Rust Pond
Wolfeboro, New Hampshire

Pond and Watershed Diagnostic Study

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

Final Report
Winter 2007

DES -R-WD-07-24

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New Hampshire Department of Environmental Services
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NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Rust Pond and Watershed Diagnostic Study
Abstract

The Rust Pond Diagnostic Study presents twelve months of limnological data and discusses watershed land use practices and presents pond quality trends over time. The diagnostic data are used to determine sources of pollutants and problem areas in the watershed that impact pond quality. The Feasibility section provides information on where to focus remediation efforts and cost estimates of watershed management practices and pond remediation techniques.

The following tasks were completed during the study and research phases of this project:

1. Identified the historical and existing water quality of Rust Pond;

2. Identified the water quality of Rust Pond's inflowing tributaries, nearshore groundwater seepage, and outflow;

3. Developed estimated hydrological and phosphorus budgets for Rust Pond;

4. Documented sources of phosphorus to Rust Pond;

5. Compared trophic models that classified Rust Pond;

6. Reviewed many potential non-point sources of phosphorus to Rust Pond;

7. Recommended non-point source Best Management Practices that will help protect the pond for future generations;

8. Recommended management strategies to minimize nutrient additions to the pond, and how to protect the pond in the future;

9. Provides cost estimates of watershed management practices and pond remediation techniques.

The results and recommendations of the Rust Pond Diagnostic Study provide a basis for lake protection through watershed management. Watershed management activities should be the immediate goals of the lake association, towns, and watershed residents.

Although this project was successful in accomplishing its goals, only upon the implementation of a watershed management program, which includes phosphorus reduction, will this project be considered a complete success.

Rust Pond and Watershed Diagnostic Study
Acknowledgements

Special thanks to the Rust Pond Association volunteers for their complete support of this study and the ongoing commitment to protecting Rust Pond.

Particular thanks to the volunteers help during the field data collection phase of this study. Volunteers dedicated time to collecting water samples, reading staff gauges, allowing installation of shoreline seepage barrels, driving samples to Concord, and reporting any unusual occurrences in and around the lake. This total two-year process could not have been successful without them. Thank you all!

Rust Pond Volunteers Included:

Keith Simpson	Tod O'Dowd	Bob Demaree
Mary Simpson	Eli Tappan	Jeb Bradley
Jill Duffield	Barbara Nelson	Libby Peard
Bob Mathes	Joe D'Appolito	Trevor Peard

A special thank you to Ed Webb for his continued involvement in VLAP, field assistance, and his dedication to this special study.

The Biology Section Staff of the Department of Environmental Services is acknowledged for its professional assistance in the field and laboratory. Particular thanks to Biology Interns, Brandy Penna, Meryl Richards, and Kirsten Pulkinnen, and Biolgy Staff, Walter Henderson, Ken Warren, Andrea Lamoreaux, Sara Sumner and Alicia Carlson. Scott Ashley is acknowledged for coordinating the computer databases.

The efforts of Garry Haworth, Jean Chwasciak and the staff of the DES Laboratory are greatly appreciated in coordinating and processing the chemical analyses for the study.

We are grateful to the United States Environmental Protection Agency for their financial support of this project, which was partially funded through a Section 319 Grant.

Rust Pond and Watershed Diagnostic Study
Glossary

ALGAL BLOOM: A dense concentration of algae due to an increase of nutrients to the water body, such as phosphorus.

ANOXIC: Lack of oxygen (also, anaerobic).

AQUATIC PLANT GROWTH: The growth of plants living in a water system.

CHLOROPHYLL-a ANALYSIS: Measurement of the chlorophyll-a, which occurs in aquatic plants and algae.

COLOR: A visual measure of the water color. Decaying organic matter and metals contribute to water color.

CULTURAL EUTROPHICATION: The addition of nutrients to a water body due to human activity, including fertilizing, dumping of yard wastes, failing septic systems, and increasing impervious surfaces and runoff.

CYANOBACTERIA: A chlorophyll producing bacteria that contains heterocysts, akinetes, may produce toxins, fixes nitrogen and may cause unsightly surface scums. These bacteria were once thought to be a Cyanophyceae or blue-green algae

DECOMPOSITION: The breakdown of an organic substance.

DECOMPOSING BACTERIA: Bacteria that break down organic matter, producing carbon dioxide as a byproduct.

DIAGNOSTIC STUDY: An intensive and comprehensive study of a lake and its watershed.

DIMICTIC: Lakes that circulate freely twice a year in the spring and in the fall. They are directly stratified in the summer and inversely stratified in the winter.

DISSOLVED OXYGEN: The oxygen that is in solution, i.e., dissolved in the water.

EPILIMNION: The upper, well-circulated, warm layer of a thermally stratified lake.

EUTROPHIC: Nutrient rich waters, generally characterized by high levels of biological production.

EUTROPHICATION: The addition of nutrients to a water body due to the natural aging of the water body or to human activity.

HYDROLOGIC BUDGET: A compilation of the total water inputs and outputs to and from a lake.

HYPOLIMNION: The deep, cold, relatively undisturbed bottom waters of a thermally stratified lake.

IPWS: Interstitial Pore Water Sampler. This device is used to collect the water held in the pore spaces of soil.

LIMNOLOGIST: A scientist who studies freshwater ecology.

MESOTROPHIC: Waters containing an intermediate level of nutrients and biological production.

METALIMNION: The middle layer of water in a thermally stratified lake, between the epilimnion and hypolimnion, where the decrease in temperature with depth is at its greatest.

NITROGEN: A necessary nutrient for life, fixed by some bacteria and plants.

OLIGOTROPHIC: Nutrient poor waters, generally characterized by low biological production.

ORGANIC MATERIAL: Matter making up dead or living organisms.

PHOTIC ZONE: The depth of lake water that receives sufficient sunlight to permit photosynthesis.

PHYTOPLANKTON: Microscopic plant life that float within or on top of lake water.

PLANKTON: General term for plant and animal life that float within or on top of a water body (see also phytoplankton and zooplankton).

RESPIRATION: The exchange of gases, such as carbon dioxide, between a living organism and its environment.

STRATIFICATION: The layering of water due to temperature differences (see also epilimnion, hypolimnion, and metalimnion).

TRANSPARENCY: The clarity of the water, commonly measured with a Secchi disk.

TROPHIC STATUS: The degree of lake aging or nutrient status of a lake (see oligotrophic, mesotrophic, and eutrophic).

WATERSHED: The total area draining into a lake, including the area of the lake itself. Also called a drainage basin.

ZOOPLANKTON: Microscopic animal life that floats within or on top of a water body.

Rust Pond and Watershed Diagnostic Study
Executive Summary

1. Introduction

The Rust Pond Diagnostic Study began at the request of the Rust Pond Association in July, 2001 and the field work completed in June, 2002. The pond is located in the town of Wolfeboro with portions of the watershed located in New Durham and Brookfield.

The goals of the diagnostic study were to provide a current pond assessment, identify and monitor the sources and mass of water and nutrients (phosphorus) to Rust Pond, compare several trophic models that provide insight to potential watershed and lake remedial actions, and provide recommendations concerning lake and watershed management activities to protect and potentially improve the current pond quality.

Prior to providing recommendations for protective and restorative measures, a better, more scientific understanding of such processes as pond flushing, watershed land use, and nutrient sources had to be achieved. This report is the culmination of a physical, geological, chemical and biological intensive study that provides key recommendations that DES hopes will provide the basis for watershed management and pond quality protection.

2. Hydrologic Budget

The hydrologic budget for the gauging period (July of 2001 to June of 2002) provided estimates of significant water flow sources to Rust Pond by gauging inlets and the outlet, estimating direct surface runoff, and measuring precipitation and evaporation. Tributaries, including Perry Brook and North Inlet provided the greatest input to the lake (52 percent). Direct pond wetfall contributed the second largest source of water to the pond, yielding 27 percent. Hydrologic inputs from wetfall runoff and groundwater were estimated to contribute 16 percent of the budget.

Outflow over the dam and groundwater recharge (not measured during the study) accounted for 84 percent of the water losses from the pond. Evaporation accounted for 15 percent of pond water losses, with change in pond storage accounting for the remaining 2 percent of the hydrologic budget.

3. Phosphorus Budget

Phosphorus loading, the primary cause of increased phytoplankton production, was determined through sampling and analysis of the sources quantified in the hydrologic budget. One of the most important project goals was to quantify phosphorus inputs to Rust Pond.

Study year mean phosphorus concentrations for North Inlet and Perry Brook were 32.9 ug/L and 15.7 ug/L, respectively. The phosphorus concentration for North Inlet is considered higher than desirable, while the Perry Brook phosphorus concentration is typical for a tributary within a mostly forested watershed. The mean phosphorus concentration at the outlet was 21.4 ug/L.

Tributaries contributed the greatest amount of phosphorus to Rust Pond, accounting for 45 percent of the phosphorus inputs. Inputs from watershed wetfall runoff and direct pond wetfall contributed 32 percent and 18 percent of the phosphorus inputs, respectively. Watershed wetfall runoff includes the overland phosphorus that directly discharges to the pond without first discharging to one of the gauged tributaries. Groundwater phosphorus loading was minimal, contributing only 5 percent of the total phosphorus load.

Mean epilimnetic and metalimnetic phosphorus concentrations for Rust Pond were 9 ug/L, during the study period. The mean phosphorus concentration in the hypolimnion was 12 ug/L. Total phosphorus concentration within each limnetic layer fell within the “average” classification for New Hampshire lakes.

Three different trophic state classification methods were utilized to evaluate current conditions and to make recommendations on the effects of increases phosphorus loading on trophic status. All three trophic state indices classified the pond as oligotrophic, nutrient poor waters with low biological activity.

4. In-Lake Data

Rust Pond is a typical central New Hampshire pond exhibiting temperature-based stratification into three layers during the summer months. In late summer, Rust Pond shows steady, oxygen concentrations greater than 7 mg mg/L from the surface to approximately eight meters, two to three meters shy of the bottom. Oxygen concentrations dropped to near zero in the bottom two to three meters. Fish species can become impacted when oxygen concentrations drop below 4 mg/L. Low oxygen forces fish out of the cooler deeper waters and into the warmer shallower waters during the summer months, potentially impacting the health of the fish. Over time, many lakes experience anoxic waters in the deeper lake zones due to accumulation, decomposition and migration of organic matter to the lake bottom. Human activities in the lake's watershed such as tree clearing, fertilizing lawns, increasing impervious areas, and faulty septic systems can accelerate this aging process.

Mean annual summer pH values for the pond ranged from a high of 7.19 in the metalimnion to a low of 6.55 in the hypolimnion during the study period. The waters of Rust Pond fall within the "satisfactory" category, meaning the lake is near neutral.

The mean ANC value for the epilimnion of Rust Pond was 10.4 mg/L (median of 11.0 mg/L) as calcium carbonate during the 2001 study year, and 10.6 mg/L (median of 11.0 mg/L) in the 2002 summer study period. Rust Pond is classified within the "sensitive" category to acid additions, bordering on "highly sensitive," meaning that the lake is not able to effectively buffer against acid additions from precipitation and runoff.

Mean annual summer conductivity values in Rust Pond were relatively similar for each water column layer, ranging from 53.1 to 56.1 umhos/cm. These values are slightly lower than the mean conductivity value of 59.4 umhos/cm for 768 New Hampshire lakes, surveyed by the DES Lake Assessment Program. Conductivity values ranged from the mid-40s to mid-50s since Rust Pond began monitoring under the VLAP Program in 1988.

Overall, turbidity values in the pond were low with a study period mean annual ranging from 0.53 NTUs in the epilimnion in 2001 to 1.49 NTUs in the hypolimnion during 2002.

Algal populations during the study period were comprised of diatoms, golden brown algae, filamentous green algae, and cyanobacteria (blue-green algae species). A variety of Pennate diatoms and *Dinobryon, Chroococcus, Chrysosphaerella, Anabaena, and Asterionella* were the most abundant species identified throughout 2001 and 2002. A decrease in overall algal abundance from June to August was observed during both of the summer periods studied.

The mean chlorophyll-a value for the summer of 2001 was 2.82 mg/m^3 while the mean concentration was 2.48 mg/m^3 during the 2002 sample season. Overall, the annual mean Rust Pond chlorophyll-a concentration has decreased roughly 1 mg/ m^3 since monitoring began in 1988. Chlorophyll concentrations are well within the "good" range for algal abundance.

The mean clarity of Rust Pond in 2001 was 4.50 meters while the 2002 mean clarity was

5.52 meters. The clarity during the study period varied from 4.0 to 6.4 meters. This is in line with historical VLAP trend data which has ranged from approximately four to six meters since 1988.

The plant community in Rust Pond is currently represented by sparse patches of the white button-like flowered plant known as pipewort, and sparse distributions of water naiad, tapegrass, turtlehead, and members of the pondweed genus. Three-way sedge, documented during a 1981 plant survey appears to no longer be present in Rust Pond. However, five plants including water naiad, pipewort, turtlehead, tapegrass and pondweed were newly documented in 2002. Rust Pond has not been impacted by exotic nuisance species such as milfoil or fanwort, but it is recommended that the Weed Watcher Program continue, as nearby lakes and ponds have milfoil infestations.

5. Tributary Data

Mean annual study period pH values for all tributaries, including the North Inlet, Perry Brook and Boulder Brook were between 6.0 and 7.0. When pH values fall below a pH of 6.0, these waters may become too acidified to support some wildlife species. Annual mean pH values North Inlet and Perry Brook are above the state mean (6.5) and within the "satisfactory" range for New Hampshire surface waters.

Conductivity values among the Rust Pond subwatershed tributaries are variable. Perry Brook had the lowest study period mean conductivity of 52.22 μmhos/cm. This stream originates from springs and pools on the Winnipesaukee Golf Club property, but is buffered from the golf course by a forested wetland complex along the length of the stream. Conductivity values in North Inlet (245.94 μmhos/cm) were almost five times greater than those in the other tributaries throughout the study period. Higher conductivity levels here are likely the result of land use changes in the North Inlet subwatershed. The addition of road salt during the winter months likely contributes to elevated conductivity levels throughout the year either via direct overland runoff or groundwater. Overall, tributary conductivity values for North Inlet are of significant concern to the North Inlet water quality and a potential impact to Rust Pond.

As suspected, tributary turbidity was higher than those measured in the lake. However, mean study period turbidities in the North Inlet were greater than two times that of Perry Brook. Again, this signifies that the water quality, including the rate of sediment load, from the North

Inlet has been impacted by land use change and development within this subwatershed. The impact of the North Inlet subwatershed to Rust Pond should be considered when planning future land use for other portions of the watershed.

6. Lake and Watershed Recommendations

To create a comprehensive protection and preservation strategy for water resources within the Rust Pond watershed encompassing portions of Wolfeboro, New Durham and Brookline, the following watershed management strategies are recommended:

Stormwater Management and Erosion Control

Stormwater management for the Rte 28/ boat launch area, Wolfeboro Camp Road Walt's Lane and the North Inlet subwatershed should be the highest priority. Water quality data and observations indicate that urbanization within the North Inlet subwatershed has elevated sediment and phosphorus loads and resulted in increased turbidity and conductivity. Increased stormwater volumes and runoff rates resulting from land use changes, and pollutant discharges from these lands are the leading cause of declining water quality within this subwatershed and the North Inlet.

Subwatershed improvements to infiltrate and detain stormwater to reduce overland runoff volumes and runoff rates should be immediately evaluated and implemented. In addition, more cognizant planning practices, watershed overlay districts, and ordinances; with a focus on stormwater management is also critical to maintaining the ecological stability of the North Inlet and the entire Rust Pond watershed which is continuously faced with increased land use changes in a developing watershed.

Septic System Management

All homes surrounding Rust Pond are served by on site wastewater disposal systems. As a result, systems in close proximity to the pond, tributary or adjacent wetland are phosphorus contributors to the pond. While the density of development for Rust Pond is relatively low compared to other waterbodies in New Hampshire, increasing the wastewater disposal system setback to no less than 75 feet and as close to 300 feet from the shoreline or surface waters should be encouraged during site planning.

The Rust Pond Association should consider developing a septic system management plan for existing wastewater disposal systems near Rust Pond. The management plan would first evaluate all septic systems through a survey, and document each system in a routinely updated database. Scheduling septic and holding tank pumping can be coordinated, potentially saving money on routine tank pumpouts and inspections. It is recommended that *all* shorefront residents pump their systems every 1-3 years. For systems within 75 ft. of the shoreline or surface waters or constructed in areas shallow to ledge or groundwater it is suggested that these systems be pumped annually.

Shoreland Protection, Development, and Zoning

The protected shoreland is the area of land between the reference line (high water mark of the waterbody), to a point 250 feet upslope. To minimize erosion and the input of nutrients, a well-vegetated buffer should be established and maintained. There is a list of native plants, shrubs, and trees available for vegetating the shorefront. A well-distributed stand of trees, shrubs, and groundcover, leaving a natural duff layer of leaves can help maintain a healthy shoreline. Setbacks under the Shoreland Protection Act for buildings and other such structures should be strictly adhered to.

The Rust Pond Association and the town of Wolfeboro, New Durham and Brookline should work toward enacting zoning ordinances and an environmental or watershed overlay district that is consistent with the Shoreland Protection Act. This would not change the zoning for the whole town, but simply for the delineated watershed area of Rust Pond. The Comprehensive Shoreland Protection Act is a good starting point to use as a model in developing guidelines for the overlay. NHDES highly recommends that representatives from the Rust Pond Association and the towns of Wolfeboro, New Durham and Brookline form a subcommittee to investigate options for developing zoning ordinances and protective overlays for areas near the lake, tributaries and wetlands as well implementing Low Impact Development strategies in the watershed.

Beach Erosion

Beach erosion results in sediment deposition and phosphorus loading the pond. To prevent runoff and subsequent erosion from beaches, eliminate or reconstruct beaches. If beaches are eliminated, replant the exposed area with a vegetated buffer of native plants and trees. If reconstructing, design beaches so that they are setback from the shore with a vegetated buffer, and perched or so that slopes are minimized to lessen the impacts of overland runoff and subsequent beach erosion. Any shoreline activities require a permit from the NHDES Wetland Bureau. Adding a vegetative buffer along the shoreline will also improve the shoreline habitat used by small mammals, birds, fish, reptiles and amphibians.

In-Lake Management – Phosphorus Inactivation

Rust Pond does not show any signs of internal phosphorus loading. Therefore, phosphorus inactivation is currently not necessary for Rust Pond. Phosphorus precipitation and sediment inactivation through aluminum salts injection are lake restoration techniques that reduce internal phosphorus loading and thereby limit the algae growth in the lake. In-lake phosphorus reduction through hypolimnetic aluminum salts injection was successful in Kezar Lake in North Sutton, New Hampshire. It is important to note that all watershed sources of phosphorus must be eliminated or reduced prior to the use of this technique or they would counteract the treatment goal.

Aquatic Plant Management

With increasing numbers of exotic plant infestations throughout New Hampshire, it is important that lake association members continue to monitor Rust Pond for new growths of exotic plant infestations as part of the NHDES Weed Watcher program. The pond association should encourage more residents to become volunteer Weed Watchers.

Education

The Rust Pond Association should continue its activities to educate pond residents and transient recreationists about shoreland protection and broaden its efforts to encompass residents within the entire Rust Pond watershed. The Association should also establish a shoreland vegetation program and encourage the use of new technology efficient marine engines.

Elementary and secondary schools within the watershed can participate in the NHDES Interactive Lake Ecology Program. Public education within the watershed is particularly important as more lake residents begin to convert seasonal homes to year-round residences.

Future Monitoring

The Rust Pond Association should continue to participate in the Volunteer Lake Assessment Program, monitoring once a month during the summer. If permanent staff gauges are installed at each of the major tributaries, flow discharge can be tracked along with pollutant concentrations. With time, and little effort, this could provide a useful, long-term data set for evaluating pollutant loads to the pond.

Lake and Watershed Restoration Projects

Alternative funding sources may be required to implement some of the recommendations of this report. One possible funding source is the NHDES Nonpoint Source (NPS) Local Initiative Grant Program. In order to apply for the grant program, you must submit a proposal the meets the requirements of the annual Request for Proposal, usually issued in early September. NPS Grant information is available on the NHDES Watershed Management Bureau website under the Watershed Assistance Section.

1.0 INTRODUCTION AND WATERSHED CHARACTERISTICS

1.1 Purpose of Study

The Rust Pond Diagnostic Study was initiated in April of 2001 and completed in October of 2002. The study was funded by a Local Lake and Watershed Non-Point Source grant through the New Hampshire Department of Environmental Services (NHDES). The Rust Pond Association provided volunteer monitors throughout the course of the study. This project was conducted to allow limnologists and lake residents the opportunity to evaluate watershed interactions with the lake that produce sources of point and nonpoint sources of pollution to the lake, evaluate the current lake biological and chemical conditions, produce current trophic models, provide watershed management action plans and provide lake protection recommendations and associated costs for remedial action.

The Rust Pond Association has actively monitored lake quality for over 17 years through the Volunteer Lake Assessment Program (VLAP). The 2005 VLAP Report for Rust Pond notes that Secchi depth (clarity) and phosphorus levels have not significantly changed since 1988. With that said, lake monitors and biologists have noted an increase in erosion problems within the Rust Pond Watershed. Erosion concerns are largely associated with the lake's North Inlet. Residential development and an increase in impervious surfaces, visual observations of road side erosion and sediment runoff, and historic beaver activity in the North Inlet subwatershed are suspected to be contributing to increased erosion, and subsequent accelerated sedimentation in the pond.

The goal of this study was to determine the watershed sources of phosphorus to the lake and to make recommendations for the overall enhancement and protection of Rust Pond and its watershed. To achieve this, tributaries were monitored for phosphorus loading to the lake. Rainfall, evaporation, in-lake samples, and outflow were monitored throughout the study. Hydrologic and phosphorus budgets were developed to determine the phosphorus loading from the watershed to the lake. This report summarizes the study results and makes recommendations on how to improve the water quality of Rust Pond through watershed management and lake protection efforts. Restorative actions should protect the health, economic value and recreational uses of Rust Pond.

1.2 Lake and Watershed History

Wolfeboro has been deemed "the Oldest Summer Resort in America." In 1771, Governor John Wentworth built his summer home, a large mansion, along the shores of the lake that would become known as Lake Wentworth. The extreme beauty and aesthetic values of the state's lakes in this area have led others to develop lakeshore property, and build houses along the shores of Lake Wentworth, Crescent Lake, Lake Winnipesaukee, and Rust Pond. The draw to Wolfeboro lies primarily in its surface waters; of Wolfeboro's 38,000-acre area, 7,800 acres are comprised of water. As visitors discovered the area's beauty and charm, Wolfeboro gradually became a summer resort area. The establishment of summer camps in the Wolfeboro area, of which there are many, date back to 1884 and recreational boating began to pick up in the early 1900's. Today, the town's population nearly quadruples during the summer months.

Wolfeboro was incorporated in 1770 and the town took its name from General James Wolfe, a British officer, who led his troops to victory against the French on the Plains of Abraham in Quebec, Canada. General Wolfe died on the battlefield, but his fame became widespread and the proprietors of the new town named it in his honor, though there is no record of General Wolfe having visited Wolfeboro. Governor Wentworth was responsible for much of the development of Wolfeboro and the surrounding area. He is known for having developed several roads, one spanning from Portsmouth to Wolfeboro, and another east-west route that is now overlaid by Route 109.

Rust Pond is named after Colonel Henry Rust of Portsmouth, NH, one of the early proprietors of Wolfeboro. A large tract of land around the pond, then called Middle Pond, had been part of the Bryant grant originally cleared and settled by Walter Bryant, Jr. in 1759. The Bryant tract later reverted to the town proprietors, and in 1767 Col. Rust drew lot 15, consisting of 600 acres within the Bryant tract. Rust and his two sons built a log cabin and farmed the land during the warmer months, returning to Portsmouth in the winter. Eventually he built a larger dwelling and he, his wife and his children moved to Wolfeboro permanently. The land remained within the Rust family for six generations. Around the turn of the 20th century, a teacher from Pennsylvania bought a portion of the Rust land to establish a summer tutoring program, which is now the Wolfeboro summer boarding school (much of this information obtained from an article written by Don Lapham, RPA website).

The Rusts, along with many other summer visitors to Wolfeboro probably traveled there via the Boston and Maine Railroad, which began transportation in 1872. There were three stations in the area: Wolfeboro, Wolfeboro Falls, and Cotton Valley. The railroad may have also transported the first bass to Rust Pond; legend holds that Elisha Goodwin of Wolfeboro introduced black bass to the pond around 1864, making it the first New Hampshire lake or pond to hold bass. The Wolfeboro train station now operates mainly as a summer tourist attraction.

Though most of the area around Rust Pond has historically been farmland or summer homes, several businesses have existed near the pond. Before 1919, Weston Auto was a blacksmith shop and store. The South Wolfeboro Blanket and Flannel Manufacturing Company, incorporated in 1861, used to be located along Rust Brook (the outlet) near the yellow Springfield house. The factory used water brought from the brook by a wooden flume, which was probably removed around the time of WWII. According to Parker's History of Wolfeboro (1901), a grist mill, saw mill, shingle mill, chair factory, pipe factory, and tannery have all also been located along Rust Brook at some point**.** The Rust Dam property, originally owned by George Rust, was passed back and forth between two of these mill companies and several private owners including Wolfeboro Mills in the 1930's and Muriel Olney in the 1940's before Rust Pond Association purchased it in 1950. Rust Pond Association was founded in that year with the purpose of purchasing and maintaining the Rust Pond dam and also to monitor the level and purity of the pond's water. In 1989 Rust Pond Association joined the state's Volunteer Lake Assessment Program (VLAP), and has been conducting regular sampling events ever since.
(Sources: Wolfeboro Online website, Wolfeboro Camp School website, NHDES Dam Bureau File 258.04 and Rust Pond Association website: http://rustpond.n3.net/)

1.3 Lake Characteristics

Rust Pond is a naturally occurring lake in east-central New Hampshire, located in the town of Wolfeboro. The lake is impounded by a dam at the southern end. The dam, operated by the Rust Pond Association (RPA) is maintained at elevation 579 ft., with the ability to remove the flashboards and lower the Pond elevation by 3.0 ft. Table 1-1 summarizes the characteristics of the lake (descriptions of data are detailed in Appendix 1). A bathymetric (depth) map is shown in Figure 1-1. A map delineating the watershed boundary can be found in Figure 1-2.

Table 1-1
Rust Pond Morphometric Data
Lake Assessment Program

Parameter	**Lake Information/ Morphometric Data**
Lake Name	Rust Pond
Towns	Wolfeboro
County	Carroll
River Basin	Merrimack
Latitude	43°34'N
Longitude	71°10'W
Elevation (ft)	579
Shoreline Length (meters)	4800
Watershed Area (ha/a)*	668.2/ 1651.16
Lake Area (ha/a/m^2)**	84.98/ 209.99/ 849,800
Maximum Depth (m)	12.2
Mean Depth (m)	7.4
Volume (m^3)	6,310,615.31
Areal Water Load (m/yr)	4.38
Flushing Rate (yr^{-1})	0.6
Phosphorus Retention Coefficient	0.68
Lake Type	Natural with dam

* Watershed Area: Using GIS analysis (Base Map: USGS digital raster graphics files, 1:24,000 – scale 7.5' topographic quadrangles) maps and calculations for this study were based upon a watershed area equal to 777.8 hectares (1922.11 acres).
** Lake Area: Using GIS analysis (Base Map: USGS digital raster graphics files, 1:24,000 – scale 7.5' topographic quadrangles) maps and calculations for this study were based upon a lake area equal to 96.72 hectares (239.9 acres or 967,200 m^2).

1.4 Climate

The climate of the region is characterized by moderately warm summers, cold, snowy winters, and ample rainfall. Precipitation in this region is typically acidic (NHDES, 1999/2000). Generally, snow is present from mid-December until the end of March or early April. Ice-out for the lake is usually mid-April.

1.5 Watershed Characteristics

The New Hampshire Lake Assessment Program provides morphometric data for the Rust Pond watershed. The Rust Pond watershed encompasses an area of approximately 668.2 hectares (1651.16 acres) which contains the major lake that covers 84.98 hectares (209.99 acres) and scattered small wetland areas. In addition, there are two year-round streams, one seasonal stream and several areas of overland seasonal runoff entering Rust Pond (see Figures 1-1 and 1-2).

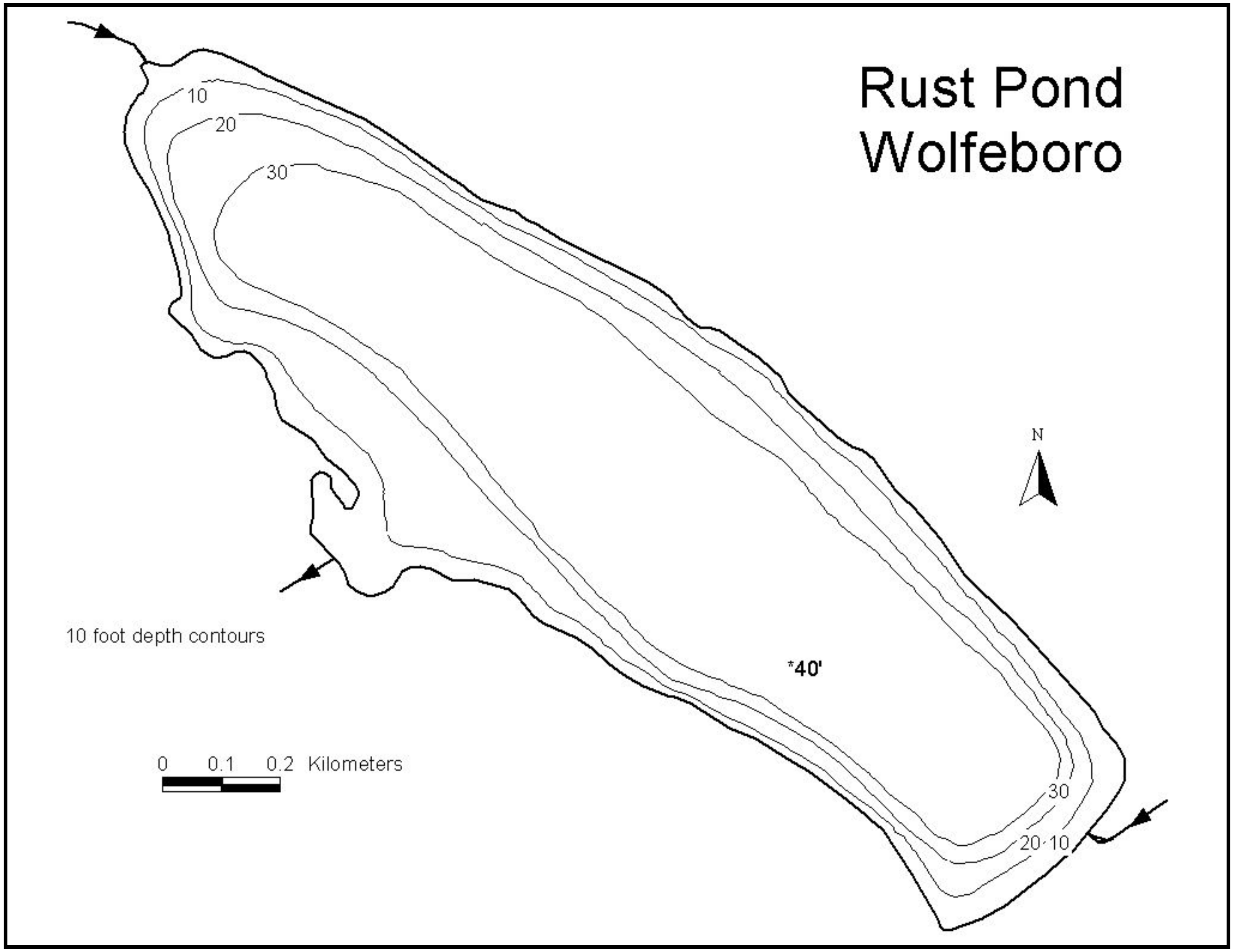

Figure 1-1: Rust Pond Bathymetric Map

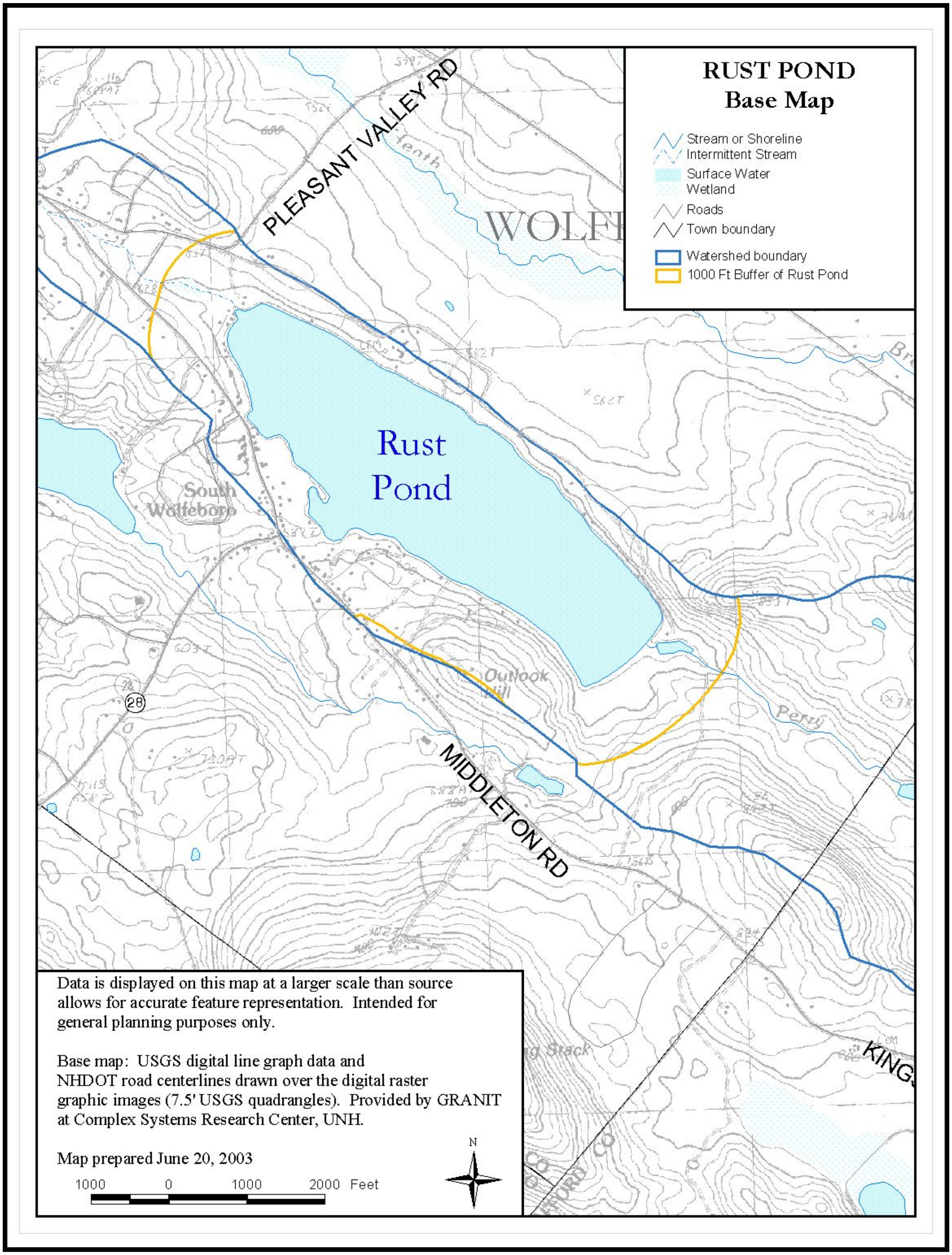

Figure 1-2: Rust Pond Base Map

Seasonal runoff, direct runoff, tributary flow, and groundwater seepage contribute to the hydrologic inputs of Rust Pond. The inlets and the outlet are shown in Figure 1-1. The outlet stream flows in a westerly direction from the lake where it eventually enters Lake Winnipesaukee to the west.

1.6 Land Cover and Land Use Patterns

The quality of the lake is influenced, in part, by the type of human and natural activities that occur within the confines of its watershed. Much of the rainwater, snow melt-water and groundwater found within the watershed eventually flow into the lake. The downward migration of the surface and groundwater carries watershed pollutants including nutrients such as phosphorus and nitrogen. Since New Hampshire lakes and ponds are phosphorus limited, inputs of phosphorus to the lake may cause increased algae and cyanobacteria production and accelerate eutrophication.

Increasing development, stream bank erosion, road runoff, septic systems, fertilization, poor agricultural practices, silvaculture and increases in impervious surfaces are the most common human activities that impair lake quality and accelerate cultural eutrophication in the Rust Pond watershed. Human disruptions of the natural watershed accelerate the degradation of water quality much faster than natural processes.

1.6.1 Rust Pond Land Use

Data pertaining to existing land use in the Rust Pond watershed were derived from a land use map prepared by the Informational Resources Management Unit at NHDES. The map was prepared from a 1990-1993 Landsat TM image and supplemental data sources. Figure 1-3 illustrates the land use cover in the Rust pond watershed. Table 1-2 shows an estimated breakdown (in acres) of the current land cover in the Rust Pond watershed.

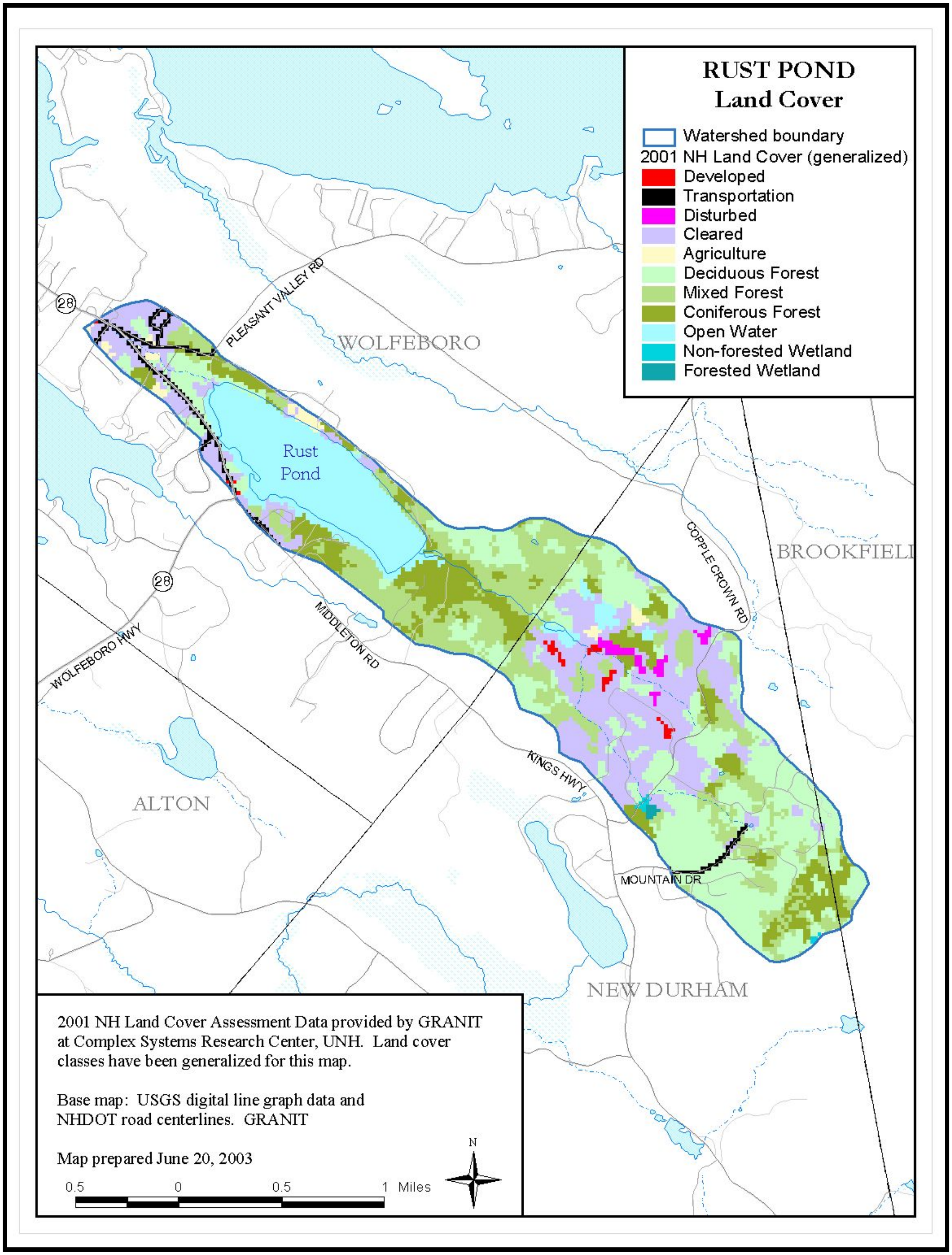

Figure 1-3: Rust Pond Watershed Land Cover Map

Table 1-2
Rust Pond Watershed Land Cover (Acres)

Land Use	Acreage
Forested	1388.559
Cleared/Disturbed/Other Open	82.815
Surface Water (including lake)	242.029
Active Agriculture	88.192
Res./Comm./Ind./Trans	56.392
Wetland	64.131
Total	**1922.118**

As the figure and table indicate, the predominant land cover type within the Rust Pond watershed is forested, comprising 1388.55 acres of the watershed. The forested portion of the watershed can be characterized as a mixed forest, with white and red pine, spruce, fir, and eastern hemlock comprising the evergreen component, and beeches, and oaks comprising the majority of the deciduous trees.

Forested areas which dominate the Rust Pond Watershed are beneficial in that the rooting systems of the plants and trees take up excess nutrients from the soil, thereby reducing the potential for excessive nutrients entering the lake. These rooting systems also provide the added benefit of soil stabilization. The root masses from the trees and shrubs form a support network, holding soil particles together and thereby preventing erosion. Forests also allow for stormwater infiltration into the ground, lowering stormwater runoff rates and recharging groundwater. In addition, forests provide a shading effect around the edge of the lake, preventing excessive heating of the lake. Cooler water temperatures allow for higher dissolved oxygen concentrations in the water column which in turn benefits the lake's ecology.

Surface water is the next largest land coverage in the watershed, covering 242 acres. This category includes Rust Pond and the open water or ponded areas of wetland habitats. For the most part, wetlands in the watershed do not have large areas of open water. Most of the wetlands are forested or emergent marshes. The forested wetlands comprise 64 acres of the Rust Pond watershed. Wetlands are critical to the water quality of Rust Pond, functioning to filter stormwater runoff before entering Rust Pond via tributaries or groundwater.

A large portion of the watershed (138 acres) is comprised of open, cleared, or disturbed or developed lands which may include residential, commercial, industrial, and transportation, land use areas. This land use coverage likely provides minimal treatment or improvement to stormwater quality. Furthermore, any areas that have been heavily disturbed by vehicles or large equipment may have increased stormwater runoff rates as soil compaction prevents water infiltration in addition to being susceptible to both wind and water erosion of sediment. However, due to their already disturbed nature, these lands are often good sites for implementing stormwater treatment or improvements by installing structural BMPs, including retrofitting stormwater collection systems or constructing stormwater detention/retention/infiltration systems. Where feasible, returning these lands to a more natural landscape, characteristic of pre-development conditions, may even be recommended.

Roadways are associated with water quality degradation through increased runoff rates transporting nonpoint source pollutants to surface waters, including streams and ponds. Currently, less than 3 percent of the Rust Pond Watershed has been converted to a transportation medium. However, once constructed transportation mediums will likely become a permanent land use change within the watershed. Considering the negative long-term water quality impacts of transportation mediums during land use planning, it is perhaps one of the most critical land use changes to consider in a watershed for protecting the pond's water quality.

Areas of low intensity residential development occur along nearly the entire shoreline of Rust Pond. Development in the Rust Pond watershed is characterized by seasonal cottages along the shoreline, with larger year round homes set farther back from the lake edge. Recent trends towards conversion of these seasonal homes to large permanent homes often contributes to the increase in impervious surfaces and the decrease in forest cover resulting in greater rates of stormwater runoff. In addition, home conversions are more likely to include modern commodities such as washing machines, dishwashers, and showers. Both of these factors, in close proximity to the lake, result in the increase of direct surface and groundwater runoff and associated pollutants without the benefit of uptake by vegetation or infiltration to the ground where they can be treated by the soil. In addition, increased stormwater runoff rates to tributaries often results in greater streambank erosion, a source of sedimentation and nutrient pollution to the pond.

Active agriculture covers a total 88 acres of the watershed. Only a small percentage of pasture, hay, and row crops are found along the Rust Pond shoreline and the Perry Brook tributary. Therefore, agriculture does not present a great concern in terms of water quality. However, over-application of fertilizer or pesticides may negatively impact water quality. In addition, maintaining or creating vegetated buffers between agriculture lands and surface waters is essential in attempting to maintain acceptable water quality.

One area of focus in this study was the Lake Winnipesaukee Golf Resort (LWGR) which is located within the Perry Brook Subwatershed, approximately 0.5 miles from Rust Pond. In 2003, DES initiated a water quality sampling program to determine if there were any adverse surface water quality impacts, specifically turbidity and phosphorus, resulting from operations at the LWGR.

A series of water quality results indicated that the facility was not adversely impacting Rust Pond. A sample site located just downstream of LWGR had only slightly higher turbidity and phosphorus concentrations than the upstream sample site. Wetland and forested areas downstream of the LWGR appear to mitigate through the "filtering" effect any increased turbidity and phosphorus concentrations. In fact samples upstream of LWGR were similar to those discharging from Perry Brook at Rust Pond.

Study recommendations for LWGR included avoiding an increase in fertilizer application and that the grounds remain stabilized and vegetated at all times. As with any open space or agricultural lands, maintaining or creating vegetated buffers between the facility roads, fairways and greens to surface waters is essential in preserving acceptable water quality.

2.0 HYDROLOGIC BUDGET

2.1 Introduction

Chapters 2 through 4 contain technical scientific methodologies that may require further reference reading. Please reference the Standard Operating Procedures of the NHDES Limnology Center and the NHDES Laboratory Services for protocols and methods used for sampling and analysis.

The water volume and associated nutrient concentrations flowing into and out of the pond are imperative information that must be collected to understand the nutrient retention and export in a pond system. Since water is considered a universal solvent that incorporates both inorganic and organic fractions that contact it, an understanding of the water source is important. To accurately account for the water (and nutrients) entering and exiting Rust Pond, many different factors must be considered. Inflows such as tributary flow, overland flow, precipitation, and groundwater input all contribute to the lake hydrologic budget. The outflow of the lake, evaporation, and areas of groundwater recharge from the lakebed are all sources of outflow. A watershed and tributary map can be found in Appendix 2 and 3. Raw data and summaries for the Hydrologic budget can be found in Appendix 4 through 16.

2.2 Budget Components

2.2.1. Precipitation/Evaporation

The data for the precipitation and evaporation calculations were obtained from the Lakeport weather station in Laconia, NH where daily weather trends are recorded. This reliable weather station is nearest to the Rust Pond area. Tables 2-1 and 2-2 summarize the precipitation and evaporation trends during the study year, respectively.

The total amount of annual precipitation and evaporation are multiplied by the surface area of the lake to determine the volume of water that fell directly on the lake and that which evaporated directly from the lake surface area using the Pan Coefficient (0.77 for a Class A pan) for standardization.

2.2.2. Tributary Inputs/Outflow

Tributary inputs, as well as the outflow, are calculated using regression analysis based on the monthly stream flow readings conducted by NHDES, and on the bi-weekly staff gauge reading by the Rust Pond volunteers.

