III. USES OF NATURAL RESOURCES AND THEIR IMPACTS

A. IMPACTS ON WATER QUALITY

Historical Water Quality of Greenwood Lake

There was evidence in 1951, when a New Jersey fisheries survey was conducted, of the deterioration of the quality of the water in Greenwood Lake.[1] The study reported the occurrence of nuisance densities of aquatic macrophytes and occasional blooms of *Spirogyra*, filamentous algae.[2] In addition, the same publication reported the summer depletion of dissolved oxygen in the hypolimnion following stratification of the lake. The observed decreases in the summer of dissolved oxygen levels were attributed to bacterial respiration resulting from the decomposition of organic material. Since the time that study was conducted, increased development, conversion of seasonal cottages to year-round homes, and the discharge of wastewater to the watershed lakes and tributaries have increased the lake's nutrient loadings and have accelerated its eutrophication.

In 1976 the National Eutrophication Survey Report on Greenwood Lake by the US Environmental Protection Agency stated that the lake was in early stages of eutrophication.[3] The data which accompanied that report characterized the lake as having a summer depression of hypolimnetic dissolved oxygen, high total phosphorous concentrations, algae blooms, and nuisance densities of aquatic macrophytes. On the basis of algal assay spike testes, the lake was found to be phosphorous limited in the spring, but possibly nitrogen limited in the summer and fall. The report also points out that total phosphorus nutrient loading to the lake was 1.4 times greater than the "permissible" load calculated for lakes of similar hydrology and morphometry.[4]

Clean Lakes Phase 1: Diagnostic-Feasibility Study of Greenwood Lake
Greenwood Lake Watershed Management District, Inc. & Princeton Aqua Science (1983)

Operating under the Clean Lakes Program (Section 314 of the Clean Water Act) with a grant from the US Environmental Protection Agency (EPA) and administered by the New Jersey Department of Environmental Protection (NJDEP), the Greenwood Lake Watershed Management District, Inc. (GLWMDI), a non-profit corporation established in 1979, commissioned Princeton Aqua Science to conduct a limnological and stream monitoring investigation that would provide the necessary data to develop a comprehensive lake management action plan.[5]

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[1] Princeton Aqua Science. 1983. Phase 1: Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and New York. Page 107.

[2] Princeton Aqua Science. 1983. Page 107. Reference: New Jersey C.E.D. 1953. New Jersey Fisheries Survey, Report Number Two, 1951, Lakes and Ponds. NJ Dept. C.E.D., Division of Fish and Game, Trenton, NJ.

[3] Princeton Aqua Science. 1983. Page 107. Reference: US Environmental Protection Agency. 1976. Report on Greenwood Lake, Passaic County, New Jersey & Orange County, New York, EPA Region II. US Environmental Protection Agency, National Eutrophication Survey. Working Paper No. 367.

[4] Vollenwier and Dillion, 1974.

[5] Princeton Aqua Science. 1983. Phase 1: Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and New York YorYork. Pages 1, 218.

The study identified major problems with Greenwood Lake which included the excessive growth of aquatic weeds, excessive growth of planktonic and benthic algae, complete oxygen depletion in hypolimnetic waters extending up into metalimnion, accumulation of sediments, presence of dangerous navigation hazards, and degrading fishery.[6] The lake was deemed to be in a state of "accelerated eutrophication".[7] The study also included an outline for a lake management plan, with the objectives of reducing external and internal nutrient and sediment loads and of reversing symptoms of eutrophication that impair the lake's status as a recreational resource.[8]

The study provides a description of both the lake and its watershed, including the physical characteristics of the lake and surrounding lands (geology, soils, and groundwater) and their socioeconomic context (classifications of lake/tributary waters, land use in the watershed, economic use of the lake as recreation site). During the study water quality monitoring was conducted. Five in-lake and twelve stream stations were designated for routine sampling. All direct tributaries to the lake, as well as Belcher Creek upstream of Pinecliff Lake, were monitored on a monthly basis. In-lake stations were selected on the basis of depth, circulation patterns, and proximity to major population centers, and were sampled bi-weekly from April through September, and monthly October through March (exclusive of December). Two additional stations, one located at the mouth of Belcher Creek and another at the Penaluna Landfill, were sampled less frequently. The water quality monitoring program is described in terms of the sampling methods and analytical techniques employed.[9] Point sources and septic systems were also investigated to determine their contributions to nutrient loading in the lake, and attention was also given to the closed Penaluna landfill, located to the north of the lake.[10] Based on the data collected, hydrological and nutrient budgets for the lake were calculated and related to the biota to determine the overall trophic state of the lake.[11] Overall, the study found that Greenwood Lake had not changed substantially in either water quality or biological diversity since a prior fishery survey conducted by the State of New Jersey in 1951, which also noted the presence of algal blooms and oxygen depletion in the depths.[12]

As the land around Greenwood Lake was developed, the lake waters became more eutrophic, the growth of algae and nuisance aquatic plants increased, and the quality of the fauna, including benthic macroinvertebrates and fish, became less diverse. This happened because too many nutrients, especially phosphorus and nitrogen compounds, entered the lake and overfed the plants growing in the lake. This eutrophication is hampering the enjoyment of the lake for recreation. The study identified excessive loadings of phosphorus as the principal nutrient of concern.[13] But nitrogen levels may also be a limiting factor, especially during summer seasons when phosphorus loadings drive the nitrogen-phosphorus ratio below 12:1.[14] The study estimated the sources of phosphorus loadings. Most phosphorus loadings (62%) were coming into the lake via its tributary streams, from nonpoint sources and point source discharges into Belcher Creek (the

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[6] Greenwood Lake Watershed Management District, Inc. 1983. Cover letter to NJDEP re Princeton Aqua Science report, page 1. & Princeton Aqua Science, page 187.
[7] Princeton Aqua Science, page 187.
[8] Princeton Aqua Science, page 191.
[9] Princeton Aqua Science, pages 52-68.
[10] Princeton Aqua Science, pages 69-91.
[11] Princeton Aqua Science, pages 92-186.
[12] Princeton Aqua Science, page 107.
[13] Princeton Aqua Science, page 64.
[14] Princeton Aqua Science, page 179.

lake's major tributary) from five sewage treatment plants, especially the Birch Hill plant (5.5%). Other major sources included septic leachate (9%), and internal loadings from lake sediments (29%).[15]

The study approached management from both the watershed and in-lake perspectives. Watershed management recommendations included activities aimed at point sources, the sewage treatment plants (STPs), and non-point sources like septic systems and stormwater management controls. The recommendations regarding point source efforts included upgrading the Birch Hill STP to remove phosphorus from its discharges and monitoring of phosphorus at the other four STPs, as well as prohibiting any future wastewater discharges into the lake or its tributaries.[16] New septic systems were to be banned within 200 meters of the lake and existing ones inspected rigorously, while surrounding communities were advised to seek federal and state aid to install sewers.[17] Stormwater management plans were to be developed by the lake communities to reduce non-point source loading. More immediately, bank stabilization on Belcher Creek was needed to reduce erosion, as well as a pollutant trap and detention basin constructed below its confluence with Morsetown Brook.[18]

In-lake management suggestions included a drawdown of the lake over two consecutive years to reduce aquatic plant growth and trap phosphorus in the lake-bottom sediments and to facilitate inspection of the lake for desnagging of navigational hazards (tree stumps remaining from lake elevation in 1836).[19] A systematic program of weed harvesting should also be instituted following the drawdowns, relying mainly on mechanical removal and limited, spot application of herbicide where mechanical means were not practicable (around docks, beaches, and other inaccessible areas).[20] To address the problem of "floating islands" (collections of loose tree stumps), desnagging approximately 20 acres of lake bottom and dredging areas of up to 400 acres on the northern and southern limits of the lake and along the Belcher Creek corridor to remove 2-3 feet of sediment were recommended.[21] Phosphorus sequestration by introducing alum (in the form of aluminum sulfate) into the hypolimnion for a potential 5-6 year reduction in the internal phosphorus load was also suggested.[22]

To garner crucial public support for the lake management plan, the study recommended that an extensive public education campaign be undertaken, with both passive informational components (news releases, newsletter mailings) and active citizen involvement (public hearings, annual lake management seminars, volunteer participation in monitoring efforts).[23] In addition, a stronger institutional arrangement to manage the lake and its watershed, with a bi-state agency being created by New Jersey and New York to implement the management plan, was required. A newer version of the Greenwood Lake Watershed Management District, with charter and bylaws revised to insure representation from the various communities within the watershed as well as NJDEP and NYDEC, was presented as the most suitable alternative. In cooperation with the new bi-state authority, the lake municipalities were to review and strengthen their individual

[15] Princeton Aqua Science, page 177.
[16] Princeton Aqua Science, pages 196-198.
[17] Princeton Aqua Science, pages 199-201.
[18] Princeton Aqua Science, pages 206-207.
[19] Princeton Aqua Science, pages 209-210.
[20] Princeton Aqua Science, pages 211-212.
[21] Princeton Aqua Science, pages 212-213.
[22] Princeton Aqua Science, page 214.
[23] Princeton Aqua Science, pages 215-216.

ordinances dealing with stormwater management, erosion control, and septic systems to ensure that future lake use practices do not exasperate eutrophication of the lake.[24]

Greenwood Lake: Clean Lakes Phase II Final Report

New York State Department of Environmental Conservation, Division of Water (1989)

In March 1989 the New York State Department of Environmental Conservation (NYDEC), Division of Water, issued a report regarding what had been accomplished under the Clean Lakes program since 1983.[25] This report provided an overview of the findings of Phase I of the study regarding the condition of Greenwood Lake and its watershed.

The report noted that the deterioration of a lake's water quality is often the result of excessive nutrient loading. Although eutrophication is a slow, natural process, which proceeds gradually over thousands of years, anthropogenic activities may accelerate the process by increasing the annual influx of sediments and nutrients. The eutrophication process becomes obvious when symptoms such as taste and odor problems, algae blooms, nuisance growths of aquatic plants, oxygen depletion, and the accumulation of organic sediments and fish kills are manifested. These symptoms signal that the lake's water quality and aesthetic attributes have deteriorated, and what was once an important community asset has been transformed into an objectionable deficit. Some of the early symptoms of eutrophication were observed in Greenwood Lake. They indicated the need to develop and implement programs which will curtail further degradations. The first step in realizing this goal was the Phase I Diagnostic Feasibility study. The comprehensive limnological and stream monitoring investigation conducted as a part of this study concluded that Greenwood Lake is undergoing accelerated eutrophication. It also served as the basis of a realistic action plan for the restoration and management of the lake. The diagnostic data identified that the lake's problems are in part due to the gradual development of the lake's watershed which has resulted in an increased influx of sediments and nutrients. The extensive shallow littoral areas associated with much of the south end and limited sections to the north end have become weed infested and silted. Water quality has declined as evidenced by seasonal algae blooms, and anoxic hypolimnetic conditions. These problems decrease the ecological, aesthetic and recreational attributes of Greenwood Lake.

The report also noted accomplishments that had been made since 1983, as a result of the Phase I study. Five sewage treatment facilities were expanded and upgraded by West Milford. Detention basins for the West Milford Park and Ride were built, and stormwater control measures were developed for new developments. Greenwood Lake Village in New York worked on improvements by implementing a street sweeping program, maintaining storm swales, and purchased runoff conveyances.[26]

Weed harvesting started in the lake in 1987 and continued through 1988. Three hundred acres were harvested, and about a million pounds of weeds were removed.[27] A hydrorake demonstration project was also conducted by Allied Biological, and it was concluded that the

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[24] Princeton Aqua Science, pages 218-222.

[25] New York State Department of Environmental Conservation, Division of Water. 1989. Greenwood Lake: Clean Lakes Phase II Final Report.

[26] Clean Lakes Phase II, pg 3.

[27] Clean Lakes Phase II, pg 4.

weed harvesting was successful enough to continue in the future.[28] Benthic barriers were installed to help control waterweeds in the shallow parts of the lake.[29]

Lake drawdown was considered and it was decided that the lake level would be dropped by 1.8 meters for a period of at least three months.[30] A lake drawdown was implemented, but the lake was only dropped 0.4 meters due to the extremely heavy rainfall.[31]

Public awareness was encouraged to reduce pollutants and quash feelings that they would be inconvenienced by the cleanup efforts. Providing dumpsters for debris and sediment of the lake also encouraged public involvement.[32] Educational programs were implemented through the project. Programs included information to local newspapers about public involvement in lake restoration activities, and a middle school curriculum.[33]

There were many ideas suggested to clean up the stormwater. Ideas included, but were not limited to, detention basins at several locations around West Milford, creation of a vegetated biofilter to intercept and treat the first flush, and retrofitting three existing areas.[34] The only one that was implemented was the upgrading of East Shore Road and Ten Eyck Avenue. This involved construction of the catch basin, grate and frame, culvert and pipe, and the staged replacement of storm drains. No reports exist on the effectiveness of these upgrades.[35]

A fish survey was proposed by the NYDEC. The project would be a two-year comprehensive study focusing on the brown trout. Particular attention was focused on spawning and how it was impacted by water quality and imbalances of predator – prey interactions.[36] However, no data were provided in this document on the results of this study.[37]

Greenwood Lake and Belcher Creek, Clean Lake Study
US Army Corps of Engineers (1989)

The US Army Corps of Engineers issued a reconnaissance report on "Greenwood Lake and Belcher Creek, New Jersey & New York Clean Lake Study" in 1989.[38] This report analyzed past studies to determine the best courses of action to take in regards to Greenwood Lake. In the mid 19th century Greenwood Lake was considered pristine and beautiful, and it supported an excellent population of fish and game.[39] In 1989 the lake was overrun with weeds and stumps which were causing problems for boaters.

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28 Clean Lakes Phase II, pg 9.
29 Clean Lakes Phase II, pg 5.
30 Clean Lakes Phase II, pg 5.
31 Clean Lakes Phase II, pg 8.
32 Clean Lakes Phase II, pg 5.
33 Clean Lakes Phase II, pg 11.
34 Clean Lakes Phase II, pg 6.
35 Clean Lakes Phase II, pg 10.
36 Clean Lakes Phase II, pg 7.
37 Clean Lakes Phase II, pg 11.
38 US Army Corps of Engineers, New York District. December 1989. Reconnaissance Report, Greenwood Lake and Belcher Creek, New Jersey & New York, Clean Lake Study.
39 Army Corp of Engineers, pg 30.

There are two approaches to lake restoration. The first approach is treating the cause of the eutrophication, and the second approach is to treat the products of the fertilization.[40] The eutrophication is caused by the influx of excess nutrients into the lake. If the excess nutrients can be cleaned, for example through sewage treatment plants, then the lake should revert to a more natural state. By targeting the products you relieve the immediate problem, but without treating the source it can reoccur.

There were several suggestions on how to treat the causes of eutrophication. One area that could be improved is septic management. An idea that was considered was that septic systems should be emptied annually and the contents be trucked to a sewage treatment facility.[41] Creating a sewer system and sewer treatment plant could clean the sewage and reduce the nutrients that are being added to the lake. However, due to the high cost associated with this project it was dismissed.[42]

The Army Corps of Engineers focused on the products of the eutrophication as a solution. The biggest way that was being used to combat the products was the weed-harvesting program.[43] This paper introduced the concept of wetland fringing as a solution. Wetland fringing is planting wetland fringes around the lake to catch nutrients before they get into the lake. This idea was dismissed because of the stigmatism associated with wetlands caused the public to be against the idea.[44] Sterile carp was another option that was presented in the paper. Carp can eat their weight in weeds a day; however, the Department of Environmental Conservation was against this option.[45]

The last option the paper mentioned was hydraulic dredging. Hydraulic dredging removes excess nutrients that have settled to the bottom of the lake, and prevents them from recycling in the lake.[46] There are several short-term effects associated with dredging. The first is obtaining a site large enough to dump all the excess water, nutrients, and sediments. Another effect is, if the slurry water is not retained long enough, all of the nutrients in the slurry would be dumped right back into the lake causing a bloom. There is also a chance that some of the fugitive nutrients would run back into the lake from the dredging process.[47] The Army Corps of Engineers recommended dredging the lake over any other option. It did specifically exclude Belcher Creek from any dredging action, because, due to the sluggish water flow, it is believed no sediment is transported into Greenwood Lake. Also, any dredging done in the creek could compromise bank stability.[48]

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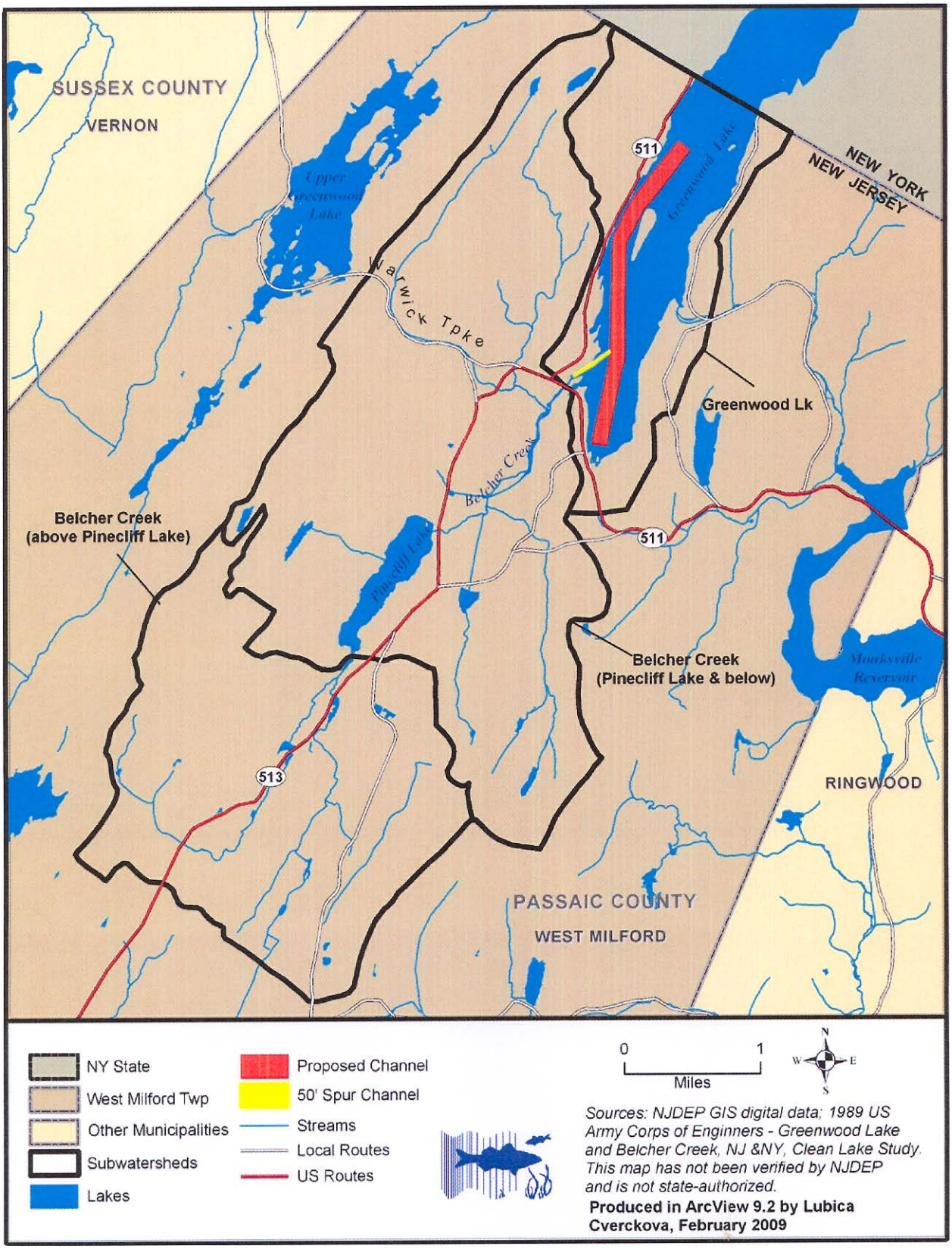
40 Army Corp of Engineers, pg 37.
41 Army Corp of Engineers, pg 37.
42 Army Corp of Engineers, pg 40.
43 Army Corp of Engineers, pg 39.
44 Army Corp of Engineers, pg 38.
45 Army Corp of Engineers, pg 62.
46 Army Corp of Engineers, pg 41.
47 Army Corp of Engineers, pg 44.
48 Army Corp of Engineers, pg 69.

Figure III-1 – Channels Proposed for Dredging



The final recommendation of the study was to dredge a 700 foot wide channel across the southern portion of the Lake and up along the western shore of the Lake.[49] The approximate location of the channel proposed is shown in Figure III-1. The channel would have a total length of 12,000 feet and be 15 feet deep. Dredging to a 15 foot depth will prevent the regrowth of vegetation because of the lack of light at that depth. The study recommended using a clamshell dredging method to excavate the sediment and transporting it to a nearby staging area with dewatering equipment. The advantage of using clamshell dredging equipment is that turbidity during excavation is minimized because the clamshell bucket clamps shut. Dredging this channel would remove an estimated 2,080,150 cubic yards of sediment from the Lake.

In order to protect local fisheries and not disrupt the recreation season, the lake cannot be dredged between March and October. This limited time frame for dredging means that the project would take several years to complete. The plan recommended in this study by the US Army Corps of Engineers was never completed because it was concluded there was no federal interest in the project.

Greenwood Lake: Clean Lakes Phase II Restoration Activities
Greenwood Lake Watershed Management District, Inc. (1992)

In 1992 the GLWMDI requested further funding for carrying out the following Phase II projects:[50]

- Drawdown of lake.
- Intensive weed harvesting.
- Siting, design and construction of stormwater quality management structure(s), including monitoring.
- Preparation of a Lake Management Plan that seeks to preserve and restore the watershed and lake resources. The plan would include habitat protection, management of land resources, water quality management, and water based recreation management.
- Fishery survey.
- Public education program.

There is no evidence that any of these projects was funded.

Belcher Creek Corridor Nonpoint Source Project
West Milford Township & Allied Biological, Inc. (1999-2005)

West Milford Township had a five year "Section 319(h)" grant from the New Jersey Department of Environmental Protection (NJDEP) to carry out a "Nonpoint Source Pollution (NPSP) Control and Management Implementation" project in the Belcher Creek corridor. The Township's application for this grant described the environmental sensitivity of the corridor as follows:[51]

> The Belcher's Creek Corridor, with its wide expanse of wetlands on both sides, is environmentally sensitive for 3 reasons: (a) its waters flow into the Monksville & Wanaque Reservoirs, which provide water for hundreds of thousands of residents of NJ; (b) it provides places for resting, feeding and breeding for hundreds of species, including

[49] Army Corp of Engineers.
[50] Greenwood Lake Watershed Management District, Inc. 1992. Request for funding. Pages 8-9.
[51] Township of West Milford. 1998. Grant Agreement between West Milford Township and the State of New Jersey by and for the Department of Environmental Protection, Attachment D-2, Project Proposal, Page 3.

threatened or endangered species such as great blue herons, osprey, bald eagles, eastern rattle snakes and wood turtles; (c) its two lakes, Pinecliff & Greenwood, provide year-round homes and recreation for thousands of people, but have been receiving substantial amounts of NPSP for over 2 decades. For these reasons, the waters and wetlands of the Belcher's Creek corridor must be protected from further degradation by NPSP including sediment, nutrients, metals, and petroleum products.

