading of 2,676 kg/yr as presented in the referenced TMDL.

The work scope of this project includes targeted sampling, lake characterization and assessment studies, development of actual relative load contributions and source loads not previously quantified, pollutant budgets, technical evaluations to refine/augment the published TMDL information, and proposed control measures for the lakeshed.

NJDEP Identified Impairments

TP Impairment – Clove Acres Lake has been classified as impaired with respect to total phosphorus (TP). Specifically, Clove Acres Lake in Sussex Borough is reported to have an average TP value in excess of New Jersey Department of Environmental Protection's (NJDEP) Lake Water Quality Regulation of 0.05 mg/l.

Benthic Macroinvertebrates / Unknown Toxicity Impairments – Clove Brook has been classified as impaired with respect to benthic macroinvertebrates at Loomis Avenue in Sussex Borough and an unknown toxicity issue at Rose Morrow Avenue in Wantage. The Wallkill River Watershed Management Group (WRWMG) will be seeking prior data from NJDEP regarding the unknown toxicity condition. If suspected impairment is confirmed, sources of the impairment will be identified and a restoration plan will be developed as part of the lakeshed restoration plan.

Project Tasks

The work scope of this project includes targeted sampling, lake characterization and assessment studies, development of actual relative load contributions and source loads not previously quantified, validation of pollutant budgets, refinement and augmentation of the published TMDL information, evaluation of proposed control measures for the lakeshed, initiation of an education and outreach program, identification of funding sources, and development of a lakeshed restoration plan.

Sampling Tasks:

Lakeshed Restoration Plan for the Clove Acres Lake / Lakeshed
Two-Year Chemical Targeted Site Sampling Program

Princeton Hydro to conduct a lake characterization and assessment study of Clove Acres Lake in accordance with NJDEP criteria for lake assessments. **Criteria to be in accordance with NJDEP document entitled "Requirements for Lake Characterization" prepared by DWM**

– BEAR and supplied by NJDEP. Version is slightly more extensive than a similar copy provided by NJDEP in late 2004. Princeton Hydro has submitted a separate QAPP covering the application and implementation of the DWM – BEAR criteria document.

1. Conduct monthly chemical sampling (one year) followed by quarterly sampling for two-quarters at five sites on the Clove Brook (Sites "O", "P', "Q", "I" and "J"); refer to attached GIS map; Sites "O", "P", "Q", and "I" are located upstream of Clove Acres Lake and Site "J" is located downstream of Clove Acres Lake. In addition, conduct total phosphorus sampling of the dam overflow waters on a monthly basis for one year. Chemical parameters to consist of ammonia as total NH_3-N, un-ionized ammonia, TKN, TP, Ortho P, TDS, nitrate, nitrite, conductance, TSS, water temperature, pH, DO, and flow rate.

   Conduct targeted but limited TP lake sampling (maximum of three locations) during and following characterization and assessment studies by Princeton Hydro to show a) analytical methods consistency between measurements taken by Princeton Hydro and WRWMG, b) supplemental data for lake load modeling, and c) trend analysis and validity of long-term monitoring results by WRWMG in tracking performance improvements. **Unless advised otherwise, there is no plan to submit a separate QAPP for conducting the three in-lake-sampling exercises. The intended lake locations for periodic sampling relate to the inlet stream region just within the lake and at the outlet prior to the dam. Collected samples would be by spot (grab) or composite using a churn-splitter. Princeton Hydro under their approved QAPP by NJDEP will conduct in-lake sampling.**

2. Conduct macro-invertebrate site assessments as indicated, as well as sampling (to be defined later) pertaining to the unknown toxicity issue at Rose Morrow Avenue in Wantage. The initial investigation will be confined to performing the stressor identification (SI) method (refer to EPA/822/B-00/025 Guidance Document) to assess potential causes of the impairment(s). Upon performing this analysis, results to be documented along with suggestions and submitted to NJDEP for follow-up monitoring that might lead to an understanding of the cause of abnormalities.

3. Following further discussions with NJDEP regarding the site data used in establishing the unknown toxicity issue at Rose Morrow Avenue, apply the stressor identification process to assess candidate causes of impairment, assess exiting data, collect additional site data as appropriate, and develop a restoration plan if indicated.

<u>Rationale for Conducting Flow measurements</u>

For chemical sampling events, HydroQual's trained personnel using appropriate and calibrated Marsh-McBirney flowmeters will conduct stream flow measurements.

<u>Rationale for the Presence or Absence of Restrictions on Sampling Based on Weather or Flow in the Selected Waterbodies</u>

HydroQual's trained personnel using appropriate and calibrated Marsh-McBirney flowmeters will conduct stream flow measurements. Envisioned flow measurement restrictions may occur occasionally when stream depths are greater than 30 inches in depth

(unsafe to enter water) and during stream freeze over (winter months). Winter weather patterns over the past four years have not restricted conducting chemical sampling events. Although sampling events are not conducted during major storm events, every effort is made to conduct the planned sampling event just prior to or immediately following a storm event.

Supplemental Data from Other Approved QAPP's to be used to Augment Data Collected Under this QAPP

Data from the following approved QAPP(s) will be used to augment data to be collected under this submitted QAPP for Clove Acres Lake/Clove Brook 319(h) Grant:

1. **The original and approved addendum for the Watershed Area 2 Surface Water Quality Sampling Program Quality Assurance/Quality Control plan (QA/QC) (Addendum approved November 2005; refer to letter from Dana Emerson to Nathaniel Sajdak, dated September 20, 2005). Collected chemical data to be used to augment data to be generated from the Clove Acres Lake /Clove Brook QAPP.**

2. **Draft QAPP submitted November 2005 for the Papakating Creek 319(h) Grant. Collected chemical data to be used to augment data to be generated from the Clove Acres Lake/Clove Brook QAPP. Intent/purpose relates to Site "L" which serves as the integrator site for the Papakating Creek and Clove Brook.**

Documentation / Report Guidelines

1. The Project Officer has the responsibility to ensure that all appropriate project personnel have the most current version of the QAPP

2. The Project Officer has the responsibility to ensure that all pertinent sampling data and reference documents/information are collected, maintained, and collated as a database:

   a) Excel spreadsheets
   b) Analytical reports from participating laboratories
   c) Field measurement reports
   d) Appropriate USGS flow gage charts (down loadable from the internet)
   e) Appropriate USGS flow station rating curves (calibration data)
   f) Appropriate calculation summaries and individual sheets
   g) Appropriate Excel charts
   h) Appropriate statistical analyses and summary sheets
   i) Individual site land use / land cover information
   j) Appropriate local municipal information that may be pertinent to the project scope
   k) Localized weather statistics
   l) Appropriate NJDEP, USGS, and other organizational technical data that may be pertinent to the project scope
   m) Site photograph directory
   n) Guidance letters and advice received from NJDEP, USGS, and other technical organizations
   o) Modeling simulations, analyses, and reports

p) Sample custody sheets
q) Copies of technical reports issued by Princeton Hydro
r) All submitted data to be in electronic format

3. Project results and findings shall be briefly summarized for quarterly reporting. A comprehensive report addressing project results shall be issued at appropriate time periods during the duration of each specific project

4. Status and audit reports will be issued as appropriate.

5. Frequent communications shall be maintained with the assigned NJDEP Project Manager

6. All reports issued shall be maintained as both hard and electronic copies

QAPP[1] Distribution List

Project Member	Title
Ernest Hofer PE	Project Officer
Nathaniel Sajdak	Field / Program Coordinator
John Nugent	Wastewater Facility Coordinator and Instrumentation / Calibration Officer
Harvey Klein	Director - Garden State Laboratories, Inc.
Dana Emerson	NJDEP – Project Manager, Division of Watershed Management
Bob Mancini	NJDEP – Section Chief, Bureau of Watershed Planning, DWM
Marc Ferko	NJDEP – Research Scientist, Office of Quality Assurance
WMA 02 Files (three copies)	
[1] Princeton Hydro to prepare a QAPP for the Clove Acres Lake characterization and assessment study	

Measurement and Data Acquisition Sections

Sampling Site Coverage

Sampling teams to consist of representatives from WRWMG (Ernie Hofer, Nathaniel Sajdak, and assigned and trained AmeriCorps Watershed Ambassador), SCMUA Wastewater Facility Laboratory personnel, field/office personnel from HydroQual, Inc. and the Sussex County Health Department.

Notification of Sampling Field Events

Advanced notification of sampling dates will be given to Dana Emerson, NJDEP Project Manager for the Wallkill River Watershed Management Group's projects, grants, and programs (WRWMG, WMA 02)

Parameter Table

Summary of Test Procedures

Parameter	Method	Sample Container[1]	Preservation Technique	Holding Time
Total Dissolved Solids	Std. Methods 2540C	P / G	Ice	7 days
Total Phosphorus	Std. Methods 4500 P-E	P / G	Cool to 4°C H_2SO_4 to pH < 2 (cold packs plus ice)	28 days
Dissolved ortho-P	Std. Methods 4500 P5+E	P / G	Cool to 4°C (cold packs plus ice)	48 hours
Ammonia-N	Std. Methods 4500-NH_3	P / G	Cool to 4°C H_2SO_4 to pH < 2 (cold packs plus ice)	28 days

Nitrate	EPA 300	P / G	Cool to 4^{o}C (cold packs plus ice)	48 hours
Nitrite	EPA 300	P / G	Cool to 4^{o}C (cold packs plus ice)	48 hours
TKN	EPA 351.3	P / G	Cool to 4^{o}C H_2SO_4 to pH < 2 (cold packs plus ice)	28 days
Chlorophyll "a"	Std. Methods 10200H-2	P (opaque)	Ice in dark	7 days
Fecal Coliform	Std. Methods 9222D	P	Cool to 4^{o}C (cold packs plus ice)	6 hours
Enterococcus	Std. Methods 9230C	P	Cool to 4^{o}C (cold packs plus ice)	6 hours
Temperature	EPA 170.1	P / G	NA	Analyze immediately
pH	EPA 150.1	P / G	NA	Analyze immediately
Conductivity	EPA 120.1	P / G	NA	**28 days**
Dissolved Oxygen	EPA 360.1	G	NA	Analyze immediately
Note: Table confirmed by Harvey Klein / Mike Reda from Garden State and Shawn Riley /				

Joyce from Marypaul Laboratories				
Total Suspended Solids (TSS)	SM 2540D	P/G (one liter)	Cool to $4^{o}C$ (cold packs plus ice)	7 day
Sediment (stream bed)	Grab sample (depending on purpose, select sample at stream edge or at stream center; collect using top one to two inches of stream bed; follow NJDEP Field Sampling Procedures Manual – May 1992 Edition or later)	P/G (1000 ml)	NA	Within 30-days (set by WMA 02) Analysis work by Rutgers Soil Testing Laboratory (Mehlich - 3 Extractant)
Coliphage / ARA (MAR)	Methods and procedures as standardized by Dr. Sobsey (coliphage) and John Tiedermann (ARA/MAR)			
BOD_5	Std. Method. 5210 B	G (dark brown; foil wrapped after sampling)	Cool to $4^{o}C$ (cold packs plus ice)	48 hours
COD	HACH Method 8000	G	Cool to $4^{o}C$ H_2SO_4 to pH < 2	28 days
[1] P = Polyethylene, G = Glass; Use of 500 and/or 1000 ml bottles unless indicated otherwise				

Note: 1. Listing of enterococcus for sampling is consistent with the list of parameters to be sampled as approved in the current WMA 02 QAPP. Limited sampling for fecal coliform and enterococcus may be considered to verify that the fecal load from the Clove Brook is relatively minor compared to the load within the Papakating Creek at the confluence of the two streams. The Papakating Creek is currently listed for fecal coliform impairment and is to be studied under a separate approved 319(h) grant.

Note 2. Until GSL is certified for testing / analyzing Chlorophyll "a" (expected by August 2006), GSL will submit samples to Environmental Compliance Monitoring, Inc. (Certification # 18630).

Note 3. Diurnal oxygen monitoring will be conducted over a time period of not less than 30 consecutive hours. Measurements will be taken hourly using an YSI – Model 58 (Spring Inc., Ohio) instrument. The following parameters will be collected: water temperature, ambient temperature, pH, dissolved oxygen, oxygen saturation, and visual observations. Procedures and methods to be in accordance with the WMA 02 QA/QC (QAPP) approved plan (November 2005) and this QAPP.

Sample Collection

Sampling Methods to be in agreement with "NJ Department of Environmental Protection Field Sampling Procedures Manual August 2005" and/or US Geological Survey's Book 9, Handbooks for" National Field Manual for the Collection of Water-Quality Data", etc. Specifically, composite samples using a churn splitter will be used for the following parameters: ammonia, TKN, total phosphorus, ortho/dissolved phosphorus, total dissolved solids, nitrate, nitrite, and specific conductance. Spot (grab) samples using appropriate containers will be used for fecal coliform, enterococcus, coliphage, chlorophyll a, and for measurement of pH. Measurements for the following parameters will be made directly within the stream, river, and/or lake: water temperature, dissolved oxygen, and percent oxygen saturation. Fecal Coliform sampling will be considered if septic issues are uncovered.

Procedures for decontamination of sampling devices to be in accordance with NJDEP's "*Field Sampling Procedures Manual*", 2005; Chapter 2 – Quality Assurance, Subsections 2.3 and 2.4. In the field, distilled water will be used for flushing the churn-splitter including cover and spigot between uses.

Clarification of References to Previous QAPP(s) and Dates when Approved.

Data from the following approved QAPP(s) will be used to augment data to be collected under this submitted QAPP for the Clove Acres Lake/Clove Brook 319(h) Grant:

1. The original and approved addendum for the Watershed Area 2 Surface Water Quality Sampling Program Quality Assurance/Quality Control plan (QA/QC) (refer to letter from Dana Emerson to Nathaniel Sajdak, dated September 20, 2005, advising NJDEP

approval of Addendum). Collected chemical and fecal coliform data to be used to augment data to be generated from the Clove Acres Lake/Clove Brook QAPP.

3. **QAPP submitted November 2005 by Princeton Hydro for conducting the Clove Acres Lake assessment and characterization study. Collected chemical data to be used to augment data to be generated from the Clove Acres Lake/Clove Brook QAPP**

Table - Parameter Detection Limits, Quantitation Limits, Accuracy, and Precision[(a)]

Parameter	Reporting Limit	Method Detection Limit	Project Detection Limit	Quantitation Limit - PQL	Accuracy % Rec.	Precision % RR	Accuracy Protocol LCL/UCL	Precision Protocol UCL %RR
Temperature	NA	-10^o – 100^oC	-10^o – 100^oC	NA	NA	NA	NA	NA
pH	NA	0.1 S.U.	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	0.2 mg/l	NA	0.2 mg/l	0.2 mg/l	NA	≤ 10%	NA	NA
Conductivity	NA	0.01	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	1.0 mg/l	NA	1.0 mg/l	1.0 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Total Phosphorous	0.010 mg/l	0.006 mg/l	0.010 mg/l	0.010 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Dissolved ortho-P	0.010 mg/l	0.005 mg/l	0.010 mg/l	0.010 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Ammonia-N	0.050 mg/l	0.011 mg/l	0.050 mg/l	0.050 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Nitrate-N	0.01 mg/l	0.006 mg/l	0.01 mg/l	0.01 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Nitrite-N	0.005 mg/l	0.001 mg/l	0.005 mg/l	0.005 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
TKN	0.5 mg/l	0.242 mg/l	0.5 mg/l	0.5 mg/l	100 ± 10%	≤ 10%	100 ± 10%	≤ 10%
Chlorophyll-a	NA	NA	NA	NA	NA	NA	NA	NA
Fecal Coliform	NA	NA	NA	NA	NA	NA	NA	NA
Enterococcus	NA	NA	NA	NA	NA	NA	NA	NA
NA – Not Applicable								

(a) Data supplied by Garden State Laboratories (GSL) NJDEP No. 20044 (Page 15 of Original QA/QC (3/0

<u>Selected Laboratories for Approved Scope of Work</u>

1. Surface Water Quality Chemical Parameters Including Chlorophyll "a":

    Garden State Laboratories, Inc.
    410 Hillside Avenue
    Hillside, New Jersey 07205
    Notes:

    a. Garden State is NJDEP Certified, Number 20044
    b. Garden State to provide all required 500 and/or 1000 ml empty and sulfuric acid and/or nitric acid preserved sample bottles (polyethylene/glass), Chain of Custody Records, and sample bottle tags.
    c. Garden State Laboratories provided all prior chemical sample(s) analyses during 2002 - 2003 - 2004 - 2005 field sampling projects. **All analytical services were covered under an approved WRWMG QAPP; all collected data were previously submitted to NJDEP by the WRWMG.**
    d. Phone # (800) 548-1874 / Fax # (973) 300-9820
    e. Marypaul Laboratories provided all prior FC sample(s) analyses during 2003 - 2004 field sampling programs. **All analytical services were covered under an approved WRWMG QAPP; all collected data were previously submitted to NJDEP by the WRWMG.**

<u>Sample Custody Procedure</u>

A general chain of custody procedure will be implemented for the project. Chain of Custody (COC) will be followed for all samples collected for this project and the forms will provide the pertinent information shown on the attached Chain of Custody Record. A sample is in one's actual possession if:
1. It is in one's actual physical possession
2. It is in one's view, after being in one's physical possession
3. It is in one's physical possession and then locked up so that no one can tamper with it
4. It is kept in a secure area, restricted to authorized personnel only

Calibration of laboratory equipment will be done in accordance with "*Regulations Governing Laboratory Certification and Standards of Performance,*" NJAC 7:18 <u>et seq.</u> and 40 CFR Part 136. The analytical laboratory will have a written Preventive Maintenance procedure, which they adhere to in the event that there is equipment failure or a problem in achieving any analysis. These procedures will be in accordance with NJAC 7:18 <u>et seq.</u> and 40 CFR Part 136.

Copies of Chain of Custody Records for Marypaul Laboratories and Garden State Laboratories are attached as follows:

MARYPAUL LABORATORIES, INC.
12 WILSON DRIVE, SPARTA, NJ 07871
973-300-9715

□ Presence/Absence Coliforms, $55

□ Presence/Absence Coliforms and Count, $65

MARYPAUL LABORATORIES CANNOT TEST WATER FOR HOME CLOSINGS.

*I certify that the water sample(s) is(are) not for a house closing.*____________________________ ___________

Signature Date

Marypaul Laboratories, Inc. **WATER CHAIN OF CUSTODY**

Client:			Date:		
Sampled By (Sign):					
□ City Water □ Well Water □ Bathing Beach (Lake) Water			Chlorinated Well Water?: □ No □ Yes, Date Chlorinated:		
Sample No.:	Date Sampled:	Time Sampled:	Sample No.:	Date Sampled:	Time Sampled:
Source: (Example: Sink) Address if different from below:			Source: (Example: Sink) Address if different from below:		
Sample No.:	Date Sampled:	Time Sampled:	Sample No.:	Date Sampled:	Time Sampled:
Source:			Source:		
Sample No.:	Date Sampled:	Time Sampled:	Sample No.:	Date Sampled:	Time Sampled:
Source:			Source:		
Send Report To:			Phone:		
Address:					
Condition of Samples Received by MPL: □ Cold □ Warm □ Unpreserved □ Preserved					
Relinquished By (Sampler Sign):			Shipment Method:		
Received By (MPL Sign):			Date/Time:		

File: H:\data\WCC-7.wpd Revision: 7 Issue Date: 3/12/03 Attachment 2 of SOP00351

Garden State Laboratories, Inc.
Bacteriological and Chemical Testing

Internet: www.gslabs.com E-mail: info@gslabs.com

CHAIN OF CUSTODY RECORD

(PRESS HARD AND PRINT CLEARLY - USE BALL POINT PEN)

North Jersey (Main)
410 Hillside Avenue
Hillside, NJ 07205
Tel. 800-273-8901/908-688-8900
Fax 908-688-8966

South Jersey (Satellite)
515 Route 9
Barnegat, NJ 08005
Tel. 800-625-7200/609-698-0199
Fax 609-698-0910

FOR SAMPLE RECEIVING USE ONLY
DATE/TIME/TEMP. REC'D AT LAB:
Page ________ of ________
GSL CLIENT #
MICRO #
CHEM. #
SAMPLE REC'D BY:
☐ GSL FIELD SAMPLER/PICK-UP
☐ PICK-UP AT DROPPED OFF LOCATION
☐ DELIVERED BY CLIENT

IMPORTANT: PRINTED NAMES & SIGNATURES ARE REQUIRED

CLIENT INFORMATION (REPORT TO BE SENT TO)

Name: Contact/Authorized by:
Mailing Address: Phone:
City/State/Zip: Fax:

SAMPLE INFORMATION

SAMPLE TYPE:
SAMPLE LOCATION:

Grab	Comp	SAMPLE ID	SAMPLE COLLECTION				ANALYSIS REQUIRED (Print Legibly)	CONTAINER INFORMATION			
			Date	Time	AM	PM	☐ List attached Total Pages ____	No.	Type*	Size	Pres.*

*Container Type: P = Plastic G = Glass A = Amber Glass T = Sterile Thio V = VOA Vial Other/Specify: ____________
*Preservation Code: A = Non Preserved B = Sulfuric Acid C = Sodium Hydroxide D = Nitric Acid E = Hydrochloric Acid (HCL) F = Zn Acetate G = Sodium Thiosulfate H = Ascorbic Acid I = Cooled Other/Specify: ____________

☐ SUBCONTRACTED WORK
SEND TO:
DATE/TIME:
METHOD OF SHIPMENT:

TURNAROUND TIME (T/A/T): ☐ Standard ☐ Rush (If RUSH REQUESTED) Rush Due by:
REPORT FORMAT: ☐ Standard Report ☐ Other/Specify:
☐ Standard Report + State Forms PWS ID#:

PAYMENT INFORMATION

☐ Sampling/Pick-up Fee: $ ☐ Composite Fee: $ ☐ Rush Fee: $ Amount Due: $
Payment Method: ☐ Credit Card Type: ☐ Check # ☐ Other:

Note:

SAMPLE CUSTODY EXCHANGES MUST BE DOCUMENTED BELOW EACH TIME SAMPLES CHANGE POSSESSION
PLEASE PRINT YOUR NAME LEGIBLY, USE FULL LEGAL SIGNATURE, DATE AND TIME

Sampled by (PRINT): Signature: Date/Time:
Client/Client's Representative (PRINT): Signature: Date/Time:
1. Received/Relinquished by (PRINT): Signature: Date/Time:
2. Received/Relinquished by (PRINT): Signature: Date/Time:

THE LIABILITY OF GARDEN STATE LABORATORIES, INC. FOR SERVICES RENDERED SHALL IN NO EVENT EXCEED THE AMOUNT OF THE INVOICE
Certified by U.S. Public Health Service, N.J. Dept. of Health, N.Y. State Dept. of Health - Lab # 11550 and N.J.D.E.P. - Lab # 20044

LR - 3/5/03-REV2

Sampling Frequency Guidelines

1. Unless approved otherwise, chemical sampling frequency shall be at least eight (8) successful sampling events per sampling location

2. Diurnal dissolved oxygen sampling shall be no less than hourly measurements collected over a minimum, continuous time period of 30-hours

3. With regard to chemical sampling, the number of duplicate samples to be collected shall be equivalent to approximately 10% of the normal samples to be collected

Instrumentation, Equipment Testing, Inspection, Calibration, and Maintenance Requirements

1. All functions to be provided by trained personnel from the Sussex County Municipal Utilities Authority (SCMUA) - Wastewater Treatment Facility.

2. All maintenance and calibration logs to be maintained at the SCMUA's Wastewater Treatment Facility.

3. All field sampling equipment shall be maintained by the Project Officer and Field Coordinator

4. All field instrumentation to be calibrated prior to each field sampling event

Data Validation Methods, Quality Objectives, Assessment, and Oversight

1. Target chemical parameter values (desired values) shall be obtained from the NJDEP Surface Water Quality Standards and EPA approved NJDEP TMDL documents

2. All collected data shall be assessed with respect to accuracy, dispersion, precision, bias, representativeness, comparability, and compliance against Standards.

3. Where and when appropriate, standard statistical methods shall be applied in the design of sampling plans and in the analysis of data results. The following tools and software packages shall be considered by the Project Officer for the assessment of the collected sampling data: a) Excel Version 2002 – statistical tools and charting methods and b) Minitab - a general-purpose statistical package. Note: Project Officer has received Six Sigma certification from Honeywell International

4. Validation and verification methods to be used by the Project Officer shall include a) cross checking field data with laboratory printouts, b) checking for data gaps, c) checking calculations prepared by WRWMG, d) checking Excel data work sheets and databases against input provided by laboratories and engineering subcontractors, e) checking for outliers; etc.

5. Consultation with NJDEP, USGS, HydroQual, and Princeton Hydro technical personnel shall be sought as needed

6. **The project QA/QC Officer will ensure that all data for the project are generated in accordance with procedures outlined in this QA/QC Project Plan. Quality control samples will be analyzed with each sample batch and results will be provided with the data reports. If a QC sample provides unacceptable results during any given sampling date, the sample analysis will be repeated for those parameters affected. All project participants will immediately report any deficiencies to the QA Officer. The QA Officer will recommend appropriate corrective action and determine the acceptability of affected data when deficiencies are noted.**

   The QA Officer will notify the Project Officer of any unacceptable data to ensure that it is not included in evaluations of water quality for reporting purposes. The QA Officer will notify the Project Officer in writing anytime that a a deviation from the approved plan occurs. Results of all corrective

Data Users

Wallkill River Watershed Management Group (WRWMG)
WRWMG's Technical Advisory Committee (TAC)
Participating Municipalities
Grant(s) Partners
New Jersey Department of Environmental Protection
U.S. Environmental Protection Agency

Sampling Site Photographs

Refer to Attachment 1

GIS Maps– Chemical /Fecal Coliform Site Locations

Refer to Attachment 2

Figure 1. Sussex County Municipalities / WMA 02 Boundary / Clove Acres Lakeshed HUC 14s

Figure 2. Clove Acres Lakeshed Subwatershed Boundary

Figure 3. Clove Acres Lakeshed and Clove Brook Surface Water sampling Sites

Previous WMA 02 QAPP Projects

Refer to Task B QA/QC Plan prepared by HydroQual, Inc. and WRWMG
NJDEP Participants: Terri Romagna (Division of Watershed Management, Project Manager) and Marzooq "Marco" Al-Ebus (NJDEP, Bureau of Environmental Analysis and Restoration, Environmental Specialist)

Prepared By: Ernest Hofer PE (Project Officer), Nathaniel Sajdak (Watershed Coordinator/Field Logistics and Sampling Coordinator), and input from Garden State Laboratories, MaryPaul Laboratories, and referenced Universities

Attachment 1 – Photographs

New Proposed Clove Brook Sampling Locations
Clove Brook (Locations Upstream of Clove Acres Lake)

Site "O" - Route 23 / Smith Road (Wantage Township)

Site "O" - Looking Upstream

Note: Selected-sampling site is approximately 100' upstream

Site “P” - Route 651 / Rose Morrow Rd (Wantage Township)

Site “P” - Looking Upstream

0198

Site “P” - Looking Downstream

0197

Site “Q” - Routes 651 / 23 (Wantage Township)

Site “Q” – Looking Upstream

0196

Site “Q” – Looking Downstream

0195

Clove Acres Lake -Inlet / Outlet Sampling (just within lake)

Inlet – Far Side to Left of House on Extreme Left

0020

Overflow at Dam

0013

Attachment 2 – GIS Maps

Figure 1. - Sussex County Municipalities / WMA 02 Boundary/ Clove Acres Lakeshed HUC 14

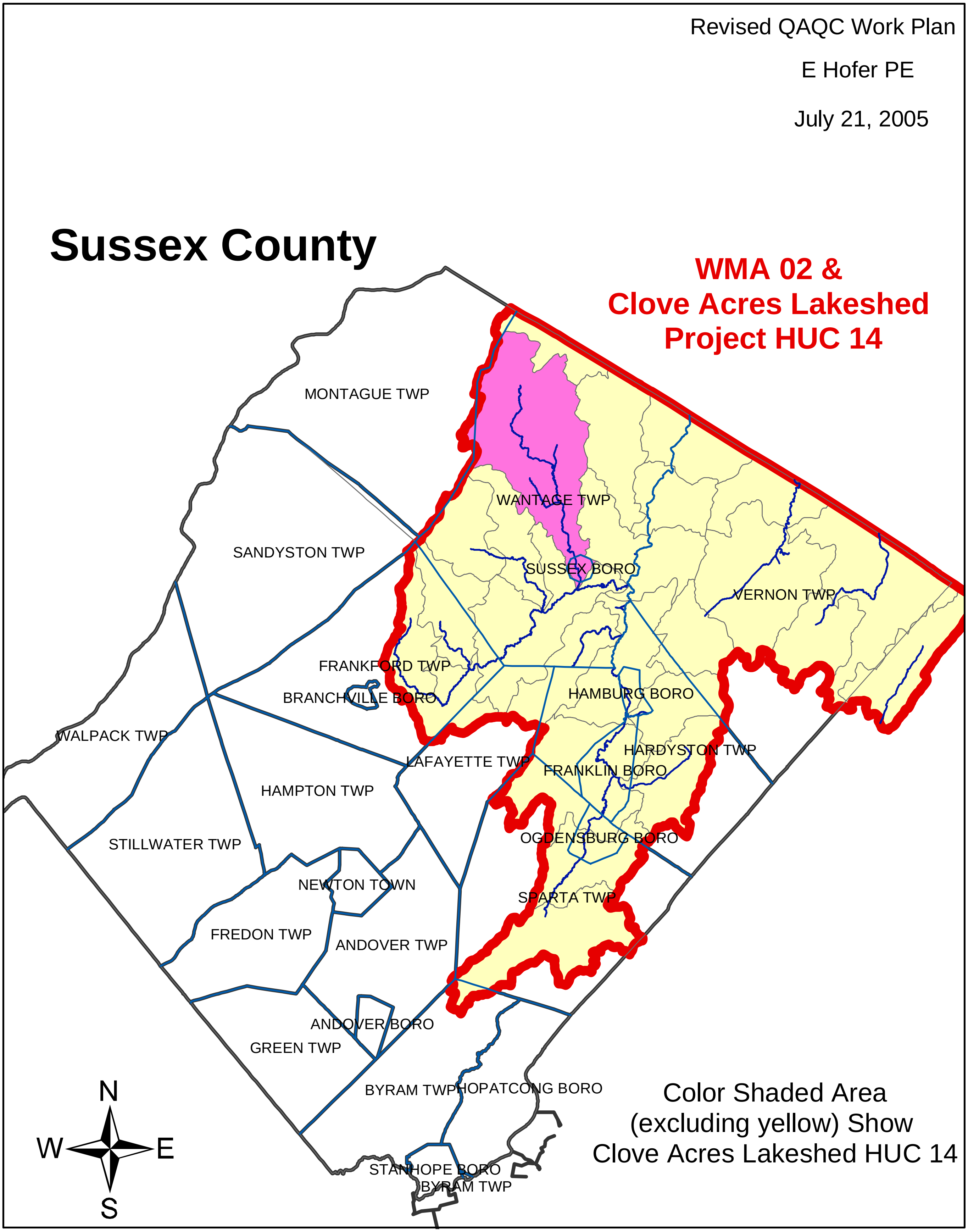
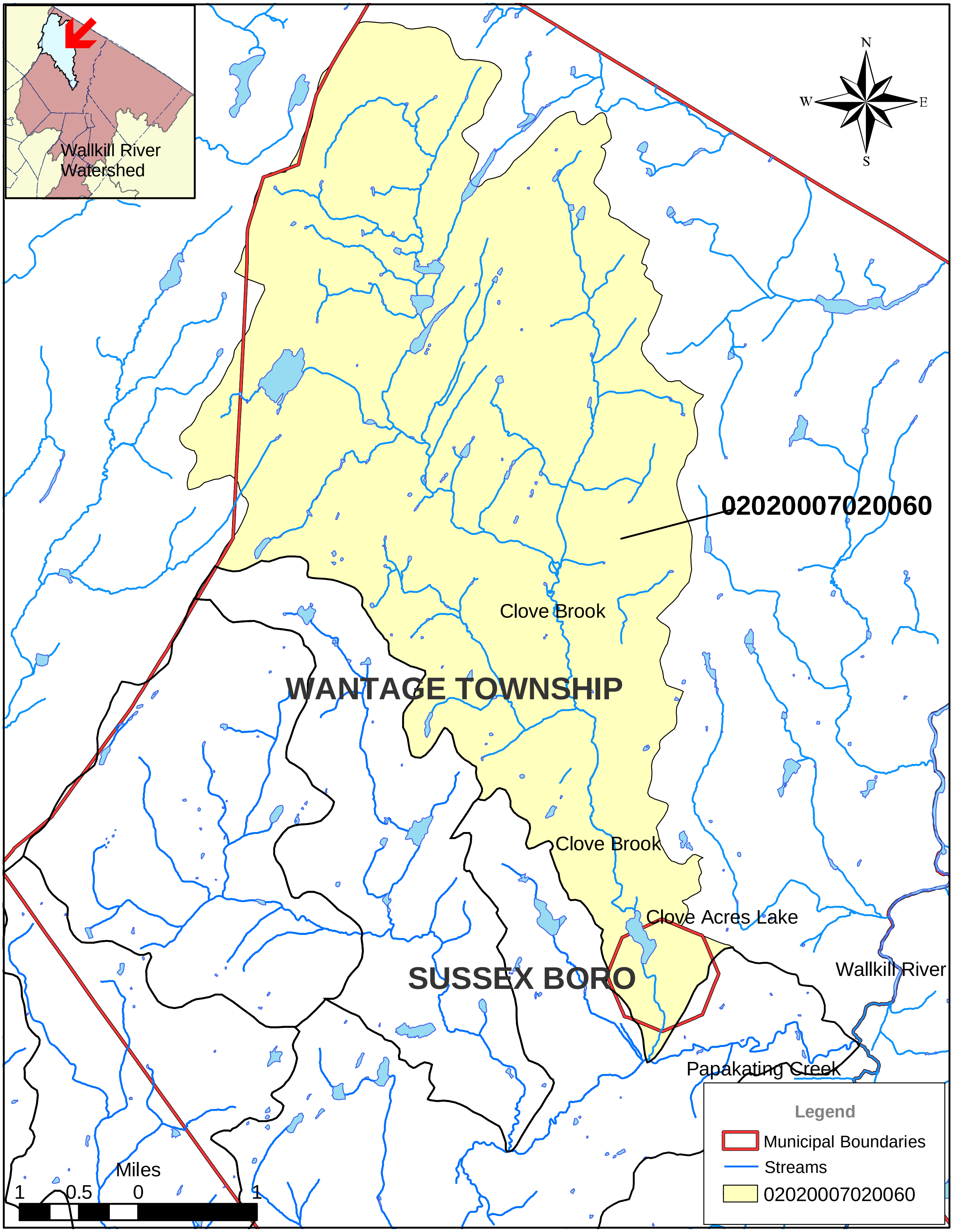


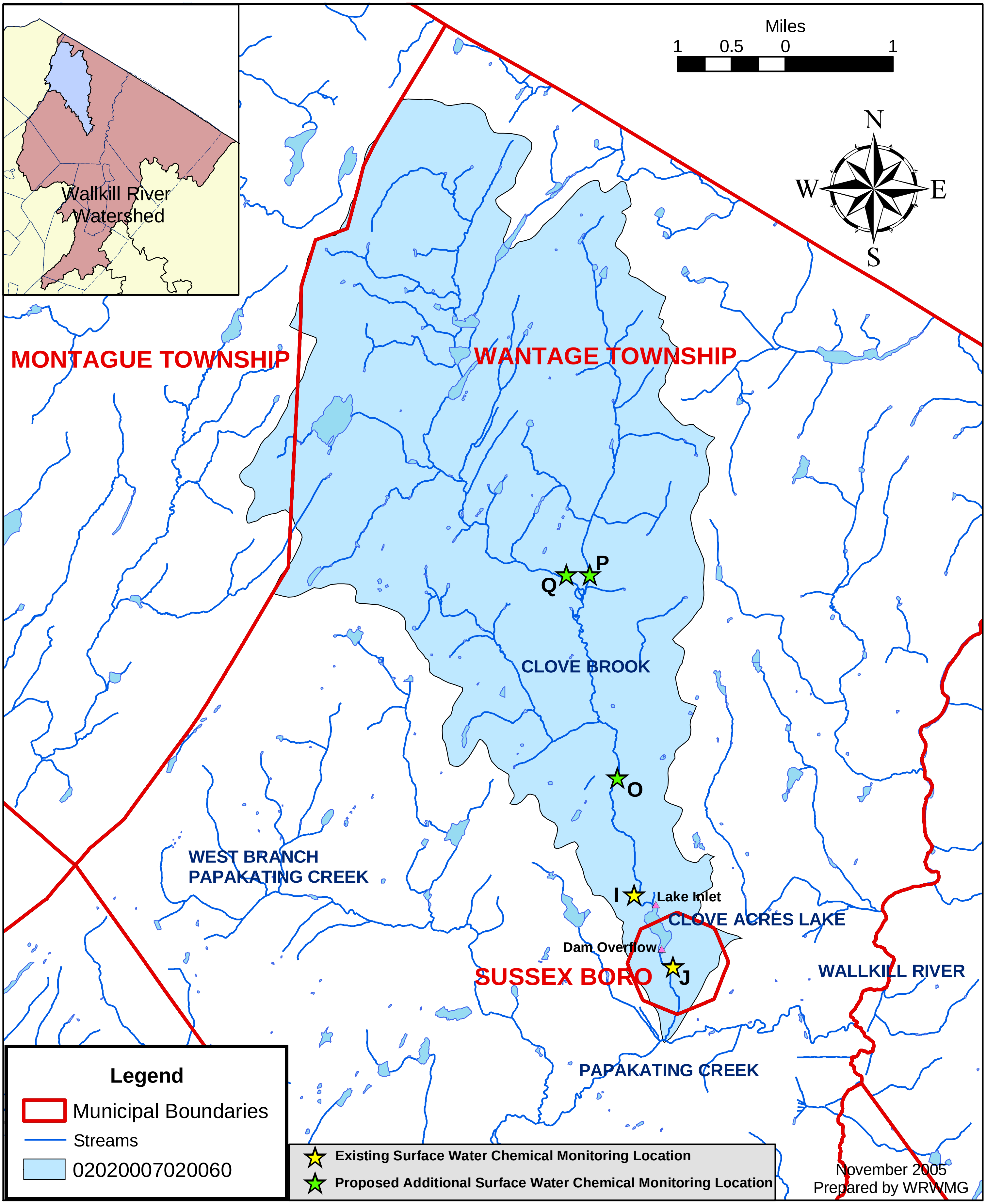
Figure 2.
Clove Acres Lakeshed Subwatershed Boundary

HUC # 02020007020060



June 30, 2004
Prepared by WRWMG, D.E.