Table 2-1
Rust Pond Monthly Precipitation (July 2001-June 2002)

Month	Monthly Total (in)	Monthly Total (m)	Precipitation (m^3)	Precipitation ($10^3 m^3$)	Percent Annual Contribution
Jul 01	2.76	0.07	138329.21	138.33	8.08
Aug 01	0.72	0.02	36085.88	36.09	2.11
Sep 01	4.03	0.10	201980.70	201.98	11.80
Oct 01	1.25	0.03	62649.10	62.65	3.66
Nov 01	1.26	0.03	63150.29	63.15	3.69
Dec 01	2.93	0.07	146849.49	146.85	8.58
Jan 02	2.14	0.05	107255.26	107.26	6.26
Feb 02	2.69	0.07	134820.86	134.82	7.87
Mar 02	3.68	0.09	184438.95	184.44	10.77
Apr 02	3.90	0.10	195465.19	195.47	11.42
May 02	4.09	0.10	204987.86	204.99	11.97
Jun 02	4.71	0.12	236061.81	236.06	13.79
Total	**34.16**	**0.87**	**1712074.60**	**1712.07**	**100.00**

Surface Area= 967,198 m^2 Precip (m^3) =Monthly (m) X Surface area

Table 2-2
Rust Pond Monthly Evaporation Rates (July 2001-June 2002)
(Pan Coef.)(Lake Surface Area)(Monthly Evap.)

Month	Total Pan Evap (in)	Total Pan Evap (m)	Evap (m^3) (Pan x Lake)	Evap (Pan X Lake) (10^3 m^3)	Adjusted Evap (Lake) (Pan Coef)
Jul 01	6.47	0.164338	324271.7416	324.27	249.69
Aug 01	6.23	0.158242	312243.1144	312.24	240.43
Sep 01	4.02	0.102108	201479.5056	201.48	155.14
Oct 01	2.51	0.063754	125799.3928	125.80	96.87
May 02	4.77	0.121158	239068.9656	963.79	742.12
Jun 02	5.13	0.130302	257111.9064	1603.32	1234.55
Total	**29.13**	**0.74**	**1459974.63**	**3530.90**	**2718.80**

Surface Area= 967,198 m^2 Pan Coef = EV($10^3 m^3$) X .77

2.2.3. Groundwater Seepage

Groundwater seepage flow data was collected three times (June, August and September) during the study period. Since limited groundwater data was available, seepage was based upon average seepage rates (12 $L/m^2/d$) from previous diagnostic feasibility studies. The seepage rates were applied to a seepage area as defined by a 25 ft. buffer from the shoreline of Rust Pond.

2.2.4. Direct Surface (Overland) Runoff (Non tributary inputs)

The water volumes calculated for this section are based on estimates of precipitation and evaporation from a watershed that had no defined tributary channel or that had perennial streams that only flowed periodically throughout the year. Runoff is estimated at 62 percent of total precipitation (Likens and Bormann, 1995). Runoff includes both groundwater and overland water runoff contributions to Rust Pond from the ungauged portion of the watershed. To calculate overland runoff, groundwater was subtracted from the total runoff and groundwater value (62 percent of the precipitation).

2.3 Hydrologic Budget

Each of the previously detailed components is combined to form a comprehensive hydrologic budget based on the following equation:

Overland runoff (gauged and ungauged watersheds) + groundwater inputs (seepage) + Direct precipitation–Evaporation–Outflow –Transfer to sediments (where appropriate) = 0

According to the completed hydrologic budget (Table 2-3), inputs from tributaries contribute the greatest volume of water to Rust Pond (52 percent). Overland runoff, hydrologic inputs from ungauged watersheds (where no channelized flow was observed), were estimated to contribute 16 percent of the budget. Together, tributary flow and overland runoff totals 69 percent of all inputs to Rust Pond. This means that most of the water that enters Rust Pond has flowed over the watershed before discharging to the lake, allowing it to transport both natural and human introduced contaminants along the way.

Hydrologic inputs from precipitation comprise the 27 percent of water that enters Rust Pond. This fraction enters from the atmosphere, bringing with it particulates and other matter that mix with the wetfall. Figure 2-1 summarizes the hydrologic inputs to Rust Pond.

Groundwater inputs from nearshore seepage contribute a small fraction of the source of water to the lake. Groundwater contributes 5 percent of the overall water to Rust Pond. According to the Soil Conservation Service data, soils are sandy around most of the watershed, allowing water that infiltrates into the soil to travel rapidly down gradient to either a tributary or directly to the lake as groundwater. However, due to limited groundwater data during this study, groundwater inputs were based upon average groundwater inputs for other studied state waterbodies. Previous studies found that the average groundwater discharge was approximately 12 $L/m^2/d$. This assumed seepage rate (12 $L/m^2/d$) was applied across the pond benthic area 25 ft. from the shoreline.

Table 2-3
Rust Pond Hydrologic Budget

Rust Pond Hydrologic Budget Table- Monthly, July, 2001 - June, 2002 (Volume reported as 10^3m^3)														
Hydrologic Component	July	August	September	October	November	December	January	February	March	April	May	June	***Annual Total***	***Monthly Average***
North Inlet	47.13	13.57	6.88	11.40	6.53	10.50	5.25	4.76	30.61	93.84	104.77	23.86	***359.10***	***29.92***
Perry Brook	239.35	108.75	85.40	42.91	33.87	42.11	27.00	24.39	47.98	286.39	347.12	39.02	***1324.28***	***110.36***
Gwi*	13.76	3.59	20.09	6.23	6.28	14.61	10.67	13.41	18.35	19.44	20.39	23.48	***170.30***	***14.19***
Watershed Overland Runoff**	41.07	10.71	59.96	18.60	18.75	0.00	0.00	0.00	170.22	58.03	60.86	70.08	***508.27***	***42.47***
Total WS Inflow	**341.30**	**136.63**	**172.33**	**79.14**	**65.43**	**67.21**	**42.92**	**42.56**	**267.16**	**457.70**	**533.14**	**156.44**	***2361.95***	***196.83***
Direct Pond Wetfall	67.80	17.69	99.00	30.71	30.95	71.98	0.00	0.00	225.03	95.81	100.48	115.71	***855.17***	***71.26***
Total Inflow*	**409.11**	**154.32**	**271.33**	**109.85**	**96.38**	**139.19**	**42.92**	**42.56**	**492.19**	**553.51**	**633.62**	**272.15**	***3217.13***	***268.09***
Outlet/Dam**** and Gwo	327.13	44.56	200.53	118.96	166.54	43.76	130.82	42.56	283.37	481.86	564.50	279.20	***2683.79***	***223.65***
Evaporation (pan)	88.91	110.85	70.56	40.86	0.00	0.00	0.00	0.00	0.00	34.05	80.96	72.07	***498.26***	***41.52***
Total Outflow***	***416.04***	***155.41***	***271.08***	***159.82***	***166.54***	***43.76***	***130.82***	***42.56***	***283.37***	***515.91***	***645.46***	***351.27***	***3182.05***	***257.34***
Δ in Basin Storage******	-6.94	-1.09	0.25	-49.97	-70.15	95.43	-87.90	0.00	208.82	37.60	-11.84	-79.12	***35.08***	***2.92***
*Gwi only monitored 3 months in 2002, therefore Gwi estimated at 12 L/m2/d based on previous DF sudies which averaged appr. 12 L/m2/d and 25 ft. buffer from shoreline. The three actual test dates which were not used as they were not representative of the annual Gwi for Rust Pond averaged appr. 16 L/m2/d.														
** Overland (direct) Runoff = 62% X monthly precipitation on overland runoff watershed														
*** Watershed and Direct Lake Wetfall														
**** Outlet/Dam = inflow-pan-Basin Storage														
*****Total outflow=dam outflow+evaporation+GWo														
******Change in Lake Basin Storage or water retention. Based on lake level fluctuations. 60.44 (10^3m^3) of lost water volume during study. Negative number= loss of storage. See dam levels spreadsheet.														

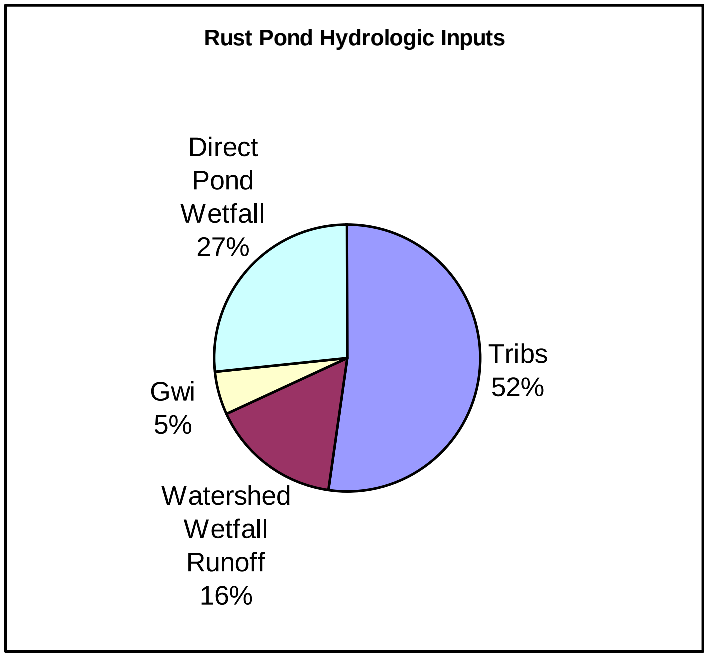

Figure 2-1: Rust Pond Hydrologic Inputs

Precipitation contributions for December through March are added to the March value. It is assumed that precipitation falling in these months is frozen, and is not mobile until the spring melt.

Tributary inputs, North Inlet, Perry Brook and Boulder Brook were assessed during the study period. Perry Brook, with a much larger watershed area, contributed the largest volume of water to Rust Pond over the course of the study year. North Inlet contributed the second largest volume of tributary flow. Boulder Brook only flowed for a portion of the study period and was therefore assessed as overland runoff for the study. Figure 2-2 shows the tributary inputs to Rust Pond.

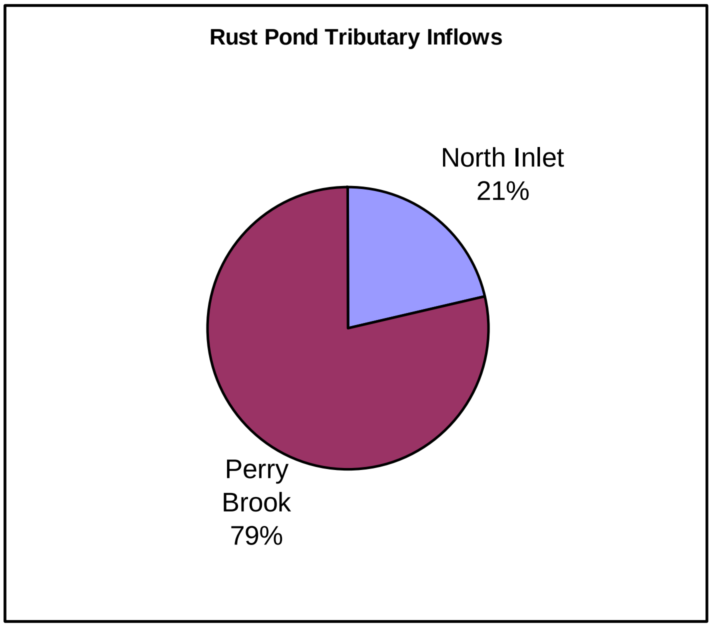

Figure 2-2: Rust Pond Tributary Inflows

The Dam Outlet and groundwater recharge accounted for the greatest loss of water from the Pond (84 percent). Evaporation accounted for most of the remaining 15 percent loss of water from the Pond. The change in pond storage accounted approximately 1 percent of the lake volume at the end of the study period. Figure 2-3 shows the percentages of outflow and pond storage from Rust Pond.

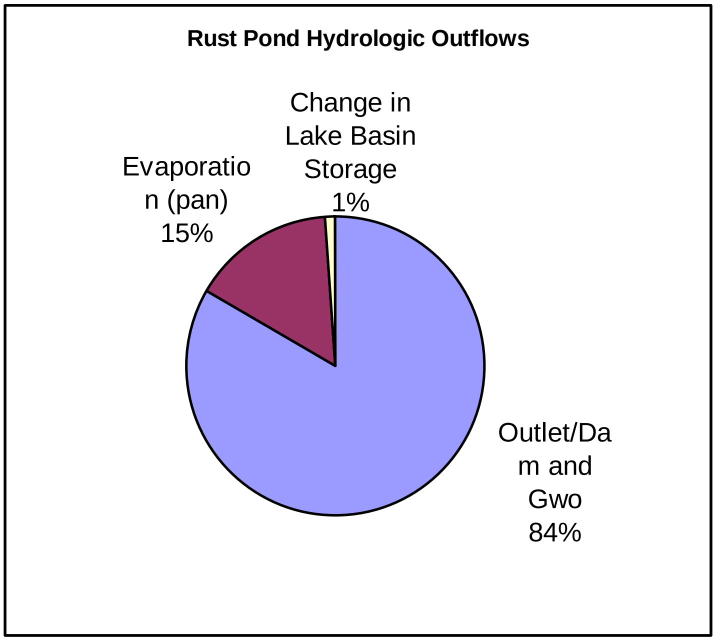

Figure 2-3: Rust Pond Hydrologic Outflows

Figure 2-4 illustrates the trends in total inflow versus total outflow for Rust Pond. Over the course of the study year Rust Pond gained approximately 1 percent of the overall volume when comparing total inflow and outflow of the Pond. Pond levels typically fluctuated month to month based on rainfall and flashboard height at the dam outlet. This is evident as the months of October and November revealed the least rainfall, with only 2.5 inches of precipitation recorded at the Lakeport Dam weather station. The difference between the lines reflects the amount of storage gain or loss in the lake each month which is illustrated in Figure 2-5.

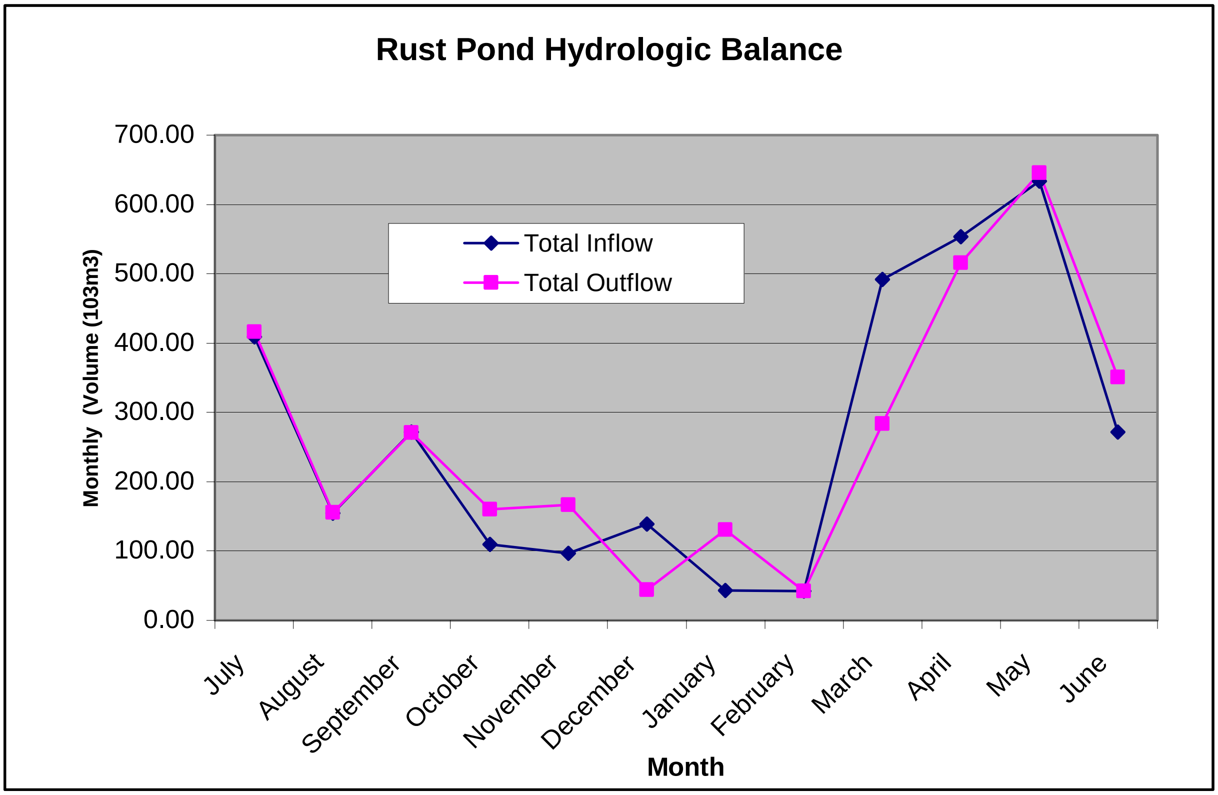

Figure 2-4: Rust Pond Hydrologic Balance

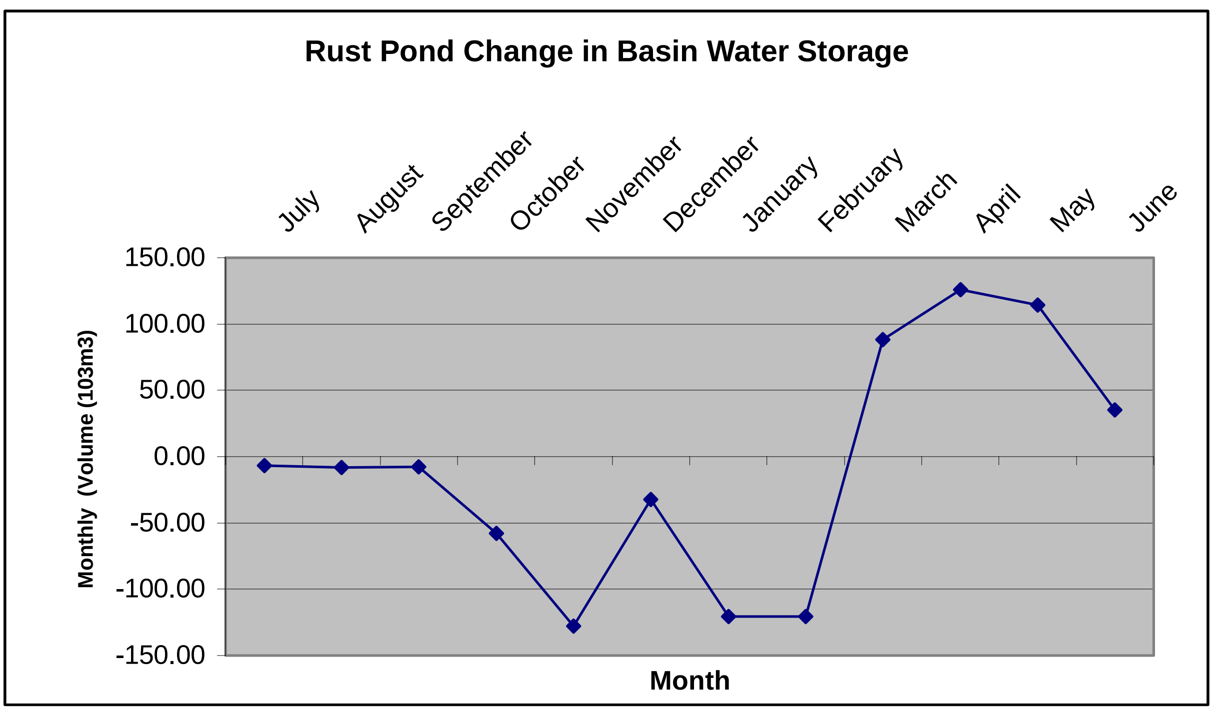

Figure 2-5: Rust Pond Change in Basin Water Storage

3.0 TOTAL PHOSPHORUS BUDGET

3.1 Introduction

A detailed hydrologic budget is essential for development of the total phosphorus (phosphorus) budget for Rust Pond. Chapter three defines each of the significant phosphorus sources and mass contributions to Rust Pond. Each source of the phosphorus is critical in understanding the dynamics of phosphorus within Rust Pond and the watershed. With this understanding, watershed management planning can take place to maintain or improve the overall water quality of Rust Pond.

It is important to remember that New Hampshire lakes are phosphorus limited and only a small amount of this nutrient is needed to aid in phytoplankton growth. Plants and algae use this nutrient in the process of photosynthesis to produce chlorophyll. A slight increase of in-lake phosphorus concentration can lead to excessive plant and algae growth.

Phosphorus is an essential element for plant and animal cell metabolism and is naturally occurring in our environment. Phosphorus is bound to organic matter (living things) such as animals, plants, insects, and humans. It is also found in sedimentary rocks, and small amounts of this nutrient are released into the soil as these rocks break up, or naturally weather. Once released from sedimentary rocks, phosphorus can attach to sediment particles and circulate through the atmosphere. Phosphorus that does reach the atmosphere returns to the earth attached to droplets of precipitation.

Mining of phosphate rock minerals provides the only significant global resource of phosphorus. The U.S. Geological Survey recently reported that in 2001, 90 percent of the phosphate rock mined was used to produce chemical fertilizers and animal feed supplements. From 1997 to 2001, phosphate rock (crude ore) mine production ranged from $1.3 X10^{6}$ to $1.66 X10^{6}$ metric tons. In 2001 the United States was the world's leading producer and consumer of phosphorus.

Phosphorus is naturally occurring in the environment and can be derived from natural or anthropogenic sources in a watershed. In addition to natural sources of phosphorus, there are many other human induced contributions of phosphorus to a waterbody. Human waste products, dishwashing detergents, gasoline and fertilizers all contribute varying amounts of phosphorus to our environment. Waste products from wildlife or domestic animals can also contribute phosphorus. Animal feed manufactured for domestic animals may be supplemented with phosphorus. Phosphorus sources do not just originate from within the watershed but are largely transported (mostly by human activity or influence) from sources outside the watershed.

The nutrient budget is an extremely important part of this project as is documents each of the significant sources of phosphorus in the watershed. Addressing phosphorus sources within the watershed assists in the planning and implementation efforts for improving or maintaining in-lake quality.

3.2 Nutrient Budget Components

The nutrient budget is based on the same components that were used to develop the water budget, with the added parameters from wildlife inputs and internal loading inputs, as applicable:

Tributary Inputs + Groundwater inputs + Direct bulk precipitation + Wildlife contributions (where appropriate) + Internal Loading from sediments (where appropriate) – Outflow – Transfer to sediments (where appropriate) = Change in Storage

Many of the calculations to determine the phosphorus budget were derived by multiplying the mean phosphorus concentration for each input by the volume of water from each input to yield total phosphorus loading. Calculations and raw data for the nutrient budget calculations can be found in Appendix 17 through 24. As Figure 3-1 depicts, the phosphorus contributions to Rust Pond include the gauged tributaries (45 percent), watershed wetfall runoff (32 percent), direct lake wetfall (18 percent), and groundwater (5 percent). Table 3-1 details the phosphorus loading mass rate ($10^3 kg/m^3$) and mass loading (kg) for each of the phosphorus loading components to Rust Pond.

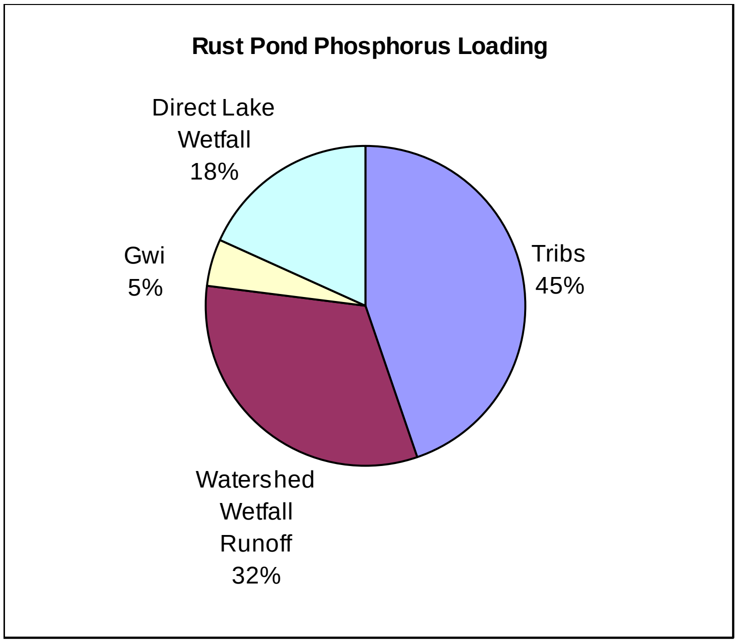

Figure 3-1: Rust Pond Total Phosphorus Inputs

Table 3-1
Rust Pond Total Phosphorus Budget Mass Rate (kg/$10^3 m^3$) and Load (kg)

Rust Pond TP Table- Monthly, July, 2001 - June, 2002 (Mass reported as kg/ $10^3 m^3$)

TP Hydrologic Mass Rate Component	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	***Annual Total***	***Monthly Average***
North Inlet**	0.0620	0.0605	0.0355	0.0465	0.0305	0.0305	0.0140	0.0165	0.0160	0.0329	0.0329	0.0170	***0.3948***	***0.0329***
Perry Brook***	0.0195	0.0230	0.0240	0.0180	0.0110	0.0110	0.0070	0.0130	0.0157	0.0140	0.0157	0.0165	***0.1884***	***0.0157***
Gwi*	0.0496	0.0200	0.0309	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0155	0.0232	***0.2473***	***0.0206***
Direct Lake Wetfall	0.0200	0.0171	0.0040	0.0290	0.0188	0.0060	0.0101	0.0120	0.0105	0.0155	0.0120	0.0450	***0.2000***	***0.0167***
Watershed Overland Runoff	0.0397	0.0497	0.0460	0.0512	0.0512	0.0000	0.0000	0.0000	0.2047	0.0512	0.0512	0.0486	***0.5933***	***0.0494***
Hypolimnetic Loading	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	***0.0000***	***0.0000***
Total Mass Rate In	**0.1511**	**0.1206**	**0.0944**	**0.1090**	**0.0757**	**0.0630**	**0.0466**	**0.0570**	**0.0577**	**0.0779**	**0.0761**	**0.1017**	***1.0305***	***0.0859***
Outlet/Dam****	0.0055	0.0095	0.0515	0.0095	0.0730	0.0105	0.0120	0.0130	0.0214	0.0214	0.0214	0.0085	***0.2573***	***0.0214***
Total Mass Rate Out	***0.0055***	***0.0095***	***0.0515***	***0.0095***	***0.0730***	***0.0105***	***0.0120***	***0.0130***	***0.0000***	***0.0000***	***0.0000***	***0.0085***	***0.1930***	***0.0168***

*Gwi- (June, July, Aug for actual value in 2003 (outside study period), May and Sept, avg. other months 0.5 X avg.)

**North Inlet Mass rate for April and May is an average of June-March data

***Perry Brook Mass rate for March and May is an average of June-February and April data

****Outlet Mass rate for March-May is an average of June-Feb. data

Rust Pond TP Table- Monthly, July, 2001 - June, 2002 (Mass reported as kg/month)

TP Hydrologic Load Component	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	***Annual Total***	***Monthly Average***
North Inlet	2.9218	0.8213	0.2441	0.5301	0.1992	0.3202	0.0735	0.0785	0.4898	3.0874	3.4470	0.4056	***12.6184***	***1.0515***
Perry Brook	4.6673	2.5013	2.0496	0.7724	0.3726	0.4632	0.1890	0.3170	0.7534	4.0095	5.4498	0.6438	***22.1887***	***1.8491***
Gwi	0.6821	0.0717	0.6212	0.0963	0.0971	0.2258	0.1649	0.2073	0.2836	0.3006	0.3152	0.5448	***3.6106***	***0.3009***
Direct Lake Wetfall	1.3561	0.3027	0.3960	0.8905	0.5810	0.4319	0.0000	0.0000	2.3628	1.4851	1.2057	5.2069	***14.2188***	***1.1849***
Watershed Overland Runoff	1.6320	0.5320	2.7577	0.9517	0.9593	0.0000	0.0000	0.0000	8.7100	2.9693	3.1140	3.4042	***25.0301***	***2.0858***
Hypolimnetic Loading	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	***0.0000***	***0.0000***
Total Load In	**11.2593**	**4.2288**	**6.0685**	**3.2411**	**2.2092**	**1.4411**	**0.4274**	**0.6029**	**12.5995**	**11.8518**	**13.5317**	**10.2053**	***77.6666***	***6.4722***
Outlet/Dam and Gwo	2.2501	1.4660	13.9737	1.0436	7.0361	1.4615	0.5150	0.5532	10.5548	11.8698	13.5876	2.3133	***66.6246***	***5.5520***
Total Load Out	***2.2501***	***1.4660***	***13.9737***	***1.0436***	***7.0361***	***1.4615***	***0.5150***	***0.5532***	***10.5548***	***11.8698***	***13.5876***	***2.3133***	***66.6246***	***5.8465***
TP Retention in Pond	***9.0092***	***2.7628***	***-7.9051***	***2.1975***	***-4.8268***	***-0.0205***	***-0.0876***	***0.0496***	***2.0448***	***-0.0180***	***-0.0559***	***7.8920***	***11.0420***	***0.2864***

Note: March Watershed Overland Runoff a summation of Dec-March TP loading

3.3 Total Phosphorus Inputs

3.3.1 Groundwater

Groundwater contributed approximately 5 percent (3.6 kg) of phosphorus load to Rust Pond. Since limited groundwater data were available, actual or average phosphorus concentrations for summer months and 50 percent of average concentrations for remaining winter months were used to generate the phosphorus loading data. Phosphorus losses from soils mostly derived from decaying organic matter and septic system leachate, can contribute phosphate ions to shallow groundwater which moves to the lake as near shore seepage discharges.

3.3.2 Runoff

It is important to monitor tributary phosphorus and other ion concentrations flowing into the waterbody because elevated concentrations are often indicative of watershed pollutants entering the streams. Throughout the year, wetlands uptake and release phosphorus from decomposing plants and other organic substances. Because wetlands are nutrient transformers, it is difficult to control wetland phosphorus sources to the lake system. In many cases, however, phosphorus concentration is influenced by human watershed activities such as application of phosphorus fertilizers, improperly sited or maintained septic systems, agricultural activities, and erosion problems from unstable soils. These are all activities that can be proactively addressed through the use of Best Management Practices (BMPs) and local planning.

Runoff from two perennial tributaries yielded the largest contribution of phosphorus to Rust Pond. As table 3-1 depicts, these inputs accounted for 45 percent (34.7 kg TP) of the phosphorus load during the study period. Perry Brook contributed almost twice the amount of phosphorus compared to North Inlet on an annual basis (22.18 vs. 12.61 kg). However, the Perry Brook subwatershed is almost 11 times larger (1291.25 vs. 118.65 acres), contributes almost 4 times as much stormwater (1324.28 vs. 359. 10 $10^3 m^3$), and has roughly only half of the average total phosphorus concentration (0.18 vs. 0.39 $kg/10^3 m^3$) as North Inlet. Phosphorus loading as a result of stormwater runoff associated with human-impacted land use is most likely the cause of this disparity. Table 3-2 details the land use differences between the Perry Brook and North Inlet subwatersheds. Perry Brook is 86 percent forested with less than 5 percent used for active agriculture and less than 1 percent used for residential/commercial/industrial purposes. This contrasts the land use within the North Inlet subwatershed which is 49 percent forested with almost 18 percent used for active agriculture and 21 percent used for residential/commercial/industrial purposes.

Table 3-2
Rust Pond Tributary Land Cover

Perry Brook Land Use	Acres	Percent
Forested	1110.29	86.02%
Cleared/Disturbed/Other	73.18	5.67%
Active Agriculture	58.59	4.54%
Wetland	41.16	3.19%
Residential/Commercial/Indus.	6.90	0.53%
Surface Water	0.60	0.05%

North Inlet Land Use	Acres	Percent
Forested	58.16	49.66%
Residential/Commercial/Indus.	24.96	21.32%
Active Agriculture	21.04	17.97%
Cleared/Disturbed/Other	8.13	6.94%
Wetland	4.60	3.93%
Surface Water	0.22	0.19%

A comparison of the calculated flow volumes versus rainfall volumes for each subwatershed further emphasizes the difference in land use characteristics. Forested, undisturbed watersheds are considered stable stormwater systems that act as porous sponges. As a result, these forested systems are excellent at detaining and infiltrating stormwater through vegetative uptake, evapotranspiration and infiltration, slowly releasing it downgradient through groundwater and natural stream beds. As watershed development increases, these forested systems and their natural ability to control stormwater, are compromised and in some instances can disappear all together. By comparing total precipitation and total flow discharging to Rust Pond it is evident that runoff rates within the North Inlet subwatershed are greater than those of the Perry Brook subwatershed, which is largely forested. The North Inlet subwatershed had an estimated 84 percent annual stormwater runoff rate, compared to the Perry Brook subwatershed which had an estimated 34 percent annual stormwater runoff rate.

Direct watershed overland runoff or runoff that reaches Rust Pond via overland sheet flow accounted for 32 percent of the total phosphorus load. Table 3-3 details the area and land uses included in the direct watershed overland runoff calculations. A phosphorus coefficient for each land use was selected by matching similar land uses at Rust Pond to those with a known phosphorus export coefficient in the northeast region. The direct phosphorus runoff was calculated by multiplying the summed land use area of un-gauged watersheds by the phosphorus coefficient.

Table 3-3
Rust Pond Direct Watershed Phosphorus Export

Land Use- Direct Wetfall Runoff	Total Acres	Hectares	TP Coefficient (kg/Ha/Yr)	kg/yr TP Load
Commercial/Industrial/Transportation	3.73	1.51	0.50	0.75
Deciduous Forest	40.78	16.50	0.20	3.30
Emergent Herbaceous Wetlands	13.37	5.41	0.05	0.27
Evergreen Forest	104.39	42.24	0.20	8.45
Low Intensity Residential	20.93	8.47	0.50	4.24
Mixed Forest	113.01	45.73	0.20	9.15
Open Water	0.43	0.17	0.00	0.00
Pasture/Hay	3.87	1.57	0.60	0.94
Row Crops	4.69	1.90	0.60	1.14
Urban/Recreation Grasses	1.50	0.61	0.50	0.30
Woody Wetlands	5.00	2.02	0.05	0.10
Total	**311.70**	**126.14**	**-----**	**28.64**

3.3.3 Precipitation

Total Phosphorus inputs from precipitation accounted for approximately 18 percent of the total phosphorus inputs to the lake (14.21 kg TP). Total phosphorus concentration in precipitation ranged from 4 ug/L to 45 ug/L, with a mean annual average of 17 ug/L. The majority of the precipitation phosphorus load to Rust Pond occurred in the spring and summer months. Phosphorus loading was reduced by more than 50 percent during the fall months and completely during the winter months of January and February when the Pond was covered with ice. The phosphorus associated with frozen precipitation in January and February was added to the pond in March after ice-out.

Overall, 77.66 kg of total phosphorus was deposited into Rust Pond during the 2000/2001 study year.

3.4 Total Phosphorus Exports

There are two mechanisms that provide export of total phosphorus from a lake system; either through out-flowing water from the outlet, or through groundwater recharge from the lake. The remainder of the phosphorus is incorporated into the system, cycling between the organic and inorganic phases by sediment accumulation and the food web.

Over the course of the study year approximately 66.62 kg TP was lost through out-flowing water over the spillway of the lake or through groundwater (not measured for this study). The remaining 11.04 kg TP was retained in the system.

Internal phosphorus loading is not evident in Rust Pond. Over the course of the summer the hypolimnetic phosphorus concentration was low, less than 14 ug/L in all sampling events during study period. Figure 3-2 shows the trends for the mean concentrations for in in-lake phosphorus since Rust Pond joined the VLAP program in 1988.

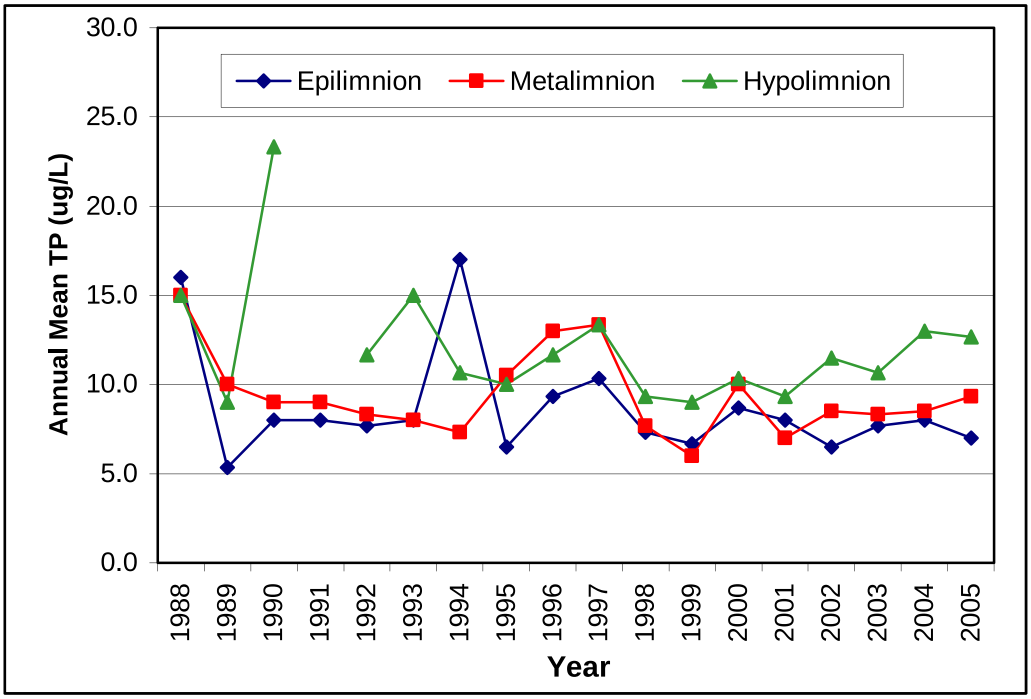

Figure 3-2: Historical In-Lake Total Phosphorus Trends

In most years the lower layer (hypolimnion) phosphorus concentration has been consistently, although only slightly, greater than the upper layer (epilimnion) and is considered average according to DES rating categories. With the exception of a few phosphorus concentration spikes above 15 ug/L prior to 1995, all phosphorus concentrations were below the

15 ug/L level since.

3.5 In-Lake Phosphorus Concentrations

Phosphorus is an essential element for plant growth, and is the limiting nutrient that regulates the productivity of New Hampshire lakes. The key to controlling lake eutrophication is minimizing the phosphorus load to a lake. Increased phosphorus levels are often associated with human activities and in most cases, the reduction of phosphorus loading to a lake will lower algal productivity. NHDES has documented lake quality improvements associated with phosphorus reductions in many New Hampshire lakes including Beaver Lake in Derry and Kezar Lake in North Sutton. The total phosphorus range for the summer epilimnetic values for New Hampshire lakes ranges between <1 and 121 ug/L, with a median value of 12 ug/L. Table 3-4 lists mean phosphorus concentrations for the in-lake station at Rust Pond from 1988 through 2005.

Table 3-4
In-Lake Annual Mean Total Phosphorus Concentrations (ug/L)

Year	Epilimnion	Metalimnion	Hypolimnion
1988	16.0	15.0	15.0
1989	5.3	10.0	9.0
1990	8.0	9.0	23.3
1991	8.0	9.0	No Data
1992	7.7	8.3	11.7
1993	8.0	8.0	15.0
1994	17.0	7.3	10.7
1995	6.5	10.5	10.0
1996	9.3	13.0	11.7
1997	10.3	13.3	13.3
1998	7.3	7.7	9.3
1999	6.7	6.0	9.0
2000	8.7	10.0	10.3
2001	8.0	7.0	9.3
2002	6.5	8.5	11.5
2003	7.7	8.3	10.7
2004	8.0	8.5	13.0
2005	7.0	9.3	12.7
Mean	8.7	9.4	12.1

The mean phosphorus concentration in the epilimnion (surface layer) and metalimnion (middle layer) of Rust Pond falls within the 'mean' range for New Hampshire lakes and ponds, with annual mean concentrations of 8.7 and 9.4 ug/L, respectively.

As the summer progresses, internal phosphorus loading from bottom sediments can be a major factor in a lake's nutrient budget. Internal loading occurs when the hypolimnion becomes anoxic, resulting in a chemical (oxidation/reduction) reaction in the sediments that breaks the chemical bonds between metals, such as iron manganese and aluminum, and phosphorus, ultimately leading to the release of phosphorus to the water column.

During the 2001-2002 study period, phosphorus concentrations remained low during the late summer months when internal phosphorus loading would typically occur. Table 3-5 and figure 3-3 depicts the in-lake total phosphorus concentrations during July and August in 2001 and 2002 for the study period. The hypolimnetic phosphorus concentration in Rust Pond is considered 'average,' with a summer mean phosphorus concentration equaling 12 ug/L. A phosphorus concentration greater than 20 ug/L is considered more than desirable and indicative of eutrophic conditions for NH lakes and ponds.

Table 3-5
In-Lake Mean Total Phosphorus Concentrations (ug/L), Study Period

Sample Depth	Mean	Median	Range	Standard Deviation
Epilimnion (upper layer)	9	8	1-21	4
Metalimnion (middle layer)	9	8	3-20	4
Hypolimnion (bottom layer)	12	11	1-46	6

Maintaining acceptable hypolimnetic oxygen levels will prevent hypolimnetic phosphorus loading and will help reduce lake productivity by limiting available phosphorus to phytoplankton growth. This can be accomplished by eliminating the sediment and organic loads associated with land use changes within the landscape. With increasing sediment and organic loads reaching Rust Pond, the organism biological oxygen demand increases as the sediment and organic matter is broken down and processed for food. A decrease in oxygen results in the release of biologically available phosphorus referred to as internal loading. Internal loading to Rust Pond would likely increase the chances of occasional algae and cyanobacteria blooms, an increase in macrophyte growth, negatively impact species dependent on hypolimnetic oxygen and lead to decreased water clarity.

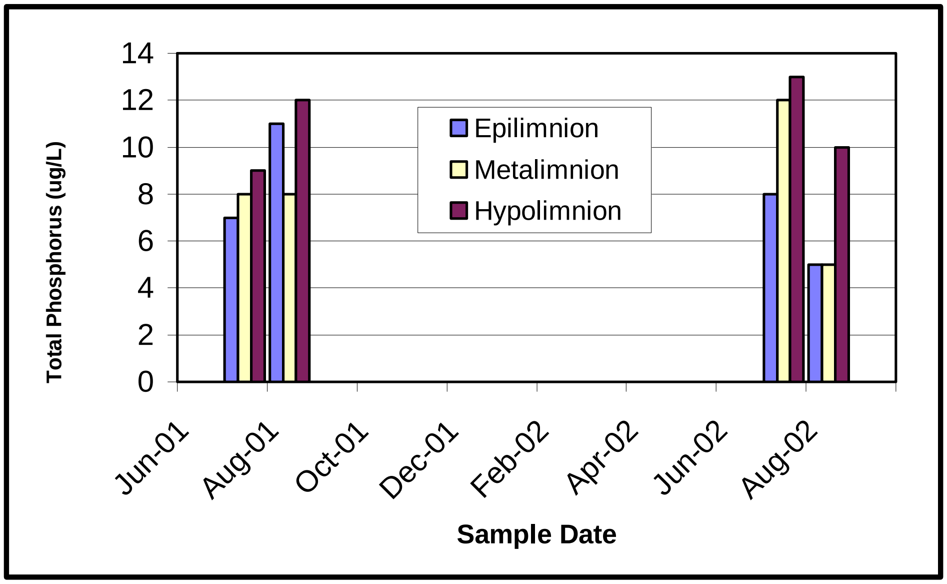

Figure 3-3: Summer 2001 and 2002, In-lake Total Phosphorus Concentrations

3.6 Trophic Classification

The trophic status of a waterbody is a hybrid concept. It refers to the nutritive level (especially phosphorus) of a lake or pond, but is often described in terms of biological activity that occurs as a result of nutrient levels. Trophic state indices or models have been developed using a single parameter or several parameters. As a result, model selection is driven by the types of data available and the level of scientific accuracy needed to meet project objectives.

Table 3-6, reproduced in part from the EPA Clean Lakes Program Guidance Manual (1980), describes the lake water characteristics of the oligotrophic and eutrophic states. Mesotrophic conditions exist between the limits of eutrophy and oligotrophy.

Table 3-6
Summaries of Quantitative Definitions of Lake Trophic Status

Characteristics	Oligotrophic	Eutrophic
Total Phosphorus (ug/L, summer)	≤ (10 to 15)	≥ (20 to 30)
Chlorophyll-a (ug/L, summer)	≤ (2 to 4)	≥ (6 to 10)
Secchi disk depth (m, summer)	≤ (3 to 5)	≥ (1.5 to 2)

Trophic classification through modeling allows biologists to determine the classification of a lake or pond based on a number of parameters. For this reason, we will evaluate Rust Pond using several models. In The following models, in-lake nutrient concentrations, oxygen profiles, clarity, lake flushing rate, phosphorus retention time and other factors are considered to gauge the current condition of Rust Pond. Trophic models are also used to determine permissible phosphorus loading to either maintain or improve the pond's trophic state. The use of more than one model is important as the models differ on the parameters used to determine trophic classification, in-lake phosphorus concentration, and acceptable loading limits.

Trophic states of lakes and ponds can range within and between three basic categories; oligotrophic, mesotrophic, and eutrophic lakes. Each of these terms is defined in the glossary of this report. Lakes and ponds and their trophic states are typically not static over time but rather are subject to the internal characteristics of the pond and especially the watershed that surrounds the pond.

Trophic classifications overall, however, do not typically change rapidly, unless the waterbody is very heavily impacted by point and non-point sources of pollution from the watershed. Most lakes can easily maintain the same trophic condition for hundreds of years. Unfortunately, many of our lakes have experienced shifts in trophic condition in the past 20-30 years due to changes in land use in their watersheds, increasing phosphorus loads and biological productivity, and increased deposition of sediment and organic debris to the lake bottom.

Following is a review of three models that are commonly used to evaluate the trophic status of a lake or pond.

3.6.1. State of New Hampshire Trophic Classification System

The classification system developed by the DES Biology Bureau utilizes four parameters, including hypolimnetic dissolved oxygen concentration, clarity, plant abundance, and the chlorophyll-a concentration of the water.

Table 3-7 presents the trophic classification system of NH lakes and ponds. Table 3-8 provides the calculated value of each classified parameter for the 1981 and 2000 summer surveys of Rust Pond. In 1981, Rust Pond received a total of 6 trophic points, placing it within the mesotrophic range. Rust Pond received a total of 4 trophic points in 2001, resulting in a trophic classification of oligotrophic. However, it should be noted that the point structure of the classification system was revised in 1989. The purpose of the revision was to provide for equal points under each attribute and to reduce the impact of the bottom dissolved oxygen criterion. Unlike in the previous trophic classification system, the extent of the oxygen depletion is evaluated in the revised trophic classification system. If the Rust Pond parameter values from 1981 were applied to the 1989 revised classification system, Rust Pond would receive a total of 4 trophic points and be considered oligotrophic according to the current classification system. See table 3-8 for the trophic classification of rust pond using the NH classification methods.