The goal of the project was to remove non-point source pollution before it gets to Greenwood Lake. Many sources of pollution had been identified, including winter road grits, ongoing development projects that bring more people, fertilizer, geese and dog droppings, and added pollutants from petroleum products.[52] This grant had three main components: stormwater retrofits for storm drain catch basins in the Pinecliff Lake area, macroinvertebrate monitoring and analysis, and public education and outreach.[53]

The Township proposed to upgrade storm drains with recessed sedimentation basins and to put in place a vacuuming schedule to maintain their proper functioning.[54] Nineteen sedimentation basins were installed, and in 6 locations cross drains were also installed connecting two sedimentation basins.[55] The work to upgrade the storm drains was completed by 2002.[56] These facilities remove sediment that would otherwise have entered Pinecliff Lake through stormwater runoff, thereby decreasing nutrient loadings and sedimentation in Pinecliff Lake and Greenwood Lake.[57] How well these storm drains are being maintained and are currently functioning should be investigated.

Allied Biological, Inc. conducted water quality testing, which included studies of benthic macroinvertebrates, paid for through the grant. These tests were conducted in the spring and fall of each year beginning in 1999 to the spring of 2003.[58] The general findings were that "water quality maintained a very consistent level through the testing period" and that water quality diminished from the test location just below the Pinecliff Lake dam to the mouth of Belcher Creek where it empties into Greenwood Lake.[59]

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[52] West Milford Township. 1998. Grant Agreement between West Milford Township and the State of New Jersey by and for the Department of Environmental Protection, Attachment D-2, Project Proposal, Page 4.

[53] NJ Department of Environmental Protection, Division of Watershed Management. 2007. Section 319(h) Success Stories, Belcher Creek, West Milford, New Jersey. Website: <http://www.state.nj.us/dep/watershedmgt/319grant_success_stories.htm>

[54] *Ibid.* Attachment D-2, Page 2.

[55] Township of West Milford, Planning Department. 2005. Belcher's Creek Nonpoint Source Pollution 319H Grant, Final Report, Page 2.

[56] Township of West Milford, Planning Department. 2002. Letter to NJDEP, Division of Watershed Management, February 22, 2002.

[57] NJ Department of Environmental Protection, Division of Watershed Management. 2007. Section 319(h) Success Stories, Belcher Creek, West Milford, New Jersey. Website: <http://www.state.nj.us/dep/watershedmgt/319grant_success_stories.htm>

[58] Township of West Milford, Planning Department. 2005. Belcher's Creek Nonpoint Source Pollution 319H Grant, Final Report, Page 1.

[59] *Ibid.*

Allied Biological, Inc. also studied the water quality and macroinvertebrates in the upstream portion of Belcher Creek to below the Pinecliff Lake dam in the fall of 2000, 2001, 2002, and 2003.[60&61] Sampling was conducted at the sites described below:[62]

BC03-1: Upstream of Dockerty Hollow Road Bridge, this station comprised shallow riffle habitat.

BC03-2: Below the dam that forms at Bald Eagle Village Pond in a riffle.

BC03-3: Upstream of Stowaway Road bridge in a channelized reach of stream.

BC03-4: Downstream of the Pinecliff Lake Dam and upstream of the Union Valley Road (Rt. 513) bridge in a riffle comprised of cobble substrate.

The following parameters were measured: pH, Air Temperature, Dissolved Oxygen Concentrations (DO), Water Temperature, Total Phosphorus (TP), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Kjeldahl Nitrogen (TKN), Fecal Coliform Bacteria, and Total Suspended Solids (TSS). Most of the parameters were within their expected range. In the fall of 2002 the Total Phosphorus (TP) concentrations were high at each sample station. However, upstream of Pinecliff Lake concentrations had decreased in caparison to the fall of 2001. Below the Pinecliff Lake dam the Total Phosphorus (TP) concentration had increased. Levels of fecal coliform bacteria increased in concentration with a downstream progression. Dissolved solids (TDS) values were approximately one-half those found in the fall of 2001. Suspended solids also exhibited an increasing downstream continuum. The same tests on samples taken in November 2003 from the same sampling sites were conducted.[63] Total Phosphorus (TP) concentrations were lower than in 2002. Fecal coliform bacteria were present at a low density in each sample and were not indicative of water quality problems. The recent refilling of the lake likely caused many particles to enter suspension that will settle out over time.

Benthic macroinvertebrates were also collected from the same sampling sites in the fall of 2000, 2001, 2002, and 2003. A number of indices were used to evaluate the stream benthic macroinvertebrates.[64] The first indicator was taxa richness, which considers the different groups of invertebrates as a cursory indicator of environmental stability. The number of EPT taxa is an indicator of the health of the area. For example, Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) generally inhabit higher quality waters so if there is a large presence of these species your water is clean. The percent EPT measures individuals within the benthos that are generally intolerant with those that are not particularly sensitive to anthropogenic stress. Percent dominance looks at the dominance of taxa over another, and if all things are perfect then all taxa should be even. The last indices used were the family biotic index, which uses the tolerance to pollution to weight the abundance data for taxa present in the stream community.[65] Allied Biological also looked at the Shannon-Weaver diversity index, which measures the number of species in a community and the evenness in which they were distributed. The Shannon–Weaver

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[60] Allied Biological Inc. Fall 2002 Report, Belcher Creek Macroinvertebrate and Water Quality Study, Township of West Milford, Passaic County. November 27, 2002.

[61] Allied Biological Inc. Fall 2003 Results, Belcher Creek Macroinvertebrate and Water Quality Study, Passaic County, NJ. March 18, 2004.

[62] Allied Biological Inc. Fall 2002 Report, Belcher Creek Macroinvertebrate and Water Quality Study, Township of West Milford, Passaic County. November 27, 2002. Pages 1-5.

[63] Allied Biological Inc. Fall 2003 Results, Belcher Creek Macroinvertebrate and Water Quality Study, Passaic County, NJ. March 18, 2004. Pages 1-5.

[64] Allied Biological Inc. Fall 2002 Report, Belcher Creek Macroinvertebrate and Water Quality Study, Township of West Milford, Passaic County. November 27, 2002. Pages 3-4.

[65] Allied Biological 2002 report, pg 3.

diversity index sums it up in one value denoted as H'.[66] This index indicates that the diversity of macroinvertebrates at all four stations in all four years was moderately or highly impacted by human activities in the Belcher Creek watershed.[67]

Sites three (BC03-3) and four (BC03-4) were completely impacted in 2003. This was probably due to the fact that Pinecliff Lake was lowered while repair work was done on the Pinecliff Lake dam.[68] The biota should have reverted back to a more natural state after the dam was finished.[69] Between 2000 and 2003 taxa richness had decreased at all four sites. This was probably caused by the changes in flow regimes. A more stable flow regime would reduce the stress on the invertebrates. Stormwater runoff should be neutralized, and groundwater should be diverted to basins to reduce extra nutrient loadings. In addition, Allied Biological recommended more testing in different areas of the Belcher Creek watershed. They want to test in an area upstream to get a baseline of a non-impacted system. It is also recommended that a study of the fish be conducted, because fish are a function of both physical and chemical environment and will be useful in evaluating the lakes.[70]

Public outreach was another major component of the project, and these efforts continue. Recommendations evolving from this project included "mandatory septic maintenance, fertilizer controls, and pet waste ordinances".[71] Educational efforts included having high school students monitor water quality at 20 sites. The importance of maintaining natural features for improved water quality was highlighted.

Watershed Management Area 3 Characterization and Assessment
North Jersey District Water Supply Commission & Other Stakeholders (2002)

The State of New Jersey initiated a program in the 1990s to help bring together interested stakeholders to help plan for the restoration and maintenance of water resources by watershed. The Greenwood Lake Watershed in New Jersey is part of Watershed Management Area 3 (WMA 3), which includes the Wanaque, Ramapo, Pequannock and Pompton River subwatersheds of the Passaic River Watershed in New Jersey. The North Jersey District Water Supply Commission, under a grant from the New Jersey Department of Environmental Protection and with the consulting services of Killam Associates, Najarian Associates, Inc. and Ecosystem Consulting Service, Inc., studied WMA 3 and prepared a characterization and assessment report.[72] This report partially reflects discussions that took place during meetings in 2000 to 2002 of interested stakeholders. The key issue that must be addressed is described as follows:[73]

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66 Allied Biological 2002 report, pg 4.

67 Allied Biological 2003 Belcher Creek study, pg 10.

68 NJ Department of Environmental Protection, Division of Watershed Management. 2007. Section 319(h) Success Stories, Belcher Creek, West Milford, New Jersey. Website: <http://www.state.nj.us/dep/watershedmgt/319grant_success_stories.htm>

69 Allied Biological 2003 Belcher Creek study, pg 8.

70 Allied Biological 2003 Belcher Creek study, pg 11.

71 Township of West Milford, Planning Department. 2005. Belcher's Creek Nonpoint Source Pollution 319H Grant, Final Report, Page 3.

72 North Jersey District Water Supply Commission. 2002. Watershed Characterization and Assessment, A Technical Report for the Passaic River Basin Watershed Management Project, Watershed Management Area 3, Pompton, Pequannock, Wanaque & Ramapo River Watersheds.

73 *Ibid.* Page ES-15.

> WMA 3 contains very large areas of pristine lands that provide habitat for wildlife and fish communities, provide recreational opportunities, and provide a high quality of surface water runoff to reservoirs and water supply intakes in the watersheds. Preservation of the quality of water in WMA 3 is essential to continued support of natural and human communities dependent upon this water supply.

WMA 3 provides surface water supplies to over 2 million residents in other WMAs in New Jersey.[74]

Specific issues, which this report raises that are especially relevant to the Greenwood Lake Watershed, express concern regarding herbicides and pesticides in Greenwood Lake, increasing trends for chloride, sodium and total dissolved solids (TDS) concentrations, and migration of contaminated ground water into streams.[75] For lake and reservoir management this report recommends reduction in nutrient loadings, reduction in the use of chemicals for weed control, sediment control, and maintenance of adequate flows and water temperatures downstream by proper control of releases from the lake.[76] Concern is expressed about the presence of new exotic species of algae, the formation of hazardous algae blooms, the potential presence of algae toxins, and the potential for the formation of total trihalomethanes (TTHMs).[77] This report makes the following observations which are especially relevant to the management of the Greenwood Lake Watershed:[78]

> Proper planning and implementation of actions to reduce the pollutants in our waterways must involve not only point source discharges, as has been done for the last 30 years, but must also take into consideration the:
> - Effects of land use changes,
> - Need to clean up contaminated areas,
> - Need to preserve environmentally sensitive areas,
> - Need to educate the public to avoid contributing to the pollution of lakes and rivers,
> - Need to change our habits to protect our environment.

Total Maximum Daily Load for Phosphorus to Address Greenwood Lake
New Jersey Department of Environmental Protection (2004)

In 2002 the New Jersey Department of Environmental Protection (NJDEP) determined that Greenwood Lake was impaired because it was eutrophic, "as evidenced by elevated total phosphorus (TP), elevated chlorophyll-a, and/or macrophyte density that impairs recreational use."[79] The Surface Water Quality Standard (SWQS) for freshwater lakes states that "phosphorus as total phosphorus shall not exceed 0.05 mg/L in any lake, pond or reservoir.[80]

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[74] *Ibid.* Page ES-1.
[75] *Ibid.* Pages ES-15, ES-16, ES-17.
[76] *Ibid.* Pages ES-17, ES-18.
[77] *Ibid.* Page ES-18.
[78] *Ibid.* Page ES-4.
[79] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004. Page 4.
[80] N.J.A.C. 7:9B-1.14(c)5. & New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004. Page 9.

Many of the water samples taken from Greenwood Lake in 1981 for the *Phase I Diagnostic-Feasibility Study of Greenwood Lake, NJ and NY*, contained levels of TP greater than 0.05 mg/L.[81] NJDEP also notes that "in addition to the Phase 1 Study, in-lake monitoring was conducted for several growing seasons between 1992 and 2001 by Princeton Hydro".[82] At the sampling location in the southern end of the lake in New Jersey 23% of the samples had TP concentrations exceeding the standard of 0.05 mg/L.[83] In order to restore an impaired water body to a more healthy condition, the State creates a plan for the restoration of the waterway, called a "Total Maximum Daily Load" or "TDML" plan. In 2004 NJDEP established a TMDL for phosphorus to try to reduce the over fertilization of Greenwood Lake.[84]

As part of the 1983 *Phase I Diagnostic-Feasibility Study of Greenwood Lake, NJ and NY*, the potential sources of phosphorus in the lake were evaluated and the annual influx of phosphorus from different sources was quantified. The annual total phosphorus (TP) load was estimated to be 5,936 kilograms per year (kg/yr). The majority of the phosphorus originated from runoff from the land surface and the internal loading. However, septic system and sewage treatment plant effluent are responsible for a sizable portion of the annual nutrient load as well. The Phase I Study was conducted over 20 years ago, so some of the contributions to the lake's annual phosphorus loadings were updated by NJDEP using more recent data. The current estimates of annual loadings of phosphorus from major sources are summarized in Table III-1.

Phosphorus loads were characterized on an annual scale, kilograms per year (kg/yr). Long-term pollutant loads are typically more critical to overall lake water quality than the load at any particular short-term time period. Storage and recycling mechanisms in the lake, such as uptake and sediment dynamics, allow phosphorus to be used as needed regardless of the rate of delivery to the system. Also, empirical lake models use annual loads rather than daily or monthly loads to estimate in-lake concentrations.

Five point sources of phosphorus other than stormwater with NJPDES Surface Water Discharge permits were identified. These point sources are the sewage treatment plant facilities that discharge into Belcher Creek or its tributaries. They are listed in Table II.D-11. There are no facilities with National Pollutant Discharge Elimination System permits located within the New York portion of the lake watershed. The estimated phosphorus loading from these sewage treatment plant discharges that reaches Greenwood Lake is 70 kg/yr. This is only 44% of the phosphorus that is discharged because much of it settles out in the sediments in Pinecliff Lake and elsewhere in Belcher Creek and its tributaries and lakes. This estimated loading is also much lower than it would have been in 1983 because treatment at these facilities has been upgraded. Thus, these five point sources only contribute 2% of the total loading.

Sewage that is treated through septic systems contributes a much larger load of phosphorus. It is estimated that 710 kg/yr of phosphorus entering Greenwood Lake (17%) comes from septic systems located within 200 meters (656 feet) of the lake.

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[81] *Ibid*. Page 15. & Princeton Aqua Science. 1983. Phase 1: Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and New York.

[82] *Ibid.* Page 14.

[83] *Ibid.* Page 14.

[84] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004.

Table III-1 – Loadings of Phosphorus in Greenwood Lake and TMDL Targeted Reductions

Source of Total Phosphorus (TP)	*Type of Source Area*	*Estimated Loading of TP (kg/yr)*	*% of Total*	*TMDL Target Reduction %*	*TMDL Target Reduction (kg/yr)*	*% of Total Reduction*
Point Sources other than Stormwater		70.0	1.7%	0%	0.0	0.0%
Septic Systems within 200 meters of Greenwood Lake		710.0	17.1%	43%	305.3	19.9%
Surface Runoff:						
	Low intensity residential	415.9	10.0%	43%	178.8	11.6%
	High intensity residential	293.6	7.1%	43%	126.2	8.2%
	Commercial/industrial/transportation	307.7	7.4%	43%	132.3	8.6%
	Pasture/hay	55.7	1.3%	43%	24.0	1.6%
	Row crops	27.2	0.7%	43%	11.7	0.8%
	Urban/recreational grasses	26.3	0.6%	43%	11.3	0.7%
	Deciduous forest	180.3	4.3%	0%	0.0	0.0%
	Evergreen forest	47.9	1.2%	0%	0.0	0.0%
	Mixed forest	202.4	4.9%	0%	0.0	0.0%
	Woody wetlands	13.0	0.3%	0%	0.0	0.0%
	Emergent herbaceous wetlands	1.1	0.0%	0%	0.0	0.0%
	Open water	6.9	0.2%	0%	0.0	0.0%
	Air deposition	53.4	1.3%	0%	0.0	0.0%
	Total from Surface Runoff	1,631.4	39.3%		484.4	31.5%
Internal Loading		1,738.8	41.9%	43%	747.7	48.6%
Total Loading Estimated by NJDEP		**4,150.2**	100.0%	**37%**	**1,537.3**	100.0%

Runoff from land surfaces into the lake, which includes nonpoint and stormwater point sources of phosphorus, contributes about 39% of the total load. Estimated loadings from various types of land use are listed in Table III-1. These estimates assume that only 44% of the load contributed by the lands within the Pinecliff Lake watershed reaches Greenwood Lake.

The largest source of phosphorus is "internal loading" (42%), in which phosphorus in the sediments in the lake is dissolved and becomes available for lake biota.

This TMDL addresses the phosphorus impairment.[85] The TMDL sets a target to reach, a mean concentration of total phosphorus (TP) in Greenwood Lake of 0.03 mg/L. This TMDL calls for current phosphorus loadings to be reduced by 37%. Nearly half (48.6%) of these reductions are to be achieved by removing phosphorus from the sediments in Greenwood Lake (internal loading). 31.5% of the reductions should come from improvements in stormwater management

[85] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004.

to reduce loadings from surface runoff, and 19.9% from improved management of septic systems located within 200 meters of Greenwood Lake.

The total phosphorus load reductions that are targeted for each source are listed in Table III-1. Phosphorus is a necessary nutrient for life in the lake and everywhere else. Phosphorus only becomes a pollutant when too much enters the aquatic ecosystem of Greenwood Lake and over-fertilizes the lake. The amount of phosphorus that enters the lake in nonpoint source stormwater runoff and base flows from forested and wetland areas, and natural ground water and surface water flows provide a healthy environment for the fish and other biota living in the lake. Therefore, no reduction in phosphorus loadings from these sources is needed, and the targeted load reduction is 0%. Other pollutants, such as excessive loadings of nitrogen compounds, can come from the same sources as those listed for phosphorus. The loadings from each source and their impacts on the lake ecosystem would be different. However, exploring how the management of water from each source listed might be improved to reduce phosphorus loadings into Greenwood Lake should provide insights into cleaning up the waters in the Greenwood Lake Watershed and beyond.

Greenwood Lake, NJ-NY, Water Quality Monitoring Report
Princeton Hydro, LLC (2005-2006)

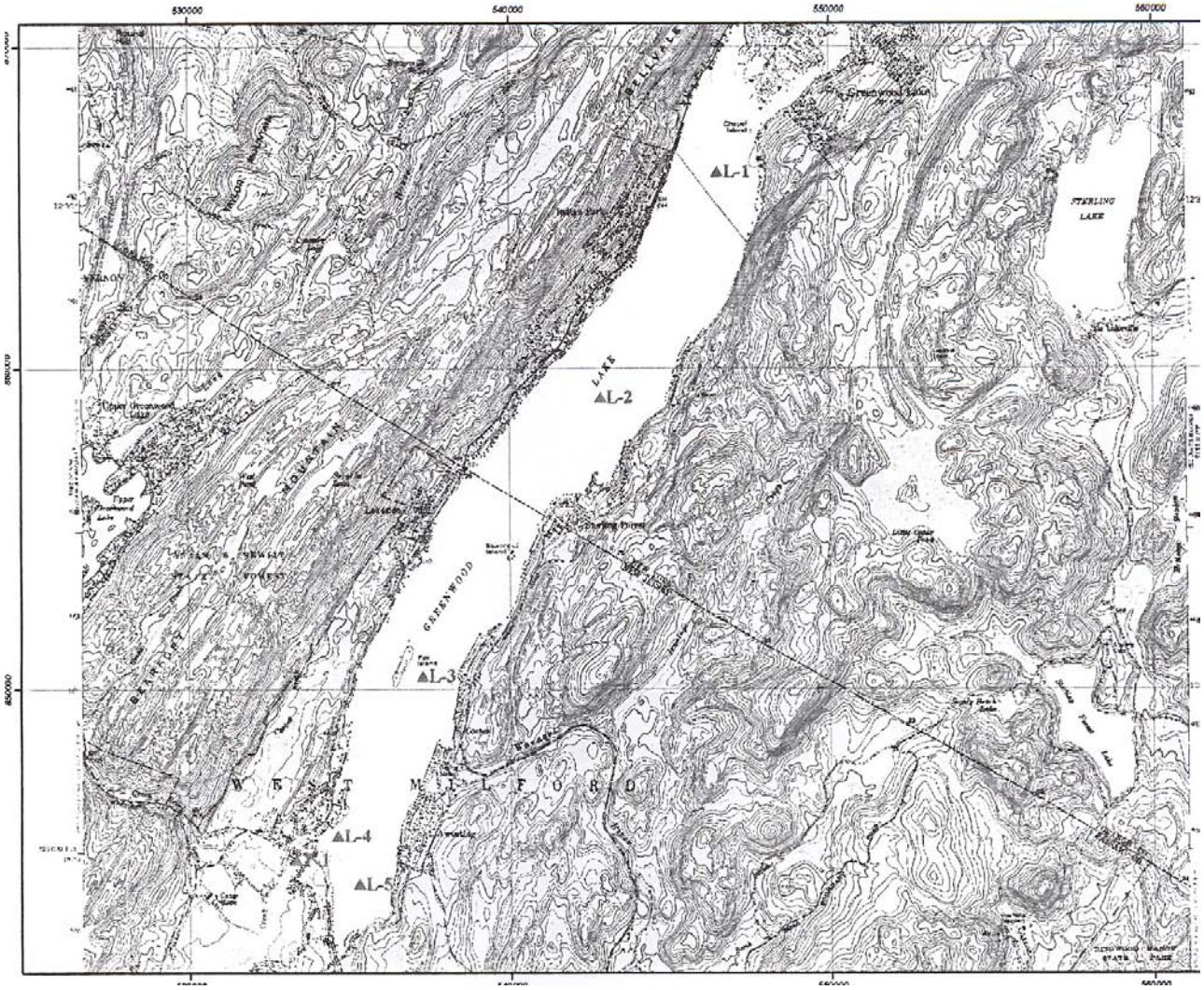
As part of a larger project carried out on behalf of the Township of West Milford and the Greenwood Lake Commission, and funded by a Non-Point Source 319(h) grant from the New Jersey Department of Environmental Protection (NJDEP), Princeton Hydro, LLC, conducted water quality monitoring in Greenwood Lake on 24 August and 2 November of 2005 and on 20 April and 1 August of 2006.[86] Monitoring was conducted at the five sites in Greenwood Lake shown in Figure III-2 and in Belcher Creek (T1).

Greenwood Lake is a typical deep, temperate water body, experiencing anoxic conditions in the bottom waters during the summer season. Dissolved oxygen (DO) and pH values were generally within the optimal range for most aquatic life. However, DO and pH values would temporarily fall out of their respective optimal ranges as a result of biological activities, particularly in the mid-depth or deep waters. A decline in DO would occur during thermal stratification as bacteria deplete DO, while an increase in pH beyond the optimal range was the result of elevated rates of algal and/or aquatic plant photosynthesis.

Total phosphorus (TP) concentrations in surface water, especially at the shallow, southern end stations in New Jersey, were occasionally out of compliance with the State's TP standard for lakes, ponds and reservoirs of 0.05 mg/L. This was particularly the case for station L-4, where Belcher Creek enters Greenwood Lake. Belcher Creek appears to be a major source of phosphorus for Greenwood Lake and it is thus responsible for a substantial portion of the lake's nuisance levels of algal growth. Elevated chlorophyll a concentrations were generally associated with elevated TP concentrations. For example, the highest TP and chlorophyll a concentrations in Greenwood Lake both occurred during the 24 August 2005 sampling event. These data provide further evidence that a strong link that exists between watershed activities generated higher TP loads and concentrations that, in turn, fuel nuisance levels of algal growth.

[86] Princeton Hydro, LLC. 2007. Greenwood Lake, NJ-NY, Water Quality Monitoring Report, January 2007.