Figure 3
Clove Acres Lakeshed and Clove Brook Surface Water Sampling Locations



Attachment 3

Clove Acres Lakeshed and Clove Brook
Chemical Sampling Site(s) Latitude / Longitude Recordings

Site	Site Location	Latitude	Longitude
"I"	Route 650 / Libertyville Road (Wantage Township)	41 13 213 N	074 36 875 W
"J"	Newton Avenue (Sussex Borough)	41 12 566 N	074 36 556 W
"O"	Route 23 / Smith Road (Wantage Township)	41 14 183 N	074 37 116 W
"P"	Route 651 / Rose Morrow Road (Wantage Township)	41 15 685 N	074 37 428 W
"Q"	Routes 651 / 23 (Wantage Township)	41 15 720 N	074 37 797 W

Note: GPS measurements by W. Dunn (HydroQual, Inc.; January 27, 2005)
Values in GPS Coordinate Units of hh mm.mmm (hh degrees mm.mmm minutes)

Attachment 4

Reference Documents

1. Kehrberger, Patricia, March 4, 2002, " *WMA 02 Quality Assurance/Quality Control Plan",* HydroQual, Inc.

2. Atherholt, Thomas, Ph.D., NJDEP, Division of Science, Research, and Technology, December 2004,"*Technology Critique – Microbial Source Tracking: Library Based Methods"*

3. NJDEP, "*Surface Water Quality Standard*s"

4. NJDEP, TMDL for Papakating Creek Streamshed

5. WMA 02 2005 SFY 319(h) Grant for the Clove Acres lake / Lakeshed (Attached)

6. NJDEP, June 2003," *Draft* - *Integrated Water Quality Monitoring and Assessment Methods"*

7. WMA 02, 2005 Contract

8. USGS, January 1999," *Field Manual for the Collection of Water-Quality Data*"

9. Hofer, Ernest; Sajdak, Nathaniel; Emerson, Dana, July 2004,"*Papakating Creek Watershed Stream Priority Assessment Report"*

10. Hofer, Ernest; Sajdak, Nathaniel, April 1, 2004. *" Papakating Creek / Black Creek Fecal Coliform Assessment Report"*

11. Hofer, Ernest; Sajdak, Nathaniel; Emerson, Dana; Sharma, Anil Ph.D., Coppolella, Mike, September 2-3, 2004. "*Papakating Creek Watershed 24-Hour Diurnal Dissolved Oxygen Sampling Program"*

12. Al-Ebus, Marzooq, NJDEP, Bureau of Environmental Analysis and Restoration, (BEAR); Email and telephone communications

13. Rancan, Helen; Milose, Jessica, March 2005, "*Appendix D – Quality Assurance Project Plan: Guidance for 319(h) Nonpoint Source Projects"*, Division of Watershed Management, NJDEP

QUALITY ASSURANCE PROJECT PLAN (QAPP)
"Lake Characterization and Restoration Plan for Clove Acres Lake"
Contract RP#: RP05-090

Prepared by: ______________________ Date: 4/5/06

Mr. Christopher L. Mikolajczyk
Princeton Hydro, LLC

Reviewed by: ______________________ Date: 4/5/06

Mr. Fred S. Lubnow, Ph.D.
Princeton Hydro, LLC

Reviewed by: ______________________ Date: 4/5/06

Mr. Ernest Hofer, P.E., Watershed Specialist
Walkill River Watershed Management Group

Reviewed by: ______________________ Date: 8/10/06

Dana Emerson, 319(h) Project Manager
Bureau of Watershed Planning

Reviewed by: ______________________ Date: 03/22/06

Helen Rancan, Statewide NPS Coordinator
Bureau of Watershed Planning

Approved by: ______________________ Date: 03/30/06

Marc Ferko, Quality Assurance Officer
Office of Quality Assurance

FINAL QUALITY ASSURANCE PROJECT PLAN
FOR CLOVE ACRES LAKE
SUSSEX COUNTY, NEW JERSEY

Submitted for the Proposed Scope of Work:
The Initiation of a Lake Characterization and Restoration Plan
RP05-090

Submitted to:

New Jersey Department of Environmental Protection
Division of Watershed Management
P.O. Box 418
Trenton, New Jersey 08625-0418

Submitted by:

Wallkill River Watershed Management Group
c/o Ernest Hofer, P.E. Watershed Specialist and
Mr. Nathaniel Sajdak, Watershed Coordinator
Sussex County Municipal Utilities Authority
Watershed Planning Division
34 South Route 94
Lafayette, New Jersey 07848

Prepared by:

Princeton Hydro, LLC
P.O. Box 720
1108 Old York Road, Suite 1
Ringoes, New Jersey 08551

September 2005
Revision I February 2006
Revision II March 2006

Second Phase of a two Phase QAPP

Project Name: Providing Technical Assistance in Conducting the Phase I Diagnostic / Feasibility Study for Clove Acres Lake

Project Requested By: Wallkill River Watershed Management Group (WRWMG)

Date Project Initiated: August 2005

Project Officer Name: Fred S. Lubnow, Ph.D.

Project Manager: Chris Mikolajczyk

Address: Princeton Hydro, LLC
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1108 Old York Road, Suite 1
Ringoes, New Jersey 08551

Phone: (908) 237-5660

QA/QC Officer Name: Fred S. Lubnow, Ph.D.

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P.O. Box 720
1108 Old York Road, Suite 1
Ringoes, New Jersey 08551

Phone: (908) 237-5660

Project Description

A. Scope Statement and Project Objectives

The Wallkill River Watershed Management Group (WRWMG) was awarded a Non-Point Source (NPS) grant under the 319 program under SFY 2005 to conduct a variety of projects throughout the Wallkill Watershed (WMA 02). One of the these projects is to conduct a Phase I Diagnostic / Feasibility Study of Clove Acres Lake, a 29-acre waterbody located in Wantage Township and Sussex Borough, Sussex County, New Jersey. As with other US EPA and NJ DEP Phase I Lake Studies, the main objectives of the project is the collection of a variety of in-lake and watershed data, the quantification of the lake's annual hydrologic and pollutant budgets and the development of a holistic Restoration Plan for the lake and the watershed.

The specific tasks of the proposed project include:

1. Update the bathymetry of the lake.

2. Collect some basic hydrologic information to develop a hydrologic budget for the lake.

3. Implement a two-year water quality-monitoring program that includes a total of six in-lake monitoring events.

4. Quantify an annual pollutant budget, which addresses total phosphorus, total nitrogen and total suspended solids.

5. Evaluate the targeted phosphorus load relative to the establishment of the clear water state.

6. Conduct a feasibility analysis to identify potential in-lake and watershed-based management techniques.

7. Assess and identify site-specific phosphorus load reduction strategies.

B. Data Usage

The data collected during this study will be utilized to develop a Restoration Plan for Clove Acres Lake and its watershed.

C. Sampling Procedures

All sampling procedures shall be in conformance with standard limnological practices and procedures listed in *Standard Methods for the Analysis of Water and Wastewater, 18th Edition* (American Public Health Association, 1992), State protocol (NJDEP, **2005**) and/or any applicable US EPA guidance document. Instrumentation used for the collection of field data (dissolved oxygen, temperature, pH and conductivity) shall be properly calibrated in conformance with manufacturer instructions. All sampling sites were chosen to be representative sites and are subject to the approval of the New Jersey Department of Environmental Protection (NJDEP) and the WRWMG.

The methodology for the biological parameters, such as chlorophyll *a*, are described in *Standard Methods for the Analysis of Water and Wastewater, 18th Edition* (American Public Health Association, 1992) and in *Limnological Analysis, Second Edition* (Wetzel and Likens, 1991).

D. Water Quality Monitoring Parameters and Frequency

1. Clove Acres Lake will be monitored six times over the course of two years. Specifically, the goal of this monitoring program will be to sample twice in the spring (late March / April), twice in early summer (late May /June) and twice in mid- to late summer (July / August / early September).

2. A total of three in-lake sampling stations will be identified for the monitoring program (see map in Appendix A). These sampling stations will include a southern sampling station (adjacent the dam), a mid-lake sampling station and a northern sampling station (next the main inlet). Prior to any sampling all in-lake sampling stations will be approved by NJDEP. **Upon approval of the in-lake sampling stations by the NJDEP, during the first sampling event the station locations will be documented and stored utilizing a Trimble GPS system. During the subsequent sampling events, the Trimble system will be utilized to return to the same sampling locations.**

3. *In-situ* water quality monitoring will be conducted at the three sampling stations established in Clove Acres Lake. Water column profiles of temperature, dissolved oxygen, pH and conductivity will be collected at 0.5 to 1.0 meter intervals from surface to bottom with a Eureka Amphibian with Manta multi-probe or similar meter at each sampling station. **While diurnal dissolved oxygen monitoring is a component of a typical Lake Characterization Plan, in the case of Clove Acres Lake it is beyond the original scope of work request.**

   Princeton Hydro is State certified for the collection of these four *in-situ* parameters (State ID # 10006). During each sampling event, at each sampling station, water clarity will also be measured with a Secchi disk. Princeton Hydro's certification for the *in-situ* parameters will expire 30 June 2006, which is prior to the end of the project. Therefore, Princeton Hydro will ensure that its certification is renewed to ensure that no lapses occur in certification.

4. Discrete **grab** water samples will also be collected during each **sampling event at the three in-lake sampling stations (L-1, L-2 and L-3)**. **Clove Acres Lake is an impoundment of Clove Brook and not a natural lake. The monitoring program takes this into consideration, since artificial waterbodies function inherently different than natural lakes. Thus, the detailed discrete monitoring of the lake will concentrate on the near-dam sampling station (L-1). In addition, L-1 is the deepest location of the lake and therefore thermal stratification / internal phosphorus loading will be strongest in this portion of the lake, a situation commonly experienced in artificial impoundments.**

5. During each sampling event, sub-surface **grab** (0.5 meters below the water's surface) samples will be collected **manually** for total phosphorus (TP), nitrate+nitrite-N (NO_3-N+NO_2-N), ammonia-N (NH_4-N), total suspended solids (TSS), and alkalinity at the **near dam sampling station (L-1)**. **Samples collected at Stations L-2 and L-3 will be analyzed for TP only.** State acceptable protocol will be followed in the collection and analysis of these discrete samples (APHA, 1992). **The following chart makes a quick reference to the in-lake sampling and analysis requirements:**

Lake Station ID	Analysis required
L-1	**TP, NO_3/NO_2-N, NH_4-N, TSS and Alkalinity**
L-1 Deep	**TP Only**
L-2	**TP Only**
L-3	**TP Only**

6. **Since the lake is only 34 acres in size, intra-lake variability will be minimal. Thus, in order to develop the most cost effective plan (that is a plan that is low in cost with a high return in data), the monitoring program focused discrete sampling on the deepest location in the lake. However, to obtain further TP data in regards to the lake's TMDL , Princeton Hydro will collect samples at Stations L-2 and L-3 for TP analysis.**

7. In addition to the sub-surface samples, a bottom water **grab** sample (0.5 meters above the sediments) will be colleted, **utilizing a Van Dorn water sampling device,** at the **L-1 sampling station** for the analysis of TP. This bottom water **grab** sample will be collected to provide information on the relative contribution of internal loading to the lake's annual phosphorus load.

8. **The mean depth of Clove Acre Lake is estimated to be between 1.8 and 2.4 meters (6 and 8 feet), with the maximum depth being between 3.0 and 3.6 meters (10 and 12 feet) adjacent to the dam. Based on the scientific literature and Princeton Hydro's experience, such shallow depths in an artificial impoundment are indicative of a well-mixed or polymictic system. Under such conditions, mid-depth and bottom water samples at shallower stations do not necessarily provide additional insight from the perspective of developing a cost effective water quality monitoring program. Therefore, no mid-depth or bottom water samples are required for L-2 and L-3. Since L-1 is greater than 8 feet, there is the opportunity for sustained thermal stratification. Under such conditions, a depletion of dissolved oxygen can occur, resulting in an increase in the internal phosphorus load. Thus, a bottom water sample will be collected from L-1 for the analysis of TP. The collection of mid-depth samples tends to be important in deeper waterbodies or reservoir (depths greater than 50 feet) where mid-depth algal blooms or mid-depth water withdrawals are important to consider. However, give the size and morphometry of Clove Acres Lake, the most cost effective approach is to collect bottom water samples at L-1 for the analysis of total phosphorus.**

9. A field duplicate and rinse blank will also be collected during each in-lake and tributary sampling event. Field duplicates will be collected from a different sampling station, and for a different water quality parameter, during each individual sampling event.

10. In addition to the chemical parameters, an additional **grab** sub-surface water sample will be collected **(0.5 meters below the water's surface) manually** at **L-1** during each sampling event for the analysis of chlorophyll *a*. Measuring chlorophyll *a*, a photosynthetic pigment possessed by all algal groups, is an effective means of quantifying algal biomass.

11. In order to quantify the current phosphorus loads entering Clove Acres Lake on an empirical basis, a certain amount of tributary monitoring is required. Such detailed, site-specific data will be necessary to refine the phosphorus TMDL for Clove Acres Lake. This site-specific tributary data will include measurements of flow and the collection of TP and TSS **grab** samples along the main inlet (**S-1**). **This inlet sampling will occur in conjunction with each in-lake sampling event, for a total of six inlet sampling events.** It should be emphasized that no tributary monitoring or sampling will occur until the identified sampling location is approved by NJDEP. **Upon approval of the in-lake sampling stations by the NJDEP, during the first sampling event the station locations will be stored utilizing a Trimble GPS system. During the subsequent sampling events, the Trimble system will be utilized to return to the same sampling locations.**

12. A staff gauge will be installed at the NJDEP-approved main inlet tributary sampling station, while a staff gauge already exists at the lake's outlet. During each lake sampling event, flow measurements will be collected at the inlet and outlet. A relationship will be established between stream flow and staff gauge height to predict water flow. The flow data will be used to estimate the hydrologic load entering the lake from the inlet (baseflow), as well as the hydrologic load leaving the lake via its outlet.

13. During each in-lake sampling event, detailed measurements of baseflow will be conducted at the NJDEP-approved tributary sampling station, established along the main stem of Clove Brook. **Baseflow conditions are defined as a period at which at least 72 hours have elapsed with no substantial amount of precipitation (< 0.1 inch).**

14. The measured baseflow will utilize USGS standard protocols (USGS 1969) to conduct detailed and precise measurements of the discharge with a flow meter USGS type AA model 6200). Staff gage depth readings will be taken immediately prior to and immediately after discharge measurements. The two values will be averaged to provide an integrated estimate of the depth at the staff gauge coincidental to the discharge measurements. *In-situ* data (**Eureka Amphibian with Manta multi-probe**) will also be collected during each baseflow measurement for temperature, dissolved oxygen, pH and conductivity. **Baseflow conditions are defined as a period at which at least 72 hours have elapsed with no substantial amount of precipitation (< 0.1 inch).**

15. In addition to the water quality parameters, a limited amount of quantitative biological data will be collected to provide detailed ecological information on Clove Acres Lake. **A grab sub-surface water sample will be collected (0.5 meters below the water's surface) manually at the L-1 during each sampling event for the analysis of chlorophyll *a*.** For the sake of the project, quantitative biological monitoring will be limited to the collection of discrete samples for the analysis of chlorophyll *a*, a

photosynthetic pigment all algae possess. Thus, measuring chlorophyll *a* is an effective means of quantifying algal biomass.

16. **Qualitative samples will be collected for the identification of the dominant phytoplankton and zooplankton in Clove Acres Lake. During each sampling event a sub-surface, whole water sample will be collected at L-1 and preserved with Lugol's solution for the identification of the dominant phytoplankton genera. Additionally, a Schindler plankton trap will be used to collect sub-surface and bottom water samples for the identification of the dominant zooplankton at L-1. These samples will also be preserved with Lugol's solution. All plankton samples will be transported to Princeton Hydro's biological laboratory. Since the samples would be collected for the qualitative examination of the dominant plankton it was not included in the original QAPP. From recently submitted QAPPs for other projects, it is understood that plankton samples need to be sent to a third party for verification. When the original Scope of Work for this project was developed, this was not incorporated into the plan. Therefore, to avoid such a requirement, it was decided to only collect qualitative samples for the identification of dominant organisms, utilizing may of common used keys. Since the TMDL for Clove Acres Lake is for total phosphorus, such a qualitative examination of the plankton seemed appropriate and therefore no quantitative examination will be completed.**

17. Observational data will be collected on the aquatic macrophyte community during each sampling event to identify desirable, nuisance and invasive plant species that may be present in Clove Acres Lake. The staff of Princeton Hydro is well trained and experienced in the identification of macrophytes to the species level.

E. Parameter Table

Summaries of all water quality parameters to be measured and analytical methods to be used are shown in Table 1. This table was developed in coordination with the independent analytical laboratory; Environmental Compliance Monitoring, Inc. (ECM), who will follow the methods and protocols listed in Table 1. ECM will be responsible for all laboratory analyses. Princeton Hydro, LLC will also conduct all *in-situ* water quality monitoring, as well as collect observational data on water clarity (Secchi depth) and the aquatic plant community.

Information on project detection limits, levels of interest, precision and accuracy for discrete parameters of interest is listed in Table 2. This table was developed in conjunction with Mr. Thomas Grenci of ECM, Inc. and indicates the data quality that is expected for this study. Information on project detection limits, levels of interest, precision and accuracy for the *in-situ* parameters is listed in Table 3.

Data Comparability: Analytical data comparability will be achieved by following the analytical methodology, preservation practices and holding times described in Table 1. Each parameter will be analyzed using the referenced methodology and changes in analytical procedures will not take place from sample to sample. The same holds true for sample preservation, holding times and QA/QC practices. The methods used are standard analytical methods that will also allow comparisons with data from the earlier and other projects.

Data Completeness: Data will be considered complete and usable for decision-making when all results have been completed and submitted to the New Jersey Department of Environmental Protection, and the WRWMG, in accordance with the sampling and analytical methodology and the required QA/QC practices listed in this project plan. However, it is recognized that some data loss may occur as a result of factors such as sampling equipment malfunction, losses during sample handling, or analysis outside of laboratory acceptance limits. Samples will be re-analyzed if results are outside of laboratory acceptance limits, providing that sufficient sample volume is available and that holding times for the affected parameters(s) have not been exceeded. **If there is a loss of samples, it is required that sampling events are repeated until such events result in six (6) verified sampling data sets.**

Spiking Protocol: ECM, the State certified laboratory who will be conducting the analysis of the discrete samples, identified the frequency of spiking of the samples is one for every twenty samples. Princeton Hydro will also contact ECM to request and ensure that the Clove Acres Lake samples be used for spiking procedures.

Project Schedule, Organization and Responsibility

Table 4 displays the sampling schedule for the Clove Acres Lake monitoring program. The sampling schedule shown in Table 4 was developed to comply with the schedule proposed in the Non-Point Source (319) grant application for completing the proposed monitoring program of Clove Acres Lake by the end of September 2007. The New Jersey Department of Environmental Protection awarded this grant to the WRWMG.

Princeton Hydro, LLC, will coordinate and implement all of the project activities associated with the Characterization and Restoration Plan for Clove Acres Lake. Dr. Fred S. Lubnow will serve as project director, ensuring that all tasks and activities are completed in a timely manner and as described in the project Scope of Work. In addition, Mr. Chris Mikolajczyk will serve as the project manager, whose responsibilities will include overall project coordination, data management, and the preparation of project reports, documents and deliverables.

The review and approval of this QAPP will be under the direction of Ms. Dana Emerson of the New Jersey Department of Environmental Protection.

Fiscal management and administration of the project will be the responsibility of the WRWMG. Additional project support will be provided by the Sussex County Municipal Utilities Authority, Borough of Sussex and Township of Wantage.

The key individuals who will be responsible for various project tasks are listed in Table 4. Mr. Chris Mikolajczyk of Princeton Hydro, LLC will be responsible for lake sampling operations and plankton identification. Environmental Compliance Monitoring Inc., of Neshanic Station, NJ, will perform the chemical analyses for the project under the direction of Mr. Thomas Grenci.

Table 1 – Parameters for the Clove Acres Lake and Watershed Restoration Plan

Parameter	Analytical Method Reference* (Standard Methods)	Sample Container and Preservation Method	Holding Time (Maximum)
Soluble Orthophosphate	4500-P E	1 Pint plastic, Filter, cool to 4^oC	48 hours
Total Phosphorus	4500-P B-5 and 4500-P E	1 Pint plastic, H_2SO_4 added to pH <2, cool to 4^oC	28 days
Total Dissolved Phosphorus	4500-P B-5 and 4500-P E	1 Pint plastic, Filter, H_2SO_4 added to pH <2, cool to 4^oC	28 days
Nitrate-N + Nitrite-N	419D/4500 NO_2B EPA 354.1/352.1	1 Pint plastic, cool to 4EC	48 hours
Ammonia-N	4500-NH_3 B	1 Pint plastic, H_2SO_4 added to pH <2, cool to 4EC	28 days
Total Kjeldahl Nitrogen	4500orgBC	1 Pint plastic, H_2SO_4 added to pH <2, cool to 4EC	28 days
Alkalinity	2320	1 Pint plastic, cool to 4^oC	14 days
Total Hardness	2340C	1 Pint plastic, HNO_3 added to pH <2, cool to 4^oC	6 months
Total Suspended Solids	2540 D	1 Pint plastic, cool to 4^oC	7 days

* As per Standard Methods (American Public Health Association, 1992).

Table 1 – Parameters for the Clove Acres Lake and Watershed Restoration Plan (continued)

Parameter	Analytical Method Reference* (Standard Methods)	Sample Container and Preservation Method	Holding Time (Maximum)
Conductivity Profile	2510 B	*in situ*	N/A
pH Profile	4500-H^+ B	*in situ*	N/A
Dissolved Oxygen Profile	4500-O G	*in situ*	N/A
Temperature Profile	2550 B	*in situ*	N/A
Chlorophyll *a*	10200 H 1 & 2	1 Quart plastic, then filter in field, freeze at -20^{o}C	30 days

* As per Standard Methods (American Public Health Association, 1992).

Table 2

Information on Detection Limits, Precision and Accuracy for Discrete Water Quality Parameters

PARAMETER DETECTION LIMITS, QUANTITATION LIMITS, ACCURACY, AND PRECISION								
Parameter	Method Detection Limit - MDL	Instrument Detection Limit - IDL	Project Detection Limit - PDL	Practical Quantitation Limit - PQL	Accuracy (Mean % Recovery)	Precision (Mean-RPD)	Accuracy Protocol % Rec for LCL/UCL	Precision Protocol UCL %RR (Max. RPD)
Parameter								
Ammonia-N	0.01 mg/L	0.009 mg/L	0.01 mg/L	0.05 mg/L	31 - 155	± 35	31 - 155	± 35
Nitrate-N	0.02 mg/L	0.0015 mg/L	0.02 mg/L	0.10 mg/L	44 - 160	± 11	44 - 160	± 11
Nitrite-N	0.002 mg/L	0.0002 mg/L	0.002 mg/L	0.010 mg/L	67 - 127	± 19	67 - 127	± 19
Total Phosphate-P	0.02 mg/L	0.0008 mg/L	0.02 mg/L	0.10 mg/L	70 - 120	± 13	70 - 120	± 13
Total Suspended Solids	3 mg/L	NA	3 mg/L	15 mg/L	NA	± 76	NA	± 76
Alkalinity (as $CaCO_3$)	1.3 mg/L	NA	1.3 mg/L	6.5 mg/L	NA	± 33	NA	± 33
Chlorophyll a	0.3 mg/M^3	NA	0.3 mg/M^3	1.5 mg/M^3	NA	± 31	NA	± 31

Note:

N/A – Non Applicable

MDL – Minimum concentration of a substance that can be measured and reported with a 99% confidence level that the analyte concentration is greater than zero. (see 40CFR 136 Appendix B)

IDL – Based on five times the photometric noise times the factor sum from the analyte calibration curve.

PDL – Will generally be the same as the MDL; however, PDL may increase towards the PQL based on sample matrices.

PQL – Represents a practical and routinely achievable detection limit with a relatively high certainty that any reported value is reliable. The PQL is often 3 to 5 times the MDL.

Table 3

Information on Detection Limits, Precision and Accuracy for *In-Situ* Parameters

Parameter	Sample Matrix	Detection Limit	Level of Interest	Relative Percent Difference	Percent Recovery
Conductivity Profile	Water	1 μmhos/cm	1 μmhos/cm	N/A	N/A
pH Profile	Water	0.1 Standard Unit	0.1 Standard Unit	N/A	N/A
Dissolved Oxygen Profile	Water	0.1 mg/L	0.1 mg/L	N/A	N/A
Temperature Profile	Water	0.5° Celsius	0.5° Celsius	N/A	N/A

Table 4

Proposed Schedule of Sampling Events for the Monitoring Program of Clove Acres Lake

Sampling Year	Apr	May	Jun	Jul	Aug	Sep
2006	X		X		X	
2007	X		X		X	

Table 5 - Project Responsibility

Area of Responsibility	Name	Affiliation
State-Based Project Management	Ms. Dana Emerson	New Jersey Department of Environmental Protection
Project Management	Chris Mikolajczyk	Princeton Hydro, LLC
Project Director	Fred Lubnow, Ph.D.	Princeton Hydro, LLC
Laboratory Analysis	Thomas Grenci	Environmental Compliance Monitoring, Inc.
Laboratory QC	Suzanne Armbruster	Environmental Compliance Monitoring, Inc.
Data Processing	Fred Lubnow, Ph.D.	Princeton Hydro, LLC
Data Processing QA/QC Officer	Chris Mikolajczyk	Princeton Hydro, LLC
Data Quality Review	Fred Lubnow, Ph.D.	Princeton Hydro, LLC
Performance Auditing	Suzanne Armbruster	Environmental Compliance Monitoring, Inc.
Systems Auditing	-----	New Jersey Department of Environmental Protection
Overall QA	Chris Mikolajczyk	Princeton Hydro, LLC
Overall Coordination	Chris Mikolajczyk	Princeton Hydro, LLC

Chain of Custody Procedures

Chain of Custody (COC) procedures will be utilized once the samples are collected and transported to the laboratory for analysis. Personnel responsible for sampling operations will inform the analytical laboratory at least twenty-four (24) hours in advance of the date that lake monitoring samples will be delivered.

The sample collector will be required to record the following information on the sampling container and field data sheets: sample number and/or station, date and time of collection, source, preservation technique and collector's name. The sample collector will also record pertinent field data; field observations and the analyses required on the field data sheets. A chain of custody form will be completed to identify the analyses requested and will be submitted to the laboratory at the time of sample delivery.

Following collection, samples will be placed on ice in an insulated container for transport to the laboratory. The sample collector or Princeton Hydro, LLC will deliver the samples to the laboratory, where laboratory personnel will visually inspect all sample containers to confirm the method of transportation, date of collection and preservation techniques. Samples will not be accepted and fresh samples will be requested if for any reason the holding time was exceeded, proper preservation techniques were not followed or transportation conditions were unsuitable.

Calibration Procedures and Preventive Maintenance

Field equipment will be calibrated on each sampling date in accordance with the manufacturer's instructions. Any problems will be corrected before samples are collected.

The Eureka Amphibian with Manta multi-probe or similar meter (i.e. Quanta, Eureka or similar device) will be used to monitor temperature, dissolved oxygen, pH and conductivity. Prior to each sampling event, the Eureka will be calibrated for these water quality parameters. The calibration standards will bracket the expected range for the monitoring. All of the calibration information will be documented. Calibration information will include, but will not be limited to, dates of calibration, name of person performing calibration, any problems and, if so, how they were corrected.

Environmental Compliance Monitoring, Inc. is a State-certified Laboratory that maintains an active Quality Assurance/Quality Control (QA/QC) program to ensure that the collected data will meet all project requirements and that laboratory instruments are properly calibrated. Standards will be analyzed with each batch of samples to ensure that instruments are operating properly. These procedures are in accordance with all applicable State and Federal regulations.

Documentation, Data Reduction, and Reporting

All QA/QC data and project information will be collected according to applicable State and Federal regulations. All data will be included in the final Lake Characterization and Restoration Plan report and will be kept on file by Princeton Hydro, LLC for a minimum of five years.

Data Validation

Data validation will be performed by Princeton Hydro, LLC and will be provided with the final report. If blank contamination is found in the equipment rinse blank, all water quality data with results less than five (5) times the concentration found in the blank should be flagged "B". The "B" qualifier indicates that the reported results may be an anomaly as a result of contamination of the blank.

Performance and Systems Audits

A. Performance Auditing

ECM is a State of New Jersey certified laboratory (Certification #18630). The laboratory participates in Performance Evaluation (PE) Studies for each category of certification and accreditation and is required to pass each of these PE studies in order to maintain certification. The NJDEP conducts performance audits of each laboratory that is certified or accredited.

ECM also participates in several additional programs to ensure data accuracy. The laboratory participates in US EPA water pollution (WP) and water supply (WS) studies and the discharge monitoring report (DMR-QA/QC) program.

Princeton Hydro is State certified (State ID # 10006) for the collection of water samples and *in-situ* field monitoring of temperature, pH, dissolved oxygen and conductivity using a multi-probe data sonde and similar monitoring meters.

B. Systems Auditing

The NJDEP periodically conducts on-site Technical Systems Audits (TSA) of each certified laboratory. The findings of these audits, together with the US EPA Performance Evaluation results, are used to update each laboratory's certification status.

Corrective Action

The project QA Officer will ensure that all data for the project are generated in accordance with procedures outlined in this QA/QC Project Plan. Quality control samples will be analyzed with each sample batch and results will be provided with the data reports. If a QC sample provides unacceptable results during any given day, the sample analysis must be repeated for those parameters affected. All project participants will immediately report any deficiencies to the QA Officer. The QA Officer will recommend appropriate corrective action and determine the acceptability of affected data when deficiencies are noted.

The QA Officer will notify the Project Director of any unacceptable data to ensure that it is not included in evaluations of water quality for reporting purposes. The QA Officer shall notify the Project Director in writing anytime a deviation from the approved plan occurs. Results of all corrective actions will then be documented.

Reports

Quarterly progress reports will be submitted to the NJDEP and the WRWMG. The progress reports will include monitoring data, a description of completed and planned activities, and other project task-related information. All data collected, as part of this project, will be integrated into the Clove Acres Lake Characterization and Restoration Plan. A final report will be prepared at the conclusion of the Project. The final report will include a summary of the water quality conditions of Clove Acres Lake and its main inlet, as well as a Characterization and Restoration Plan that will provide additional, site-specific information to refine the TMDL. All limnological and watershed data will also be included in the final report and will be provided to NJDEP and the WRWMG.

References

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Maidment, D. R. 1993. *Handbook of Hydrology*. McGraw-Hill, New York.

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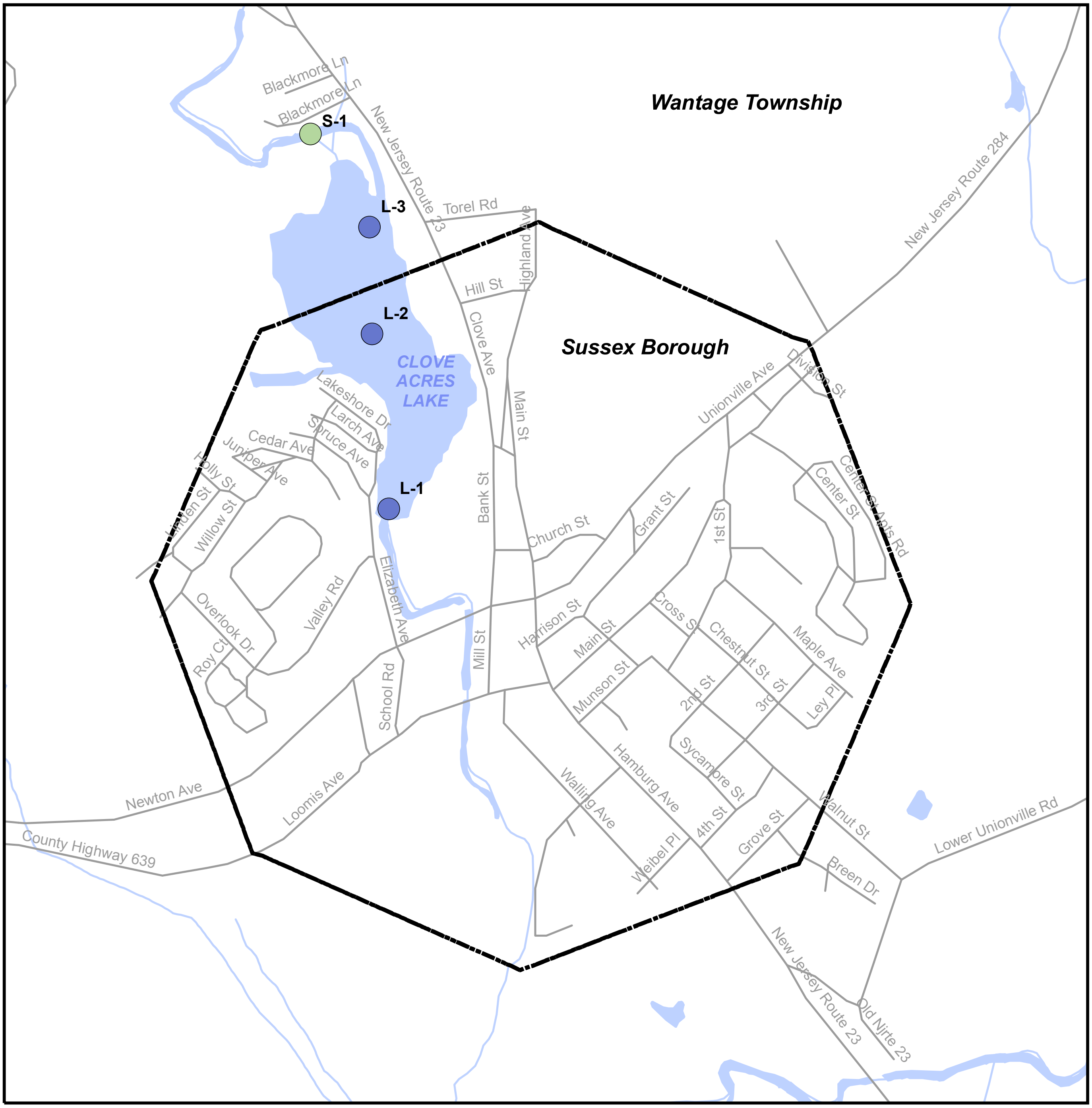
Wetzel, R.B., and G.E. Likens. 1991. *Limnological Analysis, Second Edition*. Springer – Verlag. New York.

