# Greenwood Lake Watershed Phosphorus TMDL Implementation Plan

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New York State Department of
Environmental Conservation

Division of Water

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# Executive Summary

In September 2005, EPA approved the *Impaired Waters Restoration Plan for Greenwood Lake – Total Maximum Daily Load for Total Phosphorus* which set maximum allowable phosphorus loading from the Greenwood Lake watershed. As Greenwood Lake and its watershed are both located in New Jersey as well as New York, this TMDL Implementation Plan (Plan) includes strategies to reduce phosphorus discharges specifically in New York's Greenwood Lake watershed, both through SPDES permit requirements and through recommended voluntary actions on the part of Greenwood Lake watershed stakeholders.

New York stakeholders include the Town of Warwick, Village of Greenwood Lake, New York State Department of Transportation (NYSDOT) and Orange County, all MS4 (Municipal Separate Storm Sewer Systems) General Permitees that are responsible for enforcing the terms of the SPDES General Permit and for achieving phosphorus reductions in stormwater runoff from their respective MS4s.

Other New York stakeholders include the lake community residents in the Town of Warwick and Village of Greenwood Lake. The success of this, and any, lake restoration effort relies primarily on the initiative of residents to make the changes needed, and to seek out technical assistance and funding where necessary.

This Plan emphasizes citizen involvement in setting short- and long-term goals, tracking progress, and adapting to future research and monitoring. As the controllable causes of phosphorus pollution (stormwater discharges and deficient near-shore septic systems) are often the same from lake to lake, so too are the solutions. They range from conservation practices to reduce soil erosion on developing/developed areas to achieving a mandate from the lake community to provide sewers for the individual homes near the lake.

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# 1.0 Introduction

Greenwood Lake is polluted by excessive fertilizing nutrients which are causing the growth of algae, phytoplankton and nuisance aquatic weeds in the lake. Large rafts of algae and weeds can be observed in the summer, including blue green algae, which can cause nausea, gastrointestinal distress, allergic reactions and breathing difficulties. Swimming, boating and recreating in and near the water are all impaired by the appearance and smell of algae and the excessive weed growth in the water and on the water surface. The primary pollutant causing this impairment is total phosphorus.

Greenwood Lake was added to New York State's impaired waterbody list (303d list) in 2004 as having its designated uses (public bathing/recreation) impaired, and in September 2005, EPA approved New York State's *Impaired Waters Restoration Plan For Greenwood Lake – Total Maximum Daily Load for Total Phosphorus* [approved TMDL]. The approved TMDL identified stormwater runoff, deficient septic systems, wastewater treatment facilities (in New Jersey) and internal loading as the primary sources of phosphorus to the lake. This document describes a strategy to reduce phosphorus pollution from the New York sources of phosphorus as required in the approved TMDL.

This Plan addresses requirements to meet the stormwater pollution limit in the approved TMDL, through enforcement of the requirements of the MS4 General Permit. New York State has required that the Village of Greenwood Lake, the Town of Warwick, Orange County and NYS Department of Transportation obtain Phase II MS4 General Permit coverage for the stormwater discharges from their storm sewer systems. The MS4 General Permit requires MS4 Operators to develop, implement and enforce a stormwater management program "to reduce the discharge of pollutants from their MS4s to the maximum extent practicable to protect water quality in accordance with the NYS Environmental Conservation Law and the Clean Water Act."

To facilitate water quality improvement in the Greenwood Lake watershed, the MS4 General Permit articulates enhanced criteria (in Part IX.B of the MS4 General Permit) entitled *"Watershed Improvement Strategy Requirements",* which describe additional phosphorus control measures required to meet water quality standards, including targeted education, enhanced stormwater system mapping to better understand potential phosphorus source locations, construction of stormwater retrofits and inspection and maintenance of residential septic systems.

