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Total Maximum Daily Load for Phosphorus for New Pond, Canterbury, NH

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Executive Summary

The New Hampshire Department of Environmental Services (NHDES) has developed a Total Maximum Daily Load (TMDL) for New Pond in Canterbury, New Hampshire. New Pond is currently on the 2024 Section 303(d) List of impaired waters for not meeting water quality standards for the Primary Contact Recreation and Aquatic Life Integrity designated uses, which was approved by EPA on January 15, 2025. The Primary Contact Recreation designated use is impaired for chlorophyll-*a* (chl-a) and cyanobacteria hepatotoxic microcystins (cyanobacteria) parameters. The Aquatic Life Integrity designated use is impaired for total phosphorus (TP), chl-*a*, and dissolved oxygen saturation (DO sat). Though New Pond is listed as impaired for several parameters, this TMDL will directly address TP as the parameter that is the primary stressor. The remaining impairments are considered responses to the TP impairment and will be addressed through reducing TP loading to the pond (Table 0-1). The TMDL development included: 1) the construction of a nutrient budget; 2) calculation of a target value for phosphorus such that chl-*a* and cyanobacteria bloom formation will meet applicable water quality standards and thresholds; and, 3) an estimate of the TP load reduction needed to achieve the target TP concentrations and their allocations among various sources. The TMDL is intended to cover the entire pond and three designated beaches (Table 0-1).

Modeling was performed using the Lakes Loading Response Model (LLRM) developed to predict in-lake TP and chl-a concentrations. Algal bloom frequency was also predicted. The LLRM also calculates a prediction for Secchi disk transparency (SDT) but results often exceeded the actual maximum depth of the pond, limiting the usefulness of this prediction. TP loads were estimated for atmospheric deposition, watershed transport, septic systems, and waterfowl. The internal TP load is also able to be estimated

using the LLRM, however, New Pond is a shallow unstratified pond which negates the need to account for this source.

The current TP load for New Pond is 22.5 kilograms per year (kg/yr) and the 10-year summer epilimnetic mean TP is 14.5 micrograms per liter (µg/L). The TP load is derived solely from nonpoint sources (NPSs), as there are no point sources (PSs) present in the watershed. Currently, New Hampshire does not have numeric water quality standards for nutrients; however, narrative criteria have been developed and are based on trophic status, chl-*a* concentrations, and TP concentrations. As a mesotrophic lake, the thresholds for chl-*a* and TP are 5.0 µg/L and 12.0 µg/L, respectively. As chl-a is a response to TP concentrations, it is expected that meeting the 12.0 µg/L TP threshold will result in meeting the 5.0 µg/L chl-*a* threshold. Additionally, it is expected that attainment of the TP threshold will result in meeting water quality standards for dissolved oxygen saturation (DO sat) and cyanobacteria for all designated uses.

The target TP load for this TMDL is 15.9 kg/yr, which represents a 29% (6.6 kg/yr) reduction. The target load includes a 20% implicit margin of safety (MOS). The MOS is implicit as available data and model reflect critical summer conditions when TP concentrations are typically lower than other seasons. Most of the load reduction will need to be realized from reductions in TP load from the watershed, largely resulting from stormwater runoff management through the implementation of stormwater control measures (SCMs), which are discussed in more detail in section 7.0.

Guidance for implementation, monitoring and possible funding opportunities are also provided in this report. Monitoring is recommended to document the in-lake response, trends, and compliance with water quality criteria and thresholds following implementation of TP reduction measures. After load reduction measures have been implemented, monitoring should be conducted to determine if compliance has been achieved or if additional reductions are necessary. This is especially important when the estimated TP load reductions associated with implemented activities approach the load reduction goal since it is possible that, due to the model uncertainties, compliance will be achieved before the TP load reduction goal is met.

Table 0-1: New Pond Assessment Units, Pollutants and Parameters Addressed in the TMDL

Assessment Unit	Name	Pollutant	Addressed Parameter(s)
NHLAK700060201-03	New Pond	Total Phosphorus	Total Phosphorus, Dissolved Oxygen, Dissolved Oxygen, Saturation, Chlorophyll-*a*, Cyanobacteria Hepatotoxic Microcystins
NHLAK700060201-03-01	New Pond-Sherwood Forest Shores Beach 1		
NHLAK700060201-03-02	New Pond-Sherwood Forest Shores Beach 2		
NHLAK700060201-03-03	New Pond-Sherwood Forest Shores Beach 3		

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1.0 Introduction

The objective of the Federal Water Pollution Control Act — amended in 1972 and commonly known as the Clean Water Act (CWA) — is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (U.S.C. § 1251-1387). Chapter 26, Section 1313 of the CWA codifies water quality standards and implementation plans for surface waterbodies. Subsection 303(d) of the CWA outlines each state's requirements for performing surface water assessments, developing impairment listings, and determining Total Maximum Daily Loads (TMDLs) for impaired surface waterbodies.

The processes for listing waterbodies as impaired are outlined in the Consolidated Assessment and Listing Methodology (CALM) and are based on evaluations of data from many sources including the New Hampshire Department of Environmental Services' (NHDES) Water Quality Monitoring Program. The assessment of water quality data for parameters are based on the New Hampshire Code of Administrative Rules, Env-Wq 1700, (NHSWQS) which establishes standards for the determination of water quality impairments. Waterbodies are assessed according to the six designated uses listed in Table 1-1. A parameter is determined as either fully supporting or not supporting (impaired) a designated use based on NHSWQS and available data. Table 1-2 summarizes the United States Environmental Protection Agency's (USEPA) surface water quality assessment categories. NHDES further divides these categories into sub-categories, descriptions of which can be found in the CALM.

Table 1-1: Designated Uses for New Hampshire Surface Waters

Designated Use	NH Code of Administrative Rules (Env-Wg 1702.17) Description	Applicable Surface Waters
Aquatic Life Integrity	The surface water can support aquatic life, including a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to that of similar natural habitats of the region.	All surface waters
Fish Consumption	The surface water can support a population of fish free from toxicants and pathogens that could pose a human health risk to consumers.	All surface waters
Shellfish Consumption	The tidal surface water can support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Potential Drinking Water Supply	The surface water could be suitable for human intake and meet state and federal drinking water requirements after adequate treatment.	All surface waters

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Designated Use	NH Code of Administrative Rules (Env-Wg 1702.17) Description			Applicable Surface Waters
Swimming and Other Recreation In and On the Water	The surface water is suitable for swimming, wading, boating of all types, fishing, surfing, and similar activities.	Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
		Secondary Contact Recreation (i.e.) boating	Waters that support recreational uses that involve minor contact with the water.	
Wildlife	The surface water can provide habitat capable for supporting any life stage or activity of undomesticated fauna on a regular or periodic basis.			All surface waters

Table 1-2: USEPA Surface Water Assessment Categories**.**

Category	Description
Category 1	Attaining all designated uses and no use is threatened.
Category 2	Attaining all designated uses; no use is threatened; and Insufficient or no data is available to assess other designated uses
Category 3	Insufficient or no data and information is available to determine if any designated use is attained, impaired, or threatened
Category 4	Impaired or threatened for one or more designated uses but does not require a TMDL because:
A	TMDL has been completed
B	Other pollution control requirements are reasonably expected to result in attainment of water quality standard in the near future
C	Impairment is not caused by a pollutant
Category 5	Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL

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New Pond has been assessed for six parameters for the Aquatic Life Integrity, Fish Consumption, and Primary Contact Recreation designated uses (Table 1-3). Each of the parameters were assessed as not supporting these uses. The parameters of chloride, dissolved oxygen (DO) (concentration), and turbidity were considered but data were insufficient for full assessments.