Figure III-2 – Water Quality Monitoring Stations in Greenwood Lake



Stormwater Implementation Plan for Greenwood Lake
West Milford Township, Greenwood Lake Commission & Princeton Hydro, LLC (2005-2008)

Under the same 319(h) grants, Princeton Hydro, LLC, has also developed plans to implement measures to reduce phosphorus loadings from surface runoff.[87] The Greenwood Lake Watershed in New Jersey was divided into the subwatersheds shown in Figure III-3. Then the total phosphorus (TP) loading into Greenwood Lake from stormwater runoff, based on the previous work by NJDEP and others, and the "development" in each subwatershed, was estimated. Subwatershed I has the highest "developed" TP load, and subwatershed D has the lowest. Although subwatersheds A, C and F probably contribute high loads of TP to Pinecliff Lake, West Milford Lake, and other lakes, much of the TP never reaches Greenwood Lake. Then the

[87] Princeton Hydro, LLC. 2006. Stormwater Implementation Plan for the New Jersey End of the Greenwood Lake Watershed, Township of West Milford, Passaic County, New Jersey. March 2006.

stormwater drainage systems in the subwatersheds with "High" priority were studied to assess where Best Management Practices (BMPs), such as sand filters and/or Manufactured Treatment Devices (MTDs), such as Aqua-Filters, might be installed in stormwater drainage systems to remove phosphorus and other pollutants in sediments from stormwater. Candidate sites for retrofitting with BMP structures are shown in Figure III-4.

In 2007 additional 319(h) funds were granted for Princeton Hydro, LLC, to implement retrofits or BMPs at high priority candidate sites. The sites selected for consideration are listed in Table III-2.[88] The work has been ongoing at identifying the appropriate measures to be taken at these sites and then implementing them.

Table III-2 – High Priority Candidate Sites for Stormwater Retrofits or BMPs

Sub-watershed	*High Priority Candidate Site(s)*	*Location*
I	21	Greenbrook Drive Development
	22	Development East of Lincoln Avenue
	18	Greenwood Lake Turnpike Bridge
	19	Adjacent to Browns Point Park
	5 through 11	Reidy Place, Millington Avenue, Rocky Point Road and Rte. 511
	23	Lincoln Avenue and Morsetown Brook (Wallisch Estate Tract)
	24 through 27	Eisenhower Drive and Rutgers Avenue
	12 through 15	Reidy Place and Gleason Road
	16 and 17	Union Valley Road and Warwick Turnpike
G		West Milford Lake
N	1 through 4	Storms Island Road and East Shore Road

[88] *Ibid.* Pages 7-11.

Figure III-3 – Subwatershed Prioritization for Total Phosphorus Loads in Stormwater

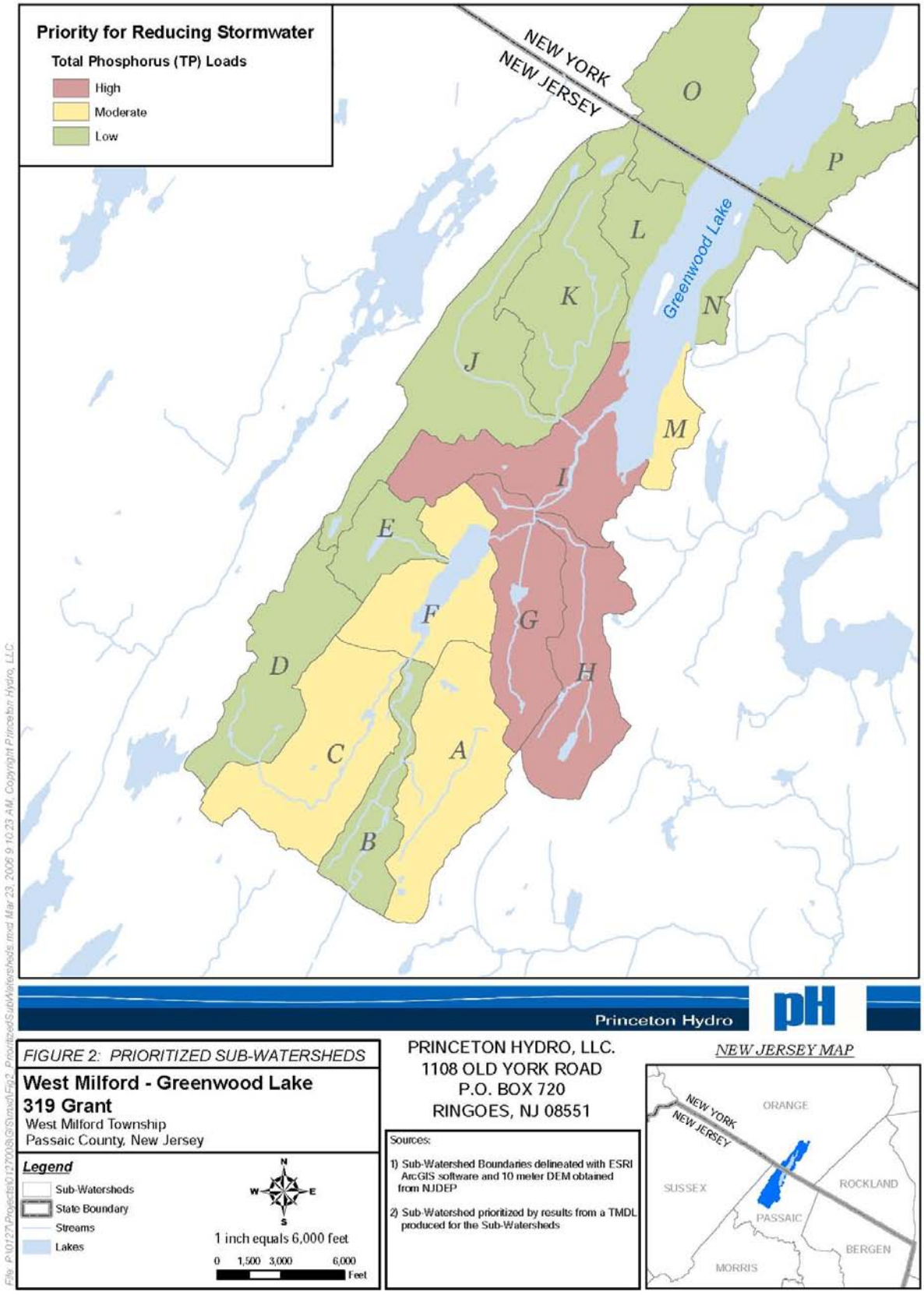
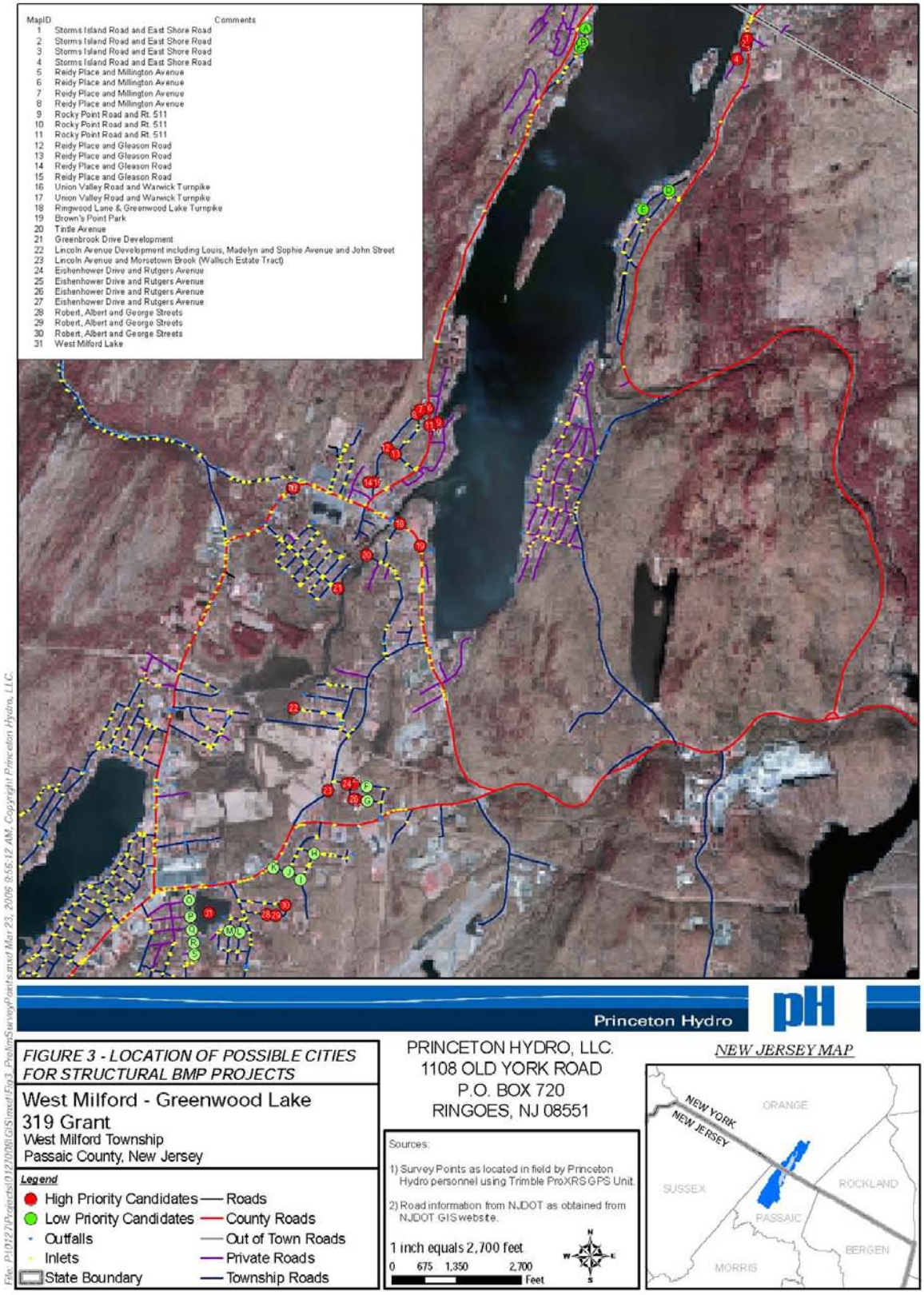


Figure III-4 – Priority Locations for Remediation of Phosphorus Loadings in Stormwater



Greenwood Lake Commission Progress Report
Greenwood Lake Commission & Passaic River Coalition (2000-2006)

In 2006 staff of the Passaic River Coalition prepared a progress report for the governors and state legislatures of New York and New Jersey on the work of the Greenwood Lake Commission and others.[89] The Commission was established in 2001 "to help ensure that the natural, scenic, and recreational resources of Greenwood lake and its watershed are protected from despoliation due to environmental and other threats from both sides of the border, so that the pristine beauty of the area will be preserved and maintained for the enjoyment and recreation of present and future generations".[90] The report described the challenges faced by the Greenwood Lake Commission as follows.[91]

Greenwood Lake is an important natural resource in northern New Jersey and southern New York for recreational, economic and ecological reasons. For decades, travelers from Paterson, New York City and other urban areas have enjoyed the tranquil atmosphere and beautiful landscape that the Highlands, specifically Greenwood Lake, have to offer. Millions of New Jersey residents continue to depend on the watershed for their water supply, which was once of pristine quality. However, there are clear environmental problems in Greenwood Lake that are severely hindering boating, swimming, and other recreational uses, as well as damaging its ecological value, and posing a threat to the health of millions. If the elevated nutrient levels are not reversed, and the eutrophication process is not slowed, Greenwood Lake may one day be irreversibly damaged. If restoration does not occur now, the local community may suffer economic consequences, millions of New Jersey residents who depend on the water supply may find their needs unmet, and the rich history of the lake may be forgotten.

Since its formation, the Greenwood Lake Commission has worked diligently and collaboratively with government bodies, researchers, and the public to understand the problems in Greenwood Lake, developed plans to reverse these problems and maintain water quality standards, and has also begun to implement many of these plans. For years the Commission has worked without the permanency of a headquarters, the security of insurance, the stability of a line item, or the assistance of paid staff. While much has been accomplished by the Greenwood Lake Commission, more is needed. The Greenwood Lake Commission recommended that the following actions be met in order to assist continual efforts to restore Greenwood Lake:

- Start-up, annual, and acquisition funding for the Greenwood Lake Commission
- State insurance for the Greenwood Lake Commission and the Commissioners
- Funding for the Greenwood Lake Commission to establish a USGS continuing monitoring program in Belchers Creek (near Greenwood Lake) and to monitor water quality
- Passage of Bill No. A329/S2171 in New Jersey to provide funding for the dredging of Greenwood Lake
- Passage of Bill No. S2866 in New Jersey to allow the Greenwood Lake Commission to collect fees for the usage of boats and docks in the New Jersey portion of Greenwood Lake as has been passed in New York

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[89] Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006.

[90] State of New Jersey, 208th Legislature. 1999. Greenwood Lake Protection Act, An Act creating the Greenwood Lake Commission. Section 2.

[91] Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006. Page 25.

- Uniform dock codes and zoning for the entire Greenwood Lake watershed
- Authority to pass ordinances for the Greenwood Lake watershed, including ordinances banning phosphorus-based fertilizer use and requiring a septic system pump-out every three years
- Legislation giving authority to the Greenwood Lake Commission to patrol and police Greenwood Lake and enact regulations on the use of the lake, including legislation requiring foam billets to be covered by plastic, and to enter into agreements with law enforcement agencies to assist in this program
- Legislation giving authority to the Greenwood Lake Commission to issue citations and fines to those who violate regulations involving Greenwood Lake
- Legislation giving authority to the Greenwood Lake Commission to review, comment, and have input on all development and building permit proposals within the Greenwood Lake watershed

Weed Harvesting and Stump Reduction Projects
Greenwood Lake Commission (2006-2007)

Major environmental problems within Greenwood Lake, especially in its shallow southern end, are stumps and weeds.[92] When Greenwood Lake was dammed and raised about twelve feet in 1836, trees in the areas about to be flooded were cut with saws and axes, leaving stumps to decay naturally.[93] And the density of weeds from eutrophication, over fertilization, is beginning to fill the lake causing it to become a swamp and eventually a forest.[94] In the cold, dark, oxygen-poor water the stumps left behind have not decayed and became a navigational hazard for boaters.

Due to the influx of nutrients several invasive species have colonized the lake. The species include *Lynbya latissima*, *Potamogeton robbinsii*, *Myriophyllum spicatum*, *Carbomba caroliniana*, and *Potamogeton ampilifolius*.[95] To reduce these invasive species a weed-harvesting program is being implemented on both the New York and New Jersey sides.[96] However, additional funding is needed to continue the weed harvesting program.

Weed harvesting has only short-term effects since the weeds grow back. Another restoration tactic with short-term effects is a drawdown. The purpose of a drawdown is to expose the sediments at the lake's bottom to drying and freezing for two to four weeks, damaging some of the rooted plant species. Lowering the surface water elevation of the lake also allows for the repair of docks, the installation of sediment covers to control plant growth, and the removal of sediment.[97] During the winter of 2006/2007 a drawdown was conducted.

In February and March of 2007, during the drawdown of the lake, a stump removal project was carried out.[98] Stumps in the southern portion of Greenwood Lake were cut to ice level and

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[92] Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006. Page 4.
[93] Greenwood Lake Commission. 2007. Stump Reduction Project, 2006-2007. Page 1.
[94] Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006. Page 4.
[95] *Ibid.*, pg 9.
[96] *Ibid.*, pg 12.
[97] *Ibid.*, pg 13.
[98] Greenwood Lake Commission. 2007. Stump Reduction Project, 2006-2007. Page 1.

ground up into wood chips below ice level. When the project ended because funding had run out, at least two-thirds of the stumps had been treated so that they are no longer a threat to boating. During the next drawdown the Greenwood Lake Commission hopes that the approximately 1,000 stumps remaining can be treated so that they are no longer a hazard. Floating islands of plant matter are also a hazard to boaters and skiers. Also, the Commission anticipates the removal of floating islands during the next few years, depending on funding availability.[99] Dredging should also be planned and funded as a way to remove the sediments loaded with excess nutrients that are at the bottom of the lake.[100]

Invasive Species Management Plan

Greenwood Lake Commission, Town of Warwick, Village of Greenwood Lake & Princeton Hydro, LLC (2007-2008)

One of the most serious problems in Greenwood Lake has been nuisance densities of aquatic macrophytes during the summer, which impair fishing, swimming, and boating activities.[101] The invasive species of weeds, fanwort (*Cabomba caroliniana*) and Eurasian watermilfoil (*Myriophyllum spicatum*), have become the dominant macrophytes in the shallower northern arms of Greenwood Lake in New York. High densities of Eurasian watermilfoil and fanwort decrease suitable habitat for fisheries and thus alter fish populations.[102] Currently, mechanical weed harvesting is the primary mode of reducing excessive macrophyte growth. The latest drawdown (2006-2007) appears to have reduced the amount of plant biomass. However, it did not eradicate the invasive species existing in the arms of Greenwood Lake.[103] Princeton Hydro, LLC, is proposing to try strategies that selectively eradicate the invasive species but allow the native, desirable plants to grow in the shallow zones of the lake. A hydro-rake is to be used to remove the mono-cultures of fanwort and/or Eurasian watermilfoil from the arms of the lake in New York. Then hand pulling of these undesirable plants will be done by divers in areas where there is a mix of invasive and desirable, native species. Techniques that are not recommended include the use of herbicides, such as Sonar, shading by using a dye in the water, stocking of sterile grass carp, or using herbivorous insects.[104] This program will be monitored to assess its effectiveness.

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99 Greenwood Lake Commission. 2007. Stump Reduction Project, 2006-2007. Page 1.

100 Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006. Page 14.

101 Princeton Hydro, LLC. 2007. Invasive Species Management Plan, Greenwood Lake, New York. Page 5.

102 Princeton Hydro, LLC. 2007. Invasive Species Management Plan, Greenwood Lake, New York. Page 4.

103 Princeton Hydro, LLC. 2007. Invasive Species Management Plan, Greenwood Lake, New York. Page 7.

104 Princeton Hydro, LLC. 2007. Invasive Species Management Plan, Greenwood Lake, New York. Pages 8-11.

Onsite Wastewater Treatment Systems Management Planning Project
West Milford Township & Princeton Hydro, LLC (2007-2008)

In 2007 West Milford Township received a grant from the NJDEP, using 604(b) funds, to develop an Onsite Wastewater Treatment Systems (OWTS) Management Plan for Greenwood Lake. The project was proposed by and will be implemented by Princeton Hydro, LLC.[105] NJDEP describes the project as follows:[106]

> This planning effort will include: the development of a digital database and establishment of a process for the tracking of OWTS; an update of the estimate of the lake's annual phosphorus load originating from the OWTS; collection of subsurface soil leachate samples to quantify the phosphorus and fecal coliform entering the lake or its tributaries; identification of potential management measures for the OWTS; an effective, aggressive, pro-active public educational initiative; an implementation schedule including budgetary and technical needs; and the development of an objective and rational prioritization scheme for the OWTS focusing on maintenance, inspection and to varying degrees rehabilitation. The grant provides for identification of potential management measures to address the prioritized OWTS within the planning area to be developed into an OWTS BMP manual. The final task will be the submission of the OWTS Management Plan by the Township to the NJDEP as a proposed amendment to the Northeast Areawide Water Quality Management Plan.

The "planning area" identified for this project includes "septic leach fields within 100 meters or 330 feet of the stream banks of Belcher Creek or the shoreline of Greenwood Lake."[107]

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[105] Township of West Milford & Princeton Hydro, LLC. 2006. Development of Onsite Wastewater Treatment Systems (OWTS) Management Plan for the New Jersey End of the Greenwood Lake Watershed, Passaic County, New Jersey. April 2006.

[106] New Jersey Department of Environmental Protection, Division of Watershed Management. 2008. Amendment to the Northeast, Upper Raritan, Sussex County and Upper Delaware Water Quality Management Plans, Total Maximum Daily Load Report for the Non-Tidal Passaic River Basin Addressing Phosphorus Impairments. Proposed: May 7, 2007; Adopted: April 2008. Page 53.

[107] Township of West Milford & Princeton Hydro, LLC. 2006. Development of Onsite Wastewater Treatment Systems (OWTS) Management Plan for the New Jersey End of the Greenwood Lake Watershed, Passaic County, New Jersey. April 2006. Page 10.

B. IMPACTS ON WATER SUPPLIES

Water Supplies from the Highlands

Reliance on water supplies from the Highlands goes back more than a century. Water supplies from the Lower Passaic River became too polluted to drink. By 1892 the City of Newark was using water from the Pequannock River in the Highlands, and deaths from typhoid dropped 79%.[108] In 1907 a report to the Potable Water Commission of New Jersey had the following finding:

> *"The Highlands' watersheds are the best in the State in respect to ease of collection, in scantiness of population, with consequent absence of contamination; in elevation, giving opportunity for gravity delivery, and in softness as shown by chemical analysis. These watersheds should be preserved from pollution at all hazards, for upon them the most populous portions of the State must depend for water-supplies. There has been too much laxness in the past regarding this important matter."*

In 1916 the North Jersey District Water Supply Commission (NJDWSC) was established to develop, acquire and operate water supply resources in northern New Jersey. The Wanaque Reservoir was completed by the NJDWSC in 1930. Today, the Commission oversees the operation of the largest water supply operation in the State of New Jersey, including the Monksville and Wanaque Reservoirs, two river-diversion pumping stations, and a water filtration plant that can process 210 million gallons per day (mgd).[109] The Greenwood Lake Watershed covers 27 square miles of the critical area draining into these reservoirs.[110] Of this area 18 square miles is in New Jersey (Table II.D-1).

The Highlands Water Protection and Planning Act, enacted in 2004, includes findings "that the New Jersey Highlands is an essential source of drinking water … for one-half of the State's population".[111] The Highlands Draft Regional Master Plan notes that over 80% of the usage of potable water from the Highlands occurs outside the Highlands.[112] It projects that sustainable capacity for bringing potable water from reservoirs in the Highlands of the Passaic River Basin to major cities like Paterson, Newark, Jersey City, and Hackensack will be exceeded in the not too distant future.[113] The reservoir systems that supply this potable water in the Passaic and Hackensack River Basins have a "nominal safe yield" of 352 mgd.[114] About half of the potable water comes from the NJDWSC Wanaque Reservoir and Wanaque South Project System, whose

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[108] Brydon, Norman F. 1974. The Passaic River: Past, Present, Future. Rutgers University Press, New Brunswick, NJ. Pages 196, 210.

[109] North Jersey District Water Supply Commission. 2007. About NJDWSC. Website: <http://www.njdwsc.com/njdw/about.htm>

[110] U.S. Geological Survey. 1999. Passaic River Basin, 01383500 Wanaque River at Awosting NJ. Water Resources Data, New Jersey, Water Year 1999, Volume 1. Surface-Water Data, Water Data Report NJ-99-1, page73.

[111] Highlands Water Protection and Planning Council. 2007. *Highlands Regional Master Plan, Final Draft, November 2007.* Page 8.

[112] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Page 20.

[113] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Page 20.

[114] Highlands Water Protection and Planning Council. *Water Resources Technical Report, Volume II, Water Use and Availability, January 2007.* Page 162.

"nominal safe yield" is 173 mgd.[115] However, a realistic estimate of "safe yield" would be much lower because development in the Highlands over the last century has greatly reduced that availability of clean water, but the population and the demand for clean water has been growing. In the Highlands Regional Master Plan the following observation is made:[116]

> In the face of the growing challenge of protecting New Jersey's finite drinking water supply and providing for the needs of a growing human population, the continued loss and fragmentation of the remaining lands that serve as the source of that water supply is no longer tenable.