Table 3-7
Trophic Classification System for New Hampshire Lakes and Ponds

1. Summer Bottom Dissolved Oxygen:	**Trophic Points**
a. D.O. > 4 mg/L	0
b. D.O. = 1 to 4 mg/L & hypolimnion volume ≤ 10% lake volume	1
c. D.O. = 1 to 4 mg/L & hypolimnion volume > 10% lake volume	2
d. D.O. < 1 mg/L in < 1/3 hypolimnion volume & hypolimnion volume ≤ 10% lake volume	3
e. D.O. < 1 mg/L in ≥ 1/3 hypolimnion volume & hypolimnion volume ≤ 10% lake volume	4
f. D.O. < 1 mg/L in < 1/3 hypolimnion volume & hypolimnion volume > 10% lake volume	5
g. D.O. < 1 mg/L in ≥ 1/3 hypolimnion volume & hypolimnion volume > 10% lake volume	6
2. Summer Secchi Disk Transparency:	**Trophic Points**
a. > 7 meters	0
b. > 5 to 7 meters	1
c. > 3 to 5 meters	2
d. > 2 to 3 meters	3
e. > 1 to 2 meters	4
f. > 0.5 to 1 meter	5
g. ≤ 0.5 meter	6
3. Aquatic Vascular Plant Abundance:	**Trophic Points**
a. Sparse	0
b. Scattered	1
c. Scattered/Common	2
d. Common	3
e. Common/Abundant	4
f. Abundant	5
g. Very abundant	6
4. Summer Epilimnetic Chlorophyll-a (mg/m^3):	**Trophic Points**
a. < 4	0
b. 4 to < 8	1
c. 8 to < 12	2
d. 12 to < 18	3
e. 18 to < 24	4
f. 24 to < 32	5
g. ≥ 32	6

	Trophic Points	
Trophic Classification	Stratified	*Unstratified
Oligotrophic	0-6	0-4
Mesotrophic	7-12	5-9
Eutrophic	13-24	10-18

*Unstratified lakes are not evaluated by the bottom dissolved oxygen criterion.

Table 3-8
Trophic Classification of Rust Pond Using NH Classification Methods

Trophic Classification – Summer 1981 (based upon pre-1989 Classification System)		
Parameter	**Value**	**Trophic Points**
Dissolved Oxygen	0.1 mg/L	6
Secchi Disk	6.7 m	1
Plant Abundance	Sparse	0
Chlorophyll-a	3.68	0
Classification : Mesotrophic*		Total = 7
Trophic Classification – Summer 2000 (based upon post 1989 Classification System)		
Parameter	**Value**	**Trophic Points**
Dissolved Oxygen	0.0 mg/L	4
Secchi Disk	5.8 m	1
Plant Abundance	Sparse	0
Chlorophyll-a	2.54 mg/m3	0
Classification : Oligotrophic		Total = 5

*In 1981, Dissolved Oxygen Trophic Points = 6, resulting in a total of 7 trophic points and a Mesotrophic status. However, if the post-1989 Classification System were applied to Rust Pond in 1981, Dissolved Oxygen Trophic Points would have been = 4, resulting in a total of 5 trophic points and an Oligotrophic status. Therefore, the actual condition of the pond has remained fairly similar.

3.6.2 Dillon/Rigler Permissible Loading Model

Mathematical models can also be useful both in diagnosing lake problems and in evaluating potential solutions. They represent, in quantitative terms, the cause-effect relationships that determine lake quality. The Dillon/Rigler Model classifies a lake as oligotrophic, mesotrophic or eutrophic by comparing calculated annual loadings with permissible annual loadings. The tolerance of the lake to phosphorus loading is predicted as a function of two lake characteristics, mean depth (z) and water retention time (T), which has been proven by several researchers to be the primary determinants of loading permissibility.

Table 3-9 shows the relationship between the phosphorus inputs and phosphorus loading tolerance for several water body characteristics.

Table 3-9
Dillon/Rigler Permissible Loading Tolerance

High Phosphorus Loading Tolerance	Low Phosphorus Loading Tolerance
Large mean water depth	Small mean water depth
Rapid flushing rate	Slow flushing rate
High retention of Phosphorus in sediment	Low retention of Phosphorus in sediment

Thus, trophic status is set by charting the model calculation (L_pT (1-R)) against the mean depth, using existing values for these parameters and annual phosphorus loading from the study period. Table 3-10 presents the Dillon/Rigler trophic status calculations for Rust Pond.

Table 3-10
Dillon/Rigler Trophic Status Calculations for Rust Pond

Parameter	Units	Equation	Values (Study Period Data)
Lake area (A)	m^2	measured	967,200
Lake volume (V)	m^3	measured	7,203,202
Mean depth (Z mean)	m	measured	7.44
Total Annual Loading (Pload)	kg	measured	77.66
Flushing rate	yr^{-1}	Flushing Rate=W_i/V	0.4
Water retention time (T)	yr	1/Flushing Rate	2.29
Water Inflow (W_i)	m^3	measured	3,141,580
Areal Water Load (q_s)	m	q_s=W_i/A	3.2481
P coefficient (R)	N/A	R=0.426exp(-0.271qs)+0.574exp(-0.00949qs)	0.7332
Total Areal Phos. Loading (L)	$g/m^2/yr$	L=Pload*1000/A	0.0803
D-R trophic status	g/m^2	D-R trophic status= L*T (1-R)	0.0491

Figure 3-4 is a graphical representation of the Dillon/Rigler model plotting trophic zones on axes of mean depth (Z_{mean}) and trophic status which is based upon areal loading. The data point indicates the predicted trophic status of Rust Pond. The zone below line 1 indicates oligotrophic conditions. The zone between lines 1 and 2 indicates a condition between oligotrophic and mesotrophic. The zone delineated by lines 2 and 3 indicates mesotrophic conditions. The zone between line 3 and 4 indicates a condition between mesotrophic and eutrophic conditions. The zone line 4 indicates eutrophic conditions. The solution of the Dillon/Rigler equation for Rust Pond data shows the existing trophic status of the lake as borderline oligotrophic. This trophic determination is based on the amount of phosphorus loading the lake receives.

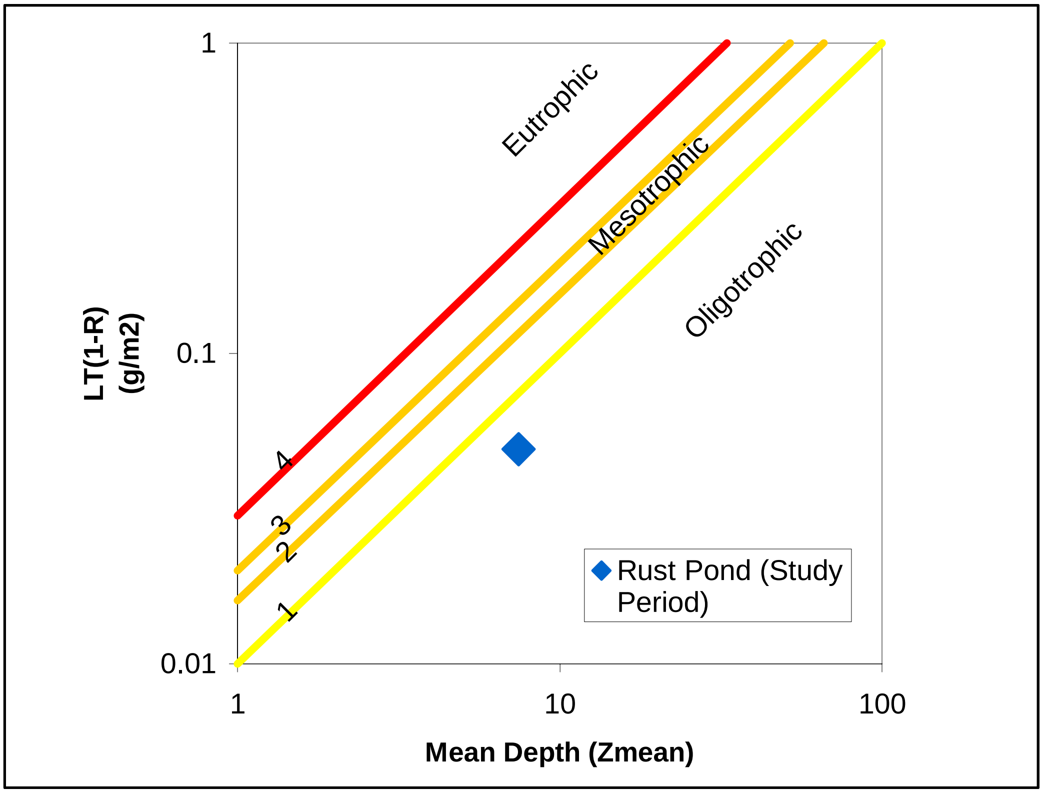

Figure 3-4: Dillon/Rigler Model

The Dillon/Rigler model also predicts in-lake phosphorus concentration. Utilizing the Dillon/Rigler equation $P=L_p$ (1-R)/qs, the calculated predicted in-lake phosphorus concentration for Rust Pond was 6.6 ug/L (Table 3-10). This was slightly less than the actual study year mean epilimnetic and hypolimnetic phosphorus concentration of 7.8 and 11 ug/L, respectively. This trend remained true when comparing the VLAP epilimnetic and hypolimnetic phosphorus concentrations of 8.7 and 12.1 ug/L, respectively.

Table 3-11
Dillon-Rigler in-lake Phosphorus Concentration Prediction

Parameter	Units	Equation	Values (Study Period Data)
Lake area (A)	m^2	measured	967,200
Lake volume (V)	m^3	measured	7,203,202
Mean depth (Z mean)	m	measured	7.44
Total Annual Loading (Pload)	kg	measured	77.66
Flushing rate	yr^{-1}	Flushing Rate=W_i/V	0.4
Water retention time (T)	yr	1/Flushing Rate	2.29
Water Inflow (W_i)	m^3	measured	3,141,580
Areal Water Load (q_s)	m	q_s=W_i/A	3.2481
P coefficient (R)	N/A	R=0.426exp(-0.271qs)+0.574exp(-0.00949qs)	0.7332
Total Areal Phos. Loading (L)	$g/m^2/yr$	L=Pload*1000/A	0.0803
D-R trophic status	g/m^2	D-R trophic status= L*T (1-R)	0.0491
D-R in-lake P concentration	mg/L	D-R P concentration=L*(1 R)/qs	0.0066

According to the Dillon-Rigler model, increasing phosphorus loading to Rust Pond by approximately 40 kg from 77.7 kg to 117.6 kg would alter the trophic status from oligotrophic to mesotrophic. In-lake phosphorus concentration would likely increase to more than 10 ug/L. This would likely impact water quality by decreasing water clarity, increasing levels of chlorophyll-a as a result of higher phytoplankton densities and decreasing hypolimnetic oxygen concentrations.

3.6.3. Vollenweider Phosphorus Loading and Surface Overflow Rate Relationship

The Vollenweider model is based on a five-year study involving the examination of phosphorus load and response characteristics for about 200 waterbodies in 22 countries in Western Europe, North America, Japan and Australia (Vollenweider, 1975).

Vollenweider developed a statistical relationship between areal annual phosphorus loading (Lp) to a lake normalized by mean depth (Z) and hydraulic residence time (T), to predict lake phosphorus concentration (P). Table 3-12 summarizes the Vollenweider model parameters for the Rust Pond study period.

Table 3-12
Vollenweider Phosphorus Concentration Prediction

Parameter	Units	Equation	Value (Study Period)
Lake area (A)	m^2	measured	967,200
Lake volume (V)	m^3	measured	7,203,202
Lake discharge (Q)	m^3	measured	3,182,050
Hydraulic Residence Time (T)	yr	T=V/Q	2.26
Mean depth (Z mean)	m	measured	7.44
Flushing rate	yr^{-1}	Flushing Rate = 1/T	0.4
Total Annual Loading (Pload)	kg	measured	77.66
Water inflow (W_i)	m^3	measured	3,141,580
Surface overflow rate (qs)	m	qs=Zmean/T	3.29
P coefficient (R)	N/A	R=0.426exp(-0.271qs)+0.574exp(-0.00949qs)	0.7312
Total areal P loading (L_p)	$g/m^2/yr$	L_p=P*1000/A	0.0803
Vollenweider in-lake P concentration	mg/L or g/m^3	$P = \frac{Lp}{qs}\left[\frac{1}{1+\sqrt{\frac{z}{qs}}}\right]$	0.0098

Thus, based on the physical constraints that control water volume, the hydraulic residence time in the lake, and mean lake depth, combined with phosphorus loading, the Vollenweider model predicts that the existing in-lake phosphorus concentration in Rust Pond should be 9.5 ug/L. An examination of actual mean epilimnetic in-lake phosphorus concentration (7.8 ug/L) during the 2001-2002 summer study period revealed that the mean measured phosphorus concentration was only slightly less than the predicted value. The mean hypolimnetic in-lake phosphorus concentration of 11 ug/L was only slightly more than the predicted value. A weighted average the epilimnetic/ metalimnetic and hypolimnetic phosphorus concentrations, assuming that that hypolimnion represents approximately 10 percent of the pond volume, results in a value (8.12 ug/L) slightly less than that (9.9 ug/L) predicted by the Vollenweider model which assumes the lake is well mixed with no thermal stratification.

Figure 3-5 graphically portrays the measured loading rates for Rust Pond and compares Rust Pond with other New Hampshire Diagnostic/Feasibility studies.

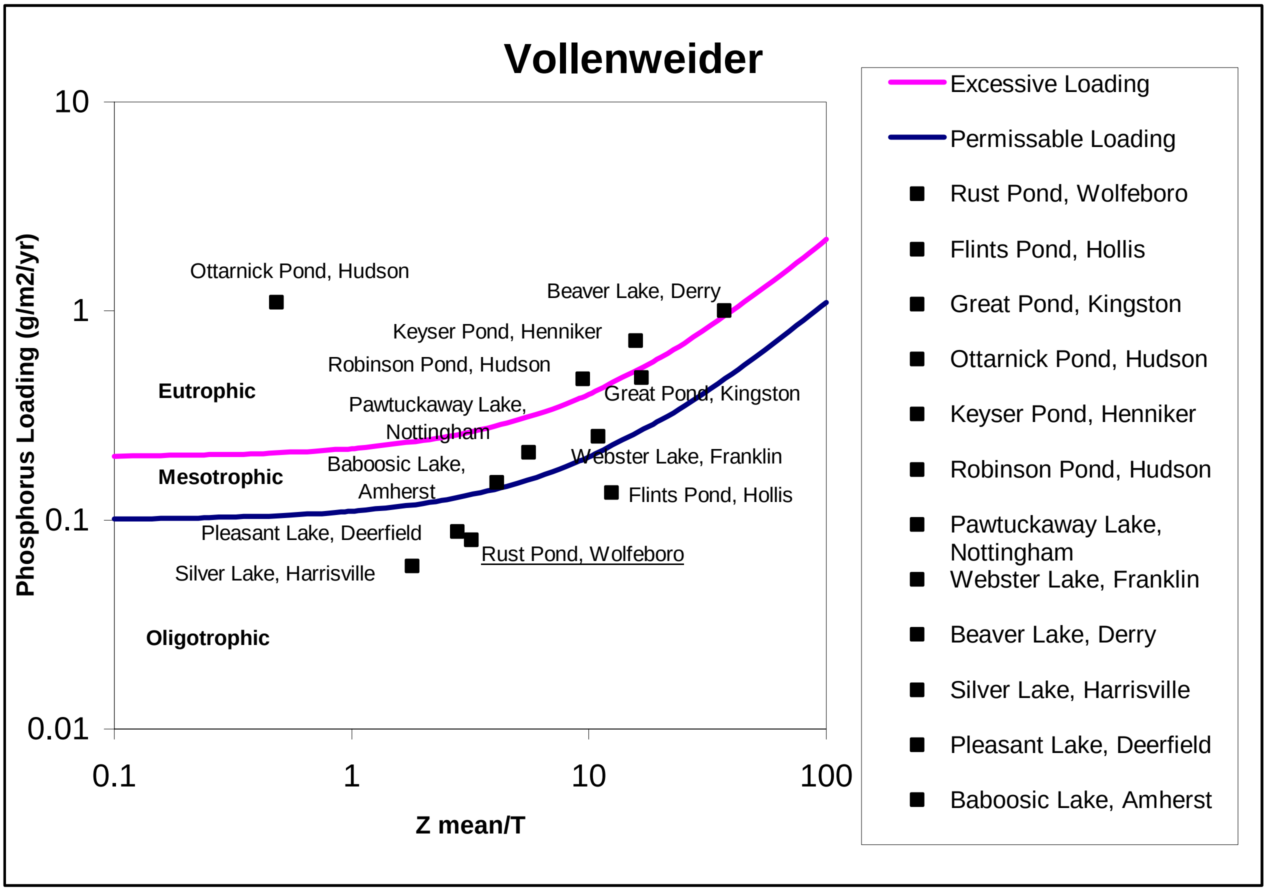

Figure 3-5: Vollenweider Phosphorus Loading and Surface Overflow Rate Relationship

Based upon the calculations, Rust Pond falls within the permissible loading/ oligotrophic classification. If the annual phosphorus loading and flushing rates remain the same, Rust Pond should maintain its Oligotrophic classification. However, according to the Vollenweider model, increasing the phosphorus loading by 48.3 kg from 77.7 kg to 126.0 kg, would likely result in a mesotrophic status, with in-lake phosphorus concentrations of more than 16 ug/L. Dramatic reduction in water clarities, decreased hypolimnetic oxygen concentrations and increased incidence of dense algal blooms, including Cyanobacteria (blue-green algae) are some of the water quality impacts observed when phosphorus concentration elevate above 15 ug/L.

3.6.4 Trophic Classification Summary

A summary of the three classification schemes utilized in this study (Table 3-13) shows that the New Hampshire, Dilllon/Rigler and Vollenweider models all classify Rust Pond as oligotrophic.

Table 3-13
Rust Pond Trophic Classification Summary

Classification Model	Trophic Status
1. New Hampshire Lake Classification	Oligotrophic
2. Dillon/Rigler	Oligotrophic
3. Vollenweider	Oligotrophic

It is imperative to continue to monitor inflowing sources of water and to manage watershed areas with a conscientious effort because they are capable of changing the trophic class of the lake. The objective of the Lake Association should be to prevent additional phosphorus loading and reduce current phosphorus loading to minimize potential lake quality impacts to Rust Pond. DES can assist the Lake Association with this goal.

4.0 AQUATIC ECOLOGY AND CHEMISTRY

4.1 In-Lake Data

4.1.1 Temperature and Dissolved Oxygen

Temperature is extremely important because of its large influence on lake chemistry and biology. The temperature determines the degree of lake stratification and is used as an ecological measurement for aquatic biota. During the summer months the surface temperatures increase, and become less dense (lighter). This top layer (epilimnion) floats over a middle layer, known as the thermocline (or metalimnion) where the temperature decreases rapidly for each meter of depth. The deepest layer, known as the hypolimnion, receives no radiation from the sun and is the coldest and most dense layer. Swimmers may notice this temperature layering when diving deep into the lake and encountering the cooler water.

In deeper lakes, there is typically no mixing throughout the summer, therefore summer stratification persists from mid-May through November. Stratification is typical for a lake with the size and depth of Rust Pond. Summer temperatures near the surface averaged approximately 22.7°C (73° F), and bottom temperatures averaged approximately 11.7°C (53º F). Each of these temperature layers is physically, chemically and biologically different. The stratification breaks up in the fall when the top layer cools and mixes with the bottom layers. Once the lake is fully isothermal, it freely mixes until ice formation, when an inverse stratification takes place (the lake is actually cooler at the surface than it is at the bottom, resulting in ice formation at the surface).

Oxygen concentrations are also very influential to the chemical and biological processes that occur in the lake. Oxygen enters a lake from the atmosphere and is aided by wind and wave action. Aquatic macrophytes and phytoplankton also contribute oxygen to the lake through the process of photosynthesis. Fish, insects, and other aquatic organisms rely on oxygen for their survival. Lakes are also sinks for oxygen, as bacteria in the sediments use up oxygen as they break down organic material, and the plants respire during the night using up the daily reservoir of oxygen.

Summer stratification serves as a barrier to atmospheric oxygen inputs to the bottom layer, so that oxygen depletion often exceeds oxygen replenishment. Decreased oxygen concentrations or ‘anoxia’ in the lower water column, would likely result in decreased fish habitat within the waterbody. Anoxia or low oxygen levels generally result in internal loading, a process by which a release of sediment bound phosphorus to the overlying water occurs as a result of sediment reduction. This process is common when bottom dissolved oxygen concentrations drops below 1 mg/L. If internal loading is occurring, the phosphorus concentration increases in the hypolimnetic area throughout the summer months and is released to the entire water column during mixing.

In-lake dissolved oxygen profiles were sampled three times during the study period (2001-2002). Rust Pond shows signs of slowly declining oxygen concentration in the hypolimnetic area as the summer progresses. Oxygen concentrations are typically greater than 7 mg/L throughout the water column, but decrease near zero in the bottom 2-3 meters in late summer. Oxygen levels less than 5 mg/L in the bottom meter of the deep spot occurred in July and August of 2002. The upper water layer is replenished with atmospheric oxygen and from plant photosynthesis during the summer months. As a result, epilimnetic or upper layer water dissolved oxygen concentration remained high throughout the summer. The physical density difference between the upper and bottom layers prevents oxygen exchange or provides minimal exchange from the upper to lower layers during stratification. Low hypolimnetic oxygen concentration is likely a result of bacteriological decomposition of an increased load of bottom organic matter. Increased bacteria respiration coincides with an increase of organic matter resulting in decreased hypolimnetic oxygen concentration. Decaying plant material, algae, leaf litter, animal waste products, and debris from the surrounding watershed all contribute to the accumulation of organic material in the lake bottom. These are all natural processes, but activities in the lake's watershed, like tree clearing, fertilizing lawns, increasing impervious areas, and failed septic systems accelerate the accumulation directly through transport of organic material or indirectly through increased nutrient loading that accelerates productivity and increases organic matter fallout.

Temperature and oxygen profiles for June 2001, July 2002 and August 2002 can be found in Appendix 24.

4.1.2 pH

The pH scale ranges from 0 – 14 units with a pH of 7 units being a neutral value. Most New Hampshire lakes are slightly acidic, with pH values between 6 and 7 units. Lake pH is important to the survival and reproduction of fish and other aquatic life. When the pH value falls between 5.5 and 6.0 units, the waters are considered endangered. Lakes with pH units from 5.0

to 5.4 are considered in the critical range, and below 5.0, lakes are considered acidified. A pH below 5.5 severely limits the growth and reproduction of fish. Table 4-1 summarizes the true mean pH of Rust Pond during the summer of 2001 and the summer of 2002.

Table 4- 1
In-Lake True Mean pH Values, Summers of 2001 and 2002

Sample Depth	Year	Average	Median	Standard Deviation
Epilimnion (surface layer)	2001	7.18	7.33	0.31
	2002	7.16	7.09	0.18
Metalimnion (middle layer)	2001	7.08	7.29	0.43
	2002	7.19	7.22	0.18
Hypolimnion (bottom layer)	2001	6.55	6.53	0.05
	2002	6.61	6.63	0.16

The true mean pH of the epilimnetic waters was slightly above neutral during both summer sampling periods, meaning that the upper layer of the lake is slightly basic. The pH decreased slightly with increased pond depth, dropping to pH 7.08 and 7.19 in 2001 and 2002, respectively, in the middle layer. The bottom pond layer was the most acidic, dropping to 6.55 in 2001 and 6.61 in 2002. The pH of lakes is typically lower at the bottom due to microbial activity and other chemical processes.

The surface and middle waters of Rust Pond would fall within the “satisfactory” category, meaning that the lake is near neutral. The bottom layer is slightly acidic but still falls within the “satisfactory” range. When the pH of a waterbody becomes acidic, fish, insects, and other aquatic life is threatened. Generally, the pH of Rust Pond has remained within the same relative range since 1988 when the lake association began monitoring Rust Pond with the Volunteer Lake Assessment Program (VLAP). Figure 4-1 illustrates the VLAP pH historical trends for Rust Pond. The epilimnion and metalimnion pH trends have closely tracked each other on an annual basis, with the metalimnion pH slightly less than the epilimnion pH annually. In contrast, the hypolimnion pH has not tracked proportionately to the upper layers, ranging 0.2 to 1.0 pH units less than the epilimnion on an annual basis since 1988.

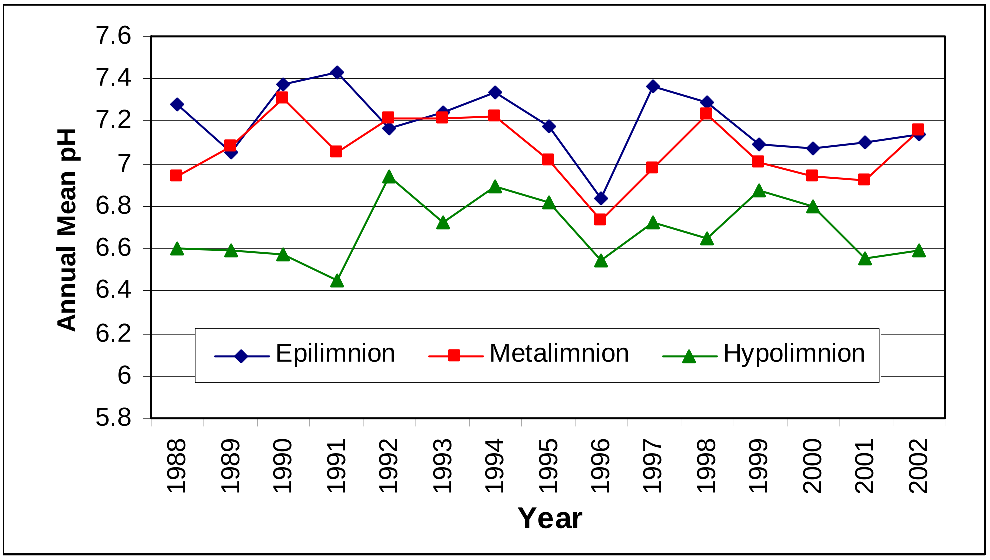

Figure 4-1: Historical Trends in Rust Pond pH (VLAP data)

4.1.3 Acid Neutralizing Capacity

The Acid Neutralizing Capacity (ANC) is the capacity of water to neutralize acid inputs. The ANC concept is comparable to the use of an antacid tablet to buffer acid reflux in the stomach. New Hampshire lake waters generally have a low ANC (ranging from 2 to 20 mg/L of $CaCO_3$). This is due in part to the State's geologic bedrock formations that contain few of the elements that buffer acids (such as calcium carbonate, of which limestone is primarily composed). Much of the available ANC components have been scavenged by the state's acid wetfall, either directly or by runoff to waterbodies. The result of low ANC or poor buffering capacity is the greater susceptibility of these waterbodies to acidic deposition. Acid neutralizing capacity is typically measured in the upper water layer where wet and dry deposition mix with the pond's surface water.

The mean ANC value for the epilimnion of Rust Pond was 10.4 mg/L (median of 11.0 mg/L) as calcium carbonate during the 2001 study year, and 10.6 mg/L (median of 11.0 mg/L) in the 2002 summer study period. Rust Pond is classified within the "sensitive" category to acid additions, bordering on "highly sensitive." Similar to most New Hampshire lakes, Rust Pond is not able to effectively buffer against acid additions from precipitation and runoff. The mean ANC value for Rust Pond is greater than the state mean ANC value (epilimnetic average of 6.6 mg/L as calcium carbonate) for 781 lakes and ponds in New Hampshire as studied by the DES Lake Assessment Program. Figure 4-2 shows the trend in epilimnetic ANC levels.

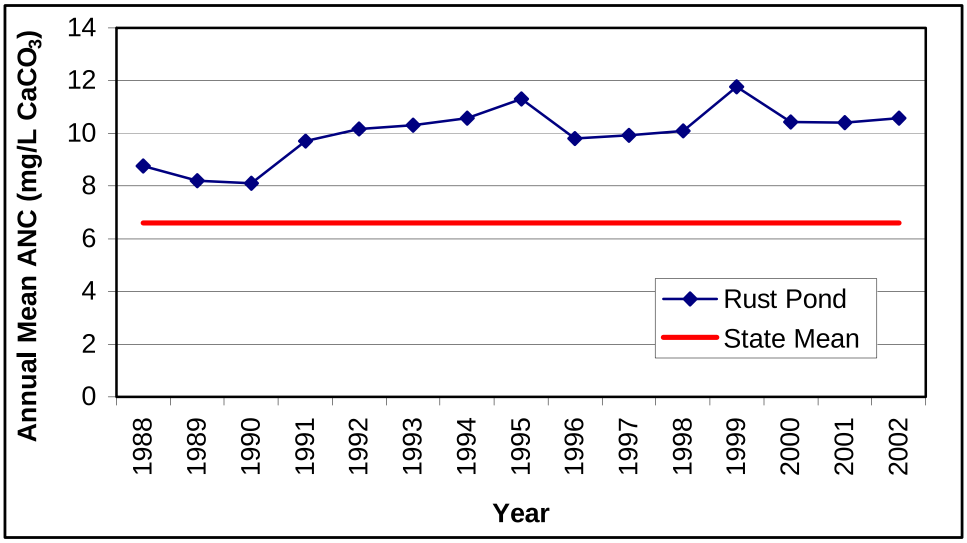

Figure 4-2: Historical Trends in Rust Pond ANC (VLAP data)

Fortunately, the overall trend since 1988 for Rust Pond ANC shows an increase in buffering capacity. The increase in ANC is likely the result of more stringent national restrictions on smokestack emissions. This increasing trend is encouraging; especially in New Hampshire where our lakes have a naturally low buffering capacity.

4.1.4 Conductivity

Specific conductance (conductivity) is a measure of the capacity of water to conduct an electrical current. The soft waters of New Hampshire generally have a low conductance relative to highly mineralized waters found in some parts of the country. The conductance of water is related to the presence of dissolved solids, such as salts and metals, and thus is usually higher in sewage and stormwater from developed areas than in natural waters. Table 4-2 summarizes the average conductivity values of Rust Pond during the study period. According to DES Lake Assessment data, the mean conductivity for 768 New Hampshire lakes is 59.4 µmhos/ cm.

Table 4-2
In-Lake Average Conductivity Values (µmhos/cm)

Sample Depth	Year	Mean	Median	Standard Deviation
Epilimnion (surface layer)	2001	53.12	53.17	1.31
	2002	54.98	54.66	4.30
Metalimnion (middle layer)	2001	53.05	52.85	0.55
	2002	54.28	53.51	4.10
Hypolimnion (bottom layer)	2001	56.08	55.75	2.17
	2002	55.67	55.06	4.75

The mean conductivity values for Rust Pond are slightly lower than the New Hampshire mean lake conductivity. Land use practices, septic systems, road salting, fertilizers, natural runoff and soil chemistry can contribute to higher-than-average levels. Typically, excessively high conductivity values can indicate human induced sources of pollution. The measured levels show that conductivity is higher in the hypolimnion where natural and man-made watershed particulates accumulate. As shown in Figure 4-3, mean summer conductivity concentration has not increased markedly over the VLAP sampling years.

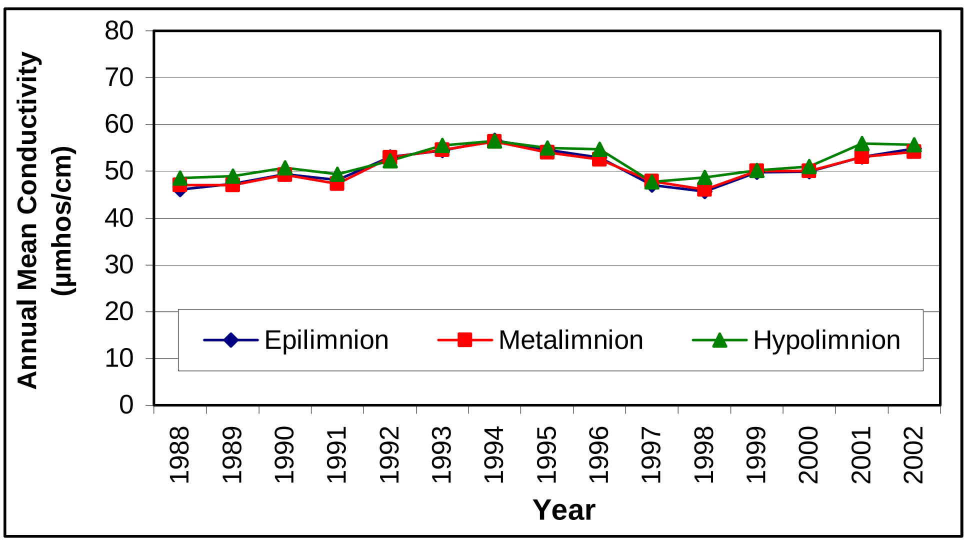

Figure 4-3: Historical Trends in Rust Pond Conductivity (VLAP data)

4.1.5 Turbidity

Turbidity is caused by the presence of suspended particles of clay, silt, algal cells and other organic detritus in the water. As light passes through the water, it is scattered, reflected or absorbed by suspended particles. Eroded watershed sediment delivered to the State's waterbodies during periods of stormwater runoff increase lake turbidity values. Also, a high population of algal cells in the water column contributes to increased turbidity. As these particles enter the pond they slowly fall through the water column and accumulate in the bottom lake sediments. Table 4-3 summarizes the Rust Pond mean turbidity levels in each stratified layer.

Table 4-3
In-Lake Average Turbidity Levels (NTU)

Sample Depth	Year	Mean	Median	Standard Deviation
Epilimnion (surface layer)	2001	0.53	0.49	0.08
	2002	0.72	0.79	0.37
Metalimnion (middle layer)	2001	0.81	0.56	0.45
	2002	1.01	1.12	0.27
Hypolimnion (bottom layer)	2001	0.93	1.12	0.36
	2002	1.49	1.39	0.36

The mean turbidity values show that the suspended sediments increase with lake depth. In most lakes, bottom sediments are loose, or flocculent. Moderate to high-horsepower engines can also disrupt the bottom in waters less than 15 feet deep. Additionally, during lake monitoring, if the sampler is not careful, the Kemmerer sampling bottle may disturb the sediments elevating the turbidity readings in the bottom layer.

Mean epilimnetic turbidity levels for Rust Pond during the 2001 and 2002 summer periods were lower than the NH VLAP lakes mean of 0.8 NTU. The mean hypolimnetic turbidity level was slightly lower than the NH VLAP lakes mean summer level (1.0 NTU) during 2001, and slightly above this level during 2002. Overall, however, the turbidity levels in the pond remain low. Figure 4-4 illustrates the trend in turbidity in Rust Pond since monitoring turbidity began in 1997.

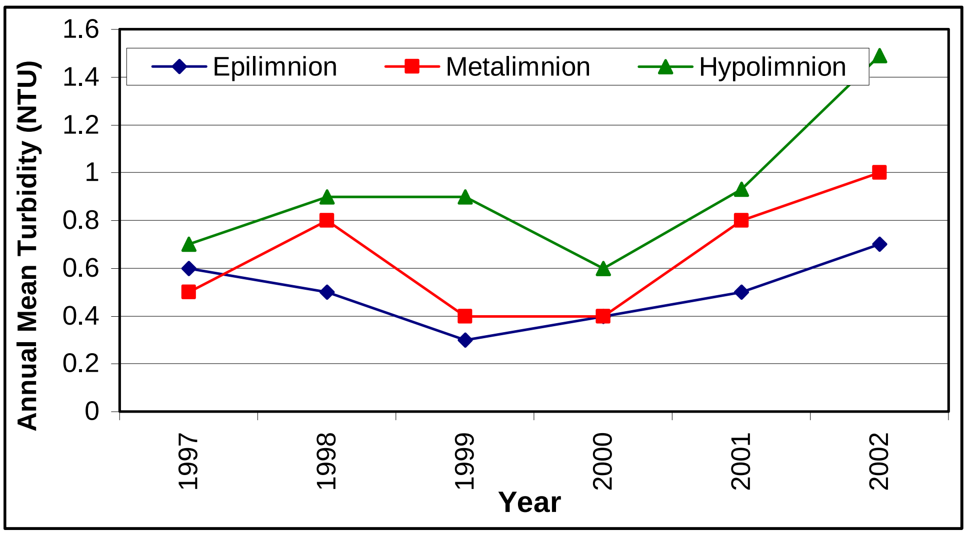

Figure 4-4: Historical Rust Pond Turbidity (VLAP data)

4.1.6 Algae

Algae, or phytoplankton, are typically microscopic plants that free-float in the lake's water column. Photosynthesizing plants use energy from the sun, nutrients from the water, and carbon dioxide from the air to produce both their food source (carbohydrates) and oxygen, which is released to the water and air.

Algae are the primary producers in the all important food chain and necessary organisms in any healthy waterbody. These small plants are consumed by microscopic animals (zooplankton), aquatic insects, tadpoles, crayfish, fish, mussels and other organisms.

Algal abundance and species dominance is dependent upon a series of chemical, physical and biological factors. Light, food and temperature are key ingredients to algal productivity and seasonal population dynamics. Waterbodies that maintain high sunlight incidence, sources of available phosphorus and moderate temperatures typically maintain an abundant population of algal cells. Nuisance levels of these algal populations can sometimes include members of the Cyanobacteria (blue-green algae), which are also influenced by the supply of the limiting nutrient phosphorus.

Wind, water currents, and morphological characteristics of waterbodies can dictate the location of algae blooms. Since some algae are free floating, a high algal cell density may be measured at certain locations in the lake, whereas in other areas only low densities may occur.

The results of the summer 2001 and 2002 algae analyses for Rust Pond are listed in Table 4-4. The Rust Pond algal community is comprised of diatoms, golden brown algae, filamentous green algae, and cyanobacteria (blue-green algae species). A variety of pennate diatoms and *Dinobryon, Chroococcus, Chrysosphaerella, Anabaena, and Asterionella* were the most abundant species identified throughout the summer months of 2001 and 2002. The overall algal abundance ranged from high to relatively low, with a usual rating between 'moderate' and 'common' being assigned to the algae population. A decrease in overall algal abundance from June to August was observed during both of the summer periods studied.

Table 4-4
Microscopic Analyses for Algae, Summers, 2001 and 2002

Date	Species	Algal Groups	Relative Abundance (%)
6/13/2001	*Dinobryon*	Golden Brown Flagellated	36.4
	Asterionella	Pennate Diatom	25.4
	Anabaena	Blue-Green Filamentous	18.6
7/16/2001	*Chroococcus*	Blue-Green Coccoid	25.3
	Rhizosolenia	Centric Diatoms	21.6
	Tabellaria	Pennate Diatoms	17.1
8/21/2001	*Chrysosphaerella*	Golden Brown Flagellated	34.1
	Tabellaria	Pennate Diatoms	26.3
	Anabaena	Blue-Green Filamentous	8.5
6/17/2002	*Anabaena*	Blue-Green Filamentous	76.0
	Uroglenopsis	Golden Brown Flagellated	9.9
	Fragellaria	Pennate Diatoms	6.6
7/22/2002	*Dinobryon*	Golden Brown Flagellated	75.0
	Chrysosphaerella	Golden Brown Flagellated	18.0
	Fragilaria	Pennate Diatoms	5.0
8/19/2002	*Asterionella*	Pennate Diatoms	28.7
	Oocystis	Green Non-Flagellated	13.2
	Staurastrum	Green Non-Flagellated Desmids	11.6

4.1.7 Chlorophyll-a

Chlorophyll-a is a measure of the concentration of the green photosynthetic pigment in algal cells. Measuring chlorophyll-a provides biologists with an indication of lake productivity through measuring the concentration of algal cells in the water at any given time. Figure 4-5 shows the trend in chlorophyll-a from June 2001 to August 2001, and again from June 2002 through August 2002. The mean chlorophyll-a value for the summer of 2001 was 2.82 mg/m^3 while the mean concentration was 2.48 mg/m^3 during the 2002 sample season.

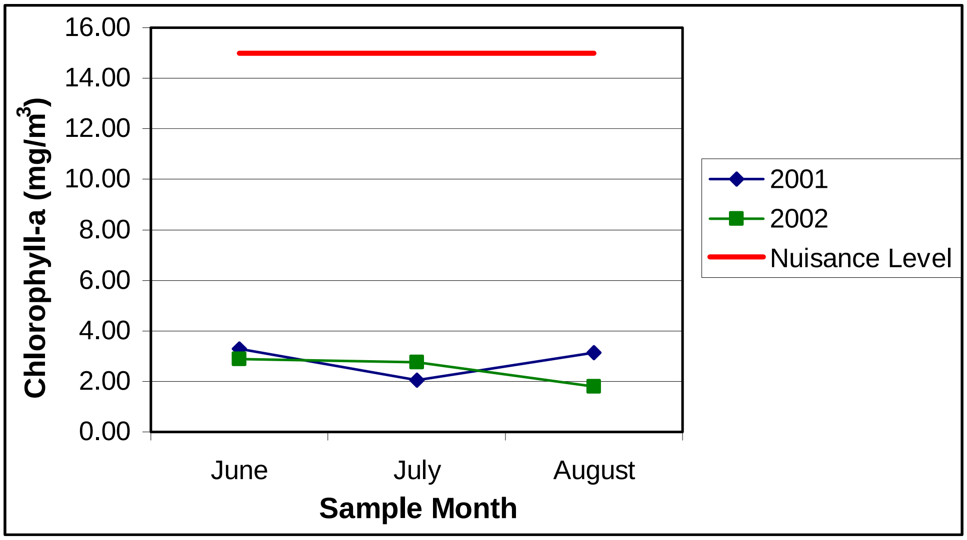

Figure 4-5: Rust Pond Chlorophyll-a Concentrations, June - August, 2001 & 2002

Historical chlorophyll data regressed with other trophic indicators collected from approximately 800 New Hampshire lakes and ponds has resulted in an index that relates chlorophyll to lake quality conditions. A range of 0 mg/m^3 - 5 mg/m^3 is considered 'good' for algal abundance (Appendix 1). Algal abundances 5.1 mg/m^3 - 15 mg/m^3 are deemed more than desirable for New Hampshire lakes and ponds. With the exception of the historical high value recorded in 1989, all chlorophyll-a measurements analyzed from Rust Pond, including those collected during the 2001-2002 study period, were within the 'good' category. Chlorophyll-a levels remained well below the nuisance level of 15 mg/m^3.

An examination of the historical chlorophyll-a trend for the lake, Figure 4-6, shows that the overall algal abundance has decreased slightly since regular sampling began in 1989. This positive trend is a good indication that Rust Pond is currently maintaining theist current trophic state.

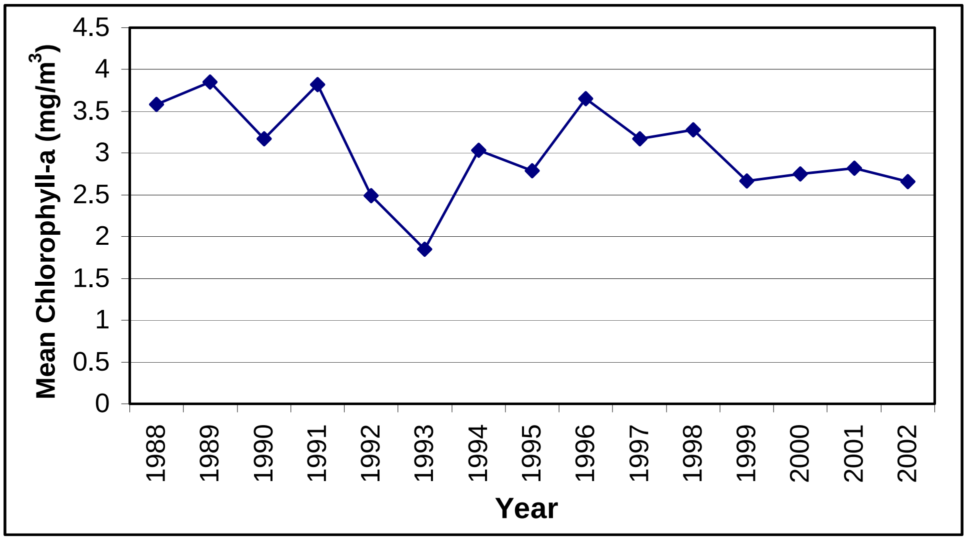

Figure 4-6: Historical Trends in Chlorophyll-a Concentrations (VLAP data)

4.1.8 Transparency

Transparency is a measure of water clarity measured by the vertical depth one can see a Secchi Disk (SD). Algae growth, water color, suspended sediments all influence water clarity measurements while the person measuring clarity, surface water waves or movement and light reflection on the water's surface can bias water clarity measurements.

Figure 4-7 shows the lake clarity trends at Rust Pond during the summers of 2001 and 2002. A comparison with the New Hampshire mean clarity of almost 800 lakes and ponds reveals that Rust Pond ranks higher than the New Hampshire mean clarity. The mean clarity of Rust Pond in 2001 was 4.50 meters while the 2002 mean clarity was 5.52 meters.

The clarity during the study period varied from 4.0 to 6.4 meters. This was lower than the reading of 7.0 meters taken during a 1992 lake assessment visit, but in line with historical VLAP trend data since 1988. Pond clarity can vary dramatically from year to year and day to day depending on seasonal and daily weather conditions. It is difficult to compare a study year or a series of monthly recordings that result in a long-term trend to a single data point collected in 1992.

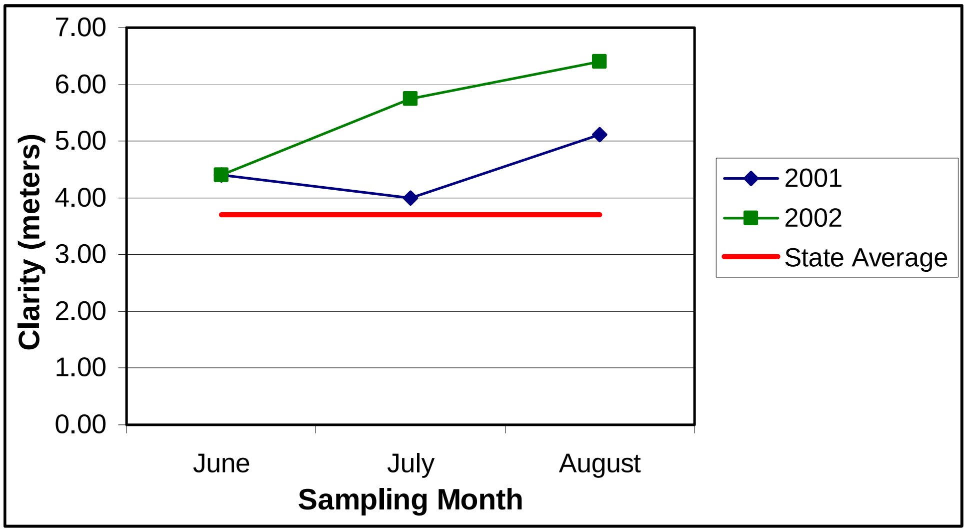

Figure 4-7: Rust Pond Clarity, June - August 2001 & 2002

Overall, lake clarity has remained steady since monitoring began in 1988. Decreasing chlorophyll-a trends and moderately high clarity measurements will likely signify high lake quality conditions. Figure 4-8 shows historical trends in Secchi depth falling between four and six meters.

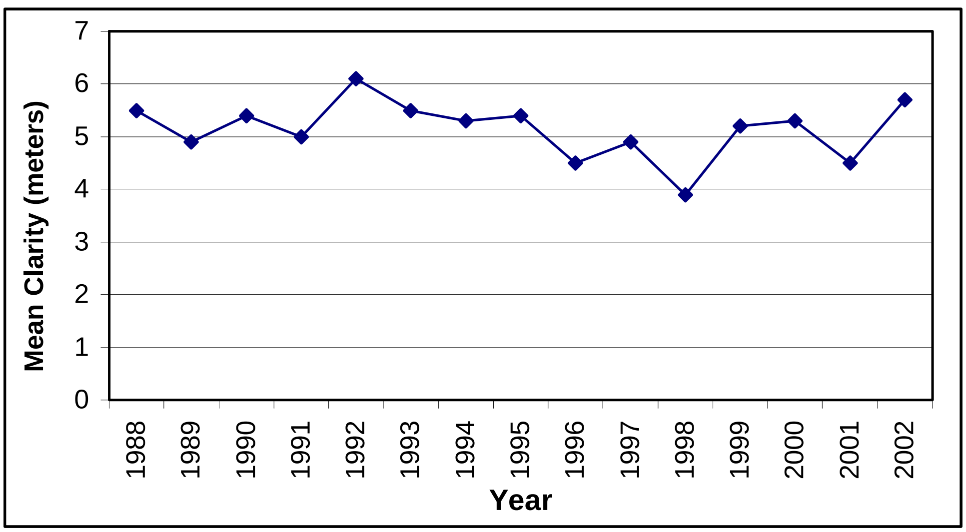

Figure 4-8: Historical Trends in Rust Pond Clarity (VLAP data)

4.1.9 Aquatic Vascular Plants

Aquatic vascular plants are another necessary component to consider in the overall goal of maintaining a healthy aquatic environment. Aquatic plants benefit a lake system by providing deep rooting systems to stabilize lake beds and shorelines, surfaces that algae grow upon, oxygen, food and nesting materials for birds and aquatic organisms, and cooling shade to the lake bed. Some aquatic plants also provide diverse above-water structure that many organisms need for habitat, especially fish. These plants can be emergent, submergent or floating. Figure 4-9 illustrates the approximated zonations of various common aquatic plants.