United States Environmental Protection Agency. 1980. *Clean Lakes Program Guidance Manual.* Report No. EPA 440/5-81-003. USEPA, Washington, D.C.

APPENDIX A



Princeton Hydro

Clove Acres Lake Phase I Study
(Sussex County MUA 319 grant)

CLOVE ACRES LAKE
WANTAGE TOWNSHIP AND SUSSEX BOROUGH
SUSSEX COUNTY, NEW JERSEY

Lake Sampling Station
Stream Sampling Station
Municipal Boundary
Roads
Streams
Lakes

N
W E
S

1 inch equals 1,000 feet

0 250 500 1,000
Feet

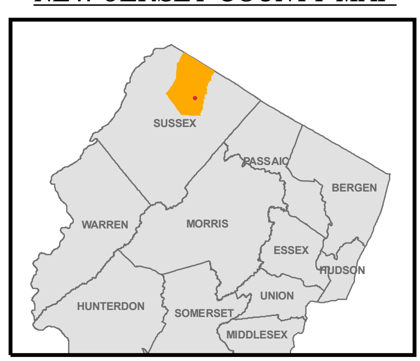
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. Municipal boundaries, lakes, and streams obtained from NJDEP

2. Road files obtained from TIGER

NEW JERSEY COUNTY MAP



APPENDIX B

CHAIN-OF-CUSTODY

ECM

environmental compliance monitoring, inc

NO.

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME				NO. OF CON-TAINERS	NO PRESERVATIVE	SULFURIC ACID	NITRIC ACID	SODIUM HYDROXIDE	Hydrochloric Acid	OTHER	SAMPLE DESIGNATION NUMBERS				
DATE	SAMPLERS															
SAMPLE DATE	TIME	COMP	GRAB	STATION LOCATION								JOB #	LOT #	SAMPLE DATE	SAMPLE #	BOTTLE ID
														B		
													A			
												L				
															E	
														S		
													U			
																Y
															L	
														N		
													O			

COOLER TEMP	pH < 2 Y N N/A	pH > 10 Y N N/A	COMMENTS

RELINQUISHED BY: (*Signature*)	DATE/TIME	RECEIVED BY: (*Signature*)	DATE/TIME
RELINQUISHED BY: (*Signature*)	DATE/TIME	RECEIVED BY: (*Signature*)	DATE/TIME
RELINQUISHED BY: (*Signature*)	DATE/TIME	RECEIVED BY: (*Signature*)	DATE/TIME

Characterization Study and Restoration Plan for Clove Acres Lake, Sussex County, New Jersey

PREPARED FOR:

Wallkill River Watershed Management Group (WRWMG)
Sussex County Municipal Utilities Authority (SCMUA)
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Lafayette, NJ 07848
(973)-579-6998 x 109
Email: nsajdak@scmua.org

PREPARED BY:

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120 East Uwchlan Avenue, Suite 204
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September 2008
Princeton Hydro, LLC

TABLE OF CONTENTS

Section 1 Introduction

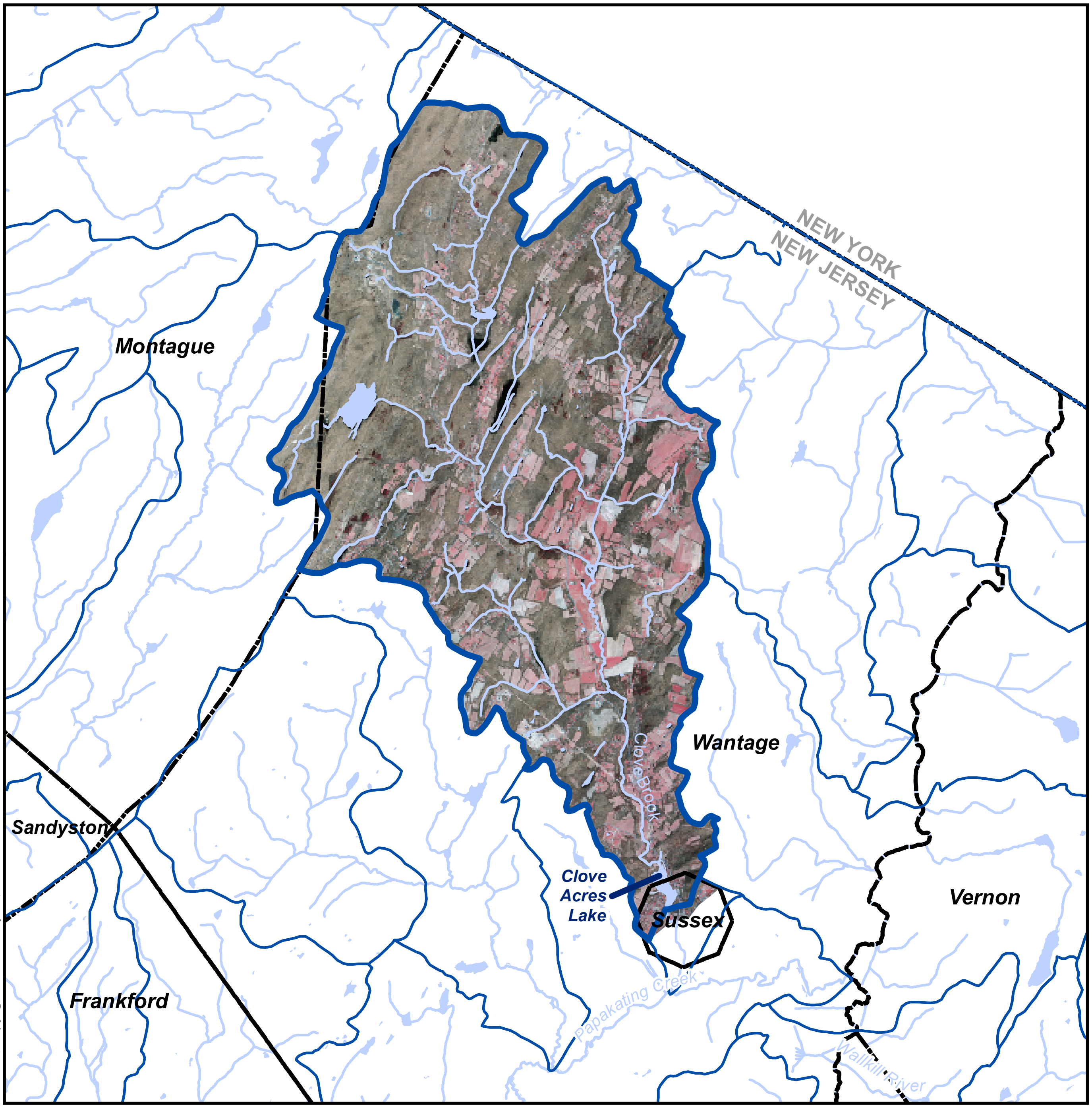
The Wallkill River Watershed Management Group (WRWMG) was awarded a Non-Point Source (NPS) grant under the 319 program under SFY 2005 to conduct a variety of projects throughout the Wallkill River Watershed (WMA 02). One of the these projects is to conduct a Lake Characterization of Clove Acres Lake, a 32.5-acre water body located in Sussex Borough and Wantage Township, Sussex County, New Jersey (Figure 1). As with other United States Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection (NJDEP) Lake Characterization studies, the assessment was done in accordance with NJDEP Lake Characterization Protocol, and as such, the main objectives of this project is the collection of a variety of in-lake and watershed data (Clove Acres Lake is a part of the NJDEP HUC 14 # 02020007020060 watershed), the quantification of the lake's annual hydrologic and pollutant budgets and the development of a holistic Restoration Plan for the lake and the watershed.

The tasks implemented in the completion of this assessment consist of the following:

1. In-Lake Water Quality Monitoring
2. Pollutant Budget Analysis
3. Bathymetric Survey
4. Basic Hydrologic Analysis
5. Evaluation of the Phosphorus Target to Maximize a Clear Water State
6. Identification of Load Reduction Strategies (including a fishery survey)

This report presents the findings as based on the completion of the water quality monitoring effort as well as the results of the bathymetric survey and nutrient and sediment budget analyses, fishery survey and finally Restoration Plan recommendations.

Although Clove Acres Lake serves as a recreational water body for fishing and canoeing, it does experience water quality problems through the growing season. Excessive densities of the invasive, submerged aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*) is the primary water quality problem in Clove Acres Lake. Thus, a substantial portion of this Lake Characterization and Restoration Plan will focus on addressing and reducing the excessive densities of this nuisance exotic plant. However, the resulting Restoration Plan generated as part of this study will also be pro-active in nature, quantifying the lake's current pollutant loads (i.e. nitrogen, phosphorus and suspended solids) and providing recommendations on how to prevent additional declines in water quality in the future.



Princeton Hydro

FIGURE 1 - 2002 AERIAL PHOTOGRAPH

CLOVE ACRES LAKE WATERSHED
SUSSEX BOROUGH AND WANTAGE TOWNSHIP
SUSSEX COUNTY, NEW JERSEY
GRANT RP05-090

LEGEND

- Project Area
- HUC14 Boundaries
- Lakes
- Streams

N W E S

1 inch equals 1.5 miles

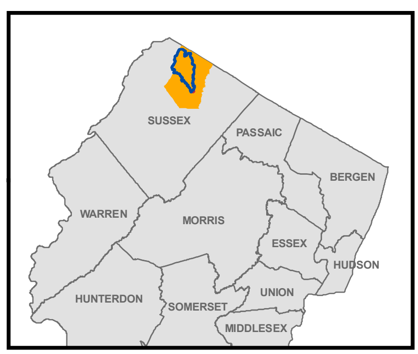
0 0.75 1.5 Miles

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. Watershed boundary, streams, and lakes as obtained from the NJDEP GIS website.
2. New Jersey 2002 High Resolution Orthophotography obtained from the New Jersey Image Warehouse.

NEW JERSEY COUNTY MAP



Section 2 Characterization of Lake Morphometry

Clove Acres Lake has a surface area of 32.5 acres (13.2 hectares) and is almost oval in shape (Figure 1). Water flows to the Lake via Clove Brook. The damming of the Brook forms Clove Acres Lake. In turn, water from Clove Acres Lake flows both over and under the dam simultaneously, depending upon seasonal water levels, and eventually drains in a southeastern direction into the Papakating Creek. The Papakating Creek then drains into the Wallkill River soon thereafter. As mentioned previously, Clove Acres Lake is a part of the overall NJDEP Watershed Management Area 02.

The lake is obviously a shallow system, with a mean depth of 4.8 ft (1.5 m) and a maximum depth of 13.5 ft (4.1 m). The resulting volume of water within Clove Acres Lake is 140 acre-ft (173,000 m^3). As will be shown in more detail later in the report, the general shape and morphometry of the lake will have a direct impact on the development of the lake's Management Plan.

A bathymetric survey of Clove Acres Lake was conducted by Princeton Hydro on 24 April 2007. A series of transects were surveyed with a dual frequency fathometer and tied into GPS via a field laptop computer. The collected data were used to generate a bathymetric map of the lake (Figure 2). In turn, the analyzed data were used to planimetrically calculate the lake's total volume as well as generate the bathymetric contours (Table 1 and Figure 2, respectively).

In addition to water depth, data were collected on the depth or "thickness" of the unconsolidated sediments in Clove Acres Lake. The quantified sediment thickness data were used to calculate the total volume of unconsolidated sediments in the lake (Figure 3). Such data are absolutely essential in order to quantify the costs associated with any future potential dredging projects.

Finally, the morphometric data were combined with select hydrologic data to calculate the hydraulic residence time and annual flushing rate, two important parameters to consider in the management of a lake. The hydraulic residence time is the amount of time required to completely replace a lake's current volume with "new" water. It can also be thought of how long one molecule of water will be in the lake before it leaves via the main outflow. The annual flushing rate, which is the inverse of the hydraulic residence time, is the rate at which water enters and leaves a lake relative to its volume. As will be shown in Sections 5 through 7, these parameters aid in determining how efficiently incoming nutrients are assimilated by algae and aquatic plants. In turn, this will determine a lake's level of productivity and its observed water quality conditions through the growing season.

TABLE 1

Lake and Watershed Characteristics for Clove Acres Lake

Parameter	Value
Lake Surface Area	32.5 acres
Watershed Area	12,557 acres
Mean Depth	4.8 feet
Maximum Depth	13.5 feet
Lake Volume	173,000 m^3
Hydraulic Residence Time	1.80 days
Flushing Rate	199.18 times/year
Watershed Area/Lake Surface Area	385.5

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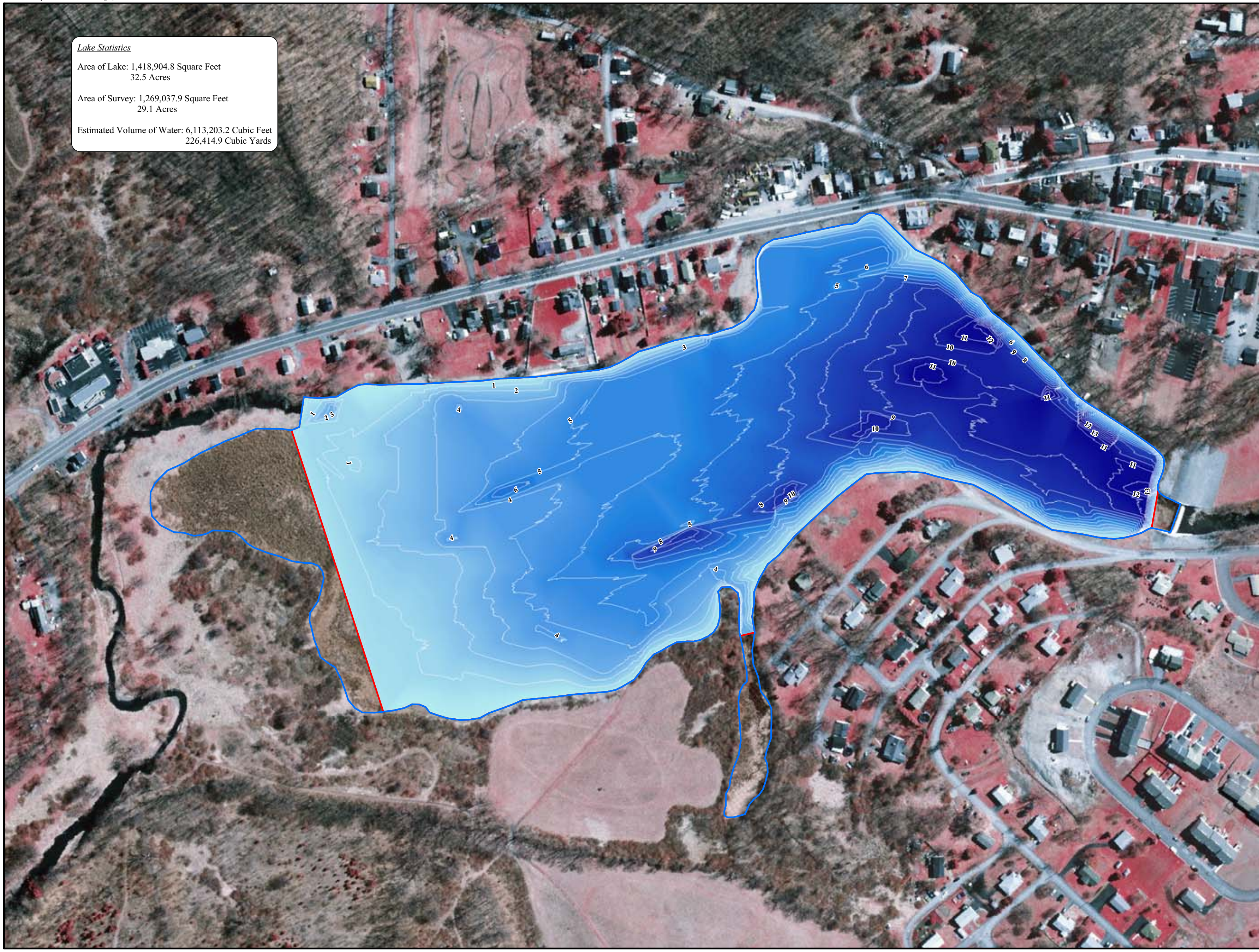
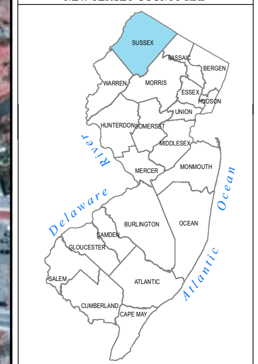


NEW JERSEY COUNTY MAP



SOURCES:

1. 2002 Aerial Photograph obtained from the New Jersey Image Warehouse website.
2. Bathymetry performed by Princeton Hydro, LLC on April 24th, 2007, utilizing a Knudsen EchoSounder in unison with a Trimble ProXH GPS unit.
3. Bathymetric data post-processed with Hypack Max software. All modeling and calculations completed with ESRI's ArcGIS and various extensions.

N

0 50 100 200 Feet

1 inch equals 100 feet

PREPARED FOR:

Sussex County Municipal Utilities Authority

PRINCETON HYDRO, LLC

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FAX. 856.346.0060
WWW.PRINCETONHYDRO.COM
OFFICES IN RINGOES,NJ AND EXTON, PA

PROJECT NAME/LOCATION:

BATHYMETRIC SURVEY OF CLOVE ACRE LAKE
SUSSEX MUNICIPAL UTILITIES AUTHORITY
SUSSEX BORO, SUSSEX COUNTY
NEW JERSEY

DRAWING NAME:

FIGURE 2 -
WATER DEPTH CONTOURS

Legend

- Lake Boundary
- Survey Limits
- Area Not Surveyed
- Water Depth Contours

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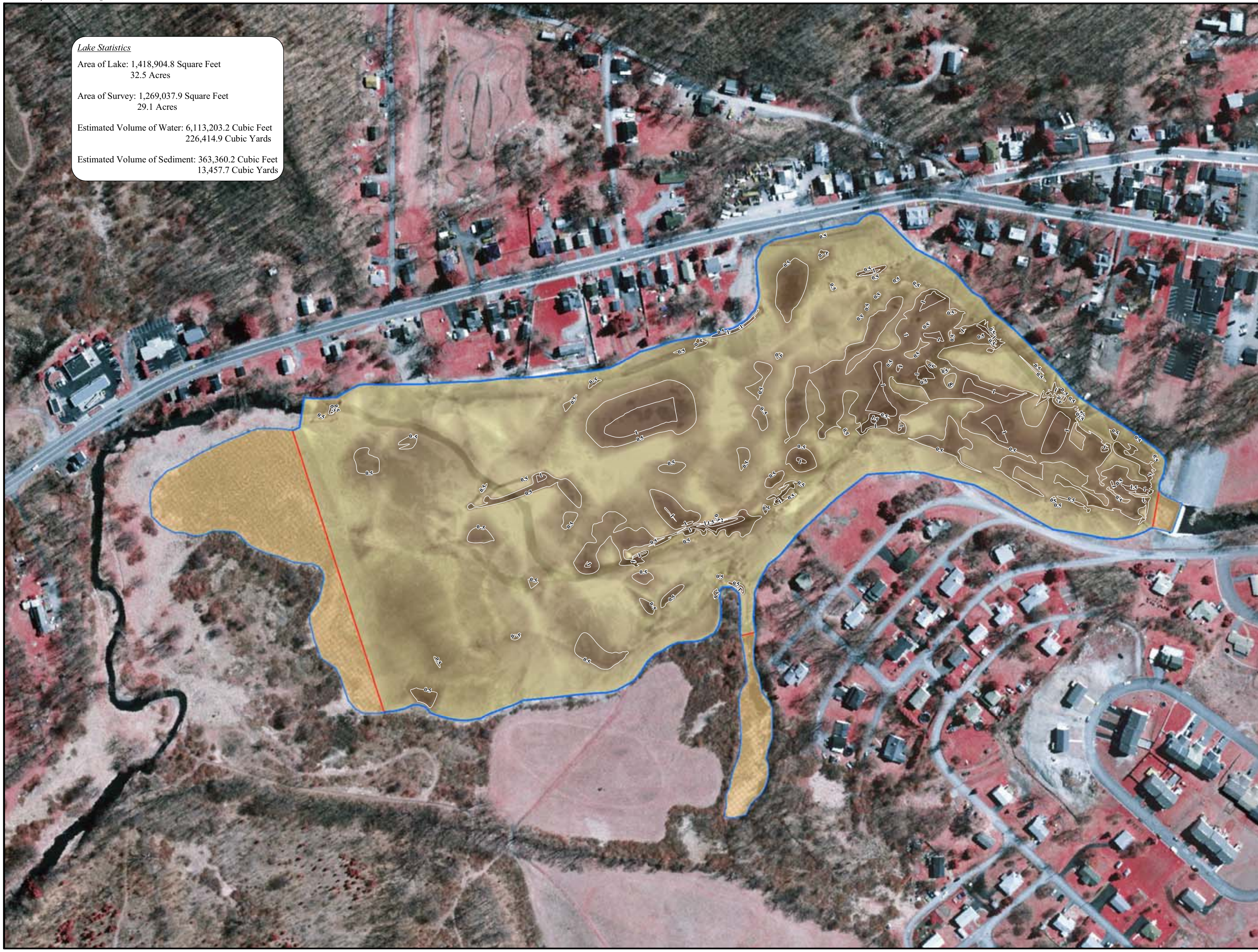
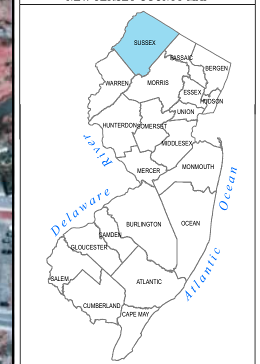


NEW JERSEY COUNTY MAP



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PROJECT NAME/LOCATION:

BATHYMETRIC SURVEY OF CLOVE ACRE LAKE
SUSSEX MUNICIPAL UTILITIES AUTHORITY
SUSSEX BORO, SUSSEX COUNTY
NEW JERSEY

DRAWING NAME:

FIGURE 3 - SEDIMENT THICKNESS CONTOURS

Legend

- Sediment Thickness Contours
- Area Not Surveyed
- Lake Boundary
- Survey Limits

Section 3 Water Quality Data

Clove Acres Lake was sampled six (6) times by Princeton Hydro, LLC during the 2006 and 2007 growing seasons: 11 May 2006, 13 July 2006, 21 September 2006, 25 April 2007, 11 July 2007 and 26 September 2007. These sampling events were conducted to document the general "health" of the lake and aid in the quantification and refinement of its annual pollutant budgets. Both *in-situ* and discrete water quality sampling was conducted for a variety of physical, chemical and biological parameters.

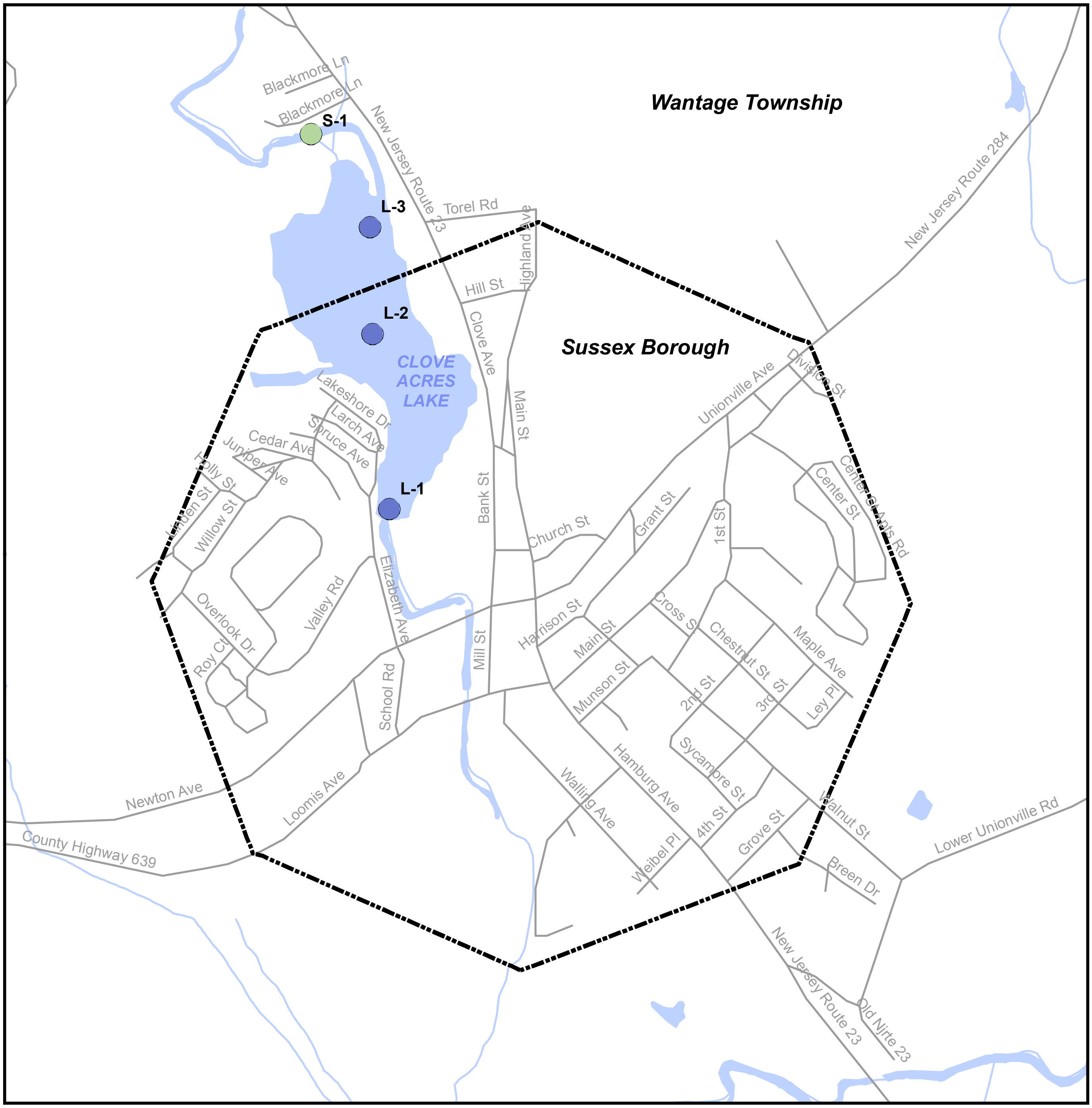
3.1 In-situ Water Quality Data

During each sampling event, temperature, dissolved oxygen (DO), pH and specific conductivity were measured at 0.5 to 1.0 meter intervals from surface to bottom at a mid-lake sampling station, L-1, and two additional stations, L-2 and L-3. In addition, *in-situ* monitoring was conducted on the main inlet to Clove Acres Lake, Clove Brook, S-1. A Eureka Manta PDA meter with Amphibian multi-probe was utilized to collect the *in-situ* data. A map identifying the sampling stations, as well as the collected *in-situ* data can be found in Appendix A.

Temperature

Temperature is one of the most important water quality parameters, since it controls the rate of all chemical and biological reactions and determines the physical structure of a lake or pond. As the air temperature increases through the growing season, the temperature of the surface waters increases. This results in the surface waters being warmer relative to the bottom waters. Once the temperature difference between the surface and bottom waters is large enough (i.e. a difference > 1° C per meter) a waterbody becomes thermally stratified. These conditions substantially minimize the transfer of materials and gases between the surface waters (the epilimnion) and the bottom waters (the hypolimnion). For example, in productive waterbodies, once the hypolimnion is cut off from the epilimnion, atmospheric oxygen can not enter the deeper waters. This can result in a depletion of DO in the bottom waters, a condition termed anoxia. Such conditions have a substantial impact on the overall water quality of a lake.

While the surface water temperatures of Clove Acres Lake were higher than those of the bottom waters at stations L-2 and L-3, this difference was relatively minor. The relatively shallow depth of the lake in these areas prevented the establishment of strong thermal differences. However, at Station L-1, the deepest portion of Clove Acres Lake, the data reveal the Lake could be defined as thermally stratified during each of the six sampling events (Appendix A). While this prevented mixing through the water column, it did not create conditions that resulted in anoxia over the sediments (dissolved oxygen concentrations < 1 mg/L; see below).



Princeton Hydro

FIGURE 4 - Clove Acres Lake Phase I Study (Sussex County MUA 319 grant)

CLOVE ACRES LAKE
WANTAGE TOWNSHIP AND SUSSEX BOROUGH
SUSSEX COUNTY, NEW JERSEY

Lake Sampling Station
Stream Sampling Station
Municipal Boundary
Roads
Lakes
Streams

1 inch equals 1,000 feet

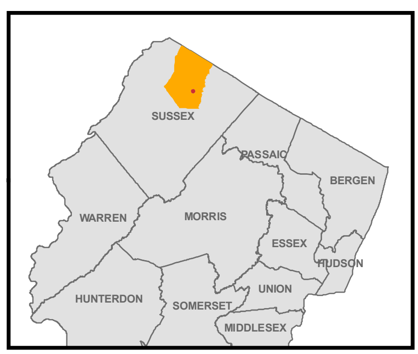
0 250 500 1,000 Feet

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. Municipal boundaries, lakes, and streams obtained from NJDEP
2. Road files obtained from TIGER

NEW JERSEY COUNTY MAP



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Dissolved Oxygen (DO)

For a healthy and diverse ecosystem, DO concentrations should be equal to or greater than 5 mg/L. Most organisms can tolerate such relatively low DO concentrations; however some, such as trout, require at least 4 mg/L of DO to survive. For the most part, DO concentrations were sufficient to maintain in-lake habitat for most aquatic organisms through the course of the program. However, more sensitive organisms, such as trout, may have been stressed at points during the program where reduced DO concentrations were observed.

During the early (April/May) and late (September) sampling events, DO concentrations were greater than 4 mg/L from surface to bottom. During the April 2006 and May 2007 sampling events, bottom water DO concentrations were actually higher than the surface water concentrations, which were attributed to high rates of photosynthesis by rooted aquatic plants and benthic algae. In contrast, during the two July sampling events, DO concentrations declined with depth in Clove Acres Lake. Bottom water DO concentrations were less than the 4 mg/L threshold during the July sampling events and were substantially lower than the DO concentrations of the overlying waters (Appendix A). However, it should be noted that anoxic conditions (DO concentrations < 1 mg/L) were not recorded during the July monitoring events. As will be discussed later, once DO concentration fall below 1 mg/L, substantial amounts of phosphorus are released from the sediment and can fuel additional algal growth, a condition called internal loading.

In conclusion, the distribution of DO through the water column in July 2006 and 2007 was typical for the mid-summer season; high rates of algal photosynthesis keep the surface waters well oxygenated while elevated rates of bacterial decomposition contribute toward the uptake of DO in the bottom waters.

pH

The pH of Clove Acres Lake was extremely alkaline, for the most part being greater than 8.00 during each sampling event. On 11 May 2006 in-lake pH varied between 8.38 and 10.89, on 13 July 2006 the in-lake pH was again varied and ranged between 7.37 and 11.49, on 21 September 2006 the in-lake pH varied between 7.79 and 10.33.

On 24 April 2007 in-lake pH varied between 7.39 and 8.23, on 11 July 2007 the in-lake pH was again varied and ranged between 6.90 and 10.22, on 26 September 2007 the in-lake pH had declined to levels between 7.13 and 8.67.

The extremely alkaline pH values in Clove Acres Lake, especially during the summer months, were attributed to the general water chemistry of the lake and geology of the watershed, as well as high rates of algal and aquatic plant photosynthesis. As rates of photosynthesis increase, both DO and pH will increase. Varying levels of primary productivity resulted in the large variations in pH that were observed through the water column and over the course of the individual seasons.

Conductivity

Conductivity is a measurement of water to carry an electric current. However, it can also be used as a measurement of the amount of dissolved substances (i.e. nutrients, minerals, salts) in water. Therefore, the higher the conductivity, the more dissolved substances present in the water. Through the course of the sampling program of Clove Acres Lake, specific conductivity varied between 0.20 mmhos/cm and 0.34 mmhos / cm (Appendix A). These conductivity values are considered moderate for a New Jersey lake. For example, conductivity in waterbodies in the Pine Barrens can be as low as < 0.1 mmhos / cm, while the conductivity in northern New Jersey lakes can be as high as 0.4 to 0.5 mmhos / cm. The measured conductivities in Clove Acres Lake are not indicative of any large-scale pollutant contamination (i.e. nutrients, heavy metals), as least during the six sampling events.

Water Clarity (measured with a Secchi disk)

The water clarity of Clove Acres Lake was measured with a Secchi disk, which is a weighted circular disk 20cm in diameter with four (4) alternating black and white sections painted on the surface. The disk is attached to a measured line that is marked in 0.2 meter intervals. The disk is slowly lowered into the water until it can no longer be seen. At this point the observer records the depth of the calibrated line. The disk is then slowly raised until it reappears. Once it reappears, this depth is recorded. The average of the two values is the Secchi depth. The clearer the water, the larger the Secchi depth value will be. Secchi depth was measured at the in-lake stations during each sampling event.

Water clarity, as measured with a Secchi disk, was at least 1.0 meters each of the six sampling events (Appendix A). The relatively shallow water depths and generally clear waters of Clove Acres Lake resulted in the high rates of benthic algal and rooted aquatic plant growth.

Inlet (Clove Brook) In-situ Data

As described earlier, Clove Brook serves as the main inlet to Clove Acres Lake. With the exception of pH and temperature, the *in-situ* conditions of Clove Brook water were similar to the in-lake conditions throughout the study. The pH of Clove Brook water was generally slightly lower than the in-lake values. This was expected since rates of plant and algal photosynthesis within the Brook were probably somewhat slowed due to the overlying canopy of vegetation. The temperature of Clove Brook water was also slightly lower relative to the in-lake values (Appendix A) due to the overlying canopy of vegetation shading the brook, as well as movement in general.

3.2 Discrete Water Quality Data

In addition to *in -situ* monitoring, discrete samples were collected during each sampling event for a variety of chemical and biological parameters. Mid-lake (L-1) samples were collected during each of the six sampling events. In addition, samples were collected from the other two in-lake stations (L-2 and L-3); however, the discrete samples of L-2 and L-3 were only analyzed for total phosphorus. Lastly, samples were also collected from the Clove Brook inlet area (S-1) during all six sampling events. Figure 4 displays the sampling locations of the study. The L-1 discrete samples were analyzed for alkalinity, ammonia-N (NH_4-N), nitrate-N (NO_3-N), nitrite-N (NO_2-N), total phosphorus (TP) and total suspended solids (TSS), while the discrete samples collected from the Clove Brook inlet were analyzed for TP and TSS. All samples were transported to a State-certified laboratory for analysis.

In addition to the chemical samples, biological samples were also collected from the L-1 sample station as part of the Clove Acres Lake water quality monitoring program. Biological monitoring included the collection of samples for chlorophyll *a*, phytoplankton and zooplankton. During each monitoring event, whole water samples were collected for chlorophyll *a* and phytoplankton, while another sample was collected with a Schindler trap for zooplankton. The phyto- and zooplankton samples were preserved with a Lugol's solution; plankton were identified to genus and enumerated. The resulting data were then used to calculate plankton abundance and biomass in Clove Acres Lake.