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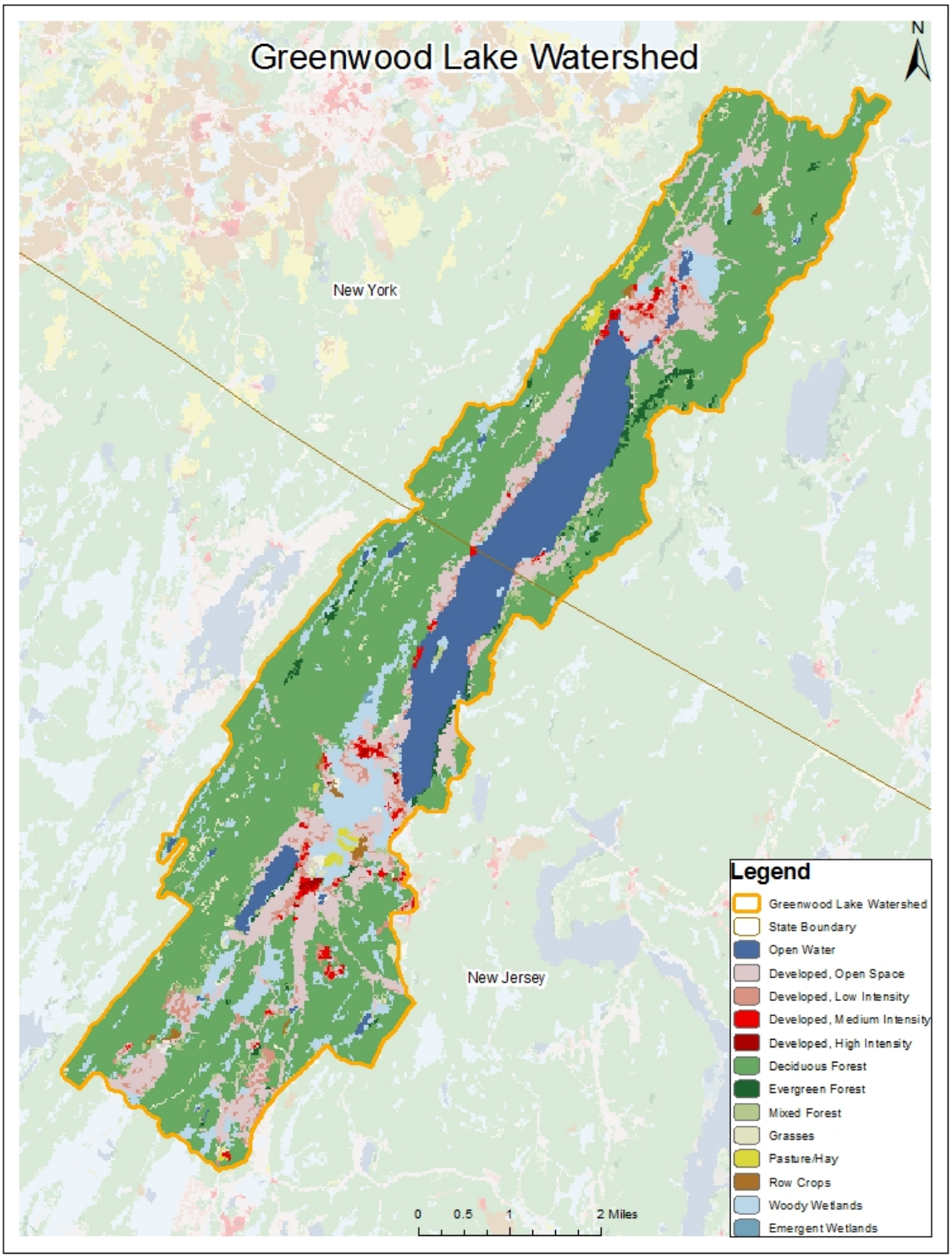
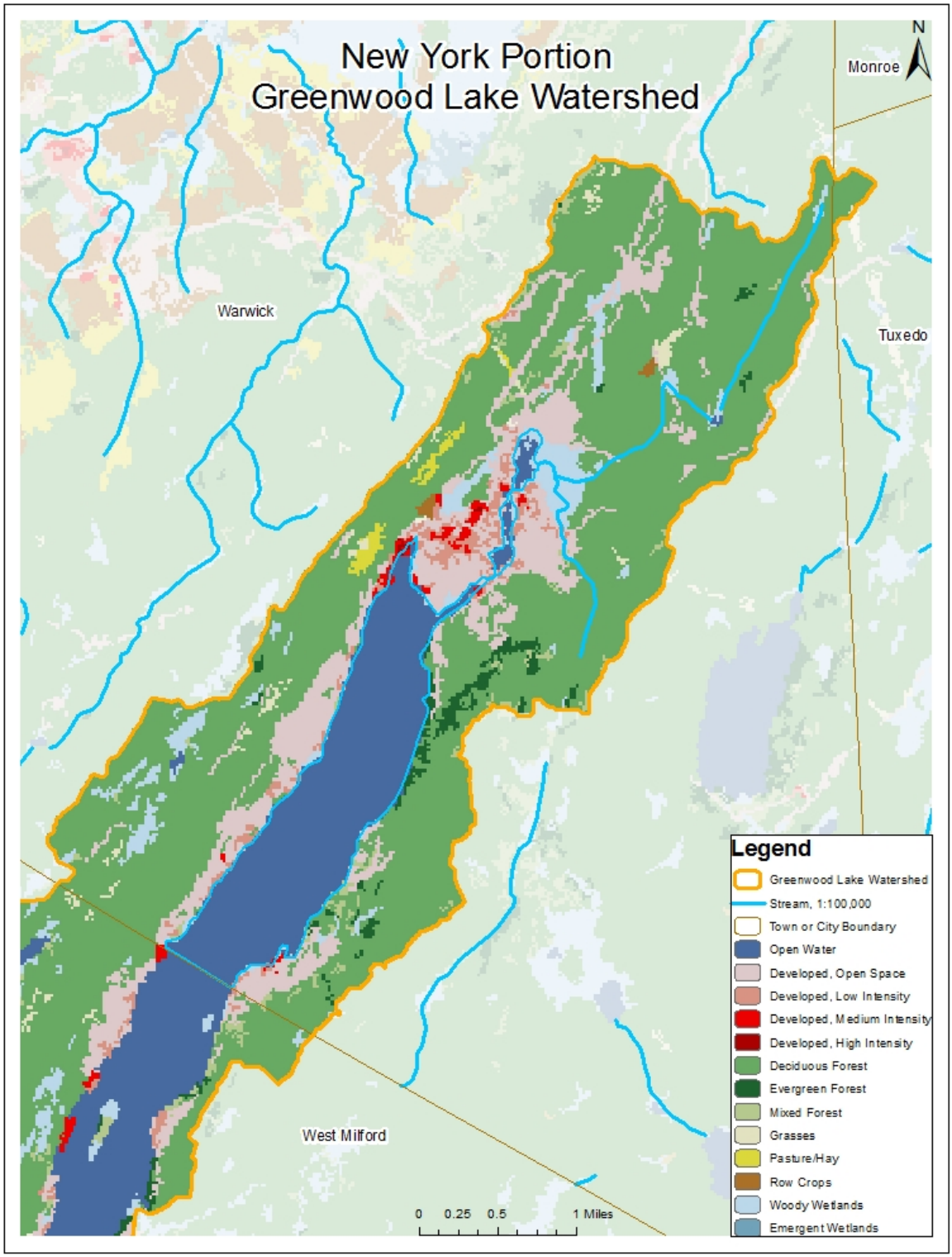

Greenwood Lake Watershed
N
New York
New Jersey
Legend
Greenwood Lake Watershed
State Boundary
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Deciduous Forest
Evergreen Forest
Mixed Forest
Grasses
Pasture/Hay
Row Crops
Woody Wetlands
Emergent Wetlands
0
0.5
1
2 Miles


New York Portion
Greenwood Lake Watershed
N
Monroe
Warwick
Tuxedo
West Milford
0 0.25 0.5 1 Miles
Legend
Greenwood Lake Watershed
Stream, 1:100,000
Town or City Boundary
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Deciduous Forest
Evergreen Forest
Mixed Forest
Grasses
Pasture/Hay
Row Crops
Woody Wetlands
Emergent Wetlands

## 2.0 Regulated Phosphorus Reductions

Greenwood Lake encompasses 1,884 acres and is located in both New Jersey and New York; the border of the two states bisects the lake roughly in half. Greenwood Lake extends northward to Warwick, New York and southward to West Milford, New Jersey. The watershed is primarily (80%) forested, with developed areas (18%) primarily along the lake, particularly at the north end of the lake in the Village of Greenwood Lake. The remainder (2%) of the New York Greenwood Lake watershed is agricultural land.

The approved TMDL estimated the pollutant load from the entire Greenwood Lake watershed. This Plan presents the estimated New York pollutant load. The analysis utilized GIS satellite imagery (National Land Cover Database 2008) land use data to estimate stormwater runoff phosphorus load, and the total dwellings within 200 meters of Greenwood Lake in the NYGL to estimate the septic system phosphorus load.

The NYGL watershed TP load presented in *Table 1* was estimated by multiplying the percentage of each given land use by the approved TMDL loading for that land use.

**Table 1- Stormwater Runoff Phosphorus Loading for New York Greenwood Lake watershed**

| Land Use Description | Entire Greenwood Lake Watershed | % of land use in NYGL watershed (see | NYGL Watershed TP Load (kg/yr) | NY required reductions (43%[2] of P load) |
|---|---|---|---|---|
| Low Intensity Residential | 415.9 | 38.6% | 160 | 69 |
| High Intensity Residential | 293.6 | 9.5% | 28 | 12 |
| Commercial/Industrial/Transport | 307.7 | 31.0% | 95 | 41 |
| Pasture/Hay | 55.7 | 48.7% | 17 | 7 |
| Row Crops | 27.2 | 14.3% | 6 | 3 |
| Grasses | 26.3 | 38.8% | 13 | 6 |
| Deciduous Forest | 180.3 | 38.2% | 68.9 | 0 |
| Evergreen Forest | 47.9 | 52.6% | 25.2 | 0 |
| Mixed Forest | 202.4 | 30.1% | 61.0 | 0 |
| Woody Wetlands | 13.0 | 23.1% | 3.0 | 0 |
| Emergent Wetlands | 1.1 | 36.4% | 0.4 | 0 |
| Open Water | 6.9 | 52.2% | 3.6 | 0 |
| Air Deposition | 53.4 | 38.0% | 20.3 | 0 |
| Total | 1631.6 | 28.8% | 468.8 | 136 |

[1] *Impaired Waters Restoration Plan For Greenwood Lake – Total Maximum Daily Load for Total Phosphorus, 2005 Table 3 (Entire Greenwood Lake Watershed)*
*2 Impaired Waters Restoration Plan for Greenwood Lake – TMDL for Total Phosphorus, 2005 Table 6*

The approved TMDL estimated the stormwater runoff phosphorus loading from developed land (i.e. Low and Medium Intensity Residential and Commercial, Industrial and Transportation Land Uses) to be 1,017.2 kg/yr. The New York portion of the total phosphorus load was determined to be 283 kg/year. The approved TMDL requires a 43% reduction in stormwater runoff phosphorus loading from developed land. To meet the approved TMDL requirement, the phosphorus load must be reduced by 43%, or 122 kg/year.