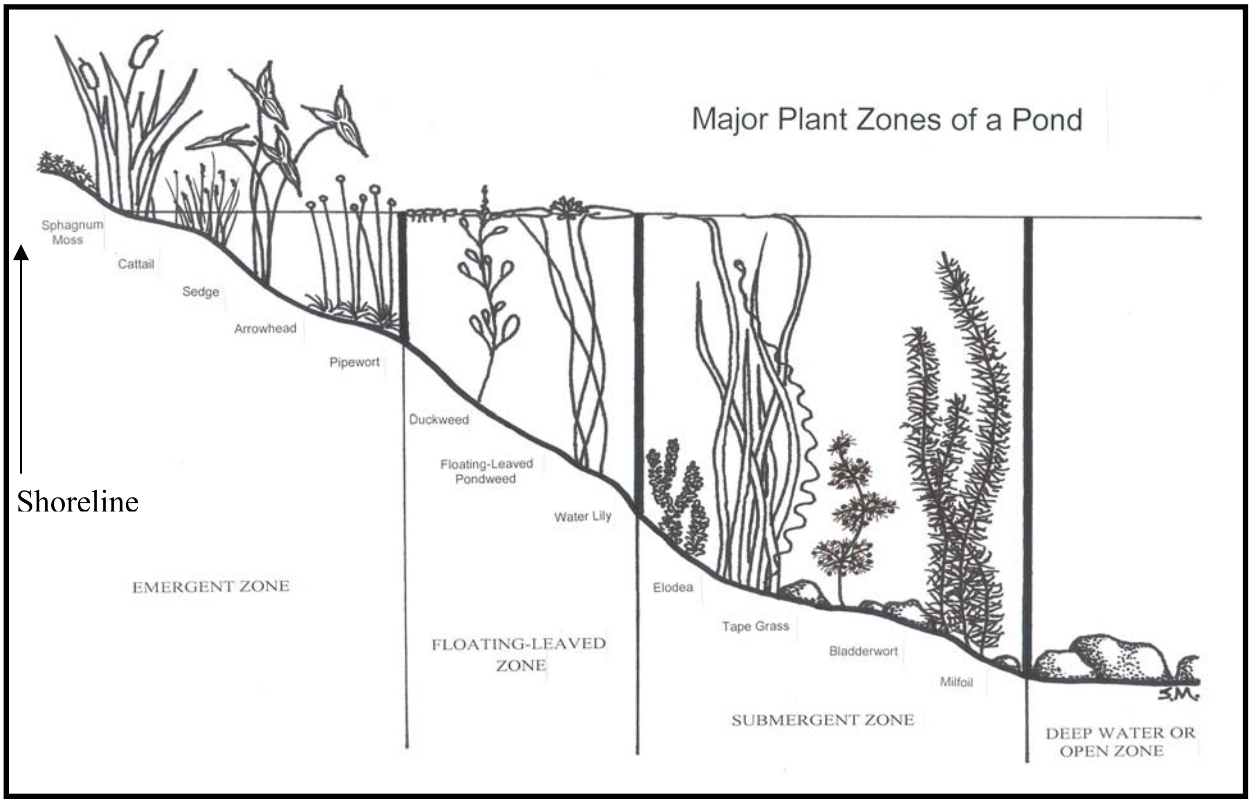

Figure 4-9: Aquatic Plant Zonation. Actual depths at which these plants are found can vary considerably depending on water clarity, substrate type, and shoreline configuration.

Aquatic plant surveys of Rust Pond were conducted in July 1981 and September 2002. Historical records of aquatic plant genera can be determined by comparing the surveys maps in Figure 4-10a and 4-10b. These records show the spread or increase of biomass of some plants or show the addition of new plants as well as the disappearance of other plants, which is a common phenomenon within aquatic plant communities over time. Table 4-5a and 4-5b list the symbol, common name, and genus of each of the macrophytes identified during the plant surveys.

The plant community of Rust Pond is currently represented by sparse patches of the white button-like flowered plant known as pipewort, and sparse distributions of water naiad, tapegrass, turtlehead, and members of the pondweed genus. Rust Pond was sparsely populated by Three-way Sedge in 1981. Interestingly, Three-way Sedge had disappeared during the 2002 plant survey, while five macrophytes (water naiad, pipewort, turtlehead, tapegrass and pondweed) were newly documented.

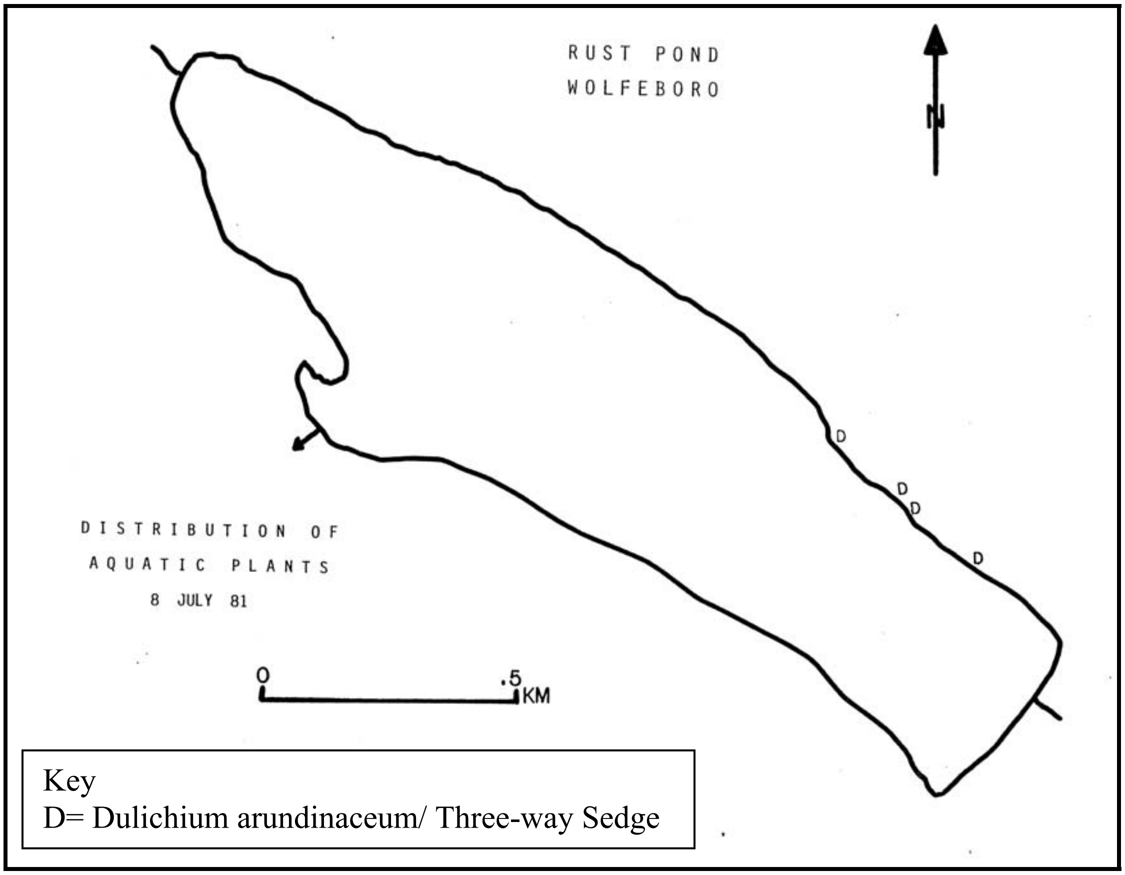

Figure 4-10a: Rust Pond Plant Survey, July 1981

Table 4-5a
Rust Pond Plant Survey, July 1981

Symbol	Latin Name	Common Name	Abundance
D	*Dulichium arundinaceum*	Three-way Sedge	Sparse

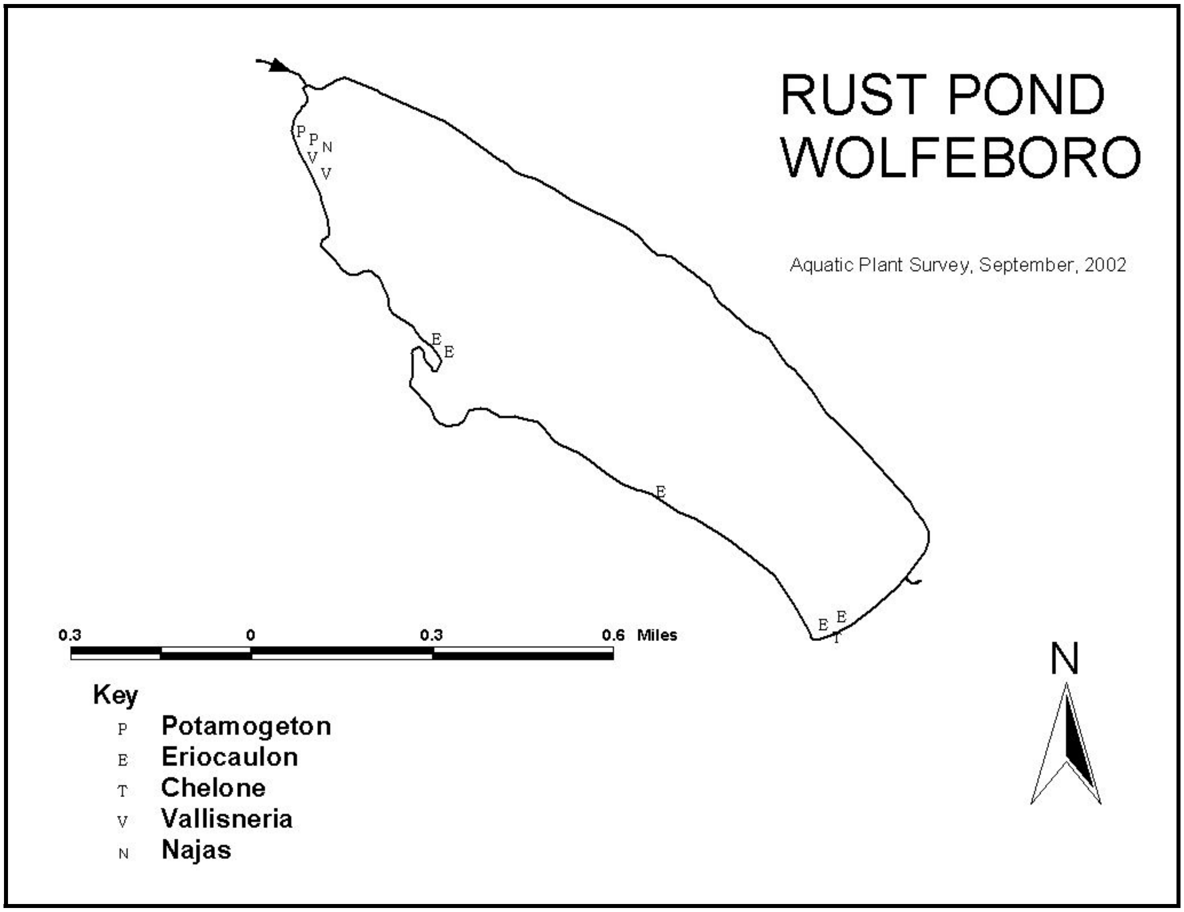

Figure 4-10b: Rust Pond Plant Survey, September 2002

Table 4-5b
Rust Pond Plant Survey, September 2002

Symbol	Latin Name	Common Name	Abundance
N	*Najas*	Water Naiad	Sparse
E	*Eriocaulon septangulare*	Pipewort	Sparse
T	*Chelone glabra*	Turtlehead	Sparse
V	*Vallisneria*	Tape Grass	Sparse
P	*Potamogeton Spp.*	Pondweed	Sparse

Fortunately, Rust Pond has been spared the impacts of nuisance growths of exotic aquatic plants like milfoil or fanwort, though nearby lakes and streams are impacted by Variable milfoil (like Lake Winnipesaukee, Lake Wentworth, Crescent Lake, and Back Bay). With a public boat ramp, it is hard to explain why Rust Pond has not been impacted by exotic aquatic plants. It is recommended that the Weed Watcher Program be continued to monitor the lake for any possible introductions and infestations, and that DES be notified immediately if any suspicious plant is found in the pond.

4.2 Tributary Data

The following sections of this chapter will present and discus the chemical data, including pH, conductivity and turbidity for the Rust Pond tributaries and outlet during the study period from July 1, 2001 through June 30, 2002. Additional turbidity and conductivity data exist for Rust Pond beyond the confines of the study period as a result of further monitoring and field work associated with the North Inlet. These will also be presented as a part of this report in sections 4.2.2 and 4.2.3.

Unlike in-lake samples, there are no New Hampshire ranges or means calculated for water quality in tributaries. Therefore, tributary data will be compared to ranges for in-lake water quality (Appendix 1) and assessed for how tributary water quality may influence in-lake water quality.

4.2.1 pH

Tributary pH was monitored throughout the study period. Table 4-6 shows the mean pH values for each tributary in the Rust Pond watershed.

Table 4-6
Rust Pond Tributary True Mean pH, Study Period

Tributary	Mean	Median	Standard Deviation
Boulder Brook	6.37	6.38	0.38
North Inlet	6.66	6.60	0.18
Perry Brook	6.93	6.91	0.16
Outlet	7.21	7.19	0.17

The mean pH of lakes and ponds in NH is approximately 6.5 units. However, it should be noted that this value is an average pH reading, not an average of hydrogen ion concentrations (or ‘true mean pH’ value). Therefore, tributary pH values were calculated the same as lake pH values. The mean tributary pH values for Rust Pond are no greater than 0.43 units and no less than 0.13 units different from the state mean pH of almost 800 lakes and ponds. The pH of the Rust Pond tributaries were all well above 6.0. When pH values fall below a pH of 6.0, these waters may become too acidified for some wildlife species. The pH of streams may be affected by acid rain, soil characteristics, land use patterns, photosynthesis and decaying plant materials.

The data show that the pH of the water leaving the lake is higher than the pH of the water entering the lake. Due to the limited buffering capacity of the minerals in the soils and rocks in the Rust Pond watershed, tributary water is minimally buffered prior to entering the pond. However, upon discharging to the pond, pH buffer elements such as Calcium and Magnesium allow for an increase in pH to occur. In addition, as algae and plants in the surface waters of Rust Pond photosynthesize during daylight hours, CO_2 concentrations are reduced, thereby increasing the pH of the surface water discharging from the pond's outlet. For the most part, the water flowing out of the lake in the summer is representative of the pH in the upper water column layer (the epilimnion).

4.2.2 Conductivity

Tributary conductivity values can be indicative of subwatershed pollution. When conductivity values in tributaries are elevated it can be the result of road salt runoff, fertilizer runoff, and septic system inputs, as well as the land use patterns and natural soil characteristics in the subwatershed. It is important to monitor conductivity to determine if there are any potential water quality problems within a tributary subwatershed. Table 4-7 lists the average tributary conductivity values for Rust Pond.

Table 4-7
Rust Pond Tributary Mean Conductivity (µmhos/cm), Study Period

Tributary	Mean	Median	Standard Deviation
Boulder Brook	57.18	58.61	12.41
North Inlet	245.94	295.00	99.59
Perry Brook	52.22	54.44	7.75
Outlet	55.15	55.05	1.95

Conductivity values among the Rust Pond subwatershed tributaries are variable. The lowest mean conductivity was recorded at Perry Brook (52.22 µmhos/cm). This stream originates from springs and pools on the Winnipesaukee Golf Club property boundaries, but is buffered from the golf course by a forested wetland complex along the length of the stream.

Mean conductivity values in North Inlet (245.94 µmhos/cm) were almost five times greater than those in the other tributaries throughout the study period. Higher conductivity levels here are likely the result of land use changes in the subwatershed of the North Inlet. More specifically, the addition of road salt during the winter months contributes to elevated conductivity levels throughout the year either via direct overland runoff or groundwater. Slight decreases in conductivity levels from June through September were noted in this stream in 2001 and 2002, and are likely a result of no direct road salt application during these months and reduced groundwater flows that typically transport residual chlorides in the soil. The highest conductivity values are evident from October, 2001 through June, 2002 as seen in Figure 4-11.

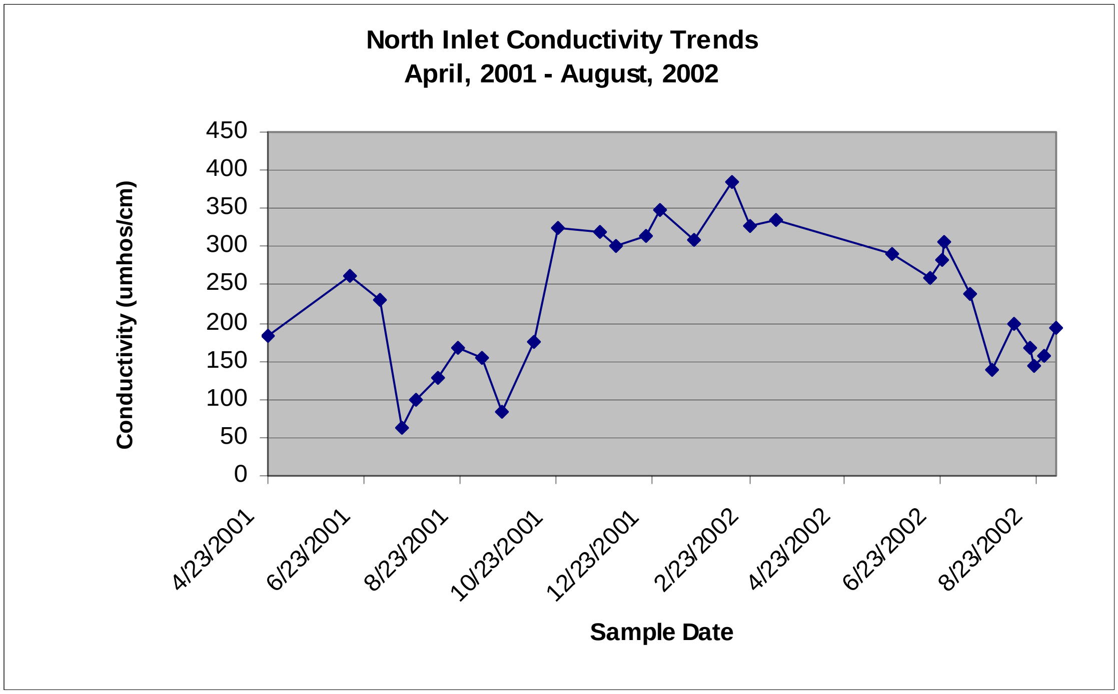

Figure 4-11: North Inlet Conductivity Trends, April, 2001 – August, 2002

4.2.3 Turbidity

Table 4-8 summarizes the average turbidity levels for the Rust Pond tributaries.

Table 4-8
Rust Pond Average Tributary Turbidity (NTU), Study Period

Tributary	Mean	Median	Standard Deviation
Boulder Brook	3.37	0.68	7.27
North Inlet	4.88	4.30	3.62
Perry Brook	1.87	1.81	0.83
Outlet	1.04	0.78	1.03

Boulder Brook and North Inlet had the highest mean tributary turbidity levels during the study period. However, both of these streams had fluctuations in turbidity levels as shown by the larger standard deviations. With the exception of two turbidity values from Boulder Brook, the majority of the turbidity values were less than 2 NTUs and of minimal concern with respect to water quality. It is important to note that this stream had a very organic bottom and extensive wetland systems through the complex.

The North Inlet had a mean turbidity value of 4.88 NTUs. This value, along with the fluctuation in turbidity values evident by a standard deviation of 3.62, indicates that the North Inlet is discharging sediment to Rust Pond. This higher mean turbidity and fluctuation in turbidity levels is characteristic of more developed watersheds that have undergone land use changes from their original forested state.

Numerous site visits have been made to the North Inlet of Rust Pond in the past 10 years. While there does not appear to be an excess amount of sediment entering the pond from a single event, it is apparent that sediment buildup has occurred over time. Generally, as tributaries discharge to the pond, heavier sediment particles will settle out closer to the mouth of the stream. This will eventually build up over time and cause shifts in the stream channel as it enters the lake, possibly altering flow. Lighter sediment particles will travel farther into the lake with the flow of the stream, and may settle and accrete in slightly deeper waters.

The increased sedimentation that has been noted in recent years at the mouth of the North Inlet is likely a result of a combination of factors causing an increase in stream bank erosion and an increase in the transport of native soils and organic material immediate to the North Inlet and its tributaries. These factors include an increase in stormwater runoff rates and volumes within the subwatershed, loss of the beaver population that previously maintained several dams that functioned as check-basins collecting sediment and organic material and breached beaver dams concentrating stream flow and erosive forces along sandy stream banks. While some sediment deposition to Rust Pond is a natural occurrence for this system, several measures can be taken to reduce the sediment deposition. See Chapter 5 for the North Inlet recommendations.

4.2.4 Total Phosphorus

Phosphorus data for the tributaries show an occasional high concentration, but for the most part phosphorus remained around the mean for New Hampshire lakes. These spikes may be attributed to external loading from the watershed (human activities), which occur more frequently in the more developed North Inlet subwatershed than the Perry Brook subwatershed. Figure 4-11 shows trends in tributary total phosphorus concentrations since the lake joined the VLAP program. Phosphorus in the tributaries to Rust Pond was discussed in more detail in chapter 3.

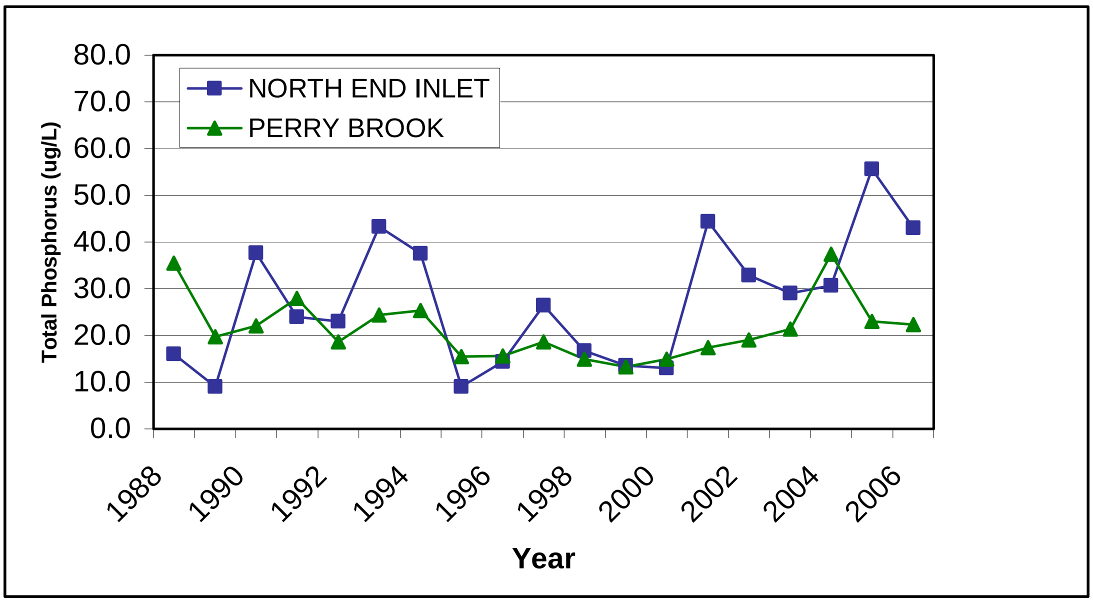

Figure 4-12: Historical Phosphorus Results for Rust Pond Tributaries

5.0 WATERSHED MANAGEMENT AND LAKE PROTECTION

5.1 Introduction

The Rust Pond Diagnostic Study has produced fourteen months of valuable data that document a series of watershed activities that contribute to decreased lake quality over time. *It is important to note that the lake is still classified as oligotrophic, but is showing signs of slight mesotrophic conditions, such as increased macrophyte (aquatic plant) growth.* This suggests that the lake is showing signs of impacts from watershed development.

The following observations and recommendations have been formulated to help maintain the current lake trophic status through slowing the aging process, to maintain the lake quality trends, and perhaps improve the water quality over time through conscientious watershed management.

In any lake protection or rehabilitation project, it is important to start first with the watershed factors affecting water quality and addressing each of those before moving on to implementing in-lake restoration or rehabilitation techniques. For each of the following sections in this chapter, a review of the general ecological and biological impacts will be made, followed by recommendations, and related rules and/or statutes (if applicable). A summary of the areas of concern (ranked by priority for management) around Rust Pond can be found in Table 5-1.

Table 5-1
Summary of Areas of Concern and Recommendations for Remediation

Problem	Recommendations	Suggested Timeframe	Cost
Septic Systems	1. Inventory all septic systems within 250 ft. of the shoreline or major tributaries to Rust Pond. 2. Upgrade individual systems or identify locations where community septic systems may be an alternative in suspected failure areas. Increasing the leach field setback from the Pond and adjacent surface waters including tributaries and wetlands is preferred where feasible. 3. Identify locations for future community septic systems. Work with the watershed Towns to purchase and reserve land parcels for this purpose. 4. For systems that may have leaky holding tanks or septic tanks, install new tanks.	Fall 2007 through Fall 2007, ongoing	$7,000 to $20,000 per system for individual upgrades
Stormwater Management, to reduce sediment and phosphorus loading	1. Develop a zoning overlay for a Lake Protection Zone for the watershed towns including Wolfeboro, New Durham and possibly Brookfield. The goal is to decrease sediment and phosphorus loads off-site via surface or groundwater 2. Design/ install problem-specific Best Management Practices (BMPs) for each area of erosion within the watershed having an impact on pond quality. Privately owned properties, town-owned properties and roadways should all be addressed.	2008-09	Varies, but could be minimal if conducted by volunteers and town officials
Stormwater Management, to reduce Chloride loading	Consider winter road, driveway and parking lot maintenance alternatives to calcium chloride, especially within the North End Inlet subwatershed	2008-09	Varies, but could be minimal if conducted by volunteers and town officials

Problem	Recommendations	Suggested Timeframe	Cost
Stormwater Management, to reduce hydrologic water quality impacts associated with increased stormwater runoff rates and volumes	Develop a zoning overlay for a Lake Protection Zone for the watershed towns including Wolfeboro, New Durham and possibly Brookfield. The goal is to keep and treat stormwater on site, maintaining pre and post land use change stormwater runoff rates and volumes. Properties that have already had a land use change from a natural landscape should be addressed where feasible.	2008-09	Varies, but could be minimal if conducted by volunteers and town officials
Stormwater Management, to reduce remaining NPS water quality impacts associated with land use change	Develop a zoning overlay for a Lake Protection Zone for the watershed towns including Wolfeboro, New Durham and Brookfield. The goal is to reduce or eliminate the transport of water quality pollutants off-site either via surface runoff or groundwater.	2008-09	Varies, but could be minimal if conducted by volunteers and town officials
Land Clearing, forestry and Development	1. Develop a zoning overlay for a Lake Protection Zone for the watershed towns including Wolfeboro, New Durham and Brookfield. The goal is to protect areas that are not suitable for land clearing, forestry and development based on soils, proximity to the lake, or other factors. Where land alteration is proposed, create mechanisms to protect water resources through established setbacks and buffers, limiting site disturbance, phasing site disturbance and requiring erosion control plans and inspection measures. Note: soils data indicates 80% of the watershed is considered highly erodeable. 2. Hire a local forester to review erosion control site plans and logging operations with the goal of protecting water quality.	2008-09	1. Minimal cost if conducted by volunteers and town officials 2. $20,000/ yr
Land Protection	1. Identify priority land areas that have the potential for the greatest negative impact to pond quality and purchase either in full or via easements to allow effective protection measures. Priority lands would include those close to surface waters and wetlands, soils susceptible to erosion, steep slopes and slopes with minimal rates of stormwater infiltration. Other priority conditions to consider are natural, scenic, recreational and cultural resources. For NH	2007, ongoing	1. Case specific

Problem	Recommendations	Suggested Timeframe	Cost
	F&G Highest Quality Wildlife Habitat see www.nhfg.net. 2. Consider local open space preservation initiatives and passing a land conservation bond.		2. Case specific
Beach Erosion	Eliminate or reconstruct beaches. If eliminating beaches replace with vegetated buffer of native plants and trees. If reconstructing, design beaches so that they are setback from the shore with a vegetated buffer, and perched or so that slopes are minimized to lessen the impacts of overland runoff and subsequent beach erosion.	2007, ongoing	Case specific, minimal if eliminating a beach area
Vegetated Shoreline	Re-establishing vegetative shorelines is critical to stormwater management, phosphorus uptake, reducing erosion, and reducing littoral shoreline temperatures important to aquatic species.	2007, ongoing	No cost, if left to vegetate naturally
Internal Loading	Currently, there is no internal loading in Rust Pond. If internal loading becomes a concern, and all watershed contributions have been addressed, conduct aluminum salt treatment to provide phosphorus inactivation at the bottom sediment level to prevent internal loading.	Not applicable since internal loading is currently not a concern.	Not applicable, but alum treatment would cost $70,000-$100,000.

5.2 Septic Systems

All of the properties around Rust Pond are either on subsurface systems or holding tanks. It is very important to have residents aware of system location, system age, operational soundness and the need to have them regularly pumped, examined, and repaired by a specialist. DES recommends that shorefront residents pump their systems every 1-3 years, preferably yearly, if the disposal system is located in mounded fill soils or soils with a minimal separation to groundwater. Native soils with a mix of sand and silt that are not completely saturated may provide moderate removal of wastewater phosphates. Under unsaturated conditions, phosphates ($H_2PO_4^-$ and HPO_4^{2-}) have maximum contact with the native soils. The native soils include hydrous oxides that adsorb these phosphates. Frequent pumping literally removes solid waste, including organic phosphorus from the tank. In addition, removal of solids may reduce clogging of septic pipes and potential failure of the septic system.

A septic system survey was not conducted for Rust Pond during the study period. However, studies conducted on New Hampshire lakes (Connor et al., 1992, and Connor and Bowser, 1997) concluded that much of the septic system phosphorus infiltrates into the groundwater and is transmitted to the shallow areas of the lake via seepage. The soil survey for this area indicates that the watershed is dominated by a till parent material with minimal limitations for septic system use based upon depth to bedrock and the height of the seasonal high water table. In fact, the most common type of individual disposal system is the septic tank - leachfield system as shown in Figure 5-1. The septic tank functions to separate the solids, both floating and settleable, from the liquid material. The accumulated sludge should be pumped out every three to five years. Having the septic system pumped on a more frequent basis will improve the removal of phosphorus and reduce the phosphorus discharged to the leach field. Therefore it is recommended that shorefront residents pump septic tanks every one-three years. The liquid effluent is discharged from the tank through piping material and distributed over the leaching area designed to absorb the effluent and to remove some impurities/pollutants before it percolates to the groundwater, and eventually into tributaries, wetlands or the pond.

In 1967, the New Hampshire legislature enacted a law to protect water supplies from pollution by subsurface disposal systems, and directed the Water Supply and Pollution Control Commission to establish minimum, statewide requirements for properly designed systems.

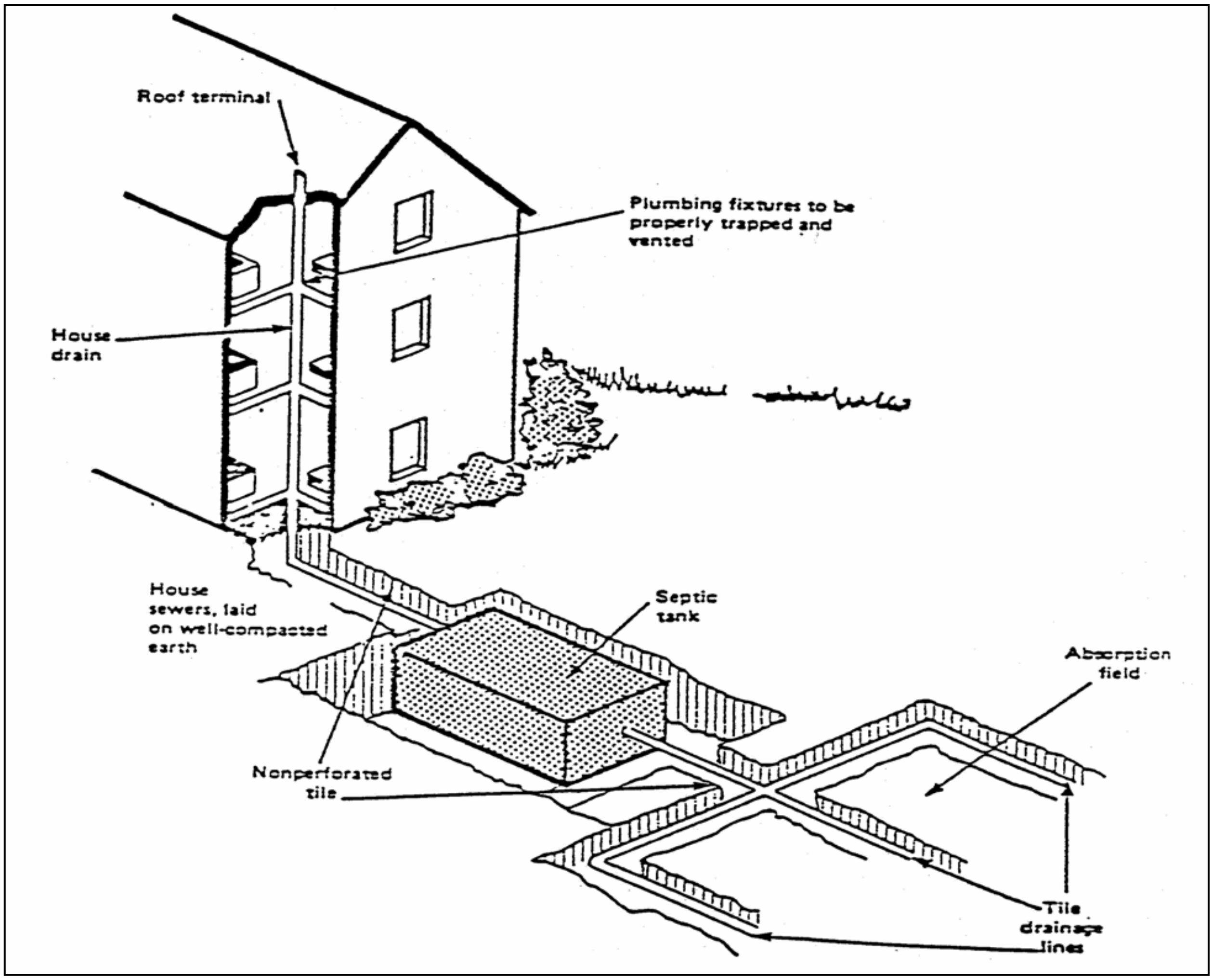

Figure 5-1: Diagram of Septic System Layout

However, this law provided no control over systems constructed prior to 1967. The requirements most pertinent to the prevention of surface water phosphorus contamination are:

- Location of the system with respect to the surface water body,
- Soil permeability: the rate of water transmission through saturated soil, of which estimated soil retention coefficients varied with different lake sections,
- Land slope: steep slopes may cause erosion problems when associated with soils of low permeability. This is the result of overland flow of water due to the lack of absorptive qualities of the soil.
- System age: soils have only a finite capacity for phosphorus absorption,
- Per capita occupancy: household population based on sanitary survey,

- Fraction of year system is in use (e.g., summer cottages or year-round dwellings),
- Additional water utilizing machinery (e.g., washing machines, dishwashers, or garbage disposals). Systems should be specially sized if additional machinery is used.
- Non-phosphate containing soaps and detergents, especially for dwellings with automatic dishwashers.

Septic system failure presents a potential health hazard in the surface and groundwater associated with the presence of pathogenic bacteria, protozoan and viruses that may be present in untreated human wastes. Groundwater contamination and subsequent pollution of drinking water is probable in many areas. Many systems will leach phosphorus into the groundwater and lake, accelerating the eutrophication process in Rust Pond. The upgrading of old or failing septic systems could occur through four channels:

- Voluntary replacement;
- Proven failure and a subsequent order to replace the system from the health officer or the DES Subsurface Bureau;
- Conversion from seasonal to year-round use or addition of bedrooms; or
- Engineering study conducted prior to the house sale showing evidence that the septic system was in need of repairs or replacement.

For detailed State regulatory information on the repair and replacement of existing systems, see http://des.nh.gov/rules/envws1000.pdf, and specifically Env-Ws 1003.10, Repair and Replacement of Existing Systems. For an example of a septic system survey, see Appendix 26.

5.2.1. Wastewater Treatment Considerations and Alternatives

a. Regional Waste Treatment. There is currently no municipal sewage system service to properties within the Rust Pond Watershed. The municipal sewer system for the Town of Wolfeboro extends from the downtown area to the crest of Rte. 28 at Edgewood Terrace intersection. If properties within the Rust Pond watershed were to consider an extension of the municipal sewer system this would likely require a pumping station and force main sewer line to the Rte. 28/ Edgewood Terrace intersection.

b. Cluster Systems. Cluster systems are innovative systems that collect and treat sewage for many homes or groups of homes around a lake. First tier development around Rust Pond could elect for alternative subsurface treatment systems with conventional collection from clusters or groups of individual homes. These cluster systems are usually simple and cost effective alternatives for the secondary treatment of small flows. Installations are suitable for discharge volumes of 500 gpd to 300,000 gpd. Small areas of land (perhaps shared lots or open lots) are necessary for the installation of such systems.

Cluster systems are becoming more popular as alternative systems, and research conducted on these units shows that more nutrients are trapped than by individual septic systems resulting in fewer nutrients available to the waterbody. There are several cluster systems that are now operational in New Hampshire. In 2004-05, the Town of Amherst, using Town and Clean Water Act Section 319 money, installed a cluster or community septic system which serves more than 10 households. A second phase serving an additional 10 households is currently under design. The total project estimated cost will be $400,000 - $500,000.

Although a construction and user fee is often required of all serviced homes, the environmental and economic benefits greatly outweigh the option of individual subsurface system upgrades that can exceed $20,000 each.

c. Maintenance/Upgrading of Individual Systems. Individual treatment systems installed in recent years normally consist of a septic tank for solids separation and degradation, and a soil absorption system or leachfield to aid liquid percolation into the soil. The size of the tank is proportional to the expected usage (water flow delivery), and the leaching field is sized according to both usage and soil characteristics. When soils are poor (i.e., low permeability) or flows are high, the leaching field must be large. Problems arise when the required design of the field is impractical or impossible due to lot restrictions and/or soil and groundwater conditions. Annual inspections of the septic tank and visual inspections of the leach field during times of peak flow are important in maintaining a functioning septic system. If the individual sewage disposal system is showing signs of degradation such as backups, eroded baffles in the septic tank or effluent breakout it is time to repair or replace the system.

d. Compost Toilets. A reduction in wastewater volume entering the leaching field is possible by the use of a waterless toilet of the composting type. Wastewater is the by-product of all water used within the home including toilet facilities, cleaning, cooking and personal hygiene.

The wastewater associated with toilet and urinal usage is considered concentrated human waste and classified as black water. Gray water comprises the remainder of the domestic wastewater such as water from baths, showers, sinks and clothes washers. An approximately 40 percent reduction in total flow can be achieved by eliminating black water.

Compost toilets decompose human wastes by a natural biological process. With the aid of air and/or some heat, human waste will degrade itself over an extended period of time. This process is similar to the decomposition process in composting leaves and manure piles used for garden and agricultural crop enrichment.

A compost system utilizes a large compost chamber that must be installed in the basement or underground, and is called an external unit. The larger external units rely completely on natural processes. They have no external heat addition or composting aids as in the smaller internal units, where the addition of heat and compost aids (such as a starter bed or enzymes) speeds the degradation process thereby decreasing the required volume. Toilet wastes enter through a toilet chute and accumulate in the compost chamber. Here, with air supplied through ventilation, warm temperatures and humidity, the waste begins to decompose. The process should create no odor since released gases and water are removed by outside ventilation and evaporation. Organic material such as food wastes should be introduced into the chamber to aid in the composting process.

The total decomposition time ranges from 1-1/2 to 2 years initially, and from 3 to 12 months thereafter. At the end of this time, the wastes have been reduced to rich, odorless humus that can be removed and used as garden soil. This is the only required maintenance except for the occasional addition of enzymes for certain internal units. For the internal units, electricity is required for heating and a ventilation fan, while some external units utilize convection currents for ventilation. The amount of humus produced varies with the system and ranges from 15 to 60 pounds per year per person. The majority of phosphorus within the compost is found as organic phosphorus. Organic phosphorus is bioavailable for uptake by plants. Therefore it is important that the compost be retained on upland areas; not in contact with ground or surface waters that could potentially transport it to the lake or pond.

e. Low Water Flush Toilets. Several low water flush toilets are available which utilize from one quart to two gallons of water instead of the average five to eight gallons used by a standard flush toilet. A limited capacity self-contained tank controls the volume of flushing water. Air in the tank is compressed as it is filled with water. When flushed, the compressed air forces the water through the toilet bowl at a faster rate, thereby requiring a lower volume to empty the bowl.

f. Gray Water Flow Reduction. Unlike concentrated human waste, gray water cannot be completely eliminated as domestic wastewater by recycling or composting. However, many devices are available for water conservation that greatly reduce gray water quantities. Flow restrictors and regulators can be placed on faucets and showerheads. The average person showering will use 6 gallons of water per minute for 7.5 minutes with a standard showerhead. Should a 3-gallon per minute flow reduction be installed, an average family of four persons could save 90 gallons of water per day, assuming each took one shower per day. Assuming the average family produced 75 gallons per day per person, an estimated flow for their household is about 300 gallons/day. Many of these flow reduction devices cost less than $15.00, and can be purchased at local hardware stores. By converting all water fixtures to low-flow fixtures and practicing water conservation, the total water discharged through the system will be reduced. This will in turn assist in maintaining system functionality and reduce the volume of phosphorus containing water discharged to the leach field, groundwater and eventually the pond.

5.2.2 Wastewater Treatment Alternatives Summary

A variety of alternatives are possible for the upgrading of individual treatment systems. Each alternative has limitations for proper operation including difficult climate, terrain, soils and/or groundwater conditions, personal acceptance, technical and administrative problems.

A wide range of individual treatment systems has been explored in the last few years due to a renewed interest in on-site disposal systems. The Federal Environmental Protection Agency (EPA) has a thorough review system in their draft report "Innovative and Alternative Technology Assessment Manual." The fact sheets from that manual give a good outline of available alternatives. In addition, please see the follwing EPA website, http://cfpub.epa.gov/owm/septic/home.cfm and EPA's publication, (625/R-00/008) "Onsite Wastewater Treatment Systems Manual."

5.2.3 Septage Handling Alternatives

The cluster system alternative includes large septic tanks that require pumping every other year at a minimum. One septage-handling alternative would involve pumping of the septage by a tank truck, owned and operated by a management district for Rust Pond or the Town Wolfeboro. Septage would be hauled to the nearest approved disposal site or wastewater treatment plant for further treatment. Wastewater treatment plants vary in their fees for septage disposal. It is cheaper and timelier to hire a contractor to suction a series of systems (such as a street or neighborhood) on a one to two day period than it is to schedule individual and random cleanings.

5.3 Stormwater Management

Development of residential areas around lakes and ponds has two main effects on stormwater. The first is the increased volume and rate of runoff as changes in the current land-use occurs within the watershed. The second effect is a significant increase of phosphorus loading, resulting in surface water and groundwater degradation (RCCD, 1992). In addition to promoting erosion and sedimentation, increased runoff acts as a medium for transporting pollutants, contaminating surface waters and accelerating cultural eutrophication.

The changes in land-use for watershed development results in decreased vegetated areas and increased impervious surfaces. Impervious surfaces include roads, streets, parking lots, rooftops, driveways, walkways, etc., all of which reduce pervious surface areas that enhance runoff filtration into the soil. As a result, increased untreated surface runoff discharges directly into Rust Pond. Natural drainage patterns are modified as a result of development, and runoff is transported via road ditches, drainage swales and constructed channels. Dirt channels or unstable drainage ditches were observed in several locations along Rust Pond's roads and driveways.

These modifications concentrate and increase runoff velocity, which decreases the runoff travel time through the watershed. The increased flow and decreased travel time of runoff has adverse impacts on the natural landscape and tributaries. The increased runoff volumes from development will likely result in more frequent flooding. Stormwater inflow to streams and drainage ditches widen and deepen the entry points to accommodate the increased flows. This process of road ditch and stream channel erosion creates a sediment problem downstream. Eroded sediment deposits destroy wildlife habitats, impair aesthetic qualities, clog road culverts, degrade water quality, and accelerate lake filling.

5.3.1 Site Specific Management of Non-Point Sources

Figure 5-2 through 5-4 detail specific concern areas in the Rust Pond watershed.

Figure 5-2 is an example of the type of erosion found along Rte. 28. Runoff and snowmelt not captured by the stormwater collection system travel over the paved surfaces along Rte. 28 and are directed over the steep and eroding boat launch site. Sites, such as the town boat launch, act as direct conduits, discharging stormwater runoff directly to the pond without any treatment to remove pollutants, including sediment, nutrients and road salt. Therefore, the town launch as it currently exists increases the pollutant load and facilitates deteriorating pond quality.

Figure 5-2: Town boat launch along Rte. 28. The shoreline of the pond is approximately 50 ft. from the paved edge or Rte. 28.

Figures 5-3 shows sediment deposition within a wetland complex just downstream of a culvert under Cross Road. The wetland is associated with the North Inlet tributary to Rust Pond. Road sand from Rte. 28 and sediment exposed during ditch maintenance are likely the primary sediment sources. During each rain event or melt event stormwater transports sediment through the stormwater collection system or in compromised ditch lines directly discharging to the wetland system. With time, this sediment may reach Rust Pond. However, and perhaps more critical now, is the reduced ability of this wetland complex to attenuate stormwater flows due to

Figure 5-3: Cross Road Wetland. Unstable drainage ditches and sediment deposition in the Cross Road wetland.

sediment buildup and reduced capacity. Furthermore, while some sediment deposition at the mouth of the North End Inlet is a typical, sediment deposition appears to have increased in recent years. Figure 5-4 shows the sediment deposition at the North End Inlet during low water conditions in September, 2006. During the September site inspection, several observations including reduced wetland capacity, breached beaver dams and streambank erosion were noted as having an impact on the sediment deposition. For the complete site inspection report, see the Appendix 27.

Figure 5-4: Sediment deposition at the mouth of the North End Inlet, September, 2006.

Figure 5-5 shows road erosion along a section of Wolfeboro Camp Road. During each rain event or melt event stormwater from this relatively small subwatershed is concentrated to flow down a dirt road. Limited space, steep slopes, poor road design, poor development practices and stormwater are some of the factors contributing to road erosion along Wolfeboro Camp Road that discharge from the Road with an inadequate 20 foot buffer separation to Rust Pond.

Figure 5-5: Road erosion along Wolfeboro Camp Road. Road washouts along this section of the roadway discharge over a steep embankment within 10 ft. of Rust Pond.