For the sake of the millions of people in New Jersey who rely on clean water supplies from the Highlands, flows of clean water from the Greenwood Lake Watershed into the Monksville and Wanaque Reservoirs should be improved, or at least maintained.

Highlands Sole Source Aquifer

Ground water supplies most of the potable water used in the Highlands and all of it in the Greenwood Lake Watershed. In order to try to protect both the quality and quantity of these water supplies in 1985 the Township of West Milford and the Passaic River Coalition petitioned the US Environmental Protection Agency (EPA) to designate the Highlands Aquifer System as a Sole Source Aquifer. An area that has "an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create significant hazard to public health" may be so designated under provisions of the Safe Drinking Water Act.[117] The area that EPA defined as the Highlands Basin Aquifer System is the Wanaque and Pequannock River drainage basins. The EPA notes that "this area is largely developed as a watershed for surface water supply. … Upper and Lower Greenwood Lakes and Wanaque Reservoir in the Wanaque River Basin are used for water supply by the North Jersey District Water Supply Commission."[118] The Highlands Aquifer System is vulnerable to contamination from many sources, including transportation routes and facilities, onsite septic systems, storm water runoff, commercial and industrial facilities, and future development.[119] The Highlands Aquifer System was designated as a Sole Source Aquifer in 1987. This designation requires EPA to review all proposed projects within the designated area that will receive federal financial assistance.[120]

New York-New Jersey Highlands Regional Study
United States Department of Agriculture, Forest Service (2002)

In 2002 the Forest Service of the US Department of Agriculture (USDA) with the assistance of the US Geological Survey (USGS) updated its 1992 study of the New York-New Jersey

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115 *Ibid.*

116 Highlands Water Protection and Planning Council. 2007. Highlands Regional Master Plan, Final Draft, November 2007. Pages 9-10.

117 Safe Drinking Water Act, Public Law 93-523, Section 1424(e), December 1974.

118 US Environmental Protection Agency, Region 2. 1987. Highlands Basin Aquifer System, Support Document, Section I.D. Website: <www.epa.gov/region2/water/aquifer/high/highland.htm>

119 US Environmental Protection Agency, Region 2. 1987. Highlands Basin Aquifer System, Support Document, Section III.

120 US Environmental Protection Agency, Region 2. 2008. Sole Source Aquifers Website: <www.epa.gov/region2/water/aquifer/>

Highlands Region.[121] The study notes that "one in nine Americans lives within a 2-hour drive of the Highlands, and its abundant natural and cultural resources provide quality drinking water, recreation, and economic opportunities for millions in the region."[122] It also notes that the population of the 108 municipalities in the Highlands region of New York and New Jersey increased 11.5% between 1990 and 2000.[123] This means that stress on these resources has increased, and that working towards the goal to "maintain an adequate supply of quality water" flowing from the Highlands is of critical importance.

The US Geological Survey (USGS) team estimated that with normal rainfall on the Highlands, about 9% is used consumptively by people, and 41% goes back into the air as evapotranspiration.[124] On average about 14% of stormwater runs off overland and sometimes causes flooding, and 36% soaks into the ground and gradually flows into streams, rivers, and reservoirs as base flow.[125] It is this 36% of rainfall that is recharged to ground water that is critical for future water supplies in the region. Most of this water is recharged in the forests and farmland of the Highlands region. The higher the percentage of total stream flow that is base flow, the better the land in that area is functioning to recharge ground water. In the Greenwood Lake Watershed the ratio of base flow to total stream flow is about average, between 70% and 79%.[126] The percentage of base flow to total stream flow depends on geology but also on the "degree of development in the watershed."[127] The study notes that "areas where base flow accounts for less than 50% of stream flow occur in some of the most urbanized areas of the study area with documented large ground water withdrawals including parts of Rockland County, New York, and eastern Morris County, New Jersey."[128] If there are to be sufficient water supplies for a growing population in the future, recharge of ground water must be improved. The USGS team estimated changes in stream flow characteristics under various development scenarios. They note that "the increase in impervious surface ... had a greater impact on changing Highlands' water budgets than did the estimated increase in ground water withdrawals by the projected larger population."[129] This indicates that land usage is a more important factor than water usage in sustaining potable water supplies. Their assessment shows that much of the NY-NJ Highlands area deserves special consideration and should be maintained with natural vegetation insofar as possible for its water resource values.

Evaluation of Groundwater Resources of West Milford Township
M^2 Associates Inc. (2003)

In 2002 West Milford Township retained the services of M^2 Associates Inc. to evaluate the ground water resources within the municipality in order to protect the quality and quantity of the water used by their own citizens and other citizens of New Jersey and the Highlands Region, as

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121 US Department of Agriculture, Forest Service, Marcus G. Phelps & Martina C. Hoppe, Compilers. 2002. New York – New Jersey Highlands Regional Study: 2002 Update. NA-TP-02-03.
122 *Ibid.* Page 2.
123 *Ibid.* Page 3.
124 *Ibid.* Page 47.
125 *Ibid.* Page 47.
126 *Ibid.* Page 45.
127 *Ibid.* Page 47.
128 *Ibid.* Page 47.
129 *Ibid.* Page 128.

well as other "ecological receptors within the critical Highlands Region".[130] They estimated that about 48% of precipitation is returned to the air as evapotranspiration, and that 36% is surface water runoff. In the Greenwood Lake Watershed the surface water runoff is high because much of the precipitation is on poorly drained soils, along steep slopes, or in developed areas with impervious surfaces.[131] It also includes water that infiltrates soils to a shallow depth and then follows along a low permeability surface to a discharge point, such as a stream. Ground water runoff, which soaks into the ground, replenishes the bedrock aquifers, and maintains stream base flow is estimated to be only 16% of precipitation, which is 8.2 inches of water per year on average. However, every year isn't average. Under drought conditions "maintainable" recharge rates of 3.8 to 4.2 inches per year were estimated.[132]

How much of this ground water can be pumped out and used for human consumption, when much of it is needed for ecosystems dependent on water and also for maintaining surface water flows into the NJDWSC reservoirs? This study uses the "Planning Threshold" proposed by the New Jersey Department of Environmental Protection (NJDEP) in the 1996 Statewide Water Supply Plan of 20% of the "maintainable" recharge rates to estimate the "Dependable Yield" for human consumption of the bedrock aquifers in the Greenwood Lake Watershed.[133] Thus, this study estimates that the consumptive usage of ground water should be limited to ~0.8 inches per year, which is 56 to 62 gallons per day per acre (gpd/acre).[134] About 5 acres of recharge area is required to sustain ground water usage in each dwelling unit in the watershed if the daily demand per unit is 290 gallons per day (gpd).

This study also examines the question of how much recharge is needed to dilute nitrate coming from septic systems and other issues. Conclusions reached in this M^2 Associates Inc. study that are particularly pertinent follow:[135]

- Water is supplied to West Milford Township residents from individual wells or public community wells completed in fractured bedrock aquifers. Surface water resources have been long dedicated to downstream urban areas of New Jersey.
- Soils beneath only 2% of the township may be appropriate for conventional septic systems. Discharges to soils with limited capacity for infiltration, dispersion, and dilution could result in degradation of surface water and/or ground water quality.
- Data from wells indicate that the aquifer systems are poor yielding and poorly transmissive.
- The recharge areas necessary for adequate water supply and quality should be in areas with flat to gentle slopes and open to precipitation. The areas should not be covered with impervious surfaces or buildings.
- In areas with existing lot sizes smaller than the recharge areas, additional areas or recharge enhancements may be needed for adequate water supply and quality. Within these areas, it may be necessary to preserve or protect upstream open areas within the same watershed to ensure sufficient water infiltrates the aquifer to meet water supply demands and to dilute septic system contaminants.

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130 Mulhall, Matthew J., P.G., M^2 Associates Inc. 2003. Evaluation of Groundwater Resources of West Milford Township, Passaic County, New Jersey, November 26, 2003. Prepared for West Milford Township. Page 2.
131 *Ibid.* Page 19.
132 *Ibid.* Page 28.
133 *Ibid.* Page 29.
134 *Ibid.* Table 7.
135 *Ibid.* Pages 34-37.

Highlands Regional Master Plan
Highlands Water Protection and Planning Council (2004-2008)

As previously noted, the Highlands Water Protection and Planning Council, which was established to implement the Highlands Water Protection and Planning Act, and its staff and others have been developing a Highlands Regional Master Plan. A critical issue to be addressed is the availability of ground water for water supplies. Some of their findings are discussed in Section II.D. Using the "Low Flow Margin of Safety" method, they estimated "Ground Water Capacity" in the Greenwood Lake Watershed to be about 3.0 inches of water per year. "How much of that capacity can be provided to human use without harm to other ground water users, the aquatic ecosystems, or downstream surface water users?"[136] In the Greenwood Lake Watershed in New Jersey, which is in the Highlands Preservation Area, the recommended allowable Ground Water Availability for potable uses is 5% of Ground Water Capacity, or 0.15 inches per year, or 0.126 million gallons per day (mgd) (Table II.D-4).[137] However, as reported in Table II.D-4, total consumptive/depletive usage of water in the watershed was estimated at 0.448 mgd.[138] This is 18% of Ground Water Capacity or 3.6 times the allowable Ground Water Availability. This is a major deficit.

The Highlands Regional Master Plan (RMP) Final Draft has many goals, policies, and objectives to address the issues related to Water Resources and Water Utilities.[139] Where a subwatershed's water use is deemed to be in deficit, the Goals, Policies and Objectives of the RMP restrict additional consumptive and depletive uses from that subwatershed so that the deficit is not exacerbated.[140] The RMP mandates that municipalities with deficits, such as West Milford, utilities and other interested stakeholders, such as the Greenwood Lake Commission, develop a Water Management Plan in order to reduce or eliminate deficits.[141] Such a plan should be a key component of the Restoration and Management Plan for the Greenwood Lake Watershed.

What the Highlands draft RMP fails to point out is the fact that, based on a summary of their estimates, throughout the Highlands within the New Jersey portion of the Passaic River Basin consumptive/depletive usage is about 7 times the estimated Ground Water Availability. This means that the Deficit is 6 times the Ground Water Availability. These data are summarized in Table III-3.[142] The Greenwood Lake Watershed is in the Wanaque Watershed. The estimate that 65% of the Ground Water Capacity is being used within the Highlands in the Passaic River Basin so that it cannot be used by downstream users in the urban areas of northeastern New Jersey should be a major concern.

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136 New Jersey Highlands Water Protection and Planning Council. 2007. Water Resources Technical Report, Volume II-Water Use and Availability, January 2007. Page 34.

137 New Jersey Highlands Water Protection and Planning Council. 2007. Draft Technical Report Addenda, November 2007. Calculation of Net Water Availability, page 28.

138 New Jersey Highlands Water Protection and Planning Council. 2007. Draft Technical Report Addenda, November 2007. Highlands Region Water Availability by HUC14 Subwatershed, table following page 29. Greenwood Lake (NJ, above Awosting gage) subwatershed values are estimated from values cited for Wanaque River/Greenwood Lake (above Monksville gage) subwatershed.

139 Highlands Water Protection and Planning Council. *Highlands Regional Master Plan, Final Draft, November 2007*. Chapter IV, Part 2, pages 125-142, and Chapter V, Part 2, pages 196-217.

140 *Ibid.* Page 197.

141 *Ibid.*

142 New Jersey Highlands Water Protection and Planning Council. 2007. Draft Technical Report Addenda, November 2007. Highlands Region Water Availability by HUC14 Subwatershed, table following page 28.

Table III-3 -- Ground Water Capacity, Availability, Uses in the Passaic Watersheds of the New Jersey Highlands

Passaic Watershed	*Ground Water Capacity (mgd)*	*Ground Water Availability (mgd)*	*Consumptive/ Depletive Uses (mgd)*	*Net Availability (mgd)*	*Availability/ Capacity*	*Uses / Ground Water Capacity*
Upper Passaic	9.70	1.23	2.92	-1.69	13%	30%
Whippany	10.68	1.63	17.14	-15.50	15%	160%
Rockaway	22.88	2.36	12.52	-10.17	10%	55%
Pequannock	13.79	0.69	2.93	-2.24	5%	21%
Wanaque	11.44	0.57	2.05	-1.48	5%	18%
Ramapo	4.40	0.35	8.69	-8.34	8%	198%
Passaic Basin in Highlands	75.84	7.18	49.42	-42.24	9%	65%

C. LAND USE IMPACTS

Land Use for the Preservation of Water Resources

Open Space Committees of Watershed Management Areas 6 & 3 (2000-2002)

Criteria for evaluating land areas for their ability to provide environmental services that preserve water resources were developed by the Open Space Committees of Watershed Management Area 6 (WMA6) and Watershed Management Area 3 (WMA3) in the Passaic River Watershed.[143] These criteria, and the scoring and mapping systems that have been developed to rank land areas according to their water resource values can be used by municipal officials and others interested in "open space" preservation and planning for water resource protection in northern New Jersey. The types of areas that are likely to provide water resource benefits if allowed to function so that their ecological benefits are optimized are as follows:

- Recharge Areas (Figures II.D-5 and II.D-6);
- Drinking Water Source Areas (The Greenwood Lake Watershed is a high replenishment area.);
- Areas with Steep Slopes (Figure II.A-3);
- Well Head Protection Areas (Figure II.D-7);
- Wetlands (Figure II.C-2);
- Surface Water Sensitive Areas (Flood Hazard Areas) (Figures II.C-3 and II.C-4); and
- Landscape Project Conservation Areas (Figures II.C-5, II.C-6 and II.C-7).

Each type of area has been subdivided or categorized according to its potential for protecting water resources. Each category of area has been given a suggested score based upon judgment regarding the relative value of the category of land at protecting water resources. These categories and suggested scores are summarized in Table III-4. Geographic information system (GIS) technology makes it feasible to assemble the criteria for water resource lands into a single composite data set, and to assign numerical scores for water resource preservation values to all land in a region. Water Resource Values for the lands in the Greenwood Lake Watershed are shown in Figure III-5. The preservation of the natural resources of lands that have high water resource values is especially important in West Milford, because without their protection ground water supplies will be diminished and degraded, Greenwood Lake will become more impaired, flooding will increase, and the health of the people, pets and wildlife may be threatened.

It is also important for the residents of West Milford to recognize that the precipitation that falls on the Township provides water for people in other areas of New Jersey where there is no longer adequate open space or well vegetated vacant land for the storage and cleansing of water by natural processes. Ground water recharge and base flows in streams must be maintained or enhanced in order to sustain adequate surface and ground water supplies for potable use. Thus, it is important to identify and protect land areas that provide optimal base flows of clean water to receiving streams and reservoirs. This approach is critical to protect both the quantity and quality of surface and ground water. The protection of critical water resource lands in West Milford and in the rest of the Highlands will contribute to public health and economic vitality here and elsewhere in New Jersey.

[143] Passaic River Coalition. 2002. Criteria for Preservation of Critical Water Resource Lands in the Passaic River Watershed.

Figure III-5 – Water Resource Values for Land in the Greenwood Lake Watershed

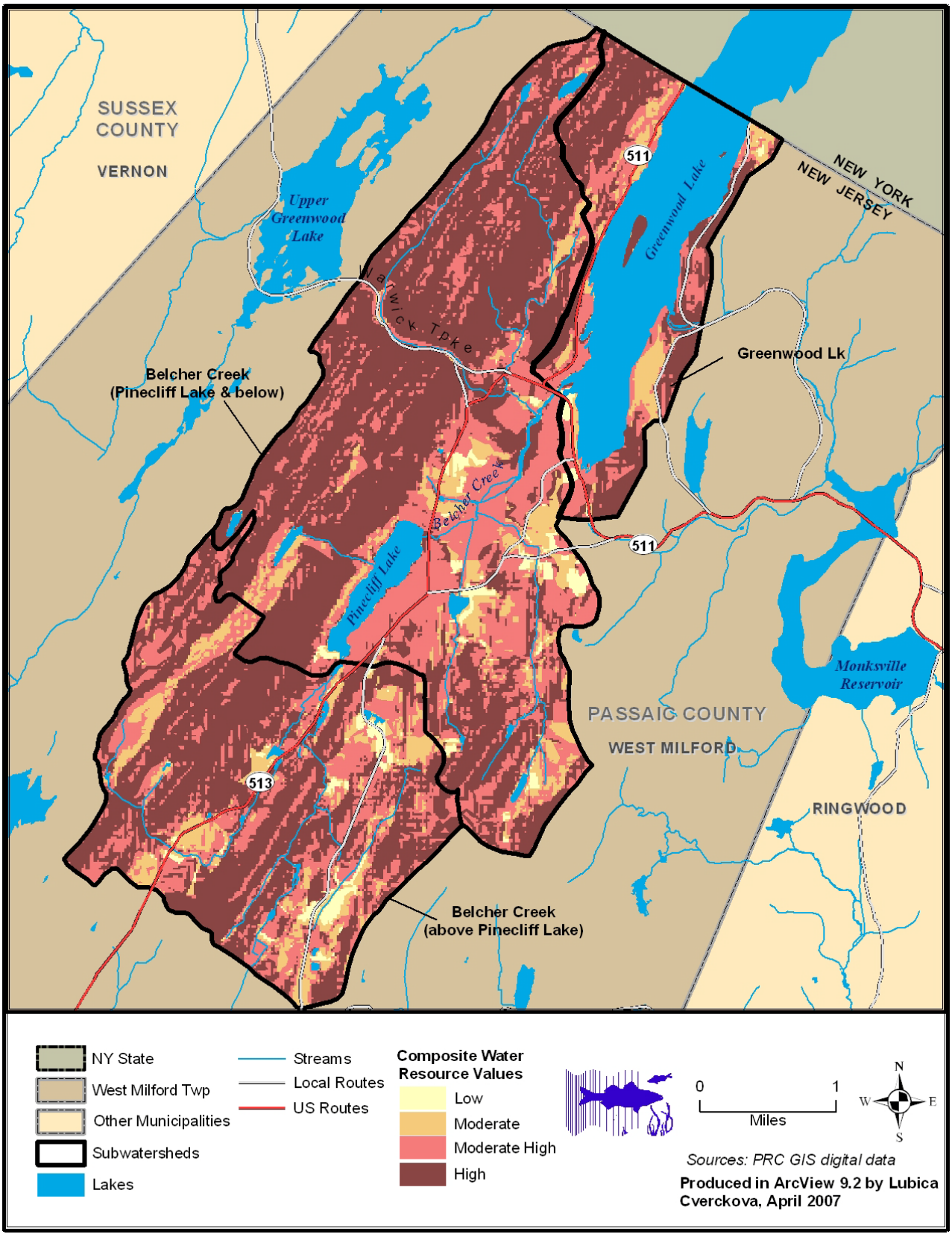

Table III-4 - Categorization of Criteria for Water Resource Lands

Type of Area	*Category of Area*	*Suggested Score*
Recharge Areas	>19 inches/year	24
	19-15 inches/year	21
	14-10 inches/year	12
	9-5 inches/year	6
	<5 inches/year	0
Drinking Water Source Areas	High replenishment area	12
	Moderate replenishment area	6
	Low replenishment area	0
Areas with Steep Slopes	>15%	12
	>12%	8
	>8%	4
	Absent	0
Well Head Protection Areas	Tier I for Public Community Well(s)	12
	Tier II for Public Community Well(s)	8
	Tier III for Public Community Well(s)	4
	Absent	0
Surface Water Sensitive Areas	Open surface water body	12
	Area within 1500 feet of reservoir	12
	Floodway*** (Floodway delineations are not currently available in a GIS data set)	12
	Flood hazard area re FEMA mapping	9
	Area within 75 feet of stream, lake or pond	9
	Area within 150 feet of stream, lake or pond	6
	Absent	0
Wetlands	Freshwater wetland	12
	Freshwater wetland buffer area within 150 feet	6
	Absent	0
Landscape Project Conservation Areas	Highest priority, rank=5	12
	High priority, rank=4	10
	Medium priority, rank=3	8
	Low priority, rank=2	6
	Lower priority, rank=1	4
	Absent	0

The New Jersey State Development and Redevelopment Plan

New Jersey State Planning Commission (2001)

In March 2001, the State Planning Commission adopted an updated version of the New Jersey State Development and Redevelopment Plan that provides more guidance and stronger policy direction than the 1992 plan.[144] The State Plan is intended to direct growth and redevelopment in an effort to prevent future suburban sprawl. It includes the following targets: improving water quality, preserving farmland and open space, revitalizing urban areas, reducing dependence on automobiles, conserving natural resources, and promoting beneficial economic growth, development and renewal.

The State Plan identifies the Highlands in New Jersey as a Special Resource Area, in recognition of the critical importance of that area to the State. The town of West Milford is located entirely within Planning Area 5 (PA5), a classification the State Master Plan reserved for environmentally sensitive areas. The State Plan provides guidance on many land use issues within the Greenwood Lake Watershed and has played an integral part in the development of West Milford's Open Space Plan.

The Landscape Project

Division of Fish & Wildlife, New Jersey Department of Environmental Protection (1994-2008)

The Endangered and Nongame Species Program (ENSP) of the NJ Division of Fish and Wildlife began the Landscape Project in 1994.[145] The on-going project entails critical area mapping for community land-use planning using an extensive database that combines imperiled and priority species location information with land-use/land-cover data. The Program identifies and maps areas of exceptional biodiversity value in order to protect rare, threatened, and endangered species in key habitat areas of New Jersey.

A comparison of the areas designated in the State Plan with critical areas identified in The Landscape Project reveals some regions where detailed mapping will be required in order to determine which areas within the designated boundaries are suitable for development. For example, within the boundaries of the Township of West Milford, the Landscape Project indicates several forest and wetland areas suitable for State Threatened species, and therefore, inappropriate for growth. Landscape Project maps of the Greenwood Lake Watershed are shown in Figures II.C-5, II.C-6 and II.C-7**.**

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144 New Jersey State Planning Commission. 2001. The New Jersey State Development and Redevelopment Plan, adopted March 1, 2001.

145 New Jersey Department of Environmental Protection, Division of Fish & Wildlife. 2008. New Jersey's Landscape Project. Website: <http://www.njfishandwildlife.com/ensp/landscape/index.htm>

Smart Growth

New Jersey Department of Community Affairs, Department of Smart Growth

Smart Growth is an approach to planning that attempts to minimize sprawl by concentrating growth according to sustainable development principals such as preserving open space, minimizing land consumption, incorporating mixed-use development, advocating for transit-oriented, pedestrian-friendly land use, and targeting resources in ways that help enhance quality of life.

The State of New Jersey established the Office of Smart Growth as the land use planning office for the State. The Office of Smart Growth is housed at the Department of Community Affairs, and works directly with the Governor through the Smart Growth Policy Council. The Council ensures that State agencies have incorporated the State Development and Redevelopment Plan and smart growth principals in their functional plans, regulations and programs.

Highlands Regional Master Plan

Highlands Water Protection and Planning Council (2004-2009)

The New Jersey Highlands Region encompasses 859,358 acres of ecologically sensitive land. In 2004, the State passed the Highlands Water Protection and Planning Act (N.J.S.A. 13:20-1 *et seq*.), a law that facilitates the preservation of open space and helps to protect the region's natural resources including clean air, wetlands, wildlife habitat, contiguous forest lands, and pristine watersheds that provide potable water for over 5.4 million New Jersey residents.

The Highlands Act delineates the geographical boundaries of the Highlands Region and establishes two land categories: the Highlands Preservation Area and the Highlands Planning Area. These areas are shown in Figure III-6. The Preservation Area contains approximately 414,970 acres, while the Planning Area is comprised of about 444,390 acres. There are five municipalities that lie entirely within the Preservation Area, 47 municipalities that have land in both the Preservation and Planning Areas and 36 municipalities that have land only in the Planning Area.[146] The New Jersey side of the Greenwood Lake Watershed is located entirely within the Highlands Preservation Area.