General observations on the dominant aquatic plants and benthic algae were also made and recorded during each sampling event. Finally, a fishery survey of Clove Acres Lake was conducted with the use of a boat-based electro-fishing system and two (2) different types of nets on 11July 2007 and 12 July 2007.

Alkalinity

The alkalinity of water is its capacity to resist a change or shift in pH; it is also known as the buffering capacity of a waterbody. Alkalinity is typically expressed in terms of calcium carbonate with concentrations ranging from 20 to 200 mg of $CaCO_3$ / L in most natural freshwater ecosystems. The in-lake alkalinities ranged from 33.8 mg to 62.5 mg of $CaCO_3$ / L, throughout the course of the sampling program (Appendix B). Based on these results, Clove Acres Lake has a relatively low amount alkalinity and is relatively prone to pH shifts. These data correlate well with the large variation observed in the Lake's pH values.

Phosphorus

Phosphorus is the primary limiting nutrient in most freshwater waterbodies within the Mid-Atlantic section of the United States. In other words, it takes very little phosphorus to stimulate large amounts of algal and/or aquatic plants growth; as phosphorus concentrations increase, the amount of algal and/or aquatic plant biomass will also increase. Thus, reducing current phosphorus loads, as well as controlling future loads, is an effective, long term strategy in improving and preserving the water quality of a lake or pond.

It has been well documented that in-lake TP concentrations greater than 0.03 mg/L can stimulate high levels of algal and/or aquatic plant growth. Under such conditions, a lake or pond is described as being eutrophic, meaning it is highly productive. Thus, such water bodies have the potential to experience algal blooms and excessive densities of aquatic plants.

Based on Princeton Hydro's in-house project experience, if the in-lake TP concentration is greater than 0.06 mg/L, and no large storms are expected within the next week, nuisance-level algal blooms will more than likely occur sometime over the next few days. This threshold of 0.06 mg/L is based on Princeton Hydro's in-house database and experience of lakes located throughout New Jersey, New York and Pennsylvania.

A single form of phosphorus was measured in Clove Acres Lake. This form of phosphorus is total phosphorus (TP), which measures all the phosphorus in the water; inorganic and organic, particulate and dissolved. Most water quality models are based on in-lake TP concentrations, since rates of phosphorus recycling is extremely fast in lakes and ponds.

TP concentrations were somewhat elevated in Clove Acres Lake, ranging from 0.02 mg/L to 0.12 mg/L during the in-lake monitoring events (Appendix B). Thus, TP concentrations at Clove Acres Lake were at times less than or greater than the 0.03 mg/L threshold. In fact, in-lake TP concentrations also exceeded the 0.06 mg/L threshold of extreme nuisance conditions. The largest TP concentrations were detected in the mid-summer sampling months of July. This indicates that Clove Acres Lake has the potential to experience nuisance algal blooms, particularly during the mid-summer season.

Clove Acres Brook inlet water TP concentrations varied from 0.02 mg/L to 0.07 mg/L, with concentrations increasing through the course of the growing season, similar to the Lake (Appendix B). These concentrations, relative the in-lake concentrations, indicate that the inlet is more than likely at times a substantial source of phosphorus for Clove Acres Lake. However, it should be cited that through the course of the growing season, a large amount of filamentous algae was found within Clove Brook. Thus, a large portion of the phosphorus measured in the Clove Brook inlet water, especially during the late summer season, may have been from the accumulation and/or decomposition of this algal biomass. In any event, in-lake TP concentrations ranged from generally low in the early portion of the growing season to elevated concentrations during the mid-summer season. Since algal and aquatic plant biomass appears to correlate well (see below) with these seasonal increases in TP, the growth of these organisms is at least partially dictated by the amount and availability of phosphorus.

Nitrogen

While phosphorus is the primary nutrient limiting relative to algal and aquatic plant growth, nitrogen is another extremely important nutrient. Nitrogen can be found in a variety of forms; particulate and dissolved, inorganic and organic. However, the two forms that are most easily utilized by algae and aquatic plants are ammonia-N and nitrate-N. Both forms are dissolved, inorganic forms of nitrogen. In addition to these forms of nitrogen, nitrite-N was also measured. Nitrite-N is a generally unstable form of nitrogen that, in the presence of oxygen, is quickly converted to nitrate-N through the microbiological process of nitrification.

Ammonia-N is a common by-product of the bacterial decomposition of organic matter. Thus, ammonia-N has the potential to accumulate in a lake or pond, however, since algae and aquatic plants easily assimilate ammonia-N for growth, concentrations tend to be low (< 0.05 mg/L) in most natural ecosystems.

In-lake ammonia-N concentrations varied between 0.02 and 0.08 mg/L through the course of the Clove Acres Lake monitoring program (Appendix B). Thus, ammonia-N concentrations in Clove Acres Lake were generally low. The observed decline in ammonia-N concentrations through the course of the 2006 and 2007 growing seasons is most likely the result of increased assimilation of this nutrient by algae and aquatic plants while seasonal temperatures increased.

Nitrate-N is another form of dissolved inorganic nitrogen that is readily utilized by algae and aquatic plants for growth. Nitrate-N tends to be more mobile in surface and groundwater relative to ammonia-N and can be generated through microbial activities, such as nitrification. However, bacterial decomposition of organic matter tends to generate reduced forms of nitrogen such as ammonia-N and not nitrate-N. Thus, algal and aquatic plant uptake of nitrate-N tends to keep its concentration relatively low in lakes and ponds.

For sources of potable water, the Federal and State limit for nitrate-N concentrations is 10 mg/L. In contrast, summer nitrate-N concentrations greater than 1 mg/L can generate excessive amounts of algal and aquatic plant biomass. In-lake nitrate-N concentrations in Clove Acres Lake varied between < 0.02 mg/L and 0.59 mg/L through the course of the monitoring program (Appendix B). Thus, in-lake nitrate-N concentrations were well below both the potable water and ecological nitrate-N threshold values.

In addition to nitrate-N, nitrite-N concentrations were also measured in Clove Acres Lake. Nitrite-N is highly unstable and is quickly converted into nitrate-N in surface waters through the microbial process of nitrification. Thus, the presence of relatively elevated concentrations of nitrite-N in a lake or pond may indicate that a large portion of the incoming hydrologic load originates from groundwater.

In-lake nitrite-N concentrations were very low in Clove Acres Lake, being at or near the analytical detection limit of 0.001 mg/L to a high concentration of 0.006 mg/L. These collected data indicate that any nitrite-N entering Clove Acres Lake is quickly converted into nitrate-N and subsequently assimilated by the resident algal and aquatic plant communities.

Total Suspended Solids

Total suspended solids (TSS) are a measure of the amount of “dirt” or particulate matter in water. The State limit for TSS is 25 mg/L. TSS concentrations greater than 25 mg/L, under baseline (non-storm event) conditions, can negatively impact aquatic habitats. Some of these negative impacts include in-filling of wetlands, lakes and waterways, the destruction of spawning habitat, and added physiological stress on fish through suspended sediments entering their gills. In addition, TSS concentrations greater than 25 mg/L are perceived by the layperson as being “dirty” or “muddy”.

In-lake TSS concentrations were low in Clove Acres Lake, varying between 2 mg/L and 9 mg/L during the sampling events. These low TSS concentrations correspond to the high degree of water clarity experienced during the same sampling events.

The Clove brook inlet also possessed low TSS concentrations during the same sampling events, ranging from ND <2 mg/L to 6 mg/L. This is important to note as some forms of phosphorous can bind with particulates and be carried into a receiving waterway adsorbed onto particulate material.

Chlorophyll a

As described above, data were also collected on the biology of Clove Acres Lake. One such biological parameter included chlorophyll *a*, a photosynthetic pigment all plants and algal groups possess. Since all algal groups contain chlorophyll *a*, measuring its concentration in lake water is an excellent means of quantifying the relative biomass of the phytoplankton within the open water of a waterbody. Concentrations of chlorophyll *a* are also utilized in gauging the in-lake productivity associated with the phytoplankton. In turn, this information can be used to quantify the trophic state of a waterbody, as well as assess and document the relative effectiveness of an implemented in-lake restoration technique.

To the layperson, chlorophyll *a* concentrations greater than 30 mg/m^3 produce algal blooms / surface scums that are considered unpleasant for recreational waterbodies. Mid-lake (L-1) chlorophyll *a* concentrations in Clove Acres Lake varied between 3.5 mg/m^3 to 96 mg/m^3 (Appendix B). Thus, planktonic (open water) algal blooms were can be a major nuisance at Clove Acres Lake, particularly during the mid-summer season. However, based on field observations, the more nuisance groups included filamentous mat algae and rooted aquatic plants.

The elevated chlorophyll *a* concentrations document that the algal community can attain nuisance densities in Clove Acres Lake during the growing season. In addition, prevailing winds can concentrate algae and other floating debris along the shoreline. Thus, while the open waters of Clove Acres Lake may have been aesthetically acceptable, some of the other areas may be inundated with high concentrations of phytoplankton, mat algae and other floating debris. However, since Clove Acres Lake does not have any bathing facilities, such conditions did not seem to be a major nuisance.

3.3 Plankton Sampling

As mentioned earlier, phytoplankton and zooplankton samples were collected at the mid-lake station during each sampling event. Samples were taken to Princeton Hydro's biological laboratory and organisms were identified to genus and/or species. Calculations were performed with the resulting data to quantify organism densities and biomass for the report (Appendix C).

As mentioned earlier, phytoplankton and zooplankton samples were collected at the mid-lake station during each sampling event. Samples were taken to Princeton Hydro's biological laboratory and organisms were identified to genus and/or species. Calculations were performed with the resulting data used to obtain organism densities and biomass for the report (Appendix C).

On 11 May 2006 the phytoplankton community of Clove Acres Lake was dominated by green algae (Chlorophyta) in terms of both abundance and biomass (Appendix C). Other algae observed on 11 May 2006 included the Chrysophytes and Cryptophytes. However, no nuisance cyanobacteria, also known as blue-green algae, were identified in Clove Acres Lake at this time.

On 13 July 2006, the green algae were once again dominant in terms of abundance, while the diatoms (Bacillariophyta) were dominant in regards to biomass. The dominant algae observed on this date were the diatom *Melosira*. Diatoms are generally the dominant constituent of phytoplankton communities seen early in the growing season, while green and blue-green algae are typically seen later in the growing season; the population observed in Clove Acres Lake on 13 July 2006 represents a community transitioning between the spring and summer. Chrysophytes also were observed on this date.

A large increase in both algal abundance and biomass was observed between the May and July sampling events. Algal diversity also increased over this period, with diatoms being replaced by green algae as the dominant algae; these are all indicative of a community transitioning from the late spring into the mid-summer / height of the growing season.

The 24 April 2007 phytoplankton community was dominated by diatoms in both algal abundance and biomass. The dominant alga observed was the filamentous diatom *Melosira*. Green algae, Cryptophytes and Chrysophytes (brown algae) were also observed during the 24 April 2007 sampling event. A community comprised mainly of diatoms is very common during spring in the temperate zone, as they are able to out compete other algae in the cooler water.

The 11 July 2007 phytoplankton community was dominated by cyanobacteria (Cyanophyta), also known as blue-green algae. Specifically, the filamentous blue-green algae *Anabaena* was dominant. Other algae observed on this date included the green algae, diatoms, dinoflagellates (Phyrophyta) and Cryptophytes. The replacement of blue-green and green algae as the dominant alga seen in Clove Acres Lake is very common as they are able to out compete the diatoms in the warmer nutrient rich waters seen later in the growing season.

The 26 September 2007 phytoplankton community continued to be dominated by the blue-green algae. A large increase was observed in the abundance and biomass as well as the diversity of the blue-greens in Clove Acres Lake. Other algae observed on this date included; green algae, diatoms, brown algae (Chrysophyta) and Cryptophytes. A three fold increase in biomass and abundance was observed in the blue-green algae community. The large increase in biomass and abundance of blue-green algae seen is very common as they are not easily grazed upon and develop slowly accumulating reaching maximum densities during the later stages of the growing season.

The phytoplankton community abundance, biomass and diversity in Clove Acres Lake between 2006 and 2007 were comparable with no drastic changes seen over the course of the study. However, an increase in the prevalence of cyanobacteria was observed from 2006 to 2007. This should be watched as it represents a shift to a less desirable community and may be indicative of a decrease in the overall "health" of Clove Acres Lake.

Zooplankton are micro-animals that live in the open waters of lakes and ponds. Many zooplankton are a source of food for forage or young game fish. Some types of zooplankton are herbivorous (eat algae) and thus can provide a natural means of controlling excessive algal growth. Therefore, given the important role of zooplankton in the aquatic food web, the Clove Acres Lake monitoring program included these organisms.

On 11 May 2006, the zooplankton community in Clove Acres Lake was composed mainly of juvenile Copepod nauplii. Other zooplankton observed included Cladocerans and rotifers as well as the other Copepods. No large bodied herbivorous zooplanktons were observed during this sampling event. Overall numbers were relatively high.

The 13 July 2006 zooplankton community was mainly comprised of rotifers, accounting for two-thirds of all zooplankton observed and over 50% of the total biomass. Other zooplankton observed on 13 July 2006 included Cladocerans and Copepods. The dominant zooplankton on this date were the rotifer *Brachionus* with the herbivorous Cladoceran *Daphnia* also observed as an important zooplankton. The *Daphnia* observed represent the first herbivores seen during 2006 monitoring activities.

The zooplankton community remained relatively steady over the course of the 2006 monitoring activities at Clove Acres Lake, with little changes observed in their abundance, biomass or diversity.

On 24 April 2007 the zooplankton community was composed entirely of Ostracods. The very low zooplankton numbers observed are presumably due to how early in the season sampling took place. Sampling appears to have taken place prior to the emergence of most zooplankton in Clove Acres Lake.

On 11 July 2007 a marked increase in the zooplankton diversity, biomass and abundance was observed from the April sampling event. The dominant zooplankton observed on this date were Rotifer's, with *Keratella* the most abundant. Other zooplankton observed on this date included Cladocerans and Copepods. The herbivorous Copepod *Diaptomus* and the herbivorous Cladocerans *Diaphanosoma* were both observed, however their numbers were modest.

On 26 September 2007 a decrease in the abundance of zooplankton was observed, while biomass remained relatively constant. This was due to changes in the distribution of the zooplankton community in Clove Acres Lake. Rotifers remained the dominant zooplankton however; there numbers fell to one-fourth of what had been observed in July. The dominant zooplankton on this date was the rotifer *Asplanchna*. Both Copepods and Cladocerans were once again observed. An increase in the diversity and abundance of large bodied zooplankton were also observed. Two herbivorous zooplankton, *Diaphanosoma* and *Ceriodaphnia*, as well as the herbivorous copepod Diaptomus were seen in Clove Acres Lake.

Overall numbers and diversity of zooplankton increased from 2006 to 2007, this was especially the case with respect to herbivorous zooplankton.

3.4 Aquatic Macrophytes

As stated previously, excessive densities of rooted aquatic plants is one of the primary water quality concerns associated with Clove Acres Lake. Specifically, the plant of particular concern is the exotic species Eurasian watermilfoil (*Myriophyllum spicatum*). This nuisance plant attained densities within Clove Acres Lake that negatively impacted recreational activities such as canoeing and fishing. In addition, Eurasian watermilfoil out-competes native aquatic vegetation that provides ecological benefits to resident wildlife. Given the impact aquatic plants have on the water quality and recreational use of Clove Acres Lake, detailed field observations were made on the aquatic plant community during each monitoring event.

During the 11 May 2006 sampling event Eurasian watermilfoil covered approximately 60% of the bottom of Clove Acres Lake. Open water areas were limited to the middle of the lake where depths limited the growth of submerged macrophytes. A large portion of the milfoil reached the water's surface in Clove Acres Lake during the May 2006 sampling event. In addition to Eurasian watermilfoil, a few stands of Curley-leaved pondweed (*Potamogeton crispus*), another invasive species, were also observed in Clove Acres Lake at this time.

On 13 July 2006, some Eurasian watermilfoil was observed along the bottom of Clove Acres Lake; however, densities did not attain nuisance levels. In addition, duckweed (*Lemna spp.*) was also observed in portions of Clove Acres Lake. Moderate amounts of filamentous mat algae, the green algae *Spirogyra* and *Zygnema*, were also observed along the bottom of the lake. Similar to the milfoil, mat algal densities were not a nuisance at this time.

Both benthic mat algae and Eurasian watermilfoil densities increased from 13 July to 21 September 2006. While conditions were not qualified as a nuisance in July, it was clearly evident that levels of algal and aquatic plant biomass had continued to increase through the course of the 2006 growing season. By late September mat algae and milfoil densities did attain nuisance levels from a recreational perspective.

On 24 April 2007, mats of *Spirogyra* and stands of Curly-leaved pondweed were observed in Clove Acres Lake; however, these organisms were not at nuisance levels. At this time, little to no Eurasian watermilfoil was observed.

By 11 July 2007 Eurasian watermilfoil was once again the dominant rooted aquatic plant in Clove Acres Lake, attaining nuisance levels that covered between 60 to 70% of the lake's surface. In addition to Eurasian watermilfoil, duckweed was found in Clove Acres Lake at this time. Mats of *Spirogyra* were also distributed throughout the lake, sporadically covering stands of milfoil.

On 26 September 2007, Eurasian watermilfoil was observed along the bottom of Clove Acres Lake at nuisance densities. In addition, duckweed (*Lemna spp.*) was observed in sections of Clove Acres Lake. Dense amounts of filamentous mat algae were also observed along the bottom of the lake. Similar to the milfoil, mat algal densities were at a nuisance at this time.

Based on field observations made during the Clove Acres Lake monitoring program, Eurasian watermilfoil was clearly the dominant plant species. Milfoil densities were relatively low to moderate during the spring season but quickly attained nuisance densities by the early to mid-summer season. Such conditions persisted through the summer and into the fall. These high densities of Eurasian watermilfoil negatively impact the ecological and recreational value of Clove Acres Lake.

3.5 Fishery Survey

The fishery of a lake is an integral component of the biological community of any aquatic ecosystem. As such, the fishery is a reliable indicator of overall ecosystem health and water quality, and can also be a major factor impacting the water quality of an aquatic ecosystem. At the same time, the fishery is also the most familiar part of aquatic ecosystems to many lake users and a primary source of lake recreation. Therefore, it is important to evaluate the fishery through a thorough survey investigation as part of any restoration or lake management strategy. Such surveys maximize the potential for increased water quality, fishery quality, and recreational opportunities.

In order to perform a comprehensive survey of the Clove Acres Lake fishery, a variety of survey techniques were utilized to sample various components of the fishery community, differentiated by habitat preference and size-class. This section details the methodology employed in the collection of fish, identification to species, and data analysis. The fishery survey in Clove Acres Lake was conducted over a two-day period from July 11 - 12, 2007. All nets and traps were deployed on July 11 and retrieved on July 12. Electrofishing was conducted on July 11. Prior to the initiation of the fishery survey, Princeton Hydro obtained a Scientific Collectors Permit from the NJDEP Bureau of Freshwater Fisheries to sample the fishery of Clove Acres Lake via electrofishing and the deployments of various nets and traps.

Gill netting was the one of the primary sampling technique used in the collection of fisheries data in Clove Acres Lake. Gill nets were selected for use because of their high efficacy in capture and the ability to deploy these nets in a variety of habitats and depths. Princeton Hydro utilized horizontal style scientific sampling gill nets. These nets are 125′ long and 6′ deep and constructed of monofilament netting. The top main line on each net is a floating line while the bottom mainline is a braided lead line; this configuration allows the net to remain horizontal and fully vertically extended in the water column. This style of gill net consists of various mesh sizes in alternating 25 foot panels, allowing the capture of a variety of size classes of fish. One of the nets utilized was termed a small mesh net and consisted of the following mesh sizes in inches for each of the 25 foot panel lengths: ½, ¾, 1, 1 ¼, and 1 ½. The other net was a large mesh net consisting of 1, 1 ½, 2, 2 ½, and 3 inch mesh sizes. Each net was deployed horizontally in the water column at the selected depth by lashing each end of the net to a buoy line anchored to the bottom with a cinder block.

In total, two (2) gill nets were deployed during the fishery study. For the purposes of this survey, gill nets were used to sample the pelagic fish community near the surface. Each net was deployed for a period of approximately 24 hours before retrieval. The stations were as follows: G-1 was a large mesh net placed at the upper end of the lake, running roughly north to south, while G-2 was a small mesh net placed approximately mid-lake in deeper water.

Trap nets were a secondary netting method used to sample the littoral community of the Lake and supplement the electrofishing results. Trap nets are designed to capture fish as they move along structures, including the lake bed, banks, or deadfall trees. Fish are guided towards the traps utilizing wing nets that basically create a funnel; the wings are each positioned at 45° to the main body of the net, or 90° to each other. As the fish move within the confines of the wings they eventually move towards the trap at which point they are captured. Trap nets (also known as fykes) consist of several metal frames and a series of more frames or rings wrapped in netting known as the body. Within the body are a series of throats and parlors which serve as the "traps" to capture fish. In front of the primary frame is a leader or a series of leaders or wings which are nets projected in front of the traps that serve to direct fish towards the traps. Princeton Hydro utilized both Indiana and New Hampshire style fykes with $^{5}/_{16}$ inch mesh net for the leader and the body of the trap; these nets vary only in the shape of the frame but are otherwise nearly identical in form and function.

In total, two (2) trap nets were utilized in this fishery. As with the gill nets, each trap net was deployed for a period of approximately 24 hours. Each net was deployed so that the wings were positioned around preferred habitat, in this case consisting of fallen trees. The front of the wings and the rear of the body were anchored in position using cinder blocks and both of these locations were marked with buoys. Trap net T-1 was placed in the northeastern inlet of the lake, while T-2 was deployed around deadfall on the southeast shoreline.

An extensive electrofishing survey was also conducted in the littoral areas of the Lake. Electrofishing is a particularly effective method of capturing fish because it allows targeting on key pieces of structure likely to harbor fish, and fish are immediately captured without the lag of using nets generally resulting in a much higher capture per unit effort (CPUE). Capture mortality is also much lower than other methods making this a preferred sampling technique. Electrofishing involves creating local electrical fields in the water that serve to stun fish. When fish enter the electrical fields generated around the electrofishing gear in the water column the nervous system of the fish is shocked and the fish float to the surface for capture. Larger fish often involuntarily orient themselves in the electric field and actually move towards the source of the stimulus.

Electrofishing was conducted from a 17 foot center console boat. Princeton Hydro utilized a Coffelt VVP boat mounted electroshocker unit rated at an operational output of 300 to 600 volts. The electrofishing unit was powered by a 4300 watt Honda generator. This system utilizes a Wisconsin ring electrode suspended off the front of the boat and a whisker array deployed off the stern. Safety protocols are outlined in Princeton Hydro's Electrofishing Safety Plan; specific requirements include the use of proper ground connections, the use of insulated gloves, and positive engagement switches.

Electrofishing was performed using 10 minute timed transects that covered on average of approximately 100 meters of linear shoreline. In total, five (5) of these timed transects were performed around the entire perimeter of Clove Acres Lake. During the operation of the electrofishing unit stunned fish were captured on the lake surface using long-handled dip nets. Captured fish were then transferred to a temporary holding tank for processing. Electrofishing activity primarily focused immediately along the shoreline and other structures such as dead fall trees and exposed root masses. While electrofishing can be used effectively in open waters most electrofishing during the survey was conducted in the littoral zone to more accurately quantify the

Lake's littoral fish community.

Upon retrieval of the gill nets, trap nets, and after the completion of each timed electrofishing transect all captured fish were processed. Processing included the identification of all fish to a species level, measuring total length (the length from the snout to the end of the caudal fin), and enumeration. Identifications were made utilizing Page and Burr, 1991 and Murdy, Birdsong, and Musick, 1997. Following their identification, measurement and enumeration, all surviving fish were returned live to the water. Dead fish were bagged and properly disposed off site.

A variety of population analyses were performed using standard statistical methods and population biology indices as well as simple descriptive statistics. This included size and mass distributions. Mass distribution was calculated using species specific mass-length models derived from published coefficients. Specific coefficients used were selected as median values or for regional fitness. These models are regressions that relate the length of a species to a mass and allow for calculation of biomass metrics without directly measuring mass in the field.

The total number of fish captured during the summer 2007 fishery survey was 236 fish; gill nets accounted for just 141 fish or 59.7% of the total catch, while trap nets and electrofishing respectively captured 6 and 89 fish or 2.5% and 37.7% of the total catch. In total, twelve (12) species were observed. Two species dominated the fishery in terms of abundance, White Sucker (*Catostomus commersoni*) and Bluegill (*Lepomis macrochirus*). However, the White Sucker clearly dominated the fishery in terms of biomass accounting for over 81% of the total fishery biomass. The second largest species in terms of biomass, Golden Shiner (*Notemigonus crysoleucas*), accounted for only 4.5% of fishery biomass.

A size distribution analysis revealed two distinct size classes of fish in the Lake. Abundance was highest in the size range between 6 and 9 inches. This size class of fish was dominated by various sunfishes (Family Centrarchidae) including Black Crappie (*Pomoxis nigromaculatus*), Bluegill, Largemouth Bass (*Micropterus salmoides*), Pumpkinseed (*Lepomis gibbosus*), and the hybrid Sunfish (*Lepomis macrochirus* x *gibbosus*, this cross is fairly common in turbid or polluted waterbodies), and the unrelated Golden Shiner. The next distinct size range were fish in the 15 to 20 inch size class. This class of fish consisted almost exclusively of the benthic feeding White Sucker, although two predators were also identified and included Largemouth Bass and Chain Pickerel (*Esox niger*). The biomass distribution exhibited a different pattern in which over 64% of all biomass was contained in the 15 to 20 inch size class and was dominated by White Sucker. This biomass and size class distribution clearly shows an abundance of 15 to 20 inch fish in Clove Acres Lake.

Several patterns are immediately clear in the analysis of the fishery data. Most noticeable and significant is that the fishery is dominated by White Suckers in terms of both abundance and biomass. The second observed pattern is that there is a distinct lack of large predators in the system that can effectively prey upon White Suckers and Golden Shiners. A third pattern is that the fishery was somewhat more balanced with greater species richness, abundance, species composition, and size distribution in the lower open water portions of the lake outside the influence of filamentous mat algae and macrophyte growth in the upper portion of the lake. Finally, the fishery is showing low recruitment (reproduction) with only Largemouth Bass exhibiting any real reproductive capacity as represented by an almost total lack of fish in the 0 to 3 inch range in the lake. However, this statement may require additional survey work since none of the methodology used in the Clove Acres Lake fishery survey focused on the young-of-the-year (i.e. shoreline seines).

The species composition and various metrics analyzed for the fishery survey show that the community is clearly impaired, with at least one of the root causes being the nuisance density of macrophytes and algae in the lake. Of greatest concern is the relative abundance of White Suckers in the lake. While the presence of White Suckers is no cause for concern and in fact is normal in most healthy impoundments of this size, the dominance in biomass relative to other species in the lake should be a concern. First, an abundance of White Suckers relative to other species can be taken as a sign of lower water quality since this species has a high tolerance for poor water quality including the ability to survive at low dissolved oxygen concentrations, with high turbidity and nutrient loads, and in the presence of other contaminants. Suckers are not just an indication of poor water quality, but can contribute to poor water quality through the re-suspension of sediments during foraging. Similarly, they can impact fisheries through the destruction of bass and sunfish nests, both directly and indirectly, and by competing with other fish for food resources such as various invertebrates that are also favored by the Centrarchids. Therefore, the abundance of White Suckers in Clove Acres Lake indicate lowered water quality, a competitive advantage to suckers created by nuisance plant and algae densities, and probable impacts on the rest of the fishery.

The impacts of nuisance plant densities also clearly observed in the composition of the fishery. The area of the lake near the dam has much lower densities of macrophytes and algae, also exhibiting more fish species and a somewhat greater abundance of fish in general; Black Crappie and Largemouth Bass were observed only in the more open water portions of the lake and generally the lower (southern) parts of the lake. This provides additional evidence that plant and algae growth negatively impacts the fishery of Clove Acres Lake.

The final observed impairment was the imbalance observed in the sunfishes and bass. With the exception of Largemouth Bass, the sunfishes exhibited no signs of sustained recruitment despite a moderate spawning stock indicating poor juvenile survival or spawning habitat impairment. Even within the Largemouth Bass population only one fish in excess of 12 inches was captured. The capture of a hybrid sunfish is also an indicator of impaired water quality since hybridization is typical in very turbid systems where visual cues used in species recognition are muted. These observed impairments can likely be attributed to poor habitat quality due to the overabundance of plant growth, poor water quality, and excessive competition for food resources from White Suckers or Golden Shiners.

Improvements in the fishery will be accomplished mainly in the through active management of the lake including a reduction in nutrient loading, improving water quality, and reducing macrophyte and algal densities. However, it may also be appropriate to manually alter the fishery. Recommendations may include limiting the catch of Largemouth Bass and stocking larger fish (greater than 12 inches) to increase spawning stock. This would accomplish several goals: recruitment would increase, more size-classes would be represented, and predation pressure on White Suckers and Golden Shiners would increase. The stocking of large predators such as Muskellunge (*Esox masquinongy*) might also be appropriate in reducing sucker density because of their preference for large fish and their known fondness for suckers. In summary, the fishery of Clove Acres Lake is clearly impacted by abundant weed growth and impaired water quality, which is evidenced by the abundance of White Suckers and the general lack of quality predators such Largemouth Bass and Chain Pickerel. These impairments in the fishery can be improved through fisheries management strategies such as stocking.

Section 4 Watershed Characteristics

4.1 Geology

Sussex County consists of valleys and ridges that are roughly oriented northeast and southwest, parallel with the Delaware River. The valleys near the river are narrow and the nearest mountain ridges are the highest in the county. High point, at an elevation of 1,804 feet, the highest elevation in New Jersey, is on Kittatinny Mountain, near the New Jersey-New York border. The valleys are mostly 400 to 600 feet above sea level. Kittatinny Mountain is a narrow, even-crested sandstone ridge. The Highlands, mountains in the eastern part of the County, are broad or flat-topped ridges of granitic gneiss. They are generally steep and very stony. Some of the wide valley between the ridges formed over limestone, shale or slate. Farmed areas are dominant in these valleys. Previously, as much as 30% of the county was farmed while up to 60% was forested.

About 7% of Sussex County is within the Delaware Gap National Recreation Area. Approximately 25% of the County is in Federal, State or Municipal parks, forests, hunting or fishing areas, recreation areas or municipal reservoir watersheds. In addition the county has the largest New Jersey public skiing area in Mountain Creek, located in Vernon.

4.2 Soils

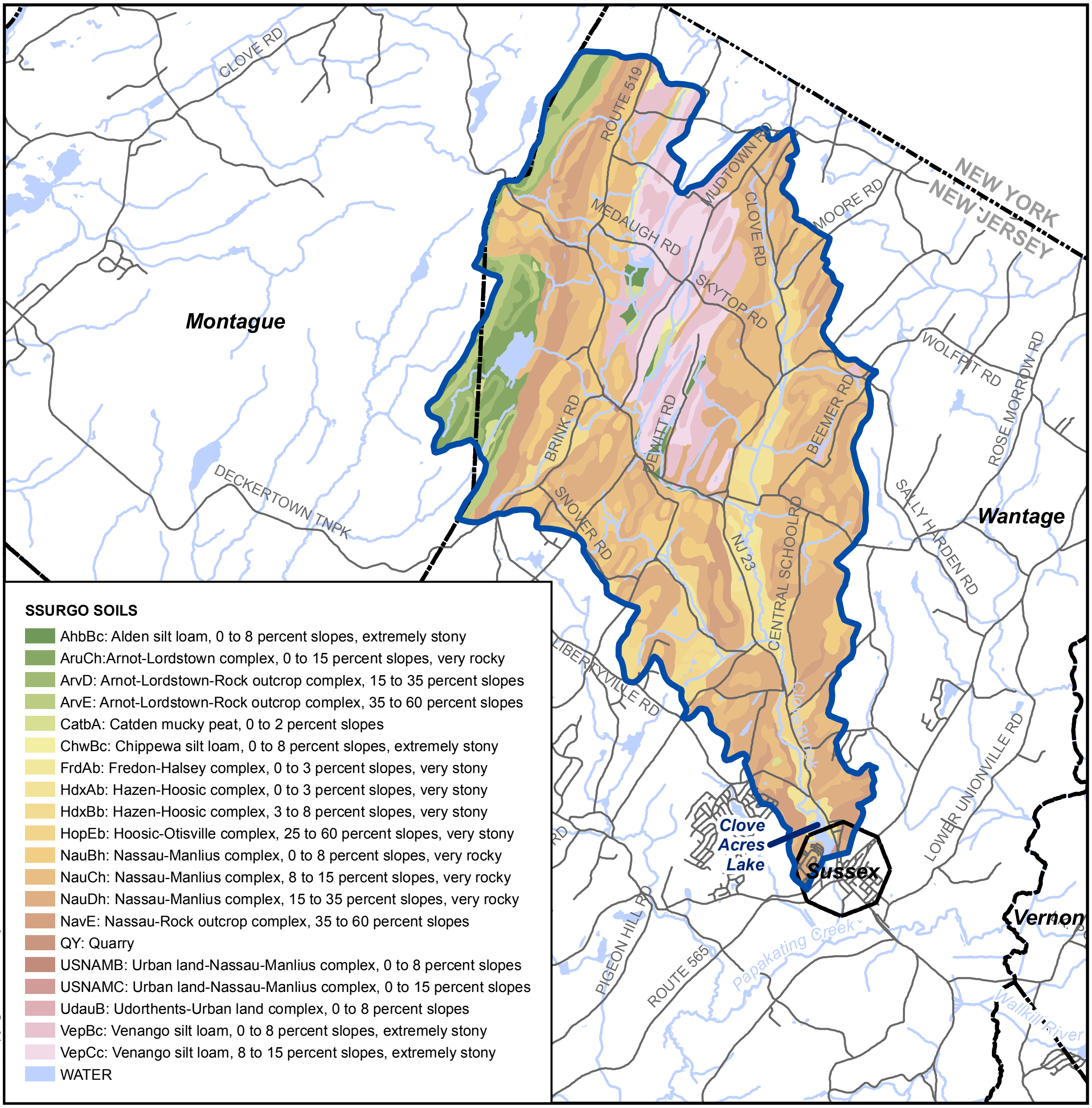
The watershed immediately adjacent to Clove Acres Lake is characterized by soils of the Nassau-Bath-Norwich association. According to the Soil Conservation Service (USDA, 1979), soils occurring in this association are characterized as *gently sloping to very steep, shallow and deep, somewhat excessively drained and well-drained loamy soils and nearly level, deep, very poorly drained very stony loamy soils, on uplands.*

This association is on hilltops and hillsides in the interior valleys. It makes up about 20 percent of the County. It is about 25 percent Nassau soils, 20 percent Bath soils, 20 percent Norwich soils and 35 percent soils of minor extent. The dominant soils within the Clove Acres Lake watershed are listed and described in both Figure 5 and Table 2.

TABLE 2

Dominant Soil Characteristics of the Clove Acres Lake Watershed

Soil Name	Erodibility	Slope (%)	Depth to seasonal water table (feet)	Depth to bedrock (feet)	Septic suitability
Nassau-Manlius complex, very rocky	Slight	8 - 15	>3	1.0 – 1.5	Severe
Nassau-Manlius complex, very rocky	Slight	15 - 35	>3	1.0 – 1.5	Severe
Nassau-Manlius complex, very rocky	Slight	35 - 60	>3	1.0 – 1.5	Severe
Nassau-Manlius complex, very rocky	Slight	0 - 8	>3	1.0 – 1.5	Severe
Venango silt loam, extremely stony	Moderate	0 - 8	>3	>4	Moderate



Princeton Hydro

FIGURE 5 - SSURGO SOILS

CLOVE ACRES LAKE WATERSHED
SUSSEX BOROUGH AND WANTAGE TOWNSHIP
SUSSEX COUNTY, NEW JERSEY
GRANT RP05-090

LEGEND

- Project Area
- Municipal Boundary
- Lakes
- Streams

1 inch equals 1.5 miles

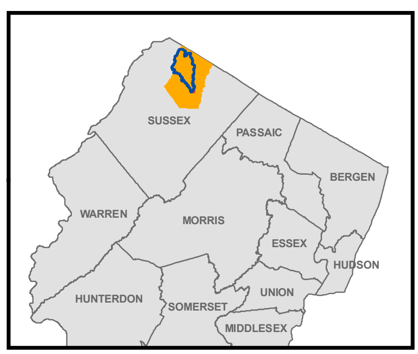
0 0.75 1.5 Miles

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. Watershed boundary, streams, lakes and roads as obtained from the NJDEP GIS website.
2. SSURGO soils obtained from Natural Resources Conservation Service.