## MS4 General Permit Requirements

The MS4 General Permit requires development of a Stormwater Management Program that includes six required program components, or six minimum control measures (MCMs):

- MCM 1 – Public Education & Outreach Program to increase public awareness on pollutant generating activities and behaviors specific to the MS4, to change behavior and increase public participation in local programs so that pollutants in storm water are reduced

- MCM 2 – Public Participation Program to involve the public in activities and decisions that relate to stormwater pollution

- MCM 3 –Illicit Discharge Detection and Elimination program to manage the MS4 so that it is not used to convey pollutants associated with flows not directly attributable to precipitation runoff.

- MCM 4 – Construction Site Runoff Control Program to ensure appropriate control measures are selected and implemented by the owner or operator of a construction site to ensure pollutants from construction sites do not enter the MS4.

- MCM 5 – Post Construction Stormwater Management Program to ensure that post construction stormwater management practices are selected, designed, installed and maintained for long term performance in removing pollutants from stormwater runoff associated with new development and redevelopment.

- MCM 6 – Pollution Prevention and Good Housekeeping Program to identify and implement appropriate practices so that municipal facilities and infrastructure/operations are minimized to the MEP.

In addition to the six minimum control measures, the MS4 General Permit includes enhanced phosphorus reduction requirements (in Part IX.B) for Greenwood Lake:

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- Education and outreach to the Greenwood Lake watershed community that targets phosphorus, its sources and actions that watershed residents can take to reduce the phosphorus load to the lake.

- MS4 system mapping within the Greenwood Lake watershed, to facilitate a clearer understanding of the MS4, and to serve as a planning tool for prioritization of efforts and to facilitate stormwater management decisions.

- Enhanced Inspection of all construction sites, other potential phosphorus hotspots and all stormwater outfalls discharging to Greenwood Lake, such as:

    - Food waste storage areas such as dumpsters serving restaurants and grocery stores
    - Yard waste composting and disposal areas
    - Areas of concentrated fertilizer use or storage
        - Wholesale and retail plant nurseries (check that management of irrigation water)
        - Fertilizer storage areas (golf courses, retail lawn and garden supply stores, commercial lawn care/landscapers)
        - Residential lawn care practices (encourage awareness of and compliance with the NYS Fertilizer Law)
    - Poorly maintained stormwater infrastructure (catch basins, post construction stormwater management practices, outfall stabilization)
    - Areas of high erosion potential (e.g. construction sites)
    - Failed, poorly sited and/or poorly operating septic systems
    - Improper disposal of pet waste

- Pump-out and inspection of residential septic systems on a minimum five-year cycle, to ensure proper functioning of systems.

- All new development and redevelopment projects within the Greenwood Lake watershed must use the Enhanced Phosphorus Removal Design Standards in Chapter 10 of the NYS Stormwater Management Design Manual (January 2015)

- Development of a retrofit program to reduce phosphorus loading from the MS4 system as described in this plan, including schedule for construction of retrofits.

These requirements are all important components of phosphorus reduction efforts for Greenwood Lake. They are particularly important in areas with high percentages of impervious land cover, small lot sizes, and compacted soils in close proximity to storm sewer systems and Greenwood Lake. The Department estimates a 10% (12 kg/yr) phosphorus reduction due to compliance with the six minimum control measures and, at a minimum, an additional 10% (12 kg/yr) due to compliance with the enhanced phosphorus reduction requirements of the MS4 General Permit.

Greenwood Lake Watershed-wide stormwater phosphorus load reductions are anticipated due to voluntary compliance with the New York State *Dishwasher Detergent and Nutrient Runoff Law*, which was signed into law on July 15, 2010. This law restricts the sale and application of fertilizers containing phosphorus for lawns and has eliminated the sale of phosphorus dishwashing detergents in New York.

The Department estimates a minimum 15% (18 kg/yr) phosphorus reduction in stormwater runoff due to compliance with the Nutrient Runoff Law. This estimate is based on the results of a Minnesota study of the effects of a similar law on stormwater concentrations, where it was reported that a 15-30% reduction in phosphorus loading was attributed to the change to usage of phosphorus-free fertilizer). https://www.pca.state.mn.us/sites/default/files/stormwaterresearch-fertilizer.pdf.

Fertilizer consumers should be also provided with tailored outreach materials such as those available at the DEC website on the Dishwasher Detergent and Nutrient Runoff Law webpage: http://www.dec.ny.gov/chemical/67239.html.

## MS4 Retrofit Requirements

The Department estimates 80 kg/yr (approximately 65% of the required reduction to the stormwater phosphorus load) could also be reduced through stormwater retrofitting, and has set that target phosphorus reduction to be accomplished over a 10-year time frame, so that 8 kg/yr is the Greenwood Lake Watershed MS4 target for phosphorus reduction through stormwater retrofits. This phosphorus reduction stormwater retrofit requirement is apportioned among the four MS4s in the Greenwood Lake watershed. The Department calculated the number of roadway miles maintained by each MS4 Operator within the Greenwood Lake watershed to determine their relative contribution and to apportion the retrofit reduction requirement.

| **Table 2 – MS4 Stormwater Runoff Phosphorus Reduction Requirement** | | | | |
|---|---|---|---|---|
| See appendix E for roadway calculations | | | | |
| Greenwood Lake MS4 Phosphorus Load Reduction Requirement | V/Greenwood Lake | T/Warwick | Orange County | NYSDOT |
| | 31%[3] | 50% | 4% | 15% |
| 8 kg/yr – annual (estimate) | 2.5 kg/yr | 4 kg/yr | 0.3 kg/yr | 1.2 kg/yr |
| 80 kg/yr-10 year requirement | 24.8 kg/yr | 40 kg/yr | 3.2 kg/yr | 12 kg/yr |

### Department-Approved Retrofit Design Criteria

The Department will credit retrofit implementation according to the criteria below. An example calculation of phosphorus loading and resultant phosphorus reduction credit is included. Also described is the water quality storm calculation that is used to size the retrofit correctly:

For the purposes of calculating phosphorus loading of runoff that drains and will be treated by a retrofit, land uses are assigned the following phosphorus concentrations:

| | |
|---|---|
| Impervious: | 0.50 mg/l |
| Residential: | 0.41 mg/l |
| Actively Grazed Pasture: | 0.40 mg/l |
| Commercial: | 0.34 mg/l |
| Developed Open Space: | 0.30 mg/l |
| Forest: | 0.15 mg/l |

These land use-specific concentrations are drawn from NYSDEC Chapter 10 Stormwater Design Manual, Table 10.1 and from recent monitoring studies. Please note that the Department has revised the *Developed Open Space* concentration downward, from the value in the Stormwater Design Manual, to reflect anticipated reduction in phosphorus loading due to compliance with the New York State Nutrient Runoff (phosphorus fertilizer) Law. This revised value is exclusively for the purpose of creating a metric to judge phosphorus reduction credits for the Greenwood Lake MS4s and does not represent a precedent.