Table 1-3: Assessed Parameters and Designated Uses for New Pond, Canterbury, NH.

	Designated Uses		
Parameter	**Aquatic Life Integrity**	**Fish Consumption**	**Primary Contact Recreation**
Total Phosphorus	Not Supported (Cat. 5)		
Chlorophyll-*a*	Not Supported		Not Supported
Cyanobacteria			Not Supported
Dissolved Oxygen (saturation)	Not Supported		
Dissolved Oxygen (concentration)	Insufficient Information (Cat. 3)		
Mercury		Not Supported Cat. (4A)	
pH	Not Supported		
Turbidity			
Chloride			

A waterbody that is assessed as not supporting a designated use, is deemed impaired (category 5) and requires the development of a TMDL. All freshwater waterbodies in New Hampshire have been determined as not supporting the fish consumption designated use due to elevated concentrations of mercury. The state has addressed this impairment through the adoption of the Northeast Regional Mercury Total Maximum Daily Load. The pH impairment for New Pond is addressed in the Determination of Total Maximum Daily Load (TMDL) for 158 Acid Impaired and 21 Aluminum Impaired New Hampshire Ponds. Because these impairments have already been addressed through a TMDL, they have been removed from the CWA Section 303(d) List and placed in category 4A. The remaining impairments will be addressed in this TMDL with total phosphorus (TP) identified as the stressor parameter and chlorophyll-*a* (chl-*a*), cyanobacteria hepatotoxic microcystins (cyanobacteria), and dissolved oxygen saturation (DO sat) as responses to elevated total phosphorus (Table 0-1: New Pond Assessment Units, Pollutants and Parameters Addressed in the TMDL).

A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody and still maintain the state's water quality standards for a particular designated use. The development of the TMDL requires the identification of all pollutant sources. These sources are categorized as point sources (PS) or nonpoint sources (NPS). Point sources are pollutant sources entering a waterbody from a discrete, identifiable conveyance such as a pipe, ditch or channel. Nonpoint sources originate from diffuse sources across the landscape that commonly enter waterbodies through surface runoff and groundwater.

Once all pollutant sources are identified, the water quality goals or target values needed to achieve water quality standards are determined, and a specific load allocation is assigned to each of the sources. Water quality goals are based on the assimilative capacity for the waterbody, which is an estimate of the waterbody's capacity to receive a pollutant and still maintain water quality standards.

The TMDL is the sum of waste load allocations (WLA) originating from point sources, load allocations (LA) originating from nonpoint sources, a margin of safety (MOS), and reserve capacity (RC) (EPA, 2023d). The MOS considers the uncertainty in identifying the origin and fate of pollutants of concern. Including the reserve capacity (RC) in the calculation is optional but allows for consideration of future development and changes in pollutant loads. This can be expressed mathematically as:

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

The TMDL is then used to determine pollutant reduction targets and allocates reductions necessary for the pollutant source(s). The process for developing a TMDL includes (EPA, 2023d):

- Identification of the pollutant of concern.
- Estimation of a waterbody's assimilative capacity.
- Estimation of the pollutant loading from all sources.
- Determination of pollutant reductions needed to meet water quality standards.
- Allocation of allowable pollutant load that will achieve and maintain water quality standards.

The pollutant of concern for New Pond is total phosphorus (TP). The remaining process steps will be addressed in the following sections. These may include the following:

- Waterbody identification and characteristics.
- Pollutant of concern and its sources.
- Loading capacity.
- Loading and waste allocations.
- MOS.
- Consideration of seasonal variation.
- Reasonable assurance that implementation of the TMDL will meet NHSWQS.
- Tracking of TMDL effectiveness.
- Implementation plan.
- Public participation.

2.0 Description of Waterbody, Standards and Targets

2.1 Watershed and Waterbody Characteristics

New Pond (Assessment Unit NHLAK700060201-03) is in the Town of Canterbury, New Hampshire, within Merrimack County. It is a small, shallow, mesotrophic (moderate amount of nutrients and biological activity) pond with an area of 12.48 hectares (30.85 acres), maximum depth of 3.0 meters (9.8 feet), and a mean depth of 1.4 meters (4.6 feet) (NHDES, 1998). New Pond is a Class B waterbody. Class B waterbodies are described as being of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for

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use as water supplies (RSA 485-A:8 II, 2023). New Pond is a natural waterbody with its elevation partially regulated by an earthen dam which discharges into Shaker Brook. The influence of the dam on the water level is evidenced by the presence of a submerged stonewall (Figure 2-1). The pond receives surface water runoff and groundwater infiltration from a 139.71 hectare (345.23 acres) sub-watershed within the Gues Meadow Brook watershed (Hydrologic Unit Code 12: 010700060201). Watershed and waterbody characteristics are summarized in Table 2-1. The Gues Meadow Brook watershed is located in the Upper Merrimack River Valley which eventually flows into the Atlantic Ocean near Newburyport, MA (Figure 2-2).

Table 2-1: Summary of Watershed and Waterbody Characteristics from 1998 Lake Trophic Data for New Pond Canterbury, NH, and the NHDES 2024 Surface Water Quality Assessment Viewer.

Parameter	Value
Assessment Unit	NHLAK700060201-03
Pond Area (hectares, acres)	12.48 ha, 30.85 acres
Pond Volume (m^3)	167000
Watershed Area	139.71 ha, 345.23 acres
Mean Depth (m, ft)	1.4 m, 4.6 ft
Maximum Depth (m, ft)	3.0 m, 9.8 ft
Flushing Rate (yr^{-1})	1.10
Summer Thermal Stratification	Non-stratified
Category 5 Impairment Designated Uses and Causes	**Aquatic Life Integrity**: -Chlorophyll-*a* -Dissolved Oxygen Saturation -Total Phosphorus **Primary Contact Recreation**: -Cyanobacteria hepatotoxic microcystins

The New Pond watershed is divided by the town boundary between Northfield and Canterbury, NH. New Pond is in the southern portion of the sub-watershed in the Town of Canterbury. The New Pond shoreline is developed and is home to the Sherwood Forest Shores Association (SFSA) Subdivision in Canterbury. There are three designated beaches along the shoreline: SFSA Beach 1 (NHLAK700060201-03-01), SFSA Beach 2 (NHLAK700060201-03-02), and SFSA Beach 3 (NHLAK700060201-03-03). The SFSA extends into the neighboring Lyford Pond sub-watershed. The SFSA in the New Pond sub-watershed is generally bounded by Shaker Road to the northwest, Old Gilmanton Road to the northeast, and the New Pond watershed to the southeast and southwest (Figure 2-2).