NEW JERSEY COUNTY MAP



4.3 Land Use

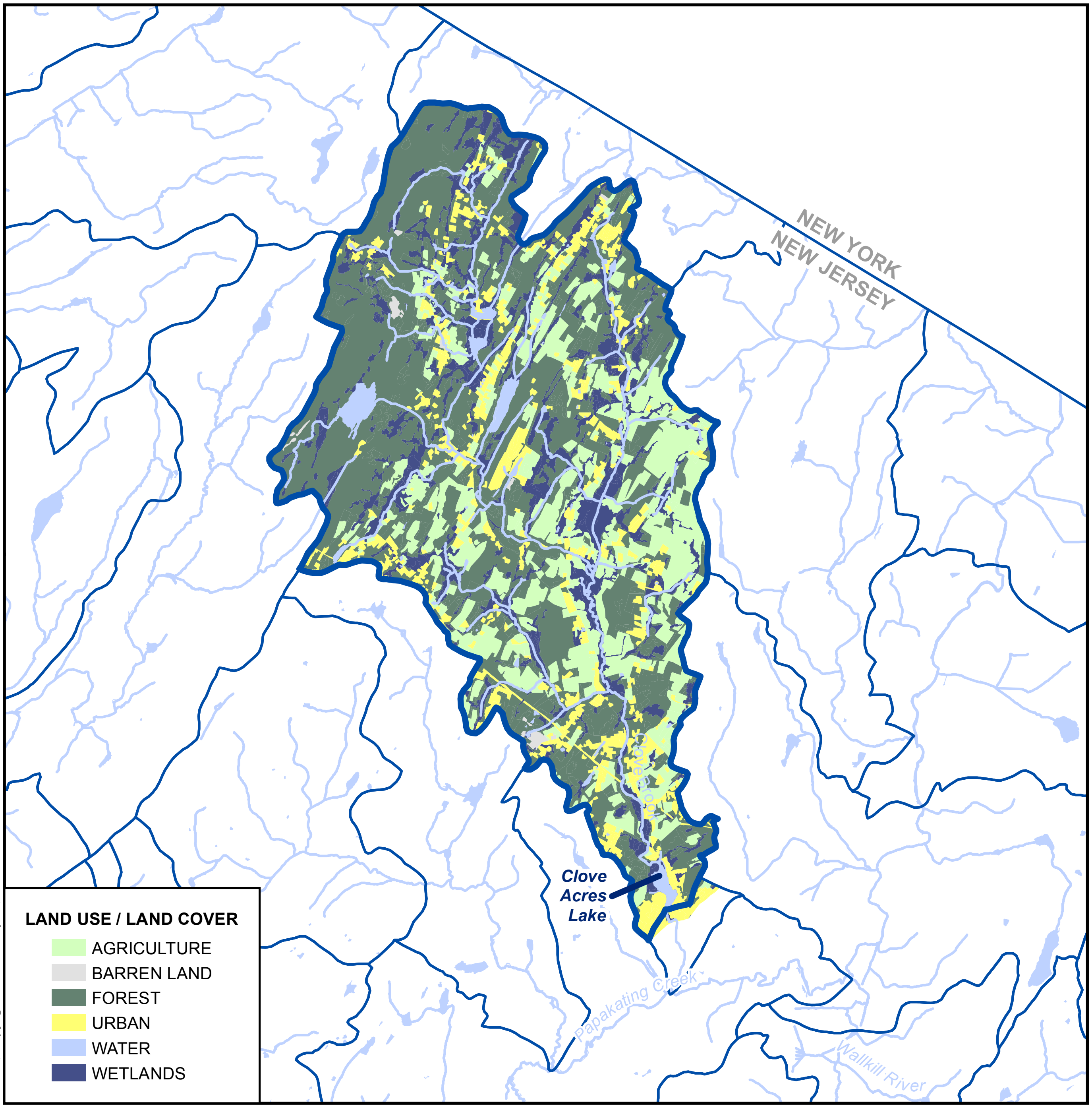
Land use within the Clove Acres Lake watershed was identified and mapped with the aid of the New Jersey Department of Environmental Protection Geographic Information System (GIS) digital data (integrated terrain unit) and U.S. Geological Survey digital data (digital line graph). The majority of this data is from the current NJDEP 2002 Land Use data available. The exception to this is the soils data, which is sourced from the NRCS SSURGO 2006 publication data and the USGS data which is acquired from the 1976 quad. The land use categories, and their respectively percent contributions to total watershed area, are listed in Table 3.

The dominate land type, by far, within the Clove Acres Lake watershed was forested which accounted for 49.1% of the total land area (Table 3 and Figure 6). The forest "type" was a fairly even mix of deciduous and coniferous forested land within the Clove Acres Lake watershed. Agricultural land accounted for 21.6% of the watershed area. Residential land uses (urban) accounted for only approximately 10.9% of the total watershed area. In contrast, water and wetlands combined for approximately 18.1% of the watershed area.

TABLE 3

Clove Acres Lake Watershed Land Use

Land Use	Acres	Hectares	Percentage
Agriculture	2708.85	1097.09	21.6
Barren Land	43.73	17.71	0.35
Forest	6165.49	2497.02	49.1
Urban	1367.84	553.97	10.9
Water	188.10	76.18	1.5
Wetlands	2083.23	843.71	16.6
Total	**12557.23**	**5085.68**	**100.0**



Princeton Hydro

FIGURE 6 - LAND USE / LAND COVER

CLOVE ACRES LAKE WATERSHED
SUSSEX BOROUGH AND WANTAGE TOWNSHIP
SUSSEX COUNTY, NEW JERSEY
GRANT RP05-090

LEGEND

- Project Area
- HUC14 Boundaries
- Lakes
- Streams

N W E S

1 inch equals 1.5 miles

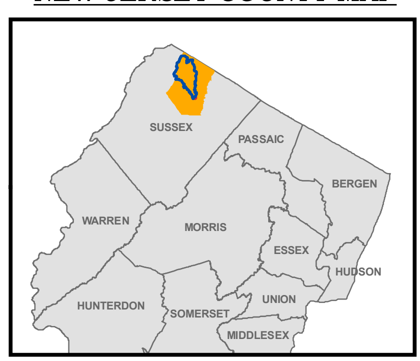
0 0.75 1.5 Miles

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. Watershed boundary, streams, lakes and land use / land cover as obtained from the NJDEP GIS website.

NEW JERSEY COUNTY MAP



Section 5 Hydrologic Budget

The hydrology of Clove Acres Lake represents, in its simplest sense, the water budget of the lake. As such, a complete budget will account for all water inputs to the lake which ultimately equal water outputs of the lake and will therefore represent a “mass balance” approach to modeling. Water inputs to the lake consist of precipitation, groundwater flow, and surface water runoff while outputs consist of lake discharge, seepage loss, and evaporation. Additionally, adjustments may be made to account for change in lake storage capacity. The methodology and results of the following analysis serves to account for all those aforementioned inputs and outputs therefore representing a complete hydrologic budget.

5.1 Precipitation / Evaporation

Direct precipitation on Clove Acres Lake was calculated using historically averaged 30 year (1971-2000) precipitation data accessed through CLIMOD at Sussex (Site ID: 288644). While precipitation data was available from the Sussex County Municipal Utilities Authority Wallkill River Watershed Management Group (WRWMG) these data were not utilized given the period of record (6 years) was much shorter than the historically available dataset recorded by the national weather service. Calculating the hydrologic model from this long term dataset will serve to normalize the effects of above or below average rainfall which may skew results obtained from a smaller dataset.

For calculation of direct precipitation on Clove Acres Lake Princeton Hydro simply multiplied precipitation (m) by the lake area (m^2) to arrive at a gross precipitation value of 1.6×10^5 m^3. In order to correct this gross value for evaporation from the lake surface, Princeton Hydro utilized empirically developed evaporation measurements accessed from CLIMOD from Canoe Brook, NJ (Site ID: 281335). Correcting the gross load for evaporation yields a net hydrologic load of 0.89×10^5 m^3 entering Clove Acres Lake on an annual basis.

5.2 Tributary Discharge and Modeled Surface Water Loading

For the purpose of calculating that load derived from surface/groundwater runoff entering the lake through Clove Brook Princeton Hydro relied primarily on directly measured discharge readings taken throughout the sampling season. These data represent site-specific hydrologic loading information and as such is considered the best data source for conducting the hydrologic budget. Given that continuous discharge was not measured Princeton Hydro further validated empirical discharge extrapolations to modeled hydrologic loadings and regional tributary analyses.

Tributary Discharge

Introduction

Stage-discharge ratings curves describe the mathematical relationship between stream stage or staff gage height and stream discharge. These ratings curves are therefore used to estimate stream discharge at a given staff gage reading. For the purposes of this project, ratings curves were developed for the two stations monitored as part of the Phase I Diagnostic/Feasibility study. Ratings curves primarily present an easy way to estimate discharge; this information can then be used in a variety of ways. The primary use of the ratings curve in this study is to estimate both baseflow and stormflow discharge and to calculate pollutant loads, particularly during stormflow events, by multiplying the calculated discharge by the concentration of various analyses sampled in the water quality monitoring portion of the study. The data are then used to verify and calibrate modeled pollutant loads in the Clove Acres Lake watershed and to provide a better understanding of the contributions of pollutant loads in the watershed.

The following sections relate in greater detail the methodology, results and discussion, and detailed uses of the stage-discharge ratings curves.

Methodology

The development of stage-discharge ratings curves consists of several distinct components. These components include the installation and reading of staff gages, collection of detailed discharge data through direct field measurement, and various regression analyses to actually calculate the ratings curve.

Note: the peculiar spelling of gage employed herein, normally spelled gauge, is a carry-over from the United States Geological Survey (USGS). The USGS is the national expert in the collection of discharge data and the development of stage-ratings curves, and it is largely their standard methodology and terminology which is utilized for this study.

Staff gage installation was the first task undertaken in this study. A staff gage is long piece of heavy-gauge sheet metal, painted and graduated into decimal feet, essentially resembling a large ruler. Staff gages are inserted somewhere in the stream channel and permanently fixed. At Clove Acres Lake staff gages were affixed to a concrete bridge abutment in Clove Creek and the lake’s concrete spillway because of the stability of these structures. A hammer-drill was utilized to drill into the concrete and the staff gages are affixed with concrete anchors. The stability of installed staff gages is of utmost importance as any vertical movement of the gage will skew the relationship between stream stage or staff gage height and discharge.

The next component of developing ratings curves is the physical measurement of stream discharge. To develop an accurate curve a number of discharge measurements must be made over a variety of discharges and stream stages. For this study, discharge measurements were recorded both by Princeton Hydro during scheduled sampling events and by a combination of HydroQual and the Wallkill River Watershed Management Group (WRWMG).

Discharge measurements performed by Princeton Hydro were made according to USGS methodology published in "Techniques of Water-Resources Investigations of the United State Geological Survey, Book 3, Applications of Hydraulics, Chapter A8, Discharge Measurements at Gaging Stations, by T.J. Buchanan and W.P. Somers, 1969". Discharge measurements consist of three distinct parts, measuring flow velocity, depth, and horizontal distance. Flow velocity measurements were made utilizing a vertical-axis Price meter, type AA, as recommended by USGS. These meters are preferred in low-velocity streams and have a high accuracy. Price meters are used in conjunction with a top-setting wading rod, which is used to measure stream depth and to set the Price meter at the 0.6-depth (six-tenths depth from the surface). Empirical evidence indicates that the average flow velocity of a narrow vertical column of water is approximated at the 0.6 depth, such that the average flow at a point in a stream with a depth of 1.0 feet is 0.4 feet, the 0.6-depth from the surface. A transect line is set across the stream, roughly parallel to the flow and perpendicular to either bank. Numerous flow velocity measurements are taken across the transect and flow velocity, depth, and distance from one selected bank is recorded.

The number of points taken is not a fixed number nor is the interval between points; however at a minimum twenty (20) such measurements must be taken. The goal is to limit each integrated point to less than 5% of total discharge along the cross section of stream investigated. The integration of a single point is a subset of the larger discharge measurement along the transect line and is the multiplicative product of flow velocity, depth, and the width between adjacent points. As such, points are taken closer together in the middle of the stream as both depth and flow velocity increase, and further apart in shallower depths and decreased flow velocity nearer the banks. Total discharge is then calculated by summing the individual points. Staff gage readings are recorded immediately before and after discharge measurements to ensure static stream depths during sampling.

Stage-discharge ratings curves are then calculated by examining the relationship between stage and instantaneous discharge measurements. The procedure for calculating ratings curves is published by USGS in "Techniques of Water-Resources Investigations of the United State Geological Survey, Book 3, Applications of Hydraulics, Chapter A10, Discharge Ratings at Gaging Stations, by E.J. Kennedy, 1984". The method utilized in this study does not involve the natural logarithmic transformation of both staff gage height and discharge as is typical, but instead relies on normal linear relationships because the closeness of fit as indicated by improved coefficient of determination (R^2) values in the untransformed regression models. In other words, stage and discharge showed a geometric relationship within the measured range. A least-squares regression analysis was then performed on the stage and discharge data that yields a variation of the curve equation and the coefficient of determination or R^2 value. The R^2 value is a statistical tool used to describe the relation between the two investigated variables such that an R^2 value of 0.900 roughly indicates that 90% of the variation in the dependent variable, in this case discharge, is explained by variation in the independent variable, stream stage; higher R^2 values indicate a tighter relationship. Discharge is then calculated by inserting the selected staff gage height as variable x into the equation. Staff gage heights are entered in feet and the resulting discharge is calculated as cubic feet per second (cfs).

The procedure described above was used for both stations. While this method may underestimate high storm flows without assuming a logarithmic relationship, the closeness of fit was much better than the logarithmic ratings curve. Additionally, this dataset did require some correction. A curious pattern was observed at both stations, but was more frequently observed at the spillway station. An analysis of the raw data indicated that several staff gage readings were approximately 0.1 feet higher than the natural trends of the data dictated. This was apparent primarily because these were observed at tightly grouped staff gage readings. This was observed on the data supplied by WRWMG at the Clove Creek station on February 1, and on three consecutive dates at the spillway station on March 1, May 3, and June 13, 2007. A simple correction of subtracting 0.1 feet in stage reading on these dates was performed which resulted in a much tighter fit and improved R^2 values for the curves. However, ratings curves were calculated for both corrected and uncorrected datasets. A final note is that no estimated discharges were used in calculating these curves. Only paired staff gage heights and instantaneous discharges were used to calculate the ratings curve; twelve paired data points were used in the preparation of the Clove Creek ratings curve while ten paired points were used in the preparation of the Spillway curves.

Upon completion of the stage-discharge ratings curves the formulas were used to obtain additional stream stage and discharge figures from supplied data without the corresponding paired discharge or staff gage data point. This was undertaken to exhibit the use of ratings curves and to further define the distribution of stream flows. In instances where only discharge was provided prior to the installation of the staff gages in September 2006 the staff gage heights were algebraically obtained using the ratings curve.

Some additional analyses were made concerning discharge and stage. Essentially, these consist of descriptive statistics of observed and calculated flow and stream stage.

Results

The following table represents the derived stage-discharge ratings curve at both the tributary and spillway stations and the R^2 values as calculated by the methods described above.

TABLE 4

Summary of Stage-Discharge Rating Curves

Station Name	Location	Stage-Discharge Ratings Curve, cfs	R^2
S-1	Clove Creek, Corrected	Discharge = 79.263*Staff Gage Height – 76.164	0.9723
S-1*	Clove Creek, Uncorrected	Discharge = 77.958*Staff Gage Height – 75.222	0.9422
S-J	Spillway, Corrected	Discharge = 58.841*Staff Gage Height – 47.327	0.9901
S-J*	Spillway, Uncorrected	Discharge = 59.683*Staff Gage Height – 50.090	0.9516

Also included in the appendices are tables relating staff gage height to discharge using the calculated curves and the graphical representation of the curve. The tables were specified over a range of both staff gage height and discharge that are likely to be seen; any observances outside the range can still be calculated manually. These tables are somewhat more convenient to use than manually calculating discharges at a given stage, while the graphs are an easy to understand graphical representation of the data relating the relationship between stage and discharge.

R^2 values for each ratings curve improved with the correction sited above. As a further confirmation of the tight ratings curve the actual field measured discharges and staff gage readings were plotted over the ratings curve displaying the good fit. Overall, the ratings curves are accurate, and represent an easy way to quickly calculate discharge with a high degree of confidence in the quality of the data. Additional graphical and tabular information is included in the appendix.

Overall, the data points used in the preparation of ratings curves for both stations reflect a wide variety of staff gage readings and consequently discharge. Raw readings for Clove Creek ranged from 0.9 feet on the staff gage and 0.4 cfs of discharge to 1.8 feet and 70.1 cfs, respectively. At the Spillway station the minimum uncorrected staff gage reading was 0.9 feet and the minimum discharge was 2.43 cfs while the maximum values were 1.7 feet and 50.1 cfs, respectively. On average, staff gage heights at Clove Creek were approximately 1.2 feet with an average discharge of 20.5 cfs and a median discharge of 14.1 cfs. At the Spillway, average staff gage height (corrected) was 1.2 feet with an average discharge of 20.6 cfs and a median discharge of 15.8 cfs. These numbers show the relatively close agreement between water entering Clove Acres Lake via the Clove Creek tributary inlet and exiting at the Spillway. Discharge at the Spillway was higher than Clove Creek for two reasons: first, the lake picks up additional runoff to Clove Creek downstream of the S-1 gage location as well as direct runoff and groundwater contributions, and second, discharge is somewhat higher because of more steady, regulated flows at the Spillway during low flow or baseflow conditions because of the storage capacity of the lake. The converse pattern of lake storage capacity is also seen during stormflow or elevated discharge times. During storms flows were consistently higher in the tributary exhibiting the lakes ability to hold and slowly release received water over time.

TABLE 5

Average and Median Staff Gage Heights and Discharges of Points Used in Stage-Discharge Ratings Curves

Station	Metric	Staff Gage Height	Discharge (cfs)
S-1 – Clove Creek, Corrected	Average	1.22	20.54
	Median	1.19	14.13
S-1* - Clove Creek, Uncorrected	Average	1.23	20.54
	Median	1.24	14.13
S-J, Spillway, Corrected	Average	1.15	20.62
	Median	1.07	15.80
S-J* - Spillway, Uncorrected	Average	1.18	20.62
	Median	1.09	18.80

As mentioned in the methodology section additional data points were provided that did not have the corresponding staff gages readings or discharge. This occurred when discharges were measured prior to staff gage installation and when staff gage readings were taken but no discharge was measured such as when flow velocities became too high to safely wade. Using these numbers in addition to the points used in the ratings curves evaluations averages and medians both increased significantly from those reported above. These readings are likely a more accurate representation in calculating annual flow as they take into account not only baseflow, whereby groundwater is the sole source of hydrologic input, but also overland flow during storm events which may actually account for the majority of total hydrologic loading. The following table lists adjusted average and median discharge values taken over a wide range of hydrologic conditions.

TABLE 6

Average and Median Staff Gage Heights and Discharges of All Data Points

Station	Metric	Staff Gage Height	Discharge (cfs)
S-1 – Clove Creek, Corrected	Average	1.42	36.10
	Median	1.32	27.27
S-1* - Clove Creek, Uncorrected	Average	1.42	35.66
	Median	1.32	27.27
S-J, Spillway, Corrected	Average	1.46	38.51
	Median	1.32	31.31
S-J* - Spillway, Uncorrected	Average	1.48	38.20
	Median	1.35	30.48

For calculating the total annual hydrologic load to the lake Princeton Hydro utilized the average discharge (38.51 cfs) developed from the S-J (Spillway, corrected) in the assumption of the lake in a steady-state whereby inflow = outflow. Use of this average discharge value equates to a measured annual hydrologic load of 34.4×10^6 m^3.

Modeled Tributary Loading

The above data was further validated through comparisons to modeling efforts and regional tributary analyses. For this effort Princeton Hydro utilized a corrected form of the modified rational methodology to calculate the volume of water entering the lake system from surface and groundwater sources.

Methodology

The Modified Rational method or model was developed the by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) to describe the runoff component of the hydrology budget. While originally designed for small sites during a single storm event as a sizing model for designing stormwater infrastructure the model is also useful when applied to a large watershed. The Modified Rational model is based on the use of curve numbers (CN) applied to delineated land parcels based on LU/LC and soil hydrological group. Curve numbers are in effect simple percents that describe how much precipitation will runoff a site which is based on the permeability characteristics of soils and factor PET and groundwater infiltration into this estimate. Using the Modified Rational in this manner tends to provide overestimates when applied to an entire watershed, because over long distances the runoff volumes tend to be more quickly converted towards PET and infiltration components before it can reach the waterbody. For this reason, Princeton Hydro has adopted a Corrected Modified Rational Model that accounts for these overestimates by accounting for PET when utilized on a watershed wide scale over the course of the year. As such, monthly precipitation values taken from the Northeast Regional Climate Center CLIMOD 30 year average climate dataset were corrected by subtracting PET values calculated using the Thornthwaite methodology to create a net precipitation category. Since PET can exceed precipitation values during the warm summer months, the precipitation minus PET value is used as the precipitation value for the model, or at least 50% of precipitation is assumed to be available as runoff, whichever value is greater.

In order to assess the applicability of our corrected modified rational hydrologic model Princeton Hydro cross validated all modeled data to geographically referenced tributary discharge data obtained from the United States Geologic Survey (USGS). For this process three (3) continuously monitored tributary stations located within the same physiographic province, sharing similar catchment areas and land use activities were selected. Discharge coefficients in the units of ($m^3/m^2/yr$) were derived for each of the three tributaries and averaged. This normalized discharge value was then compared to that obtained from Princeton Hydro's modeling efforts for similarity.

Results

Several iterations of our corrected modified rational were ran in order to determine which best represented the true hydrologic loading to Clove Acres Lake. For the purpose of this study we found that correcting the modified rational for 50% of precipitation available for runoff during periods whereby evaporation exceeded precipitation provided excellent congruence both with the empirical discharge data and that obtained from our regional tributary analysis. This corrected model resulted in an annual hydrologic load of 34.6 x 10^6 m^3. This value was then normalized to the watershed area which resulted in a load coefficient of 0.682 $m^3/m^2/yr$ which compared remarkably well with an average regional tributary load coefficient of 0.649 $m^3/m^2/yr$.

5.3 Flushing and Retention

The hydraulic flushing rate and the hydraulic retention period are often regarded as some of the most critical hydrologic data in describing both the hydrologic and ecological functions of a waterbody. In particular, both are valuable for assessing nutrient dynamics in lakes and can be used to quantify nutrient retention which is a basic descriptor in predicting water quality. These numbers are also critical in summing up water budgets in an easily understood format.

Both of these calculations are easily performed. Flushing rate, which is a measure of the amount of times a waterbody flushes or volumetrically exchanges, is calculated by dividing the total volume of the annual inflow by the volume of the waterbody. Hydraulic retention period is the inverse metric that shows the retention period; essentially how long a single drop of water is expected to remain within a waterbody. This is calculated by dividing the volume of the waterbody by the total annual inputs and multiplying the result by a time, generally days in a year.

The results for hydraulic flushing and retention are as follows:

- Hydraulic Retention (days) – 1.8
- Hydraulic Flushing – 199.2 times per year

5.4 Summary

The above data as it relates to direct precipitation, surface / groundwater flow, comparison metrics, and resulting flushing and retention times are hereby listed in tables 7 through 9.

TABLE 7

Hydrology Summary

Net Precipitation on Lake (m^3)	Annual Tributary Discharge – Measured (m^3)	Modeled Hydrologic Load (m^3)	Retention Time (days)	Flushing Rate (per year)
8.9×10^4	34.4×10^6	34.6×10^6	1.8	199.2

TABLE 8

Hydrology Comparison

Load Coefficient ($m^3/m^2/yr$)		
Measured	**Modeled**	**Regional Analysis**
0.678	0.682	0.649

TABLE 9

Hydrology Comparison – Percent Difference

Measured vs. Modeled	Measured vs. Regional	Modeled vs. Regional
0.5%	4.3%	4.8%

Section 6 Pollutant Budget

Pollutants can enter a lake either as discrete discharges from known sources or through runoff from a variety of sources within the watershed. Discrete discharges are referred to as point sources, and all other sources of pollutants are referred to as non-point sources. Non-point sources (NPS) contribute pollutants through stormwater runoff, precipitation on the lake's surface, and internal sources, such as groundwater inputs and release from lake sediments. By quantifying all of the pollutant sources for a lake, a pollutant budget can be developed. This pollutant budget is absolutely necessary in assessing the ecological and recreational health of a waterbody. In addition, pollutant budgets are also used to develop and/or evaluate various in-lake and watershed management strategies. For the purposes of this study, the term pollutant refers to the nutrients nitrogen and phosphorus and suspended sediments.

Typically, the largest source of pollution originates from a lake's watershed. Therefore, land use practices impact a lake through extensive sedimentation and/or heavy nutrient loading. Most of this loading occurs during storm events; eroded soils, fertilizers, heavy metals and petroleum hydrocarbons are all constituents of storm runoff. A large majority of these storm runoff pollutants are either absorbed or adsorbed onto the surface of sediment particles (Wanielista, et al., 1982).

As a watershed becomes more developed, there is an increase in impervious surfaces. Such conditions substantially reduce the opportunity for stormwater to percolate through the soil. Thus, more watershed-generated pollutants will be discharged into receiving waterbodies. As such, residential areas will contribute, on a unit areal basis, more nutrients and suspended sediments than forested areas.

There are also internal processes that are responsible for a given amount of a lake's annual pollutant load. Die back of weeds and algae can generate a considerable amount of nitrogen and phosphorus as a result of the bacterial decomposition of plant tissue and algal cells. This process can also lead to the accumulation of organic sediments. It is also possible, under anoxic (no measurable amount of DO) conditions, to liberate substantial amounts of phosphorus from the sediments into the overlying water column. Depending on certain physical factors, this internally regenerated phosphorus can be a significant component of a lake's total annual phosphorus load.

Intuitively, pollutants are generally thought of as having a direct and harmful impact on organisms and the environment. In contrast, nitrogen and phosphorus stimulate algal and aquatic plant growth, which typically results in an increase in the biomass and growth of other organisms (i.e. fish). However, excessive amounts of nitrogen and phosphorus can also generate nuisance densities of algae and/or aquatic plants which, in turn, results a decline in water quality and overall ecological value.

In contrast to nitrogen and phosphorus, total suspended solids (TSS) do not stimulate excessive algal or aquatic plant growth. In fact, elevated TSS concentrations limit algal / aquatic plant growth by limiting the amount of light available for photosynthesis. Elevated TSS concentrations can destroy fish habitat (i.e. spawning beds), directly impact the health of fish (covering the surface of the gills), and accelerate the rate of in-filling of aquatic ecosystems. Similar to nitrogen and phosphorus, the impacts of TSS concentrations are cumulative in nature. As the TSS load increases, its impact on the environment increases. As such, the impact of the NPS pollutants TP, TN and TSS on aquatic ecosystems needs to be evaluated with a cumulative perspective in mind.

It is thus important, when preparing a lake's nutrient and sediment budget, to properly account for all site specific factors which contribute to the magnitude of these pollutant loads. This includes an assessment of the relative contributory effects of such factors as lake morphometry, land use, slope, soil, wastewater treatment practices and stormwater management. In this study, three (3) main components of the Clove Acres Lake nutrient and sediment budgets are analyzed:

1. Overland (surface runoff),
2. Internally recycled,
3. Atmospheric (precipitation and dryfall)

The methodologies used to calculate the loads associated with each of these components, as well as the results of these analyses, are presented in the following sub-sections.

6.1 Non-Point Source (NPS) Loading from Surface Runoff

Overland runoff contributions from the lake's watershed were calculated using field validated, U.S. EPA modified, unit area loading (UAL) coefficients. A set of appropriate UAL coefficients were selected for each land type (Table10). Selected UAL coefficients, as developed by US EPA, (1990) and modified by Souza and Koppen (1983), were used to compute the lake's annual NPS nitrogen, phosphorus and sediment loads. By using the UAL coefficients in Table 10, along with the areas of each land type (Table 3 and Figure 6), the TN, TP and TSS annual loads originating from surface runoff were calculated for Clove Acres Lake (Table 11).

The results of the UAL surface runoff analysis for Clove Acres Lake show that the annual nitrogen (TN) load is 20,463 kg, the annual phosphorus (TP) load is 2,473 kg and the annual sediment (TSS) load is 21,976,36 kg (Table 11). The highest amounts of TN, TP, and TSS originated from agricultural lands. In fact, agricultural lands accounted for 66.5% of TP runoff, while residential/urban land accounted for another 19%. Thus, the dominance of agricultural and residential lands in the surface runoff pollutant loads are a result of the typical earth-moving and fertilizing activities associated with agriculture and high rates of sediment transport associated with developed lands, resulting in larger pollutant loads. As previously described, agricultural land accounts for approximately 21.6% while residential land accounts for approximately 10.9% of the land within the Clove Acres Lake watershed (Table 3).

6.2 Internal Regeneration of Phosphorus

As previously mentioned, internal regeneration is another potential source of phosphorus loading to lakes. In-sediment chemical reactions release substantial amounts of phosphorus into the overlying water column once the bottom waters become anoxic (DO concentrations < 1 mg/L). Phosphorus can accumulate in the bottom waters and be subsequently transported to the surface waters where it can stimulate high levels of algal and aquatic plant growth. This mechanism is defined as internal phosphorus loading. Under certain conditions, internal loading can account for a large proportion of a lake's annual phosphorus load, particularly during the dry summer months when surface runoff is minimal. Therefore, in order to develop a more accurate annual phosphorus load for Clove Acres Lake the internal load was quantified.

Clove Acres Lake was for the most part oxygenated from surface to bottom, which was chiefly due to its relatively shallow depth and high flushing rate (Appendix A). This combined with the general morphometry of Clove Acres Lake usually prevented the establishment of thermal stratification. In turn, this allowed the water column to remain fairly well oxygenated from surface to bottom. Thus, the quantification of Clove Acres Lake's annual phosphorus load was based on the bottom waters remaining fairly well oxygenated through the growing season. Under such conditions, bacterial decomposition would be the dominant source of internally regenerated phosphorus.

A number of TP release rates for aerobic (oxygenated; DO concentrations > 1 mg/L) sediments were reviewed (Nurnberg, 1982; Mawson, et.al., 1983) and a flux rate of 0.6 mg m^{-2} day^{-1} was selected for Clove Acres Lake. Accounting for temperature effects on bacterial and chemical activity, it was determined that 1.5 kg (3.2 lbs) of TP would be released from the sediments from mid-May through mid-September, over the course of 120 days (Table 12).

6.3 Groundwater Loading

Groundwater can be a source of phosphorus loading, especially in areas where agriculture predominates. Phosphorus from fertilizers can leach through the soil and eventually contaminate groundwater, which is the source for baseline flow during dry periods. However, calculations for groundwater phosphorus should be performed using dissolved forms of phosphorus. Total phosphorus, which contains particulate phosphorus, can lead to erroneous load calculations. This study tested only for total phosphorous, so groundwater phosphorus loading was not included in the pollutant budget. In addition, groundwater loads were not utilized in the TMDL.

However, in the future, the quantification of ground water nutrient concentrations should be considered. For example, based on the growing residential development of Sussex County and the septic systems that may be a part of these developments, the potential for ground water nutrient concentrations, specifically nitrate-N and TP, to raise is straightforward.

6.4 Atmospheric Loading

The final source of nutrients for the Clove Acres Lake pollutant budget pertains to precipitation and atmospheric dryfall. Once again, US EPA loading coefficients were used (Table 10). These sources of nutrients were relatively minor, but were included in order to increase the accuracy of the budget. It was calculated that direct precipitation accounted for 131.6 kg of TN per year and 3.3 kg of TP per year, while atmospheric dryfall accounted for 5.3 kg of TN per year and 0.03 kg of TP per year. Nutrient loads from precipitation and dryfall were combined and reported as the atmospheric contribution to Clove Acres Lake (Table 12).

6.5 Pollutant Budget Summary

All of the pollutant sources of Clove Acres Lake were categorized into one of three (3) main sources. Their relative contributions are shown in Table 12. While surface runoff accounted for the largest source of TP entering Clove Acres Lake, atmospheric and internal loading also contributed a small amount of phosphorus to the lake.

Based on the low in-lake phosphorus concentrations and the general absence of nuisance forming blue-green algae, it was determined that phosphorus is most likely the primary limiting nutrient for Clove Acres Lake. That is, a relatively small increase in the phosphorus load can stimulate substantially large amounts of algae and/or aquatic plant growth. Therefore, this study primarily focuses on the annual phosphorus budget for Clove Acres Lake.

Table 13 summarizes the annual TP budget for Clove Acres Lake in kilograms, pounds and on a percent contribution. Surface runoff accounts for 99.8% of Clove Acres Lake's annual TP load, while internal loading and atmospheric sources combined accounted for less than 1.0% of the annual TP load (Table 13). Based on this budget analysis, management efforts need to focus on watershed-based techniques. Since the Clove Acres Lake watershed is largely forested, such efforts should focus on the preservation and protection of those existing conditions. However, the moderate portion of the watershed is agricultural (approximately 21%) and residential (13%) in nature and will require both preservation and restoration efforts. Thus, a pro-active strategy is required to ensure that water quality conditions in Clove Acres Lake do not decline in the future.

TABLE 10

Non-point Source (NPS) Loading Coefficients (kg / ha / yr) for Clove Acres Lake

Non-point Source	TN	TP	TSS
Residential/Urban	10	1.6	4000
Agriculture	7.5	1.5	1000
Barren Land	10	0.5	4000
Forested	2.5	0.1	250
Water	0	0.1	-200
Wetlands	0	0.1	-200
Precipitation on Lake *	10	0.25	-----
Dryfall on Watershed **	0.4	0.002	-----

* Precipitation related pollutant load that falls directly on the lake's surface.
** Dust and other atmospheric-borne dryfall pollutants deposited on the watershed.

TABLE 11

Annual Surface Runoff Pollutant Loads (kg) for Clove Acres Lake

Land Use	TN	TP	TSS
Residential/Urban	3,187	477.7	425,893
Agriculture	9,394	1,645.6	1,114,784
Barren Land	132	8.9	43,789
Forested	7,741	249.7	761,274
Water	-	7.6	-15,228
Wetlands	9	84.4	-132,876
Total	**20,463**	**2,473.9**	**2,197,636**

TABLE 12

Pollutant Budget for Clove Acres Lake (kg per year)

Sources of Pollutants	TN	TP	TSS
Surface Runoff	20,463	2,473.9	2,197,636
Internal Loading	-	1.5	-
Atmospheric	137	3.33	-
Total	**20,600**	**2,478.7**	**2,197,636**

TABLE 13

Annual Phosphorus Budget for Clove Acres Lake

Sources of Pollutants	Kilograms	Pounds	Percent Contribution
Surface Runoff	2,473.9	5,450	99.8
Internal Loading	1.5	3.3	0.07
Atmospheric	3.33	7.3	0.13
Total	**2,478.7**	**5460.6**	**100.0**

Section 7 Trophic State Modeling Analysis

Waterbodies are typically categorized in terms of overall biological productivity. Trophic state modeling essentially consists of the quantification of a lake's relative potential productivity by regression analysis of nutrient, hydrologic and morphometric data (Uttormark et al., 1974). A variety of models have been developed for this purpose but most are very similar in their mathematical origin. The modeling not only quantifies the productivity of a waterbody, buy may also be used to make predictions of changes in water quality (i.e. transparency, productivity, frequency and magnitude of blooms, etc.) arising from changes in land use, pollutant loading, climatic variability and alternative lake management strategies. As such, these models serve as valuable planning and management tools.