The following Retrofit BMP efficiencies are adapted from the *Total Phosphorus Accounting Strategy for the Croton-Kensico Retrofit Program*, *December 2009(Accounting Strategy),* approved by the Department in June 2010. The values in the *Accounting Strategy* were derived from Winer, 2000, pp. 14-15:

| Retrofit BMP Efficiencies | % |
|---|---|
| Wet Ponds | 50 |
| Wet ED Pond | 55 |
| Multiple Pond System | 75 |
| Pocket Pond | 65 |
| Micropool ED Pond | 40 |
| Shallow Wetland | 40 |
| ED Shallow Wetland | 40 |
| Pond/Wetland System | 55 |
| Pocket Wetland | 55 |
| Infiltration Trench | 65 |
| Infiltration Basin | 50 |
| Surface Sand Filter | 60 |
| Underground Sand Filter | 60 |
| Perimeter Sand Filter | 40 |
| Organic Filter | 60 |
| Bioretention | 65 |
| Dry Swale | 50 |
| Wet Swale | 30 |

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Example: Runoff from one-acre parking lot treated by an infiltration basin:

L = 0.226(P)(Pj)(Rv)(C)(A)
Where:
L = Annual load (lbs)
P = annual rainfall (45 inches for Greenwood Lake)
Pj = fraction of P that becomes runoff (usually 0.9)
Rv = runoff coefficient = 0.05 + 0.9I
I = impervious fraction expressed in percent
C = pollutant concentration (mg/l)
A = area (ac)

BMPs receive full credit when sized to treat runoff from a 90% storm, 1.4" for Greenwood Lake:
Water Quality Volume = 90% Storm * Sub-drainage area
WQV= (1.4"/12")(1 ac)(43,560 SF/ac)
WQV= 5,082 cubic feet
Then L = 0.226(45")(0.9)(0.95)(0.5 mg/l)(1ac)
so L = 4.3477 lb/yr
The BMP is rated at 50%, so the phosphorus reduction is 2.2 lb/yr = 1.0 kg/yr

Stream Channel/Ditch Stabilization Retrofits

Phosphorus loading and reduction for channel stabilization is calculated by assessing the estimated soil loss from a channel cross-section of a specific length over a fixed time frame, given as 67 years, (the "relaxation period" or time for an eroded channel to reach a steady state). An estimation of phosphorus in soils is shown as the average phosphorus content (P-test) in mg/Kg of soil. The mathematical expression for calculation P-load is as follows:

Pload = (0.4536) ((R-1)(A)(L)(BD)(Ptest)) / ((RP)(1,000,000))
Where: Pload = Total Phosphorus Loading (Kg/yr)

$R = 0.0012(i)^2 + 0.0239(i) + 1$

I = Imperviousness (%)
A = existing channel cross sectional area (SF)
L = channel or stream length (ft)
BD = bulk density (typ. 95 lb/CF)
Ptest = phosphorus level in soil (typ. 300 mg/kg)
RP = relaxation period (typ. 67 years for alluvial streams); the time required for channel to reach equilibrium with level of watershed alteration, where channel erosion is in relative balance with watershed forces causing erosion.
0.4536 and 1,000,000 are conversion factors

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For the purposes of assigning load reduction, the Department allows that the phosphorus reduction due to channel stabilization is equivalent to the loading rate, i.e. P reduction = P load.

## 3.0 Non-Regulated Phosphorus Reductions

### Residential Septic Systems

The approved TMDL identifies septic systems near Greenwood Lake as a source of phosphorus loading, primarily due to high groundwater table near the lake shore. Additionally, septic systems may not be adequately designed and constructed, or may not be sited in soils where there is sufficient soil depth to bedrock or other impervious conditions. These characteristics all reduce the ability of the septic systems to adequately treat wastewaters, so pollutants enter the groundwater and from there can enter the lake.

A septic system can also malfunction if there is not sufficient permeable soil for the wastewater to travel through and the wastewater is forced upward to discharge to the ground surface. A septic system in close proximity to surface waters can malfunction because the groundwater table is high and there is insufficient treatment of effluent before it reaches the groundwater.

This Implementation Plan counted 760 houses located within 200 meters of Greenwood Lake. The approved TMDL considered septic systems located less than 200 meters from the lake to be discharging to the lake via groundwater. Support for this proximity-based determination of impairment is contained in a recent near-shore septic study by the Otsego Lake Watershed Council, which determined a 50% malfunction rate for septic systems within 500 feet of Otsego Lake.

The laterals for these septic systems in many cases are discharging directly to the groundwater without treatment due to the high groundwater table near the lake shore. This process over time continues to contribute significant phosphorus loads to Greenwood Lake.

Homeowners may conduct dye tests for the purpose of identifying if wastewater is being discharged to Greenwood Lake. If dye released in a toilet later appears in the lake water, then there is a discharge of wastewater to the lake.

It is recommended that the Greenwood Lake community, in partnership with the Orange County Health Department, conduct an assessment of septic systems and cesspools close to the lake and to tributary streams in the Greenwood Lake watershed to determine where deficient systems occur. Properties adjacent to the lake are the highest priority for dye testing. The assessment should include development of a database of wastewater systems in proximity to Greenwood Lake and tributary streams. The septic system

information in the table below was taken from the approved TMDL.

**Near Shore Septic Systems in New York Greenwood Lake Watershed**

| Watershed-wide Septic Systems w/in 200m. of the lake | NY Septic Systems w/in 200m. of the lake |
|---|---|
| 2,075 | 760 |
| 100% of septic systems are in Greenwood Lake watershed | 36.6% of septic systems are in NYGL watershed |
| TMDL-Calculated Phosphorus load = 710 kg/yr | 36.6% of the calculated load = 260 kg/yr |
| TMDL load allocation = 401 (309 kg/yr reduction required) | TDML load allocation = 147 (113 kg/yr reduction reqd) |

### Phosphorus Reductions from Septic Systems

The approved TMDL requires a 43% reduction in septic system phosphorus load, estimated to be 260 kg/yr for the entire Greenwood Lake watershed; New York's proportionate approved TMDL requirement is to reduce septic system loading by 113 kg/yr.

To eliminate phosphorus loading from the near-lake septic systems, it is recommended to design and construct a community wastewater system, including a related sewerage collection system to collect effluent from the houses in the Greenwood Lake watershed and direct it to a wastewater treatment facility.