The New Pond watershed land cover mostly consists of forest cover with deciduous, non-deciduous and mixed forest types accounting for 75.2% of the area. Low, medium and high development intensity account for 16.7%, 2.0%, and 0.5% of the watershed area, respectively. Wetlands account for 5.1% of the area with the remaining area associated with agricultural activity. More detail concerning the New Pond watershed is provided in section 3.0 Water Quality Modeling.

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Figure 2-1: Bathymetry Map of New Pond, Canterbury, NH (NHDES, 1998)

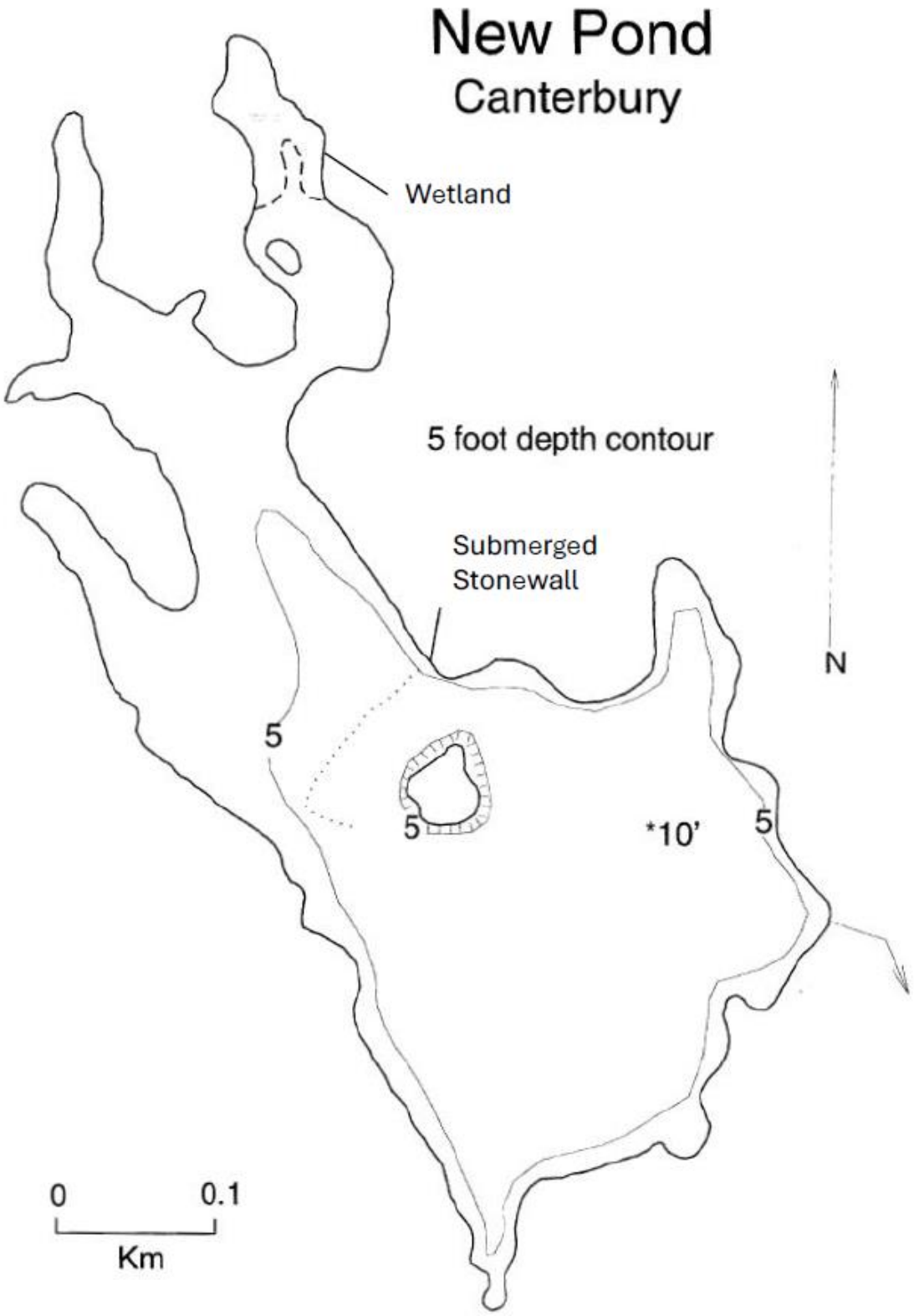


Figure 2-2: Merrimack River (left) and Gues Meadow Brook watersheds (right). Gues Meadow Brook watershed is Hydrologic Unit Code 12 010700060201 as assigned by the United States Geological Survey.