Stormwater management within the Rust Pond watershed should focus on developing, implementing, and maintaining appropriate BMPs on a site-specific basis for individual sub-watersheds. NHDES, local conservation districts and the Natural Resources Conservation Service (NRCS) can assist in choosing site specific BMPs. Appropriate permits or certifications may be necessary from the New Hampshire Wetlands Bureau, Shoreland Protection Program, and Subsurface Bureau, in addition to any local permits.

Between direct stream flow and runoff from ungauged watersheds, overland flow contributes an estimated 31 percent of the Pond's phosphorus. Storm water is a critical focal point for reducing nutrient inputs to the pond. Dirt roads within the watershed should be inspected, graded to direct runoff into forested areas to promote infiltration and their shoulders stabilized to prevent runoff. Riprapping the extensive drainage ditches and vegetating settling basins along these dirt roads will lessen sediment transport. Standard or porous pavement should be considered for extreme situations where other BMPs are not feasible. Table 5-2 summarizes further recommendations for BMPs in the Rust Pond watershed. Appendix 28 details various aspects of stormwater BMPs.

5.4 Land-clearing, Development, and Shoreland Protection

As the population continues to increase in New Hampshire and surrounding states, the acceleration of development in our watersheds is inevitable. Ultimately, more people will be drawn to the beauty of New Hampshire's lakes and ponds, and thus, development in nearshore watershed areas must be well-planned to prevent further degradation of our precious waterbodies. Poorly planned development can lead to problems with sedimentation, nutrient loading, algal blooms, decreased lake clarity, and declining property values. In the Rust Pond watershed, new homes were recently developed within the 250 foot Protected Shoreland area. Careful consideration should be used when planning for and permitting future development. This section is intended to guide the town and the watershed residents in making wise and informed decisions on how to conserve and develop in the area of Rust Pond and implement Low Impact Development (LID) concepts for future development.

Table 5-2
Areas for Stormwater Management BMPs in the Rust Pond Watershed

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Town Boat Launch- Rte. 28	1. Locate an alternative boat launch site and eliminate the boat launch from this property 2. Due to significant site constraints implementation of BMPs at the boat launch will be more successful with design/ implementation of stormwater BMPs to reduce flow and velocities starting at the top of the subwatershed. This would include increasing the capacity of road ditches to reduce velocities and promote infiltration. In addition installation of a turnout to a wooded area just north of the boat launch would reduce stormwater flow over the boat launch. Boat launch BMP(s) would include water bars to redirect water, concrete pavers, infiltration or slow release of stormwater.	40-80	0.12-0.24

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
State Hwy Rte. 28 (Town Boat Launch subwatershed)	The Rte. 28/ Town Boat Launch subwatershed collects stormwater in a closed system and discharges just south of the Town Boat Launch. Suggestions/Alternatives include: 1. Schedule street sweeping in early spring before spring rains wash road sand into the stormwater collection system. 2. Eliminate catch basins and replace with vegetated swales and rain gardens designed to promote groundwater infiltration of stormwater. 3. Install deep sump catch basins accompanied by a routine maintenance schedule tracking the cleaning frequency and volume of material removed from the catch basins. 4. Redirect collected stormwater into a stormwater retention area. Potential locations include land between Abenaki Drive entrance and exit roads or just south of the Abenaki Drive exit. 5. Work with private property landowners to sheet flow stormwater from their property into wetlands or rain gardens.	200-300	0.06-0.09

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Town Road- Walt's Lane	Subwatershed includes a portion of State Hwy Rte. 28. Suggestions/ Alternatives include: 1. Work with private landowners on the uphill side of Rte. 28 responsible for discharging stormwater to the Rte. 28 system. Encourage infiltration/ retention when feasible. 2. Work with NH DOT- Infiltration/ retention/ turnouts of Rte. 28 stormwater within the Rte. 28 ROW. 3. Work with private landowners on the downhill side of Rte. 28 to capture stormwater for infiltration/retention. Most feasible location being on the north side of Walts Lane. 4. Improve open drainage ways along Walt's Lane. This may include adding driveway culverts, widening drainage ditches and installing small retention areas. Reduce driveway/ditch erosion, water velocities and allow for sediment removal before discharging to the pond. 5. Develop a maintenance schedule for tracking the cleaning frequency and volume of material removed from the ditch lines or retention areas.	200-300	0.06-0.09

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Town Road- Cross Road (Timber Lane), North Inlet subwatershed	North Inlet subwatershed receives stormwater flow from Rte. 28, Pleasant Valley Road and land adjacent to Rte. 28 and Pleasant Valley Road. The primary concern is sediment loading to the wetland area/ North Inlet from Rte. 28 and Cross Road. Recommendations include: 1. Develop stormwater ordinances to maintain pre and post development stormwater conditions. 2. Evaluate areas within the subwatershed that may be used for stormwater management. 3. Install and maintain deep sump catch basins at cross pipes under Rte. 28, to collect sediment before discharging to wetlands adjacent to Cross Road. 4. Place plunge pools at outlets of above mentioned cross-pipes to collect sediment. 5. Stabilize banks of Cross Road ditchlines. When ditch line maintenance occurs, immediately stabilize the banks with vegetation, rock, or matting. 6. Construct sediment retention barrier at the outlet of the cross pipe under Cross Road and discharging to wetland system. Retention area should be constructed to allow access for dredge maintenance. 7. Stabilize banks of North Inlet adjacent to beaver dam activity and any other actively eroding areas downstream of Cross Road. 8. Upon successful implementation of the above recommendations, evaluate a one-time dredge project at the mouth of North Inlet.	1. Current sediment load is 500-1000 kg 2. Future sediment load 2000-3000 kg	1. 0.15-0.30 2. Future phosphorus load estimated at 0.6-0.9 kg. Sediment currently does not discharge from Cross Road wetland complex to Rust Pond. However, as sediment capacity within the wetland complex diminishes with time, this sediment may migrate and discharge to Rust Pond.

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Town Road- Wolfeboro Camp Road/ Camp School Rd.	Subwatershed includes Camp School Road and adjacent properties just uphill of #289 Camp School Road. Primary concern is reducing stormwater volumes and velocities at the uppermost part of the subwatershed to minimize erosion at lower most part of Camp Road approximately 20 ft. from Rust Pond. Recommendations include: 1. Redirect stormwater into woods north of #289 Camp School Rd. 2. Reduce roadway and driveway areas at intersection of Camp School Rd. and drive #289. 3. Place turnouts along road between house #289 and house #269 to small retention/infiltration areas. 4. Plant trees, shrubs, construct terraces on steep slope across from new house #269. 5. Terrace downslope of septic system (upslope of garage) associated with house #299. 6. Install porous pavement, gravel pavement or concrete pavers for garage driveway for house #299. 7. Collect roof gutter water from the garage of house #299 and direct into dry well or rain barrel. 8. Install dry well in driveway of new house #269 and redirect some Camp School Rd. storm water to this location. 9. Protect any vacant land within this subwatershed, especially the parcel across the road from new house #269. 10. Design/ install porous pavement or gravel pavement if erosion problems persist.	40-80	0.12-0.24

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Residential- Private Beaches	Beach sand is often easily transported to lakes and ponds since these areas are often constructed adjacent to surface waters. Beach areas that require beach replenishment contribute to increase sedimentation rates and phosphorus loading to Rust Pond. Recommendations to eliminate or minimize sediment and phosphorus loading due to transport of beach sand to Rust Pond include: 1. Eliminate all private beaches, replanting with native vegetation/landscapes 2. Reduce the beach area by establishing a dense vegetative buffer around the beach area, especially between the beach and the shoreline. This will eliminate direct contact of unstable sand with surface waters. 3. Relocate the beach area, increasing the setback from Rust Pond. 4. Direct sheet flow runoff to infiltration BMPs rather than allow runoff over beach areas.	Estimate per beach: 50-100	Estimate per beach: 0.015-0.03

Location	Management Suggestions/ Recommendations	Potential Annual Sediment Load Reduction (kg)	Potential Annual Phosphorus Load Reduction (kg) (300 mg P/kg sediment)
Residential- Private Yards and Shorelines	Stormwater contributes to the transport of pollutants from individual properties to surface waters. Assuming that pollutant source control has been addressed, implement methods for reducing stormwater runoff or improving stormwater infiltration that allow for stormwater treatment prior to discharging to Rust Pond. Recommendations to reduce runoff and improve infiltration include: 1. Provide vegetated buffer strips to reduce runoff, improve water quality and sustain groundwater 2. Install rain barrels and cisterns to reduce runoff and conserve water. 3. Direct gutter downspouts into the ground or constructed drywells or rain barrels to reduce runoff, improve water quality and sustain groundwater. 4. Construct swales and infiltration trenches to reduce runoff and sustain groundwater. 5. Reduce roadway and driveway areas and widths to reduce runoff, improve water quality and sustain groundwater. 6. Provide permeable pavement to reduce runoff, improve water quality and sustain groundwater 7. Use plants and groundcovers in place of turfgrass to reduce the need for unnecessary irrigation, fertilizer application and pesticide application which may negatively impact groundwater and surface water quality. This practice is especially critical for steep slopes or soils with limited infiltration capacity.	Highly variable, Estimate per yard: 10-50	Highly variable, Estimate per yard: 0.003-0.015

5.4.1 Minimizing the Impact of Future Development

The location of development within the watershed and the design of individual developments and subdivisions will determine the effect of future development on Rust Pond. Local zoning and land use regulations should be evaluated to determine if revisions are needed to prevent sprawling development from occurring throughout the watershed and encourage (or require) more environmentally-friendly site design, including improved on-site stormwater management, for new development. See Appendix 29 for a comparison of water quality sensitive zoning requirements for Wolfeboro, New Durham compared to existing state regulations.

Sprawling development across a watershed increases run-off pollution and poses a significant threat to the continued health of a waterbody. Low-density, large-lot development results in more clearing and land disturbance and generates more impervious cover per household and per person than clustering and village development. Local zoning and land use regulations should encourage new development within or close to existing developed areas and allow for clustering and higher-density, mixed-use village type development in areas where the impacts to natural resources and the community will be minimized. Local zoning should restrict development near surface waters and sensitive resources, especially small streams and wetland systems.

In addition, new developments should be encouraged (or required) to implement the practices of conservation design, which reduce impervious cover, protect sensitive resources, and better maintain the natural hydrology of the landscape. Conservation design not only reduces potential impacts on water resources, but also ensures that the new development is consistent with the broader environmental and social goals of the community. These principles can be applied when developing a land use plan for a community or watershed, to subdivision plans, and to individual residential, commercial and industrial sites.

5.4.2 Shoreland Protection

The theme throughout this study has been that activities taking place within the watershed affect the quality of the lake and other downstream surface waters. Evaluating this theory on a closer level, it should be evident that activities that take place directly adjacent to the lake acutely affect water quality (for both overland flow and tributary flow). The

Comprehensive Shoreland Protection Act (CSPA) establishes guidelines for activities taking place within 250 feet of the high water line of the lake (or the elevation of the top of the dam), commonly called “the protected shoreland.” The activities addressed within these rules include building, development, and forestry activities, to name a few. A complete copy of “The Protected Shoreland” guide to the Comprehensive Shoreland Protection Act can be found online at *www.des.state.nh.us*, or can be purchased through the NHDES Public Information Center at 603-271-2975. Shoreline residents of Rust Pond should be aware of the provisions in the Comprehensive Shoreland Protection Act.

It has been shown that maintaining or establishing a well-vegetated buffer along a water body can minimize erosion and nutrient inputs from the land surrounding the lake. In addition, establishing building and accessory structure setbacks allows for a buffer of natural land surrounding the lake for infiltration and uptake of nutrients prior to their entering the lake. Since a lot of the shoreline area is already developed, maintaining the trees that are still standing is now critical.

Residents of shoreline areas should be encouraged to maintain a healthy, well-distributed stand of trees, shrubs, and groundcovers. These plants not only serve to take up nutrients and stabilize soils, but they also provide privacy and shade. Appendix 30 provides a list of trees, shrubs and groundcovers native to New Hampshire.

5.4.3 Zoning

Impacts from development can be reduced through the establishment of appropriate zoning ordinances. The purpose of a zoning ordinance is to regulate the use of land in a manner that promotes the health and welfare of a municipality. It includes requirements to lessen congestion in the streets, secure safety from fires, panic and other dangers, and to prevent detrimental environmental impacts from development. Ordinances are primarily designed to provide adequate infrastructure to meet municipal needs for such services as transportation, solid waste facilities, water, sewerage, schools and parks. Zoning ordinances can also be used to provide greater protection of important natural resources.

Some towns have established ordinances that pertain directly to surface water protection. These may include ordinances to protect special or unique natural resources throughout the community, like a wetlands ordinance, or identify a specific area warranting greater protection. The Towns with the largest land holdings in the Rust Pond watershed, Wolfeboro and New Durham have a mostly rely on state regulations to guide them with land use planning with respect to water quality. However, New Durham's draft master plan has proposed several measures to increase water quality protections beyond state regulations. With that said, all towns within the watershed should look at establishing or improving their stormwater ordinances. Improving stormwater ordinances could greatly benefit water quality. Without these improvements, water quality could slowly decline, resulting in significant costs to the community and municipality to reverse declining water quality trends and restore lost water uses.

The Towns of Wolfeboro and New Durham should strongly consider establishing an environmental protection overlay or watershed district to provide greater protections for Rust Pond. Grants may be available to aid towns in these activities.

Many cities and towns have chosen to use overlay zones or districts to protect valuable water resources. An overlay zoning district is a district that is applied on top of the existing district in a particular area. It can either add or remove restrictions in the underlying area; in the case of shoreland or surface water protection districts, it usually adds restrictions.

Overlay districts in other cities or towns could serve as a starting point for establishing such protection around Rust Pond. The towns of Sunapee and New London have watershed overlay districts written into their zoning code. Sunapee, New Hampshire has designated all lands within 300' of lakes and ponds greater than 10 acres as part of its Shoreline Overlay District. Junkyards, waste facilities, and fertilizer are prohibited within the district. The town also requires erosion and sedimentation control plans for any construction within the district and has set a "natural woodland buffer" within 150' of shoreline where any cutting or clearing is subject to specific restrictions. Details of Sunapee's zoning code can be found at http://www.town.sunapee.nh.us/Pages/SunapeeNH_ZBA/ordinance. See section 4.33- Shorelines, Specific Provisions.

The town of New London has a shoreland overlay district protecting 300' inland from its lakes and ponds. The zoning code specifies minimum setbacks from shore, requires erosion and sedimentation control plans for any construction, and sets limits on beach replenishment. Article XVI of New London's code describes its shoreland overlay regulations: http://www.nlnh.com/vertical/Sites/{26F9F697-D5BE-4423-95D7-E1EECBB7F549}/uploads/{5E3671E0-266A-4B3E-9C6B-701513698C0E}.PDF

Two other towns in NH have recently put a lot of effort into changing their zoning ordinances to protect their waterbodies. Appendix 31 has copies of the zoning ordinance overlays for the towns of Deering and Franklin, New Hampshire

Cities and towns in other states have also incorporated shoreland protection into their zoning code. The city of Big Lake, Minnesota has a shoreland management overlay district for the purpose of "providing for the wise utilization of shoreland areas in order to preserve the quality and natural character of these protected waters of the City," as stated in the city code. The city has outlined what development uses are permitted within the shoreland overlay district and what additional measures must be taken to protect the water body in question. Commercial planned unit developments are prohibited within the shoreland overlay district and any industrial or semi-public developments without water-oriented needs (such as boat rental businesses) must not be located directly on the waterfront. Agricultural use is permitted within the overlay district, but the city requires that any steep slopes or shore impact zones be maintained with permanent vegetation to prevent erosion and runoff. Any steeply sloped areas within the overlay district must be examined by the zoning administrator before being approved for any type of construction or development.

Additionally, there are restrictions on vegetative clearing in the overlay zone, and all roads and parking areas and any construction activities must be designed to limit erosion and runoff to waterbodies. Zoning requirements in the overlay district also subject proposed septic system sites to strict evaluation with an eye to possible water contamination. Details of the Big Lake shoreland management overlay district can be found in Chapter 10, section 1065 of the code of the City of Big Lake: http://www.biglakemn.org/city_code/2004%20Master%20Adobe%20Format/Chapter%2010%20Zoning/ZO%2065%20SHORELAND.pdf.

The city of Plymouth, Minnesota has a shoreland overlay district similar to that of Big Lake that also specifies lot size and minimum setback requirements for buildings, roads, and septic systems within the overlay district, as well as setting limits on the percentage of impermeable surface of each lot. To read Plymouth's regulations go to: http://www2.ci.plymouth.mn.us

/pls/cop/docs/FOLDER/CITY_GOV/CG_ZONE/ZONING_TOC/21665-SHORELAND_ MANAGEMENT_OVERLAY_DISTRICT.PDF.

While none of these examples are comprehensive, they may provide helpful suggestions for what types of protection can be included in shoreland overlay zoning. Town planning boards and lake associations should always refer to the Comprehensive Shoreland Protection Act to ensure that proposed zoning regulations comply with its requirements.

For additional guidance on implementing shoreland protection zoning, the Wisconsin Lakes Partnership has published a series of fact sheets pertaining to zoning ordinances and shoreland management. These can be found at http://www.uwsp.edu/cnr/uwexlakes/ FactSheetList.htm.

Maintaining permeable areas, forested and ground cover buffers, and keeping lawns and paved areas to a minimum are critical in maintaining the health of the lake. Zoning ordinances and overlay districts should be created or expanded in ways that are consistent with the provisions of the Shoreland Protection Act and with new and innovative Smart Growth and Low Impact Development planning. It is recommended that the Rust Pond Association and the Town of Wolfeboro designate a subcommittee to investigate options for developing town and watershed wide zoning overlays and districts that are consistent around the lake.

This subcommittee should use plans that are already established as guidelines when formulating appropriate zoning and overlay districts for the watershed area of Rust Pond. Examples and references cited in this section are a good start for the committee.

5.5 Beach Erosion

Sand beaches are potentially damaging to the lake due to the filling in of shoreline habitat and the introduction of nutrients into the lake (phosphorus binds to sediment particles). There are several beaches on Rust Pond that are likely replenished with fresh sand, due to the grade steepness, exposure to stormwater runoff and no or inadequate vegetative shoreline buffers separating the beach area from the pond. Figure 5-6 shows beach erosion occurring at several sites on Rust Pond. Shallow areas newly created by beach erosion allow for greater areas of sunlight penetration, and may also encourage even more abundant plant establishment along the shoreline areas of the lake.

Areas of the lakebed near eroding beaches often show signs of sedimentation. Fresh sand is easy to identify on the lakebed, as it appears cleaner (less organic build-up) than surrounding bottom sediments. As new layers of sand cover shoreline habitat, macroinvertebrate communities, fish spawning areas, and amphibian habitat may be covered or destroyed. In addition, ambient water temperatures may be altered, forcing many water dependent species, including birds, fish and macroinvertebrates to find refuge elsewhere.

Figure 5-6: Rust Pond Beaches. Several beaches along the Rust Pond shoreline have inadequate measures to prevent erosion of sand into Rust Pond.

The removal of constructed beaches and replacement with a natural vegetated buffer of native trees shrubs and groundcovers would have the greatest beneficial impact to the water quality of Rust Pond. However, reconstructing existing beaches in conformance with a perched beach design can limit the erosion of sand into the Pond. By installing a permitted perched beach with a diversion trench along the upper limit of sand, overland runoff is diverted around a sloping beach, and rocks or vegetation placed at the toe of the slope prevent direct washing of the sand to the lake. The beach slope may also be reduced allowing infiltration of rain and melt water directly into the soil, reducing runoff and erosion potential. The NHDES Wetlands Bureau has guidelines for establishing perched beaches to reduce the likelihood of erosion and sedimentation (Appendix 32). The Wetlands Bureau not only requires permits for beach construction and replenishment, but also restricts the time interval between beach replenishments to once every 6 years. If beach replenishment is being considered, it is likely that the previous beach supply of beach sand is likely in the pond.

5.6 In-Lake Management - Phosphorus Inactivation

Thankfully, phosphorus inactivation is not necessary for Rust Pond since excessive internal phosphorus loading is not currently a problem in the pond. However, if watershed sources of sediment and phosphorus discharging to the pond are not addressed, phosphorus inactivation may be a necessary lake restorative technique to consider. Unfortunately, phosphorus activation is costly and can only be supported following the reduction of watershed sources of phosphorus to pre-development or low-level impact conditions, to prevent the potential for future internal phosphorus loading.

Phosphorus precipitation and sediment inactivation through aluminum salts injection are lake restoration techniques that reduce phosphorus concentrations and thereby limit the growth of algae. Sediment phosphorus inactivation results in longer-term lake quality improvement when compared to water column precipitation. Sediment inactivation is particularly useful in accelerating lake improvement in those areas where internal phosphorus loading contributes a significant portion of the nutrient budget. It is also important to note that all watershed sources of phosphorus must be reduced or eliminated prior to the use of this technique. Watershed inputs that are high in nutrients would only counteract the goal of phosphorus control from within the lake.

Some of the benefits of aluminum salts injection include the reduction of in-lake phosphorus concentration and internal loading, increased transparency, and reductions in algal abundance.

Some potential drawbacks of this procedure deal with the chemistry of the compounds being added. In lakes with low buffering capacity (low ANC), small doses of aluminum sulfate can exhaust the buffering capacity to a point that causes lake pH to fall below 6.0. When this happens, aluminum may be released from the compound, causing aluminum toxicity to occur. There are methods to ameliorate this potential, which involve adding salts to buffer the acidity.

A local example of such a treatment is Kezar Lake, North Sutton, New Hampshire. Lyon Brook, the main tributary to Kezar Lake, received a high phosphorus load from the discharge of treated sewage effluent from the now defunct New London Sewage Treatment Facility (Connor, 1983). After elimination of the treated wastewater discharge, aluminum sulfate and sodium aluminate were used as sediment phosphorus inactivants to improve lake quality (Connor, 1986). The treatment occurred during June of 1984. A four-year monitoring program provided an extensive lake database to evaluate the short-and-long-term effectiveness of sediment phosphorus inactivation as a lake restoration technique (Connor and Martin, 1989, Connor and Smagula, 2000). An immediate impact of treatment was a reduction in the depletion of oxygen in the hypolimnion, resulting in the maintenance of oxygen in the hypolimnion, a decrease in algal abundance (measured by chlorophyll-a concentrations), improved transparency, a shift from cyanobacteria dominance to species of algae typical to lakes and ponds in New Hampshire and an increase of trophic status from eutrophic to mesotrophic. No negative impacts to lake organisms or lake chemistry were detected in the post-treatment monitoring program (Connor and Smagula, 2000). Now, nearly twenty years later, the lake is still showing signs of good water quality.

If Aluminum salts treatment for Rust Pond were necessary, it would cost approximately $70,000- $100,000.

5.7 Other Considerations

5.7.1 Aquatic Plant Management

As indicated in Chapter 4.0 of this report, aquatic plants are rated as “sparse.” For the most part, aquatic vegetation can be found along limited segments of the pond shoreline, with sparse mixes of emergent, floating and submergent vegetation. Due to limited plant growth aquatic plant management is unnecessary.

It should be remembered, that nutrients are constantly being supplied to the lake, and these nutrients are used by both plants and algae. In addition, drastic changes in lake community components should be avoided. Removal of large amounts of plants and their nutrient uptake functions may shift the plant dominance in the lake over to algae, causing decreased clarity and algae blooms. If plant removal is considered, controlled removal of plants, on a schedule that allows a few years in between each management practice, is the best for the lake. Lastly, permits are needed by the Department of Agriculture for any herbicide control of plants, and permits from the NHDES Wetlands Bureau are needed for any physical removal of plants in a lake or pond.

The lake association and lake residents should continue to be active in the volunteer Weed Watcher Program offered by NHDES. This program involves a once a month survey of the shallow areas of the lake for growths of any exotic plants, such as milfoil. The surveys should be conducted from late May through the end of September. There is no way to eradicate exotic plants once they find their way into a lake or pond, but it is easier to manage them if they are identified early, should they be introduced.

5.7.2 Public Education

The Rust Pond Association should continue with their efforts aimed at educating pond and watershed residents and transient pond users. This education program should be expanded to encompass residents within the entire watershed, specifically targeting developed areas adjacent to surface waters. The ultimate goal of this type of program is to reduce the amount of nonpoint source pollution within the watershed and to eliminate the effects of cultural eutrophication upon Rust Pond. Pollution prevention is much less costly than rehabilitation and remediation techniques.

Given a choice and a better understanding of the consequences of their actions, most people will opt to improve their environment. If all residents of the Rust Pond watershed could enjoy the benefits of a choice recreational resource, they would likely take a greater interest in protecting water quality.

The lake association is a valuable and effective vehicle for conveying information to the residents and transient population of the Rust Pond watershed. The existing infrastructure and long term goals of the Rust Pond Association will coincide with the recommendations for public education outlined in this study and should include the following:

- Continuation of Rust Pond Association sponsored activities revolving around public education as it pertains to shoreland protection, watershed management and lake ecology. Other lake associations have developed folders or binders of information which are distributed to lakeshore residents. These folders contain fact sheets, laws and regulations dealing with Subsurface Bureau Rules, Shoreland Protection Rules, Wetlands Bureau rules, and other pertinent information.

- Continued participation in an organized volunteer monitoring program and the Weed Watcher Program.
- The town of Wolfeboro should encourage their elementary and secondary schools to participate in the NHDES Interactive Lake Ecology program. This program is designed to educate the young on principles of lake ecology and preservation of these resources, ensuring that the future residents of the area have the necessary education to safeguard their water resources.
- Promote the use of new technology efficient marine engines
- Obtain grant money or other funds to purchase and distribute low flow showerheads to residents adjacent to the lake.
- Establish a shoreland vegetation program to promote a well-vegetated buffer of native plant species along shorelines. Perhaps the lake association can work with local garden centers to establish a list of stocked or available native plants, and work on an annual plant sale for the Rust Pond watershed.
- Seasonal to year-round residence conversions on Rust Pond, coupled with the increasing utilization of the lake, necessitate a comprehensive educational program within the Rust Pond watershed. Implementation of the recommendations listed above will act to mitigate nonpoint source pollution around Rust Pond and reduce the impacts of cultural eutrophication.

5.7.3 Future Monitoring

Because the study was conducted during a confined time frame, only a representative data set could be collected for that period in time. Water chemistry, physical conditions, and biology can vary between seasons, between weather events, with development, and with time.

Residents, biologists, and the community as a whole must understand and document watershed and lake activities occurring throughout the watershed. Any water quality trends occurring within the pond will only be documented through continued watershed and pond monitoring.

Recommendations for Monitoring

- Continue monitoring the lake each spring and summer with an organized volunteer lake monitoring program. Continuous data over a long period of time enable scientists to determine realistic trends in the watershed and the lake. These trends may occur from year to year, or may occur over many years. Rust Pond has been monitored regularly for nearly 20 years, and this monitoring program should be continued in the future.
- Consider establishing staff gauges at each tributary and develop stage-discharge relationships for stream flow. Flow information with pollutant concentration will allow pollutant discharges to be evaluated. Pollutant load trends are more useful than pollutant concentration trends for evaluating long-term data sets.
- Encourage more lake residents to become volunteer Weed Watchers. Long-term records of plant growth (both native and exotic) can be valuable tools in tracking the aging of a lake.

5.8 Lake and Watershed Projects- Assistance and Funding

To implement some of the recommendations of this report, alternative funding sources may be required. While federal funding that supports the NHDES Nonpoint Source (NPS) Local Initiative Grant Program has decreased in recent years, this program still remains as the most viable funding source for implementation and/or further watershed assessment. This NHDES administered program is the result of Clean Water Act, Section 319 (h) nonpoint source funding provided by the United States Environmental Protection Agency (USEPA).

The NPS Local Initiative Grant Program is available to municipalities, regional planning agencies, non-profit organizations and conservation districts, and can be used to address nonpoint source issues ranging from contaminated storm water runoff to streambank erosion to watershed planning. In order to apply for the grant program, you must submit a proposal that meets the requirements of the annual Request for Pre-Proposal, which historically has been issued in early September with a deadline of October. Applications are reviewed, interviews held and final projects selected to complete full proposals. While the requirements may change, presently applicants need to meet two key criteria:

1. 40 percent of the total project expense must be provided by the applicant

This 40% soft match can include volunteer time, town employee time, donated materials, etc. For example, the lake association or town Conservation Commission could submit a NPS Local Initiative proposal for storm event monitoring to identify pollution sources. The proposal could be crafted so that 60 percent of the total funding amount could pay for sample analysis, and the remaining soft match could be the volunteer time (presently valued at $17.19/hr) used to collect the samples.

2. Projects should indicate a clear path towards implementation

This simply means the applicant has to outline the schedule for the project from start to finish. Using the above example, the applicant would provide estimated dates for recruiting and training of volunteers, when the sampling window would be*, and when the final report would be submitted to the DES. (**Note: Since the theoretical proposal would include a monitoring component, a Quality Assurance Project Plan would have to be submitted and approved by the USEPA prior to commencement of monitoring).*

The NPS Local Initiative Grant Program is the logical next step to help protect Partridge Lake. The Biology Section of NHDES has a staff person designated to assist lake associations and communities in the development and submittal of grant proposals, and assist with the implementation of grants that are awarded. Please contact the Clean Lakes Program/ NPS Program Coordinator at 603-271-5334 if you are interested in pursuing water quality improvement funds through the NPS Local Initiative Grant Program.

Rust Pond and Watershed Diagnostic Study
Bibliography

Burns, N.M. 1970. Temperature, Oxygen and Nutrient Distribution Patterns in Lake Erie. J. Fish Res. Board Can. 33:485-511.

Carlson, R.E. 1977. Trophic State Index for Lakes. Limnol. Oceanogr. 22:361-369.

Connor, J.N. and M. Bowser. 1997. Flints Pond Diagnostic and Feasibility Study. Final Report. New Hampshire Dept. Envir. Serv. NHDES-WD-1997-1.

Connor, J.N. and S. Landry. 1995. Pawtuckaway Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Division. Staff Report No. 95-2. 690 pp.

Connor, J.N. and M.R. Martin 1988. French and Keyser Ponds Diagnostic and Feasibility Study. New Hampshire Dept. Envir. Serv. Staff Report No. 157. 395 pp.

Connor, J.N., P.M. McCarthy and M. O'Loan. 1992. Mendums Pond Diagnostic/Feasibility Study. Final Report. New Hampshire Dept. Envir. Serv. NHDES-WSPCD-92-4.

Connor, J.N. and M. O'Loan. 1992. Beaver Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Division. Staff Report No. 92-15. 690 pp.

Connor, J.N. and A.P. Smagula. 2000. A Study of the Effectiveness, Longevity, and Ecological Impacts of Hypolimnetic Aluminum Injection in Kezar Lake, North Sutton, New Hampshire. Final Report. New Hampshire Dept. of Env. Svcs. NHDES-WD-00-2.

Connor, J.N. and G.N. Smith. 1983. Kezar Lake Diagnostic/Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Commission. Staff Report No. 35. 690 pp.

Connor, J.N. and G.N. Smith. 1986. An Efficient Method of Applying Aluminum Salts for Sediment Phosphorus Inactivation in Lakes. Water Resources Bull. 22(4): 661-664

Connor, J.N. and M.R. Martin. 1989. An Assessment of Sediment Phosphorus Inactivation, Kezar Lake, New Hampshire. Water Resources Bull. 25(4):845-853.

Connor, J.N. and M. O'Loan. 1992. Beaver Lake Diagnostic Feasibility Study. Final Report. New Hampshire Water Supply and Pollution Control Division. Staff Report No. 92-15.

Dillon, P.J. and F.H. Rigler. 1974. The Phosphorus - Chlorophyll Relationship in Lakes. Limnol.Oceangr. 18(5):767-773.

Edmondson, W.T., 1972. Nutrients and Phytoplankton in Lake Washington. P. 172-188. IN: G.E. Likens Nutrients and Eutrophication. Special Symposia Volume I. Amer. Soc. Limnol. Oceanogr.

Jones, R.A. and G.F. Lee. 1977. Septic Tank Disposal Systems as Phosphorus Sources for Surface Waters. EPA 600/3-77/129. 62 pp.

Knox, C.E. and T.J. Nordenson. 1955. Average Annual Runoff and Precipitation in the New England-New York Area. Hydrologic Invest. Atlas HA 7. U.S. Geol. Surv. 6pp.

Lakes Region Planning Commission. 1978. Lakes Region Water Quality Management Plan. Final Plan/EIS.

Lee, D.R. 1972. Septic Tank Nutrients in Groundwater Entering Lake Sallie, MN. Masters Thesis, Univ. Of North Dakota. 96 pp.

Lorenzen, M. and A. Fast. 1977. A Guide to Aeration/Circulation Techniques for Lake Management. EPA-600/3-77-044. 126 pp.

New Hampshire Water Supply and Pollution Control Commission. 1975. Nutrient Removal Effectiveness of A Septic Tank-Leaching Field System. Staff Report No. 65. State of New Hampshire. 145 pp.

New Hampshire Department of Environmental Services. 1996. Informational Resources Management Unit.

New Hampshire Department of Environmental Services. 1996. Quality of New Hampshire Lakes and Ponds. A Layman's Guide.

New Hampshire Office of State Planning. 1991. Squam Lakes Watershed Plan.

Normandeau Associates. 1975. Limnological Survey of Pleasant Lake, Deerfield, New Hampshire.

Rockingham County Conservation District. 1992. Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire. Prepared for NHDES in cooperation with USDA and SCS. 422 pp.

Scalf, M.R., W.J. Dunlap and J.F. Kreissl. 1977. Environmental Effects of Septic Tank Systems. EPA-600/3-77-096. 34 pp.

United States Environmental Protection Agency. 1980. Clean Lakes Program Guidance Manual. Washington, D.C. EPA-440/5-81-003. 148 pp.

Vollenweider, R.A. 1975. Input-output Models, with Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrologic. 37:53-84.

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Appendix One

Data Descriptions/ NH Data Ranges

Introduction to Limnological Data Ranges and Explanations

Lakes are important natural resources to both the citizens of New Hampshire and to its visitors. Lakes provide enjoyment through many recreational activities such as swimming, fishing, and boating. The people who utilize these lakes provide an important source of revenue for many New Hampshire communities and the State of New Hampshire. It must be realized that lakes are not unalterable systems. The natural lake aging process whereby a lake becomes enriched and gradually fills in can be greatly accelerated by the activities of people. It is extremely important that we all take the necessary steps to preserve New Hampshire's lakes and ponds as valuable recreational resources and to minimize our impacts on them. The Biology Bureau of the New Hampshire Department of Environmental Services, Water Division, serves an important role in the preservation of New Hampshire lakes by determining the condition of the lakes, by identifying problem areas and initiating corrective action, and by informing the public of its findings.

Considerable amounts of chemical and biological data have been collected from New Hampshire's lakes since 1975. A listing of the data most often sought by lake residents, lake associations, homebuyers and real estate professionals is presented here, and the sources and explanation of that data are itemized below. If you require additional information or just have a particular question, please feel free to call or write this office at 603-271-2963. Thank you for being concerned about the well-being of the quality of New Hampshire's lakes and ponds.

This report lists water quality data from 749 different lakes and ponds.

Sources and Explanation of Data

This section describes the lake quality data which follows. The sources of the data listed, or the methodologies of calculating those data, are outlined. Also, generalized explanations in layman's terms are provided for the data to assist the reader in understanding a particular lake or pond of interest.

LAKE

The name of the lake, pond, or reservoir, as listed in the New Hampshire State Planning Project publication (NHSPP, 1964). There may be alternate names used locally for a lake.

TOWN

The municipality in which the largest part of the waterbody is located, from NHSPP, 1964.

COUNTY

The county in which the waterbody (or largest portion) is located, from NHSPP, 1964.

AREA

The surface area of the lake to the nearest 0.1 acre, from NHDES, 1991.

ZMAX

The maximum depth, to the nearest 0.1 foot, found in the lake during the current survey. Prior to 1986 a field value was listed only if greater than any published historical value.

DATE

The date the summer field survey was conducted.

pH

A measure of the hydrogen ions in the water or, in general terms, the acidity. New Hampshire lakes historically have had pH values in the mid to upper sixes in most cases. As the pH decreases to between 5 and 6, many fish and other aquatic organisms become stressed, and some disappear. Little or no fish life remains when the pH falls much below 5.

Category	pH (units)
Acidified	<5
Critical	5.0 – 5.4
Endangered	5.5 – 6.0
Satisfactory	6.0 – 8.0

ALK

Alkalinity or acid neutralizing capacity (ANC) measures the buffering capacity of a lake to neutralize acid inputs. New Hampshire has historically had naturally low alkaline waters because of granitic bedrock. The median ANC for New Hampshire's lakes is only 4.9 mg/L.

Sensitivity Category	ANC (mg/L)
Acidified	<0
Critical	>0-2
Endangered	>2-5
Highly Sensitive	>5-10
Sensitive	>10-20
Not Sensitive	>20

COLOR

A visual measure of the color of water. This color is generally caused by naturally occurring metals in soils, such as iron and manganese, and by decaying organic matter. A highly colored lake generally has extensive wetlands along the shore or within the watershed, and often a mucky bottom. Color itself usually does not indicate the quality of a particular waterbody.

Apparent Color	Units
Clear	0-25
Light Tea-colored	25-40
Tea-colored	40-75
Highly Colored	>75

COND

Conductivity is a measure of the ability of water to conduct an electric current. It is determined primarily by the number of ionic particles present. The soft waters of New Hampshire have traditionally had low conductivity values. Specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations in conductivity. However, values in New Hampshire lakes exceeding 100 generally indicate cultural (man-made) sources of ions, such as salted highways and runoff from urbanized areas.

TP

A measure of all the phosphorus forms present in the water, including both inorganic and organic forms. This directly relates to trophic state and the perceived aesthetics of the lake or pond. Values less than 0.010 mg/L generally indicate oligotrophic waters, values greater than 0.020 mg/L indicate eutrophic waters, while mesotrophic conditions exist between these two values. Excessive amounts of total phosphorus may impair the aesthetics and recreational use of a waterbody by causing increased weed growth and obnoxious blooms of algae.

Category	TP (mg/L)
Low (good)	0.001-0.010
Average	0.011-0.020
High	0.021-0.040
Excessive	>0.040

CHL-A

Chlorophyll-a is a measure of the phytoplankton or algae biomass (abundance) found in lakes and ponds.

Category	Chlorophyll-a (mg/m^3)
Good	0-5
More Than Desirable	5.1-15
Nuisance Amounts	>15

SECCHI

A measure of water clarity or a measure of the distance one can see into the water. This depth is variable with weather conditions, suspended matter (usually algae) in the water and the eyesight of the observer. A 20 centimeter black and white disk (Secchi Disk) lowered into the water on a calibrated chain is used to estimate this depth.

Category	Transparency (m)
Poor	<1
Good	1-5
Exceptional	>5

PLANTS

A measure of the abundance of rooted (usually) aquatic plants in a lake. They can be found in most of the lakes and ponds in New Hampshire. Aquatic plants are a natural component and vital link to a healthy and diverse aquatic ecosystem. When aquatic plants interfere with man's activities, the plants are quickly designated "weeds." Complete eradication of native weeds is not recommended! Plant abundance in a lake is categorized using the following terms in order of relative abundance.

Abundance	Description
Sparse	Few emergent plants observed; submerged plants not obvious.
Scattered	Several small patches or 1 or 2 large patches or much of shoreline with a sparsely growing plant; submerged plants not obvious.
Scattered/Common	Intermediate between Scattered and Common.
Common	Plants around most of the shoreline but not a problem to navigation or several large patches of plants.
Common/Abundant	Intermediate between Common and Abundant.
Abundant	Plants around entire shoreline and with thick patches in some areas.
Very Abundant	At least 1/2 of the surface area with emergent plants or submerged plants thick throughout the lake; navigation and swimming impaired.

CLASS

Class is a designation of the trophic classification of a lake. New Hampshire's Trophic Classification System places lakes into similar groups according to algal production, weed growth, water clarity and bottom dissolved oxygen levels. A lake or pond can be placed in one of the following classes:

OLIGO - Oligotrophic lakes are usually nutrient poor and as a result do not support nuisance algae blooms and massive weed infestations. Aesthetically, these lakes are the best of the three ratings.

MESO - Mesotrophic is intermediate between an oligotrophic and eutrophic waterbody. Algal production is moderate. Phosphorus input and water clarity are also intermediate compared to the other two lake ratings. If the lake is abused it eventually may move into the eutrophic category.

EUTRO - Eutrophic lakes are characterized by high production of algae and aquatic weeds, which indicates that the system is receiving excessive amounts of phosphorus or nitrogen. Water clarity is reduced dramatically during algae blooms.

A BLANK entry under class indicates that sufficient data is not available to properly classify the pond.

BTTM DO

A measure of the dissolved oxygen concentration at the deepest point in the lake during the summer. Adequate dissolved oxygen is important for the ongoing survival of fish populations, especially cold-water species, such as trout and salmon. A full understanding of the significance of a given dissolved oxygen level to a lake is possible only if temperature data from that lake is known. Temperature data is not presented in this report.

Statistical Summary Information

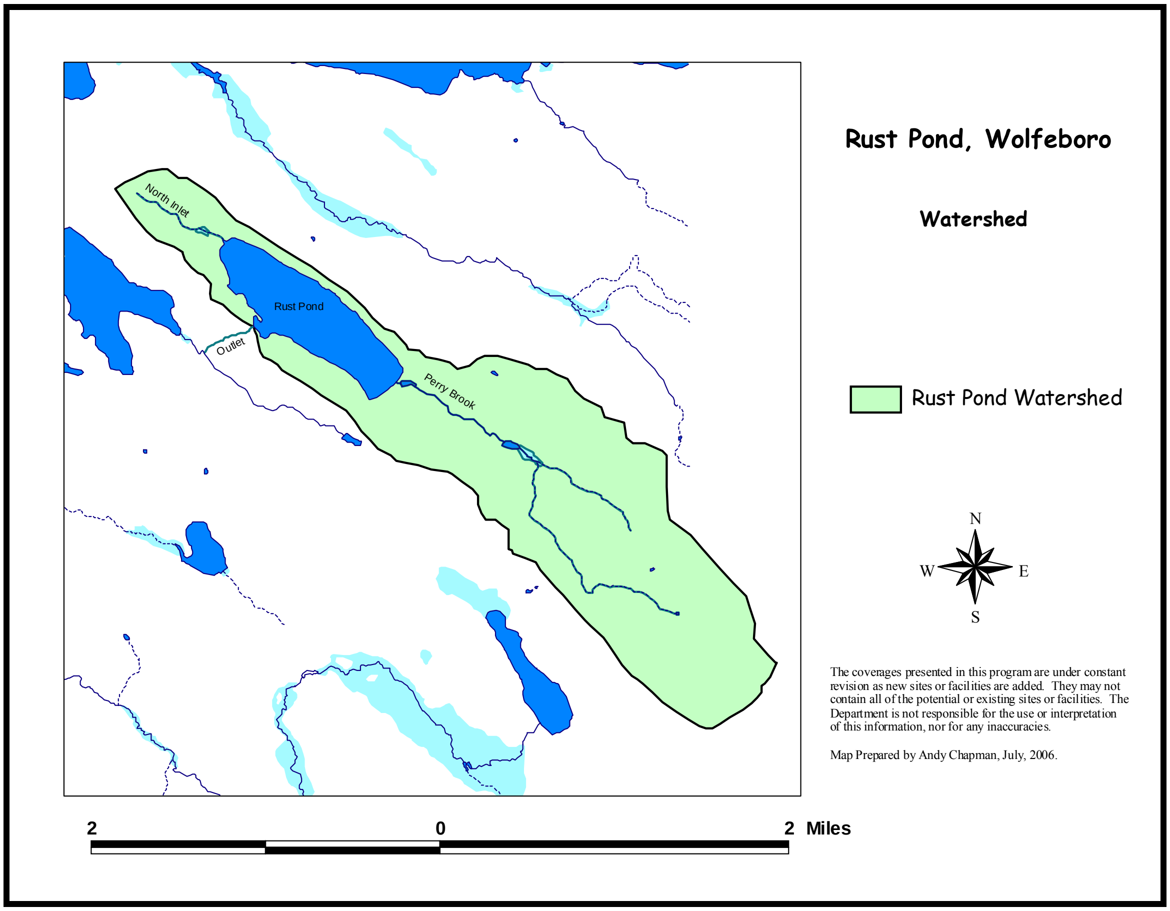
To provide an understanding of how a particular lake compares to other New Hampshire lakes, the following table summarized key biological and chemical parameters for all the state's lakes surveyed since 1975.