Toward this goal, in 2009, the Village of Greenwood Lake submitted an engineering study as part of an application for funding entitled "*Planning, design and construction of new collector sewers, force mains, pump stations and a sewerage treatment plant in the Greater Greenwood Lake area to improve water quality in Greenwood Lake"* to the Environmental Facilities Corporation (EFC). The CWSRF provides low-interest financing to municipalities to construct water quality protection projects such as sewers and wastewater treatment facilities. The project as submitted to EFC would accept effluent from 2,500 houses in the Village of Greenwood Lake and the communities along the lake (including the Sterling Knolls, Sterling Forest and Furnace Brook areas).

The proposed sewering project was placed on the 2009 Final Clean Water State Revolving Fund (CWSRF) Intended Use Plan (IUP) as an eligible project, and has remained on each subsequent annual IUP list to date. Greenwood Lake's proposed project is presently listed on the 2016 Final IUP as eligible for $72 million dollars in low-interest loan money. The project was ranked high because CWSRF scoring is water-quality based, and as Greenwood Lake is impaired in large part due to septic system effluent into the lake, the Greater Greenwood Lake area is judged to be a good candidate for sewers and a wastewater treatment facility.

It is therefore a specific priority of this Greenwood Lake TMDL Implementation Plan that the proposed sewering project be implemented.

## Agricultural Land Use

Fertilizer, animal manure and wastewater are primary phosphorus sources throughout the state of New York. Although wastewater generation will continue, phosphorus source control must play an important role.

Although the New York Greenwood Lake watershed is largely forested or developed, where it is present, agricultural land discharges phosphorus-laden runoff that may be reduced at its source. Some strategies include fencing tributaries to the lake to prevent animal waste from entering streams, offstream watering of farm animals, and other means of excluding animals from tributaries to the lake, as well as planting native plants and trees to create such a riparian buffer.

Pet stores and animal care/boarding facilities should be evaluated for illicit connections to the MS4 and exposure to stormwater, and owners of such stores should be provided with stormwater pollution outreach materials, for distribution to animal owners.

### Phosphorus Reductions from Agricultural Land

The approved TMDL states that total phosphorus loading from agricultural land use is 109 kg/yr. The TMDL allocation for agricultural land use is 62 kg/yr, which represents a 43% reduction (or a reduction of 47 kg/yr). Since the NYGL watershed contributes 36 kg/yr of phosphorus loading from agricultural land use in the GL watershed, New York is required to reduce its phosphorus load from agricultural land use in New York's portion of the Greenwood Lake watershed by 16 kg/yr.

Below are some suggested BMPs to control phosphorus in stormwater runoff from agricultural land:

<u>Cropland Best Management Practices</u>

Test the soil to manage phosphorus levels; apply phosphorus only as needed
Carefully time phosphorus fertilizer application to avoid imminent heavy rainfalls
Mine phosphorus from high-phosphorus soils with certain crops and grasses
Use cover crops, terracing, strip cropping, furrow management to minimize runoff and erosion. Retain crop residues to minimize erosion and runoff
Practice comprehensive nutrient management planning (CNMP)

## Stream Bank Erosion

Streambank erosion in the NY portion of the Greenwood Lake watershed is contributing to sediment deposition in the lake. There are many methods for dealing with streambank erosion, stabilization and restoration. Solutions such as rock riprap or gabions (wire baskets filled with rock) can solve the erosion problem, but may degrade

stream habitat and its aesthetic value. Natural channel design principles look to nature for the blueprint to restore a stream to an appropriate dimension, pattern and profile. Soil bioengineering practices, native material revetments and in stream structures help to stabilize eroding banks. The rate of sedimentation and resultant phosphorus loading to the lake can be reduced by:

- Working to stabilize the stream channels that empty into Greenwood Lake; i.e. providing toe protection, native or non-invasive vegetative cover, drop structures, armoring stream banks with materials that combine structure with vegetation.

- Working to site stormwater retrofits that reduce stormwater runoff from developed land from adversely affecting the lake, through the construction of infiltration and filtration stormwater practices.

- Working to identify large areas of impervious cover which currently discharge directly to waterbodies during runoff events and attempt to install runoff reduction practices to reduce the rate of runoff and therefore reduce in-stream erosion. These practices would also potentially reduce the phosphorous being discharged to Greenwood Lake.

- Establishing protected riparian buffer strips along the stream to filter pollutants and debris in runoff before it enters the stream channel via regulatory land use changes.

#### *Soil Bioengineering Practices*

Bioengineering uses plant materials in a structural way to reinforce and stabilize eroding streambanks. This technique relies on the use of dormant cuttings of willows, shrub dogwoods and other plants that root easily. Bioengineering practices range from simple live stakes to complex structures such as fabricated lifts incorporating erosion control blankets, plants and compacted soil.

#### *Native Material Revetments*

These practices use native materials, wood and stone, to armor streambanks and deflect flow away from them. Low rock walls and log cribwalls can be used to armor the bank. Rootwads armor the bank and provide protection downstream by deflecting the flow away from the bank.

#### *In-Stream Structures*

Rock and logs can be used to construct a variety of structures that stabilize the streambed and banks. Cross vanes are rock structures that stabilize the streambed while aiding in streambank stabilization. Rock or log vanes redirect stream flow away from the toe of the streambank and help to stabilize the bank upstream and downstream from the structure. Where these practices are used, the protection should last long enough to allow appropriate vegetation to become established and provide for long term bank stability. The streamside vegetation improves habitat on the land and in the stream by providing shade, cover and food. Several of the streambank stabilization structures, such as root wads, are also excellent fish habitat improvement structures.

#### *Riparian Buffers*

A riparian buffer is any land near a stream where the vegetation acts as a buffer to the

flow of pollutant-laden stormwater. These areas usually contain native grasses, flowers, shrubs and trees that line the stream banks. Riparian areas help to prevent sediment, nutrient and other pollutants from reaching a stream by slowing stormwater and thus maintaining stable streambanks and channels. Riparian buffers are most effective at improving water quality when they include a native grass or herbaceous filter strip along with deep rooted trees and shrubs along the stream.

Degraded riparian buffers reduce water quality values, reduce wildlife and fish populations, cause serious property damage (bank erosion) and loss of valuable agricultural lands. Removal of riparian vegetation results in increased water temperatures and decreased dissolved oxygen. The loss of shade exposes soils to drying out by wind and sunlight and reduces the water storage capacity of the riparian area. Loss of riparian vegetation causes streambank erosion. Eroding banks contribute to sedimentation and lead to a wide shallow stream with little habitat value. These factors result in significant reductions in aquatic stream life.

Rehabilitating riparian buffers is key to restoring natural stream functions and aquatic habitats. There are many economic benefits derived from increased riparian habitat, channel stabilization, improved water quality, improved wildlife and fish populations, improved aesthetics, and other associated values. Depending on the surrounding land use and area topography, riparian buffers should range from 25 to 100 feet wide on each side of the stream.

Runoff can be directed towards riparian buffers and other undisturbed natural areas delineated in site planning to infiltrate runoff, reduce runoff velocity and remove pollutants. Natural depressions can be used to temporarily detain and infiltrate water, particularly in areas with more permeable soils. Preserving steep slopes and building on flatter areas helps to prevent soil erosion and minimizes stormwater runoff; helps to stabilize hillsides and soils and reduces the need for cut-and-fill and grading.