The Highlands Act called for the creation of the Highlands Water Protection and Planning Council to develop a Regional Master Plan for the entire Highlands Region. A Draft Regional Master Plan was issued for public review in November 2006. A Final Draft was released in November 2007. In July 2008 the Highlands Council adopted the Highlands Regional Master Plan (RMP), which was approved by the Governor of New Jersey in September 2008.[147]

In accordance with the Highlands Act, the NJ Department of Environmental Protection (NJDEP) adopted the Highlands Water Protection and Planning Act Rules at N.J.A.C. 7:38 (NJDEP Highlands Rules). These rules establish the environmental standards and regulations for the Preservation Area and form the basis for the Regional Master Plan, as well as NJDEP's Highlands permitting program. The NJDEP rules call for the immediate imposition of stringent water and natural resource standards in the Highlands Preservation Area, which is especially sensitive to development pressure.

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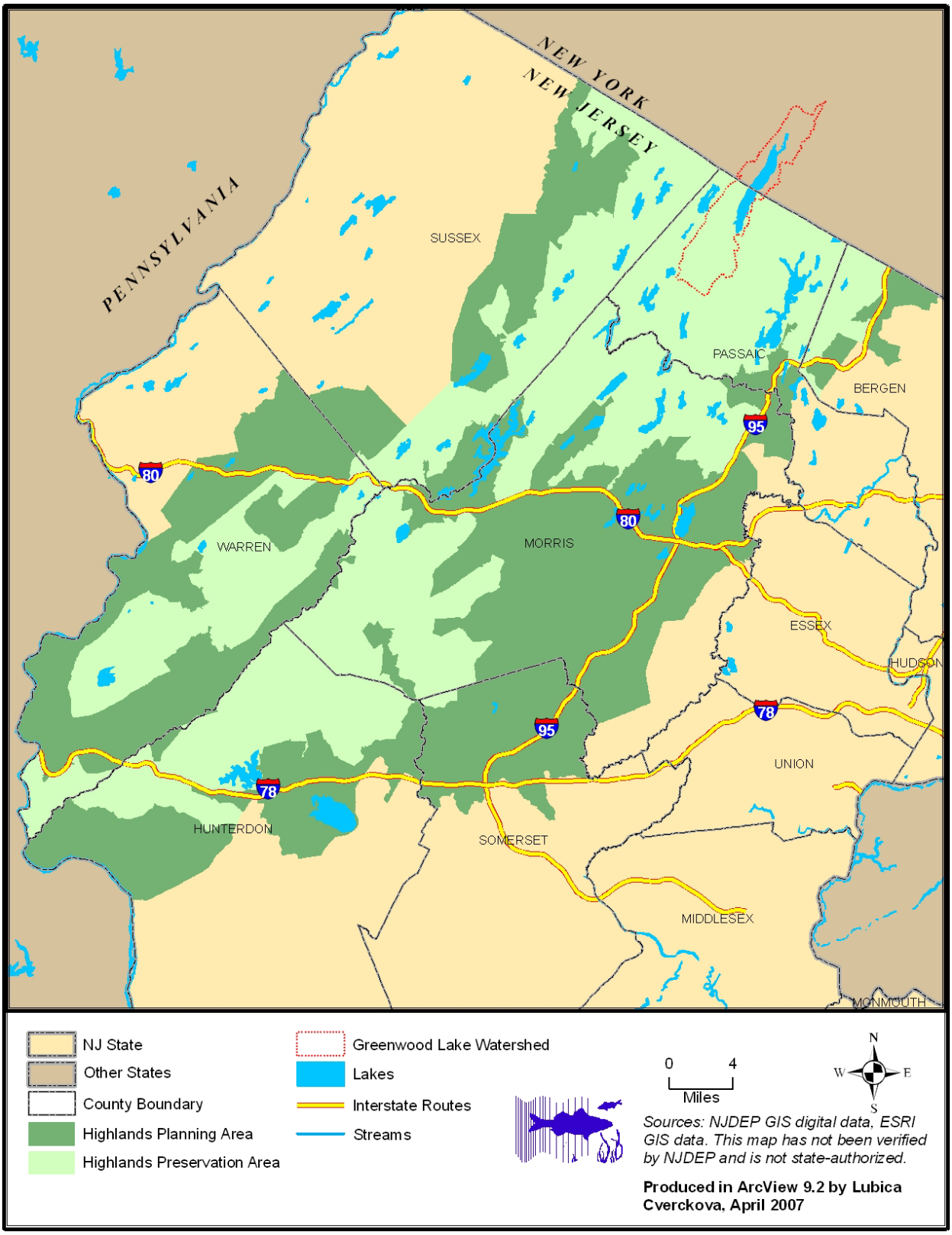
[146] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Pages 2-3.

[147] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan.

Figure III-6 – Greenwood Lake Watershed in the New Jersey Highlands



The NJDEP Highlands Rules include and expand upon the following water standards established by the Highlands Act: limits on water supply permits; septic system density standards to protect and restore water quality; limits in flood hazard areas; requirements to maintain, restore and enhance existing water quality; 300-foot buffers adjacent to Highlands Open Waters; Category One antidegradation requirements for Highlands Open Waters; prohibitions to limit impervious surfaces and protect steep slopes, forested areas, and habitat for animal and plant species; and prohibitions to limit the construction or extension of water and wastewater systems.[148]

The NJDEP Highlands Rules also include specific requirements for the Highlands permitting program to ensure a coordinated review of any Major Highlands Development in the Preservation Area. The term "major highlands development" applies to all non-residential development, as well as any residential development, activity, or any capital or other project of a State entity or local government unit (excluding agricultural or horticultural activity) that requires an environmental land use or water permit, or results in the disturbance of one acre or more of land, or causes a cumulative increase in impervious surface by one-quarter acre or more.[149]

A fundamental distinction between the Preservation Area and the Planning Area is that municipal and county conformance with the Regional Master Plan is required in the Preservation Area and is voluntary in the Planning Area. The Township of West Milford, including the Greenwood Lake Watershed, is located within a Preservation Area, and is thus subject to the aforementioned regulations, in addition to all other stipulations found in the Highlands Water Protection and Planning Act.

West Milford Open Space Plan
Township of West Milford (2003 Revision)

The present West Milford Open Space Plan represents a 2003 revision of the original Open Space Plan done in 1979.[150] It is intended to become a part of the West Milford Master Plan, just as the 1979 Open Space Plan was successfully integrated into the 1987 Township Master Plan. West Milford is currently involved in a comprehensive Master Plan program, which began in 2000 after the town Planning Board conducted two reexamination reports regarding the 1987 Master Plan. The State Municipal Land Use Law stipulates that such plans should be reexamined at least every six years. If the Open Space Plan is to be an effective tool it must be reviewed and updated on a regular basis in conjunction with the Master Plan review process. Some areas in the Greenwood Lake Watershed that are already preserved as Open Space are shown in Figure I-5.

In November of 2000, the voters of West Milford approved an Open Space Acquisition tax at one cent per $100 of assessed property value. In early 2001, an Open Space Advisory Committee was formed, consisting of citizen representatives, as well as liaison representatives from the Environmental Commission, Planning Department, Township Council, and Recreation Department. These efforts coincided with State initiatives to provide funding for open space purchase and Passaic County's recent adoption of an open space tax.

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148 Highlands Water Protection and Planning Council. 2006. Highlands Draft Regional Master Plan, November 2006. Pages **??**.

149 Highlands Water Protection and Preservation Act, 2004.

150 Township of West Milford. 2003. Open Space Plan.

The West Milford Open Space Plan is congruent with the NJ State Development and Redevelopment Plan. Although West Milford's plan was created before the passing of the Highlands Act, it was greatly influenced by the 1992 Highlands Regional Study. The Highlands report included many significant land use management recommendations and identified several sensitive areas around and within the Greenwood Lake Watershed, including Sterling Forest and the Wyanokie Highlands.

The function of the West Milford Open Space Plan is to evaluate and document the current open space conditions in West Milford and to increase public awareness about this critical, but often overlooked resource. This task is accomplished through the identification and classification of specific sites, along with the examination of scientific data and complex policy issues associated with open space.

An effective Open Space Management plan requires knowledge of the past, comprehension of the present, and vision for the future. The goal of acquiring new land should be balanced with the need to protect and maintain existing parcels. The West Milford Open Space Plan identifies as one of its objectives that "the open spaces that will be preserved are to be interconnected to the greatest degree possible".[151] Contiguous tracts of land are much more valuable than isolated pockets of open space because they enable unique, functioning ecosystems that provide valuable wildlife habitat, extensive buffers for waterways, and exceptional recreational opportunities.

It is noted in the Open Space Plan that although West Milford already has a considerable amount of open space, many residents "do not have legal access to these areas or access is inconvenient".[152] Fluid open space corridors are more prominent and accessible than fragmented land.

At the core of the Open Space Plan are the Open Space System Components, specifically tailored to West Milford's unique environment. The four primary factors are Steep Slopes, Rock Outcroppings, Vegetation and Wildlife, and Existing Protected Open Space. These components are integrated with secondary components (Historic Sites, Scenic and Unique Features, Trails, Surface Water, and Active Recreation Areas). In some cases, the secondary components will act as focal points and in other instances, they will act as physical connectors. The interplay of primary and secondary components allows the West Milford open space system to effectively balance the needs of humans and the environment. The sites proposed for Open Space protection are shown in Figures III-7 and III-8, and described in Table III-5.

The Open Space Plan offers a conceptual framework for open space management and a sound Preservation Strategy. The Plan concludes with a section discussing the role of community involvement and support, as well as a list of areas to preserve. These critical areas were targeted by the Open Space Advisory Committee due to their proximity to existing protected open space and environmental sensitivity. These properties are demarcated, expanded upon, and mapped according to the Open Space Greenway and Prioritization Plan.

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151 *Ibid.*
152 *Ibid.*

The Open Space Greenway and Prioritization Plan

West Milford Environmental Commission Open Space Subcommittee (2003-200?)

In response to recommendations of the West Milford Open Space Plan (2003 Revision), the Planning Board requested that the Environmental Commission form an Open Space Subcommittee to prioritize the acquisition of land. The subcommittee created The Open Space Greenway and Prioritization Plan and identified the following goals: connecting the Town's open space parcels and providing recreational open space for residents.

The subcommittee returned to a previous project of the Environmental Commission and Planning Department—creating a greenway around the Town's immediate central commercial district and a greenway connecting the entire Town. The subcommittee created a Preliminary Open Space Map of the parcels to be acquired and a map of the Open Space Greenway and Prioritization Plan, which outlines the priority greenways. The sub-committee recommended that funds available from the Open Space Tax be used to float a bond issue for the purchase of these parcels.

The Open Space Subcommittee also proposed that a recreational complex be created on 80 acres of the former Jungle Habitat property. A large central facility would be environmentally sound and of greater value to the residents than diffuse facilities, small and scattered throughout the Township. Although West Milford will have use of 80 acres as part of the Highlands Preservation legislation, the Township must undergo negotiations with the State of New Jersey since a portion of the former Jungle Habitat is State Green Acres property.

Eagle Ridge (Block 5301 Lot 20 and Block 5405 Lot 8) was designated as the #1 priority of the Township Governing Body in an addendum to the Open Space Committee Draft Plan (2003 Revision) and The Greenway and Prioritization Plan. On May 24, 2006, the township adopted Resolution 2006-195, reallocating $300,000 in funds from the Passaic County Open Space and Farmland Preservation Trust Fund. The resolution states that the open space funds, previously allotted to the Sheridan Property (Block 5301, Lots 39 and 40), be transferred to Eagle Ridge property, under recommendations from the Governing Body of the Township of West Milford.

An important facet of the Open Space Greenway and Prioritization Plan is water quality protection. The priority greenways and sites to preserve identified by the town are primarily concentrated in the area surrounding Pinecliff Lake. The Plan would also extend the buffer on the Belcher's Creek corridor. The proposed greenways link to form a large greenbelt from the Greenwood Lake watershed to the watersheds of Belcher's Creek and Pinecliff Lake vastly increases the area's ecological value. The Greenways proposed for Open Space acquisition are shown in Figure III-9. Acquisition of the properties designated in the Open Space Greenway and Prioritization Plan will deeply enrich the landscape and provide countless benefits to the residents of West Milford.

Figure III-7 – Preserved Open Space and Sites to Preserve

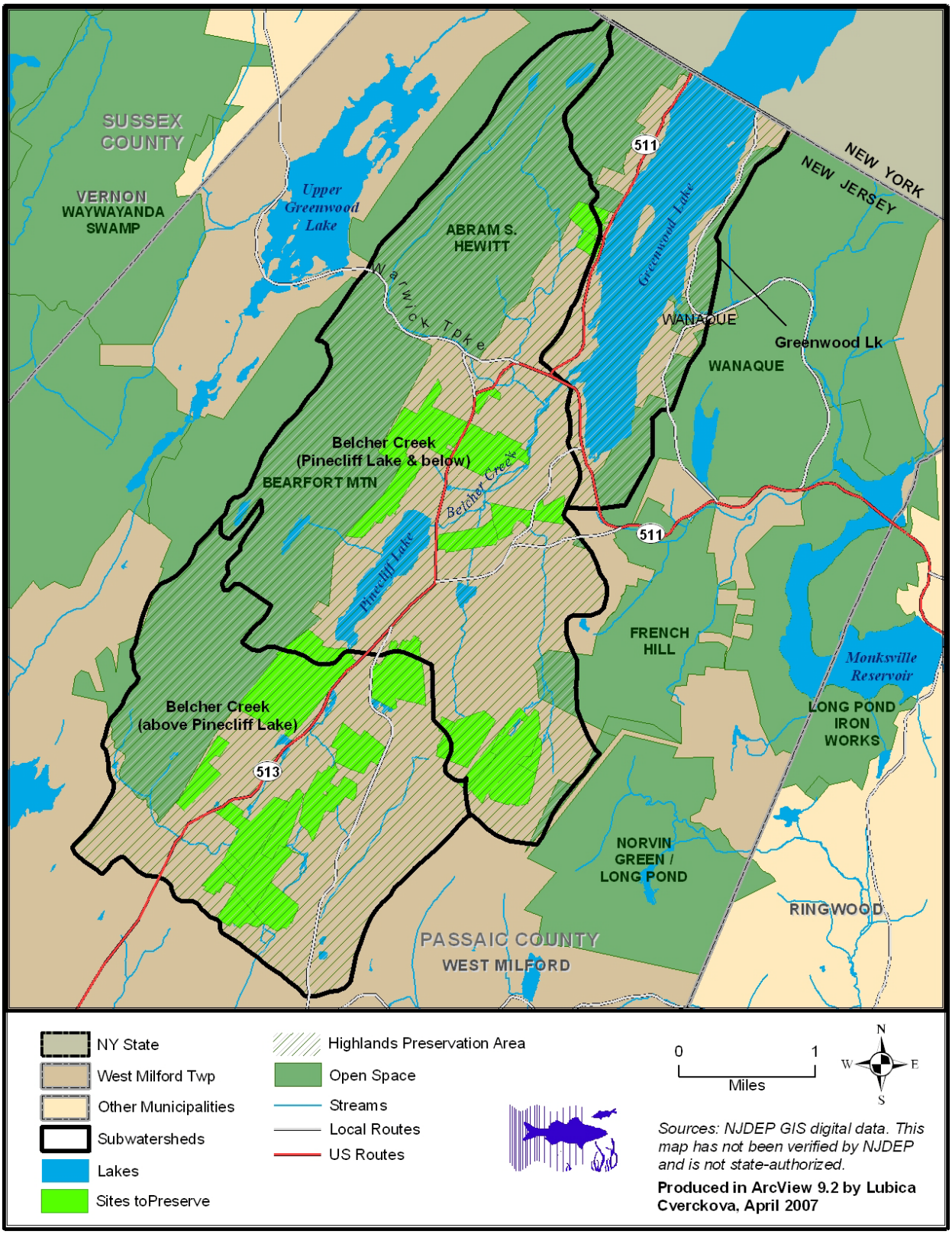


Table III-5 – Open Space Plan Sites to Preserve

ID	*BLOCK*	*LOT*	*ZONE*	*CURRENT LAND USE*	*LOCATION*	*LAND AREA (ACRES)*
1	6401	7		FARM WITH HOUSE	1566 UNION VALLEY RD	40
2	5301	20	R1/PN	VACANT LAND	RIDGE RD	70
3	17302	9		VACANT LAND	BEARFORT MT	50.272
4	9901	21	R-4	FARM	DOCKERTY HOLLOW	59.06
5	6402	5		COMMERCIAL	UNION VALLEY RD	5.0
				FARM		78.00
6	8002	1		VACANT LAND	DOCKERTY HOLLOW	63.17
7	6402	3		VACANT LAND	UNION VALLEY RD.	10.24
8	3201	8	R4	FARM	LAKESIDE RD	14.46AC
9	6401	6.01		PUBLIC PROPERTY	65 LINCOLN AVE	
						L15 1.5
10	5301	42.01	R3	FARM WITH HOUSE	367 MORSETOWN RD.	12.88
11	3201	4	R4	FARM	LAKESIDE RD	30.5446
12	9901	20	R4	FARM	DOCKERTY HOLLOW	37.02
13	6902	32		FARM WITH HOUSE	1735 UNION VALLEY RD	112
14	7701	20.01		FARM WITH HOUSE	48 STEPHENS ROAD	45.17
15	9901	10	R4	VACANT LAND	SUSSEX DR.	20.04
16	5301	42.02	R3	FARM WITH HOUSE	363 MORSETOWN RD	41.8
17	9901	11	R4	VACANT LAND	UNION VALLEY ROAD	12.2
18	5405	8		VACANT LAND	BROWN CT	54X560
19	7702	4		FARM	UNION VALLEY	221.31
20	5301	38	R4	FARM	MORSETOWN RD	21.61
21	9901	28		FARM	WOOLEY RD.	29.75
22	6404	12		PUBLIC PROPERTY	LINCOLN AVE	
23	5301	39	R4	FARM WITH HOUSE	445 MORSETOWN RD	70
24	5301	36	R4	FARM WITH HOUSE	21 LOUISE AVE	16.494
25	9901	12	R4	VACANT LAND	UNION VALLEY RD	73.68
26	8001	1		VACANT LAND	RIDGE RD	98.9955
27	8301	1		VACANT LAND	MACOPIN RD	57.63
28	9901	27	R4	FARM WITH HOUSES	267 WOOLEY ROAD	42.02
29	6402	6		PUBLIC PROPERTY	BELCHERS CREEK	7.59
30	6404	2.01		COMMERCIAL	1815 GREENWOOD LAKE TPKE	26.37
31	6608	1		PUBLIC PROPERTY	CORNELIA AVENUE	248X630
32	6609	1		PUBLIC PROPERTY	CORNELIA AVENUE	270X980
33	5708	1		COMMERCIAL	W MILFORD LAKE	13.99
34	6002	15		FARM WITH HOUSE	73 MOORE RD.	32.22
35	5301	45		FARM	MORESTOWN RD	38.365

Figure III-8 – Open Space Plan Sites to Preserve

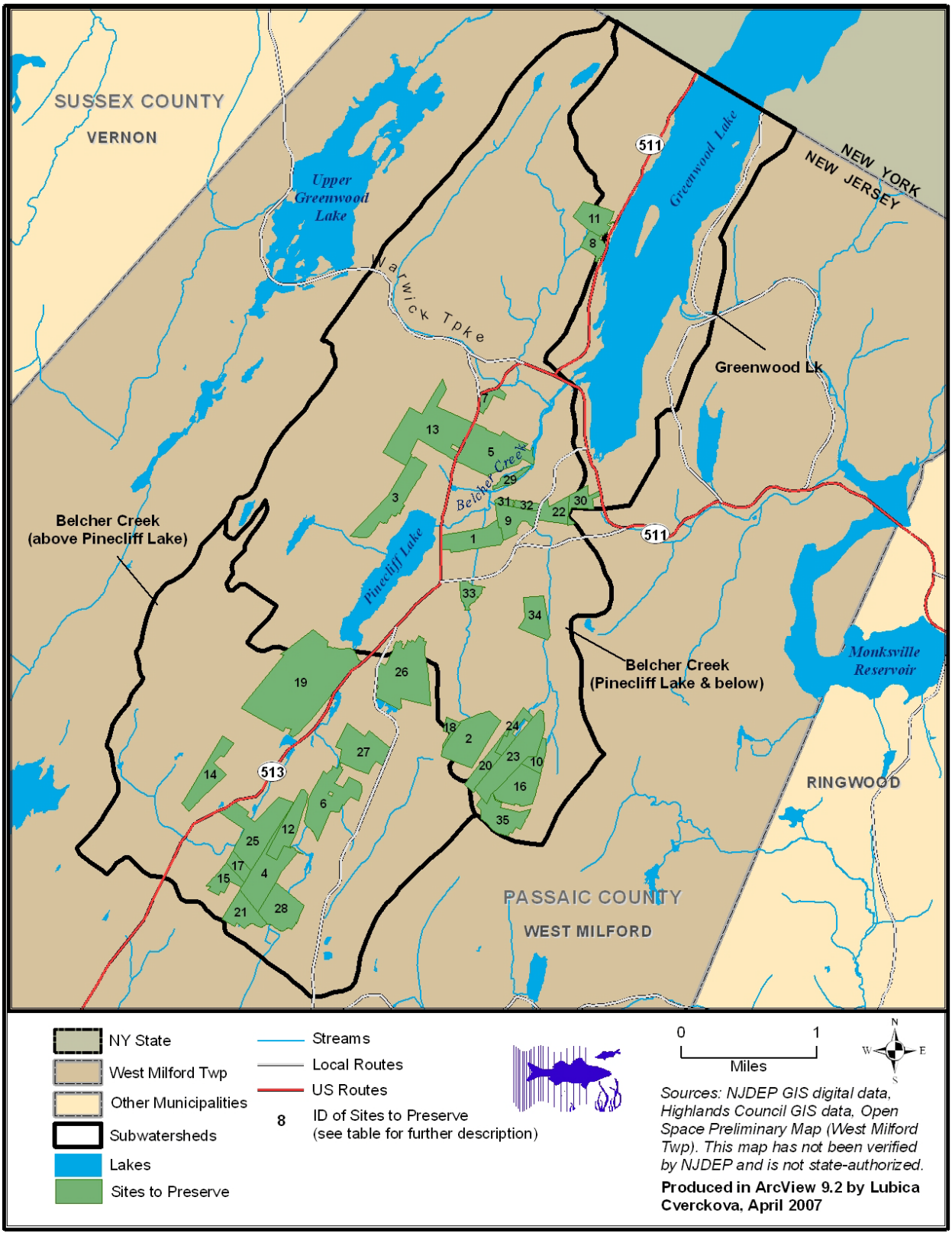
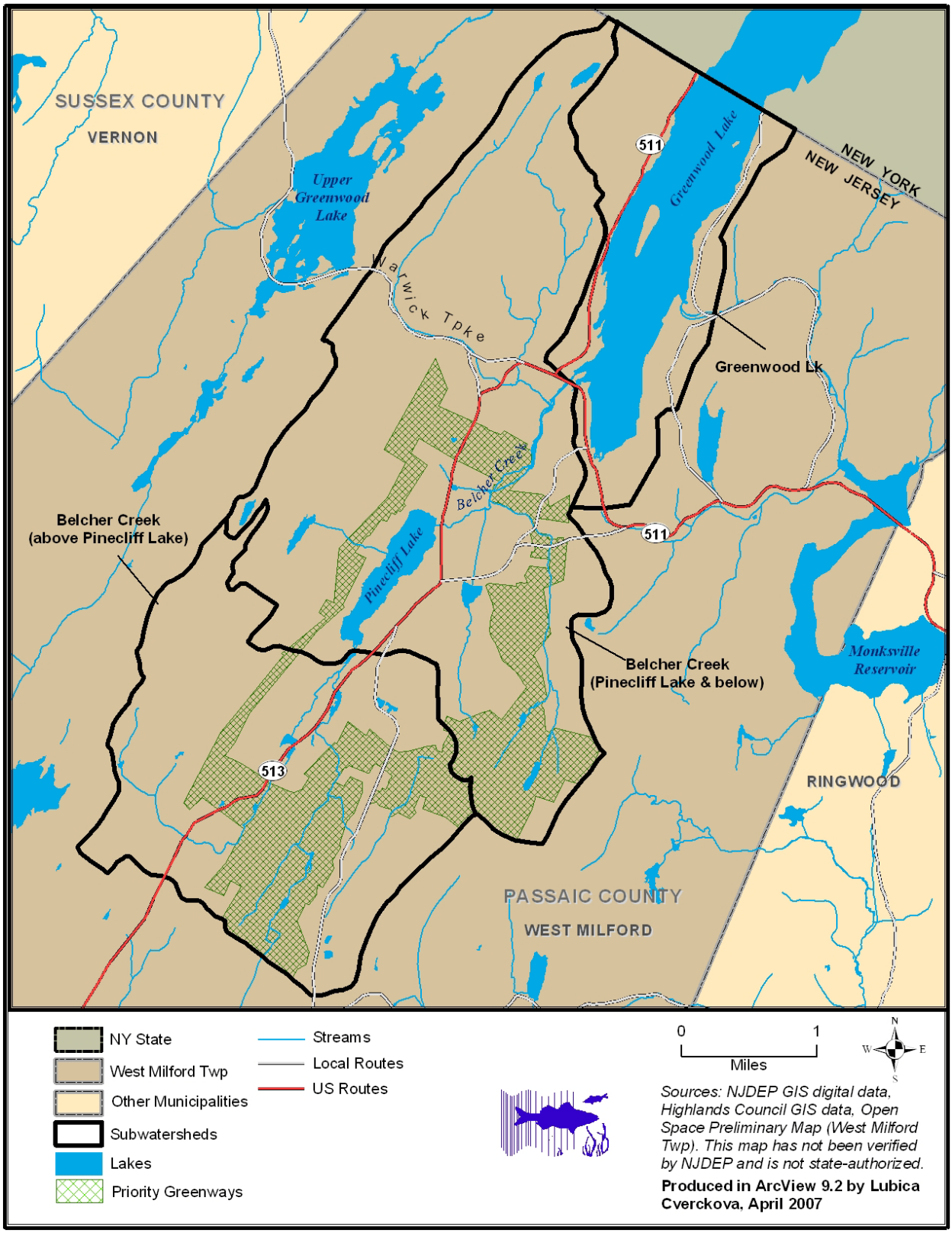