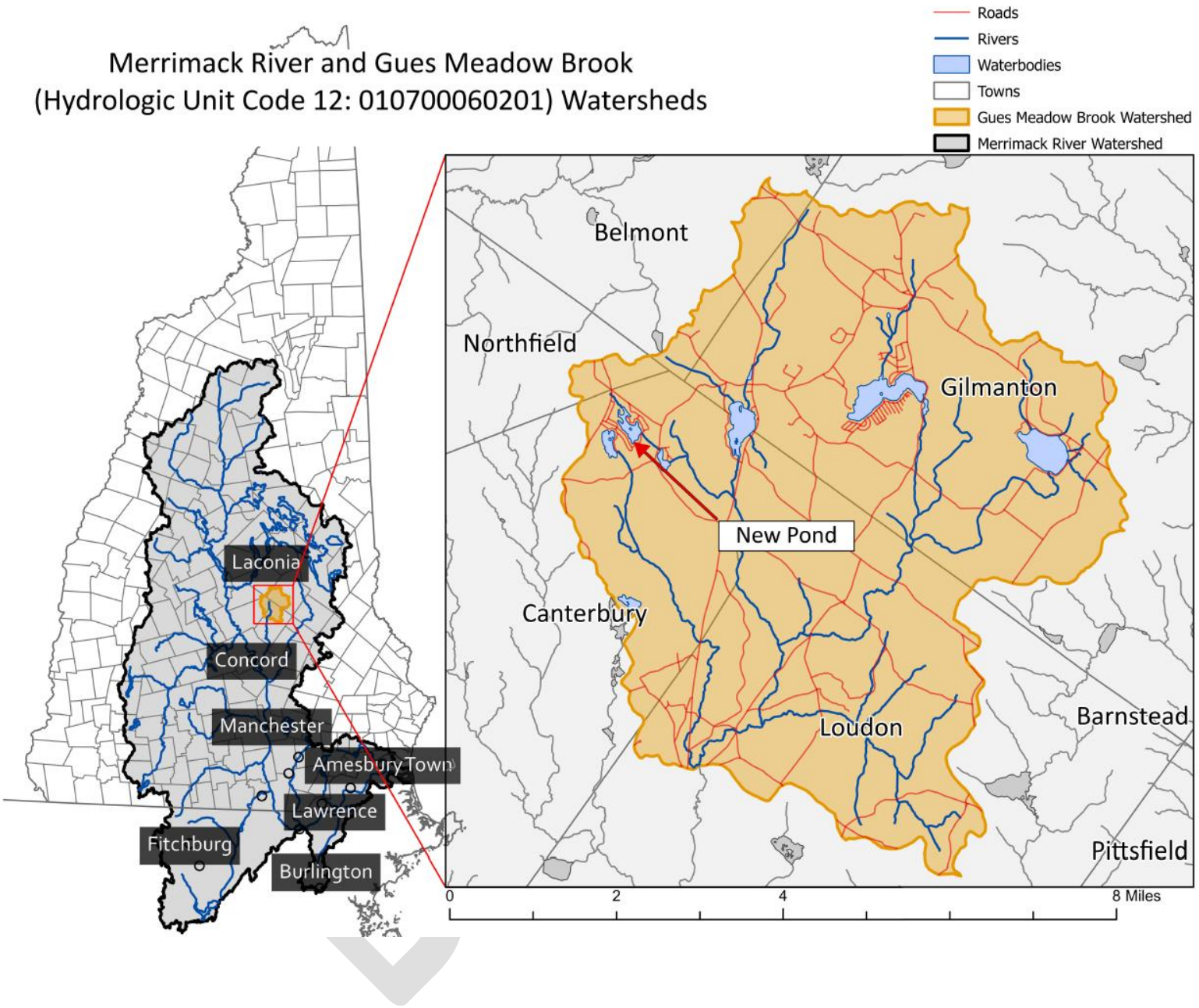
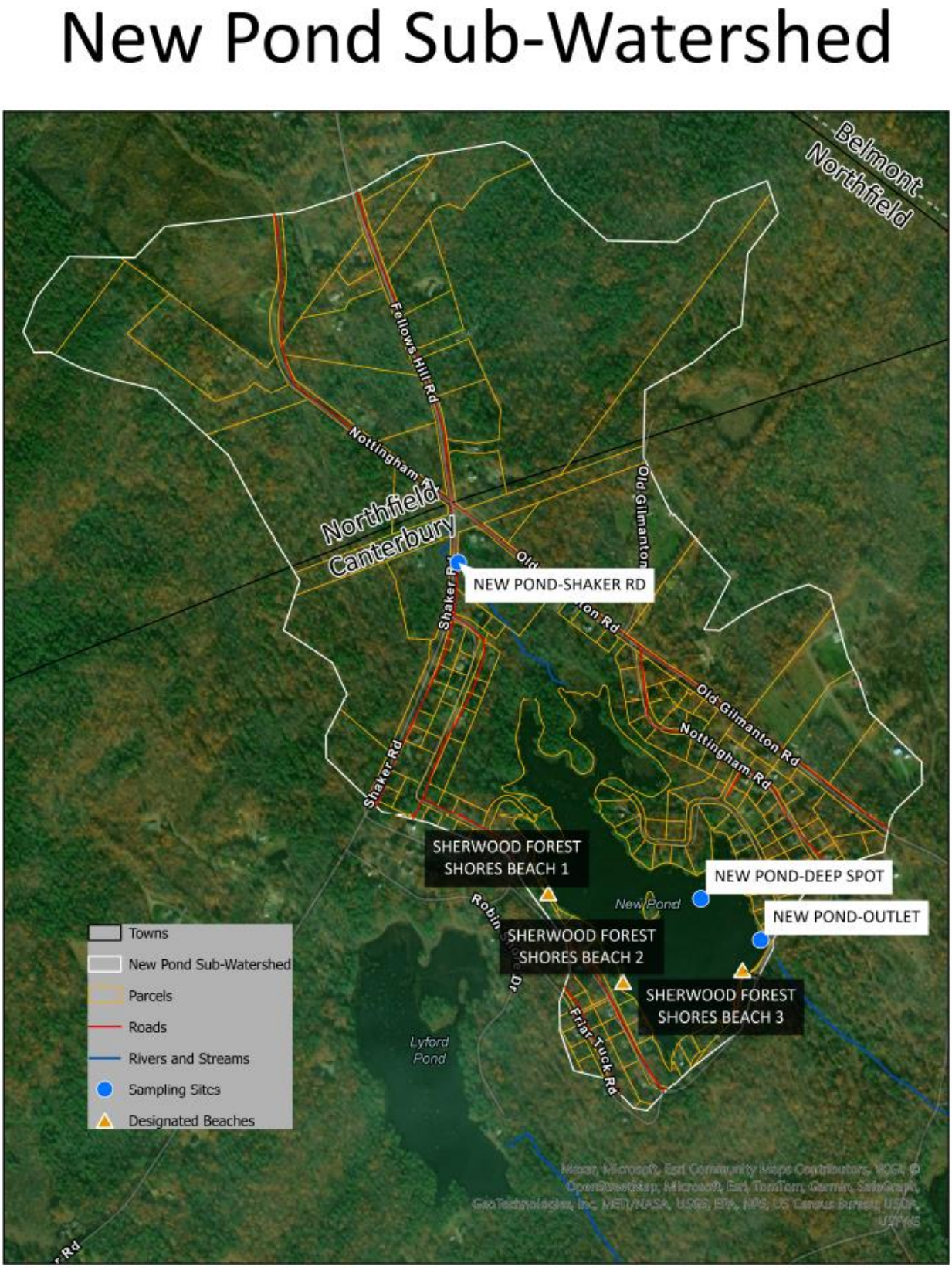


Figure 2-3: New Pond Sub-Watershed



2.2 Priority Ranking

New Pond was prioritized for a TMDL based on the impairments listed above and their relationship to public health and health risks to animals. Health risks are present in New Pond during blooms of cyanobacteria, also referred to as harmful algal blooms (HABs), with the potential release of toxins that may affect the liver and nervous systems of humans, livestock, pets, and wildlife (EPA, 2024). Total phosphorus (TP) elevates health risks based on the stressor-response relationship, with greater phosphorus concentrations potentially leading to blooms of cyanobacteria. The surface water TMDL selection process is described in New Hampshire's Long-term Vision for implementing CWA 303(d) Program Responsibilities.

Water Quality and Applicable Standards

Early water quality data for New Pond dates back to 1985 and were collected through the Lake Trophic Survey Program (LTSP) (NHDES, 2019). The LTSP determines the trophic status, or overall biological productivity, for New Hampshire's lakes and ponds as well as sharing data to assist water quality assessments and meeting federal requirements for water quality reporting. There has been consistent summertime sampling since 2002 as a result of collaboration with the local volunteers involved in NHDES' between the Volunteer Lake Assessment Program (VLAP) and local volunteers (NHDES, 2024).