## Aquatic Plants

Plant species in Greenwood Lake include Lyngbya latissma, fern pondweed, Eurasian water milfoil, fanwort and bass weed. Lyngbya is a blue-green algae that grows in long filaments, forming large, layered mats. Fern pondweed is a submerged plant with firm, narrow leaves arranged in ranks resembling fern fronds. Bass weed (aka pondweed) is a perennial herb that produces broad, submerged leaves and occasional floating, surface leaves. Both fern pondweed and bass weed are native species. Eurasian water milfoil is a long-stemmed plant that forms thick canopies of surface vegetation, often blocking light for other plant species as well as becoming an obstacle to recreational boating and swimming. Fanwort is a submerged herb with long (up to 6 feet), slender stems covered with gelatinous slime, forming thick stands that crowd out other plants and can clog water channels. Eurasian water milfoil and fanwort are both classified as aggressive, non-native (i.e. invasive) species.

The increase of invasive plant species has reduced the water quality for native fish. Invasive species out-compete native aquatic plants like tape grass (Vallisneria americana) that offer preferred habitat for spawning. Denser stands of invasives can also restrict access to the lake for human visitors, decreasing their recreational opportunities and even interfering with aesthetic appreciation of shoreline views. Eurasian water milfoil and fanwort have both been identified as dominant species in shallow areas of the lake.

Eurasian Watermilfoil- Eurasian watermilfoil has slender stems up to 3 m long. The submerged leaves are usually between 15–35 mm long and are borne in pinnate (feather-like) whorls of four, with numerous thread-like leaflets roughly 4–13 mm long. Flowers are produced in the leaf axils (male above, female below) on a spike 5–15 cm long held vertically above the water surface, each flower inconspicuous, orange-red, 4–6 mm long. Eurasian water milfoil has 12- 21 pairs of leaflets.
In lakes or other aquatic areas where native aquatic plants are not well established, Eurasian watermilfoil can quickly spread. It has been known to crowd out native plants and create dense surface canopies or dense stands within the water that interfere with recreational activity. Eurasian watermilfoil can grow from broken off stems which increases the rate in which the plant can spread and grow.

Fanwort- Fanwort is native to the southern states but not to New York. It prefers shallow water, but, in recent years, it has been found in deep waters of isolated lakes in the southeastern Adirondacks, and on both sides of the southern-to-mid Lower-Hudson River basin. It has thread-like leaves that fan out from opposite sides of the stem. It probably spreads by both seeds and fragmentation, although fragmentation seems to be its primary method in the northeastern United States. The white or pink flowers of the fanwort are occasionally seen in New York State lakes. For the most part, fanwort control has been attempted only on Long Island.

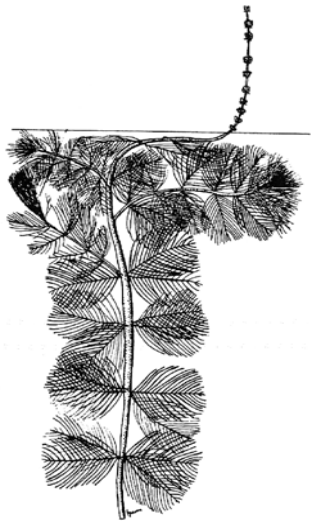

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*Fig. 3–2. Eurasian watermilfoil*
*(Credit: Crow and Hellquist)*

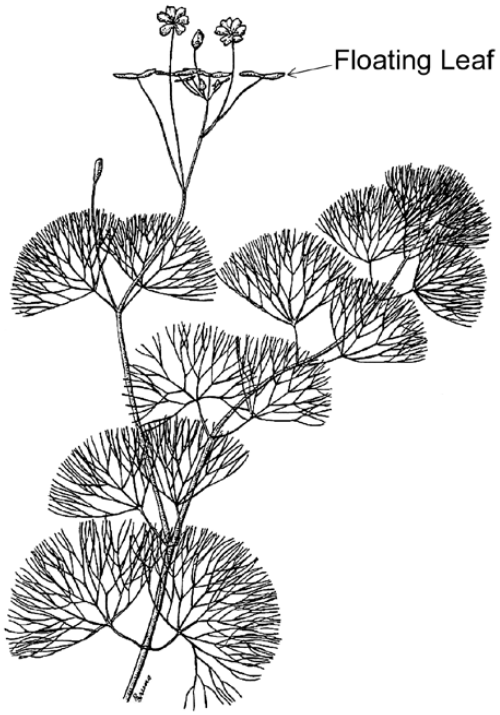


*Fig. 3–5. Fanwort*
*(Credit: Crow And Hellquist)*

### *Aquatic Plant Control*

Most strategies involve removal of the invasive species plants. Some management tools may create significant impacts and as such, the benefits may not outweigh risks. Consider selecting actions with lesser side effects. Potential goals for weed management in Greenwood Lake include surface reduction of weeds to: 1) improve boating; 2) clear edges for anglers; and 3) clear lake areas for swimming. Decisions need to be made as to whether to manage weeds in: 1) part of or the whole lake; 2) in the early summer or the entire summer; and short or long term control. Other factors include the budget for weed management, and whether will be done by a consultant or by citizen volunteers. The first and best line of defense is PREVENTION:

- Visual inspection - assume all dangling plants are invasive
- Disinfection - Hot water, disinfectant
- Quarantining - Delay entering lake until any transported plants have been dried or inactivated
- Intercepting - Remove plants before they leave other infected lakes

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- Regulating their sale and transport

Aquatic plant management actions are discussed in detail in Diet for a Small Lake, Chapter 6 (http://www.dec.ny.gov/ chemical/82123.html).

If the goal is to manage relatively small areas (swimming area, boat channels), it is possible to implement the following techniques with citizen volunteers:

- Hand harvesting
- Benthic barriers

If the goal is to manage a large area (whole lake), a consultant would need to be retained and consideration could be given to the following techniques:

- Herbicides- EWM only- triclopyr; EWM and coontail- fluridone
- Grass carp

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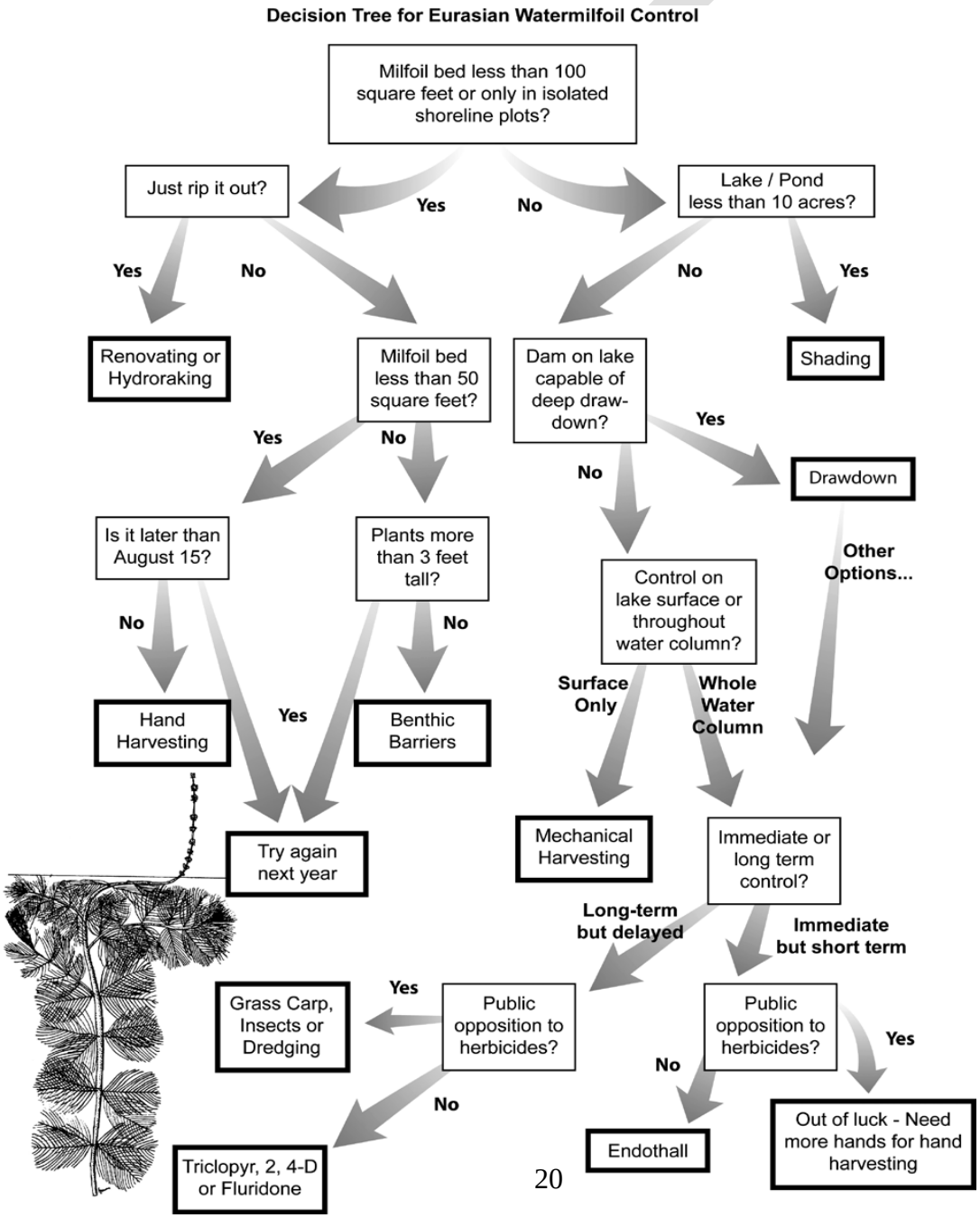
## *Aquatic Plant Control Options for Greenwood Lake*

| *Control Options* | Is it possible? | How effective at controlling bad plants? | How will it damage good plants? | How much does it cost? | Permits needed? | Can we do it ourselves? |
|---|---|---|---|---|---|---|
| **Do Nothing** | Yes | Not Applicable | Not applicable | Pay Later | None | Yes |
| **Hand/diver Harvesting** | Yes | Will control any plant in easy-to-pluck patches | May remove good plants by accident | Whole lake—approx $600k Swimming area(s)—approx. $10k ea | No (unless whole lake) | Yes |
| **Benthic Barrier** | Yes, but limited to swimming or boating channel | Will control plants under the barriers | Will also eliminate good plants under barrier | Whole—not used Swimming areas—approx. 10k ea | No (unless whole lake or barriers permanent) | Yes |
| **Cutting** | Yes | Not very effective with Eurasian Watermilfoil and coontail | Good plants may be cut by accident | Whole lake—not viable Swimming areas= labor only | No | Yes (but be careful) |
| **Shading** | Yes | Not very effective | If it works, will impact good plants too | Whole lake—approx $400k Swimming areas—not viable | Yes, if certain products are used | Yes, if landscaping product used No, if pesticides used |
| **Herbivorous insects** | Yes | Not effective with Eurasian Watermilfoil | Will not damage good plants | Whole lake—approx. $2 million Swimming areas—not likely restricted to area | Yes, Article 11 (Possess?) | No, authorized applicator through permit |
| **Drawdown** | No | Somewhat effective, but some exotics will increase | May remove good plants by accident | Whole lake—no cost Swimming areas—not possible | Maybe, Article 15 (Protection of Waters Permit**) | Not possible as plant control tool |
| **Mechanical harvesting** | Probably not | Effective | Good plants will be removed too | Whole lake—approx. $150k to purchase Swimming areas—not likely | Probably not | No |
| **Aquatic herbicides** | Yes | Eurasian watermilfoil-very effective Coontail—fairly effective | Less effective on lilies, duckweed Depends on herbicide used | Whole lake—approx. $1.5 million Swimming areas—not likely to stay in area | Yes | No, need licensed applicator |
| **Grass Carp** | Yes, if outlet can be screened | Fairly effective | Some good plants may be damaged | Whole lake—approx. $600k Swimming areas—fish will wander | Yes, Article 11 | No, need licensed applicator |
| **Dredging** | Probably not | Fairly effective | Good plants will be removed too | Whole lake—prob. not feasible Swimming areas-$300k? | Yes | No |

Other alternatives include utilizing Integrated Plant Management (IPM), (combining two or more management techniques). IPM can target any/all invasives and is often viewed as a more comprehensive approach as it can combine local and lakewide management techniques. Care should be taken to ensure that techniques are compatible so there are no side effects. The costs and need for permits will depend on the management techniques chosen.

Decision trees help guide initial decision-making process based on the key factors for each infestation. Key factors may include: Management objectives, permitting, side effects, longevity and cost. A decision tree for watermilfoil control follows:



### Blue Green Algae Blooms

Blue green algae can release toxins that affect people through skin exposure and gastrointestinal or asthma-like symptoms, including nausea, vomiting, diarrhea, skin or throat irritation, allergic reactions or breathing difficulties. Swimming can also be affected by the ugly appearance and smell from algae that accumulated along the surface or shoreline. People and pets should avoid swimming in heavily discolored water or surface scums, and they should also not handle algae material--scums or algae covering weeds along the shoreline.

Lake residents can reduce the likelihood of algae blooms in Greenwood Lake by reducing the amount of nutrients (phosphorus and nitrogen) that enter the lake. This can be accomplished by:

- sewering the near lake properties,
- maintaining and pumping out septic tanks,
- limiting lawn fertilization,
- maintaining shoreline buffers,
- reducing streambank erosion and stormwater runoff, and
- maintaining water movement in the lake.