Figure III-9 – Priority Greenways Proposed for Open Space Acquisition



IV. PLANNING FOR ACTIONS TO RESTORE THE NATURAL RESOURCES OF THE GREENWOOD LAKE WATERSHED

A. POTENTIAL ACTIONS

The goal for this project is to implement action plans that improve the water resources and recreational uses of the Greenwood Lake Watershed and that maintain flows of clean water to downstream users. Suggestions for actions that might be undertaken to protect and restore water quality and quantity within the Greenwood Lake Watershed in New Jersey so that the habitats for flora and fauna, including people, are enhanced are described in this section. These suggestions are to be reviewed, evaluated, and prioritized by the Greenwood Lake Commission. Plans for actions to take that are given a high priority by the Commission are described more fully in Section VII.

Water is the lifeblood of all living organisms, especially including the people who live and work and find recreation in the Greenwood Lake Watershed. But "the work that healthy watersheds and freshwater ecosystems perform naturally to purify drinking water, mitigate flood damages, and meet other societal goals … are being lost at a rapid rate."[1] These "ecosystem services" are being lost because "commercial markets rarely put a price on these services, and because governments are failing to protect them."[2] However, the Greenwood Lake Commission is concerned.

A critical issue that the Commission needs to consider with respect to water resources is whether or not there will be sufficient water supplies for the millions of people using water from the watershed at affordable costs in the future. "Current research on the effects of urban and agricultural runoff in raw water sources on public health and recognition of the high costs and limitations of technological fixes has lead water supply and watershed managers to revisit two principles that were taken for granted a century ago: (1) the public's water supply should be reasonably clean to begin with; (2) forests and natural lands are critical to the quantity and quality of water supplies."[3]

Another critical issue is the restoration of the exceptional recreational opportunities and economic benefits that residents and tourists could enjoy, such as swimming, boating, hiking, and savoring the beautiful scenery. As actions are considered about how to restore recreation and to protect water supplies for people, it should be remembered that the ecosystem of the Greenwood Lake Watershed and all its component parts could be impacted by whatever is done. The overall goal of this planning process should be to make the whole ecosystem, including people, healthier.

Suggestions for actions that might be taken are grouped into the following categories:

- Improving natural resources and recreational opportunities of Greenwood Lake;
- Restoring the waters of the Greenwood Lake Watershed to more natural conditions by reducing nutrient loadings;

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[1] Postel, Sandra. 2005. Liquid Assets, The Critical Need to Safeguard Freshwater Ecosystems, State of the World Library 2005, Worldwatch Paper 170, July 2005, page 5.

[2] *Ibid*.

[3] Ernst, Caryn, Richard Gulick & Kirk Nixon. 2004. Protecting the Source: Conserving Forests to Protect Water. *Opflow*, American Water Works Association, vol. 30, no. 5, May 2004, page 4.

- Improving the availability of water supplies from the Greenwood Lake Watershed;
- Implementing the Highlands Regional Master Plan.

B. IMPROVING NATURAL RESOURCES AND RECREATION OF GREENWOOD LAKE

Reducing Eutrophication in Greenwood Lake

Greenwood Lake has experienced increases in nutrient loadings, especially of phosphorus, which has led to eutrophication of the lake. Eutrophication is defined as an abundant accumulation of nutrients that support a dense growth of algae and other plants and organisms, the decay of which depletes the shallow waters of oxygen in the summer.[4] The natural process of eutrophication will lead to an evolution of Greenwood Lake from a lake to a swamp. However, the excess nutrients that are being dumped into the lake and that are already in the lake are accelerating this process. Internal loading of nutrients in the lake is an increasing problem. Internal loading occurs when nutrients that have settled to the bottom of the lake are resuspended or used by algae or other organisms. Currently, about 42% of the Greenwood Lake's phosphorus is contributed from internal loadings (Table III-1).[5] Once phosphorus has entered the lake there is no way for it leave. The weed-harvesting program in combination with the lake drawdown is reducing the phosphorus load by removing plants before they decay and killing the ones that are already there. These programs should be maintained, as there are many invasive plants that bloom and decay. However, this does not address the phosphorus that is already in the lake. This issue can be resolved with dredging. Dredging simply involves removing the excess soil that is in the lake. This soil will be trucked off to areas that could utilize it. This option will remove much of the phosphorus from the lake thus reducing the eutrophication. Dredging, weed harvesting, and lake drawdown will reduce phosphorus loads significantly.

Lake Drawdown:

High priority should be given to cleaning up Greenwood Lake itself. The drawdown of the lake and the stump removal project in 2007 was helpful, but about a third of the stumps remain in the lake. These should be removed as soon as feasible, so that they don't impede boating and swimming on the lake. Furthermore, if this could be done in conjunction with dredging portions of the lake, many benefits would result.

Dredging of Greenwood Lake:

Dredging the lake, if done appropriately, could have the following benefits:

- Less algae and fewer weeds would grow in the lake because some of the nutrients in the bottom lake sediments would be removed. Almost half of the phosphorus loading in Greenwood Lake comes from these bottom sediments (Table III-1).
- The composition of the plants and fish that grow in the lake in the future should improve so that fewer invasive species are present.
- Boats would have more space to maneuver without getting grounded or caught up in weeds, roots or stumps.

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[4] Website: <www.dictionary.com>

[5] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004. Page 4.

- Opportunities for swimming should be improved.
- The sediments and organic matter dredged out of the lake could be used beneficially to restore the soil on degraded upland sites.
- The capacity of the lake to hold water would be increased so that more water could be diverted to the downstream reservoirs if needed.

The 1989 Greenwood Lake and Belcher Creek Clean Lake Study by the U.S. Army Corps of Engineers recommended a plan to dredge a 700-foot wide channel in the southern end of Greenwood Lake.[6] The recommended depth of dredging was 15 feet in order to reduce plant growth by limiting the amount of light reaching the lakebed. This project would remove over 2 million cubic yards of sediment from Greenwood Lake (Figure III-1). The Commission may see fit to reduce the size and scope of this recommended plan to reduce its cost and time frame. Other details that will affect the cost of the dredging project include the location of dewatering sites and the location for disposing (or reusing) the excavated sediment. The original suggestions for dewatering sites included Brown's Point and the Greenwood Lake Dam. These sites should be reevaluated for staging dewatering activities as their location impacts the cost of the project. The Commission should also consider dredging a channel into Belcher's Creek. The Clean Lake Study cautioned that dredging into Belcher's Creek could lead to bank instability, but this portion of the plan should be reconsidered. The dredging should be carefully planned in order to maximize the removal of nutrient laden sediments and to facilitate boating and swimming opportunities. A plan for dredging is presented in Section VI.

Weed Harvesting:

Mechanical weed harvesting and removing the weeds from the lake should be continued as needed. After dredging there should be less need for weed harvesting. The program to reduce invasive species by pulling the weeds out of the water should also be pursued.

Controlling Nuisance Macrophytes by Chemical or Biological Techniques:

Killing weeds by chemical herbicides, such as Sonar, may be used, but these methods do not remove the nutrients from the water or sediments, and the weeds grow again. Making phosphorus in the lake sediments less available for algal growth by inactivation with alum or lime might reduce the internal phosphorus load, but may have unknown consequences by changing the ecology of the lake. Oxygenating sediments in the lake will lead to decomposition of the dead plant material, but the vital nutrients for new plant growth, phosphorus and nitrogen, will still be in the lake. Introducing sterile grass carp fish into the lake to feed on undesirable nuisance aquatic plants, such as pondweed, duckweed, watermilfoil and bladderwort, has also been proposed.[7] Only sterile grass carp should be allowed. Overstocking can have negative impacts, both ecologically and aesthetically.[8] Therefore, only physical control techniques, lake drawdown, dredging, and weed harvesting, which remove weeds and sediments and the nutrients they carry from the lake, provide long term benefits.

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6 US Army Corps of Engineers, New York District. December 1989. Reconnaissance Report, Greenwood Lake and Belcher Creek, New Jersey & New York, Clean Lake Study.

7 Princeton Hydro, LLC, Fred S. Lubnow, Ph.D. 2006. The Control of Nuisance Macrophytes in Greenwood Lake, New Jersey – New York. PowerPoint presentation to West Milford Township Council, November 11, 2006.

8 Princeton Hydro, LLC, Fred S. Lubnow, Ph.D. 2006. The Control of Nuisance Macrophytes in Greenwood Lake, New Jersey – New York. PowerPoint presentation to West Milford Township Council, November 11, 2006.

Improving Lake Recreation

Reducing Lake Pollution from Boating:
Some of the pollutants entering the lake can come from boats. Oil or fuel may be spilled. Toilet, sink, or cooler water should not be discharged into the lake. Also, boats can come into the lake from other waters from which they have picked up dirt or undesirable biota, such as barnacles or zebra mussels. Further education and regulation is needed to reduce pollution from boating activities.

Improving Fishing:
Greenwood Lake is now considered "impaired" for fish consumption.[9] The lake is supposed to be able to maintain trout, but the excessive growth of algae and other nuisance macrophytes is not helping the trout and other native fish to thrive. The best way to improve fishing in Greenwood Lake is to reduce the rate of eutrophication by reducing nutrient loadings and improving base flows into the lake. Dredging the lake to remove the excessive nutrients, stumps, and other plant material already in the lake may impact fish habitat temporarily, but will improve the habitat for native fish, such as trout and bass, in the lake. It is not recommended that the lake be stocked with fish. Stocking the lake in the past with Muskellunge has led to a diminution of the native species of fish, because the Muskellunge eat them. They also usurp the breeding grounds for other fish. After the dredging project is completed, the native fish will find new habitats in which to breed.

Improving Boating and Sailing:
In the stump removal project of 2007 it was found that many boat propeller blades were broken and stuck in stumps.[10] Further removal of stumps and dredging out sediments at marinas and in boating channels will greatly improve boating and sailing on Greenwood Lake. Points of interest, including marinas, are shown in Figure IV-1.

Improving Swimming:
In considering plans for dredging, the addition of locations where swimming is facilitated might be considered.

Improving Access to Greenwood Lake:
The only public park along Greenwood Lake in New Jersey where visitors can park, and go to picnic and enjoy the scenery is at Brown's Point. More places are needed.

Community Education:
There is a continuing need to increase the awareness of lake front residents and watershed residents alike on how their activities can and do impact the lake.

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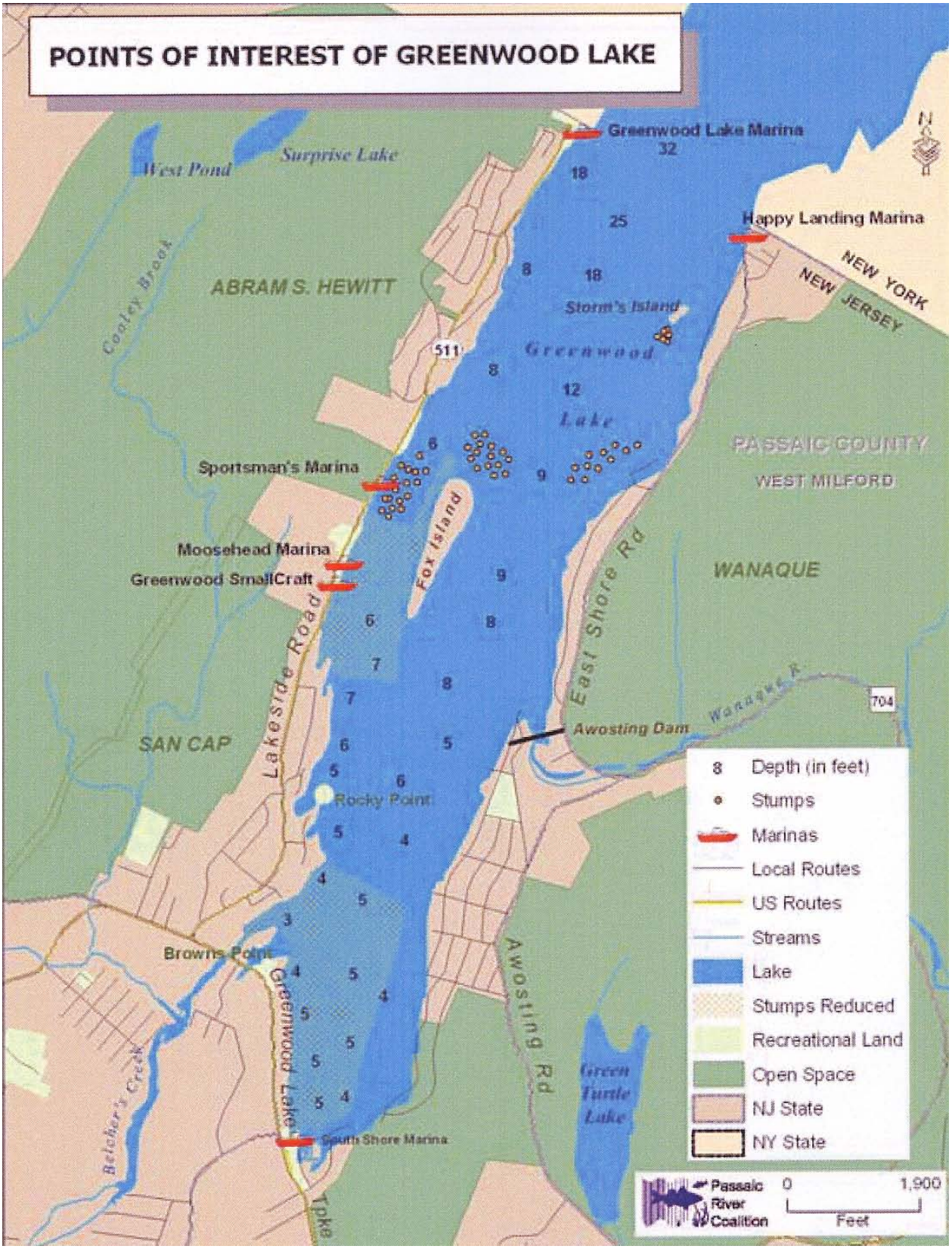
[9] NJ Department of Environmental Protection, Water Monitoring and Standards. 2006. New Jersey Integrated Water Quality Monitoring and Assessment Report, 2006. Appendix B (New Jersey's 303(b) List of Impaired Waters) & Appendix C.

[10] Greenwood Lake Commission. 2007. Stump Reduction Project, 2006-2007. Prepared for New Jersey Department of Environmental Protection.

Figure IV-1 – Points of Interest on Greenwood Lake



Improving Management of Lake Community Zones

A goal of the Highlands Regional Master Plan is "protection of Highlands Region lakes from the impacts of present and future development".[11] Lake Community Zones have been delineated around portions of Greenwood Lake, Pinecliff Lake, and West Milford Lake, as shown in Figure IV-2.[12] These are areas within 1,000 feet of the shoreline of the lakes where there is existing development. The Plan's description of Highlands lake communities is applicable to Greenwood Lake:[13]

> Overbuilt, damaged and poorly managed shore land areas can result in the degradation of water quality, harm to the lake ecosystem, the decrease of natural aesthetic values, and the overall loss of property values for lake communities. Lakes can be harmed by pollutant sources in the watershed area draining to them. Most existing lake communities were built out prior to modern environmental requirements. Some have sewer systems, but many rely on septic systems (or even cesspools) on inadequately sized lots. … Many lake communities have been experiencing intensifying land uses as the original buildings are torn down and replaced by larger structures. The Council seeks to identify redevelopment opportunities to improve community character and value, to protect both natural resources and to enhance and restore the quality of lake environments to the Region.

The Highlands Council will establish standards for all new development within these zones that should be met in the future. Some of these standards are listed in the Highlands Regional Master Plan.[14] To help prepare for compliance with these standards, and "to protect the unique character" (Goal 1M[15]) of the Greenwood Lake community, the following actions are suggested:

Conforming to the Highlands Regional Master Plan:
An overview of actions that might be taken to help implement the Highlands Regional Master Plan is presented in Section IV.E.

Planning for the Lakeside Community of the Future:
The Commission might consider how the Lake Community Zones should be developed in the future.

C. REDUCING NUTRIENT LOADINGS INTO GREENWOOD LAKE

Reducing Eutrophication of the Waters of the Greenwood Lake Watershed

The excess nutrients that are being dumped into Greenwood Lake are accelerating the eutrophication process. Even if Greenwood Lake is cleaned up with lake drawdowns, dredging, and weed harvesting, nuisance macrophytes will continue to grow excessively unless loadings of

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[11] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 4, Part 1, page 156.

[12] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008, and other documents. Website: <www.highlands.state.nj.us>

[13] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 1, page 236.

[14] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 1, pages 240-241.

[15] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 4, Part 1, page 158.

nutrients flowing into the lake from the watershed are reduced. The Greenwood Lake Watershed has many point and non-point sources of nutrients that support the dense growth of algae and invasive plants. These sources include landfills, malfunctioning septic systems, sewage treatment plants, underground fuel storage tanks, road salts, and runoff from the land.[16] It is recommended that steps be taken to reduce nutrient loadings from these sources and others.

Improving Understandings about Impacts of Nutrient Loadings on Eutrophication

The following potential contributing causes of excessive algal and plant growth were not adequately evaluated in previous studies:

- *Nitrogen Loadings:* No estimates had been made of nitrogen loadings, or of the impacts of these loadings on aquatic algal and plant growth. The 1983 study notes that in Greenwood Lake "during the summer months nitrogen, not phosphorus, is possibly the limiting nutrient."[17] Nitrogen is more likely to enter waterways from ground water or air-borne sources than phosphorus. These sources include septic systems which are leaching pollutants into ground water. Only the septic systems within 200 meters of the shoreline of Greenwood Lake have been surveyed to date. Sewage treatment plants are another source of nitrogen.
- *Nutrient Loadings from Groundwater and Base Flow Influx:* Not all nutrients and pollutants are washed into the lake or Belcher Creek in stormwater runoff. Some, such as soluble nitrogen compounds and dissolved organic matter, seep into Belcher Creek or Greenwood Lake in base flow.
- *Nutrient Loadings within the Belcher Creek Watershed:* The quality of the waters in the Belcher Creek Watershed required additional study. Purple loosestrife and parrot feather have invaded the shoreline of Pinecliff Lake. All the waters of the Greenwood Lake Watershed in New Jersey are either Category One (C1) or Nondegradation (FW1) waterways, which should be protected from degradation. Further information is needed to plan for the restoration or protection of these waters.

Therefore, an "Ecological Investigation of Belcher Creek in the Greenwood Lake Watershed" was carried out in 2009. The results of this study are reported in Section V. The information gathered in previous studies and this study will be analyzed and interpreted to assess the most environmentally and economically responsible means for ameliorating the excessive growth of algae and nuisance plants in Greenwood Lake and the Belcher Creek Watershed. By improving point source and nonpoint source management in the watershed, including flow patterns, the need for weed harvesting, dredging, and other temporary remedies should be reduced.

Reducing Nutrient Loadings from Surface Runoff

In order to reduce the total phosphorus levels in Greenwood Lake to less than 0.05 milligrams per liter (mg/L), the "Total Maximum Daily Load (TMDL) for Phosphorus to Address Greenwood Lake" estimates that 39% of the loadings of phosphorus come from surface runoff

[16] Greenwood Lake Commission & Passaic River Coalition. 2006. Greenwood Lake Commission Progress Report, 2000-2006. Page 4.

[17] Princeton Aqua Science. 1983. Phase 1: Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and New York. Prepared for Greenwood Lake Watershed Management District, Inc. & New Jersey Department of Environmental Protection. Page 179.

and that these loadings should be reduced by almost one-third (Table III-1).[18] Most of these phosphorus loadings come in stormwater runoff from land areas that are developed for residential and other uses. Thus, the management of stormwater is of critical importance. Actions that might be taken to improve stormwater management are suggested below.

Development and Implementation of Stormwater Management Rules:
In 2004 the New Jersey Department of Environmental Protection (NJDEP) promulgated major revisions to the Stormwater Management Rules. Some of these rules are implemented by NJDEP through the Land Use Regulation permit programs for Stream Encroachment and Freshwater Wetlands. They are also implemented by local authorities through the Municipal Land Use Law and the Residential Site Improvement Standards. Appropriate implementation of these rules by the Township of West Milford would be helpful. For further information on these stormwater management rules and how to reduce nonpoint source pollution consult the NJDEP website.[19] One of the requirements for a Stormwater Management Plan is the mapping of conveyances for discharges of water into surface waters. Discharges from these conveyances are regulated under New Jersey's new municipal stormwater regulation program, which is required as a result of US Environmental Protection Agency's Phase II stormwater rules.[20] Aspects of the Highlands Regional Master Plan prepared by the Highlands Water Protection and Planning Council should be considered in the development of stormwater management rules for West Milford.[21]

Installation of Stormwater Retrofits or BMPs:
Stormwater retrofits or BMPs (Best Management Practices) need to be installed at high priority sites, as described in the "Stormwater Implementation Plan" developed by Princeton Hydro, LLC.[22] High priority sites are described in Table III-2 and mapped in Figure III-4.