Most trophic state models are based on field measurements and empirical data. Since such data can be very site specific, the use of a model in a region or waterbody type other than where it has been verified can generate erroneous information. In order to minimize the degree of error, extremely generalized trophic state models were used in this study. These models were primarily derived from natural and man-made lakes in the United States and Canada. For the purposes of this study, these generalized models will serve as an effective means of quantifying and predicting algal productivity and biomass in Clove Acres Lake.

The data collected during 2006-07 monitoring program were used to model Clove Acres Lake's phosphorus retention coefficient (Kirchner and Dillon, 1975) and relative level of productivity via the chlorophyll *a* productivity equivalent (Carlson, 1977). In addition, models were used to predict the total phosphorus and chlorophyll *a* under varying scenarios.

7.1 Phosphorus Retention Coefficient

The first step in the modeling process involved the calculation of the phosphorus retention coefficient (Equation 1); that is, the percentage of the annual phosphorus load that is retained annually in the lake. This value is important in that it largely determines the amount of phosphorus that is actually available for plant and algal uptake. Waterbodies with a substantial annual hydrologic load flush frequently, typically have a lower phosphorus retention value and usually, but not always, support less dense assemblages of weeds and/or algae than do infrequently flushed waterbodies.

The importance of flushing on phosphorus availability and trophic state stems from its relationship with the areal water load (q_s). The areal water load is a function of the lake's surface area and the annual amount of water outflow. This areal water load was used to calculate the phosphorus retention coefficient using equation 2 (Kirchner and Dillon 1974):

Equation 1 – Phosphorus Retention Coefficient

$$R = 0.426e^{(-0.27qs)} + 0.547e^{(-0.00949qs)}$$

Where R = Phosphorus Retention

qs = Areal Water load = $\frac{\text{Annual Outflow from the Lake}}{\text{Surface Area of the Lake}}$

e = 2.718 (natural log)

Based on the results of the hydrologic budget that was calculated for the Clove Acres Lake Characterization and Restoration Plan, the phosphorus retention coefficient for Clove Acres Lake was determined to be 0.054. This means that 5.4% of the phosphorus entering the lake remains in the lake while the rest of the phosphorus exits the lake through discharge. This value was based on a calculated annual hydrologic load of 34,403,721 m^3.

In general, waterbodies with phosphorus retention coefficients greater than 0.6 (60%) should be productive and prone to excessive planktonic algal blooms. Thus, according to the calculated phosphorus retention coefficient, Clove Acres Lake is not likely to experience excessive planktonic algal blooms under typical climatic conditions. For the most part, this statement is accurate. While planktonic algal blooms are not commonly experienced in Clove Acres Lake, nuisance densities of aquatic plants, particularly the invasive species Eurasian watermilfoil (*Myriophyllum spicatum*), are common. Since these rooted aquatic plants obtain the majority of their nutrient requirements from the sediments, a highly flushed system with a relatively low phosphorus retention coefficient would not limit their growth. However, elevated nutrient concentrations within the water column can stimulate the growth of benthic algae that grow attached to or over the stands of aquatic plants, sediments, or rocks. These algae can detach from these substrates and produce nuisance conditions in the form of algal surface mats, which can periodically attain nuisance densities in Clove Acres Lake.

7.2 Predicting Total Phosphorus

The next step in this modeling procedure was the selection of a general model that could be used for the lake to predict in-lake phosphorus concentrations. NJDEP previously reviewed a variety of empirically based water quality models and selected the Reckhow model (1979) to relate annual phosphorus loading to steady-state, in-lake phosphorus concentrations (NJDEP, 2004).

To meet the objectives of the TMDL, the Reckhow model was selected because it has the broadest range of hydrologic, morphological and loading characteristics in its database of north temperate lakes (Equation 2). As outlined in the State's TMDL document, the water quality characteristics of Clove Acres Lake are within the parameter ranges established for the Reckhow model (NJDEP, 2004). Thus, the Reckhow model was used to model steady state, in-lake TP concentrations in the lake.

Equation 2: $$[TP] = L / (11.6 + 1.2 * qs)$$

Where:

[TP] = Predicted mean TP concentration (mg/L)
L = areal phosphorus loading ($g/m^2/yr$)
qs = areal water loading (m/yr)

The results of these calculated in-lake TP concentrations were compared to empirical data collected from the lake to determine how close the predicted modeled data compare to the measured data. The results of the calculated Reckhow model analysis, as well as the reference pre-development (assumed conditions) and measured (field collected data) concentrations are provided in Table 14. Based on the NJDEP TMDL, the mean in-lake TP concentration under reference conditions for Clove Acres Lake would be 0.016 mg/l. The reference condition represents a state in which no one is living within the Clove Acres Lake watershed and none of the land is developed. Thus, the reference TP concentration is the "absolute baseline" concentration for the lake; it is not possible to reduce the in-lake concentrations below 0.016 mg/L, even in the absence of human impacts.

Using the Reckhow model, the existing mean TP concentration in Clove Acres Lake as per 2007 watershed conditions was calculated to be 0.058 mg/L. Using the 2006-2007 monitoring data for Clove Acres Lake, the mean growing season (April to September) TP concentration was 0.06 mg/L . Thus, the measured mean concentration agrees reasonably well with the predicted (modeled) concentration. The percent agreement between the measured and predicted concentrations was 96.7%. Thus, the Reckhow model reasonably predicted in-lake TP concentrations in Clove Acres Lake.

TABLE 14

Results of the Reckhow Model for Clove Acres Lake, Under Various TMDL-based Loading Conditions (mg/L)

Water Quality Scenario	Clove Acres Lake
Reference Condition	0.016
Existing conditions – 2007 (as per the Reckhow Model)	0.058
Measured Concentration*	0.06
Targeted Conditions (as per the TMDL)	0.02

* The measured concentration is based on surface water TP data collected from 2006 through 2007 at three sampling stations during the growing season.

7.3 Predicting Chlorophyll a Concentration

In order to gauge the water quality response to reference, existing and targeted conditions, mean TP concentrations were converted into chlorophyll *a* concentrations. Chlorophyll *a* is a pigment all algae and plants possess and use in the process of photosynthesis. Therefore, measuring chlorophyll *a* in lake water is an effective way of quantifying phytoplankton (free-floating algae) biomass.

It must be emphasized that measurements of open water chlorophyll *a* concentrations do not typically include benthic dwelling algae or rooted aquatic plant biomass. Thus, a complete reliance on phytoplankton biomass as a means of assessing the primary productivity has the potential to substantially underestimate the ecosystem-based level of primary productivity. In spite of this, the particularly strong relationship between TP and chlorophyll *a* does provide a means of translating TMDL-based phosphorus loads into a distinct, measurable and perceived "ecological" endpoint (i.e., algal blooms). Therefore, chlorophyll *a* will be used to confirm the validity of the established targeted phosphorus loads. However, the ecological and economic impacts associated with benthic algae and aquatic plants were considered in the development of the Clove Acres Lake Restoration Plan.

A variety of water quality models can be used to predict chlorophyll *a* concentrations based on the various phosphorus loading scenarios for the lake. Although each model has particular requirements and limitations, Vollenweider (1976) was selected for consideration because it is more appropriate for highly-flushed waterbodies such as Clove Acres Lake. Thus, the predicted (Reckhow model) and measured TP concentrations for the lake were used to calculate chlorophyll *a* concentrations for the lake. Model results were then compared to the lake's respective measured chlorophyll *a* concentration.

The Vollenweider model slightly overestimated the amount of algae that would result from the incoming phosphorus loads for Clove Acres Lake. This overestimate of the amount of algal biomass, as chlorophyll *a*, was more than likely the result of not taking into account aquatic plants and/or benthic algae, which directly assimilate a portion of the phosphorus entering Clove Acres Lake. Such organisms utilize phosphorus but are not well represented when measuring open water chlorophyll *a* concentrations.

Using the targeted in-lake TP concentration of 0.02 mg/L as identified in the Clove Acres Lake TMDL, the targeted mean chlorophyll *a* concentration through the course of the growing season is predicted to be 8.7 mg/m^3 (Table 15). Relative to the predicted mean chlorophyll *a* concentration (31 mg/m^3) based on the measured TP concentrations, this represents a 73% reduction in chlorophyll *a* concentrations in order to comply with the TMDL.

TABLE 15

Measured and Predicted Total Phosphorus and Chlorophyll *a* Concentrations for Clove Acres Lake

Parameter and Scenario	Clove Acres Lake
Measured TP	**0.06 mg/L**
Predicted TP (as per Reckow Model)	0.058 mg/L
Target TP (from TMDL)	0.02 mg/L
Measured Chlorophyll *a* (mean concentration)	**29 mg/m^3**
Predicted Chlorophyll *a* (using measured TP)	31.3 mg/m^3
Predicted Chlorophyll *a* (using predicted TP)	31.2 mg/m^3
Predicted Target Chlorophyll *a* (using TP from TMDL)	8.7 mg/m^3

The bold values are empirical data. The remaining data are model results.

As mentioned above, the trophic state of a lake is a way of describing its biological productivity on a relative basis. The Trophic State Index (TSI) presented here is one of the most commonly used indicators in limnology (Carlson, 1977). The index is based on three water quality parameters, total phosphorus, chlorophyll *a* and Secchi depth, from a variety of lakes. Total phosphorus was chosen since it is commonly the most limiting nutrient for algal growth. Chlorophyll *a* is a pigment used in photosynthesis that all algal groups possess and therefore is an excellent means of measuring algal biomass. Secchi depth is a common measurement of water clarity.

Mean values of TP, chlorophyll *a* and Secchi depth for a lake are logarithmically converted to a scale of relative trophic state ranging from 1 to 100 where increasing values are indicative of increasing trophic state. A TSI of less than 35 indicates oligotrophic (low productivity) conditions, a TSI between 35 and 50 indicates mesotrophic (moderate productivity) conditions, and a TSI greater than 50 indicates eutrophic (high productivity) conditions. Hypereutrophic (extremely high productivity) TSI value, greater than 60, are typically associated with nuisance conditions. Higher numbers are associated with increased probabilities of encountering nuisance conditions such as aesthetic problems and algal scums.

The trophic state indices for Clove Acres Lake are shown in Table16. These values were calculated using the in-lake water quality data that were collected as part of this Study (Carlson, 1977).

TABLE 16

Trophic State Indices for Clove Acres Lake

Trophic State	**Water Quality Parameter**		
	Total Phosphorus (mg / L)	**Chlorophyll *a* (mg / m^3)**	**Secchi Depth (m)**
Clove Acres Lake (L-1) mean water quality value	0.06	29	1.2
Clove Acres Lake TSI values (log value)	63	64	57

All three trophic state indices were greater than 50, indicating that Clove Acres Lake is a eutrophic (highly productive) waterbody. In addition, the TP and chlorophyll a TSI values were greater than 60, indicating hyper-eutrophic conditions.

In summary, Clove Acres Lake is a eutrophic to hypereutrophic waterbody that has the potential, and periodically does, experience nuisance water quality conditions. These nuisance conditions include the development of algal mats and excessive densities of rooted aquatic plants, primarily the exotic species Eurasian Watermilfoil. While phytoplankton (open water) algal blooms or surface scums are not typically experienced in Clove Acres Lake, an increase in its current phosphorus load would result in a higher probability of such conditions. Therefore, the long-term management and restoration of Clove Acres Lake should concentrate on a pro-active strategy of managing the lake as a eutrophic waterbody, reduce phosphorus and solid loads entering the lake, and preserve existing watershed resources. Finally, a number of both in-lake and watershed management measures should be considered for implementation in Clove Acres Lake to enhance its recreational fishery potential and control / eradication of the invasive species Eurasian watermilfoil.

Section 8 Establishing Water Quality Goals and Linking Restoration Plan to TMDL

Over the course of the two year monitoring program at Clove Acres Lake, Secchi depth remained above 1 meter (3.3 feet). Secchi depths greater than 1 meters are generally acceptable by the layperson for a recreational waterbody; Secchi depths less than 1 meters are considered undesirable (Princeton Hydro, in-house data on Mid-Atlantic waterbodies). Thus, Secchi depth values in Clove Acres Lake were generally considered acceptable for recreational use. In fact, the acceptable Secchi depth, coupled with the shallow mean depth of 1.5 meters, is the cause for the nuisance densities of benthic mat algae and the invasive submerged plant Eurasian watermilfoil. Given these conditions, there is no concern over the need to improve water clarity conditions in Clove Acres Lake. In contrast, the main water quality concern is to reduce stands of Eurasian watermilfoil, nuisance densities of filamentous mat algae and, to a lesser extent, planktonic algal blooms (surface scums).

Based on the TMDL, the recommended overall percent reduction in TP should be 75% (NJDEP, 2004). This recommended percent reduction is based on maintaining a target concentration of 0.02 mg/L and having an upper bound target concentration of 0.03 mg/L.

Based on existing conditions within the lake, the measured and predicted TP concentrations, and the other factors related to implementation, it is recommended that the percent reduction in TP should be lowered to 30%. The following provides a series of points to support this recommendation.

- Clove Acres Lake is a small artificial impoundment of Clove Brook; such waterbodies do not function and process nutrients the same as natural waterbodies. Artificial impoundments tend to experience higher rates of sedimentation and nutrient loading but also tend to have higher flushing rates (Thornton, et. al., 1990). In addition, the watershed area to surface water area ratio for impoundments tends to be substantially larger relative to natural waterbodies. This is certainly the case for Clove Acres Lake, which has a watershed : surface water ratio of 386.4. Given these differences, Clove Acres Lake should not be managed as a natural lake.

- The targeted TP concentration under the TMDL is 0.02 mg/L. Based on this study's analysis, if the entire Clove Acres Lake watershed was completely forested and no one lived in the watershed, the TP concentration would be 0.021 mg/L. Thus, under the TMDL's existing targeted TP concentration scenario, the entire watershed would need to be completely re-forested. Again, this is largely a reflection of the fact that Clove Acres Lake is an artificial impoundment of Clove Brook; such watersheds have larger pollutant loads on an aerial basis, relative to natural lakes.

- The dominant water quality problems impacting the recreational and ecological value of Clove Acres Lake is the presence of the nuisance exotic submerged macrophyte Eurasian watermilfoil. This nuisance plant negatively impacts the lake's fishery and recreational potential as well as facilitates the growth of filamentous mat algae along the water's surface. In contrast, planktonic algal blooms do not persist long in Clove Acres Lake due to the lake's high flushing rate; the lake flushes slightly less than 200 times per year. Given these conditions, the focus on Clove Acres Lake should be placed on the eradication of the invasive species, coupled with some watershed management.

Recommended Water Quality Goals for Clove Acres Lake

Based on the observed and modeled conditions of Clove Acres Lake, Princeton Hydro recommended that the targeted TP concentration for this waterbody be 0.04 mg/L and not 0.02 mg/L. A targeted concentration of 0.02 mg/L would be achieved if all residential / agricultural land is converted into forested / wetlands. If pre-development conditions are the goal for the Clove Acres Lake watershed, then the dam should be breeched to restore Clove Brook to its original condition. However, since the lake is a valuable ecological and recreational resource for the local stakeholders, such an action is unlikely and the TMDL and associated Restoration Plan need to focus on managing the lake.

Such a scenario of reducing the in-lake TP concentration to 0.02 mg/L is unlikely; therefore the proposed targeted TP concentration for Clove Acres Lake is 0.04 mg/L. Such a TP concentration is 20% below the State's Total Phosphorus Water Quality Criteria of 0.05 mg/L (N.J.A.C. 7:9B-1.14(c)). Such a targeted TP concentration for Clove Acres Lake would require a 30% reduction in the existing annual TP load. With an existing TP load of 2,479 kg and a targeted TP load of 1,712 kg, the annual load would need to be reduced by 767 kg (1,690 lbs) in order to comply with this proposed modification to the TMDL.

The "developed" land within the Clove Acres Lake watershed, residential / urban and agriculture, account for approximately 86% of the annual surface runoff TP load. Thus, the identified reduction in the existing TP load focuses almost exclusively on these two land covers. On a proportional basis, the residential / urban TP load is approximately 30% of the agricultural TP load. Using these percentages as a guide, the identified reduction in the TP load required to attain the targeted load, was divided according to developed land cover in the following manner:

Identified TP load targeted for reduction for residential / urban lands	230 kg
Identified TP load targeted for reduction for agricultural lands	537 kg
Total TP load identified for reduction to comply with TMDL	**767 kg**

Based on this analysis, the WRWMG will need to continue their efforts in working with the farmers within the Clove Acres Lake watershed as well as the Sussex County Soil Conservation District in reducing the TP, as well as other pollutants, loads entering the lake. As will be discussed in detail in the Management Plan, a large part of these efforts will focus on streambank and shoreline stabilization, which includes both agricultural and residential lands.

In order to determine how reducing the in-lake TP load will improve water quality conditions, the Vollenweider (1976) model was once again employed to translate phosphorus loading to chlorophyll *a* concentrations, which is a quantification of planktonic algae biomass (for details see Section VII). As shown in Table 15, under existing TP loading conditions the predicted chlorophyll *a* concentration in Clove Acres Lake is 31 mg/m^3, which agrees reasonably well with the measured mean chlorophyll *a* concentration of 29 mg/m^3.

Based on user perception, chlorophyll *a* concentrations greater than 30 mg/m^3, typically result in severe nuisance conditions from a recreational perspective (Table 17). However, if the targeted in-lake TP concentration is 0.04 mg/L, a series of calculations result in the chlorophyll *a* concentration being 22 mg/m^3. Thus, based on the Walmsley and Butty (1979) user perception guide, reducing the mean TP load from 0.06 mg/L to 0.04 mg/L will result in conditions where algal scums or nuisance conditions are evident. This is a measurable and observable improvement relative to the severe nuisance algal conditions encountered as chlorophyll *a* concentrations exceed 30 mg/m^3. Indeed, the 30 mg/m^3 value is a threshold of concern used in managing Lake Mohawk, Sussex County, New Jersey. For that lake the goal is to keep chlorophyll *a* concentrations below 30 mg/m^3. If concentrations exceed that value more pro-active management actions are implemented in order to prevent a further escalation of the bloom. Such a management strategy has been very effective at managing Lake Mohawk and a similar threshold would benefit Clove Acres Lake as well.

TABLE 17

Impact of Chlorophyll *a* Concentrations on Perceived Water Quality

Chlorophyll *a* Concentration	Nuisance Value
0 to 10 mg/m^3	No problems evident
10 to 20 mg/m^3	Algal scums evident
20 to 30 mg/m^3	Nuisance conditions encountered
Greater than 30 mg/m^3	Severe nuisance conditions encountered

* As per Walmsley and Butty (1979)

The data compiled and computed in Section 2 through 6, were utilized to prepare a Restoration and Management Plan for Clove Acres Lake. This Plan provides specific objectives and recommendations for the short and long-term management of Clove Acres Lake. Both in-lake and watershed management options are provided in the Plan. In-lake measures include physical, chemical and biological recommendations, while the watershed measures include structural and non-structural recommendations. When considering the proposed measures, all of the following needs to be carefully contemplated as to how the strategy coincides with the philosophy and guidance of the WRWMG: applicability, regulatory constraints, technical feasibility, degree of effectiveness, initial implementation costs and operations and maintenance costs.

Section 9 In-Lake and Watershed Restoration Plan

The data compiled and computed in Section 2 through 6, were utilized to prepare a Restoration and Management Plan for Clove Acres Lake. This Plan provides specific objectives and recommendations for the short and long-term management of Clove Acres Lake. Both in-lake and watershed management options are provided in the Plan. In-lake measures include physical, chemical and biological recommendations, while the watershed measures include structural and non-structural recommendations. When considering the proposed measures, all of the following needs to be carefully contemplated as to how the strategy coincides with the philosophy and guidance of the WRWMG: applicability, regulatory constraints, technical feasibility, degree of effectiveness, initial implementation costs and operations and maintenance costs.

9.1 In-lake Restoration Techniques

In-lake restoration techniques are designed to improve the water quality of a waterbody by alleviating specific symptoms of eutrophication. Although these measures typically provide only short-term relief without controlling the source of the pollutants, they can substantially improve the aesthetics of a lake while the long-term, watershed-based management practices are being implemented.

For convenience, the in-lake restoration measures were divided into two groups. The first represents measures that focus on the control / management of planktonic (open water) algal blooms, primarily blue-green algae and nuisance filamentous mat algae. The second group represents measures that focus on the control / management of aquatic macrophytes, primarily the invasive, aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*). It should be emphasized that the dominant nuisance organism in Clove Acres Lake is Eurasian watermilfoil. Thus, the proposed in-lake restoration strategy for Clove Acres Lake focuses on the eradication of this invasive species.

9.1.1 Copper-based Algicides Products

One of the most obvious and frequently applied means of controlling excessive algal growth is through the use of the algicide copper sulfate ($CuSO_4$). Copper sulfate is an extremely effective means of killing a large portion of the resident algal community; however, this response is brief and only controls the symptom of the problem and not the cause.

Several undesirable environmental impacts are known to be associated with copper sulfate treatments; negative impacts include potential fish and zooplankton toxicity, depletion of dissolved oxygen (DO), copper accumulation in sediments, increased internal nutrient recycling and increased tolerance to copper by some nuisance blue-green algae. Zooplankton, organisms which serve as a natural means of controlling excessive algal growth, are known to be more sensitive to copper than algae. In addition, the generation times of fish and zooplankton are substantially longer than algae. Therefore, these organisms require a longer amount of time to recover from copper treatments relative to algae. The result is a perturbation of the lake's food web; while the phytoplankton community can recover from a copper treatment within 1-2 weeks, recovery of zooplankton and fish can vary from several weeks to several years. Thus, the phytoplankton will rebound quicker from copper-based algicide treatments than other aquatic organisms.

Although the depletion of dissolved oxygen would more than likely not be a problem in Clove Acres Lake due to its relative shallow depth and extreme propensity to mixing, the potential still exists for such a situation to develop. Large-scale DO depletion events can occur especially when copper treatments are extensive and conducted frequently within a short period of time. Once the copper kills the algal biomass, bacterial decomposition can result in a reduction, and sometimes depletion, of DO, which can result in fish kills and/or contribute to unpleasant tastes and odors.

One of the most convincing reasons for minimizing the frequency and magnitude of large-scale copper sulfate treatments is the fact that several studies have demonstrated that many of the nuisance blue-green algae, such as *Anabaena* and *Coelosphaerium*, have increased in tolerance to long-term applications of copper sulfate (Hanson and Stefan, 1984). Indeed, studies have shown that blue-green algae tolerance to the liberal application of copper sulfate can increase to the point were it is no longer economically feasible to use copper sulfate as a means of algal control (Alhgren, 1970).

Based upon the data collected throughout the course of this study, copper based algicides would provide a temporary solution, at best, to the observed algal conditions. The overwhelming majority of the nuisance algal conditions observed in Clove Acres Lake were filamentous mat algae growing over submerged aquatic vegetation, specifically the invasive species Eurasian watermilfoil. Thus, by reducing the densities of Eurasian watermilfoil, the aesthetic and ecological impact of the filamentous algae should decline (see below for in-lake techniques designed to control the watermilfoil).

Due to the prevailing wind patterns and morphometry of the lake, surface blooms and scums tend to be pushed towards the southern end of the lake and over the dam. In combination with lake's high flushing rate, nuisance surface scums typically do not persist for extended periods of time. Therefore, given the potential undesirable ecological impacts and limited amount of benefits associated with its use, the application of copper-based algicides is not recommended for Clove Acres Lake. As previously cited, most in-lake restoration techniques for Clove Acres Lake will focus on the eradication of the Eurasian watermilfoil and the management of native species.

9.1.2 Biomanipulation

Within the scope of this study, biomanipulation is defined as "a series of manipulations of the biota of lakes and of their habitats to facilitate certain interactions and results which we as lake users consider beneficial - namely reduction of algal biomass and, in particular, of blue-greens" (Sharpiro, 1990). In effect biomanipulation is structuring the aquatic food web to favor the growth of non-scum forming algae and minimizing the density of blue-green algae. An increase in piscivore (large, game fish) biomass could result in a decrease in planktivore (smaller forage fish) biomass, which would reduce grazing on zooplankton and lead to an increase herbivore (zooplankton) biomass and a decrease in producer (phytoplankton) biomass. These conditions ultimately produce an increase in water clarity and quality. However, it needs to be emphasized that biomanipulation does not replace nutrient control and management. Relative to algal growth, the primary means of minimizing nuisance algal blooms is through a reduction in the nutrient load, primarily phosphorus. Biomanipulation is a supplement to a nutrient control program, and thus it should be used to enhance a nutrient control program and not replace it.

Based on the fishery survey of Clove Acres Lake, the fish-community biomass was dominated by the large bottom feeding white sucker. In addition, there was a general absence of larger piscivore fish. Biomanipulation recommendations for Clove Acres Lake may include limiting the catch of largemouth bass and stocking larger fish (greater than 12 inches) to increase spawning stock. This would increase recruitment, size-class diversity, as well as predation pressure on white suckers and golden shiners. Stocking large predators such as muskellunge (*Esox masquinongy*) might also aid in reducing sucker densities because of their preference for large species and their known fondness for suckers.

There are several commercial hatcheries in New Jersey, eastern Pennsylvania and southeastern New York that could supply the desired fish species for Clove Acres Lake. As expected, commercial stocking costs would vary depending upon number and size of fish stocked, delivery charges, and time of year that stocking occurs. As a general rule of thumb, a largemouth bass greater than 12 inches in length can be stocked for approximately $16.00 to $20.00 per fish, depending on the previously mentioned factors. Similarly sized muskellunge are generally within the same price range. It is important to note that depending upon the species of fish stocked, the recommended number of fish to stock per acre differs. Generally, as predator size increases, the number of fish needed to stock a waterbody decreases, thereby, reducing costs. Also, if any forage fish species are included in a stocking program, it is strongly recommended to avoid alewife, gizzard shad and panfish species. Fathead minnows are the recommended forage fish species.

However, before any formal fishery stocking plan is developed for the purposes of biomanipulation, the nuisance densities of aquatic macrophytes needs to be addressed. Thus, the following long-term goals should be established:

- The eradication of the invasive species Eurasian watermilfoil.
- The management of native macrophytes; attempt to maintain an aerial cover of the macrophytes over the lake bottom of approximately 30%.

The fishery community of Clove Acre Lake is clearly impacted by abundant weed growth, particularly Eurasian watermilfoil, which is evident by the abundance of white suckers and general lack of quality predators such largemouth bass and chain pickerel or similar muskellunge species. Thus, as previously mentioned the actual implementation of a biomanipulation program in Clove Acres Lake should be held off until the nuisance densities of macrophytes are under control. For the sake of this report a preliminary fishery stocking plan for biomanipulation is proposed. However, it should be emphasized that this proposed stocking plan assumes the Eurasian watermilfoil has been eradicated from the lake and the aerial cover of submerged vegetation is between 30-40%.

- Stock approximately 325 largemouth bass (+12”)
- Stock approximately 1,625 largemouth bass (5-6”)
- Stock approximately 100 muskellunge (+12”)
- Stock approximately 16,000 fathead minnows (approx. 1”)

Such a stocking plan is estimated to cost approximately $13,000.00, not including transportation of the fish. Given the morphometry, patterns of thermal stratification, and level of biological productivity, Clove Acres Lake would be best managed as a largemouth bass fishery. Such a proposed stocking strategy would increase both the recreational value and effectiveness of biomanipulation in Clove Acres Lake.

9.1.3 Chemical Control of Nuisance Aquatic Plants

A number of aquatic plant control management techniques can be utilized as part of a Restoration and Management Plan. The most well known, and frequently implemented, technique is the use of contact herbicides. These products function by “burning” the plant tissue upon contact. An alternative to contact herbicides are systemic herbicides, primarily those with the active ingredient fluridone, which functions by internally interfering with the plant's metabolism.

Substantial amounts of aquatic vegetation, namely Eurasian watermilfoil, were found in Clove Acres Lake during the 2006 to 2007 monitoring program. Therefore, a number of aquatic plant management techniques were assessed for use at Clove Acres Lake. This assessment includes the use of State-registered herbicides.

Contact aquatic herbicides provide immediate, short-term relief and/or control of excessive densities of nuisance plants. Thus, the primary advantages of contact herbicides include their fairly immediate (days to weeks) reduction in nuisance plant densities and relatively low product costs.

The disadvantages of using contact herbicides include potential impacts on non-target organisms, depletion of DO concentrations as a result of bacterial decomposition of dead plant material, and recycling of nutrients back into the water column that would otherwise be bound in plant biomass. For example, algal blooms frequently occur immediately after the application of contact herbicides (due to increased nutrient recycling).

Other potentially negative impacts associated with contact herbicides include the non-discriminate impacts on both nuisance and favorable (i.e. native) aquatic plants and the possible destruction of fish habitat. It should be noted that more than one treatment of contact herbicides may be required to achieve the desirable level of control through the entire growing season. Depending on local climatic conditions and the nuisance species targeted for control, between two to three treatments may be required through the course of one growing season.

In contrast to contact herbicides, systemic herbicides affect the targeted plant internally. The uptake of the herbicide's active ingredient disrupts biochemical functions, thereby, killing the plant. Systemic herbicides such Sonar^R, which has fluridone as its active ingredient, are assimilated through the roots and into the plant tissue early in the growing season. There the herbicide begins to disrupt the production of chlorophyll pigments, which are used in photosynthesis. This effectively "starves" the plant and it dies. This mechanism is in sharp contrast to contact herbicides which "burn" the plant tissue from the outside.

There are a number of advantages to using fluridone-based herbicides instead of contact herbicides. First, contact herbicides typically require multiple applications, between two and four, through the course of one growing season to obtain an acceptable level of control. In contrast, if properly timed and executed, one Sonar^R application can result in an entire year of control. In some excessive cases, two or three years of control may be realized with Sonar^R.

While contact herbicides need to be applied to lakes when there is a sufficient amount of plant biomass to react with the chemical, Sonar^R is typically applied in the spring immediately prior to the exponential growth of the plants. Since fluridone enters the plant through the roots it is best applied in the spring, when seasonal growth rates are high. This treatment strategy effectively eliminates the possibility of fish kills that are the result of depleted DO from the bacterial decomposition of decaying plant biomass. Other advantages Sonar^R has over contact herbicides include its extremely low toxicity on non-target organisms, its ability to control certain nuisance/exotic species with extremely low concentrations, and its ability to quickly break down in the open waters of a lake (i.e. it does not accumulate in the sediments or in aquatic organisms).

As with any in-lake restoration/management technique, there are some disadvantages associated with the use of the systemic herbicide Sonar^R. The primary disadvantage associated with Sonar^R is its relatively high product cost, although it takes very little fluridone to impact the targeted nuisance species. For most Sonar^R lake treatment programs, the required concentrations are low, typically ranging between 5 and 100 ppb. Such low concentrations mean that relatively low amounts of product need to be added to achieve the desired level of control. However, in spite of the relatively low amount of required product, Sonar^R is substantially more expensive than contact herbicides. For example, on a per gallon basis, Sonar^R costs approximately $5,000.00. Whereas, most contact herbicides registered for use in New Jersey are substantially lower in price.

Another disadvantage with Sonar^R is that it is a slow acting herbicide, taking a minimum of 30 days to manifest some observable degree of plant control. Since Sonar^R is such a slow acting herbicide, targeted control concentrations need to be sustained over the course of at least a month. The outflow from the lake may need to be reduced, for at least 30 days after Sonar^R is added to the lake. An alternative to lowering the water level to reduce outflow is to use the solid Sonar^R product that slowly release the fluridone into the water over time.

Another recommended strategy of maximizing the effectiveness of a spring Sonar^R treatment program is to divide or "split" the application into a series of two to four sub-treatments, to ensure the targeted concentration remains consistent. Based on the size of Clove Acres Lake and the previously documented amount of Eurasian watermilfoil, Princeton Hydro recommends a total of three to four split applications. Between each application, samples should be collected for the analysis of fluridone concentrations within the lake water (e.g. a FasTest analysis). This information would be used to schedule the split treatment to ensure the targeted fluridone concentration is as consistent as possible. Such efforts will optimize the effectiveness of a fluridone treatment program for Clove Acres Lake.

The benefits of implementing a Sonar^R treatment program should be weighed against the costs and potential disadvantages of such a program. However, given the potential ecological impacts associated with contact herbicides, as well as the need for numerous treatments through the course of the growing season, a fluridone-based systematic herbicide is preferred over a contact herbicide in Clove Acres Lake. The following is a proposed outline for the implementation of a Sonar^R treatment program at Clove Acres Lake.

- A State-certified applicator is required to implement the Sonar^R treatment program. The applicator must file for an aquatic pesticide permit through the New Jersey Department of Environmental Protection (NJDEP).

- Eurasian Watermilfoil has historically been the primary nuisance species targeted for control in Clove Acres Lake. In general, the recommended range of fluridone concentrations used to control Eurasian watermilfoil is between 10 and 20 ppb. Such a targeted range will result in control and possible eradication of Eurasian watermilfoil with negligible impacts on the desirable, native aquatic vegetation.

- Assuming that a State certified applicator performs the application, the implementation of a whole-lake fluridone treatment program is estimated to cost between $25,000.00 and $30,000.00, depending on the dosage rate, the type of product used (liquid and/or solid) and flow controls. This estimated cost includes product, labor, monitoring, filing for the State permit, and documentation of the project. Based on a preliminary assessment of the size of Clove Acres Lake, its hydrologic load, and the extent of milfoil growth, a lower fluridone dosage rate (slightly less than 10 ppb) should be sufficient to effectively control the milfoil.

- If implemented, the Sonar^R treatment program should be scheduled for initiation sometime in mid-April to May (depending on late winter and spring climatological conditions). While the actual number of split treatments is dependent upon current hydrologic conditions, either three or four sub-applications of fluridone would sufficiently control excessive weed growth in Clove Acres Lake. However, given the flushing rate of the lake, a combination of liquid and solid product will be used to maximize the treatment efficiency of the Sonar^R treatment program.

Of the in-lake restoration treatment programs designed to control nuisance densities of macrophytes in Clove Acres Lake, the development and implementation of a Sonar^R treatment program is one of the highest ranked since it addresses the nuisance invasive species and has negligible impacts on the native vegetation. In addition, by reducing the densities and surface water canopy of the Eurasian watermilfoil, the nuisance conditions associated with the surface mats of filamentous mat algae will also decline.

9.1.4 Sterile Grass Carp

In addition to chemical approaches to control nuisance densities of aquatic vegetation, there are also a number of biological techniques that can be used to control excessive densities of aquatic plants. One of these biological techniques is the stocking of sterile grass carp.

Grass carp (*Ctenopharyngodon idella*) are a non-native species of fish that voraciously feeds on many species of aquatic plants. These fish have been well documented to effectively control excessive densities of nuisance aquatic plants throughout the United States. Their high growth rates and relatively broad diets make them particularly effective at feeding on submerged, “fleshy” plants. It should be noted that they will not eat emergent species such as common reed and cattail, as well as planktonic and mat algae. However, since grass carp are a non-native species, only fish that have been certified as made sterile are permissible for stocking in New Jersey.

The stocking of a lake or pond with sterile grass carp to control nuisance densities of aquatic plants is allowed within the State of New Jersey; however, a NJDEP permit must be filed in order to stock a waterbody with the fish. The New Jersey permit is limited to waterbodies with a surface area equal to or less than 10 acres. Since Clove Acres Lake has a surface area of approximately 32.5 acres, it does not qualify for a sterile grass carp stocking permit from NJDEP. Thus, no additional assessment of this in-lake restoration technique was conducted for Clove Acres Lake.

9.1.5 Aquatic Weevils

Another biological management technique that can be used to control excessive densities of Eurasian watermilfoil is the use of the milfoil weevil *Euhrychiopsis lecontei*. This weevil is a milfoil (*Myriophyllum spp.*) specialist that feeds and develops only on plants within the *Myriophyllum* genus. In addition, it is a native of North America and not an exotic species like grass carp or Eurasian watermilfoil. In fact, the southernmost limit of the weevil's range is northern New Jersey. However, the goal of stocking a lake or pond with the weevil is to substantially increase the weevil population above "background" or natural levels.