Impairments requiring a TMDL include chlorophyll-*a* (chl-*a*) and cyanobacteria for the Primary Contact Recreation designated use, as well TP, chl-*a*, and dissolved oxygen saturation (DO sat) for the Aquatic Life Integrity designated use (Table 1-3). Impairments are listed when the assessment of water quality data reveal that a pollutant or parameter does not meet New Hampshire's Surface Water Quality Standards (NHSWQS). The process of assessment follows the Consolidated Assessment and Listing Methodology (CALM). A summary of water quality results for five of the six impairments are summarized below (Table 2-2).

Table 2-2: 2002-2024 summary of total phosphorus, chlorophyll-*a*, and dissolved oxygen saturation water quality from the deep spot, inlet, and outlet.

	Deep Spot			**Inlet***	**Outlet**
	Total Phosphorus (µg/L)	Chlorophyll-*a* (µg/L)	Dissolved Oxygen (% Saturation)	Total Phosphorus (µg/L)	Total Phosphorus (µg/L)
# of Samples	54	56	13	22	13
Range	9 to 28	1.5 to 57.9	68.2 to 97	14.3 to 76.5	9.0 to 28
Mean	14.4	7.1	79.6	37.9	17.3
Median	14	5.3	78.1	33.6	16.1

µg/L = micrograms per liter

*The data used for the inlet was collected from an unnamed brook assessment unit (NHRIV700060201-17) at the New Pond Shaker Rd. sampling site.

Chl-*a*, DO sat, and cyanobacteria are often response indicators relative to elevated nutrient concentrations such as total phosphorus. Addressing these impairments in freshwaters focuses on the reduction of phosphorus concentrations as it is the limiting factor in chl-*a* concentrations and dissolved

oxygen consumption. Chl-*a* is a photosynthetic plant pigment and its concentration in a waterbody is a measure of algae growth. Increases in chl-*a* concentrations are a response to increased TP concentrations, which promotes plant growth, DO sat is impacted through algal consumption of oxygen through respiration as well as through decomposition of dead and decaying algae and other material. Phosphorus is also a limiting nutrient for photosynthetic cyanobacteria (once known as blue-green algae), which has a similar relationship to chl-*a* and DO sat as algae.

The Primary Contact Recreation impairments for chl-*a* and cyanobacteria are based on General Water Quality Criteria Section Env-Wq 1703.03 (c)(1) c and e of the New Hampshire Surface Water Quality Standards, which requires surface waters be free of substances that produce color or turbidity making the water unsuitable for the designated use, or interfere with recreational activities (NHDES, 2016). Chl-*a* concentrations above 15 µg/L indicate excessive algal growth (in freshwater) that would interfere with recreational activities. A freshwater can be listed as impaired if this threshold is exceeded on two or more occasions. Results from New Pond have exceeded chl-*a* thresholds on three occasions, with two results exceeding the "Magnitude of Exceedance Thresholds" (MAGEX) (Figure 2-4). MAGEX thresholds are typically set well above the water quality criteria outlined in the NHSWQS, as an indicator of poor water quality. The MAGEX threshold for chl-*a* is 30 µg/L for freshwaters, twice the 15 µg/L threshold.

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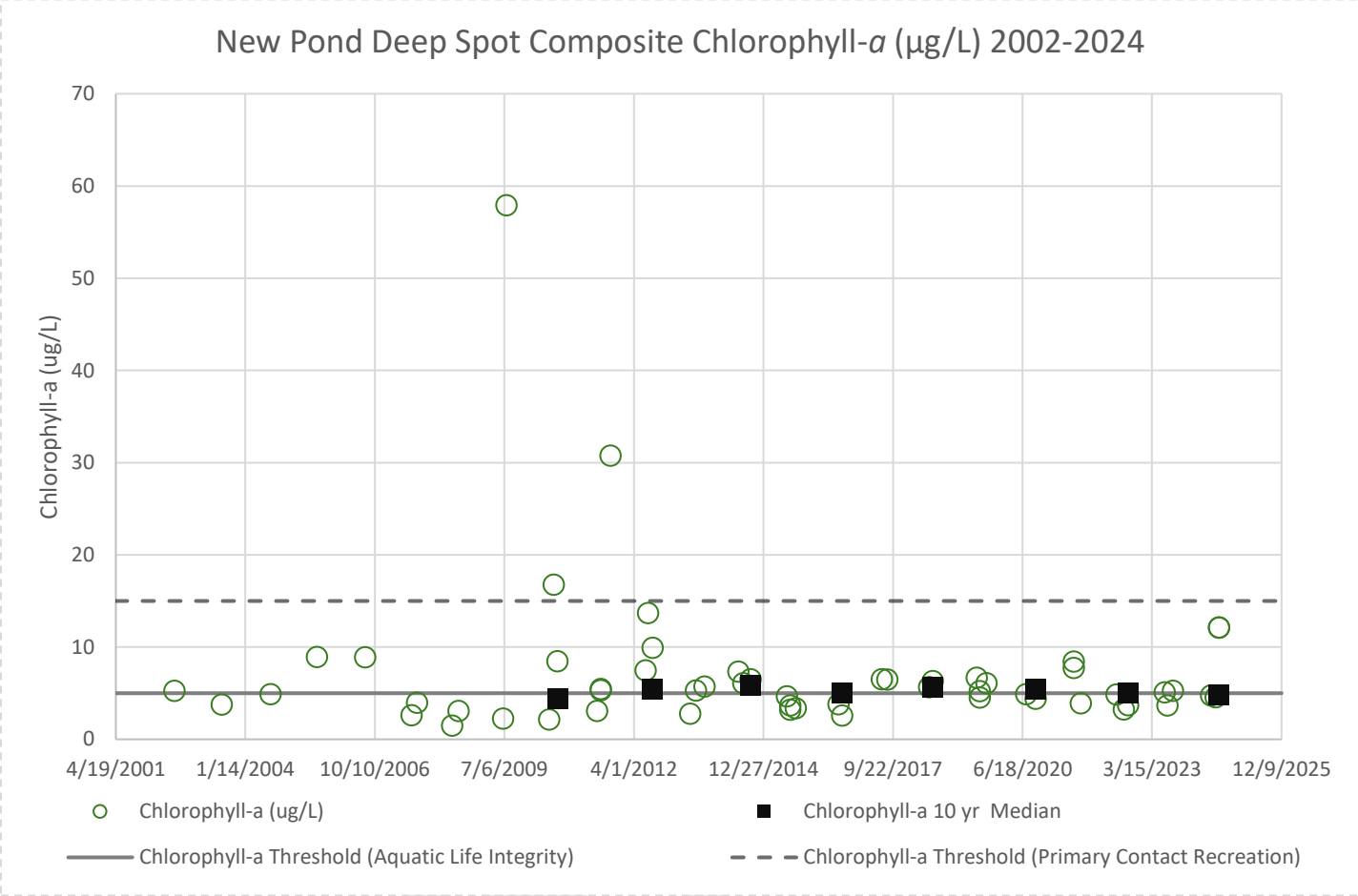
Figure 2-4: New Pond deep spot chlorophyll-*a* results