Maintenance of Structural Stormwater BMPs:
Structural BMPs in stormwater drainage systems, where sediment and plant material is partially removed from stormwater before being discharged into surface water, must have the solids removed occasionally. It is critical that the West Milford Township and Passaic County implement cleanup of these devices routinely.

Cleanup of Streamside Areas:
Passaic River Coalition staff with the aid of Steve DeFeo of the Greenwood Lake Commission surveyed some of the stream banks and lake shores in the Belcher Creek watershed. At too many locations, especially in the developed areas, they found garbage. An effort should be made to clean up areas where garbage and debris is likely to be washed into streams, lakes, or stormwater drains.

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[18] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004. Page 3.

[19] New Jersey Department of Environmental Protection. 2006. Stormwater and Nonpoint Source Pollution. Website: <www.state.nj.us/dep/stormwater> & <www.njstormwater.org>

[20] NJ Department of Environmental Protection, Division of Water Quality. 2004. Municipal Stormwater Regulation Program. Website: <http://www.state.nj.us/dep/dwq/municstw.html>

[21] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan, and other documents. Website: <www.highlands.state.nj.us>

[22] Princeton Hydro, LLC. 2006. Stormwater Implementation Plan for the New Jersey End of the Greenwood Lake Watershed, Township of West Milford, Passaic County, New Jersey. March 2006.

Education about Reducing Stormwater Pollution:

Educating people about techniques to help restore Greenwood Lake by reducing pollution should be a high priority. The Passaic River Coalition has prepared homeowner guides to help residents improve stormwater management at their homes, to "Contain Your Rain, Soak It, Don't Send It, For Tomorrow You Drink It."[23] The New Jersey Department of Environmental Protection suggests "Solutions to Stormwater Pollution, Easy Things You Can Do Every Day To Protect Our Water."[24] This sheet suggests ways to implement the following actions:

- Limit your use of fertilizers and pesticides;
- Properly use and dispose of hazardous products;
- Keep pollution out of storm drains;
- Clean up after your pet;
- Don't feed wildlife;
- Don't litter;
- Dispose of yard waste properly.

This advice is especially important for farmers. For instance the animal waste from the horse farm in the Belcher Creek watershed needs to be properly managed. Everybody in the Greenwood Lake Watershed can help to restore Greenwood Lake and the other natural resources of the watershed by remembering to "reduce, reuse, recycle."

Reducing Nutrient Loadings from Septic Systems

Septic systems, which are also known as onsite wastewater treatment systems (OWTS) or individual subsurface sewage disposal systems, are a highly significant source of excessive loadings of both phosphorus and nitrogen nutrients. The "Total Maximum Daily Load (TMDL) for Phosphorus to Address Greenwood Lake" estimates that 17% of the loadings of phosphorus come from septic systems within 200 meters of Greenwood Lake (Table III-1).[25] This does not include the phosphorus coming from septic systems in the Belcher Creek Watershed, especially those around Pinecliff Lake. Furthermore, the TMDL does not address nitrogen loadings. Much of the phosphorus in onsite wastewater is adsorbed on soils and removed before the ground water reaches a stream or lake. However, nitrogen compounds, such as nitrates and ammonia, are much more soluble and move further in ground water, and pose greater risks. In order to reduce loadings of both nitrogen and phosphorus the following actions are needed.

Maintenance of Septic Systems:

The Highlands Regional Master Plan articulates some of the requirements for wastewater system maintenance.[26] In 2008 the Municipal Council of the Township of West Milford made the following finding:[27]

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[23] Passaic River Coalition. 2004. Contain Your Rain, Soak It, Don't Send It, For Tomorrow You Drink It! Homeowners Guides.

[24] New Jersey Department of Environmental Protection, Division of Water Quality. 2004. Solutions to Stormwater Pollution, Easy Things You Can Do Every Day To Protect Our Water. Website: <www.njstormwater.org>

[25] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004.

[26] Highlands Water Protection and Planning Council. *Highlands Regional Master Plan, Final Draft, November 2007*. Chapter V, Part 2, pages 212 *et seq.*

[27] Township of West Milford. 2008. Ordinance No. 2008-050.

> Subsurface sewage disposal systems of existing systems have malfunctioned even when the systems have been designed, constructed, and sited in accordance with applicable standards, largely due to lack of proper system management or improper operation, poor soil conditions and maintenance. These malfunctions have been shown to adversely affect public health and welfare and the environment. Such systems constitute a potential source of pollution of ground and surface waters, contamination of potable water supplies, foul odors, nuisance problems and other hazards to public health.

Therefore, the Municipal Council adopted regulations to improve the management of septic systems in West Milford that became effective in December 2008. This ordinance (No. 2008-050) contains the following provisions:

- Any individual or company that owns property with a subsurface sewage disposal system (septic system) must obtain a license to operate the septic system within two years of the adoption of the ordinance. This licensing program is run by the West Milford Department of Health.
- To obtain an initial license, the owner of an existing septic system presents a plot plan showing the location of the septic system and all its components to the Department of Health. This plot plan should also show the location of any nearby wells or other septic systems if appropriate. The ordinance says that this license comes with a fee, but no applicable fee is described in the fee section of the ordinance, or anywhere else in the ordinance.
- The initial license (and all subsequent licenses) expires three years after its issuance. Before those three years are up the owner must have his/her septic system pumped out by a licensed sludge removal operator. The owner must show proof that the septic tank (and any other applicable tanks) has been pumped out. The pumped sludge must be disposed of at a Sewage Treatment Plant.
- The license can be suspended if the septic system is malfunctioning, if the owner does not properly operate or maintain the system, or if the owner denies the Department of Health a right of entry to inspect the property.
- The Department of Health has the authority to alter the time period of the license by making the period to pump the tank more frequent based on several factors: if the tank is of limited size; if the system is a cesspool; if the system is old; if the system has a history of malfunction; if the system is located in an environmentally sensitive area or near a well or water body.
- The ordinance contains standards for the use of septic systems and related components (such as, toxic substances should not be disposed of using a septic system). There are also requirements for sealing abandoned septic systems.
- Fines for violating the ordinance range from $100 - $1,000 per day or up to 90 days of community service.

Enforcement of these regulations will be helpful in reducing nutrient loadings from septic systems.

Implementation of Septic System Density Standards:

In December 2006 the Highlands Water Protection and Planning Act Rules (N.J.A.C. 7:38) were adopted to implement the enhanced environmental standards established in the Highlands Act.[28] Since wastewater sewerage is not allowed in Preservation Areas, which include all of the

[28] New Jersey Department of Environmental Protection. 2008. DEP Guidance for the Highlands Water Protection and Planning Act. Website: <http://www.state.nj.us/dep/highlands/>.

Greenwood Lake Watershed, septic systems would be needed to treat wastewater in new developments, and septic system density standards are needed in order to prevent the degradation of water quality. The NJDEP has developed such standards, and they are included in the regulations.[29] The bases for these standards are described below:[30]

> To comply with the direction of the Legislature, the Department (NJDEP) needed to determine the parameter(s) of concern, the existing quality of the groundwater with respect to the parameter(s) in the Highlands, the loading of the parameter(s) contributed by a typical septic system and the appropriate model to relate load to concentration in order to achieve no degradation of the water quality. In accordance with the HWPPA (Highlands Water Protection and Planning Act), the Department evaluated and selected a dilution model to relate load to concentration. Nitrate was selected as the indicator parameter because, of the constituents present in significant and predictable concentrations in septic system effluent, nitrate required the greatest dilution in order to attain ambient quality. To apply the model, values for the following model inputs were selected: an annual recharge rate representative of the Highlands region (9.8 inches per year); a number of persons per household unit representative of the region's population (4 persons per unit); the load of nitrate contributed per system (10 pounds per person per year); and target concentrations of nitrate. Two ambient nitrate concentration standards were selected, 0.21 mg/L for forest land use and 0.76 mg/L for mixed land use. Applying these model inputs, the Department calculated two regional standards to be applied across the Highlands Preservation Area based on the land use. For forest land use, 88 acres per septic system are required. For mixed land use, 25 acres per septic system are required.

If the land is currently forested, then 88 acres would be required to build one new residence. How this restriction will be applied in the redevelopment of the West Milford Master Plan and zoning ordinances will need to be explored by both the municipality and the Greenwood Lake Commission.

Upgrading of Septic Systems to Reduce Nutrient Loadings and Address Pollution Threats:
Residential areas outside of sewer service areas where existing septic system density significantly exceeds that calculated needed to maintain nitrate targets should be studied. Upgrading some of these systems to meet current NJDEP requirements, or installing alternative onsite treatment systems may be required.

Reducing Nutrient Loadings from Sewage Treatment Plants

In the 1980s about 5.5% of the phosphorus loadings were estimated to be coming into Greenwood Lake from five sewage treatment plant point source discharges into Belcher Creek, especially from the Birch Hill plant.[31] The current TMDL for phosphorus estimates that less than 2% of the phosphorus loadings come from sewage treatment plants, and does not require

[29] New Jersey Department of Environmental Protection, New Jersey Geological Survey. 2005. Basis & Background of the Septic Density Standard of the Highlands Water Protection and Planning Act Rule at N.J.A.C. 7:38-3.4. Website: <www.state.nj.us/dep/highlands/docs/septicdensity.pdf>

[30] *Ibid.* Pages 1-2.

[31] Princeton Aqua Science. 1983. Phase 1: Diagnostic-Feasibility Study of Greenwood Lake, New Jersey and New York. Page 177..

any reductions in these loadings (Table III-1).[32] No estimates of nitrogen loadings have been made. It is recommended that further study and evaluation be made of the quality of the water, especially with regards to phosphorus and nitrogen, being discharged by the six sewage treatment plants in the watershed (Table II.D-13).

D. IMPROVING WATER SUPPLIES

Reducing the Deficit in Ground Water Availability in the Greenwood Lake Watershed

Adequate, clean water supplies are critical for the well-being of the people who live, work or visit in the Greenwood Lake Watershed. These supplies rely exclusively from precipitation that falls on the watershed and recharges ground water. As noted by staff of the Highlands Council the Net Ground Water Availability is in serious deficit. Consumptive/depletive uses throughout the watershed are about 3.5 times the Ground Water Availability, and in the Belcher Creek above Pinecliff Lake subwatershed, they are over 5 times what should be used to sustain and restore the ecology of the watershed, and to supply clean water to users throughout the Passaic River Basin (Table II.D-4).[33] Therefore, it is critical that the recharge of water be improved in the watershed, that the water recharged be clean, and that consumptive/depletive ground water uses be limited so that ground water levels and base flows into Greenwood Lake and the Wanaque River are maintained or improved, even under drought conditions. Improving base flows would also help to reduce the rates of eutrophication in Greenwood Lake and the other waters of the watershed.

Protecting Lands with High Water Resource Values

Preserving land as dedicated "open space" can be a significant tool of watershed management in areas where water resources are becoming stressed from suburban development pressures. Is there any more critical need than clean and plentiful water supplies to sustain the economic vitality of the Greenwood Lake Watershed and all of northeastern New Jersey? In spite of recent snow and rain we should not forget that in recent years we have experienced lower than normal precipitation rates, serious aquifer drawdowns, and nearly dried up reservoirs. What are we doing to prevent serious economic consequences from water shortages in the future? We are ignoring the essential services that natural, ecological processes provide in sustaining these water supplies, because we think that they are free, come at no economic cost. Stakeholders, people interested in water resource management, in WMA#6 and WMA#3 got together to discuss and evaluate the impacts of land uses on water supplies in the Passaic River Basin. They recognized that clean and adequate water supplies are essential for public health, and that public health is intimately intertwined with ecologic and economic health. To protect economic health, watershed management should focus on protecting from deleterious development those land

[32] New Jersey Department of Environmental Protection, Division of Watershed Management. 2004. Amendment to the Northeast Water Quality Management Plan, Total Maximum Daily Load for Phosphorus to Address Greenwood Lake in the Northeast Region. Proposed: June 7, 2004; approved: Sept. 2004.

[33] New Jersey Highlands Water Protection and Planning Council. 2007. Draft Technical Report Addenda, November 2007. Highlands Region Water Availability by HUC14 Subwatershed, table following page 29. Greenwood Lake (NJ, above Awosting gage) subwatershed values are estimated from values cited for Wanaque River/Greenwood Lake (above Monksville gage) subwatershed.

areas that currently maximize ecologic services that provide cost-free or low cost benefits, or are capital assets. The "Water Resource Values" for land in the Greenwood Lake Watershed are depicted in Figure III-5 and described in Section III-C. The "high" values lands tend to be well vegetated with little imperviousness so that water can soak into the ground, replenish ground water, and provide base flow. Ways that might be used to protect the high water resource values of these lands are as follows.

Preserving Land as Dedicated "Open Space":
Limited funding for "open space" protection makes it important to identify and rank potential preservation targets by their value for maintaining water resources. The acquisition and preservation of additional sites with high water resource value as "open space" should be further studied and pursued.

Providing Economic Incentives for Land Owners to Protect Water Resource Values:
Many land owners would like to maintain or restore the natural resource values of their land, but lack the economic incentives to do so. The society that benefits from this "Green Infrastructure" should find the means to compensate land owners who protect the water resource values of their land. Perhaps their property taxes could be reduced, or subsidized through a trust fund for preservation of farmland and open space. Suggestions for funding sources have included bond issues, water user fees, and sales tax revenues.[34]

Increasing Ground Water in Storage

In order to replenish ground water supplies, storm water needs to soak into the ground instead of running off over the surface or through storm drains. Some of the ways to improve ground water recharge are discussed below.

Increasing Ground Water Recharge:
West Milford needs to adopt a storm water control ordinance which will implement best management practices required by the New Jersey Department of Environmental Protection (NJDEP). This ordinance must require that regulated "development" meet erosion control, ground water recharge, and runoff quantity standards. The design for a site and its stormwater management measures must either maintain 100% of the average annual pre-construction groundwater recharge volume for the site or assure that the increase of stormwater runoff volume from pre-construction to post-construction for the 2-year storm is infiltrated. The Highlands Council may require that 125% of the pre-construction ground water volume be recharged because of the deficit. Appropriate implementation of this standard for new development or redevelopment in West Milford is crucial for maintaining recharge to ground water.

Using Low Impact Development Techniques:
Recharge can be improved whenever changes to a site are made by using low impact development (LID) techniques.[35] Low impact development techniques help rain water to soak into the ground instead of running off rapidly, to mimic a site's natural hydrology. Paul

[34] Hester, Tom & Joe Tyrrell. 2008. Farmland protection funding is drying up. *The Star-Ledger*, July 31, 2008, page 17.

[35] Schiariti, Paul, P.E. (Mercer County Soil Conservation District). 2002. Integrating Low Impact Development Techniques into the Site Planning Process. PowerPoint presentation to NEIWPCC & NJ DEP Annual Nonpoint Source Technology Transfer Workshop, 18 December 2002, Trenton, NJ.

Schiariti, P.E., of the Mercer County Soil Conservation Service, suggests using the following low impact development techniques:[36]

- Minimize the amount of impervious surface;
- Disconnect impervious surfaces;
- Maintain natural vegetated buffer areas;
- Increase water flow "time of concentration" by flattening slopes, increasing surface roughness, and using vegetated swales;
- Concentrate development on soils with low permeability rates and minimize development on soils with high permeability rates; and
- Maintain natural drainage patterns.

By reducing impervious surfaces, runoff is reduced. Driveway and parking lot areas should be minimized as much as possible. Porous pavement materials should be considered. Disconnecting impervious surfaces can be done by redirecting runoff from impervious surfaces to vegetated areas. Roof leaders can be directed into dry wells. By maintaining or restoring "natural" buffer areas, such as meadows or woods, water can infiltrate into the ground instead of running off. If turf grass is replaced with meadow or woodland plants, then more water will soak into the ground, and fewer nutrients from fertilizers will pollute the water. If the velocity of water running off the land is slowed down, then the rushing water does less damage from erosion, and doesn't reach a stream so fast that flooding results. Runoff velocities can be reduced by flattening slopes, increasing surface roughness, and using vegetated swales instead of "hard" storm water drainage conveyance systems. By employing these low impact development techniques in future development and redevelopment, including improvements made by homeowners, the following benefits could be realized:

- Reduction in peak rates of runoff;
- Reduction in peak runoff volumes;
- Reduction in size of storm water management infrastructure needed, such as storm drains and detention basins;
- Reduction in erosion;
- Reduction in need for water quality treatment structures;
- Reduction in nonpoint source pollution;
- Increase in recharge to ground water!

There are so many benefits to be gained from using these low impact development and redevelopment techniques that educating people about these techniques for recharging ground water and restoring natural resources should be a high priority.

Recharging Clean Water:

In order to protect the quality of ground water withdrawn from Public Community and Public Noncommunity wells in the future, West Milford should enact a Well Head Protection Ordinance. Areas around all wells need to be protected so pollutants are not able to penetrate drinking water supplies, and water levels in these wells are maintained. Also contaminated sites should be cleaned up. A major source of contamination of ground water is malfunctioning or densely sited septic systems. Septic systems should not be placed in soils where the seasonally high water table is less than six feet from the surface. In order to attenuate the pollutants getting into ground water from septic systems, especially nitrogen compounds, the density of on-site sewage disposal systems needs to be low. A 2005 study suggests that in order to keep levels of

[36] *Ibid.*

nitrate below 1 milligram per liter (mg/L) in ground water, 25 acres per household septic system are required.[37] This is the maximum septic density proposed for the Highlands Preservation Area.

Reducing Ground Water Withdrawals

The "availability" of ground water in the Greenwood Lake Watershed in New Jersey is estimated at 0.13 million gallons per day (mgd) on average, or about 6,700 gallons per day per square mile.[38] This means that if more is pumped out of the ground and used for consumptive or depletive uses, then less ground water will be available in the future for replenishing the water in Greenwood Lake, and wells may go dry or require deepening. Everyone should be encouraged to conserve water, to use less water. Ways to reduce ground water usage are suggested below.

Encouraging Water Conservation:

The New Jersey Department of Environmental Protection (NJDEP) is developing a *Water Conservation Best Management Practices Manual*.[39] The goal of this manual is as follows:

> To serve as a tool for water utilities to implement demand-side management water conservation measures, in conjunction with traditional supply-side activities, which are consistent with the State's initiative to increase water use efficiency and avoid drought. The efficient use of water lowers demand while ensuring adequate ground and surface water supplies for future population growth without the construction of costly new source development and wastewater treatment facilities. Water conservation also enables more water to be in our streams, lakes and rivers while providing habitat for our wildlife and recreational opportunities for our citizens and visitors.

The NJDEP suggests that possible ordinances and legislative actions might be used to encourage water conservation. Such actions might include:[40]

- Mandatory audits and leak detection programs for water purveyors;
- Incentives for consumers to purchase water efficient plumbing fixtures and appliances;
- Water conserving landscape design requirements supported by incentives;
- Mandates that as a condition of sale that homes with automatic sprinklers be retrofitted with rain sensors and all plumbing fixtures and appliances be retrofitted with water conserving models;
- Water use efficiency regulations and water conservation implementation plans for water purveyors;
- A water use tax to support a Water Conservation Fund.

For instance, the manual discusses ways to help homeowners conserve water by using high efficiency clothes washers. It notes that "conventional top-loading clothes washers use 41 gallons of water per load while water efficient washers use 11 to 25 gallons of water per load."[41] Perhaps, the citizens of the Greenwood Lake Watershed should be educated about the benefits of

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[37] New Jersey Department of Environmental Protection, New Jersey Geological Survey. 2005. Basis & Background of the Septic Density Standard of the Highlands Water Protection and Planning Act Rule at N.J.A.C. 7:38-3.4. Page 1. Website: <www.state.nj.us/dep/highlands/docs/septicdensity.pdf>

[38] See Table II.C-4.

[39] New Jersey Department of Environmental Protection. 2006. Water Conservation Best Management Practices Manual, Draft Outline, January 1, 2006.

[40] *Ibid.*

[41] New Jersey Department of Environmental Protection. 2006. Water Conservation Best Management Practices Manual, High Efficiency Washing Machine Replacement Program, Draft, January 1, 2006.

using less water, and explore the possibilities for implementing some of these programs in order to sustain ground water supplies for the future.

Reducing Ground Water Allocations for Public Wells:
The NJDEP regulates ground water withdrawals from public wells. The public community wells in the Greenwood Lake Watershed in New Jersey are listed in Table II.D-3. Consideration might be given in the future to lowering their allocations in order to reduce the deficit in ground water availability (Table II.D-4).

Regulating Domestic Ground Water Withdrawals:
Ground water withdrawals from domestic wells are currently unregulated. Appropriate regulation of these wells might encourage less wastage of ground water resources.

Improving Base Flows

Steam flow data indicate losses in water that can be stored and used when needed by downstream users.[42] Very little of storm water runoff can be captured for use. Base flow, which is water that soaks into the ground and seeps slowly into streams after the storms have ceased, is a measure of the amount of precipitation that has recharged ground water, and not been consumed by ground water pumpage. Base flow should be over 80% of stream flow in the New York-New Jersey Highlands, but now it averages only 74%. **"**In some of the most urbanized areas within the Highlands with documented large ground water withdrawals, including Rockland County, New York, and eastern Morris County, New Jersey" base flow has been reduced to less than half of stream flow.[43] Base flows need to be improved by improving recharge, reducing consumptive/depletive usage of ground water, and by helping the areas where ground water discharges to surface waters, such as wetlands, flood plains, and riparian forest buffers, to function naturally.

Protecting Wetlands:
Wetlands are the areas on the landscape where land and water meet. They are valuable habitat for many wildlife and plant species. Wetland areas in the Greenwood Lake Watershed are shown on Figure II.C-2. The State of New Jersey prohibits development of wetlands under the Freshwater Wetlands Protection Act.[44] A potential developer must define the extent and character of the wetlands, and potential impact on the wetlands. This includes delineation of the wetlands based on soils, vegetation, and presence or absence of water. At a minimum a 150 foot transition or buffer area around a wetland that is naturally vegetated should be maintained or restored so that the natural functions of a wetland are protected. For more information on wetlands and how they are regulated see the NJDEP website on the Freshwater Wetlands Program.[45]

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[42] United States Department of Agriculture Forest Service, Phelps, Marcus G. & Hoppe, M., Compilers. 2002. New York-New Jersey Highlands Regional Study, 2002 Update. NA-TP-02-03. Page 41.

[43] United States Department of Agriculture Forest Service, Phelps, Marcus G. & Hoppe, M., Compilers. 2002. New York-New Jersey Highlands Regional Study, 2002 Update. NA-TP-02-03. Page 47.

[44] Freshwater Wetlands Protection Act, N.J.S.A. 13:9B-1 *et seq.* (P.L. 1987, c.156) and N.J.S.A. 58:10A-1 *et seq.* (N.J.A.C. 7:7A-1 *et seq.*).