The weevils feed on the milfoil plant during their larval and adult life stages; the larvae are stem miners and feed primarily on stem tissues while the adults feed primarily on the leaves. The complete life cycle from egg to adult stage is between 17 and 30 days at typical summer temperatures (20-27^{o}C); overall survival success is between 20 and 70% (successful egg hatching, larval survival, and successful pupation). Biocontrol is achieved by decreasing the standing biomass of the milfoil through stem and root mining and reductions in viable milfoil rather than through total consumption of tissues. In addition, it is felt that stem mining also results in a decrease in plant carbohydrate levels that affects the plant's ability to successfully overwinter.

Based on documented cases of stocking the weevils, including the project implemented in Swartswood Lake, Sussex County, New Jersey, these organisms can be effective in controlling excessive densities of Eurasian watermilfoil. However, there are a number of disadvantages associated with this biological restoration technique that need to be addressed. First, as with most biological techniques, it takes a considerable amount of time to detect improvements. This is in contrast to the relatively immediate responses obtained through chemical management techniques. For example, it took approximately a year and a half to obtain a measurable degree of control in Swartswood Lake. Therefore, if the weevils were stocked in Clove Acres Lake in early 2008, measurable control of the milfoil may not be realized until spring or summer of 2009.

Another disadvantage of relying solely on weevils is the potential for ecological perturbations. For example, weevil and milfoil populations may settle into predator - prey oscillations over time. That is, the weevils may significantly eradicate the milfoil leading, in turn, to a substantial decline in the density of weevils. With weevil densities at reduced levels, the abundance of milfoil may increase and the plants may re-attain nuisance densities.

Finally, the weevils themselves are relatively expensive, costing approximately $2.00 per adult weevil; this price includes purchase of the weevils, their stocking and some subsequent monitoring of their numbers. Given this cost, any potentially large perturbation, such as a particularly large storm event (> 100 yrs), could negatively impact the stocked population of weevils. Therefore, the weevil population, along with the milfoil, must be closely monitored to ensure that the weevils are exerting an impact on the milfoil.

Based on past studies and information provided by EnviroScience Inc. (Stow, Ohio), the vendor of the "domesticated" milfoil weevil, a weevil stocking program for Clove Acres Lake would require a substantial amount of weevils. Specifically, four plots or sites should be established, each plot being 100 m x 100 m in area. Approximately 3,000 to 5,000 weevils would be stocked in three of the four plots, with the fourth being used as a control for the initial phase of the project. It should be noted that a minimum of 3,000 weevils are required for each of the three treatment plots; however, the recommended stocking rate is 5,000 weevils per treated plot.

The cost of implementing the proposed milfoil weevil stocking program is estimated to be between $52,000.00 and $72,000.00. The actual price is dependent upon the selected density of the weevils. This estimated price includes the purchase, transport, and stocking of the weevils, as well as monitoring of the weevils by EnviroScience Inc. over the course of two years and some essential baseline ecological data (i.e. coverage and density of the Eurasian watermilfoil; fishery survey work) collected by Princeton Hydro.

While the stocking of the weevils is more expensive than using the systemic herbicide Sonar^{R}, no permit is required to stock the weevils. In addition, from a long-term perspective the weevils may be lower in cost relative to the herbicide since such treatments may be required once every 1-3 years. Of all of the in-lake restoration techniques, stocking Clove Acres Lake with weevils to control / eradicate the Eurasian watermilfoil is the highest ranked. Given the size of Clove Acres Lake and the fact that milfoil is the dominant nuisance species, a weevil stocking program would be the most appropriate control technique.

9.1.6 Mechanical Weed Harvesting

Based on its overall shallow nature, most sections of Clove Acres Lake are susceptible to the proliferation of nuisance densities of rooted aquatic plants, including the invasive species Eurasian watermilfoil. Mechanical weed harvesting is a cost effective and ecologically sound method of controlling nuisance weed densities. One consistent advantage mechanical weed harvesting has over other management techniques, such as the application of herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, based on a plant biomass study conducted at Lake Hopatcong in 2006 and the plant harvesting records of 2006 and 2007, approximately 6 to 8% of the total phosphorus load targeted for reduction under the established Total Maximum Daily Load (TMDL) for Lake Hopatcong was removed through their mechanical weed harvesting program.

Continuing to use Lake Hopatcong as an example, during the 2007 growing season the Lake Hopatcong Commission's Operation Staff removed a total of 1,600 tons of aquatic vegetation from Lake Hopatcong. This roughly equates to 3.2 million pounds of wet plant biomass removed from the lake. Using the results of the 2006 plant biomass / phosphorus study, it was estimated that the 2007 mechanical weed harvesting program removed 571 lbs (259 kg) of total phosphorus from the lake. This accounted for approximately 7.8% of the amount of phosphorus targeted for removal under the lake's established TMDL. If this removed phosphorus was utilized by filamentous and planktonic algae, it would have the potential to generate approximately 628,000 lbs of wet algae biomass. Thus, the mechanical harvesting program of Lake Hopatcong contributes toward improving the water quality of the lake, as well as removing nuisance densities of submerged vegetation.

While harvesting is an effective non-chemical means of controlling nuisance plant growth, it should be emphasized that harvesting will not eradicate the targeted plant. Harvesting functions as a lawn mower cutting a portion of the above sediment biomass, allowing the plant to continue to growth. Thus, more than one harvesting event is typically required for lakes in the Mid-Atlantic States; at least one in the first and another in the second half of the growing season. In addition, issues such as areas of access into the lake, shoreline staging areas to temporarily store the cut plant biomass, and a location for the final disposal of the plants all need to be addressed prior to harvesting. While it may not be an issue for Clove Acres Lake, harvesting can spread cut fragments of a plant, particularly Eurasian watermilfoil, to non-infested areas and promote additional growth.

Harvesting typically ranges from $300.00 to $500.00 per acre, not including the disposal of the plants. While harvesting would remove phosphorus, it is not the recommended method to control the Eurasian watermilfoil in Clove Acres Lake. Issues associated with access into and out of the lake, as well as the long-term costs associated with the disposal of the harvested plant material complicate the use of harvesting in Clove Acres Lakes. In addition, harvesting will not eradicate the dominant nuisance plant, Eurasian watermilfoil.

Summary of Recommended In-Lake Strategy for Clove Acres Lake

- Eradicate the nuisance, invasive species Eurasian Watermilfoil

    1. Primary recommended measure is to use the systemic herbicide Sonar^{R}.
    2. Secondary recommended measure, if grant funding is available and the local

community is against the use of an herbicide, is to utilize milfoil weevils to eradicate the Eurasian watermilfoil.

- Manage the native species

  1. Using Sonar^{R} at a selected concentration can eradicate the invasive species and reduce, but not eliminate, the native species. In fact, using either Sonar^{R} or the weevils will favor the growth and establishment of native plant species, which will enhance fishery habitat and reduce the impacts associated with algal blooms.

- Control of algal blooms

  1. Once the invasive species Eurasian Watermilfoil is under control, surface mats of filamentous algae should decline due to the absence of the surface water habitat that the milfoil creates.
  2. Given the high flushing rates and morphometry of the lake, planktonic algal blooms should be short-lived and not persist over long periods of time.
  3. However, during drought conditions a decline in the flushing rate may favor larger and longer algal blooms. Thus, the watershed management recommendations outlined in the subsequent section need to be reviewed and implemented. The goal will be to reduce the pollutant load, primarily phosphorus, entering Clove Acres Lake from Clove Brook.
  4. Finally, once the aquatic plant community is better managed, a biomanipulation program can be developed and implemented to aid in controlling nuisance algal growth. While biomanipulation does not replace watershed-based, nutrient control measures, they can supplement or enhance such efforts.

9.2 Watershed Restoration Techniques

In contrast to in-lake restoration techniques, watershed-based techniques focus on the cause of eutrophication rather than the symptoms. The implementation of watershed techniques are not as visible as in-lake techniques and tend to take more time to produce their desired results because sediments within the watershed and associated waterways contain a large pool of nutrients accumulated over many years. However, such watershed-based efforts are absolutely necessary in reducing pollutant loads and producing long-term water quality improvements of lakes. Unless watershed pollutant inputs are reduced, any long-term benefits associated with reducing the cause of the in-lake problems will not be realized.

Watershed control measures are designed to reduce non-point source (NPS) pollution. NPS pollution is very diffuse, generated over a relatively large area, and originates from a wide variety of sources. Some examples of NPS pollution include lawn and garden fertilizers, septic leachate, pet and wildlife wastes, the atmosphere, as well as surface runoff from paved surfaces, construction sites, eroded streambanks and shorelines, and agricultural areas. This type of pollution is in sharp contrast to point sources of pollution, where the pollutants are generated and discharged from a specific point or source. An example of a point source is a sewage treatment plant. Relatively speaking, point source pollution is easy to control. If a sewage treatment plant is responsible for the problem, efforts and money are only needed to control that one source. Unfortunately, NPS pollutants can often be more difficult and expensive to control relative to point source pollutants. Nevertheless, NPS pollution needs to be reduced to achieve observable water quality improvements when it accounts for all or a large fraction of the total pollutant load.

One of the reasons NPS pollution is difficult to control is that it does not follow municipal or property boundaries. Since NPS pollution is generated over the entire watershed, stakeholders adjacent to the lake may not be responsible for the majority of the pollutant load. In the case of the Clove Acres Lake watershed, the shoreline property is located within the Borough of Sussex and the Township of Wantage, with approximately 95% of the total watershed area located within Wantage. Since near-shore stakeholders benefit the most from improvements in the lake's water quality, many of the recommended watershed management measures focus on communities immediately adjacent to the lakeshore,.

While all watershed-based management measures implemented within the Clove Acres Lake watershed will directly benefit the lake and shoreline property owners, downstream stakeholders will also benefit from reductions in the pollutant loads. In addition, all of the municipalities within the Clove Acres Lake watershed will benefit from a regulatory perspective in the implementation of such watershed measures.

All municipalities within the State of New Jersey must submit a Municipal Separate Storm Sewer

System (MS4) permit to document what is being done on a local level to address the water quality and quantity impacts of stormwater. The municipalities can incorporate their participating efforts in the development and implementation of the Clove Acres Lake Restoration Plan into their own MS4 permits to demonstrate how they have been contributing toward the management of stormwater within New Jersey. Thus, the implementation of the Clove Acres Lake Restoration Plan benefits both stakeholders who live immediately around the lake as well as those who live upstream and downstream.

General Watershed Strategy for Clove Acres Lake

As discussed in Section 7, the proposed revision of the Clove Acres Lake total phosphorus TMDL is to attain a mean, in-lake TP concentration of 0.04 mg/L during the growing season. Thus, from a water quality perspective, the recommended watershed management measures are designed to comply with this modified TMDL-based targeted in-lake TP concentration by reducing the existing TP loads entering the lake.

For the sake of convenience, the stormwater-based TP reductions were divided based on land use. Thus, the agricultural TP load targeted for reduction is 537 kg (1,181 lbs), while the targeted TP load originating from residential lands is 230 kg (506 lbs). Both agricultural and residential Best Management Practices (BMPs) will be recommended to reduce the TP loads entering Clove Acres Lake to the acceptable levels. However, this report will focus primarily on the residential portion of the TP load since additional planning and stakeholder interface is required to build the local collation necessary to address the agricultural sources of phosphorus. One source of phosphorus that will be addressed from both residential and agricultural sources is eroded streambanks.

9.2.1 Agricultural BMPs

Agricultural land is the second largest land type within the Clove Acres Lake watershed, accounting for approximately 23% of the watershed's total area. In addition, surface runoff from agricultural land accounts for 66% of the lake's annual TP load. Thus, reducing the TP load originating from agricultural sources will be critical in both complying with the lake's TMDL and improving its water quality. Thus, the following recommendations are made:

- Clearly identify the number of farms within the watershed and what they produce (i.e. row crops, livestock).
- Reach out to the agricultural stakeholders in terms of providing information on the efforts designed to preserve and protect both Clove Acres Lake and Clove Brook.
- Provide information to stakeholders on potential agricultural BMPs and associated sources of funding that may be available for the implementation / installation of such BMPs. The

information provided to the agricultural stakeholders needs to emphasize the economic benefits associated with the implementation of the suggested BMPs as well as identify the water quality and community-wide benefits.

Clearly, the WRWMG is already underway at implementing this strategy; plans are underway to meet with a number of farmers within the watershed sometime in fall of 2008. Their participation is absolutely critical in the implementation of any agricultural BMP and finding sources of funding for their implementation can provide the stimulus for initiation of such efforts. From Princeton Hydro's experience with agricultural stakeholders, if funding / support is provided to farmers for the implementation of such projects, and there is a long-term economic benefit, most are more than willing to participate in watershed-based programs. Thus, briefly described below is a list of potential source of funding and/or support for the design and implementation of agricultural BMPs.

US Department of Agriculture:
Funds are available through the 2008 Farm Bill to assist farmers and ranchers to solve natural resource problems though the Environmental Quality Incentives Program (EQIP). The program is geared to help producers meet their conservation goals and supply the public with cleaner water, enhanced air quality, healthy soils, and abundance wildlife. The USDA and its agencies provide technical and financial assistance to Resource Conservation and Development programs (see below).

Natural Resources Conservation Service:
The Farmland Protection Policy Act of 1994 specifies the need to reduce the impact that Federal programs have on farmland that is being converted for non-agricultural use. The Farm and Ranch Land Protection Program (FRPP) provides matching funds to help purchase development rights to keep productive farms and ranchlands in agricultural use.

The Resource Conservation and Development Program (RC & D) encourages volunteer local elected and civic leaders to design and execute projects geared toward resource conservation and community development. The program provides for the purchase of conservation easements through the matching of funds to State, Tribal, local governments, and non-government organizations that have existing farm and ranch land protection programs.

The Natural Resources Conservation Service (NRCS) makes funding available through Conservation Innovation Grants (CIG). Grant funding is awarded to projects pertaining to one of the three categories: Natural Resource Concerns, Technology, and the Chesapeake Bay Watershed. The purpose of the Conservation Innovation Grants is to stimulate the development of and implementation of innovative conservation methods and technologies.

The Sussex County Soil Conservation District:

The District hosts a variety of talks and seminars geared towards the public. The District also sponsors workshops, specially designed for planners, which provide information on current conservation practices. In addition, they participate in the New Jersey Envirothon; a nationally advertised educational competition that focuses on the significance of environmental consciousness and the necessity for natural resource conservation.

New Jersey Stormwater Permitting Program:

A program created by the Sussex County Soil Conservation District was designed to improve the overall water quality of New Jersey's rivers, lakes, and streams. Where construction and mining activities exist, a permit is required if one acre or more of land is disturbed. This program is managed by NJDEP and implemented by NJ Department of Agriculture and the State Soil Conservation Committee.

New Jersey Non-Point Source Pollution Program:

Under Section 319 of the Clean Water Act, funding is provided to each State for the implementation of projects to reduce the non-point source (NPS) pollution loads that enter our county's waterways. NJDEP typically has a Request for Proposals each year for projects that focus on reducing NPS pollution. Both the agricultural and residential stormwater projects identified in this Restoration Plan may be eligible for funding under the State's NPS grant program.

Finally, since the collection of detailed information on specific farms within the Clove Acres watershed was beyond the scope of this project, a list of commonly utilized agriculturally-based BMPs is provided (Table 18). Included with the described BMPs are conservative estimates of their relative efficiency at removing total phosphorus, as well as the source of the estimated values. Again, prior to the selection and implementation of any of the identified agricultural BMPs, a watershed inventory of the existing farms, their size, and the agricultural products they produce should be conducted.

TABLE 18

Agricultural BMPs Identified for Clove Acres Lake Watershed

Agricultural Best Management Practice	Estimated Removal Rate of TP per Acre	Source of Removal Efficiency
Animal Waste Management - Livestock	75%	Chesapeake Bay Program Best Management Practices
Horse Pasture Management	20%	Chesapeake Bay Program Best Management Practices
Barnyard Runoff Control (With Storage)	20%	Chesapeake Bay Program Best Management Practices
Barnyard Runoff Controls (Without Storage)	10%	Chesapeake Bay Program Best Management Practices
Stream Protection from Livestock with Fencing and Off-Stream Watering	60%	Chesapeake Bay Program Best Management Practices
Stream Protection from Livestock without Fencing and Off-Stream Watering	30%	Chesapeake Bay Program Best Management Practices
Re-Establishment of Wetlands on Agricultural Lands	50%	Chesapeake Bay Program Best Management Practices / NJDEP
Conservation Till	5%	Chesapeake Bay Program Best Management Practices
Advanced No-Till	35%	Chesapeake Bay Program Best Management Practices
Water and Sediment Control Basins	50%	Chesapeake Bay Program Best Management Practices / NJDEP
Vegetative Filters	30%	NJDEP
Bio-retention Basin	60%	NJDEP

9.2.2 Streambank Stabilization

Eroded streambanks can account for substantial load of NPS pollution. Increases in imperviousness surfaces associated with development increase the volume and velocity of stormwater; therefore, less stormwater infiltrates the ground and more is transported to stormwater infrastructure and receiving waterways. In turn, this results in an increase in the rate of streambank erosion. As a watershed is developed, the proportion of the total suspended solids (TSS) load originating from eroded streambanks increases. For example, some preliminary modeling of the Manalapan Brook watershed (Middlesex and Monmouth Counties, New Jersey) indicates that approximately 70% of its annual TSS load originates from streambank erosion. Since between 70-80% of the TP found in stormwater is typically adsorbed onto soil particles, a large portion of the stormwater-based phosphorus entering a lake can originate from streambank erosion. Such conditions indicate that implementing measures to reduce streambank erosion will reduce the TSS and TP loads entering a receiving waterbody. Thus, streambank stabilization is an important component of the Clove Acres Lake Watershed Management Plan.

In order to obtain an estimate of the amount of streambank stabilization that may be required in the Clove Acres Lake watershed, the existing GIS database was used to quantify the stream miles that flow through each land type. As shown in Table 19, approximately 90% of the stream miles throughout the Clove Acres Lake watershed are located in forested lands and/or wetlands. The remaining 10% is approximately equally distributed between agricultural and residential / urban lands. Thus, approximately 2 stream miles are located in agricultural lands, while another 2 stream miles are located in residential / urban lands.

For the sake of this Management Plan, streambank stabilization is not being considered for those stream sections that flow through forested lands and wetlands. While it is possible that sections of streambank within forested lands and wetland may require some stabilization, watershed-wide streambank assessments should be conducted in order to identify such possible projects.

Streambank Restoration for Agricultural Lands

For agricultural streambanks, stabilization efforts may be as simple as fencing off the stream from livestock, to planting and establishing a riparian stream buffer, to a full scale re-grading and restoration of a streambank which may include both vegetative and structural stabilization techniques. The two key elements in dictating what stabilization measures should be implementation at a specific site are:

1. The presence / absence of livestock
2. The slope, streambank soil type, and order of the stream

TABLE 19

Breakdown of Stream Miles Based on Land Use / Land Cover

Land Use / Land Cover	Length (Miles)	% Per Type
Agriculture	2.06	4.93
Barren	0.04	0.10
Forest	11.08	26.53
Urban	1.98	4.73
Wetland	26.62	63.71
Total	41.79	100.00

Since very little site specific information is available on the network of streams that flow through agricultural lands in the Clove Acres Lake watershed, formal visual streambank assessments should be conducted with the cooperation and participation of landowners. These site assessments would identify both the problem and solution(s) to the observed streambank erosion. Some limited watershed field reconnaissance work was conducted to identify potential streambank projects in agricultural and residential / urban lands. Based on the field work, as well as a number of assumptions, a proposed implementation strategy for streambank stabilization in agricultural lands was developed. Please refer to the outline below for the proposed implementation strategy:

- Approximately 2 miles of the 42 stream miles in the Clove Acres Lake watershed runs through agricultural lands. This means that 4 miles of streambank is found in agricultural lands.
- Of the 4 miles of agricultural streambank, it is estimated that approximately 50% of the associated agricultural land is for livestock. Thus, it was assumed that 50% of the associated agricultural streambank would benefit from simply fencing the stream to prevent livestock impacts.
- As shown in Table 18, the TP removal associated with fencing streams from livestock is

estimated to vary between 30 and 60%, depending on if off-stream watering is provided. Using a conservative approach, the 30% TP removal rate was ascribed for this analysis.

- The remaining 2 miles of agricultural streambank was assumed to require some type of stabilization, varying from plantings to expand or create a riparian buffer to large scale streambank re-grading. Again, a conservative approach was taken and the TP removal rate associated with these projects was estimated to be 30%.

Using the assumptions described above, it is estimated that if all 4 miles of agricultural streambanks were protected and/or stabilized, such efforts have the potential to remove approximately 493 kg of TP annually. This would account for slightly over 90% of the agricultural TP load targeted for reduction. While the assumptions outlined above emphasize the need to collect site-specific data in order to make a more accurate assessment, this analysis clearly demonstrates that restoring streambanks that flow through agricultural lands will have a measurable impact on the TP load entering Clove Acres Lake.

To provide an estimate of costs associated with these agricultural streambank projects, it was again assumed that 2 miles of streambank would require fencing, while 1 mile of streambank would require plantings and another 1 mile of streambank would require some re-grading along with plantings or structural measures (i.e. rip-rap). The estimated costs provided in Table 20 are based on information obtained from US EPA, NJDEP, and past project experience in the implementation of such watershed measures. The actual cost for the design and implementation of an actual project will depend on site-specific conditions and may be higher or lower than expected. However, the provided costs are a good estimate for long-term planning purposes.

TABLE 20

Cost Estimates for the Implementation of Various Agricultural Streambank Projects for the Clove Acres Lake Watershed

Streambank Project	Prince Range
Fencing of streambank to protect the stream against the impacts of livestock (Estimated total linear feet is 10,560 l.f.)	Between $52,800.00 and $105,600.00
Planting and establishment of vegetation along the streambank (Estimated total linear feet is 5,280 l.f.)	Between $79,200.00 and $132,000.00
Streambank re-grading coupled with plantings and/or installation of structural measures to reduce erosion (Estimated total linear feet is 5,280 l.f.)	Between $184,000.00 and $264,000.00

<u>Streambank Restoration for Residential / Urban Lands</u>

For residential / urban lands the majority of the streambank erosion problems stem from larger volumes of stormwater hitting the streambanks at higher velocities, as a result of an increase in impervious cover associated with development. Thus, in many cases, the long-term protection of the streams are linked to more grass roots efforts such as installing rain barrels and rain gardens to move as much surface runoff back into the ground as possible. Coupled with such course control actions, some level of restoration and stabilization of damaged streambanks may be required. This section of the Management Plan focuses on streambank restoration of streams that flow through residential / urban lands.

As with streams that flow through agricultural lands, the slope, soil type, and order of the streams that flow through residential lands will dictate what type of stabilization measure should be implemented. Such measures include biological (plantings, creating flood plains) and structural (rock, rip-rap) techniques. In general, the steeper the slope, the more one has to rely on structural measures. However, in most cases both biological and structural measures are implemented.

Proposed Sites for Streambank Stabilization

Based on the water quality monitoring events and site visits, a list of locations was developed that have the potential for streambank or swale stabilization. The list serves as a starting point in further identifying appropriate locations for such projects. Obviously, issues such as property ownership, easements, right-of-ways, and environmental constraints all need to be considered and evaluated. However, further investigations into potential sites of stabilization should begin with these locations.

- ***Route 651 and Clove Road, Wantage***. Roadside swale along the southbound side of Route 651 near the intersection with Clove Road. Site is surrounded by agricultural fields and is located to the northeast of Clove Acres Lake.

- ***Rose Morrow Road, Wantage***. A 12" plastic pipe from an upslope swale discharges directly into the stream, which exhibits signs of erosion and scouring. Both the swale and the streambank could be stabilized.

- ***Northwest End of Bridge Crossing 57, Wantage***. Streambank has a substantial amount of erosion. In addition, there is a wetland with a berm that prevents water flowing into it from the stream. In spite of this, the wetland was still discharging water. This site may include some additional hydrologic work to move some of the stream flow through the wetland.

- ***Brown Road, Wantage***. Small tributary that exhibits streambank erosion along Brown Road. The tributary enters Clove Brook behind an adjacent graveyard.

- ***Along Route 23, Near the American Legion Hall, Wantage***. Cattle walk into Clove Brook on both sides on the farm adjacent to the graveyard and the American Legion Hall. In addition, a low-lying field adjacent to the Hall may be an excellent site for the creation of a wetland BMP.

- ***Along State Route 23, Approximately 0.5 Miles South of DeWitt Road***. There are some very steep slopes from Route 23 down to Clove Brook. This slope is covered with rip-rap and is infested with the nuisance invasive species, Tree-of-Heaven. While it would be preferable to have native plant species along this steep streambank, the Tree-of-Heaven does provide some stabilization. Thus, unless funding is available through some local or State agency (i.e. NJDOT or NJDEP), specifically targeted to the eradication of invasive species, the site should be periodically monitored to identify any erosion and/or de-stabilization problems.

- ***Clove Acres Lake Recreational Park, Borough of Sussex***. A planting project is already scheduled for the lake shoreline within the Park. This planting project is being funded by North Jersey RC&D and will be coordinated by the WRWMG. While the planting project will greatly enhance the recreational and ecological value of the lake, additional plantings and shoreline stabilization efforts within the Park would provided additional benefits.

Similar to the agricultural streambank projects, it was estimated that all 4 miles of residential / urban streambanks are in need of some degree of stabilization. It was assumed that half of the 4 miles of residential / urban streambank could be stabilization with some additional planting of vegetation, while the other half would require more extensive re-grading and streambed restoration. Using this set of assumptions, the implementation of the residential / urban streambank measures is estimated to cost between $300,000.00 and $800,000.00. However, as with the agricultural BMPs, it must be emphasized that the amount of required stabilization may be higher or lower than what has been estimated in this Plan. In addition, the actual costs associated with site specific projects may be higher or lower than expected. The estimates provided in this Plan are being projected for the purposes of long-term planning.

9.2.3 Residential / Urban BMPs

While residential / urban land within the Clove Acres Lake watershed accounts for approximately 10% of the total land area, it accounts for approximately 20% of the annual TP load entering the lake. It is the second largest source of surface runoff TP, with the largest being agricultural. In addition, a large portion of the residential land is located along the shoreline of Clove Acres Lake. As is typical for many lake communities, the near-shore homes tend to be on smaller lots (< 0.5 - 1 acre) with little room for larger, more conventional BMPs as identified in the New Jersey Stormwater Best Management Practices Manual (NJDEP, 2006). Thus, many of the recommended BMPs, beyond the streambank and shoreline stabilization actions, are retrofits with Manufactured Treatment Devices (MTDs) that are installed into the existing stormwater infrastructure.

Stormwater retrofits are essentially modifications or enhancements that can be implemented to an existing stormwater conveyance system to improve the system's NPS pollutant reduction capacity. The advantages to such retrofits are that they require substantially smaller amounts of space for installation and are lower in cost relative to larger BMP's. However, as with any BMP, retrofits will require a certain degree of maintenance to optimize their effectiveness. In addition, the frequency of maintenance for retrofits may be higher than larger BMP'S, especially during particularly wet years. In spite of the required maintenance, stormwater retrofits are a very cost effective means of reducing the NPS pollutant loads (i.e. nutrients and suspended solids) that enter receiving waterways via stormwater surface runoff.

Standard catch basins have little, if any, positive impact on water quality. The replacement of existing catch basins with water quality inlets is a method used to improve water quality of storm runoff and is particularly well-suited for residential areas. Water quality inlets are specially designed catch basins which remove sediments, nutrients, and trash from collected surface runoff. These inlets can be used to replace existing catch basins without extensive modifications to the existing conveyance (piping) system. There are a number of different designs available for water quality inlets, but all rely on the same general techniques for pollutant removal. They all remove pollutants by using various methods to collect trash and settle out sediments. Another design consists of three separate chambers that also function to slow water down and remove sediment. Furthermore, some water quality inlets also incorporate some type of filter media to remove dissolved nutrients, particularly phosphorus. In addition to trapping sediments and nutrients, water quality inlets can also be designed to remove petroleum hydrocarbons.

Proper maintenance is essential in order for the retrofits to achieve effective pollutant removal since deposited pollutants are only permanently removed during pump-outs. The normal method used to clean out many of these structures is to pump out the contents of each chamber; this should be done twice a year, once in late fall after all the leaves have fallen and once after the spring thaw when all de-icing/snow clearing activities have ceased. It should be noted that large MTDs may only need to be cleaned out once a year. However, additional pump-outs may be required after particularly large storm events. Proper maintenance enhances pollutant removal and helps prevent re-suspension of sediment particles. **In fact, if the stormwater retrofits cannot be pumped out at the recommended intervals then they should not be considered for use.** The pump-outs should be performed by a licensed waste management company or the municipality's Department of Public Works.

Due to financial constraints, stormwater retrofit projects should be prioritized so those sites immediately adjacent to the shoreline are implemented first. However, prior to implementing any stormwater project, it is strongly recommended that the existing stormwater conveyance system be mapped. The field data could be collected with GPS technology and placed into a GIS format to develop digitized maps. In turn, the maps can be placed over other types of watershed data (i.e. slopes, soils, structures) to locate and target specific sites for stormwater retrofits. Finally, the local watershed data would be used to select the most cost effective retrofit for each targeted location.

The local municipalities may already have some information on their existing stormwater conveyance system as part of their required Municipal Separate Storm Sewer System (MS4) permits. In addition to the selection of project and initiating the engineering design work, such locational information is also required in seeking State and/or Federal sources of funding for the implementation of such stormwater projects.

Provided below is a list of some of the water quality inlet MTDs that could be installed within the Clove Acres Lake watershed. The installation and cost of each MTD is highly dependent upon site specific conditions that need to be assessed. Some can be retrofitted to existing catch basins, while others replace the basin. Still others may require a little more space; however, all of these MTDs generally require less space relative to more conventional BMPs. More detailed descriptions of these retrofits can be found in Appendix D.

- ***Nutrient Separating Baffle Box*** – Comprised of three sediment settling chambers and a filtration screen system that collects vegetation and litter. A boom located between the screen system and a skimmer collects and absorbs hydrocarbons.
- ***Aqua-filter™*** – The Aqua-filter™ treatment system consists of two steps; the first step removes sediment, floating debris, and free oil with a Swirl Concentrator™. The second step consists of a filtration unit that refines and enhances stormwater; the filtration unit can substantially reduce dissolved phosphorus concentrations.
- ***Aqua-Swirl™*-** Uses vortex separation to remove sediment, floating debris, and free-oil. This MTD is larger than the average catch basin so it usually replaces the existing basin.
- ***Aqua-Guardian™*** **–** Can fit into existing catch basin. Removes coarse sediment, trash/debris, and pollutants such as dissolved oil, nutrients and metal. Requires more frequent clean-outs than the larger devices. Uses a filtering media to remove dissolved phosphorus.
- ***Stormceptor*** – Similar to a water quality inlet; collects primarily particulate material. However, these retrofits tend to have higher pollutant removal efficiencies.
- ***Grated Inlet Skimmer Box*** – Fits into any size grated inlet to capture leaves, trash, and hydrocarbons. Can be retrofitted with iron oxide for the removal of dissolved phosphorus.

In order to install any of these structures, additional site specific information is required. However, the amount of required information is dependent on the size and specific structure. For examples, some of the smaller structures such as the Grated Inlet Skimmer Box are installed into existing drop inlet catch basins. Thus, for this structure some measurements of the existing catch basin are required. However, for others such as the Nutrient Separating Baffle Box and the Aqua-filter system, a considerable amount of survey work, engineering design, and planning is involved.

In order to identify potential locations for the installation of such MTDs, Princeton Hydro conducted a site visit of Clove Acres Lake watershed on 21 January 2008. It should be noted that this field visit was in no means comprehensive; additional such field surveys should be conducted to identify additional locations. It would also be beneficial to conduct such future surveys during rain events to observe the movement and drainage of stormwater through the watershed.

No formal topographic or property boundary surveys were conducted during the January 2008 site visit. Such survey work is absolutely necessary in the development of engineering plans for the installation of any stormwater structure. However, the January 2008 field survey served as a starting point in the identification of potential stormwater projects that would reduce pollutant loads entering Clove Acres Lake. For convenience, the seven potential projects suggested for consideration are summarized below with estimated costs for design and implementation.

Princeton Hydro has experience in the design and/or installation of each of the identified MTDs described above in residential / suburban settings. However, it should be emphasized that Princeton Hydro does not endorse any particular technology over another. Each MTDs has its own set of advantages and disadvantages and each one is suited for a particular set of conditions.

Recommended Stormwater Projects for Clove Acres Lake:

1. ***Intersection of Route 651 and State Route 23***. There is a significant amount of erosion just before the bridge caused by a channel that conveys stormwater. While the bridge will eventually require some structural repairs, such effort could include upgrades to the existing stormwater infrastructure. Some of these efforts may include both channel stabilization and the installation of a nearby MTD (i.e. Aqua-Filter or Nutrient Separating Baffle Box). The design and implementation of such a project is estimated to cost approximately $250,000.00. This ballpark estimate does <u>not</u> include any design or structural repair work on the bridge.

2. ***Coleville Reservoir outlet on Brink Road, Coleville***. The outflow from Coleville Reservoir meets a small stream, flows beneath the Mudtown Road and then into Clove Brook. A set of MTDs, perhaps a set of Nutrient Separating Baffle Boxes, could be installed on either side of the bridge. The survey work, design, engineering calculations, possible permitting, and installation of the structure is estimated to cost approximately $300,000.00.

3. ***Clove Acres Lake Recreational Park, Borough of Sussex***. While a shoreline stabilization project is underway at the Park (see Section 8.2.2), the site may also be an appropriate location for the installation of a large MTD or conventional BMP. Since the Park is owned by the Borough, issues associated with obtaining right-of-ways or easements from private property owners may not be an issue. Thus, if feasible, re-routing some of the existing, local stormwater to a large BMP in the Park may be a long-term, cost effective means of removing a substantial portion of the TP load from stormwater. Thus, the design and installation of an Aqua-Filter or Nutrient Separating Baffle Box and associated stormwater conveyance system could vary in cost between $250,000.00 and >$500,000.00, depending on the size of the total land cover targeted for treatment.

4. ***American Legion Hall, Wantage***. There are a couple of catch basins along the road and driveway at this site that are collected in a pipe that discharges directly into Clove Brook. These catch basins could be retrofitted with MTDs such as Aqua-Guards. The design and implementation of such a project is estimated to cost between $10,000.00 and $15,000.00.

5. ***Northern Shoreline of Clove Acres Lake, Borough of Sussex***. There are four catch basins along this shoreline that can be retrofitted to function as water quality inlets with the aid of Aqua-Guards. In addition, the area between the road and lake could be converted into a bioretention swale. The survey work, design, engineering calculations, possible permitting,

and installation of the Aqua-Guards and bioretention swale is estimated to cost approximately $100,000.00.

6. ***Colesville Bridge Crossing 48***. A series of 4-6 catch basins along this road could be retrofitted with water quality inlets MTDs such as Aqua-Guardians. Downstream of this site and the bridge crossing, there is a considerable amount of grit and gravel within the streambed of Clove Brook. The survey work, design, engineering calculations, installation of the Aqua-Guards, permitting, and removal of the gravel bar is estimated to cost approximately $125,000.00.

7. ***Southern Shoreline of Clove Acres Lake, Elizabeth Avenue and Lakeshore Drive, Borough of Sussex***. Between two and six catch basins could be retrofitted in this area or one larger MTD (i.e. Aqua-Filter or Nutrient Separating Baffle Box) could be installed into the existing stormwater conveyance system. Such a project is estimated to cost approximately $200,000.00.

Please note the estimated costs are subject to change based on the size of the drainage area targeted for treatment, which in turn impacts the size of the BMP. In addition, the estimated costs do not include any upgrades / modifications that may be required on the existing network of stormwater pipes. Also, prior to initiating any engineering design work, it is strongly recommended that property boundary surveys be conducted at each site to identify private / public landowners and the potential existence of easements / right-of-ways.