The cyanobacteria impairment is further supported by New Hampshire Code of Administrative Rules Chapter Env-Wq 1100 Public Bathing Places, which requires beach owners post a cyanobacteria advisory provided by NHDES whenever a toxic cyanobacteria scum is present in the bathing/swimming area that is dominant and represents more than 50% of the algal cell count or the total cell count of cyanobacteria at the beach area is greater than 70,000 total cells/mL of water (Env-Wq 1108.14) (NHDES, 2021). On July 19, 2018, cyanobacteria counts were over 500,000 cells/mL, which resulted in a warning that lasted 19 days for New Pond. On July 20, 2018, the presence of large benthic mats of cyanobacteria were observed at the three New Pond beaches. These results and observations led to the impairment listing for cyanobacteria for New Pond in 2020. Current information regarding cyanobacteria blooms can be found at the NHDES Healthy Swimming website.

Aquatic Life Integrity designated use impairments are determined using a stressor-response decision matrix based on the relationship between TP and chl-*a* as discussed above and summarized in Table 2-3 (NHDES, 2024). The stressor-response matrix is used to assess compliance with NHSWQS Surface Water Quality Criteria Sections Env-Wq 1703.14- Nutrients and Env-Wq 1703.-19- Biological and Aquatic Community Integrity (NHDES, 2016). Assessments for these thresholds consider the trophic status (level of biological activity) of the waterbody. The most recent lake trophic study was completed in 1997, and New Pond was determined to be mesotrophic (NHDES, 1998). As a mesotrophic lake, the chl-*a* threshold concentration is and 5.0 µg/L and the TP threshold concentration is 12.0 µg/L.

Table 2-3: Decision Matrix from the NHDES Consolidated Assessment and Listing Methodology (CALM) to Assign a Final Assessment Category to Phosphorus for Lakes and Impoundments Using the Results from Both Response (i.e., Chlorophyll-a) and Stressor (i.e., Nutrient) Indicators. Chlorophyll-a Will Be Assigned the 'Use Support' Category Determined by the Chlorophyll-a Concentration.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="6">Preliminary Assessment for Stressor Indicator (TP)</td></tr>
<tr><td colspan="2">Category 4 or 5
(Not Supporting)</td><td colspan="2">Category 2
(Fully Supporting)</td><td colspan="2">Category 3
(Insufficient Information)
(See Note b)</td></tr>
<tr><td rowspan="5">Final Assessment for Response Indicator</td><td>Category 4 or 5
(Not Supporting)</td><td colspan="2">Category 4 or 5</td><td colspan="2">Category 3-PNS
(Category 4 or 5 if response is Chl-a)
See Note e</td><td colspan="2">Category 3-PNS
(Category 4 or 5 if response is Chl-a)
See Note e</td></tr>
<tr><td>Category 2
(Fully Supporting)</td><td colspan="2">Category 3-PNS</td><td colspan="2">Category 2</td><td colspan="2">Category 3
See Note b</td></tr>
<tr><td rowspan="4">Category 3
(Insufficient Information)
(See Note b)</td><td colspan="2" rowspan="3">If Response Indicator is 3-PNS, then Category 4 or 5.

If Response Indicator is 3-PAS or 3-ND, then Category 3-PNS.

See Note c</td><td colspan="2" rowspan="3">If Response Indicator is 3-PAS, then Category 2.

If Response Indicator is 3-PNS or 3-ND, then Category 3-PAS.

See Note c</td><td></td><td>3-ND</td><td>3-PAS</td><td>3-PNS</td></tr>
<tr><td>3-ND</td><td>3-ND</td><td>3-PAS</td><td>3-PNS</td></tr>
<tr><td>3-PAS</td><td>3-ND</td><td>3-PAS</td><td>See Note d</td></tr>
<tr><td>3-PNS</td><td>3-ND</td><td>See Note d</td><td>3-PNS</td></tr>
</table>