[45] New Jersey Department of Environmental Protection. 2005. Land Use Regulation Program, Freshwater Wetlands Program. Website: <www.nj.gov/dep/landuse/fww>

Reducing Flooding:

Adjacent to the lakes, brooks, ponds, and rivers are flood plains. A flood plain is the relatively flat area adjoining the channel of the stream or river that is covered with water during periods of high flow. Flood plains were formed by the action of seasonal floodwaters over time. Flooding is exacerbated by increases in impervious cover and compacted soils, which change surface conditions and thereby increase the velocity and volume of surface runoff. Preserving flood plains in a natural state with trees and other vegetation is essential to reducing flooding problems. In New Jersey, the flood plain is regulated by the New Jersey Department of Environmental Protection (NJDEP) under the Flood Hazard Area Control Act of 1979.[46] Flood Hazard Areas can be expected to flood at least once in a hundred years. Flood Hazard Areas are divided into the stream channel, the floodway, and flood fringe areas. Floodways flood frequently, at least once in ten years on average. Flood Hazard Areas in the Greenwood Lake Watershed are shown on Figure II.C-3. Many developments in Flood Hazard Areas require Stream Encroachment Permits. These requirements are described by the NJDEP on the Internet.[47]

Restoring Streams and Riparian Areas:

"Streams transport floodwater, stormwater and suspended materials, support aquatic ecosystems, protect fish and wildlife habitat, and provide recreation opportunities and aesthetic beauty. Riparian areas moderate fluctuations in water temperature, help maintain ground water recharge and stream base flow, stabilize stream banks, and provide flood storage areas."[48] The Highlands Regional Master Plan provides a protection buffer of 300 feet from the edge of Highlands Open Water features.[49] These areas in the Greenwood Lake Watershed are depicted in Figure II.C-4.

Riparian areas should be managed to function naturally in order to reduce the impact of neighboring land uses and nonpoint source pollution. Native trees, shrubs, and other vegetation, growing on the land on either side of waterways provide a transition zone between aquatic and the terrestrial environments. Protection or restoration of the natural resources of riparian buffers is especially critical in the Greenwood Lake Watershed in order to protect water supplies and to reduce eutrophication, pollution and flooding.

Improving the Availability of Water from the Greenwood Lake Watershed

Water supplies for the Greenwood Lake Watershed are pumped from ground water. "Ground Water Capacity" is defined as "the natural ability of a subwatershed to support stream flow over time, during varied climatic conditions."[50] As noted in section II.D., the Ground Water Capacity for the Greenwood Lake Watershed in New Jersey to Awosting is estimated at 2.53 mgd (million gallons per day). If this amount of ground water were to be pumped out of the ground, and used consumptively or depletively, then the ground water levels in wells would go down, flows in

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[46] Flood Hazard Area Control Act, N.J.S.A. 58:16A-50 *et seq.* 1979. (N.J.A.C. 7:13 *et seq.*)

[47] N.J. Department of Environmental Protection, Land Use Regulation Program. 2005. Stream Encroachment Program. Website: <www.state.nj.us/dep/landuse/se>

[48] Highlands Water Protection and Planning Council. *Highlands Regional Master Plan, Final Draft, November 2007.* Chapter IV, Part 1, pages 172 *et seq.*

[49] Highlands Water Protection and Planning Council. *Highlands Regional Master Plan, Final Draft, November 2007.* Chapter VI, Part 2, page 332.

[50] New Jersey Highlands Water Protection and Planning Council. 2007. Water Resources Technical Report, Volume II-Water Use and Availability, January 2007. Page 34.

Belcher Creek would go down or dry up, especially in late summer, and water levels during dry periods would go down in Greenwood Lake and the Monksville Reservoir. The question then becomes "how much of that capacity can be provided to human use without harm to other ground water users, the aquatic ecosystems or downstream water users."[51]

Downstream users include millions of people in the Passaic River Basin, who have long-standing rights to this water. Consequently, the Highlands Council is recommending that only 5% of the Ground Water Capacity calculated using the Low Flow Margin of Safety method be considered available for human use within each subwatershed in a Protection Zone in the Highlands, which includes the Greenwood Lake Watershed.[52] Thus, the Ground Water Availability for use in the Greenwood Lake Watershed is estimated to be 0.126 mgd. Consumptive/depletive uses greatly exceed the Ground Water Availability in the Greenwood Lake Watershed, as reported in Table II.D-4. Consumptive/depletive uses throughout the watershed are about 3.5 times the Ground Water Availability, what should be used to sustain and restore the ecology of the watershed, and to supply clean water to users throughout the Passaic River Basin.

The Highlands Draft Regional Master Plan notes that over 80% of the usage of potable water from the Highlands occurs outside the Highlands.[53] It projects that sustainable capacity for bringing potable water from reservoirs in the Highlands of the Passaic River Basin to northeastern New Jersey will be exceeded in the not too distant future.[54] The Highlands Draft Regional Master Plan of 2006 makes the following statement:[55]

> In the face of the growing challenge of protecting New Jersey's finite drinking water supply and providing for the needs of a growing human population, the continued loss and fragmentation of the remaining lands that serve as the source of that water supply is no longer tenable.

Consequently, the first step must be to STOP the deficit from increasing. Because of the deficit and the Highlands Regional Master Plan's recognition of the serious consequences for the future of water supply in New Jersey, aggressive measures must be pursued to assure clean and plentiful water for the future. The choices made now will affect public health and the economy of New Jersey for years to come. Actions that might be taken to improve the availability of clean water to downstream users and ecosystems include those discussed below.

Evaluating the New Jersey Water Supply Plan:

The New Jersey Department of Environmental Protection (NJDEP) is developing the "2011 New Jersey Water Supply Plan" which should be available for public comment within 2011. The Commission might consider the implications in this plan regarding the availability of water from the Greenwood Lake Watershed.

Improving Low Flows of Water from Greenwood Lake to the Wanaque River:

It is legally required that at least 3 mgd (million gallons per day) be released at the weir below the Greenwood Lake dam when natural stream flow ebbs. This flow is essential to maintain

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[51] *Ibid.* Page 34.

[52] *Ibid.*

[53] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Page 20.

[54] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Page 20.

[55] Highlands Water Protection and Planning Council. *Highlands Draft Regional Master Plan, November 2006.* Page 1.

water supplies in the Wanaque Reservoir and other supplies regulated by the North Jersey District Water Supply Commission. It has been suggested that the required minimum flow be increased to 10 mgd to support downstream trout fisheries. Whatever can be done to improve the flow of water from the lake under low flow conditions would be beneficial.

Planning for Implementation of the Highlands Regional Master Plan:

The actions of Greenwood Lake users and West Milford residents directly impact both local and regional water supplies. West Milford's ground water, Greenwood Lake, and the downstream reservoirs are intrinsically linked, and the Highlands Regional Master Plan (RMP) provides guidance and planning policies that protect all of these resources. As the Township of West Milford and Passaic County carry out the RMP conformance process, the Greenwood Lake Commission should provide comments and suggestions for the revision of Township and County Plans. The Commission should work to ensure that the needs of Greenwood Lake described in this Restoration Plan be adequately addressed and incorporated into the documents made as part of the conformance process, as suggested in the next section.

E. IMPLEMENTING THE HIGHLANDS REGIONAL MASTER PLAN

Pursuing the Purposes of the Highlands Water Protection and Planning Act

In enacting the Highlands Water Protection and Planning Act in 2004 the New Jersey Legislature made the following declaration of findings:[56]

> The Legislature further finds and declares that the New Jersey Highlands is an essential source of drinking water, providing clean and plentiful drinking water for one-half of the State's population, including communities beyond the New Jersey Highlands, from only 13 percent of the State's land area.

The Greenwood Lake Watershed is an especially important source of drinking water for the millions of people living and working in northeastern New Jersey. The availability of supplies flowing out of Greenwood Lake into the Wanaque River and the reservoirs operated by the North Jersey District Water Supply Commission needs to be improved. The deficit in ground water availability needs to be reduced. The actions that are needed are the provision of assistance to the Township of West Milford and Passaic County to conform to the Highlands Regional Master Plan.

The Legislature also made the following findings:[57]

> … the New Jersey Highlands contains other exceptional natural resources such as clean air, contiguous forest lands, wetlands, pristine watersheds, and habitat for fauna and flora, includes many sites of historic significance, and provides abundant recreational opportunities for the citizens of the State. The Legislature further finds and declares that the New Jersey Highlands provides a desirable quality of life and place where people live and work; that it is important to ensure economic viability of communities throughout the New Jersey Highlands; and that residential, commercial, and industrial development, redevelopment, and economic growth in certain appropriate areas of the New Jersey

[56] Senate and General Assembly of the State of New Jersey. 2004. Highlands Water Protection and Planning Act, section 2.

[57] Senate and General Assembly of the State of New Jersey. 2004. Highlands Water Protection and Planning Act, section 2.

> Highlands are also in the best interests of all the citizens of the State, providing innumerable social, cultural, and economic benefits and opportunities.

It will be especially beneficial to the Greenwood Lake Watershed, both ecologically and economically, if the act is appropriately implemented. It will be ecologically beneficial because it will help to sustain and restore the natural resources that the watershed now enjoys. It will also be economically beneficial. The New Jersey Department of Environmental Protection has analyzed the economic benefits of the program being developed under the act, and reached the following conclusions:[58]

> The availability of permit waivers, statutory exemptions, funds for State and private acquisition of property, and municipal assistance from the Highlands Protection Fund and other sources will have a significant, positive economic impact upon taxpayers in the Highlands Region. The environmental resource protection standards established under the rules will prevent the destruction or deterioration of irreplaceable natural capital of enormous value that provides high-value services to the State on a long-term basis; will save billions of dollars in future avoided costs related to water treatment and other infrastructure improvement; will create significant numbers of jobs associated with the identification, protection and enjoyment of natural resources; will permit a reasonable level of development to proceed in the preservation area, including redevelopment of contaminated sites; and will likely yield a general increase in the value of property in the preservation area by preserving nearby high quality natural resources.

Therefore, it should be advantageous for the Greenwood Lake Commission to work in cooperation with the Township of West Milford, Passaic County, the Highlands Water Protection and Planning Council and other Highlands groups to develop an effective, cooperative program that will help to implement the intent of the Highlands Water Protection and Planning Act.

Conforming to the Highlands Regional Master Plan

In July 2008 the Highlands Council adopted the Highlands Regional Master Plan (RMP), which was approved by the Governor of New Jersey in September 2008.[59] The RMP makes the following statement:[60]

> Municipal and county conformance with the RMP (Plan Conformance) is the overall goal for implementation of the various elements of the RMP. The Highlands Act establishes the requirement that all municipalities and counties for land in the Preservation Area bring their local plans and development regulations into conformance with the "goals, requirements, and provisions of the regional master plan."

The Highlands Council laid out Plan Conformance Guidelines for municipalities in the Preservation Area including West Milford Township.[61] The documents required for a municipal Petition for Plan Conformance are listed below:[62]

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[58] New Jersey Department of Environmental Protection. 2005. Environmental Protection, Land Use Management, Land Use Regulation Program, Highlands Water Protection and Planning Act Rules, Proposed Readoption with Amendments: N.J.A.C. 7:38. Page 231.

[59] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan.

[60] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan, page 366.

[61] Highlands Water Protection and Planning Council. 2008. Plan Conformance Guidelines, pages 2-3.

[62] Highlands Water Protection and Planning Council. 2008. Plan Conformance Guidelines, pages 10-11.

1. Environmental Resource Inventory
2. Environmental/Infrastructure Capacity Analysis
3. Municipal Master Plan
4. Master Plan Reexamination Reports
5. Zoning/Land Use Ordinances & Development Regulations, including Water Use & Wastewater Treatment Regulations (including septic systems)
6. Management Plans
7. Resource Protections & Supporting Regulations/Plans
8. Zoning Map and Schedule of Requirements
9. Redevelopment and/or Rehabilitation Plans
10. Official Map

To be included in the petition is a "Self-Assessment Report which shall specify, if applicable, the status of each item and the level of preparedness toward achieving Plan Conformance." The documents required for county petitions are similar.[63]

The municipal Management Plans that are required are listed below:[64]

- Ground Water Recharge Protection and Mitigation Plan
- Water Use and Conservation Management Plan
- Well Head Protection Plan
- Septic System Management/Maintenance Plan
- Stormwater Management Plan

The appropriate development and implementation of each of these plans will be important for the restoration and protection of the water resources for more than half the people in New Jersey. Suggestions for the development of each of these plans are provided in previous sections.

Plans or regulations for Resource Protection are also required. The natural resources that are particularly important in the Greenwood Lake Watershed are the following:[65]

- Open Water and Riparian Areas
- Ground Water Recharge
- Well Head Protection
- Stormwater
- Steep Slopes
- Forest Areas
- Open Space Stewardship
- Critical Habitat
- Lake Management

Plans for protecting these resources have been discussed in previous sections.

Land Use Capability Zoning

The current zoning of the Greenwood Lake Watershed is shown in Figure I-4. The Highlands Council staff has developed a Land Use Capability Zone Map.[66] Their zone designations in the

[63] Highlands Water Protection and Planning Council. 2008. Plan Conformance Guidelines, pages 11-12.
[64] Highlands Water Protection and Planning Council. 2008. Plan Conformance Guidelines, page 11.
[65] *Ibid.* Page 11.
[66] Highlands Water Protection and Planning Council. 2007. Land Use Capability Zone Map.

Greenwood Lake Watershed are shown in Figure IV-2. These zones are labeled Overlay Zones, which means that they could be superimposed on the current land use zones. Most of the Greenwood Lake Watershed would be in a Protection Zone. Areas around Greenwood Lake, Belcher Creek, Pinecliff Lake and West Milford Lake would be Lake Community Zones. There are also areas of Existing Community and Existing Community Constrained Zones. Future land uses in each of these zones should be compatible with the Highlands RMP. Whatever is proposed should meet the approval of the Greenwood Lake Commission and the Highlands Council, as well as West Milford and the NJDEP.

Protection Zones:

"The Protection Zone include(s) lands within the Highlands Region which contain the highest quality resource value lands, which are essential to maintaining and enhancing water quality and quantity and preserving ecological function."[67] Some of the land in the Protection Zone in the Greenwood Lake Watershed is already protected as Open Space (Figure I-5). In the future the highest land acquisition priorities should be given to non-preserved, undeveloped lands within the Protection Zone.[68]

Existing Community Zones:

Existing Community Zones are areas with existing development "that often are currently or more easily served with public infrastructure."[69] These zones may be developed or redeveloped in the future provided that there is compliance with all standards and criteria, and that natural resources are not adversely affected.[70] Existing Community Constrained Sub-zones, the red areas in Figure IV-2, have existing development with natural resource constraints. Future development should be directed away from such areas to the maximum extent feasible.[71]

Lake Community Zones:

For the Shoreland Protection Tier, an area from the shore line of the lake to the first public road or 300 feet away from the lake, the following standards among others will apply:[72]

- Alteration of shorelines shall be limited to the minimum disturbance necessary to provide for water dependent recreational uses such as beaches, docks and boat houses.
- Existing shoreland vegetation shall be protected and preserved. Restoration of native vegetation shall be required where development is proposed on property with existing disturbed areas within 25 feet of the shoreline.
- Areas of disturbance by structures or other land "improvements" shall not be increased other than through Highlands Act exemptions or waivers.

These restrictions are especially critical in the Lake Community Zones in the Greenwood Lake Watershed.

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[67] Highlands Water Protection and Planning Council. 2008. *Highlands Regional Master Plan, 2008.* Page 187.

[68] Highlands Water Protection and Planning Council. 2008. *Highlands Regional Master Plan, 2008.* Page 188, Policy 6B3.

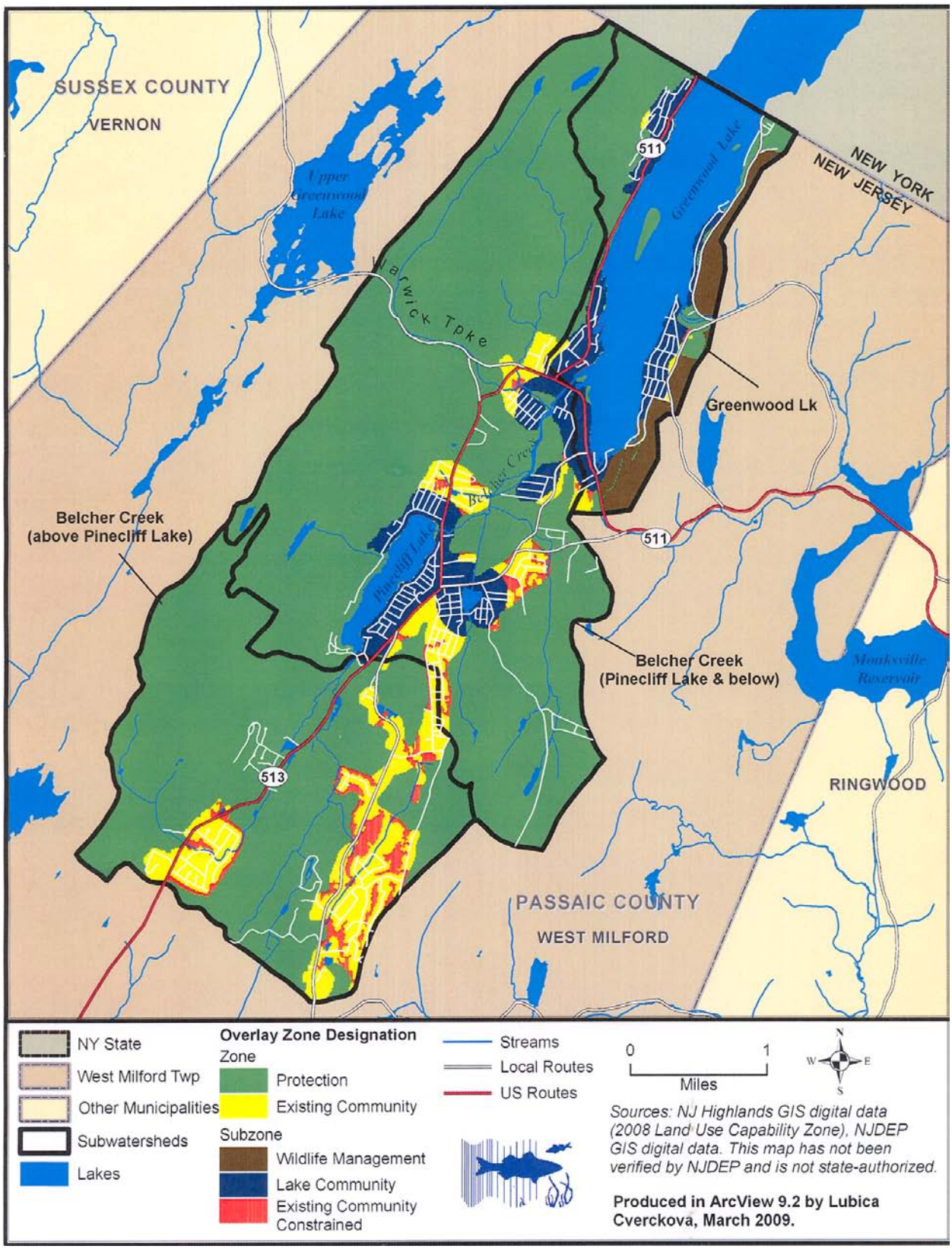
[69] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 4, page 188.

[70] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 4, Policy 6F3, page 190.

[71] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 4, Objective 6E2a, page 190.

[72] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 1, pages 240-241.

Figure IV-2 – Land Use Capability Zone Map of Greenwood Lake Watershed



Protecting the Resources of the West Milford Lake Area

West Milford Lake is in a "Lake Community Zone", as shown in Figure IV-2. The discussion below explores how conforming to the Highlands Regional Master Plan might help to protect the resources of the West Milford Lake area.

West Milford Lake, a 12 acre impoundment, was created by building an earthen dam on an unnamed stream that flows into Belcher Creek downstream from Pinecliff Lake. An aerial photograph of West Milford Lake is shown in Figure IV-3. The major road north of West Milford Lake is Marshall Hill Road. Figure IV-4 shows West Milford Lake and Pinecliff Lake in the Belcher Creek watershed. Much of the area is developed with residences, shopping centers and other facilities.

Figure IV-3 – Aerial Photograph of West Milford Lake

The New Jersey Department of Environmental Protection (NJDEP) Bureau of Dam Safety and Flood Control has deemed the West Milford Lake dam to be hazardous, and ordered that it either be removed or repaired. The current owner of the dam and lake, Marshall Hill LLC, has proposed partially draining the lake and replacing the water with wetland and riparian vegetation. Whatever is proposed should meet the approval of the Greenwood Lake Commission and the Highlands Council, as well as West Milford and the NJDEP. The Highlands Regional Master Plan (RMP) addresses the issues that are important for this project, and some of these are discussed below.

Figure IV-4 – Aerial Photograph of West Milford Lake, Pinecliff Lake, Belcher Creek and Tributaries

Reduction of Water Deficit:

The houses and other facilities around West Milford Lake rely on ground water for their water supplies. If the level of West Milford Lake were to be drawn down, then the water level in the wells around the lake would also go down, and there would be less water available. The base flow into Belcher Creek would also be decreased. Since this area already has a water supply deficit (Table II.D-4), reducing the deficit is a critical part of the Highlands RMP. Lowering the level of the lake would worsen the deficit. To protect the existing availability of ground water in the area the dam should be repaired so that West Milford Lake remains at its current elevation.

Water Quality Restoration:

The Highlands RMP has the following objective: "Prohibit land uses that would increase pollutant loadings to waters for which TMDLs have been adopted by NJDEP unless in compliance with the relevant TMDL."[73] There is concern that disturbance of the lake bottom might increase the loadings of phosphorus into Belcher Creek and Greenwood Lake, which would be in violation of the TMDL described in Section III.A.

[73] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 2, Objective 2G3a, page 256.

Management of Lake Community Zone:
The area around West Milford Lake has been designated a Lake Community Zone (Figure IV-2). For the Shoreland Protection Tier, an area from the shore line of the lake to the first public road or 300 feet away from the lake, the following standard, among others, will apply: "Alteration of shorelines shall be limited to the minimum disturbance necessary to provide for water dependent recreational uses such as beaches, docks and boat houses."[74] If the West Milford Lake dam were to be lowered or removed, as now proposed, then the shoreline would be altered. This would not be done to provide water dependent recreational uses. Thus, the community needs to decide whether a lake or wetlands are wanted in this area. Both of these land uses must be protected from disturbance of the natural resources of the area.

Application of Transfer of Development Rights:
The Highlands RMP proposes as Transfer of Development Rights (TDR) program. The current owner of West Milford Lake is seeking Highlands Development Credits (HDCs) in order to be compensated for the loss of rights to develop the land, and for remediation of the dam safety problem. However, should land under water be considered as developable land? Furthermore, the Highlands RMP program may provide HDCs for land in Protection Zones, but no mention is made of Lake Community Zones.[75] Since West Milford Lake is in a Lake Community Zone it is implied that the TDR program is not applicable.

Maintaining West Milford Lake Dam Safety:
Action should be taken to assure the safety of the West Milford Lake dam. However, the present proposal to partially drain the lake does not adequately protect the critical water resources of the Greenwood Lake Watershed. In our judgment the actions that should be taken are as follows:

- Assessment of the problems with the dam found by the NJDEP;
- Analysis of the means to correct these problems;
- Identification of funding sources to repair the dam;
- Repairing the dam.

Planning for the Future of the Area:
How people use the land and water resources in the Belcher Creek watershed, of which West Milford Lake is a part, will be extremely important to the fate of Greenwood Lake. The findings from the monitoring study, an Ecological Investigation of Belcher Creek in the Greenwood Lake Watershed, are reported in Section V. This study helps to inform people about current conditions in the watershed and what needs to be done in the future. Planning for the future of the area should have top priority for the Commission, so that the actions taken to restore dam safety do not cause more harm than good.

[74] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 1, pages 240-241.
[75] Highlands Water Protection and Planning Council. 2008. Highlands Regional Master Plan 2008. Chapter 5, Part 7, pages 349-351.