It is estimated that each of the proposed projects will remove approximately 15 kg (33 lbs) of TP on an annual basis; however, the actually removal rates will be based on the size of the drainage area being treated, the land use / land cover within the drainage area, and the selected BMP or MTD. Thus, stormwater monitoring of any installed stormwater structure is strongly recommended in order to obtain more site specific removal efficiencies and better quantify the amount of phosphorus removed on an annual basis. In turn, such information will be use track progress made on complying with the total phosphorus TMDL developed for the Clove Acres Lake watershed.

Using a removal rate of 15 kg per year for each stormwater BMP or MTD site, it is estimated that if the seven projects listed above were implemented, and thus they would collectively remove approximately 105 kg per year. Combined with the 33.5 kg estimated to be removed through residential / urban streambank stabilization, the TP load removed through these implementation measures is estimated to be 138.5 kg. Thus, if all of the residential streambank and stormwater projects described above were implemented, they would account for 60% of the 230 kg of TP targeted for removal from residential / urban lands under the Clove Acres Lake TMDL.

With the implementation of all of the proposed streambank and stormwater projects, there would still be 91.5 kg of TP that would need to be removed in order for the residential / urban lands to comply with the targeted TMDL. Using an estimate of 15 kg of TP removed per stormwater BMP or MTD project, six more projects would be required within the Clove Acres Lake watershed in order to comply with the residential / urban portion of the established TMDL. However, as described below, there are a number of non-structural BMPs that can be implemented to contribute towards reducing the TP load. While these non-structural BMPs can be more difficult to quantify relative to this pollutant reducing efficiencies, they can still produce improvements in water quality. In addition, since non-structural BMPs tend to focus more on source control management techniques, public outreach and education targeted towards watershed stakeholders is absolutely critical for their success.

9.2.4 Nonstructural Best Management Practices

Nonstructural Best Management Practices (BMPs) are designed to minimize pollutants at their source. They typically involve source control strategies that decrease the use of potential pollutants or minimize their release into the environment. Thus, they function to reduce or eliminate pollutants before they enter stormwater runoff. Nonstructural BMPs rely primarily on changing Standard Operating Procedures (SOPs) and observed lifestyles of community members. Since the success of these BMPs depend on changes in the lake user's behavior, a strong educational and public outreach programs are necessary.

An aggressive public education program, focusing on fertilizer management, goose control, and the preservation of vegetated lands would encourage the implementation of nonstructural BMPs. Fact sheets and other educational materials should be developed and distributed to residents living within the Clove Acres Lake watershed. Local workshops can also be held to educate the lake / watershed residents and distribute educational material. It cannot be overstated that public education is a major requirement for these types of BMPs to be successful; furthermore, public education needs to be a long-term program that consistently reminds stakeholders on how their actions and behaviors impact the water quality as well as the lake's ecological and recreational value.

Lawn/Garden Fertilization Management

An important nonstructural BMP technique for residential landscaping is fertilizer management. Significant nutrient loading can result from over-application of lawn fertilizers in urban and suburban areas. For example, a watershed-based inventory of two sub-watersheds in the Musconetcong watershed in New Jersey revealed that the majority of the NPS pollutants entering Lake Hopatcong originated from either septic systems or residential lawns (Coastal, 1997).

Limiting the amount of fertilizer needed for optimum plant growth minimizes the potential for surface or groundwater contamination. Not only will such a program reduce the amount of pollutants entering Clove Acres Lake, but it will also maximize the effectiveness of fertilizer applied per dollar spent. However, it must be noted that the effectiveness of a fertilizer management program depends upon cumulative efforts within the watershed. This means that an aggressive educational/public outreach program will be required to implement this nonstructural BMP.

Maintaining a near neutral soil pH is critical for the maximum assimilation of soil nutrients. Acidic soils (low pH) make essential nutrients unavailable for uptake and may result in increased leaching of nutrients to the lake. For lawns, pH values should be between 6 and 7, depending on the type of grass. Liming a lawn can move the soil pH towards a neutral value of 7, where the chemical reactions in the soil are such that the elements nitrogen and phosphorus are more available for plant uptake. Lime also improves the soil structure and creates an environment that is more conducive for microorganisms that decompose organic matter. Liming is best done in the fall, since its effects are more gradual than those of fertilizers.

The use of lawn fertilizers represents a controllable NPS of phosphorus for Clove Acres Lake. The growth of turf grasses are typically limited by nitrogen and/or potassium, and only need small quantities of phosphorus. Additional phosphorus added to the soil leaches out and enters ground and/or surface waters. Thus, by encouraging lake residents to use non-phosphorus fertilizers (i.e. Lake Side or similar fertilizers available from a number of commercial sources) it is conceivable to substantially decrease the external load of phosphorus to the lake. For example, studies in Minnesota have revealed that by simply switching from phosphorus to non-phosphorus fertilizers the individual on-lot phosphorus load decrease by 12-18%.

Non-phosphorus fertilizers are increasingly used around lakes; in fact some municipalities and lake associations have banned the use of phosphorus fertilizers. In contrast to turf grass, aquatic plant and algal growth is limited by phosphorus, so applying fertilizers with excess phosphorus only results in the degradation of ground and lake water. WRWMG should work with local hardware stores to promote and sell non-phosphorus fertilizers. If a phosphorus-containing fertilizer must be used, the pH of the soil should be tested. Phosphorus binds with soils at an optimum level when soil pH is approximately 6.5.

The timing of fertilizer application is just as important as the amount being applied. Applications should coincide with the lawn's needs. Most lawns in the northeast do not require equal amounts of or constant levels of nutrients throughout the year. Typical lawns are composed of grass types that grow rapidly in the spring and fall, but grow slowly during the hot, dry summer months. Therefore, fertilizer is primarily needed only in the spring and fall. Spring fertilization helps to "build up" the grass and protect the lawn from weeds and pests. Fall fertilization provides a healthier, hardier turf longer into the colder months. In addition, fertilization should occur when the soil is moist; however, applications should not be performed immediately prior to a forecasted rainstorm and should never be performed when the ground is frozen.

Canada Geese Control

Canada geese have the potential to be major contributors to the phosphorous problem at Clove Acres Lake and also contribute substantial aesthetic problems by leaving large amounts of feces on the park and picnic areas, as well as on the lawns of individual homeowners. Furthermore, Canada geese can also be extremely aggressive towards people and other animals when they nest and fledge their young.

When geese defecate on a lawn area, the feces and associated phosphorus can be quickly transported to the lake via stormwater, where it can stimulate algal and plant growth. Thus, goose waste accounts for a large component of the phosphorus found in stormwater. Thus, reducing the number of geese that reside around the lake will reduce the amount of phosphorus that enters the lake.

There are many methods aimed towards lowering the population of Canada geese that reside adjacent to waterways. They range from very simple and inexpensive techniques to very costly and complicated techniques. In general, those control programs that implement a number of techniques on a consistent basis tend to be the most successful.

The most common goose control technique is through the use of a barrier. Barrier fences can be used to exclude geese from an area, and are made of a variety of materials including snow fence, picket fence, chicken wire, etc. Barrier fences are well suited for keeping geese out of yards near a lake or pond. In addition, barrier fences should be considered when there are few geese, when they are molting, and before they begin using the area. However, it should be noted that barriers may not deter geese from flying into an area.

Another management technique that can be used is scare tape, which is a short-term method used to deter geese from walking into an area. Scare tape is a ½ in. shiny ribbon that flashes in the breeze. In addition, when a breeze hits the tape it will make a rattling noise, which also scares the geese. Similar to barrier fences, this method may not prevent geese from flying into an area. This method is most effective when there is a small population and where there are similar lawn-lake environments nearby.

Vegetated buffers and aquascaping can be effective long-term methods to reduce the number of geese and their impacts to a lawn / shoreline area. Canada geese primarily consume grasses with ideal foraging habitat consisting of fertilized and closely mowed lawns / recreational areas (with few trees and shrubs) that have easy access to lakes or ponds. These areas are preferred because grass shoots are plentiful, there is easy access to the water, and there is high visibility (>30 ft.) so geese can see potential predators.

Vegetated buffers provide areas around a lake that are not mowed, and thus, the geese have a harder time foraging. In addition, vegetation around a lake reduces their access to the water and makes seeing predators more difficult. Vegetated buffers and aquascaping (planting vegetation either in water or immediately along the shoreline) can be done using a variety of native trees, shrubs, tall grasses, wild flowers, and emergent aquatic plants. Not only do vegetated buffers and aquascaping reduce the amount of geese around a waterbody by making the habitat less suitable for them, but these techniques are aesthetically pleasing and can help reduce erosion by stabilizing the soils around the lake or pond.

Another option that is commonly used is the constant harassment of geese by either people or dogs; this method is known as hazing and is one of the simplest methods for deterring geese. This is usually done by local residents, town employees, or a hired independent company. In addition to simply chasing geese from an area, personnel may also use "thunder flash" types of fireworks. These may be thrown or launched toward the geese. These fireworks explode with a very loud sound and intense flash of light. This method is very expensive considering that personnel must be diverted from their ordinary job or a company must be paid to perform this service. This method is also not very effective because the geese simply move to another part of the lake.

Many places that have goose population problems apply a variety of chemicals to the grass or field areas that geese use to feed. The chemicals are not toxic to the geese but tend to make the grass and other food the geese eat unpalatable to them. The theory is that the geese will move to different areas that have better food sources. Unfortunately for most areas, this method is cost prohibitive. The chemicals alone are very expensive and additional costs are added for the application to all feeding areas. Depending on the brand of chemical used, additional applications may also be required after rainfall or the mowing of the grass. In conjunction with this practice, visitors must not be allowed to feed the geese thereby eliminating a supplemental food source. Both hazing with dogs and the use of the chemicals tend to be limited to the management of geese on golf courses.

A method that is not generally used is live trapping and removal of the geese from an area. This technique is both very time consuming and expensive. The general concept is that geese are netted by throwing or firing a rocket propelled net over the flock of geese while they feed in an open area. Personnel then capture the geese and put them in boxes for transport to a new area where they are released. This process usually needs to be repeated several times to capture the whole flock and becomes less effective with every attempt as the geese learn to spot and avoid such set-ups.

Finally, New Jersey allows for special permits that let the applicant addle the eggs of nesting geese. Addling the eggs destroys the embryo inside the egg; however, the female goose will continue to sit on the eggs and not produce another set. Although this will not immediately eliminate the entire goose population, it will keep the population from rising. Additionally, if implemented over more than one growing season, the geese will tend to move on to other locations. Egg addling has been successful in reducing geese local geese populations in New Jersey, however, it typically takes at least two growing seasons to exhibit a reduction.

Unfortunately, there is no one management technique to control the goose population, and thus a combination of techniques should be used. It is recommended that Clove Acres Lake apply for a special addling permit and if possible harass the geese as much as possible when they enter into undesirable locations. In addition, wherever possible, the planting of shoreline vegetation should be conducted as well.

Based on conversations with the WRWMG, it is understood that sometime in the near future a shoreline stabilization and restoration project will occur in the picnic and recreational areas of the park adjacent to the Lake. This restoration and stabilization project will no doubt utilize a vegetative buffer along the eroded portions of the shoreline. This buffer may also end up serving as a vegetative barrier thus preventing the geese from gaining access to the recreational lawn areas to feed. As stated previously, this will not completely eliminate the goose / phosphorous problem within Clove Acres Lake, but will deter future geese from utilizing the Lake as no easily accessible food source is near.

Preservation of Existing Wetlands and Forested Areas

Approximately 65% of the Clove Acres Lake watershed is composed of forested land and/or wetlands. Whenever possible, existing wetlands should not be disturbed as they help to minimize local flooding, act as a nutrient sink (especially phosphorus), and provide food and habitat for wildlife. Establishing a buffer strip around the lake and associated stream network would provide a pro-active means of protecting existing wetlands and riparian vegetation. Forested lands reduce sedimentation, act as a nutrient sink, and reduce runoff, thereby lowering the amount of nutrients and sediment entering the lake. Efforts should be made to preserve as much forested land as possible.

APPENDIX A

In-situ Data

May 2006

In-Situ Monitoring for Clove Acres Lake 5/11/06							
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(mmhos/cm)**	**(mg/L)**	**(units)**
L-1	**3.2**	**1**	**Surface**	17.51	0.264	11.8	9.56
			1.00	16.04	0.265	13.39	9.45
			2.00	14.95	0.27	12.07	8.91
			3.00	13.36	0.266	9.07	8.38
L-2	**2.1**	**1**	**Surface**	17.34	0.265	12.44	10.89
			1.00	17.24	0.266	12.32	9.56
			2.00	15.13	0.271	12.96	9.09
L-3	**0.7**	**0.7**	**Surface**	16.92	0.267	11.65	10.86
			0.50	15.21	0.28	12.09	9.33
S-1	**N/A**	**N/A**	**Surface**	14.52	0.28	10.54	8.03

July 2006

In-Situ Monitoring for Clove Acres Lake 7/13/06							
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(mmhos/cm)**	**(mg/L)**	**(units)**
L-1	**3.4**	**1**	**Surface**	24.34	0.261	12.28	11.47
			1.00	24.14	0.26	11.73	11.49
			2.00	20.9	0.261	11.64	8.3
			3.00	19.55	0.257	4.5	7.59
			3.25	19.44	0.258	3.55	7.37
L-2	**2.7**	**1**	**Surface**	24.12	0.262	11.14	10.97
			1.00	23.95	0.263	10.55	11.46
			2.00	20.84	0.277	7.91	8.11
			2.50	20.43	0.266	6.7	7.76
L-3	**1.8**	**1**	**Surface**	22.79	0.257	9.9	8.36
			1.00	21.12	0.258	9.59	7.79
			1.50	20.9	0.261	9.42	7.7
S-1	**N/A**	**N/A**	**Surface**	20.85	0.254	10.11	8.32

September 2006

In-Situ Monitoring for Clove Acres Lake 9/21/06							
Station	DEPTH (meters)			Temperature	Conductivity	pH	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(units)	(mg/L)
L-1	3.2	1.1	Surface	18.6	0.322	7.59	8.66
			1.00	18.5	0.323	7.63	8.22
			2.00	18.2	0.324	7.64	8.05
			3.00	17.3	0.333	7.7	7.79
L-2	2.1	1.2	Surface	18.1	0.325	7.64	8.52
			1.00	18.1	0.324	7.6	8.43
			2.00	17.5	0.324	7.58	7.91
L-3	1.5	1.5	Surface	16.3	0.34	7.66	10.33
			1.00	15.7	0.34	7.79	10.03
S-1	N/A	N/A	Surface	14.7	0.3	7.55	9.74

April 2007

In-Situ Monitoring for Clove Acres Lake 4/24/07							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
L-1	3.5	1.5	Surface	16.76	0.209	8.68	7.5
			1.00	16.65	0.209	8.75	7.49
			2.00	16.42	0.209	8.83	7.46
			3.00	12.48	0.203	10.3	7.42
			3.25	11.37	0.2	10.34	7.39
L-2	1.5	1	Surface	16.67	0.211	9.24	8.23
			0.50	16.42	0.211	9.32	8.17
			1.00	16.36	0.21	9.32	8.1
L-3	0.5	0.5	Surface	17.59	0.214	9.8	7.72
			0.50	17.16	0.213	9.63	7.72
S-1	N/A	N/A	Surface	14.74	0.212	9.07	7.58

July 2007

In-Situ Monitoring for Clove Acres Lake 7/11/07							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
L-1	3.5	1	Surface	27.89	0.298	14.89	9.94
			1.00	26.98	0.304	14.83	9.52
			2.00	24.42	0.317	3.94	7.05
			3.00	22.48	0.32	1.36	6.94
L-2	1.7	1	Surface	28.48	0.298	13.96	10.22
			1.00	28.17	0.3	14.45	10.18
			1.50	25.34	0.328	1.97	6.9
L-3	0.75	0.75	Surface	27.66	0.318	7.97	8.31
			0.50	25.12	0.36	6.22	7.42
S-1	N/A	N/A	Surface	24.95	0.363	11.6	9.13

September 2007

***In-Situ* Monitoring for Clove Acres Lake 9/26/07**							
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**pH**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(mmhos/cm)**	**(units)**	**(mg/L)**
L-1	**3**	**1.5**	**Surface**	21.2	0.302	8.1	9.77
			1.00	20.54	0.302	8	9.4
			2.00	19.71	0.302	7.71	8.49
			3.00	19.27	0.304	7.13	4.51
L-2	**1.75**	**1.25**	**Surface**	22.48	0.302	8.43	10.11
			1.00	21.18	0.301	8.34	10.18
			1.50	20.61	0.305	7.92	9.25
L-3	**0.8**	**0.8**	**Surface**	23.27	0.302	8.67	10.5
			0.50	19.02	0.319	8.05	10.28
S-1	**N/A**	**N/A**	**Surface**	19.09	0.314	8.57	12.86

APPENDIX B

Discrete Data

2006 Discrete Data

11 May 2006	STATION	TP	TSS	ALKALINITY	CHL A	NH3-N	NO3-N	NO2-N
	S-1	0.04	ND <2					
	L-1	0.06	4	45	12.1	0.05	0.14	0.006
	L-2	0.08						
	L-3	0.07						
	FIELD REP (L-3)	0.08						
13 July 2006	**STATION**	**TP**	**TSS**	**ALKALINITY**	**CHL A**	**NH3-N**	**NO3-N**	**NO2-N**
	S-1	0.07	ND <2					
	L-1	0.06	2	58.3	30.4	0.02	0.4	0.006
	L-2	0.06						
	L-3	0.06						
	FIELD REP	0.04						
	L-1 DEEP	0.49						
21 September 2006	**STATION**	**TP**	**TSS**	**ALKALINITY**	**CHL A**	**NH3-N**	**NO3-N**	**NO2-N**
	S-1	0.02	2					
	L-1	0.04	5	49.7	20.9	0.08	0.46	0.003
	L-2	0.04						
	L-3	0.02						
	FIELD REP (L-1 DEEP)	0.06						
	L-1 DEEP	0.06						

2007 Discrete Data

25 April 2007	STATION	TP	TSS	ALKALINITY	CHL A	NH3-N	NO3-N	NO2-N
	S-1	0.03	6					
	L-1	0.04	9	33.8	3.5	0.07	0.59	0.005
	L-2	0.05						
	L-3	0.05						
	FIELD REP (S-1)	0.03	ND <3					
11 July 2007	STATION	TP	TSS	ALKALINITY	CHL A	NH3-N	NO3-N	NO2-N
	S-1	0.03	ND <3					
	L-1	0.12	9	51.8	96	0.07	0.05	ND <0.001
	L-2	0.09						
	L-3	0.1						
	L-1 DEEP	0.15						
26 September 2007	STATION	TP	TSS	ALKALINITY	CHL A	NH3-N	NO3-N	NO2-N
	S-1	0.02	ND <3					
	L-1	0.04	5	62.5	11.9	0.05	ND <0.02	ND <0.001
	L-2	0.05						
	L-3	0.05						

APPENDIX C

Plankton Data

2006 Phytoplankton Data

Date	Organism	Cells / ml	ug / L
11 May 2006	**Green Algae**		
	Chlorella	26	14.46
	Chlamydomonas	58	6.05
	Golenkinia	15	1.67
	Haematococcus	22	23.89
	Total	**121**	**46.06**
	Chrysophyta		
	Ochromonas	11	1.15
	Cryptophyta		
	Rhodomonas	26	14.46
	Total	**158**	**61.66**
13 July 2006	**Green Algae**		
	Chlorella	135	75.06
	Chlamydomonas	631	65.78
	Scenedesmus	45	5.00
	Tetraedron	23	3.81
	Actinastrum	60	10.00
	Micractinium	135	31.66
	Rhizclonium	225	312.58
	Spondylosium	1051	474.76
	Total	**2305**	**978.65**
	Chrysophyta		
	Ochromonas	143	14.91
	Chromulina	465	173.19
	Total	**608**	**188.10**
	Diatoms		
	Melosira	1877	1935.19
	Asterionella	135	374.22
	Navicula	15	57.98
	Synedra	8	74.83
	Total	**2035**	**2442.21**
	Total	**4948**	**3608.96**

2007 Phytoplankton Data

Date	Organism	Cells / ml	ug / L
24 April 2007	**Chlorophyta**		
	Chlamydomonas	9.9	1.0
	Staurastrum	9.9	99.5
	Chlorella	29.8	23.6
	Total	49.6	124.1
	Bacillariophyta		
	Frustulia	39.7	77.3
	Fragilaria	992.1	3964.3
	Total	1031.7	4041.5
	Cryptophyta		
	Rhodomonas	9.9	1.9
	Total	9.9	1.9
	Chrysophyta		
	Dinobryon	129.0	45.4
	Total	129.0	45.4
	Total	1220.2	4212.9
11 July 2007	**Chlorophyta**		
	Actinastrum	82.2	21.93
	Chlamydomonas	552.1	57.6
	Chlorella	117.5	93.0
	Ankistrodesmus	11.7	0.2
	Total	763.6	172.7
	Bacillariophyta		
	Synedra	11.7	40.4
	Total	11.7	40.4
	Phyrophyta		
	Ceratium	11.7	105.7
	Total	11.7	105.7
	Cyanophyta		
	Anabaena	1069.0	2548.2
	Total	1069.0	2548.2
	Cryptophyta		
	Cryptomonas	23.5	22.7
	Rhodomonas	23.5	4.6
	Total	47.0	27.3
	Total	1139.5	2894.3
26 September 2007	**Chlorophyta**		
	Chlorella	121.8	96.4
	Keriochlamys	33.2	18.5
	Oocystis	88.6	12.3
	Sphaerocystis	88.6	14.7
	Protococcus	243.6	192.8
	Gloeocystis	254.7	141.6
	Total	830.5	476.3

	Bacillariophyta		
	Cyclotella	22.1	10.1
	Synedra	11.1	38.0
	Asterionella	55.4	80.2
	Total	88.6	128.4
	Chrysophyta		
	Chromulina	11.1	2.6
	Total	11.1	2.6
	Cyanophyta		
	Microcystis	2878.9	5401.9
	Aphanocapsa	44.3	3.1
	Chroococcus	232.5	186.0
	Anabaena	221.5	527.9
	Total	3377.2	6118.9
	Cryptophyta		
	Rhodomonas	11.1	2.2
	Total	11.1	2.2
	Total	4318.4	6728.4

2006 Zooplankton Data

Date	Organism	Cells / ml	ug / L
11 May 2006	**Cladocerans**		
	Bosmina	65	65.6
	Chydorus	16	11.6
	Total	**81**	**77.2**
	Copepods		
	Cyclops	33	17.8
	nauplii	180	140.6
	Total	**213**	**158.4**
	Rotifers		
	Keratella	98	3.3
	Brachionus	33	13.7
	Total	**131**	**17.0**
	Total	**425**	**252.6**
13 July 2006	**Cladocerans**		
	Daphnia	33	40.8
	Bosmina	11	11.1
	Total	**44**	**51.9**
	Copepods		
	Cyclops	22	11.9
	nauplii	44	34.4
	Total	**66**	**46.3**
	Rotifers		
	Keratella	44	1.5
	Brachionus playta	99	95.9
	Conochilus	33	4.1
	Asplanchna	22	29.3
	Total	**198**	**130.7**
	Total	**308**	**228.9**

2007 Zooplankton Data

Date	Organism	Cells / ml	ug / L
24 April 2007	**Ostracods**	36	XXXX
	Total	36	XXXX
11 July 2007	**Copepods**		
	Cyclops	12	2.3
	Diaptomus	23	39.0
	nauplii	437	341.4
	Total	472	382.7
	Cladocerans		
	Diaphanosoma	12	15.4
	Bosmnia	207	209.0
	Total	219	224.4
	Rotifers		
	Brachionus	207	85.9
	Trichocerca	92	30.5
	Kellicottia	23	2.3
	Asplanchna	46	61.3
	Polyarthura	46	44.6
	Keratella	748	24.9
	Total	1162	249.5
	Total	1852	856.7
26 September 2007	**Ostracods**	48	XXXX
	Total	48	XXXX
	Copepods		
	Cyclops	119	24.1
	Diaptomus	16	26.9
	nauplii	119	92.8
	Total	253	143.8
	Cladocerans		
	Diaphanosoma	8	10.6
	Ceriodaphnia	63	111.6
	Bosmnia	119	119.9
	Chydorus	40	28.7
	Total	230	270.8
	Rotifers		
	Asplanchna	301	400.9
	Polyarthura	8	7.7
	Keratella	8	0.3
	Total	317	408.8
	Total	847	823.4

APPENDIX D

Retrofits

Three Chambered Nutrient Separating Baffle Box

Except where otherwise noted, the information presented in this factsheet has been provided by the manufacturer (Suntree Technologies, Inc. www.suntree.com)

Manufactured treatment devices are intended to capture sediments, metals, hydrocarbons, floatables, and/or other pollutants in stormwater runoff before being conveyed to a storm sewer, or waterbody (NJDEP 2004). The Three Chambered Nutrient Separating Baffle Box captures rich vegetation and litter in a filtration screen and allows sediment to settle to the bottom of the structure. Thus, the organic pollutant load is separated from the water. After stormevents, the vegetation and litter dry out. Baffle boxes are concrete or fiberglass structures with a series of settling chambers.

Advantages: (EPA 2001)

- Simple, inexpensive stormwater BMPs that effectively remove sediment and suspended solids.
- Can be retrofitted in existing storm lines.

Disadvantages: (EPA 2001)

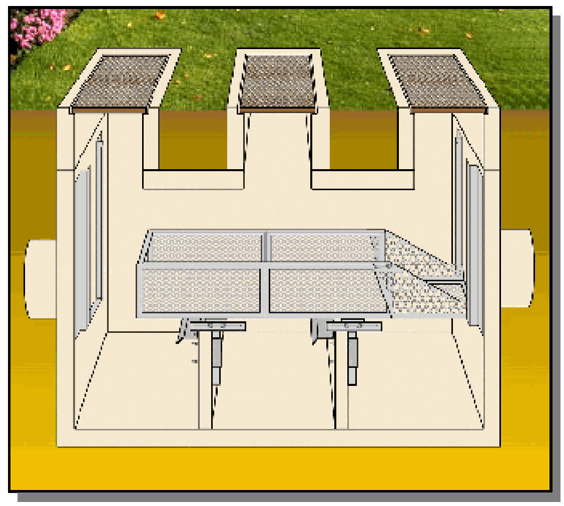
- Require significant maintenance to remove accumulated sediment.
- Trash racks may release accumulated trash during high flows.
- Not designed for nutrient removal.

Estimated Costs:
Installation for most pre-cast baffle boxes is between $20,000 and $30,000. The average cost for cleaning a baffle box is $450 (England 1998 as cited in EPA 2001).

Maintenance Requirements:
Baffle boxes need regular maintenance such as routine inspections and cleaning. The frequency of cleaning the baffle boxes depends on the amount of rain and accumulated material. Baffle boxes are cleaned using vacuum trucks and are accessed though manholes.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: 90% (Suntree) 71% (EPA 2001)
- Total phosphorus removal rate: 38% (EPA 2001)
- Total nitrogen removal rate: N/A



Aqua-Swirl

Except where otherwise noted, the information presented in this factsheet has been provided by the manufacturer or representative (AquaShield Stormwater Treatment Solutions http://aquashieldinc.com or Shri Agencies)

The Aqua-Swirl is an effective way to remove sediments, floating debris, and free-oil from stormwater. Both gravitational and hydrodynamic forces allow solids to settle at the bottom of the device. Treated water exits the MTD behind an arched outer baffle. A vent pipe exposes the backside of the baffle to atmospheric conditions; this prevents a siphon from forming at the bottom of the baffle.

The Aqua-Swirl can be shipped fully assembled after leak testing in the factory since the units are light weight.

Advantages:

- The Aqua-Swirl is highly adaptable.
- Allows for easy retrofit.

Disadvantages:

- No data on phosphorus and nitrogen removal efficiencies.

Estimated Costs:

The cost per unit ranges from $5,300 to $50,000, depending on the size and configuration. Prices are available upon request on a case by case basis.

Maintenance Requirements:

Inspections and maintenance can take place from the surface; free-floating oil and debris can be removed through the service access. It is recommended that inspections are conducted quarterly for the first year of operation in order to determine an appropriate maintenance schedule. Once the usable storage volume is occupied, the accumulated material needs to be removed using a vacuum truck.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: 80%
- Total phosphorus removal rate: No data
- Total nitrogen removal rate: No data

Aqua-Guardian

Except where otherwise noted, the information presented in this factsheet has been provided by the manufacturer or representative (AquaShield Stormwater Treatment Solutions http://aquashieldinc.com or Shri Agencies)

The Aqua-Guardian (Aqua-Guard) is a catch basin insert that is suspended inside the catch basin by a stainless steel support collar. The collar acts as a funnel to direct stormwater runoff into the sediment collection/ storage area. In addition, the collar traps floatable debris by forming a baffle around the inside of the insert. As water flows through the locked filter screen standpipe it is filtered by media (100% hydrophobic cellulose) that removed fine sediments, nutrients, and heavy metals.

The Aqua-Guard comes in three sizes to fir into the catch basin opening. These inserts are typically used for retrofit applications and can also be used as pretreatment devices before a swirl separator or Aqua-Filter.

Advantages:

- The Aqua-Swirl is highly adaptable.
- Allows for easy retrofit.

Disadvantages:

- No data on pollutant removal efficiencies.

Estimated Costs:
The Aqua-Guard system costs between $1,350 and $2,750 per unit. This price includes shipping.

Maintenance Requirements:
In most cases, the Aqua-Guard MTD should be inspected monthly and after significant storm events. The MTD can be visually inspected from the surface and a tape measure can be used to determine the amount of sediment in the collection area. Once the sediment reaches the bottom "filter screen outlets" the unit needs to be serviced. Servicing is conducted by using a wet/dry shop-vac to remove sediment and debris inside the chamber. The filter bag also needs to bee removed and replaced; sediment in the filter area should be removed prior to inserting a new filter.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: No data
- Total phosphorus removal rate: No data
- Total nitrogen removal rate: No data

Aqua-Filter

Except where otherwise noted, the information presented in this factsheet has been provided by the manufacturer or representative (AquaShield Stormwater Treatment Solutions http://aquashieldinc.com)

The Aqua-Filter is designed for locations that require advanced stormwater runoff treatment. This product can be designed for new construction projects or as a retrofit for existing structures. The Aqua-filter is capable of removing total suspended solids as well as hydrocarbons, phosphorus, and some heavy metals (such as copper and zinc). The filter media is capable of removing pollutants in water (i.e. dissolved oils, clays, fine silts, nutrients, and heavy metals). Each system is engineered so the filter capacity complies with the established water quality treatment required.

Advantages:

- Can be used to treat runoff entering sensitive receiving waters.
- Provides advanced stormwater runoff treatment.
- Easy installation and maintenance.

Disadvantages:

- No data on nutrient removal efficiencies.

Estimated Costs:

Price ranges from $25,000 to $110,000 per system. The cost for installation ranges from $5,000 to $10,000. (Charbeneau et al 2004)

Maintenance Requirements:

There is a two-fold maintenance process. The first step is to inspect and clean out the pre-treatment chamber; a vacuum truck can be used to remove accumulated sediment and debris. The second step is to inspect and cleanout the filtration chamber. This step involves checking the filter media; if the media is dark brown then it needs to be replaced. Entry into the system is required to replace the filter.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: 80%
- Total phosphorus removal rate: No data
- Total nitrogen removal rate: No data

Stormceptor – Stormwater Pollutant Removal System

Except where otherwise noted, the information presented in this factsheet has been provided by the manufacturer or representative (Stormceptor, www.stormceptor.com).

Stormceptor offers a range of treatment systems to remove pollutants from stormwater. Stormceptor offers products for pollutant removal, oil storage, oil and sand removal, and large capacity systems. This document will focus on the stormwater pollutant removal (STC) system.

This system slows stormwater such that oil, debris, and sediment can settle. There are four styles of STC systems: inlet, inline, submerged, and series. The inlet stormceptor is the most popular design model to treat stormwater. The inline stormceptor is designed to direct flow into the unit from a grated inlet, which can be used to treat runoff from parking lots, loading bays, and gas stations. The submerged stormceptor is designed for costal acres with standing water, and treats stormwater in submerged pipes. The last model, series stormceptor, is designed to treat large areas by having two stormceptors functioning in parallel.

Advantages:

- Easy installation and maintenance.
- Varity of styles.

Estimated Costs:

Maintenance costs for cleaning the unit is approximately $600. Price varies depending on style.

Maintenance Requirements:

Units should be inspected after construction and every six months for the first year of operation to determine the oil and sediment accumulation rate. Inspections after a year should be based on the accumulation rate observed in the first year of operation. The system needs to be cleaned when the sediment depth is 15% of the storage capacity. Again, this will depend on site specific conditions; however, cleaning generally takes place annually.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: 80%
- Total phosphorus removal rate: 20-30%
- Total nitrogen removal rate: no data

Grate Inlet Skimmer Box

Except where otherwise noted, the information presenting in this factsheet has been provided by the manufacturer (Suntree Technologies Inc. www.suntree.com)

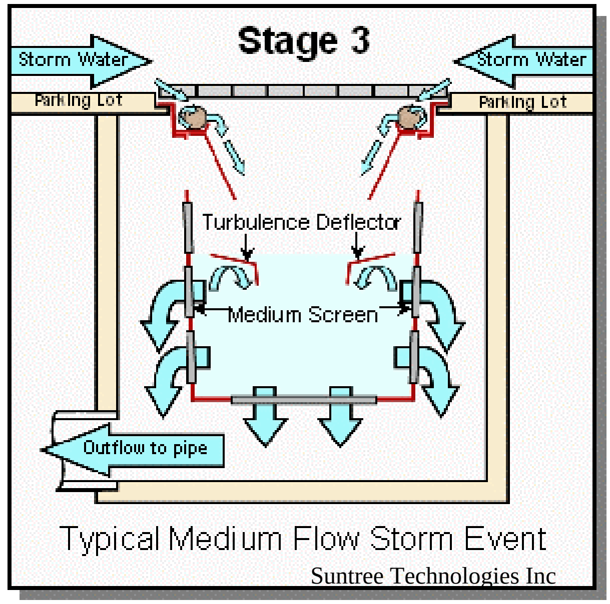
Manufactured treatment devices are intended to capture sediments, metals, hydrocarbons, floatables, and/or other pollutants in stormwater runoff before being conveyed to a storm sewer, additionally stormwater quality treatment measure, or waterbody (NJDEP 2004). The Suntree Grate Inlet Skimmer Box is a retrofitted device that can be installed within an existing stormwater inlet/ catch basin. It uses a serious of filtration screens to remove sediment, floatables, and debris from stormwater.

Advantages:

- Manufactured treatment devices are appropriate for small drainage areas with high impervious cover likely to contribute high hydrocarbon and sediment loadings (e.g. small parking lots and gas stations). NJDEP 2004
- Debris collected in the unit is stored in a dry state (helps to contain nutrient pollutant load and reduces mosquito breeding).
- Can be sized to fit any size inlet.
- Low cost compared to other BMPs.
- Easy to install and maintain with hand tools.
- Useful retrofit designed to modify existing stormwater infrastructure (catch basins).

Disadvantages:

- For larger sites, multiple devices may be necessary.
- Manufactured treatment devices are normally used for pretreatment of runoff before discharging to other more effective stormwater quality treatment facilities (NJDEP 2004).



Estimated Costs:

Based on information provided by the manufactured, the cost for materials to retrofit one catch basin ranges from approximately $700 to $1,000.

Maintenance Requirements:

<u>Monthly for the first year:</u> Monitor to ensure proper functioning of device.
<u>As needed:</u> Remove skimmer tray and deflection shield; turn over filter box and empty for disposal.
<u>Four times/year and after storm <0.5in.:</u> Inspect all device components excepted to receive and/or trap debris for clogging and excessive debris and sediment accumulation; dispose of debris, sediment and other waste material at suitable disposal/recycling sites and in compliance with applicable waste regulations.
<u>Once/year:</u> Inspect all structural components for cracking, subsidence, and deterioration.

Ascribed Pollutant Removal Efficiencies:

- TSS reduction: 73% (England 2001)
- Total phosphorus removal rate: no data
- Total nitrogen removal rate: no data

References

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