Parameter*	**Number**	**Min.**	**Max.**	**Mean**	**Median**
pH (units)	736	4.3	9.6	**6.5	6.6
Alkalinity	737	-3	77	6.4	4.8
Color (units)	718	<5	250	---	28
Conductivity (mhos/cm)	727	13.1	629	56.8	37.2
Total Phosphorus	729	<0.001	0.121	---	0.012
Chlorophyll-a (g/L)	732	0.19	143.8	7.4	4.51
Secchi Disk (ft.)	628	0.25	13.0	3.7	3.3

* All parameters in mg/L unless otherwise noted. ** True mean pH

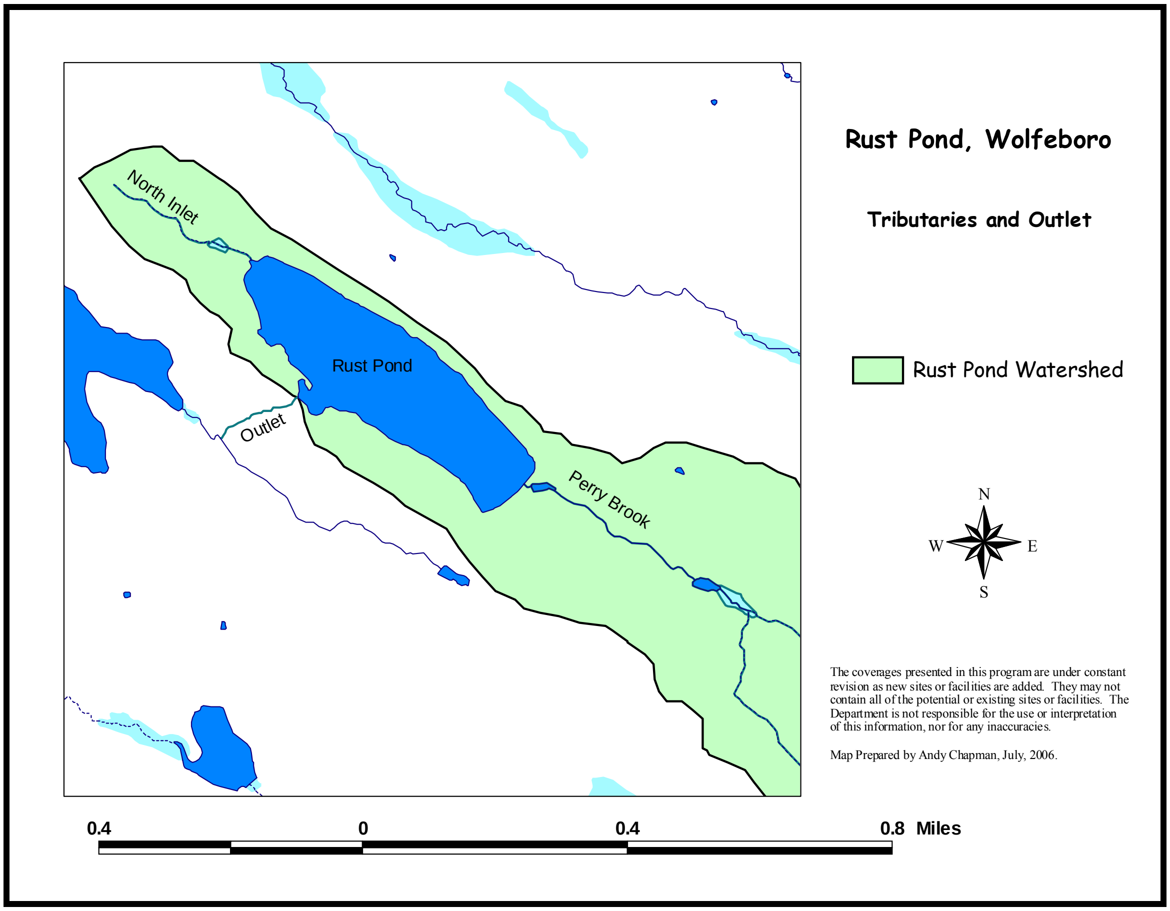
Appendix Two

Rust Pond Watershed Map



Appendix Three

Tributary and Outlet Map



Appendix Four

Hydrologic Budget Raw Data- Tributary and Outlet Flows

Date	Station	Gauge (ft)	Calculated Flow (cfs) from field
07/03/01	Boulder Brook	1.78	0.16
07/03/01	North Inlet	1.46	0.35
07/03/01	Outlet	0.98	1.43
07/03/01	Perry Brook	1.60	2.32
08/21/01	Boulder Brook	0.60	0.01
08/21/01	North Inlet	1.28	0.05
08/21/01	Outlet	0.67	0.28
08/21/01	Perry Brook	1.48	0.50
10/04/01	Boulder Brook	1.50	0.10
10/04/01	North Inlet	1.18	0.48
10/04/01	Outlet	1.20	3.98
10/04/01	Perry Brook	1.38	0.90
11/29/01	Boulder Brook	1.38	0.03
11/29/01	North Inlet	0.90	0.15
11/29/01	Outlet	1.16	0.75
11/29/01	Perry Brook	1.18	0.68
12/27/01	Boulder Brook	1.40	0.01
12/27/01	North Inlet	1.00	0.21
12/27/01	Outlet	1.24	2.33
12/27/01	Perry Brook	1.24	0.72
02/22/02	Boulder Brook	NR	NR
02/22/02	North Inlet	NR	0.48
02/22/02	Outlet	1.22	4.04
02/22/02	Perry Brook	1.00	2.50
05/17/02	Boulder Brook	NR	NR
05/17/02	North Inlet	1.80	1.80
05/17/02	Outlet	1.53	5.72
05/17/02	Perry Brook	1.70	4.14
06/26/02	Boulder Brook	1.74	0.10
06/26/02	North Inlet	1.38	0.27
06/26/02	Outlet	0.98	2.19
06/26/02	Perry Brook	1.29	2.58
07/22/02	Boulder Brook	NR	NR
07/22/02	North Inlet	1.18	NR
07/22/02	Outlet	0.64	0.32
07/22/02	Perry Brook	1.17	0.72
08/28/02	Boulder Brook	1.30	NR
08/28/02	North Inlet	0.90	0.03
08/28/02	Outlet	NR	NR
08/28/02	Perry Brook	1.00	0.4

Appendix Five

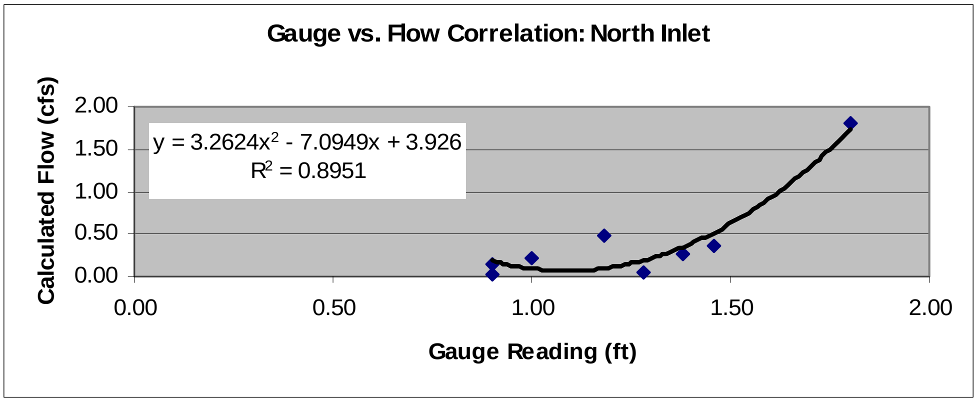
Hydrologic Budget Raw Data- Tributary and Outlet Gage Readings

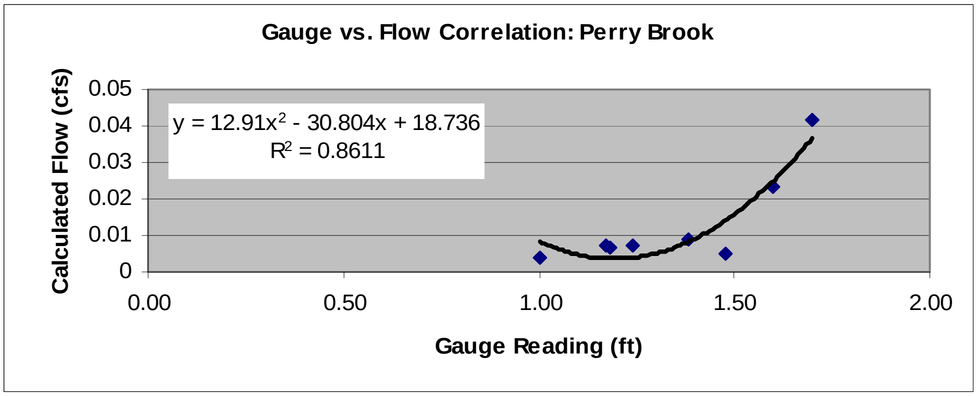
Date	Station	Gauge (ft)
7/12/2001	North Inlet	1.52
7/19/2001	North Inlet	1.58
7/25/2001	North Inlet	1.50
8/2/2001	North Inlet	
8/8/2001	North Inlet	1.38
8/15/2001	North Inlet	1.30
8/29/2001	North Inlet	1.20
9/3/2001	North Inlet	1.20
9/10/2001	North Inlet	1.18
9/18/2001	North Inlet	1.14
9/26/2001	North Inlet	
10/3/2001	North Inlet	1.03
10/10/2001	North Inlet	
10/17/2001	North Inlet	0.98
10/24/2001	North Inlet	0.96
10/31/2001	North Inlet	0.92
11/7/2001	North Inlet	0.97
11/14/2001	North Inlet	0.91
11/21/2001	North Inlet	0.88
12/16/2001	North Inlet	1.00
1/16/2002	North Inlet	1.00
2/11/2002	North Inlet	1.11
3/12/2002	North Inlet	1.41
4/10/2002	North Inlet	1.70
5/24/2002	North Inlet	1.62
6/24/2002	North Inlet	1.40
7/12/02	North Inlet	1.24
7/26/2002	North Inlet	1.20
8/8/2002	North Inlet	1.08
8/21/2002	North Inlet	0.98
9/4/2002	North Inlet	0.96
9/17/2002	North Inlet	0.97
7/12/2001	Perry Brook	1.68
7/19/2001	Perry Brook	1.73
7/25/2001	Perry Brook	1.64
8/2/2001	Perry Brook	1.58
8/8/2001	Perry Brook	1.55
8/15/2001	Perry Brook	1.48
8/29/2001	Perry Brook	1.42
9/3/2001	Perry Brook	1.51
9/10/2001	Perry Brook	1.48
9/18/2001	Perry Brook	1.38
9/26/2001	Perry Brook	1.38
10/3/2001	Perry Brook	1.40
10/10/2001	Perry Brook	1.31
10/17/2001	Perry Brook	1.20

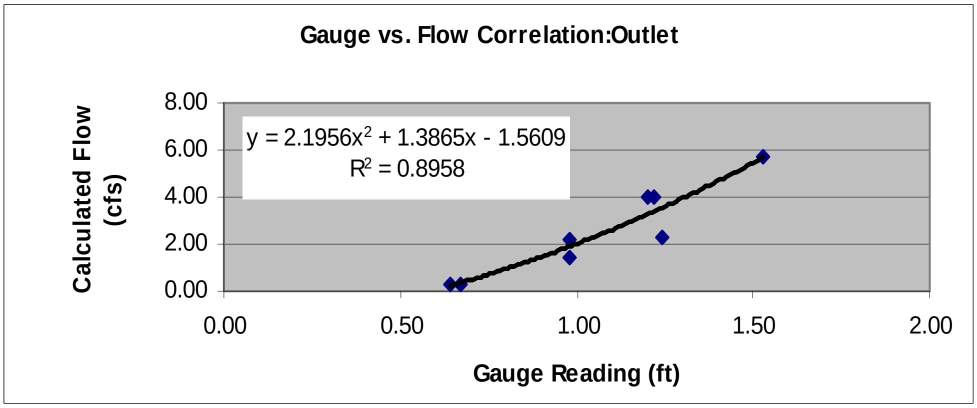
Date	Station	Gauge (ft)
10/24/2001	Perry Brook	1.15
10/31/2001	Perry Brook	1.10
11/7/2001	Perry Brook	
11/14/2001	Perry Brook	1.05
11/21/2001	Perry Brook	1.00
12/16/2001	Perry Brook	1.25
1/16/2002	Perry Brook	1.15
2/11/2002	Perry Brook	1.10
3/12/2002	Perry Brook	1.34
4/10/2002	Perry Brook	1.72
5/24/2002	Perry Brook	1.80
6/24/2002	Perry Brook	1.31
7/12/02	Perry Brook	1.18
7/26/2002	Perry Brook	1.17
8/8/2002	Perry Brook	1.22
8/21/2002	Perry Brook	1.05
9/4/2002	Perry Brook	0.96
9/17/2002	Perry Brook	0.96
7/12/2001	Outlet	1.04
7/19/2001	Outlet	1.14
7/25/2001	Outlet	1.06
8/2/2001	Outlet	0.98
8/8/2001	Outlet	0.80
8/15/2001	Outlet	0.58
8/29/2001	Outlet	0.46
8/29/2001	Outlet	
9/3/2001	Outlet	0.54
9/10/2001	Outlet	0.74
9/18/2001	Outlet	0.60
9/26/2001	Outlet	0.98
10/3/2001	Outlet	1.22
10/10/2001	Outlet	1.10
10/17/2001	Outlet	
10/24/2001	Outlet	1.00
10/31/2001	Outlet	
11/7/2001	Outlet	1.05
11/14/2001	Outlet	0.98
11/21/2001	Outlet	0.80
12/16/2001	Outlet	1.20
1/16/2002	Outlet	1.20
2/11/2002	Outlet	1.25
3/12/2002	Outlet	1.20
4/10/2002	Outlet	1.56
5/24/2002	Outlet	1.75
6/24/2002	Outlet	0.97
7/12/02	Outlet	0.68
7/26/2002	Outlet	0.62
8/8/2002	Outlet	0.48
8/21/2002	Outlet	0.42
9/4/2002	Outlet	0.40
9/17/2002	Outlet	0.40

Appendix Six

Hydrologic Budget Tributary and Outlet Stage-Discharge Relationships







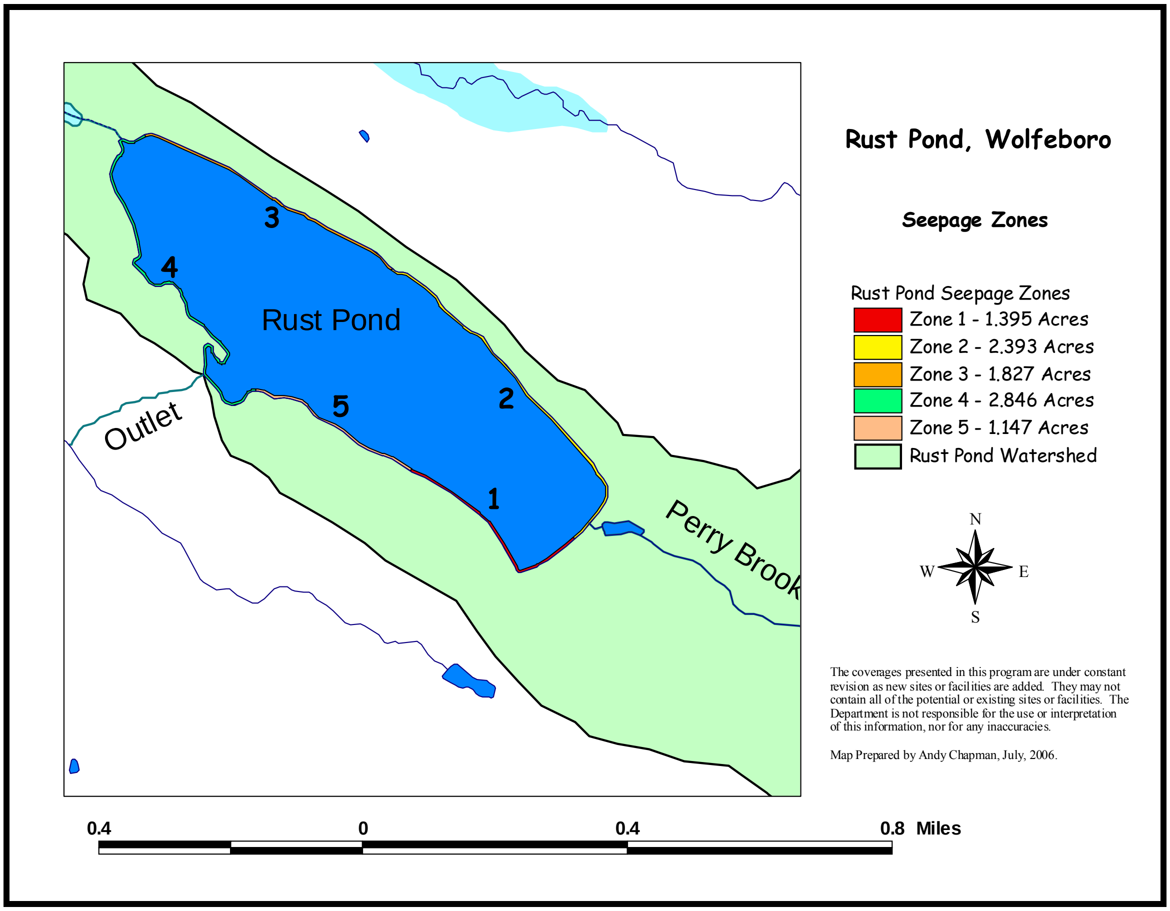
Appendix Seven

Hydrologic Budget Summary- Tributary and Outlet Flows

Tributary	*Year*	*Month*	*Avg. Flow (cfs)*	*Avg. Flow (m3/s)*	*Avg. Flow (m3/d)*	*#d/ month*	*Flow (m3/mo)*	*Flow (103m3)*	*Yearly Sum (103m3)*	*Annual Monthly Average (103m3)*
North Inlet	2001	July	0.63	0.02	1520.20	31	47126.31	47.13		
North Inlet	2001	August	0.18	0.01	437.88	31	13574.40	13.57		
North Inlet	2001	September	0.09	0.00	229.17	30	6875.10	6.88		
North Inlet	2001	October	0.15	0.00	367.72	31	11399.27	11.40		
North Inlet	2001	November	0.09	0.00	217.73	30	6531.84	6.53		
North Inlet	2001	December	0.14	0.00	338.69	31	10499.33	10.50		
North Inlet	2002	January	0.07	0.00	169.34	31	5249.66	5.25		
North Inlet	2002	February	0.07	0.00	169.98	28	4759.52	4.76		
North Inlet	2002	March	0.41	0.01	987.44	31	30610.67	30.61		
North Inlet	2002	April	1.29	0.04	3128.04	30	93841.20	93.84		
North Inlet	2002	May	1.40	0.04	3379.75	31	104772.22	104.77		
North Inlet	2002	June	0.33	0.01	795.24	30	23857.33	23.86	359.10	29.92
Perry Brook	2001	July	3.19	0.09	7720.91	31	239348.29	239.35		
Perry Brook	2001	August	1.45	0.04	3508.07	31	108750.04	108.75		
Perry Brook	2001	September	1.18	0.03	2846.65	30	85399.51	85.40		
Perry Brook	2001	October	0.57	0.02	1384.27	31	42912.39	42.91		
Perry Brook	2001	November	0.47	0.01	1128.96	30	33868.80	33.87		
Perry Brook	2001	December	0.56	0.02	1358.23	31	42105.12	42.11		
Perry Brook	2002	January	0.36	0.01	870.91	31	26998.27	27.00		
Perry Brook	2002	February	0.36	0.01	870.91	28	24385.54	24.39		
Perry Brook	2002	March	0.64	0.02	1547.89	31	47984.63	47.98		
Perry Brook	2002	April	3.95	0.11	9546.32	30	286389.54	286.39		
Perry Brook	2002	May	4.63	0.13	11197.51	31	347122.78	347.12		
Perry Brook	2002	June	0.54	0.02	1300.59	30	39017.66	39.02	1324.28	110.36
Outlet	2001	July	2.23	0.06	5403.71	31	167514.88	167.51		
Outlet	2001	August	0.63	0.02	1519.26	31	47097.11	47.10		
Outlet	2001	September	0.66	0.02	1593.87	30	47815.99	47.82		
Outlet	2001	October	3.01	0.08	7270.11	31	225373.46	225.37		
Outlet	2001	November	1.73	0.05	4173.59	30	125207.69	125.21		
Outlet	2001	December	2.80	0.08	6767.18	31	209782.72	209.78		
Outlet	2002	January	3.26	0.09	7897.63	31	244826.63	244.83		
Outlet	2002	February	3.82	0.11	9244.79	28	258854.16	258.85		
Outlet	2002	March	3.26	0.09	7897.63	31	244826.63	244.83		
Outlet	2002	April	5.95	0.17	14382.75	30	431482.62	431.48		
Outlet	2002	May	6.65	0.19	16099.17	31	499074.31	499.07		
Outlet	2002	June	2.02	0.06	4886.60	30	146597.90	146.60	2648.45	220.70

Appendix Eight

Hydrologic Budget – Groundwater Seepage Zones Map



Appendix Nine

Hydrologic Budget Raw Data- Groundwater Flows

Date	Station	T beginning	T stop	FV* (mL)	Mean GW (mL) by station
6/26/2002	1 A	10:33:04	12:10:37	235	
8/27/2002	1 A	11:12:17	N/A	N/A	
9/11/2002	1 A	9:39:28	N/A	N/A	235.00
6/26/2002	1 B	10:39:08	12:12:28	395	
8/27/2002	1 B	11:13:16	12:37:56	210	
9/11/2002	1 B	9:39:54	10:38:50	180	261.67
6/26/2002	2	10:50:14	12:32:58	285	
8/27/2002	2	11:38:38	12:43:22	148	
9/11/2002	2	9:46:17	10:49:02	195	209.33
6/26/2002	3	MIA			
8/27/2002	3	11:56:25	12:58:50	162	
9/11/2002	3	9:54:36	11:26:34	270	216.00
6/26/2002	4	11:20:54	1:01:46	395	
8/27/2002	4	12:03:04	1:05:00	305	
9/11/2002	4	9:59:05	11:09:08	190	296.67
6/26/2002	5	10:23:48	11:30:29	235	
8/27/2002	5	11:00:59	12:29:12	242	
9/11/2002	5	9:29:19	10:54:44	330	269.00

Appendix Ten

Hydrologic Budget Estimated Data- Groundwater Flows

Station	Lake Seepage Area (ac) 25 ft. buffer	Lake Seepage Area (m2) 25 ft. buffer	Est. L/m2/d	Est. Lake Seepage (L/d)	Est. Lake Seepage ($10^3 m^3$/d)
1A	1.395	5645.37	12	67744.48	0.07
2	2.393	9684.14	12	116209.71	0.12
3	1.827	7393.62	12	88723.42	0.09
4	2.846	11517.37	12	138208.45	0.14
5	1.147	4641.75	12	55701.02	0.06
					0.47

Month/yr	days/month	Est. Lake Seepage ($10^3 m^3$/month)	Total Precip (in)	Precip Based Gwi Runoff to calc. overland RO ($10^3 m^3$)
July, 2001	31	14.46	2.76	13.76
August, 2001	31	14.46	0.72	3.59
September, 2001	30	14.00	4.03	20.09
October, 2001	31	14.46	1.25	6.23
November, 2001	30	14.00	1.26	6.28
December, 2001	31	14.46	2.93	14.61
January, 2002	31	14.46	2.14	10.67
February, 2002	28	13.06	2.69	13.41
March, 2002	31	14.46	3.68	18.35
April, 2002	30	14.00	3.90	19.44
May, 2002	31	14.46	4.09	20.39
June, 2002	30	14.00	4.71	23.48
		170.30	34.16	170.30

Appendix Eleven

Hydrologic Budget Summary- Direct Pond Wetfall

Lake Wetfall

Month	***Total Precip (in)***	***Total Precip (m)***	***Lake Precip (m^3)***	***Lake Precip (10^3 m^3)***	***Manipulated Lake Precip (10^3 m^3)***
Jul-01	2.76	0.07	67804.50	67.80	67.80
Aug-01	0.72	0.02	17688.13	17.69	17.69
Sep-01	4.03	0.10	99004.39	99.00	99.00
Oct-01	1.25	0.03	30708.56	30.71	30.71
Nov-01	1.26	0.03	30954.23	30.95	30.95
Dec-01	2.93	0.07	71980.86	71.98	71.98
Jan-02	2.14	0.05	52573.05	52.57	0.00
Feb-02	3.34	0.08	82053.27	82.05	0.00
Mar-02	3.68	0.09	90406.00	90.41	225.03
Apr-02	3.90	0.10	95810.70	95.81	95.81
May-02	4.09	0.10	100478.40	100.48	100.48
Jun-02	4.71	0.12	115709.85	115.71	115.71
Total	34.81	0.88	855171.93	855.17	855.17

Appendix Twelve

Hydrologic Budget Summary- Pan Evaporation

Pan Evaporation

Month	***Total Evap (in)***	***Total Evap (m)***	***Total Evap (m^3)***	***Evap ($10^3 m^3$)***	***Evap (103m3) * Pan Coef.***
Jul-01	4.70	0.12	115464.18	115.46	88.91
Aug-01	5.86	0.15	143961.72	143.96	110.85
Sep-01	3.73	0.09	91634.34	91.63	70.56
Oct-01	2.16	0.05	53064.39	53.06	40.86
Nov-01	0.00	0.00	0.00	0.00	0.00
Dec-01	0.00	0.00	0.00	0.00	0.00
Jan-02	0.00	0.00	0.00	0.00	0.00
Feb-02	0.00	0.00	0.00	0.00	0.00
Mar-02	0.00	0.00	0.00	0.00	0.00
Apr-02	1.80	0.05	44220.32	44.22	34.05
May-02	4.28	0.11	105146.10	105.15	80.96
Jun-02	3.81	0.10	93599.69	93.60	72.07
Total	26.34	0.67	647090.74	647.09	498.26

Appendix Thirteen

Hydrologic Budget Summary- Overland Flow

Month	Total Precip (in)	Total Overland Precip (10^3 m^3)	Overland and Gwi (0.62* Monthly Precip. (10^3m^3))	Overland Runoff Manipulated (10^3m^3)
Jul-01	2.76	88.43	54.83	41.07
Aug-01	0.72	23.07	14.30	10.71
Sep-01	4.03	129.12	80.05	59.96
Oct-01	1.25	40.05	24.83	18.60
Nov-01	1.26	40.37	25.03	18.75
Dec-01	2.93	93.88	58.20	0.00
Jan-02	2.14	68.56	42.51	0.00
Feb-02	2.69	86.19	53.44	0.00
Mar-02	3.68	117.91	73.10	170.22
Apr-02	3.90	124.95	77.47	58.03
May-02	4.09	131.04	81.25	60.86
Jun-02	4.71	150.91	93.56	70.08
Total	34.16	1094.48	678.58	508.27

Rust Overland WS Runoff Area (acres)	311.7
Rust Overland WS Runoff Area (m2)	1261405.147
Rust Study Period Runoff/Year (in)	34.16

Appendix Fourteen

Hydrologic Budget Raw Data- Basin Storage, Dam Elevations

Date	Recent Weather	Pond Level Below Concrete Spillway (in)	Height (actually depth) of Stoplogs Below Spillway (in)	Height of Water over Stoplogs (in)	Storage elevation above "stoplog spillway) (in)	Seepage of Water?	Comments
4/1/2001	Snowy winter, start of thaw	11.0	16.0	5.0	25.0	None	None
4/23/2001	Dry, but thawing snow	1.5	16.0	14.5	34.5	None	None
5/10/2001	Very dry	8.0	16.0	8.0	28.0	Slight	Added cut board to restrict flow due to past + predicted dry weather (5" tall board, 3ft. Wide and 2" deep notch cut in top for flow) (See diagram)
6/5/2001	Wet	5.0	16.0	11.0	31.0	None	Heavy rain past 2 weekends, Approx. 3"
6/11/2001	Wet	5.0	16.0	11.0	31.0	N/A	Removed notched board 6/11/2001, Measurements taken this day are after removal
6/21/2001	Little rain, but rain promising	10.0	16.0	6.0	26.0	None	Before addition of 5" board
6/21/2001	Little rain, but rain promising	10.0	11.0	1.0	26.0	None	After addition of 5" board
7/16/2001	Normal	9.0	11.0	2.0	27.0	None	Board was removed by kids, first week in July. Westons notified, and board was replaced
8/3/2001	Dry	10.0	11.0	1.0	26.0	None	None
8/9/2001	Dry	11.0	11.0	0.0	25.0	Slight	APPROXIMATE DATE; One 6" board was removed, and one 6" board with notch to allow some water over dam added (no dimensions given); (Same notch dimensions as above?? Board is different)
9/20/2001	Dry	9.0	10.0	1.0	27.0	N/A	APPROXIMATE DATE; Before notched board removed
9/20/2001	Dry	9.0	16.0	7.0	27.0	N/A	APPROXIMATE DATE; After notched board removed
12/2/2001	Normal	15.0	16.0	1.0	21.0	Slight	None
1/4/2002	Some precipitation,	14.5	16.0	1.5	21.5	Slight	Although little rain or snow, level seems to have gone up

Date	Recent Weather	Pond Level Below Concrete Spillway (in)	Height (actually depth) of Stoplogs Below Spillway (in)	Height of Water over Stoplogs (in)	Storage elevation above "stoplog spillway) (in)	Seepage of Water?	Comments
3/20/2002	not much	10.5	11.0	1.5	25.5		Added this data line based upon 4/1/02 comment, (notched board)
4/1/2002	Dry	6.0	11.0	5.0	30.0	Very slight	Notched board on top; Joe must have put notched out board in sometime after ice out because of dry weather
5/20/2002	Mild, Sunny; Recent rain	3.5	13.0	6.0	32.5	None	Recent heavy rains raised level substantially; Before pulled out one stoplog (likely notched stoplog ??)
5/20/2002	Mild, Sunny; Recent rain	3.5	16.0	10.0	32.5	None	After pulled out stoplog (likely notched stoplog ??)
8/2/2002	Hot, humid, cloudy	13.0	13.5	0.5	23.0	Slight	Some seepage between stop logs + due to dam crack (crack on left side has opened some, but not great)
10/23/2002	Snow, morning; Sunny	12.0	13.0	1.5	24.0	None	Before removal of notched log; Stoplog height below spillway measured IN NOTCH
10/23/2002	Snow, morning; Sunny	12.0	16.5	4.5	24.0	None	After removal of notched log; Set stop log depth at 17" below spillway, per operation procedures for winter months (Actually at 16.5" if take depth measurement into account??)

Appendix Fifteen

Hydrologic Budget Summary- Basin Storage

Date	Pond Storage (10^3m^3) above stoplog spillway	Month to Month Difference in Pond Storage (10^3m^3) above stoplog spillway
July, 2001	641.6282	-6.9365
August, 2001	640.5356	-1.0926
September, 2001	640.7852	0.2497
October, 2001	590.8125	-49.9727
November, 2001	520.6587	-70.1539
December, 2001	616.0904	95.4318
January, 2002	528.1877	-87.9027
February, 2002	528.1883	0.0005
March, 2002	737.0054	208.8171
April, 2002	774.6077	37.6023
May, 2002	762.7665	-11.8412
June, 2002	683.6430	-79.1235
Total		35.0782

Appendix Sixteen

Nutrient Budget Raw Data- Tributary and Outlet TP

Date	*Tributary*	*Total Phosphorus (mg/L)*
7/16/01	North End Inlet	0.043
07/25/01	North End Inlet	0.081
08/08/01	North End Inlet	0.058
08/21/01	North End Inlet	0.063
09/05/01	North End Inlet	0.046
09/18/01	North End Inlet	0.025
10/08/01	North End Inlet	0.052
10/23/01	North End Inlet	0.041
11/19/01	North End Inlet	0.037
11/29/01	North End Inlet	0.024
12/18/01	North End Inlet	0.041
12/27/01	North End Inlet	0.02
01/18/02	North End Inlet	0.014
02/11/02	North End Inlet	0.02
02/22/02	North End Inlet	0.013
03/11/02	North End Inlet	0.016
06/24/02	North End Inlet	0.028
06/26/02	North End Inlet	0.028
07/16/01	Outlet	0.006
07/25/01	Outlet	0.005
08/08/01	Outlet	0.006
08/21/01	Outlet	0.013
09/05/01	Outlet	0.069
09/18/01	Outlet	0.034
10/08/01	Outlet	0.009
10/23/01	Outlet	0.01
11/19/01	Outlet	0.016
11/29/01	Outlet	0.13
12/17/01	Outlet	0.013
12/27/01	Outlet	0.008
01/18/02	Outlet	0.012
02/11/02	Outlet	0.013
02/22/02	Outlet	< 0.005
06/24/02	Outlet	0.009
06/26/02	Outlet	0.008
07/16/01	Perry Brook	0.017
07/25/01	Perry Brook	0.022
08/08/01	Perry Brook	0.021
08/21/01	Perry Brook	0.025
09/05/01	Perry Brook	0.02
09/18/01	Perry Brook	0.028
10/08/01	Perry Brook	0.018
11/29/01	Perry Brook	0.011
12/17/01	Perry Brook	0.011
12/27/01	Perry Brook	0.011
01/18/02	Perry Brook	0.007
02/22/02	Perry Brook	0.013
04/02/02	Perry Brook	0.014
06/24/02	Perry Brook	0.017
06/26/02	Perry Brook	0.016

Appendix Seventeen

Nutrient Budget Summary- Tributary and Outlet TP

Tributary	Year	Month	Avg. TP (mg/L)	Manipulated Avg. TP (mg/L)	Manipulated Avg. TP (Kg/m3)	Manipulated Avg. TP (Kg/103m3)
North Inlet	2001	July	0.062	0.062	0.000062	0.0620
North Inlet	2001	August	0.0605	0.0605	0.0000605	0.0605
North Inlet	2001	September	0.0355	0.0355	0.0000355	0.0355
North Inlet	2001	October	0.0465	0.0465	0.0000465	0.0465
North Inlet	2001	November	0.0305	0.0305	0.0000305	0.0305
North Inlet	2001	December	0.0305	0.0305	0.0000305	0.0305
North Inlet	2002	January	0.014	0.014	0.000014	0.0140
North Inlet	2002	February	0.0165	0.0165	0.0000165	0.0165
North Inlet	2002	March	0.016	0.016	0.000016	0.0160
North Inlet	2002	April	no data	0.0329	0.0000329	0.0329
North Inlet	2002	May	no data	0.0329	0.0000329	0.0329
North Inlet	2002	June	0.017	0.017	0.000017	0.0170
Outlet	2001	July	0.0055	0.0055	0.0000055	0.0055
Outlet	2001	August	0.0095	0.0095	0.0000095	0.0095
Outlet	2001	September	0.0515	0.0515	0.0000515	0.0515
Outlet	2001	October	0.0095	0.0095	0.0000095	0.0095
Outlet	2001	November	0.073	0.073	0.000073	0.0730
Outlet	2001	December	0.0105	0.0105	0.0000105	0.0105
Outlet	2002	January	0.012	0.012	0.000012	0.0120
Outlet	2002	February	0.013	0.013	0.000013	0.0130
Outlet	2002	March	no data	0.021444444	2.14444E-05	0.0214
Outlet	2002	April	no data	0.021444444	2.14444E-05	0.0214
Outlet	2002	May	no data	0.021444444	2.14444E-05	0.0214
Outlet	2002	June	0.0085	0.0085	0.0000085	0.0085
Perry Brook	2001	July	0.0195	0.0195	0.0000195	0.0195
Perry Brook	2001	August	0.023	0.023	0.000023	0.0230
Perry Brook	2001	September	0.024	0.024	0.000024	0.0240
Perry Brook	2001	October	0.018	0.018	0.000018	0.0180
Perry Brook	2001	November	0.011	0.011	0.000011	0.0110
Perry Brook	2001	December	0.011	0.011	0.000011	0.0110
Perry Brook	2002	January	0.007	0.007	0.000007	0.0070
Perry Brook	2002	February	0.013	0.013	0.000013	0.0130
Perry Brook	2002	March	no data	0.0157	0.0000157	0.0157
Perry Brook	2002	April	0.014	0.014	0.000014	0.0140
Perry Brook	2002	May	no data	0.0157	0.0000157	0.0157
Perry Brook	2002	June	0.0165	0.0165	0.0000165	0.0165

Appendix Eighteen

Nutrient Budget Raw Data, Groundwater TP

Date	StationID	StationID	TP (ug/L)	TP (mg/L)	Average Mo. TP (mg/L)	Weighted TP (mg/L)	Weighted Avg. Mo. TP (mg/L)	Weighted Average Mo. TP (Kg/m3))	Weighted Average Mo. TP (Kg/103m3))	Lake Seepage Area (m2)
06/11/03	1	End of Lake	36	0.036		0.0052				5645.37
06/11/03	2	Peard	118	0.118		0.0171				9684.14
06/11/03	3	Simpson	101	0.101		0.0147				7393.62
06/11/03	4	28 Launch	461	0.461		0.0669				11517.37
06/11/03	5	Webb Launch	83	0.083	0.1598	0.0121	0.0232	0.0000232	0.0232	4641.75
07/30/03	1	End of Lake	182	0.182		0.0264				38882.26
07/30/03	2	Peard	171	0.171		0.0248				
07/30/03	3	Simpson	403	0.403		0.0585				
07/30/03	4	28 Launch	620	0.62		0.0900				
07/30/03	5	Webb Launch	331	0.331	0.3414	0.0481	0.0496	0.0000496	0.0496	
08/28/03	1	End of Lake	17	0.017		0.0025				
08/28/03	2	Peard	337	0.337		0.0489				
08/28/03	3	Simpson	125	0.125		0.0181				
08/28/03	4	28 Launch	125	0.125		0.0181				
08/28/03	5	Webb Launch	84	0.084	0.1376	0.0122	0.0200	0.0000200	0.0200	

Appendix Nineteen

Nutrient Budget Summary, Groundwater TP

Month	Weighted Avg. Mo. TP (mg/L)	Weighted Average Mo. TP (Kg/m^3)	Weighted Average Mo. TP ($Kg/10^3m^3$)	Comments
July, 2003	0.0496	0.0000	0.0496	Monthly Avg.
August, 2003	0.0200	0.0000	0.0200	Monthly Avg.
September	0.0309	0.0000	0.0309	June-Aug. Avg.
October	0.0155	0.0000	0.0155	50%Avg. June-Aug.
November	0.0155	0.0000	0.0155	50%Avg. June-Aug.
December	0.0155	0.0000	0.0155	50%Avg. June-Aug.
January	0.0155	0.0000	0.0155	50%Avg. June-Aug.
February	0.0155	0.0000	0.0155	50%Avg. June-Aug.
March	0.0155	0.0000	0.0155	50%Avg. June-Aug.
April	0.0155	0.0000	0.0155	50%Avg. June-Aug.
May	0.0155	0.0000	0.0155	50%Avg. June-Aug.
June, 2003	0.0232	0.0000	0.0232	Monthly Avg.

Appendix Twenty

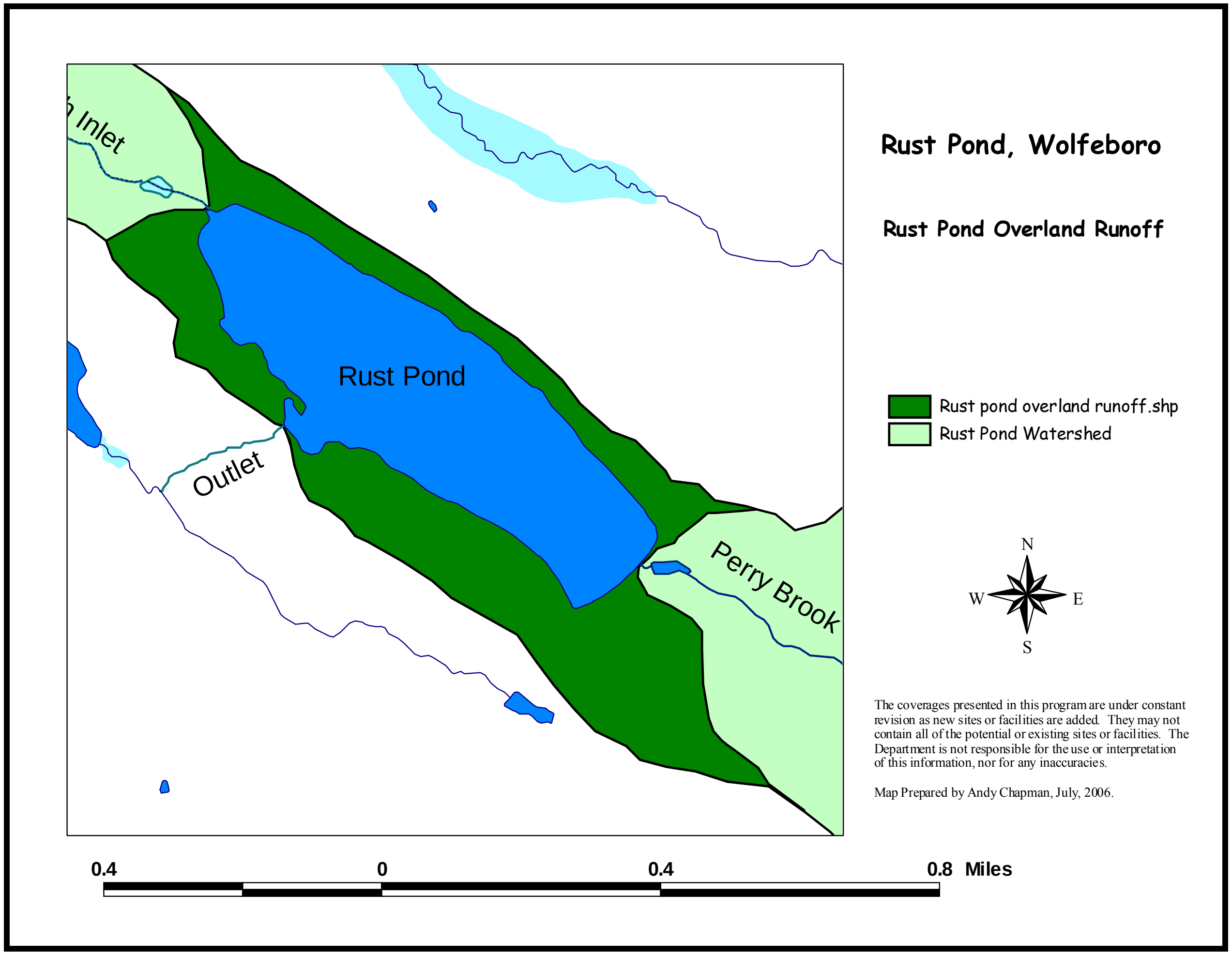
Nutrient Budget Summary, Raw Data and Summary, Precipitation TP

date	TP (mg/L)
07/02/01	0.030
07/27/01	0.010
09/27/01	<0.005
10/15/01	0.029
12/20/01	0.005
12/27/01	0.007
02/04/02	0.012
03/22/02	0.014
03/27/02	0.007
04/15/02	0.017
04/30/02	0.014
05/03/02	0.007
05/14/02	0.017
06/12/02	0.045

Month/Year	TP Monthly Avg (mg/L)	Manipulated TP Monthly Sample Avg (mg/L)	Manipulated TP Monthly Sample Avg ($Kg/10^3m^3$)	Comments
July, 2001	0.020	0.020	0.020	monthly average
August, 2001	no data	0.017	0.017	average of all months
September, 2001	<0.005	0.004	0.004	less than .005, use .004
October, 2001	0.029	0.029	0.029	monthly average
November, 2001	no data	0.019	0.019	average of all months
December, 2001	0.006	0.006	0.006	monthly average
January, 2002	no data	0.010	0.010	average of all months
February, 2002	0.012	0.012	0.012	monthly average
March, 2002	0.011	0.011	0.011	monthly average
April, 2002	0.016	0.016	0.016	monthly average
May, 2002	0.012	0.012	0.012	monthly average
June, 2002	0.045	0.045	0.045	monthly average

Appendix Twenty One

Nutrient Budget Overland Runoff Map



Appendix Twenty Two

Nutrient Budget Raw Data- Non Gaged Watersheds-Land Use

Land Use- Direct Wetfall Runoff	Total Acres	Hectares	TP Coefficient (Kg/Ha/Yr)	Overland and Gwi (Kg/yr TP Load)
Commercial/Industrial/Transportation	3.73	1.51	0.50	0.75
Deciduous Forest	40.78	16.50	0.20	3.30
Emergent Herbaceous Wetlands	13.37	5.41	0.05	0.27
Evergreen Forest	104.39	42.24	0.20	8.45
Low Intensity Residential	20.93	8.47	0.50	4.24
Mixed Forest	113.01	45.73	0.20	9.15
Open Water	0.43	0.17	0.00	0.00
Pasture/Hay	3.87	1.57	0.60	0.94
Row Crops	4.69	1.90	0.60	1.14
Urban/Recreation Grasses	1.50	0.61	0.50	0.30
Woody Wetlands	5.00	2.02	0.05	0.10
Total	**311.70**	**126.14**		**28.64**

Appendix Twenty Three

Nutrient Budget Summary Data- Non Gauged Watersheds-Land Use TP

Month	*Total Precip (in)*	*% Annual*	*Total Precip(10^3m^3)*	*Total LU (Overland and Gwi) Runoff Precip(10^3m^3)*	*Direct Overland Runoff Precip. (10^3m^3)*	*Direct Overland TP (LU TP - Gwi TP) (Kg)*	*Direct Overland Runoff Monthly TP(Kg/10^3m^3)*	*Direct Overland Runoff Manipulated Monthly TP(Kg/10^3m^3)*
July-01	2.76	0.08	88.4298	54.8265	41.0665	1.6320	0.0397	0.0397
August-01	0.72	0.02	23.0687	14.3026	10.7130	0.5320	0.0497	0.0497
September-01	4.03	0.12	129.1204	80.0546	59.9631	2.7577	0.0460	0.0460
October-01	1.25	0.04	40.0497	24.8308	18.5990	0.9517	0.0512	0.0512
November-01	1.26	0.04	40.3701	25.0295	18.7478	0.9593	0.0512	0.0512
December-01	2.93	0.09	93.8766	58.2035	43.5960	2.2308	0.0512	0.0000
January-02	2.14	0.06	68.5652	42.5104	31.8415	1.6293	0.0512	0.0000
February-02	2.69	0.08	86.1870	53.4360	40.0250	2.0481	0.0512	0.0000
March-02	3.68	0.11	117.9064	73.1020	54.7554	2.8018	0.0512	0.2047
April-02	3.9	0.11	124.9552	77.4722	58.0288	2.9693	0.0512	0.0512
May-02	4.09	0.12	131.0428	81.2465	60.8559	3.1140	0.0512	0.0512
June-02	4.71	0.14	150.9074	93.5626	70.0810	3.4042	0.0486	0.0486
Total	**34.16**	**1**	**1094.4793**	**678.5772**	**508.2729**	**25.0302**	**0.5933**	**0.5933**

Rust Direct Watershed Area (hectares):	126.10
Rust Direct Watershed Area (ac):	311.70
Rust Direct Watershed Area (m2):	1261409.19