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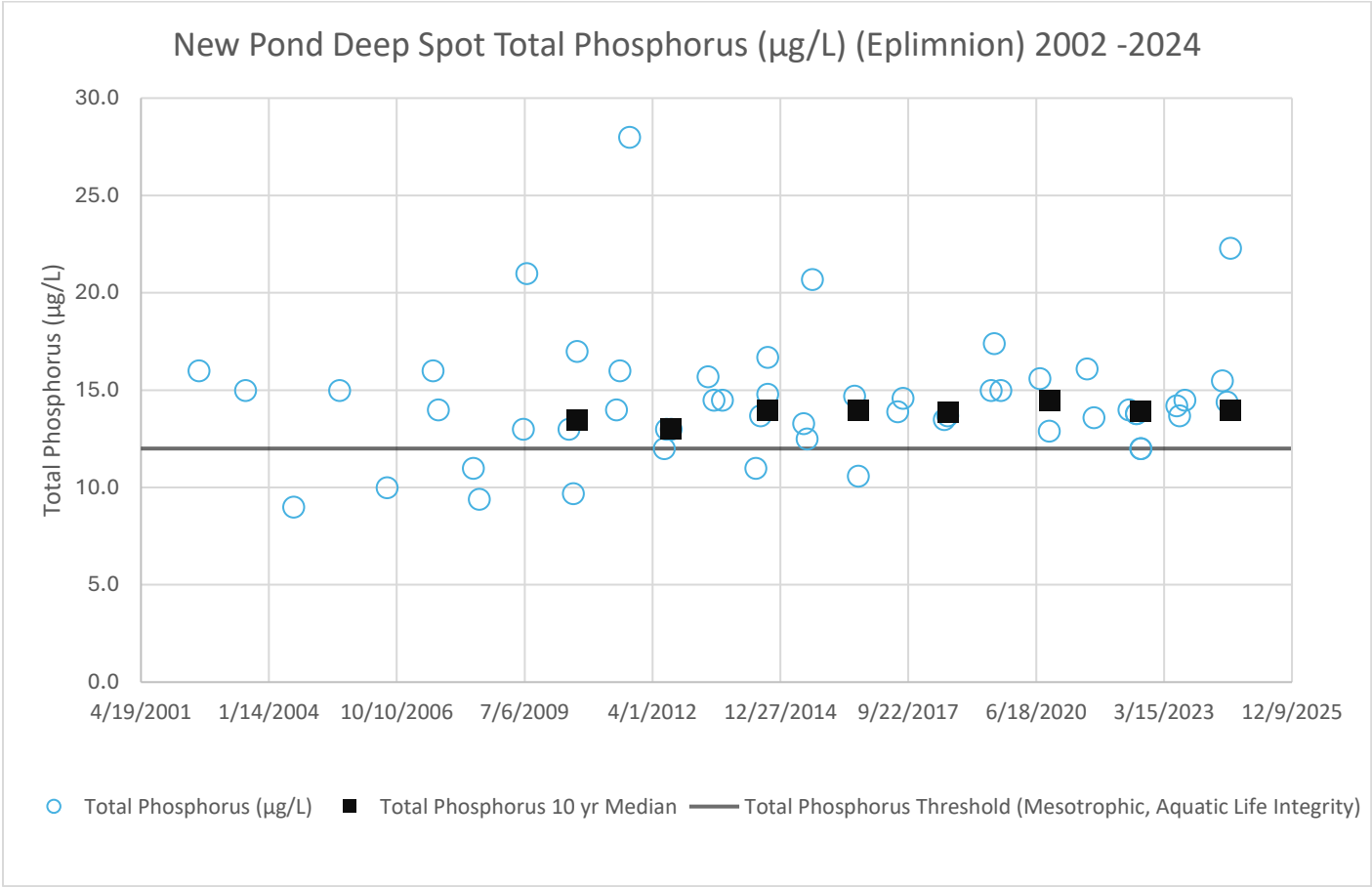
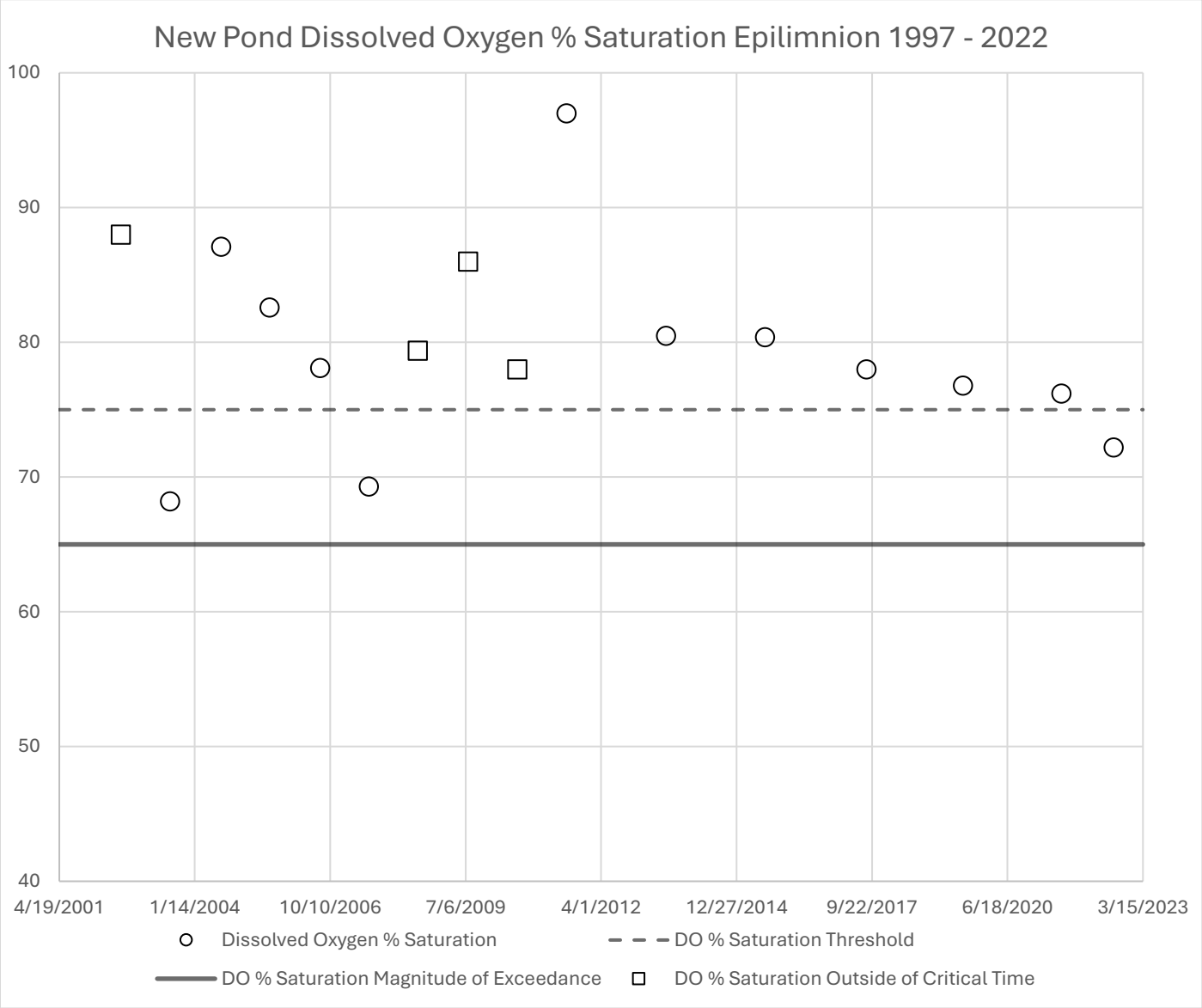
Figure 2-4 shows that 30 of the 56 results were above the 5.0 µg/L threshold for chlorophyll-a. Total phosphorus results exceeded the 12.0 µg/L threshold in 47 of the 54 samples collected between 2002 and 2024 (**Figure 2-5**). These results support the designated use impairment listings for total phosphorus (stressor) and chlorophyll-a (response) for New Pond'

Figure 2-5: New Pond deep spot total phosphorus (epilimnion).



The remaining impairment for the Aquatic Life Integrity designated use for New Pond is dissolved oxygen (saturation) (DO_{sat}). Dissolved oxygen saturation assessment considers the time of day that a sample is taken and defines a critical time between 10 am and 2 pm. This is done to avoid the extremes of the morning that tend to be lower following a night of respiration and the early evening following a day dominated by photosynthesis. Figure 2-6 shows three of the 13 results taken during the critical time were below the 75% DO_{sat} threshold for freshwater lakes, ponds and impoundments leading to the impairment. Dissolved oxygen saturation is also considered a response to the TP stressor.

Figure 2-6: New Pond Dissolved Oxygen Percent Saturation from the deep spot epilimnion. Threshold values represent daily average percent saturation.



2.3 Numeric Water Quality Target

The numeric water quality target for New Pond will be set for TP, as the remaining impairments (chl-*a*, cyanobacteria, and DO sat) are responses to this limiting nutrient. NHSWQS (Env Wq 1700) section 1703.14 states, "Class B waters shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring." This surface water quality standard is assessed through the process discussed in section 2.3. The numeric water quality target for TP is obtained using narrative thresholds based upon the lake trophic status and the stressor-response indicator matrix (Table 2-3).