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## *Algae Control Options for Greenwood Lake*

| *Control Options* | Is it possible? | Pros | Cons | How much does it cost? | Permits needed? | Can we do it ourselves? |
|---|---|---|---|---|---|---|
| **Barley Straw** | Yes | Cheap, Easy, DIY, No Evidence of Harm, Some Anecdotal Evidence It Works | Only Anecdotal Evidence, Removal of Spent Bales | Whole Lake = $50-60k<br><br>area) | None or Not Allowed | Yes |
| **Algeacides** | Yes - Chemically Wipe Out Algae by Contact | Short Term Control, Immediate, Usually Effective | Non-Target Impacts, Controversial, Some Limits on Use, Can Push Toxins Into Water | Whole lake—approx $120-150k. | ECL Article 15/Part 327, Article 17/SPDES General Permit, Article 24) | No – need licensed applicator |
| **Biomanipulation** | Yes – stock fish to eat algae (or to eat fish that eat zooplankton that eat algae) | Can be effective. One and Done, "Natural", Improve Fishery | Unclear as to how effective Disrupt Fish/food web Community, Hard To Reverse, Highly Variable Success; Assume BB/Carp Dominate Lake | $100-200/ 100 fish; 100-1000 fish/acre | Article 11 | No – need permit applicator |

## Lake Management Resources

*Diet for a Small Lake*
(http://www.dec.ny.gov/chemical/82123.html)

- Chapter 6 discusses each aquatic plant management option in detail
- Chapter 7 discusses each algae control option in detail

Harmful Blue-green Algae Blooms

- General information— http://www.dec.ny.gov/chemical/77118.html
- Bloom Notices— http://www.dec.ny.gov/chemical/83310.html
- Frequently Asked Questions— http://www.dec.ny.gov/chemical/91570.html

Invasive Species

- General information about invasive species—http://www.dec.ny.gov/animals/265.html
- Aquatic invasive species in NYS— http://www.dec.ny.gov/animals/50121.html
- How to prevent the spread of aquatic invasive species— http://www.dec.ny.gov/animals/48221.html

Citizens Statewide Lake Assessment Program (CSLAP)

- Need to be a member of the NY Federation of Lake Associations— http://www.nysfola.org/
- Apply to NYSFOLA for 2015
- General information about CSLAP— http://www.dec.ny.gov/chemical/81576.html

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## 4.0 Funding Sources

The following funding sources may be used to support this Plan:

Water Quality Improvement Projects (WQIP): The Department supports water quality improvements through the Water Quality Improvement Project (WQIP) Statewide Grant Program. The WQIP program is a competitive, reimbursement grant program that uses New York State Environmental Protection Funds for projects that reduce polluted runoff, improve water quality and restore habitat in New York's waterbodies. Through the Regional Economic Development Council (REDC) initiative, the Department has made millions of dollars available to support water quality improvements through the Water Quality Improvement Project (WQIP) Grant Program.

New York State DEC/EFC Wastewater Infrastructure Engineering Planning Grant: The Department, in cooperation with the New York State Environmental Facilities Corporation (EFC), have made up to $2 million available in 2016 for municipalities that need to construct or improve their municipal wastewater system. Grant funds can be used to pay for engineering and/or consultant fees for engineering and planning services for the production of an engineering report. Municipalities can apply for the funding through the Consolidated Funding Application (CFA). Individual grants will be up to $100,000 and municipalities will have to provide a 20% match.

The NYS Environmental Protection Fund has an annual funding cycle. Requests for funding are announced by the Department and are routinely published in the NYS Environmental Notice Bulletin (http://www.dec.ny.gov/enb/enb.html). Municipalities are encouraged to apply for these competitive grants.

Various other competitive grants for environmental protection are available for municipalities. For more information about eligibility requirements, enrollment periods, eligible projects and FAQs for these grants, please see DEC's Grant Application webpage:

http://www.dec.ny.gov/pubs/grants.html

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## Appendix A: 2017 MS4 General Permit

http://www.dec.ny.gov/chemical/43150.html#Permit

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## Appendix B: Greenwood Lake Watershed MS4 Operator list

| Permitee | Permit Number |
|---|---|
| Village of Greenwood Lake | NYR20A117 |
| Town of Warwick | NYR20A409 |
| Orange County | NYR20A322 |
| New York State Department of Transportation | NYR20A288 |

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## Appendix C: Greenwood Lake Watershed - Land Use Values

| | Percent of Land uses in New York portion of Greenwood Lake Watershed | Percent of Land uses in New Jersey portion of Greenwood Lake Watershed |
|---|---|---|
| open water | 15.1 | 8.7 |
| developed, open space | 13.0 | 11.9 |
| developed, low intensity | 1.9 | 2.8 |
| developed, medium intensity | 0.6 | 0.8 |
| developed, high intensity | 0.0 | 0.2 |
| barren land (rock, sand, clay) | NA | 0.0 |
| deciduous forest | 60.0 | 60.3 |
| evergreen forest | 1.4 | 0.8 |
| mixed forest | 1.4 | 2.0 |
| shrub/scrub | 0.1 | 0.5 |
| grasslands/herbaceous | 0.8 | 0.8 |
| pasture/hay | 0.5 | 0.4 |
| cultivated crops | 0.2 | 0.6 |
| woody wetlands | 5.0 | 10.2 |
| Total | 100.0 | 100.0 |
| | | |
| | | |
| Land Use Totals (Sq M) | 28,164,600 | 45,121,500 |
| | | |
| % Greenwood Lake Watershed | 38% | 62% |
| | | |

*For the purposes of redistribution of land uses on a per state basis, the developed open space category was added to the low intensity developed category so the land uses would match the land uses in the approved TMDL.

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## Appendix D: New York and New Jersey Relative Land Uses

| DEC-modeled land use categories * | NY Land Use (SM) | NJ Land Use (SM) | NY Percentage | Entire Watershed (kg/yr) | NY Watershed (kg/yr) |
|---|---|---|---|---|---|
| Low Intensity Residential | 4,193,100 | 6,672,600 | 39% | 415.9 | 160 |
| High Intensity Residential | 9,000 | 85,500 | 10% | 293.6 | 28 |
| Commercial/Industrial/Transport | 156,600 | 348,300 | 31% | 307.7 | 95 |
| Pasture/Hay | 153,900 | 162,900 | 49% | 55.7 | 27 |
| Row Crops | 49,500 | 291,600 | 15% | 27.2 | 4 |
| Grasses | 224,100 | 355,500 | 39% | 26.3 | 10 |
| Deciduous Forest | 16,921,800 | 27,351,000 | 38% | 180.3 | 69 |
| Evergreen Forest | 397,800 | 357,300 | 53% | 47.9 | 25 |
| Mixed Forest | 393,300 | 910,800 | 30% | 202.4 | 61 |
| Woody Wetlands | 1,419,300 | 4,631,400 | 23% | 13 | 3 |
| Emergent Wetlands | - | - | | 1.1 | 0 |
| Open Water | 4,246,200 | 3,954,600 | 52% | 6.9 | 4 |
| Air Deposition | 0 | 0 | | 53.4 | 0 |

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**Land Use Descriptions**

| Approved TMDL land uses | TMDL Implementation Plan Land Uses |
|---|---|
| Developed, open space + low intensity | Low Intensity Residential |
| Developed high intensity | High Intensity Residential |
| Developed, medium intensity | Commercial/Industrial/Transport |

## Appendix E: MS4 Roadway Miles – Metric for allocating Retrofit responsibility

| MS4 | Total Length (m) | Roadway miles (%) |
|---|---|---|
| New York State Roads | 14,745 | 15% |
| Orange County Roads | 3,756 | 4% |
| T/Warwick Roads | 50,504 | 50% |
| V/Greenwood Lake Roads | 31,400 | 31% |

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