Appendix Twenty Four

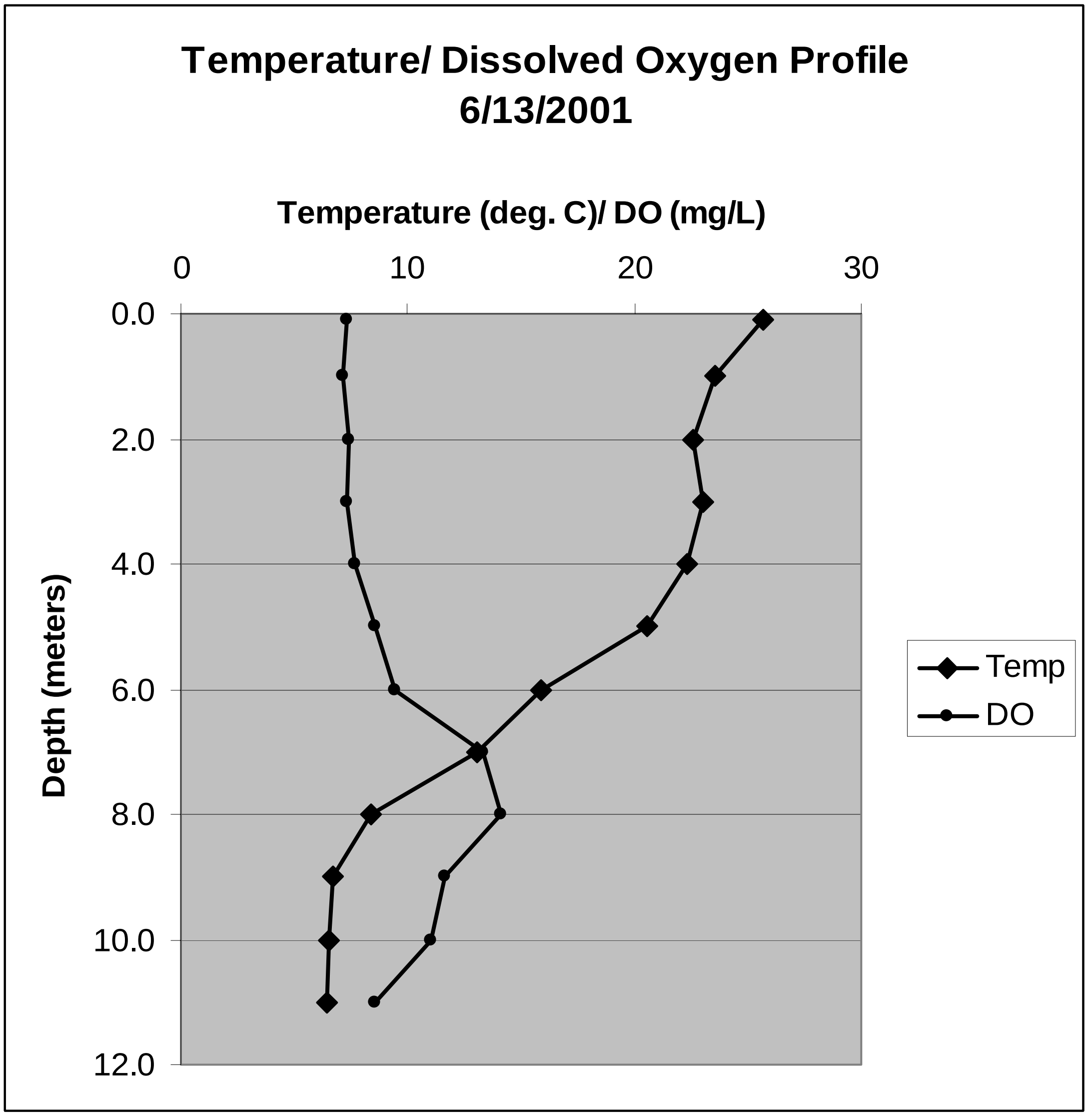
In-lake Raw Data, Study Period

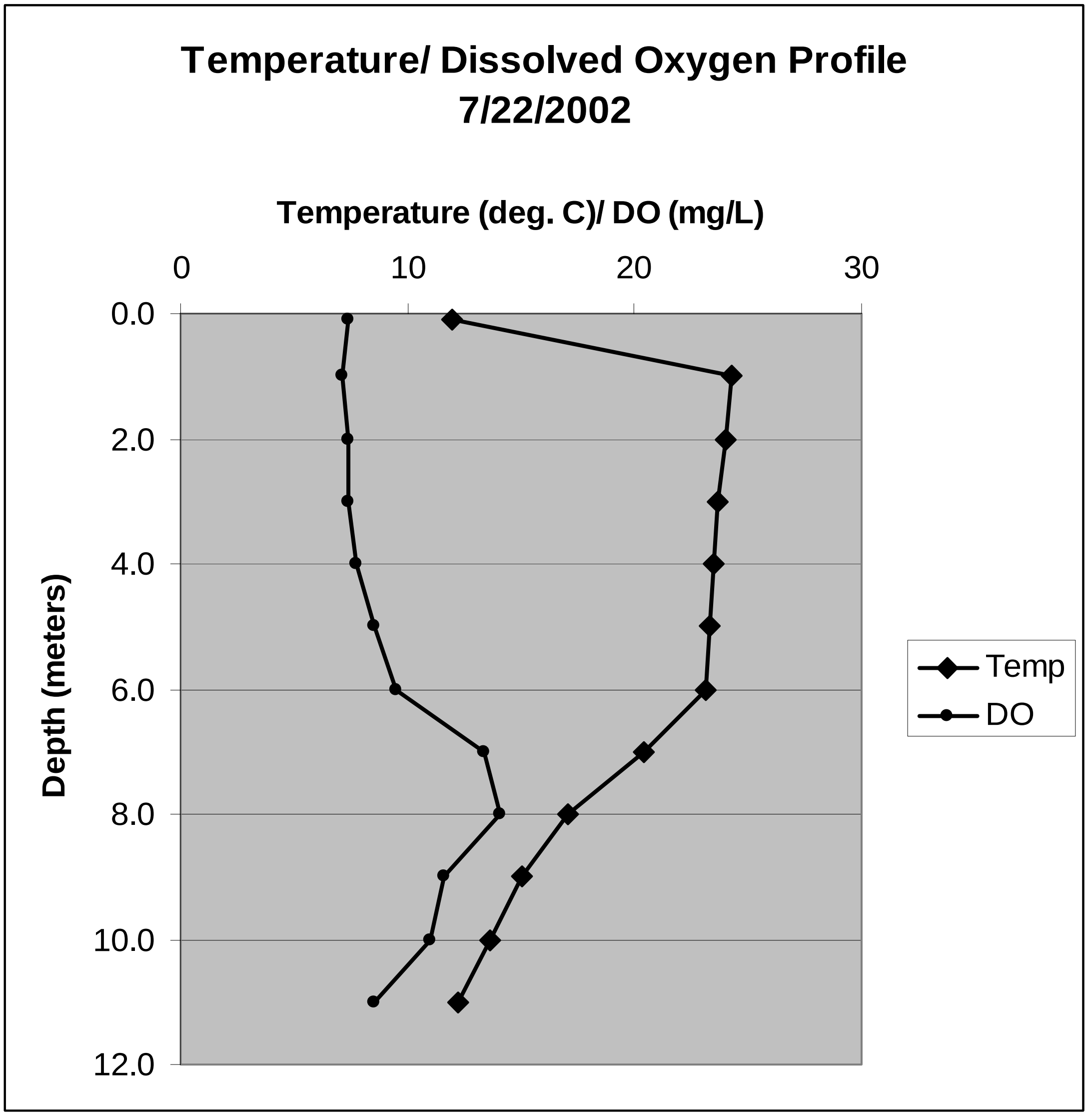
Station	Date	Turbidity (NTU)	pH	Conductivity (umhos/cm)	Alkalinity	Secchi
EPILIMNION	13-Jun-01	0.48	6.82	51.79	11.00	4.40
EPILIMNION	16-Jul-01	0.62	7.33	53.17	11.20	4.00
EPILIMNION	21-Aug-01	0.49	7.39	54.41	9.00	5.11
EPILIMNION	17-Jun-02	1.04	7.03	50.85	11.20	4.40
EPILIMNION	22-Jul-02	0.32	7.09	54.66	11.00	5.75
EPILIMNION	19-Aug-02	0.79	7.36	59.43	9.50	6.40
Mean Overall		**0.62**	**7.17**	**54.05**	**10.48**	**5.01**
Median Overall		**0.53**	**7.16**	**53.17**	**10.57**	**4.50**
St. Dev. Overall		**0.26**	**0.23**	**3.02**	**0.97**	**0.92**
METALIMNION	13-Jun-01	0.56	6.58	52.63		
METALIMNION	16-Jul-01	0.54	7.29	52.85		
METALIMNION	21-Aug-01	1.33	7.37	53.67		
METALIMNION	17-Jun-02	1.12	6.99	50.62		
METALIMNION	22-Jul-02	1.21	7.22	53.51		
METALIMNION	19-Aug-02	0.71	7.35	58.71		
Mean Overall		**0.91**	**7.13**	**53.67**		
Median Overall		**0.92**	**7.26**	**53.18**		
St. Dev. Overall		**0.35**	**0.30**	**2.70**		
HYPOLIMNION	13-Jun-01	0.52	6.53	54.09		
HYPOLIMNION	16-Jul-01	1.12	6.61	55.75		
HYPOLIMNION	21-Aug-01	1.15	6.51	58.40		
HYPOLIMNION	17-Jun-02	1.20	6.63	51.25		
HYPOLIMNION	22-Jul-02	1.39	6.76	55.06		
HYPOLIMNION	19-Aug-02	1.89	6.44	60.70		
Mean Overall		**1.21**	**6.58**	**55.88**		
Median Overall		**1.18**	**6.57**	**55.41**		
St. Dev. Overall		**0.44**	**0.11**	**3.31**		

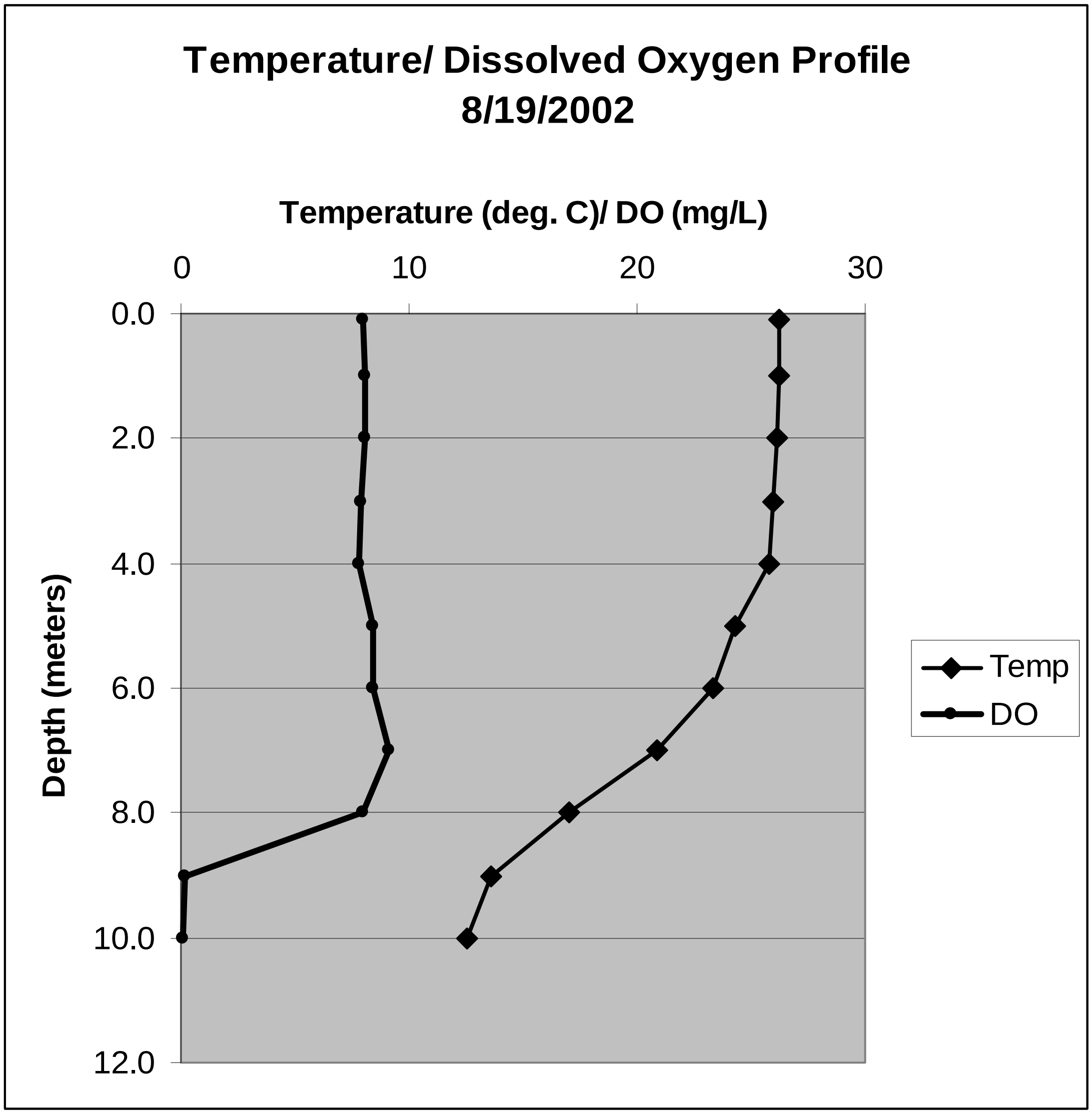
Station ID	Date	Chl-a
Deep Spot	13-Jun-01	3.29
Deep Spot	16-Jul-01	2.04
Deep Spot	21-Aug-01	3.13
Deep Spot	17-Jun-02	2.89
Deep Spot	22-Jul-02	2.75
Deep Spot	19-Aug-02	1.8
Mean Overall		**2.65**
Median Overall		**2.82**
St. Dev. Overall		**0.60**

Appendix Twenty Five

Temperature-Dissolved Oxygen Profiles, Study Period




Temperature/ Dissolved Oxygen Profile
7/22/2002
Temperature (deg. C)/ DO (mg/L)
0
10
20
30
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Depth (meters)
Temp
DO


Temperature/ Dissolved Oxygen Profile
8/19/2002
Temperature (deg. C)/ DO (mg/L)
0
10
20
30
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Depth (meters)
Temp
DO

Appendix Twenty Six

Sewage Disposal System Survey

Sewage Disposal System Survey

1. What type of sewage disposal system do you have on your property?

Septic Tank/Leach Field   Cesspool   Holding Tank   Chemical Toilet
Outhouse

2. How old is your disposal system (in years)?

1-10   10-15   15-20   20-25   I don't know

3. At least how many feet from the shore of the lake is your septic system located?

10-20   20-50   50-75   Greater than 75 feet

4. Are you a year round resident or seasonal?

Year round   Seasonal

5. If you are a seasonal resident, how many months out of the year do you spend in your lake home?

____

6. In what condition is your septic system?

Good   Moderate   Poor   I don't know

7. Do you have any problems with your septic system (odors, surface discharge, clogging)?

Yes   No

8. Have you made any repairs on your septic system?

Yes   No

9. How often do you have your septic tank pumped?

Every 1-3 years   Every 3-5 years   Every 10 years   Never

10. What size lot do you own?

1/4 acre   1/2 acre   1 acre   >1 acre

11. How far away from the lake edge is your home located?

10-20 feet   20-50 feet   50-75 feet   >75 feet

12. What is your drinking water source?

Dug Well   Drilled Well   Public Water   Bottled Water   I don't know

13. How many bedrooms does your home/cottage have?

1   2   3   More than 3

14. How many people typically occupy your lot?

1   2   3   4   5   >5

15. Which of the following water-using machines do you have on your lakefront dwelling?

Washing Machine   Garbage Disposal   Dishwasher   Water Softener

Other_____________________________

16. Location Information:

Your Name:
Lake Address:
Lot #:
Phone Number:

Comments (optional):

When form is complete, please mail to:
Andy Chapman
NH Department of Environmental Services
PO Box 95
29 Hazen Drive
Concord, NH 03302-0095
or fax to (603)271-7894

Appendix Twenty Seven

North End Inlet Site Inspection

The State of New Hampshire
Department of Environmental Services

Michael P. Nolin
Commissioner

September 25, 2006

Karen and Richard Coan
PO Box 1574
Wolfeboro, NH 03894

Re: North Inlet Sedimentation, Rust Pond, Wolfeboro

Dear Mr. and Mrs. Coan:

Thank you for meeting with the NH Department of Environmental Services (DES) to discuss the Rust Pond's North Inlet on September 20, 2006. Also at the meeting was Andre Bover, Wolfeboro Public Works Department and Patrick Bowman, Rust Pond Resident.

The purpose of the inspection was to determine the cause of the sediment load at the mouth of the North Inlet.

DES has conducted several site inspections of the North Inlet in recent years with documented records dating back to December, 1999. Observations from 1999 were similar to those from yesterday's site inspection. They are as follows:

1. The sediment delta appears to have extended into Rust Pond in recent years.
2. Sediment deposition has resulted in no or limited boat access to two docks.
3. A stone wall intersects the North Inlet, approximately 300 yards downstream of Cross Road or 200 yards upstream of Rust Pond.
4. Several abandoned beaver dams exist upstream of Rust Pond, between the pond and stone wall.
5. The stream channel meanders around the abandoned beaver dams at several locations. This is causing the banks of the stream channel in a few sections to significantly erode.
6. The southern most portion of the North Inlet, extending from the stone wall to Rust Pond is comprised mainly of loamy sand and stony sandy loams. Loamy sand and stony sandy loams are evident in the stream channel, floodway and banks of the North Inlet extending from the stone wall to Rust Pond. Silty clays were also observed in several areas along the stream bank. The Soil Conservation Service Soil type along the southwest and northeast stream banks indicate Leicester-Walpole very stony fine sandy loams and Woodbridge fine sandy loam, respectively.
7. The substrate within the stream channel and floodway downstream of the stone wall has alternating layers of organics and sediment, but is dominated by sandy sediment.
8. The substrate immediately downstream of Cross Road has distinct layers of sediment within the wetland system, extending over a 30 ft. x 50 ft. area, varying in depth between 6 and 18 inches.
9. The substrate immediately upstream of the stone wall does not indicate distinct layers of sandy sediment within the wetlands system with the exception several small sand deposit areas along the stream channel.

The increased sedimentation in recent years at the mouth of the North Inlet is likely a result of a combination of several factors causing an increase in stream bank erosion and an increase in the transport

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P.O. Box 95, 29 Hazen Drive, Concord, New Hampshire 03302-0095
Telephone: (603) 271-2457 • Fax: (603) 271-7894 • TDD Access: Relay NH 1-800-735-2964
DES Web site: **www.des.nh.gov**

of native soils. These factors include an increase in stormwater runoff rates and volumes within the subwatershed, loss of the beaver population that previously maintained dams that performed as sediment basins and breached beaver dams concentrating stream flow and erosive forces along sandy stream banks.

While some sediment deposition to Rust Pond is a natural occurrence for this system, the DES Watershed Management Bureau recommends the following measures to reduce sediment deposition:

1. The Town of Wolfeboro consider adopting stormwater ordinances to minimize the impact of increased stormwater runoff rates and volumes as a result of future development and other land use changes.
2. An assessment of the subwatershed to identify areas where stormwater can be better managed to reduce the increase in stormwater runoff rates and volumes that has likely resulted from past development and land use changes over recent years.
3. An assessment of the Cross Road wetland as a potential dredge site to construct a sediment and stormwater control structure to allow for sediment removal and regain stormwater capacity. A DES Wetlands Dredge and Fill Permit would be required for any wetland alteration.
4. An assessment to consider partial beaver dam removal to disperse stream flows away from actively eroding stream banks.
5. Low impact bank stabilization for banks that are actively eroding. This may include establishing a stable bank slope with vegetation. A DES Wetlands Dredge and Fill permit would be required for this work.
6. Maintaining or increasing vegetated buffers along the North Inlet Wetlands complex to reduce stormwater runoff rates and volumes which will assist in maintaining stable stream banks.
7. Contacting DES Wetlands Bureau to discuss dredging the North Inlet to allow for boat access to existing docks where necessary.

Please do not hesitate to contact me further regarding this letter or water quality recommendations for Rust Pond watershed. I can be reached at 603-271-5334 or achapman@des.state.nh.us.

Sincerely,

Andy Chapman
Clean Lakes Program Coordinator

Cc: Jody Connor, Limnology Center Director (via email)
Andre Bover, Wolfeboro Public Works
Patrick Bowman, Rust Pond (via email, pbowman387@aol.com)
Geordy Hutchinson (via email, geordy@yankeepedlarrealtors.com)
Jocelyn Deglar, DES Wetlands Bureau

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Appendix Twenty Eight

Stormwater Best Management Practices (BMPs)

Stormwater Management Best Management Practices (BMPs)

The following is a select list of stormwater management (BMPs) for New Hampshire (RCCD, 1992):

- ***Detention and Retention Basins*** control the runoff from a given storm event and release the excess runoff in a way to reduce the impact on downstream systems. The basin releases the temporarily stored runoff over an extended period of time at a rate equal to or less than the pre-development conditions. The existing stream system will experience no greater flooding than would have occurred before development took place. However, longer duration flows may cause some stream degradation. It should be understood that detention and retention basins generally do not decrease the volume of runoff, but do decrease the rate of runoff. This practice applies to sites where the physical conditions are conducive to constructing an embankment, emergency spillway, a storage area and a structural outlet system.
- ***Diversions*** intercept and divert water from areas where it is in excess to sites where it can be used or disposed of safely.

  Diversions are used to:

  - Divert runoff from highly erodible areas where the runoff is damaging property, causing erosion, or interfering with the establishment of vegetation;
  - Divert surface flow and subsurface flow away from steeply sloping land;

- ***Stone lined infiltration trenches*** provide temporary storage of runoff in the void spaces around the stone and allows the stored runoff to infiltrate into the surrounding soil. This practice applies to sites where the soils are sufficiently permeable to provide a reasonable rate of infiltration. The water table and bedrock must be lower than the design depth of the trench. This practice is not recommended where runoff water contains a high percentage of suspended materials, oils and greases unless measures are taken to remove them before they reach the trench.

- An ***extended detention dry basin*** is used to reduce peak discharges from a given storm event by controlling the release rate and to improve water quality by removing pollutants from runoff. This practice applies to sites where the physical conditions are conducive to constructing an embankment, emergency spillway, a storage area, and a designed outlet system.
- A ***dry well*** is similar to an infiltration trench. It provides temporary storage of runoff in the constructed chamber and/or in the void spaces in the aggregate, and allows the stored runoff to infiltrate into the soil. This practice applies to sites where the soils are sufficiently permeable to provide a reasonable rate of infiltration. Both the water table and bedrock must be lower than the design depth of the well. This practice is not recommended where runoff water contains high concentrations of sediment, oils, greases, and floatable organic materials unless measures are taken to remove them before they reach the well. Dry wells are generally used to store runoff from roof top areas; however, they can be used to provide storage and infiltration from catch basins where conditions permit.
- A ***level spreader*** changes concentrated flow into sheet flow and then outlets it onto stable areas without causing erosion. An example would be at the outlet of a diversion or a waterway. The level spreader is used where it can be constructed on undisturbed soils, where the area directly below the spreader is stabilized by existing vegetation, where the water will not re-concentrate immediately below the spreader, and where there is at least 100 feet of vegetated area between the spreader and surface water.
- ***Rock riprap*** protects soil from erosion due to concentrated runoff. It is used to stabilize slopes that are unstable due to seepage. It is also used to slow the velocity of concentrated runoff which in turn increases the potential for infiltration. Rock riprap can be used at the outlets of pipes and constructed channels where the velocity of flow from

these structures exceeds the capacity of the downstream area to resist erosion. Rock riprap can be used for wave protection on lakeshores and beaches. The practice can be used for storm drain outlets, in channels, in roadside ditches, on unstable slopes, at the top of slopes, and for drop structures.

- A ***vegetated filter strip*** improves water quality by removing sediment, nutrients, and other pollutants from runoff as it flows through the filter strip. Some of the sediment and pollutants are removed by filtering, absorption, adsorption and settling as the velocity of flow is reduced. This practice applies to any site where adequate vegetation can be established and maintained. Vegetative filter strips can be used effectively:
    1. Surrounding stormwater management infiltration practices to reduce the sediment load delivered to the structures;
    2. Adjacent to all water courses such as waterways and diversions and water bodies such as streams, ponds, and lakes;
    3. At the outlets of stormwater management structures; or
    4. Along the top of and at the base of slopes.
- ***Vegetated swales*** improve water quality by treating and removing pollutants from stormwater runoff, increasing infiltration, and reducing potential erosion from the discharge of runoff. This practice applies to all sites where a dense stand of vegetation can be established and where either a stable outlet exists or can be constructed as a suitable conveyance system to safely dispose of the runoff flowing from the swale. The swale can be used by itself or in combination with other stormwater management and/or erosion and sediment control practices to achieve the water quality improvement or flood peak reduction.

Appendix Twenty Nine

Zoning Regulations, Wolfeboro and New Durham

Regulation	Wolfeboro	New Durham	New Durham (Master Plan Recommendations)	State of NH
Primary Structure (house) Building Setback to:				
Lake/Pond	50 ft.	Rely on State of NH laws, rules and regs.	100 ft.	50 ft.
Perennial Stream	50 ft.	Rely on State of NH laws, rules and regs.	100 ft. (for streams on USGS map)	50 ft. if 4th order, none for <4th order
Intermittent/Seasonal Stream	50 ft.	Rely on State of NH laws, rules and regs.	50 ft. (for streams on USGS map)	none
Wetland	75 ft. (50 ft. with soil provisons)	Rely on State of NH laws, rules and regs.	25 ft.	none
Primary Structure (road/drive) Building Setback to:				
Lake/Pond	50 ft.	Rely on State of NH laws, rules and regs.	100 ft	50 ft.
Perennial Stream	50 ft.	Rely on State of NH laws, rules and regs.	100 ft.	50 ft. if 4th order, none for <4th order
Intermittent/Seasonal Stream	50 ft.	Rely on State of NH laws, rules and regs.	50 ft.	none
Wetland	75 ft. (50 ft. with soil provisons)	Rely on State of NH laws, rules and regs.	25 ft.	none
Accessory Structure Building Setback to:				
Lake/Pond	50 ft.	Rely on State of NH laws, rules and regs.	20 ft.	20 ft.
Perennial Stream	50 ft.	Rely on State of NH laws, rules and regs.	20 ft.	20 ft. if 4th order, none for < 4th order
Intermittent/Seasonal Stream	50 ft.	Rely on State of NH laws, rules and regs.	20 ft.	none
Wetland	75 ft. (50 ft. with soil provisions)	Rely on State of NH laws, rules and regs.	20 ft.	none
Septic System (leach field) Setback to:				
Lake/Pond	75 ft.	Rely on State of NH laws, rules and regs.	75 ft.	125 ft. (75 ft. with soil provisions)
Perennial Stream	75 ft.	Rely on State of NH laws, rules and regs.	75 ft.	75 ft.
Intermittent/Seasonal Stream	75 ft.	Rely on State of NH laws, rules and regs.	75 ft.	75 ft.

Regulation	Wolfeboro	New Durham	New Durham (Master Plan Recommendations)	State of NH
Wetland	75 ft. (50 ft. with soil provisions)	Rely on State of NH laws, rules and regs.	75 ft.	75 ft. (50 ft. with soil provisions)
Tree Clearing Setback to:				
Lake/Pond	50 ft. - 250 ft. planting provision	Rely on State of NH laws, rules and regs.	100 ft.	150 ft. (50 ft. with provisions)
Perennial Stream	50 ft.	Rely on State of NH laws, rules and regs.	100 ft. (for streams on USGS map)	150 ft. (50 ft. with provisions) if 4th order
Intermittent/Seasonal Stream	50 ft.	Rely on State of NH laws, rules and regs.	50 ft. (for streams on USGS map)	none
Wetland	75 ft. (50 ft. with provisions)	Rely on State of NH laws, rules and regs.	25 ft.	none
Earth Disturbance Setback to:				
Lake/Pond	follow shoreland protection	Rely on State of NH laws, rules and regs.	100 ft.	250 ft. (provisions)
Perennial Stream	50 ft.	Rely on State of NH laws, rules and regs.	100 ft. (for streams on USGS map)	250 ft. (4th order), none for <4th order
Intermittent/Seasonal Stream	50 ft.	Rely on State of NH laws, rules and regs.	50 ft. (for streams on USGS map)	none
Wetland	50 ft.	Rely on State of NH laws, rules and regs.	25 ft.	none
Maximum Slope Development for:				
Roadway	12%	12%	no recommendation	none
Driveway	No Requirement	No Requirement	no recommendation	none
Primary Structure	No Requirement	No Requirement	no recommendation	none
Minimum Lot Size	1 acre for all zones, except agriculture	Based un soil type, 60K square feet for optimal soil types.	Varies based on zone: Town Center Zone: based on soil type Rural/Res./Ag. Zone: 1 dwelling/5 acres Rural/Forestry/Cons. Zone: 1 dwelling/ 10 acres	based on soils for septic system where applicable
Erosion Control Provisions	Erosion/ sediment control for properties with waterfront or wetlands. Plan is reviewed by town planner and building inspector. Conservation Commission notified of projects requiring erosion/ sediment control plans only when there is a special use	No Requirement	no recommendation	Site alteration permit required for land disturbances in excess of 50,000 sq. ft. and within 250 ft. of reference line of lakes, ponds and 4th order streams

Regulation	Wolfeboro	New Durham	New Durham (Master Plan Recommendations)	State of NH
	request.			
Stormwater Management/ Runoff Rates	Some requirements for maintaining pre-development runoff rates	No Requirement	no recommendation	For development requiring a Site Alternation of Terrain Permit: Stormwater drainage shall be calculated for pre and post construction, for storms with minimum return frequencies of once in two years and once in ten years using the "Rational Method," Technical Release 20 (TR20), Technical Release 55 (TR55), developed by the USDA-Natural Resources Conservation Service, for determining the rate of runoff. Note: this rule is subject to two additional requirements. See New Hampshire Code of Administrative Rules, part Env-Ws 415, Permits for RSA-485-A:17 Activities.
Stormwater Management/ Runoff Volumes	No Requirement	No Requirement	no recommendation	No Requirement

Appendix Thirty
Native Shoreland/Riparian Buffer Plantings for New Hampshire

Native Shoreland*/Riparian Buffer Plantings for New Hampshire

* The protected shoreland is the area of land that exists between the reference line of a waterbody and 250 feet from the reference line.

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees								
American Basswood (American Linden)	*Tilia americana*	Medium-Large 60-100’	Moderate	Deep	Full/Part Shade or Full Sun	Moist	Rich woods, valleys, gentle slopes	**Wildlife:** Pileated woodpecker, wood duck, other birds; deer, rabbit, squirrel **Food:** Seeds, twigs
American Beech	*Fagus grandifolia*	Medium-Large 60-90’	Slow	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Rich woods, well-drained lowlands	**Wildlife:** Blue jay, chickadees, nuthatches, quail, ruffed grouse, tufted titmouse, wild turkey, wood duck, woodpeckers; bear, chipmunk, deer, fox, porcupine, snowshoe hare, squirrel **Food:** Nuts, buds, sap
American Hophornbeam (Ironwood)	*Ostrya virginiana*	Small 20-40’	Slow	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Rich woods	**Wildlife:** Downy woodpecker, mockingbird, purple finch, ring-necked pheasant, rose-breasted grosbeak, ruffed grouse, wild turkey, wood quail; deer, rabbit, squirrel **Food:** Nuts, buds, seeds
American Hornbeam (Blue Beech/Musclewood)	*Carpinus caroliniana*	Small/Shrubby 20-40’	Slow	Moderate	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Rich woods, forested wetlands, ravines, streambanks	**Wildlife:** Quail, ruffed grouse, wood duck; beaver, deer, squirrel **Food:** Seeds, buds
American Mountain Ash	*Sorbus americana*	Small Up to 25’	Fast	Shallow	Full/Part Shade or Full-Sun	Dry, Moist	Forested wetlands, rich woods	**Wildlife:** Bluebird, brown thrasher, catbird, cedar waxwing, grosbeak, mockingbird, robin, thrushes, wild turkey; bear **Food:** Fruit, twigs
Balsam Fir	*Abies balsamea*	Small-Medium 40-60’	Fast	Shallow	Full Sun	Moist, Flood Tolerant	Forested wetlands, streambanks, rich woods	**Wildlife:** Ruffed grouse, songbirds; small mammals, moose **Food:** Seeds

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Black Willow	*Salix nigra*	Small-Medium Up to 50'	Very Fast	Very Shallow	Full Sun	Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	**Wildlife:** Songbirds and mammals **Food:** Buds, catkins
Box Elder	*Acer negundo*	Medium 40-70'	Very Fast	Deep, Lateral	Full Sun	Dry, Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	**Wildlife:** Songbirds and mammals **Food:** Seeds
Eastern Cottonwood	*Populus deltoides*	Medium-Large 80-100'	Fast	Shallow	Full Sun	Dry or Moist	Floodplains, streambanks, valleys	**Wildlife:** Ruffed grouse **Food:** Catkins
Eastern White Pine	*Pinus strobus*	Large 70-120'	Moderate	Shallow	Full Sun	Dry or Moist, Well-Drained	Forested wetlands, bogs, ravines, cool shady north slopes	**Wildlife:** Brown creeper, chickadee, crossbill, grosbeak, junco, nuthatch, pine warbler, sparrows, spruce grouse, wild turkey, woodpeckers; beaver, chipmunk, deer, snowshoe hare, squirrel **Food:** Seeds, foliage, twigs; excellent winter food
Gray Birch (Wire Birch)	*Betula populifolia*	Small 20-35'	Fast	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Pioneer Species; poorest of sterile soils, sandy or gravelly slopes	**Wildlife:** American goldfinch, blue jay, chickadee, northern junco, pine siskin, red-tailed hawk, ruffed grouse, sparrows, vireo, yellow-bellied sapsucker, woodpeckers; snowshoe hare **Food:** Seeds, buds
Green Ash	*Fraxinus pennsylvanica*	Medium-Large 60-80'	Fast	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Forested wetlands, floodplains, streambanks; never on dry soils	**Wildlife:** Cardinal, finches, evening grosbeak, mourning dove, red-winged blackbird, wood duck; beaver, chipmunk, deer, porcupine, squirrel **Food:** Seeds, foliage

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Black Willow	*Salix nigra*	Small-Medium Up to 50’	Very Fast	Very Shallow	Full Sun	Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	**Wildlife:** Songbirds and mammals **Food:** Buds, catkins
Box Elder	*Acer negundo*	Medium 40-70’	Very Fast	Deep, Lateral	Full Sun	Dry, Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	**Wildlife:** Songbirds and mammals **Food:** Seeds
Eastern Cottonwood	*Populus deltoides*	Medium-Large 80-100’	Fast	Shallow	Full Sun	Dry or Moist	Floodplains, streambanks, valleys	**Wildlife:** Ruffed grouse **Food:** Catkins
Eastern White Pine	*Pinus strobus*	Large 70-120’	Moderate	Shallow	Full Sun	Dry or Moist, Well-Drained	Forested wetlands, bogs, ravines, cool shady north slopes	**Wildlife:** Brown creeper, chickadee, crossbill, grosbeak, junco, nuthatch, pine warbler, sparrows, spruce grouse, wild turkey, woodpeckers; beaver, chipmunk, deer, snowshoe hare, squirrel **Food:** Seeds, foliage, twigs; excellent winter food
Gray Birch (Wire Birch)	*Betula populifolia*	Small 20-35’	Fast	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Pioneer Species; poorest of sterile soils, sandy or gravelly slopes	**Wildlife:** American goldfinch, blue jay, chickadee, northern junco, pine siskin, red-tailed hawk, ruffed grouse, sparrows, vireo, yellow-bellied sapsucker, woodpeckers; snowshoe hare **Food:** Seeds, buds
Green Ash	*Fraxinus pennsylvanica*	Medium-Large 60-80’	Fast	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Forested wetlands, floodplains, streambanks; never on dry soils	**Wildlife:** Cardinal, finches, evening grosbeak, mourning dove, red-winged blackbird, wood duck; beaver, chipmunk, deer, porcupine, squirrel **Food:** Seeds, foliage

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Striped Maple (Moosewood/ Moose Maple)	*Acerpensylvanicum*	Small/Shrubby 20-30’	Moderate	Shallow	Full/Part-Shade	Moist	Rich woods, cool moist sites	**Wildlife:** Ruffed grouse; beaver, deer, moose, porcupine, rabbit **Food:** Buds, bark, samaras
Sugar Maple	*Acer saccharum*	Medium-Large 60-100’	Slow	Shallow	Full/Part Shade or Full Sun	Moist	Valleys and uplands; tolerates almost all soil types	**Wildlife:** Cardinal, goldfinch, grosbeak, ring-necked pheasant, robin, ruffed grouse, vireo; beaver, chipmunk, porcupine; Browse for deer, rabbit, snowshoe hare **Food:** Seeds, twigs, bark
Swamp White Oak	*Quercus bicolor*	Medium 60-70’	Fast	No Information Available	Full/Part Shade	Moist	Forested wetlands, floodplains, streambanks	**Wildlife:** Barred owl, blue jay, cardinal, brown thrasher, grouse, mallards, nuthatch, quail, red-bellied woodpecker, red-tailed hawk, ruffed grouse, starling, towhee, wild turkey, yellow-throated wabler, wren; beaver, chipmunk, cottontail, deer, gopher, opossum, raccoon, squirrel, white-footed mouse, wild turkey **Food:** Acorns
Sweet Gum	*Liquidambar styraciflua*	Medium-Large 60-100’	Moderate	No Information Available	Full Sun	Moist	Valleys, Lower slopes, mixed woodlands	**Wildlife:** Mourning dove, finches, junco, wren; beaver, chipmunk, squirrel **Food:** Seeds
Sycamore (Planetree/Buttonwood)	*Platanus occidentalis*	Large 80-100’	Slow	No Information Available	Full/Part Shade or Full-Sun	Dry or Moist	Floodplains, lakeshores, streambanks	**Wildlife:** Finches; chipmunk, squirrel **Food:** Seeds
Tamarack (American/Eastern Larch)	*Larix laricina*	Small-Medium 40-80’	Variable	Moderate	Full Sun	Moist, Flood Tolerant	Bogs, swamps, wet peaty soils, drier upland loamy soils	**Wildlife:** Blue jay, kinglets, pheasant, red crossbill, robin, ruffed grouse, spruce grouse, yellow-bellied sapsucker; chipmunk, deer, porcupine, red squirrel, snowshoe hare **Food:** Needles, twigs, inner bark, seeds

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
White Ash	*Fraxinus americana*	Medium-Large 70-100’	Moderate	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, valleys, slopes, forested wetlands, floodplains, streambanks	**Wildlife:** Finches, grosbeaks, red-winged blackbird, wood duck; deer, squirrel **Food:** Seeds, foliage
White Birch (Paper Birch)	*Betula papyrifera*	Medium 50-75’	Fast	Shallow	Full Sun	Dry or Moist	Forested wetlands, rich woods	**Wildlife:** Grouse, siskins **Food:** Seeds, buds
White Oak	*Quercus alba*	Medium-Large 50-90’	Moderate	Deep	Full/Part Shade or Full Sun	Deep, rich, well-drained	Streambanks, lakeshores, gentle slopes; adapts to almost any condition	**Wildlife:** Blue jay, brown thrasher, nuthatch, quail, ruffed grouse, towhee, wild turkey, wood duck, woodpecker; chipmunk, bear, deer, gopher, opossum, raccoon, squirrel **Food:** Acorns
White Spruce	*Picea glauca*	Medium 40-70’	Moderate	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Streambanks, lakeshores, rich woods, adjacent slopes	**Wildlife:** Fishers, martens, snowshoe hare, voles **Food:** Seeds
Yellow Birch (Sweet Birch)	*Betula alleghaniensis*	Medium-Large 70-100’	Slow	Shallow/ Moderate	Full/Part Shade	Dry or Moist	Forested wetlands, floodplains, ravines, cool, rich woods of high elevations	**Wildlife:** Black-capped chickadee, common redpoll, goldfinch, pine siskins, red-shouldered hawk, ring-necked pheasant, ruffed grouse, wild turkey, wood duck, yellow-bellied sapsucker; beaver, chipmunk, deer, porcupine, squirrel, snowshow hare **Food:** Catkins, buds, bark, twigs, foliage, seeds

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs							
American Hazelnut	*Corylus americana*	Medium 5-10’	Moderate	Full/Part Shade or Full Sun	Moist	Borders of woods, hillsides, thickets	**Wildlife:** Blue jay, brown thrasher, cedar waxwing, hairy woodpecker, ring-necked pheasant, ruffed grouse; chipmunk, deer, rabbit, squirrel **Food:** Nuts, berries, foliage
Beaked Hazelnut	*Corylus cornuta*	Small 6-10’	Moderate	Full/Part Shade or Full Sun	Dry	Dry places	**Wildlife:** Birds, mammals **Food:** Beaked nuts
Black Chokeberry	*Aronia meloncarpa*	Medium Up to 10’	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands	**Wildlife:** Cedar waxwing, chickadees, ruffed grouse, sharp-tailed grouse; deer, rabbit, squirrel **Food:** Berries, buds
Buttonbush	*Cephalanthus occidentalis*	Medium 6-12’	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Streambanks, lakeshores, ponds, shrub and forested wetlands	**Wildlife:** Ducks, rails, ruby-throated hummingbird; beaver, deer, muskrat, butterflies, honeybees and other insects **Food:** Fruit, twigs, leaves, seeds, nectar
Chokecherry	*Prunus virginiana*	Small 3-6’	Moderate	Full/Part Shade or Full Sun	Dry or Moist	With Aspen; dry soils	**Wildlife:** Bluebird, brown thrasher, catbird, crow, eastern kingbird, evening grosbeak, orioles, pileated woodpecker, ring-necked pheasant, robin, rose grosbeak, ruffed grouse, thrushes, yellow-bellied sapsucker; rabbit, squirrel **Food:** Berries, buds, foliage
Elderberry	*Sambucus canadensis*	Small-Medium 3-12’	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, shrub and forested wetlands, marshes	**Wildlife:** Bluebirds, blue jay, brown thrasher, cardinal, catbird, grosbeak, indigo bunting, pileated woodpecker, ringed-neck pheasant, robin, rose-breasted grosbeak, ruffed grouse, thrushes, wild turkey, woodpecker; chipmunk, deer, rabbit, squirrel **Food:** Berries, nectar, twigs, bugs
Gray Dogwood (Red-Panicle Dogwood)	*Cornus racemosa*	Medium 10-15’	Moderate	Full/Part Shade or Full Sun	Dry or Moist	Roadsides, thickets, wetlands	**Wildlife:** Blue jay, cardinal, catbird, cedar waxwing, eastern kingbird, finch, flycatcher, grosbeak, hairy woodpecker, northern flicker, phoebe, pileated woodpecker, pine grosbeak, pine warbler, red-bellied woodpecker, ring-necked pheasant, robin, ruffed grouse, starling, swamp sparrow, tufted titmouse, veery, vireo, wild turkey, wood duck, wood thrush, woodcock, yellow-bellied sapsucker; chipmunk, deer, red fox, rabbit, squirrel **Food:** Berries, twigs

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Highbush Blueberry	*Vaccinium corymbosum*	Medium 5-15’	Slow	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	**Wildlife:** Baltimore oriole, bluebird, blue jay, cardinal, chickadee, gray catbird, kingbird, orioles, phoebe, red-bellied woodpecker, ring-necked pheasant, robin, ruffed grouse, rufos-sided towhee, scarlet tanager, tufted titmouse, veery, wild turkey, woodpeckers, wood thrush; black beer, chipmunk, deer, muskrat, rabbit, squirrel, white-footed mouse **Food:** Berries, foliage, twigs, buds
Hobblebush	*Viburnum alnifolium*	Medium Up to 10’	Moderate	Full/Part Shade	Moist, Flood Tolerant	Cool, moist ravines, shady lakeshores	**Wildlife:** Brown thrasher, cardinal, cedar waxwing, evening grosbeak, robin **Food:** Fruit
Juniper	*Juniperus communis*	Small 1-4’	Slow	Full Sun	Dry	Dry open land	**Wildlife:** Cedar waxwing, finches, grosbeaks, grouse, pheasant, robin; deer, rabbit, moose **Food:** Twigs, foliage, fruit
Lowbush Blueberry	*Vaccinium angustifolium*	1-2’	Slow	Full/Part Shade or Full Sun	Dry or Moist	Bogs, dry sandy flats, rocky slopes	**Wildlife:** Blue jay, grouse, kingbird, oriole, robin, tanagers, woodpeckers; squirrel **Food:** Berries, foliage, twigs
Maleberry	*Lyonia ligustris*	Up to 10’	Moderate	Full/Part Shade or Full Sun	Moist	Shrub and forested wetlands, rich woods, gentle slopes	**Wildlife:** Songbirds and mammals **Food:** Fruit
Mapleleaf Viburnum	*Viburnum acerifolium*	Small 3-6’	Moderate	Full/Part Shade or Full Sun	Moist	Rich woods	**Wildlife:** Songbirds and mammals **Food:** Fruit
Mountain Laurel	*Kalmia latifolia*	Up to 20’	Moderate	Full/Part Shade or Full Sun	Dry or Moist	Mixed uplands, acid soils	**Wildlife:** Ruffed grouse; deer **Food:** Foliage, buds, twigs, nectar
Nannyberry	*Viburnum lentago*	Medium-Large 10-25’	Moderate	Fall/Part Shade or Full Sun	Dry or Moist	Rich woods	**Wildlife:** Songbirds, mammals **Food:** Berries
Northern Arrowwood	*Viburnum recognitum*	Medium 10-15’	Moderate	Fall/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	**Wildlife:** Ruffed grouse, songbirds; bear, chipmunks, raccoon, squirrel, skunk, white-footed mouse **Food:** Berries

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Northern Wild Raisin (Witherod Viburnum)	*Viburnum nudum var.cassinoides*	Medium 6-10	Moderate	Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands, valleys, slopes, streambanks	**Wildlife:** Brown thrasher, cedar waxwing, flycatcher, ruffed grouse, veery, woodcock, yellow-warbler; chipmunk, deer, muskrat, squirrel, snowshoe hare **Food:** Bark, twigs, buds
Pussy Willow	*Salix discolor*	Medium-Large Up to 15'	Fast	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks, lakeshores	**Wildlife:** American goldfinch, ruffed grouse; beaver, hare, rabbits, squirrel **Food:** Buds, catkins, twigs, bark
Raspberry	*Rubus idaeus*	Small Up to 6'	Fast	Full/Part Shade or Full Sun	Dry or Moist	Thickets, edges of woods	**Wildlife:** Songbirds and mammals **Food:** Fruits
Red Osier Dogwood	*Cornus stolonifera*	Small-Medium 4-8'	Fast	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, streambanks, lakeshores	**Wildlife:** Bluebird, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, finches, northern flicker, pine warbler, purple finch, ringed-neck pheasant, ruffed grouse, vireo, wild turkey, woodpeckers, wood duck; chipmunk, deer, rabbit, squirrel **Food:** Berries, twigs
Rhodora	*Rhododendron canadense*	Small 3-4'	Slow	Full Sun	Moist, Flood Tolerant	Bogs, slopes, rocky summits	**Wildlife:** Songbirds and mammals **Food:** Leaves
Shadbush (Serviceberry/Juneberry)	*Amelanchier spp.*	Large 15-25'	Slow	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, floodplains, streambanks, rich woods	**Wildlife:** Bluebird, brown thrasher, cardinal, catbird, cedar waxwing, gray catbird, junco, orioles, red squirrel, robin, ruffed grouse, scarlet tanager, thrushes, veery, woodpeckers; beaver, deer, red squirrel, skunk **Food:** Berries, twigs
Silky Dogwood	*Cornus amomum*	Medium 6-10'	Fast	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, streambanks	**Wildlife:** Baltimore oriole, black-capped chickadee, blue jay, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, flycatcher, mockingbird, northern flicker, pine warbler, purple finch, red-bellied woodpecker, ringed-necl pheasant, robin, rose-breasted grosbeak, ruffed grouse, song sparrow, starlings, tufted-titmouse, wild turkey, wood duck, wood thrush, veery; chipmunk, deer, rabbit, raccoon, skunk, squirrel, white-footed mouse **Food:** Berries, buds, twigs

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Speckled Alder	*Alnus rugosa*	Large 15-25'	Fast	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks, lakeshores	**Wildlife:** Alder flycatcher, catbird, goldfinch, mallards, pheasant, pine siskin, red-winged blackbird, ruffed grouse, swamp sparrow, yellow-bellied flycatcher, woodcock; bear, beaver, deer, cottontail, moose, muskrat, snowshoe hare **Food:** Buds, twigs, bark, leaves
Spicebush	*Lindera benzoin*	Small-Large 6-17'	Moderate	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	**Wildlife:** Catbird, kingbird, pheasant, quail, robin, ruffed grouse, veery, vireo, wood thrush; swallowtail butterflies; deer, muskrat **Food:** Fruit, buds, twigs, leaves
Swamp Azalea	*Rhododendron viscosum*	Up to 5'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	**Wildlife:** Hummingbird; butterflies and other insects; deer **Food:** Leaves, nectar
Swamp Blackberry	*Rubus hispidus*	Small Up to 6'	Slow	Full/Part Shade	Dry or Moist	Shrub and forested wetlands, rich woods	**Wildlife:** Blue jay, brown thrasher, cardinal, cedar waxwing, grackle, gray catbird, grosbeak, mockingbird, oriole tanager, ring-necked pheasant, robin, ruffed grouse, rufus-sided thrushes, towhee, veery, wild turkey, woodcock, woodpeckers, wood thrush; chipmunk, cottontail, deer, raccoon, skunk, squirrel **Food:** Fruit, canes
Sweet Gale	*Myrica gale*	Small 1-4'	Slow	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	**Wildlife:** Black-capped chickadee, catbird, common yellowthroat, phoebe, pied-billed grebe, ruffed grouse, tree swallow, tufted titmouse, wild turkey; deer, muskrat **Food:** Buds, leaves
Sweet Pepperbush	*Clethra alnifolia*	Medium 3-10'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	**Wildlife:** Butterflies and other insects **Food:** Fruit, seeds, nectar
Winterberry Holly (Black Alder)	*Ilex verticillata*	Medium 6-10'	Slow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streamabanks	**Wildlife:** Cardinal, catbird, cedar waxwing, chickadees, finches, flickers, ruffed grouse, thrushes, vireo, woodpeckers; bear, cottontail, deer, moose, skunk, white-footed mouse **Food:** Berries, twigs, leaves
Witch Hazel	*Hammamelis virginiana*	Large 20-30'	Slow	Full/Part Shade or Full Sun	Moist	Dry or rich woods	**Wildlife:** Cardinal, ring-necked pheasant, ruffed grouse, wild turkey; deer, squirrels **Food:** Seeds, buds, twigs, bark

Common Name(s)	Latin Name	Height	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials						
Boneset	*Eupatorium perfoliatum*	4-6'	Full Sun	Dry or Moist	Wet meadows, marshes, pond edges	**Wildlife:** Mallards, ruffed grouse, swamp sparrow, wild turkey; butterflies and other insects **Food:** Nectar
Blue Flag Iris	*Iris versicolor*	2-3'	Full Sun	Moist, Flood Tolerant	Marshes, lakeshores, streambanks	**Wildlife:** Blue-winged teal, ruby-throated hummingbird, wood duck; butterflies and other insects; muskrat **Food:** Nectar, shoots
Bunchberry	*Cornus canadensis*	3-8"	Full/Part Shade	Moist	Cool, moist woods	**Wildlife:** Sharp-tailed grouse, spruce-grouse; moose **Food:** Fruit, buds
Cardinal Flower	*Lobelia cardinalis*	2-4'	Full Sun	Moist, Flood Tolerant	Damp sites, streambanks	**Wildlife:** Ruby-throated hummingbirds; butterflies and other insects; bear, deer **Food:** Nectar
Cattail (Broad-Leaf)	*Typha latifolia*	Up to 10'	Full Sun	Moist, Flood Tolerant	Marshes, lakeshores, streambanks	**Wildlife:** Blue-winged teal, black-crowned night heron, red-winged blackbird, king rail, least and American bittern, mallards, marsh wren, swamp sparrow, Virginia rail; chipmunk, deer, muskrat **Food:** Seed heads
Christmas Fern	*Polystichium acrostichoides*	Up to 1'	Full/Part Shade	Moist	Rich woods	**Wildlife:** Ruffed grouse; box turtle, chipmunk, rabbit **Food:** Fronds, filldeheads
Cinnamon Fern	*Osmunda cinnamomea*	Up to 3'	Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands	**Wildlife:** Brown thrasher, ruby-throated hummingbird, ruffed grouse, yellow throat; chipmunk, deer, white-footed mouse, vole **Food:** Fronds, filldeheads
Foamflower	*Tiarella cordifolia*	Up to 1'	Full/Part Shade	Moist	Rich woods	**Wildlife:** Songbirds and mammals **Food:** Leaves
Goldenrod (Rough or Grass-Leaved)	*Solidago spp.*	1-5'	Full Sun	Dry or Moist	Wet meadows, marshes, damp swales	**Wildlife:** Goldfinch, junco, ruffed grouse, swamp sparrow; butterflies and other insects; cottontail, meadow mice **Food:** Seeds, nectar

Common Name(s)	Latin Name	Height	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials (Continued)						
Hay-Scented Fern	*Dennstaedtia punctiloula*	Up to 2'	Full/Part Shade or Full Sun	Moist	Woodlands, hillside pastures	**Wildlife:** Mammals **Food:** Fronds, filldeheads
Interrupted Fern	*Osmunda punctiloula*	3-4'	Full/Part Shade	Moist	Woodland edges, stony dry soil	**Wildlife:** Mammals **Food:** Fronds, filldeheads
Jewelweed (Spotted-Touch-Me-Not)	*Impatiens capensis*	2-5'	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks	**Wildlife:** Ring-necked pheasant, ruffed grouse, ruby-throated hummingbird, veery; butterflies and other insects; white-footed mouse **Food:** Nectar, seeds
Joe Pye Weed	*Eupatorium purpureum*	2-6'	Full Sun	Moist, Flood Tolerant	Wet meadows, marshes, shores	**Wildlife:** Ruby-throated hummingbird, swamp sparrow; butterflies and other insects; cottontail, muskrat, raccoon **Food:** Nectar
New England Aster	*Aster novae-angliae*	Up to 5'	Full Sun	Dry or Moist	Wet meadows, wetlands	**Wildlife:** Songbirds; butterflies and other insects **Food:** Nectar, seeds
Ostrich Fern	*Pteretis pensylvanica*	Up to 6'	Full/Part Shade		Shrub and forested wetlands	**Wildlife:** Mammals **Food:** Fronds, fiddleheads
Partridgeberry	*Mitchella repens*	Up to 1'	Full/Part Shade	Dry or Moist	Rich woods	**Wildlife:** Grouse, mammals **Food:** Berries
Rattlesnake Manna Grass	*Glyceria canadensis*	Up to 3'	Full Sun	Moist	Marshes, bogs, forested wetlands, lakeshores	**Wildlife:** Songbirds and mammals **Food:** Seeds
Rice Cutgrass	*Leersia oryzoides*	Up to 5'	Full Sun	Moist, Flood Tolerant	Primarily fresh marshes	**Wildlife:** Deer, muskrat, moose **Food:** Seeds, foliage
Riverbank Grape (Vine)	*Vistis riparia*	Up to 25'	Full/Part Shade or Full Sun	Moist	Streambanks	**Wildlife:** Pileated woodpecker, ruffed grouse, wild turkey, wood duck; various mammals **Food:** Fruit
Royal Fern	*Osmunda regalis*	Up to 5'	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands	**Wildlife:** Mammals **Food:** Fronds, fiddleheads

Common Name(s)	Latin Name	Height	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials (Continued)						
Sensitive Fern	*Onoclea sensibilis*	Up to 3'	Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands	**Wildlife:** Black-capped chickadee, ruffed grouse; bear, deer **Food:** Buds, foliage
Sheep Laurel	*Kalmia angustifolia*	Up to 4'	Fall/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forest wetlands, fields/pastures	Poisonous to livestock.
Swamp Milkweed	*Asclepias incarnata*	Up to 2'	Fall/Part Shade	Moist	Wet meadows, wetlands, thickets, shores	**Wildlife:** Black duck, mallards, red-winged blackbird, ruby-throated hummingbird; Monarch butterfly, other butterflies and insects; muskrat **Food:** Nectar, seeds
Sweet Fern	*Componia perigrina*	1-3'	Full/Part Shade or Full Sun	Dry	Open, dry sandy soils and pastures	**Wildlife:** Flickers, sharp-tailed grouse; deer, moose **Food:** Fruit
Tall Meadow Rue	*Thalictrum polyganum*	2-8'	Full/Part Shade	Moist	Wetlands, wet meadows, streamsides	**Wildlife:** Bees, butterflies **Food:** Nectar
Tussock Sedge	*Carex stricta*	Up to 4"	Full Sun	Moist, Flood Tolerant	Marshes, rich woods	**Wildlife:** Finches, ruffed grouse, snipe, sparrows; deer **Food:** Seeds, foliage
Twinflower	*Linnaea borealis*	Up to 6"	Full/Part Shade	Moist	Rich woods	**Wildlife:** Mammals **Food:** Foliage
Virginia Creeper (Vine)	*Parthenocissus quinquefolia*	Up to 25'	Full/Part Shade or Full Sun	Dry or Moist	Woods, rocky banks	**Wildlife:** Bluebird, great-crested flycatcher, red-eyes vireo, pileated woodpecker **Food:** Berries
Whorled Loosestrife	*Lysimachia quadrifolia*	Up to 4'	Full/Part Shade or Full Sun	Dry or Moist	Dry or moist open woods, thickets	**Wildlife:** Mammals **Food:** Foliage
Wild Sarsaparilla	*Aralia nudicanlis*	8-15"	Full/Part Shade	Dry or Moist	Upland woods	**Wildlife:** Mammals **Food:** Foliage, seeds, berries
Wintergreen (Teaberry/Checkerberry)	*Gaultheria procumbens*	Up to 4"	Full Sun	Dry	Oak woods, sandy soils	**Wildlife:** Partridge, ruffed grouse, songbirds; chipmunk, deer, moose **Food:** Fruit, foliage

References

Baldwin, Henry Ives. "*Forest Leaves: How to Identify Trees and Shrubs of Northern New England*", Peter E. Randall Publisher, 1993

Connecticut River Joint Commission, "*Riparian Buffers for the Connecticut River Watershed*", 2000 http://www.crjc.org/pdffiles/Plant%20lists.pdf

Harlow, William M., "*Trees of the Eastern and Central United States and Canada*", Dover Publications, 1942

New Hampshire Department of Environmental Services, *The Critical Edge*, Appendix D, 1998

New Hampshire Department of Resources and Economic Development, Division of Forests and Lands, State Forest Nursury, "*Wildlife Conservation Species Descriptions*" , 2001

Niering, William A. *"National Audubon Society Nature Guides: Wetlands"* Chanticleer Press, Inc., 1997

Redington, Charles B. *"Plants in Wetland: Field Guide to Biological Interactionss"*, Kendall/Hunt Publishing Company, 1994

Sutton, Ann and Myron. *"National Audubon Society Nature Guides: Eastern Forests"* Alfred A Knopf, Inc., 1997

University of New Hampshire Cooperative Extension, "*Trees and Shrubs in New Hampshire: A Guidebook for Natural Beauty Projects*", Bulletin 163

University of New Hampshire Cooperative Extension, "N*ew Hampshire's Native Trees, Shrubs, and Vines with Wildlife Value"*

Compiled by

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March 2006

Appendix Thirty One
Watershed Overlay Districts

Deering Lake, Deering

Watershed Protection Ordinance-preamble
Deering Lake, Deering, New Hampshire

Are you in favor of amending the Zoning Ordinance to add Section 12 Watershed Protection Ordinance as proposed by the Planning Board, to help protect Deering Lake from the effects of pollution and runoff caused by new development within its watershed?

Explanation:

- This Section will create an overlay to the Zoning Ordinance that applies minimal but essential requirements primarily to new development within the Deering Lake watershed that will protect the lake and its water quality from the increased sediment and nutrient run-off that enters the watershed when reasonable practices are not followed.

- Although there have been increases in sediment and nutrient loading caused by new development involving Lake properties, Deering Lake has been able to withstand these increases with little diminishment in water quality. Our lake has water quality that is among the best in NH.

- This will not remain the case as the rapid pace of development continues. A newly-commissioned study calculated the likely damage caused by new development scenarios. This ordinance reflects the findings of that study.

- Deteriorated water quality diminishes wildlife, scenic beauty, and recreational uses and destroys the values of Lake properties.

- Diminished property values affect the tax base of the town.

- This Overlay Ordinance would apply primarily to new development within the defined watershed of Deering lake and would require new subdivisions to demonstrate that they would “do no harm” to the lake and new home construction to include a soil erosion plan. Other development would be required to put in place “best practices” to protect the lake.

Deering Lake Watershed Protection Ordinance

SECTION 12: WATERSHED PROTECTION ORDINANCE
(Adopted March 9, 2005)

12.1 Authority and Statement of Intent

a. Pursuant to RSA 674: 21, the Town of Deering adopts a Watershed Protection Overlay Zone, and accompanying regulations to ensure the protection and preservation of Deering Reservoir, hereafter referred to as Deering Lake, the Deering Lake watershed and the water bodies within the Watershed Protection Overlay Zone from the effects of point and non-point source pollution or sedimentation . The establishment of the Watershed Protection Overlay Zone and the adoption of these regulations are intended:
(1) to protect public health,
(2) to protect aquifers, which serve as existing or potential water supplies, and the aquifer recharge system
(3) to protect surface waters and wetlands contiguous to surface waters,
(4) to protect the natural areas and wildlife habitats within the Watershed Protection Overlay Zone by maintaining ecological balances, and
(5) to prevent the degradation of the water quality through the regulation of land uses and development within the Watershed Protection Overlay Zone.

b. Within this district, and in the event of a conflict between the requirements of this section and other provisions of the Deering Zoning Ordinance or state law, the more stringent requirement shall govern.

12.2 Applicability

a. The special provisions established herein shall apply to all development proposals and to potential contaminating activities within the Watershed Protection Overlay Zone, and all such proposals and activities shall be subject to the review requirements set forth in Section 12.6. The boundaries of the Watershed Protection Overlay Zone have been delineated by the Planning Board using current location data. The Watershed Protection Overlay Zone is shown on the master zoning map kept on file in the Town Hall.

b. The boundaries of the Watershed Protection Overlay Zone may be identified through drainage, groundwater and soils analyses and are considered to be essential to the protection of the watershed from the effects of point and non-point source pollution or sedimentation. These boundaries may be modified as necessary by the Planning Board as new data becomes available.

12.3 Administration

a. General: The Deering Planning Board shall have sole and exclusive authority to administer the provisions of the Watershed Protection Ordinance. The Planning Board is further authorized to adopt amendments to the subdivision regulations in order to further administer the requirements of this section. All development proposals and other potential contaminating activity occurring wholly or partly in an area within the Watershed Protection Overlay Zone shall be subject to this Ordinance and to review and approval by the Planning Board as specified herein. Such review and approval shall be in addition to that required by statute, other provisions of the Deering Zoning Ordinance or Planning Board's rules or regulations. Such review, approval, and all conditions attached to the approval shall be properly documented before issuance of any building permit by the Town. Initial reviews and evaluations required by Section 12.6 c. shall be conducted by the Town of Deering Planning and Zoning Administrator on behalf of the Planning Board. If it is desired to have the full Planning Board consider an initial review or evaluation, a request for full Board consideration must be filed with the Planning and

Zoning Administrator within 3 weeks of its issuance. If no such request is filed, the initial evaluation will become final.

b. Enforcement: The Board of Selectmen shall be responsible for the enforcement of the provisions and conditions of this Watershed Protection Ordinance, pursuant to the provisions of Section 7.

12.4 Definitions

a. Buffer Zone. The undisturbed natural area sufficient in size to mitigate runoff effects harmful to water quality.

b. Contamination. Sedimentation, point and non-point source pollution, septage, or the discharge of hazardous materials.

c. Development. Any construction, change in use, external repair, land disturbing activity, grading, road building, pipe laying, or other activity resulting in a change in the physical character of any parcel of land.

d. Hazardous Materials. As defined in Superfund Amendment and Reauthorization Act of 1986 and Identification and Listing of Hazardous Wastes, 40 C.F.R. §261 (1987).

e. Hydrology**.** The study of the earth's waters, their distribution and the cycle involving precipitation, infiltration into the soil and evaporation.

f. Impervious surface. An area whose water absorbing characteristics are greatly reduced as compared to the natural land and therefore less easily penetrated by moisture including, but not limited to, dirt and paved roads, driveways, parking lots, sidewalks, and roofs.

g. Infiltration rate. The amount and measure of time for surface water to filter into the soil.

h. Potential Contaminating Activity. Activities that have the potential to create a new discharge of contaminants or to increase the discharge of contaminants to surface or ground-waters.

i. Runoff Volume. The measure of surface water runoff during a storm event.

j. Sedimentation. The deposition of sand, silt, soil or other matter into a watercourse or wetland, including that resulting from post-development surface runoff.

k. Storm event. A period of sustained rainfall with a minimum total accumulation of 0.25 inches of precipitation over a 24 hour period.

l. Storm water. Surface water runoff from a non point source caused by a storm event.

m. Tributary stream. Any perennial or intermittent stream, flowing either directly or indirectly into Deering Lake.

n. Watershed. The area lying within the drainage basins of Deering Lake.

o. Non-point Source Pollution. Contaminants including, but not limited to; pesticides, fertilizers, animal wastes, sediments, nutrients, and heavy metals that are deposited on the ground surface and that may flow into and pollute nearby surface waters.

p. Best Management Practices. As defined in "Innovative Stormwater Treatment Technologies, Best Management Practices Manual-May 2002" and "Best Management Practices to Control NonPoint Source Pollution, A Guide for Citizens and Town Officials-January 2004" prepared by the New Hampshire Department of Environmental services and "Buffer for Wetlands and Surface Waters, a guidebook for New Hampshire Municipalities" May 1997 or any updated versions thereof.

12.5 Use regulations

a. Permitted uses, special exception uses, accessory uses, dimensional standards and special requirements established by the underlying zoning district shall apply, except as modified below:

b. The following uses shall be specifically prohibited within the Watershed Protection Overlay Zone:

(1) Storage or production of hazardous materials as defined in either or both of the following:

(a) Superfund Amendment and Reauthorization Act of 1986.

(b) Identification and Listing of Hazardous Wastes, 40 C.F.R. §261 (1987)

(2) Disposal of hazardous materials or solid wastes

(3) Treatment of hazardous material, except rehabilitation programs authorized by a government agency to treat hazardous material present at a site prior to the adoption of this ordinance.

(4) Dry-cleaning, dyeing, printing, photo processing and any other business that stores, uses, or disposes of hazardous material, unless all facilities and equipment are designed and operated to prevent the release or discharge of hazardous materials and have undergone an inspection by the Town of

Deering Code Enforcement Officer to certify they are in compliance with hazardous material regulations.

(5) Disposal of septage or septic sludge, as defined by New Hampshire Solid Waste Rules Env-Wm101-300 & 2100 - 3700.

(6) Automobile service and repair stations

(7) Junkyards and Salvage Yards

12.6 Review requirements for Development in the Watershed Protection Overlay Zone

a. **General.** Applications for subdivision of land and for site plan review and approval are subject to all review requirements of this Section, including the requirement in 12.6 b. that they shall be accompanied by a hydrologic study. Applications for new home construction, and additions, modifications and repairs of existing homes, need not be accompanied by a hydrologic study, but must meet the other review requirements of this Section. New home construction applications must include a soil erosion plan as set forth in 12.6 c. This Watershed Protection Ordinance does not establish any pre-approval requirements for other land development proposals that do not involve potential contamination.

b. Any application for a land development proposal involving the subdivision of land or site review and approval, occurring wholly or partly in the Watershed Protection Overlay Zone, shall be submitted to the Planning Board for approval and shall be accompanied by a hydrologic study prepared in accordance with the requirements set forth in subsection 12.7 below. Said study must document, in a manner acceptable to the Planning Board, that the land development proposed would provide the same or a greater degree of water quality protection as existed on the site(s) in question at the time the application is made.

c. All development within the Watershed Protection Overlay Zone will be evaluated by the Planning Board to ensure that:

(1) Non-point source pollution is prevented to the maximum extent possible, taking into account site conditions such as slope, soil type and erosivity, and vegetative cover. The amount of lawn is limited to 10% of all dry land.

(2) Best Management Practices (BMPs) are in place sufficient to remove or neutralize those pollutants that present a potential impact to the water body. In the case of proposals for new home construction, the proposal

shall include an erosion and sedimentation control plan prepared by a licensed engineer. The use or creation of holding-ponds is not allowed for runoff control.

(3) Grading and removal of vegetation at a development site is minimized and erosion and sedimentation control measures are in place and properly installed.

(4) All septic tanks will be pumped and inspected by a State of New Hampshire licensed septic services provider to ensure proper functioning and a copy of the pumping and inspection report shall be sent to the Town of Deering Planning and Zoning Administrator within 30 days of its occurrence. Such pumping and inspection shall occur at least every three years or at the interval recommended by the licensed septic service provider in writing at the time of last service. If two or more dwelling units share a common sewage treatment system, a perpetual maintenance agreement binding the dwelling owner is required.

(5) Activities involved in potential contamination within the Watershed Protection Overlay Zone, but which have received a special exception, must submit a spill prevention control and countermeasures plan (SPCC Plan) for approval. This plan shall include the following elements:

(a) Disclosure statements describing the types, quantities, and storage locations of all contaminants that will be part of the proposed project.

(b) Contaminant handling and spill prevention techniques

(c) Spill reporting procedures, including a list of affected agencies to be contacted in the event of a spill

(d) Spill recovery plans, including a list of available equipment

(e) Spill clean-up and disposal plans

d. Existing land uses located within the Watershed Protection Overlay Zone and identified as potential contaminating activities by the Planning Board shall comply with the requirements of Section 12.6, Subsection c.(5) listed above.

12.7 Hydrologic Study

a. A hydrologic study shall be performed by a registered professional engineer or hydrologist and it shall include, at a minimum, the following information:

(1) Description of the proposed project including location and extent of impervious surfaces; on-site processes or storage of materials; the

anticipated use of the land and buildings; description of the site including topographic, hydrologic, and vegetative features.

(2) Characteristics of natural runoff on the site and projected runoff with the proposed project, including its rate and chemical characteristics deemed necessary to make an adequate assessment of water quality.

(3) Measures proposed to be employed to reduce the rate of runoff and pollutant loading of runoff from the project area, both during construction and after.

(4) Proposed runoff control and watershed protection measures for the site. These measures shall be designed with the goal of ensuring that the rate of surface water runoff from the site does not exceed pre-development conditions and that the quality of such runoff will not be less than pre-development conditions. Special emphasis shall be placed on the impacts of proposed encroachments into the required buffer.

(5) Where the developer of property subject to the terms of this Watershed Protection Ordinance seeks to utilize existing or planned off-site storm-water quality management facilities, the developer shall provide a written certification that the owner of the off-site facilities will accept the runoff and be responsible for its adequate treatment and that the arrangement will run with the land in a manner that will be acceptable to the Planning Board.

b. The study will make use of existing Deering Lake water quality historical data to the maximum extent possible. If new data is to be introduced, the Town reserves the right to have the data reviewed by an independent expert at the expense of the property developer.

c. The study shall be submitted to the Planning Board for review and approval concurrent with the submission of applications for review and approval of site or subdivision plans or applications for land disturbing or erosion and sediment control permits.

12.8 Buffer Requirements

a. A 75 foot wide buffer zone shall be maintained along the edge of any tributary stream discharging into Deering Lake and along the edge of any wetlands associated with those tributary streams. The required setback distance shall be measured from the centerline of such tributary stream and from the delineated edge of a wetland. Streams and wetlands shall be delineated from their mean high water mark. The buffer zone shall be maintained in its natural state to the maximum extent possible.

b. A reduction in the required buffer zone width down to an absolute minimum of fifty-feet (50') may be granted by the Planning Board upon presentation of a hydrologic or other study that provides documentation and justification, acceptable to the Planning Board, that even with the reduction, the same or a greater degree of water quality protection would be afforded as would be with the full-width buffer zone. In granting such a reduction, the Planning Board may require certain conditions of approval which may include, but are not necessarily limited to, restrictions on use or type of construction, and/or additional erosion, runoff or sedimentation control measures, as deemed necessary to protect water quality.

c. All development shall be located outside of the required buffer zone.

d. The following uses shall not be permitted within the buffer zone or within twenty-five feet (25') of any required buffer zone:

(1) septic tanks and drain-fields;

(2) feed lots or other livestock impoundments;

(3) trash containers and dumpsters which are not under roof or which are located so that leachate from the receptacle could escape unfiltered and untreated;

(4). fuel storage in excess of fifty (50) gallons [200L];

(5). sanitary landfills;

(6). activities involving the manufacture, bulk storage or any type of distribution of petroleum, chemical or asphalt products or any materials hazardous to Deering Lake (as defined in the Hazardous Materials Spills Emergency Handbook, American Waterworks Association, 1975, as revised) including specifically the following general classes of materials:

(a) oil and oil products

(b) radioactive materials

(c) any material transported in large commercial quantities that is a very soluble acid or base, highly biodegradable, or can create a severe oxygen demand

(d) biologically accumulative poisons

(e) the active ingredients of poisons that are or were ever registered in accordance with the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended (7 USC 135 et seq.)

(f) substances lethal to mammalian or aquatic life.

(g) road salt

(h) lawns

(7). No more than 50 % of basal area of timber may be cut over a twenty (20) year period.

WEBSTER LAKE OVERLAY DISTRICT (8/25/04)

Add new Section 309.29.2 to the Franklin Zoning Ordinance

A. Purpose:

a. Webster Lake is a public water body. In as much, the City of Franklin shares with the State of New Hampshire, jurisdiction and responsibility to protect and maintain the quality of this valuable resource for the greatest public benefit.

b. The Webster Lake watershed, which falls within the municipalities of Andover, Hill and Franklin, is a valuable and fragile natural resource and has direct influence on the integrity of the water quality of Webster Lake.

c. Under current local and state laws the potential exists for random, piecemeal or uncoordinated uses of the land within the watershed, which could have significant negative impact on the water quality of Webster Lake, and it's tributaries. The environmental quality of the watershed has been degraded due to agricultural run-off, the destabilization soils from development activities, and the failure of septic systems.

d. The creation of performance standards for certain land use activities within the watershed will provide for increased long-term protection of Webster Lake and its watershed.

e. Where the Webster Lake watershed transcends municipal boundaries, the City of Franklin will seek opportunities to work cooperatively with neighboring towns toward the common objective of improved water quality within the subject watershed. In the spirit of a regional approach to resource management, the City will foster cooperation among regional and state officials to further enhance the quality of water found in this overlay district.

B. Authority:

a. Under RSA 674:16 the Planning Board has the authority to promulgate recommendations to modify or create zoning changes and for the City Council to adopt such recommended changes.

b. RSA 674:21 Innovative Land Use Controls sections (h) and (j) allow municipalities to adopt ordinances which contain performance standards and environmental characteristics zoning that allow the City to promulgate standards to ensure the continued integrity of these natural resources.

c. In any case where a provision of these regulations is found to be in conflict with provisions of other regulations, ordinances or codes of either the State or the City, the provisions, which are more restrictive, shall prevail.

C. DEFINITIONS:

1. Bank: the transitional slope adjacent to the edge of a surface water, the upper limits of which is usually defined by a break in slope or, for a wetland, where a line delineated in accordance with DES Administrative Rules Wt. 301.01 indicates a change from wetland to upland area.
2. Individual Sewage Disposal System: as defined by the NH Department of Environmental Services [NH DES] and associated Code of Administrative Rules, as amended.
3. Surface Water or Surface Water Body: any portion of the waters of the state, which have standing or flowing water at or on the ground. This includes, but is not limited to, rivers, streams (perennial or intermittent), lakes, or ponds.
4. Watershed: a geographic area in which all water drains to a given stream, lake, estuary, or ocean.
5. Webster Lake Watershed: The Webster Lake Watershed consists of the area shown on the map titled Webster Lake Watershed Land Use, prepared by NH DES, October 2003.
6. Webster Lake Watershed Overlay District: The area shown as the Overlay District on the map attached to the Franklin Zoning Ordinance and which is subject to the provisions contained herein.
7. Wetland: an area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions does support, a prevalence or vegetation typically adapted for life in saturated soil conditions. Wetlands include, but are not limited to, swamps, marshes, bogs, wet meadows, and other similar areas

PERFORMANCE STANDARDS

D. AGRICULTURE (Includes any agricultural activities)

1. Livestock are not allowed direct access to surface waters. Drinking water for livestock shall be provided by the use of a tub or other container located a minimum of 150 feet away from any surface water or wetland.
2. Application of fertilizers or pesticides is not allowed within 200 feet from any surface water or wetland.
3. All livestock grazing and feeding areas shall be a minimum of 200 feet away from surface waters.
4. All runoff from livestock feeding areas shall be directed away from surface water or wetland area.
5. No spreading of animal manure on fields or pastures is allowed any closer than 200 feet away from any surface water or wetland. No stockpiling of manure is allowed any closer than 200 feet from any surface water or wetland area and the stockpiling must be placed on an impervious surface and contained to prevent the release of leachate.
6. Unless stricter setbacks or operational requirements are outlined above, all agricultural operations shall be conducted in accordance with the Manual of Best Management Practices for Agriculture in New Hampshire, NH Dept. of Agriculture, June 1993, as amended**,** and in accordance with all appropriate sections of the Comprehensive Shoreland Protection Act, as amended.

E. WETLANDS and SURFACE WATERS

1. No filling, alteration, or any other work is allowed within any wetland area without the required permits from the NH DES.
2. The property owner or his/her designee is responsible for obtaining all necessary state or federal permits pertaining to, but not necessarily limited to, the construction and/or installation of any docks, boathouses, footpaths or steps to the water. Copies of all permits shall be submitted to the Franklin Conservation Commission.
3. For any plans or designs required as part of this Overlay District which involves analysis and determination of wetland boundaries, the work to determine said boundaries whall be done by a Certified Wetland Scientist and/or a Certified Soil Scientist as defined by RSA 310-A:76 II. and III, as amended.

F. FORESTRY (Includes all commercial forestry activities)

1. A minimum 75-foot undisturbed natural vegetated buffer shall be maintained adjacent all surface waters or wetland areas.
2. Unless stricter setbacks or operational requirements are outlined above, all forestry operations shall be conducted in accordance with the Best Management Practices for Erosion Controls on Timber Harvesting Operations in New Hampshire, NH Division of Forests and Lands, February 2000, as amended, and in accordance with all appropriate sections of the Comprehensive Shoreland Protection Act, as amended

G. SITE CONSTRUCTION (Commercial / Industrial or Residential)

1. No new structures or driveways are allowed within 50 feet of any surface water or wetland area. Accessory structures are allowed when permitted by the NH DES
2. The impervious area of any building lot is limited to 30%. Impervious area includes building area, gravel or asphalt driveway and parking area.
3. For any use that will render impervious more than 20% or more than 2,500 square feet of any lot, whichever is greater, a storm water management and erosion control plan, consistent with Storm water Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire, Rockingham County Conservation District, August 1992, as amended, shall be prepared and submitted to the Planning and Zoning Office for review. No building Permit shall be issued until such time as the Planning and Zoning Administrator has reviewed and approve said plan.

H. SEPTIC SYSTEMS

1. For any new construction, no Individual Sewage Disposal System [ISDS] shall be installed any closer than 100 feet to any surface water or wetland area.
2. For any expansion of an existing structure, or the seasonal conversion of an existing structure, the owner shall conform to RSA 485-A: 38 and the associated Code of Administrative Rules for Subdivision and ISDS Design Rules, as amended.

3. For a new subdivision development for which ISDS's are proposed, if the lots are under 5 acres, then all plans and permit application shall conform to all relevant NH DES rules and regulations. For lots that are greater than 5 acres, all plans and permit applications shall show an area of 4000 sq. ft., with test pit and percolation test data to verify the site suitability for a septic system.

4. If any septic assessment or an on-site inspection, indicates that the existing system is in failure, a plan for a replacement system shall be submitted to NH DES within the next 30 days.

I. GENERAL PERFORMANCE STANDARDS FOR ALL ACTIVITIES AND LAND USES

1. No new underground storage tanks for flammable or combustible liquid fuels shall be allowed.

J. EXCEPTIONS

1. If the property owner or his/her designee can document that property, or a portion of a property, which is shown to be inside of the Webster Lake Watershed Overlay District is outside of the Webster Lake Watershed, and said documentation is accepted by the Planning and Zoning Administrator, then the provisions of the Webster Lake Watershed Overlay District shall not apply.

K. ENFORCEMENT

1. The Enforcement of these provisions shall adhere to the provisions of Section 305.38 of the Franklin Zoning Ordinance.

Appendix Thirty Two
Perched Beach Guidance

New Hampshire Department of Environmental Services
29 Hazen Drive Concord NH 03301

Wetlands Bureau

Guidebook for Wetlands Permits

Tuesday, January 9, 2007

Introduction

How to Complete a Wetlands Application

Beach Construction

Glossary

Appendices...
Letter to Abutters
Prime Wetlands
Natural Landmarks

Comments

Wetlands Home
NHDES Home Page

Beach Construction and Maintenance

Owners of waterfront property sometimes want to add a sandy beach for recreational enjoyment and incorporate it into a landscape design for the property. This may require modification of the natural shoreline by clearing vegetation. In accordance with RSA 482-A, a permit from the DES Wetlands Bureau is needed for construction of a beach if the area is within the banks of a surface water body (even if no wetland is affected). Beaches that are permitted by DES must comply with the Comprehensive Shoreland Protection Act (RSA 483-B). DES' Shoreland Protection rules require that a healthy, well-distributed stand of trees, shrubs, saplings, and ground cover remains and that stumps not be removed from the area surrounding the beach. Other local and federal regulations also may apply to construction of beaches.

- **Design Guidelines and Information Requirements**

The design guidelines detailed below provide information, which will allow you to design your project in accordance with the Department of Environmental Services' (DES) wetlands and shoreland protection rules. The incorporation of all of these guidelines and information requirements into your design, plans, and application materials will increase the likelihood of receiving a permit.

- **Beach Location, Size, & Configuration**

A beach needs to be placed in a location on the frontage that poses the least environmental impact. To select an appropriate location, look for an area that requires the least amount of tree and vegetation removal and the least amount of rock and earth removal. Choose an area where the slope is naturally more flat. Locate an area of the shoreline where the adjacent lakebed is not mucky and has little aquatic weed growth. This will provide better conditions for swimming and less disturbance to water quality and lake habitat. Dredging of the lake bottom or placement of sand in the water for beach construction is rarely permitted. Beaches may not be constructed in wetland areas. A beach and associated construction activities must be located at least 20 feet from property boundaries unless written permission is received from the affected abutter.

Most beaches may be no larger than 20 percent of the entire contiguous frontage (up to a maximum of 50 linear feet) and may not alter more than 900 square feet. A beach for a single family residence must adhere to these size limits Beaches larger than this are considered major impact projects and the need for a larger beach must be well documented.

Current policy requires that new beaches are "perched." The beach must have little or no slope and must be located entirely out of the water, above and landward of the existing undisturbed natural shoreline. All sand is placed above the high water mark and out of the water. The construction of a beach in a perched position helps prevent the erosion of sand into the water and degradation of the lake environment. In addition, a perched beach requires less maintenance, which is a benefit to the homeowner.

The beach should be constructed in a manner that disturbs no boulders on the shoreline. If the frontage is not naturally rocky, a barrier of no more than 12 to 18 inches should be constructed landward of the high water mark to separate the perched beach from the water. If excavation into the bank is required, the project must incorporate an appropriate method to stabilize the landward side of the cut. A stone retaining wall is used often to stabilize this landward side.

- **Access to Water from Beach**

Steps leading to the water from the beach may be included in the design. They should be constructed so that they are cut back into the bank, rather than extending into the lake. If removable wood stairs are used, they should be constructed over the existing grade. Stairs that are constructed over the existing grade and removable at the end of the season are a preferred alternative. Steps should be no more than four feet wide. Very limited dredging (less than one cubic yard) beyond the steps may be permitted where the need is demonstrated.

- **Surface Water Diversion**

Beach projects must incorporate methods for diversion of surface runoff around the beach to prevent erosion of the sand into the lake during storm events. Many designs incorporate a shallow grass or stone-lined swale around the landward side of the beach.

- **Construction Materials and Guidelines**

Any sand placed in the beach area must be clean. Clean sand is sand that contains little or no silt or loam. Silt or loam can cause water quality problems if it enters the lake. No more than 10 cubic yards of sand may be placed on a new, perched beach. To estimate the quantity of sand needed for a beach, the depth of sand on the beach should not exceed six inches.

Construction should be planned to take place during the lake drawdown. If this is not possible, the work should be scheduled for when the lake is at its lowest level. Appropriate siltation controls need to be installed prior to construction and maintained until all disturbed areas are stabilized. Machinery should not enter the water during construction. Care should be taken when landscaping around newly constructed beach areas. Revegetation of trees, shrubs and ground covers representing the density and species diversity of the existing vegetation removed for the project shall begin at a distance no greater than five feet from the beach area.

- **Replenishment of Sand**

Replenishment of beach sand may be allowed once every six years, if needed. In general, it may not exceed more than 10 cubic yards. Placement of sand below the high water mark is classified as a major project (see the "Classification of Projects" section) and is usually not allowed, even on previously permitted or grandfathered beaches. Applications for beach replenishment should incorporate methods for diversion of surface runoff around the beach area. This is required if requests for beach replenishment are too frequent or the migration of sand has resulted in the need to maintenance dredge the adjacent area.

No permit is required for maintenance of an existing beach if the project:

Involves hand raking of leaves or other organic debris from the shoreline or lakebed provided that:

a. At the time the raking is done, the area raked is exposed by drawdown; or
b. Raking does not disturb vegetative roots and is limited to 900 square feet of area.

Classification of Projects

Each project is assigned a classification as a minimum, minor, or major impact project. The classification of a project is related to the potential for impact that a project might cause to occur. Use the chart below to determine the classification of the project.

A beach construction or replenishment project is classified as a **MINIMUM** project if it:

1. Is for a privately owned, single-family residence; and
2. Requires no fill below the high water line; and
3. Involves no more than 900 square feet of dredge or fill; and
4. Is not located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; and
5. Alters no more than 20 percent of frontage (up to 50 feet) and
6. Involves placement of 10 cubic yards of sand or less; and
7. Requires replenishment once during a 6-year period.
8. It involves cutting of aquatic weeds above the roots provided that:
    a. There is no disturbance of the bottom sediments; and
    b. It is not in prime wetlands, marshes, bogs and does not impact an exemplary natural community or endangered or threatened species.

A beach construction or replenishment project is classified as a **MINOR** project if it:

1. Is for a privately owned, single-family residence; and
2. Requires fill below the high water line; and
3. Involves no more than 900 square feet of dredge or fill; and
4. Is not located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; and
5. Alters no more than 20 percent of frontage (up to 50 feet); and
6. Involves placement of between 10 and 20 cubic yards of sand.
7. Involves removal of emergent or submergent vegetation requiring disturbance of the bottom sediments and is not otherwise classified as a major project. [See minimum above for projects involving control of exotic aquatic weeds Cabomba carolina, fanwort, or Myrophyllum heterophyllum, exotic milfoil.]
8. Requires removal of less than 20 cubic yards of material from public waters and is not otherwise classified as a major project.

A beach construction or replenishment project is classified as a **MAJOR** project if it:

1. Is NOT for a privately owned single family residence; or
2. Requires dredge or fill below the high water line; or
3. Involves more than 900 square feet of dredge or fill; or
4. Is located in a swamp, marsh, tidal buffer zone, bog, or in or adjacent to prime wetland; or
5. Alters more than 20 percent of frontage (or more than 50 feet); or
6. Involves placement of more than 20 cubic yards of sand; or
7. Requires replenishment more than once during a six-year period; or
8. It involves work in an area identified as an exemplary natural community or has documented occurrences of a state or federally listed endangered or threatened species.
9. Involves dredge of more than 20 cubic yards of sand from public waters (below high water).

For all minor and major projects, the following information must be provided. Any projects that are classified as minor or major need to demonstrate by plan and example that the 20 questions in the table below have been considered in the assessment of impacts that would result from the proposed project.

302.04(a) element	Explanation	Beach-specific concerns or examples
(1) The need for the proposed impact;	Explain the need for this project.	
(2) The alternative proposed by the applicant is the one with the least impact to wetlands or surface waters on site;	(address size of impact, type of impact, resource) Address on-site and off-site locations considered for projects	Area of jurisdiction that is subject to impacts should be limited to the area within the bank of the surface water body. No wetlands should be subject to impacts for construction of a beach.
(3) The type/classification of the wetlands involved;	According to Cowardin's *Classification of Wetlands and Deepwater Habitats of the United States*	No wetlands should be subject to impacts for construction of a beach. Impacts should be limited to within the bank of the surface water body.
(4) The relationship of the proposed wetlands to be impacted relative to nearby wetlands and surface waters;	The plan and cross sectional views should illustrate the location of wetlands, top of bank and the high water line on the property.	No wetlands should be subject to impacts for construction of a beach. Impacts should be limited to within the bank of the surface water body.
(5) The rarity of the wetland, surface water, sand dunes, or tidal buffer zone area;	Describe the resource and indicate why the wetland, surface water, sand dune, or tidal buffer zone is or is not rare.	Check resources list to obtain information about the specific area of interest.
(6) The surface area of the wetlands that will be impacted;	Provide surface area of wetlands (or other jurisdictional area -- such as bank or surface water) subject to temporary or permanent impacts from the project.	Identify the temporary and permanent impacts. Explain how the area of disturbance will be minimized.
(7) The impact on plants, fish, and	Information about plant and	There should be no issue to plant

wildlife including: a. Rare, special concern species; b. State and federally listed threatened and endangered species; c. Species at the extremities of their ranges; d. Migratory fish and wildlife; and e. Exemplary natural communities identified by the New Hampshire Natural Heritage Inventory (NHI) - Department of Resources and Economic Development.	wildlife species and exemplary natural communities may be requested from the Natural Heritage Inventory staff at the N.H. Department of Resources and Economic Development. Information about migratory fish may be obtained from the N.H. Fish and Game Department. Note: Evaluation of impacts should not be limited to those categories identified in a. through d.	or animal species in the surface water because no work should occur there. Any species habitat that may be subject to impacts from construction in the bank would need to be addressed. Migratory fish species are not a concern if no work is done in the water (and the proper precautions are taken during construction).
(8) The impact of the proposed project on public commerce, navigation and recreation;		If the project is for a private beach, there should be no effect on the public. If the project is for a public beach, the project would add recreation opportunities for the public, and could have a positive impact on commerce.
(9) The extent to which a project interferes with the aesthetic interests of the general public.	For example, indicate the type of material to be utilized and the effect of the construction of the project on the view of other users of the area.	The construction of a perched-style beach and compliance with the Comprehensive Shoreland Protection Act would reduce the visible impacts to the public.
(10) The extent to which a project interferes with or obstructs public rights of passage or access.		If the project is for a private beach, there should be no effect on the public. If the project is for a public beach, the project may improve access to the water for the public.
(11) The impact upon abutting owners pursuant to RSA 482-A:11, II.	No work should be done within 20 ft. of an abutter.	The construction of a perched-style beach and compliance with the Comprehensive Shoreland Protection Act would reduce the visible impacts to the public.
(12) The benefit of a project to the health, safety, and well being of the general public;		If the project is for a private beach, there are no benefits to the public. If the project is for a public beach, the project may improve safe access to the water for the public.
(13) The impact of a proposed project on quantity or quality of surface and ground water.	For example, where an applicant proposes to fill wetlands he/she would be required to document the impact of the proposed fill on the amount of drainage entering the site versus the amount of drainage exiting the site and the difference in the quality of water entering and exiting the site;	A beach has no impervious surface and therefore should not impact the quantity of surface water or quantity or quality of groundwater. The proper design, construction and maintenance of swales to divert runoff needs to prevent sediment from migrating into the lake, thus protecting the quality of surface water.
(14) The potential of a proposed project to cause or increase flooding, erosion, or sedimentation;		Since the project is entirely above the normal high water elevation, current or wave energy should not be affected.

(15) The extent to which a project that is located in surface waters reflects or redirects current or wave energy which might cause damage or hazards;		Perched beaches should not affect wave energy if the natural shoreline at the high water line remains undisturbed.
(16) The cumulative impact that would result if all parties owning or abutting a portion of the affected wetland or wetland complex were also permitted alterations to the wetland proportional to the extent of their property rights.	For example, an applicant who owned only a portion of a wetland (or other jurisdictional area -- such as bank or surface water) would document his/her percentage of ownership of that wetland and the percentage of that ownership that would be impacted;	How much shoreline or bank would be subject to impact if every shoreline property owner requested similar impacts.
(17) The impact of the proposed project on the values and functions of the total wetland or wetland complex;		Identify impacts of project to the functions and values of wetlands (or other jurisdictional area -- such as bank or surface water).
(18) The impact upon the value of the sites included in the latest published edition of the National Register of Natural Landmarks, or sites eligible for such publication;		Check current list of Natural Landmarks. Construction of a beach adjacent to a natural or historic landmark may have a negative effect on the aesthetics.
(19) The impact upon the value of areas named in acts of congress or presidential proclamations as national rivers, national wilderness areas, national lakeshores, and such areas as may be established under federal, state, or municipal laws for similar and related purposes such as estuarine and marine sanctuaries;		Check current lists in guidebook for information or sources of information.
(20) The degree to which a project redirects water from one watershed to another.		A beach has no impervious surface and is very close to the lake -- therefore it should not redirect water into other watersheds.

Plan View

Applications for beach construction must include two different views of the project: a "plan view" and a "cross-sectional plan." Examples of each type of plan follow. Both plans must clearly show that the design considerations and criteria for beach construction described herein have been incorporated into the design.

A "plan view" may be visualized as a view looking down on the land from the sky. This plan must show the following information:

___ The entire frontage of the parcel in question, which accurately depicts the shape or contour of the frontage;

___ The length of the shoreline frontage (in feet);

___ The location and dimensions (length and width) of the proposed beach area -- and access steps, if applicable;

___ The distance from the edges of the proposed beach area to each abutting property boundary;

___ The location and dimensions (length and width) of all existing structures on the frontage;

___ An arrow showing the direction north;

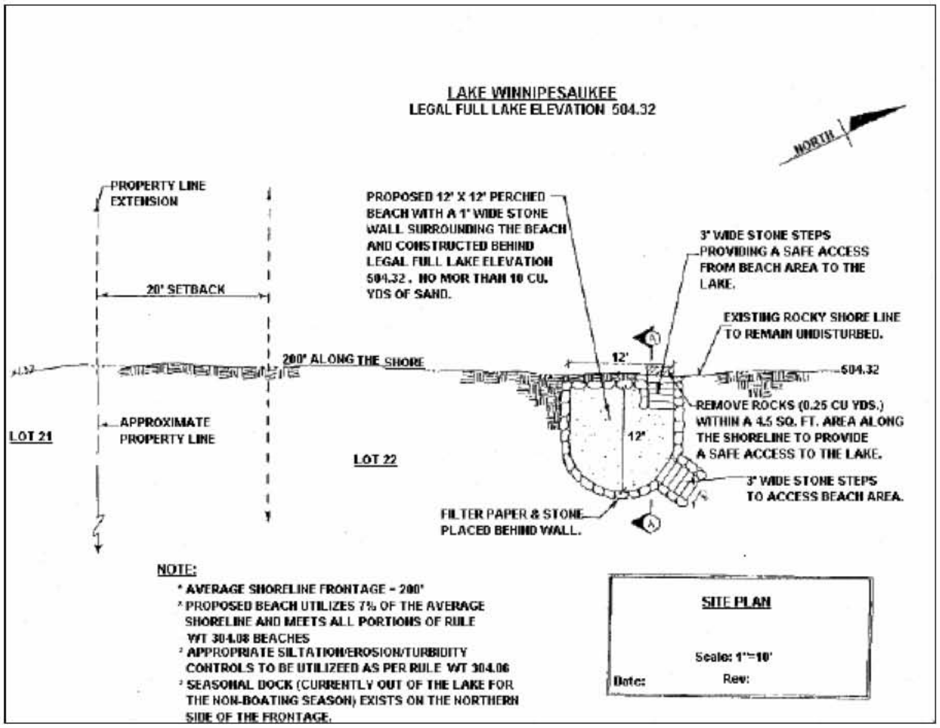
___ The scale of the plan (such as 1 inch = 10 feet) if it is drawn to scale;

___ Notes to indicate the proposed quantity of sand to be placed on the beach and that the sand will be placed above the normal high water mark;

___ Notes to indicate the proposed sequence of construction activities;

___ Note the location and diameter of any tree that needs to be removed as part of the beach construction.

___ Any wetlands on the frontage.



Larger View of Plan || Plan PDF file

Cross-Sectional View

A cross-sectional view is a vertical slice through the bank. This plan must show the following information:

___ The existing slope of the bank;

___ The proposed slope after the beach has been constructed;

___ The location of the normal high water mark in relation to the proposed perched beach;

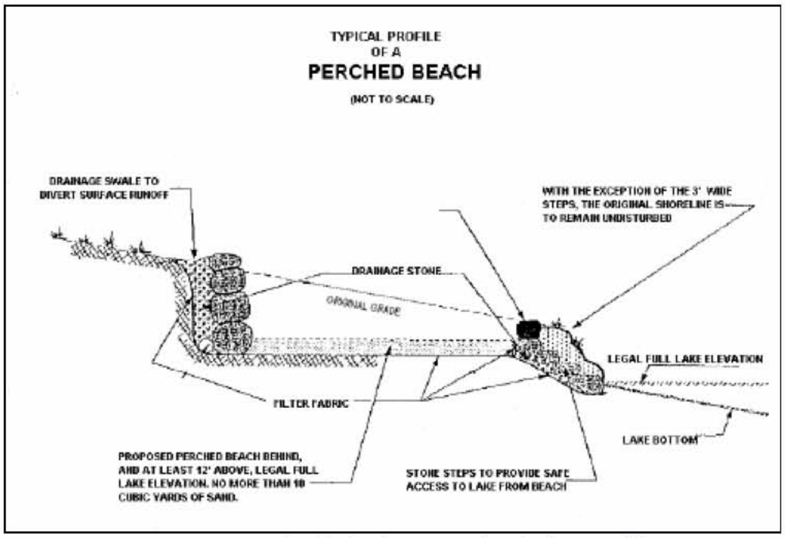
___ The scale of the plan (such as 1 in.= 20 ft.) if it is drawn to scale;

___ The height and width of stone placed along the lakeward edge of the beach;

___ The height and width of the wall or riprap that is used to stabilize the back (landward) side of the beach;

___ Drainage devices, such as swales, trench drains, etc.;

___ Location of steps relative to the original shoreline and high water elevation.



Larger Cross-Sectional View || Cross-Sectional View PDF file