The New Hampshire Lake Trophic Survey assessed New Pond as mesotrophic for both the 1985 and 1997 surveys. Numeric total phosphorus target concentration for mesotrophic lakes should be set at 12.0 µg/L, unless it is determined that under natural conditions the predicted concentration is higher. As will be discussed in the section 3, the Lake Loading Response Model (LLRM) was used to predict total phosphorus concentrations for several scenarios including a natural (pre-development) condition, which resulted in a prediction of 4.6 µg/L total phosphorus. Therefore, the numeric target of 12 µg/L total phosphorus is appropriate for New Pond.

3.0 Water Quality Modeling

Current loading of TP into New Pond was modelled using the Lake Loading Response Model (LLRM), also known as SHEDMOD or ENSR-LRM. The LLRM assigns export coefficients for different types of land cover/uses within a watershed which allows for estimation of nutrients transported to the pond through runoff and groundwater inputs. The sum of these inputs is determined for a one-year period and combined with additional inputs such as atmospheric deposition, septic system contributions, and direct inputs from waterfowl. The model can also include contributions of phosphorus from pond sediments, known as internal loading, but the conditions for internal loading in New Pond are minimal as it is a shallow non-stratified pond. Therefore, internal loading was not included in the modeling for New Pond. The combination of all phosphorus inputs is referred to as the TP load. Determination of the current load of TP is required for identifying load reduction needs and informing implementation recommendations. References for export coefficients are detailed in the LLRM spreadsheet and are discussed in the Lake Loading Response Model Users Guide and Quality Assurance Project Plan. The prediction of in-lake concentrations of TP was obtained from the means from four models included in the LLRM: Kirchner and Dillon (1975), Larsen and Mercier (1976), Jones and Bachmann (1976), and Reckhow (1977). The LLRM includes results from the Vollenweider (1975) model, but, for the New Pond LLRM, this model was excluded from the results as it overpredicted in-lake TP concentrations in all model runs such as calibration checks and scenarios such as predevelopment.

The New Pond watershed was divided into two basins and three areas of direct drainage, which represent the sub-watersheds (Figure 3-1). The two basins are referred to as North Basin and Blue Boar Basin based on location and proximity to Blue Boar Road, respectively. The basins were identified through the presence of a stream (permanent or ephemeral) that concentrates surface water runoff and conveys it to the pond. Direct drainages lack prominent streams or channels, and stormwater reaches the pond in a more diffuse manner. Direct drainages were named by location: North, East and West Direct Drainages. TP was estimated for each sub-watershed based on the land cover and associated export coefficients. The predicted in-lake TP concentrations from the LLRM were compared to 10 years of observed median and mean values. Perfect agreement between the predicted TP concentrations and observed concentrations was not expected as data are limited and only represent summer values. The summertime bias of observed data leads to an expectation that model results be slightly higher than observed results.

3.1 Hydrologic Inputs and Hydraulics

Hydraulic transport is the primary mechanism for phosphorus to enter New Pond and is a key component for estimating the nutrient load. Providing this information for the LLRM requires the

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calculation of water inputs that account for precipitation, runoff, and baseflow. A 10-year mean (2014-2023) of annual precipitation of 1.06 meters (41.7 inches) was obtained from data collected at the Concord Municipal Airport precipitation gauge (USW00014745). Hydrologic contributions to New Pond are summarized in Table3-1.

Table 3-1: Estimated hydrologic inputs to the New Pond watershed prior to attenuation.

Source	Cubic Meters / Year (m^3/yr)
Atmospheric	132,288
Watershed Runoff	290,753
Watershed Baseflow	491,400
Total	**914,441**

Table 3-2: Estimated hydrologic inputs by sub-watershed for New Pond, Canterbury, NH

Sub-watershed	Runoff (m^3/yr)	Baseflow (m^3/yr)	Attenuation Factor	Estimated Output to New Pond (m^3/yr)
North Basin	144,918	263,574	0.68	277,775
Blue Boar Basin	51,919	91,721	0.68	97,676
North Direct	286	2,289	0.90	2,318
East Direct	70,713	108,014	0.70	125,109
West Direct	22,917	25,800	0.70	34,102
Total	**290,753**	**491,400**		**536,980**

Runoff is the portion of precipitation that is not absorbed by, or adhered to, the landscape and flows over the surface. Runoff was calculated for each sub-watershed by multiplying the mean annual precipitation, sub-watershed area, and a landcover specific runoff coefficient. For example, the North Basin has 60,000 square meters (6 hectares) of low-density residential development within the sub-watershed. The yearly runoff contribution from this area of the North Basin was calculated using a 0.30 runoff coefficient (Dunn & Leopold, 1978). This combined with the mean annual precipitation of 1.06 meters results in a runoff of 19,080 cubic meters of runoff per year contributed to New Pond from areas of low residential development within the North Basin (13% of the North Basin runoff (144,918 m^3/yr)).

Baseflow is a portion of precipitation that is absorbed by the soil and enters the groundwater system that eventually contributes water to the pond. Calculation of baseflow contribution is similar to the runoff calculation and uses baseflow coefficients (Dunn & Leopold, 1978). Using the North Basin as an example again, the baseflow contribution of 15,900 cubic meters per year (6% of the 262,574 m^3/yr

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North Basin baseflow contribution) is the result of multiplying the baseflow coefficient of 0.25 (low density residential development), by the area (60,000 square meters), and 1.06 meters of mean annual precipitation.

Meteorological data, land-use data, and export coefficients are necessary to estimate the potential volume of water generated from different areas of the watershed. However, not all the water originating from within the watershed is discharged into the pond. Additional attenuation (removal) factors such as evapotranspiration and interactions with the physical environment and diverse land uses must be accounted for in the model. These attenuation factors were derived from Dunn & Leopold (1978) and are listed for each basin in Table 3-2 .

3.2 Nutrient Loading

3.2.1 Land Cover Export

Nutrient loading calculations build on the hydrological data described in the previous section. Export coefficients are assigned to land cover type and provide an estimate of the amount of TP transported to the pond through runoff and baseflow associated with a specific land cover type. Figure 3-1 provides a map of the land cover distribution within the New Pond watershed. Land cover in the New Pond watershed was extracted from the 2019 National Land Cover Database (NLCD) imagery which assigns a land cover type in 30 meters by 30 meters pixels/cells (USGS, 2019). Table 3-3 summarizes the TP exported by land cover type for the five sub-watersheds prior to basin attenuation and includes the TP export coefficients. TP load from a particular land cover type is calculated by multiplying the area of the cover type by the export coefficient. For example, in the North Basin sub-watershed there are 6.0 hectares of low-density residential land cover. This area multiplied by the TP export coefficient of 0.34 kg/hectare/year results in an estimated 2.04 kg of TP exported from this land cover type. Not all the TP exported from a land cover type will make it to New Pond as attenuation occurs and the basins retain some of the TP which varies by land cover type. This loss of TP is accounted for using attenuation factors. Larger basins are assigned an attenuation factor of 0.70; and direct drainages are assigned attenuation factors between 0.85-0.90 (Table 3-2). Table 3-4 summarizes similar data but represent total phosphorus loading to New Pond from baseflow.

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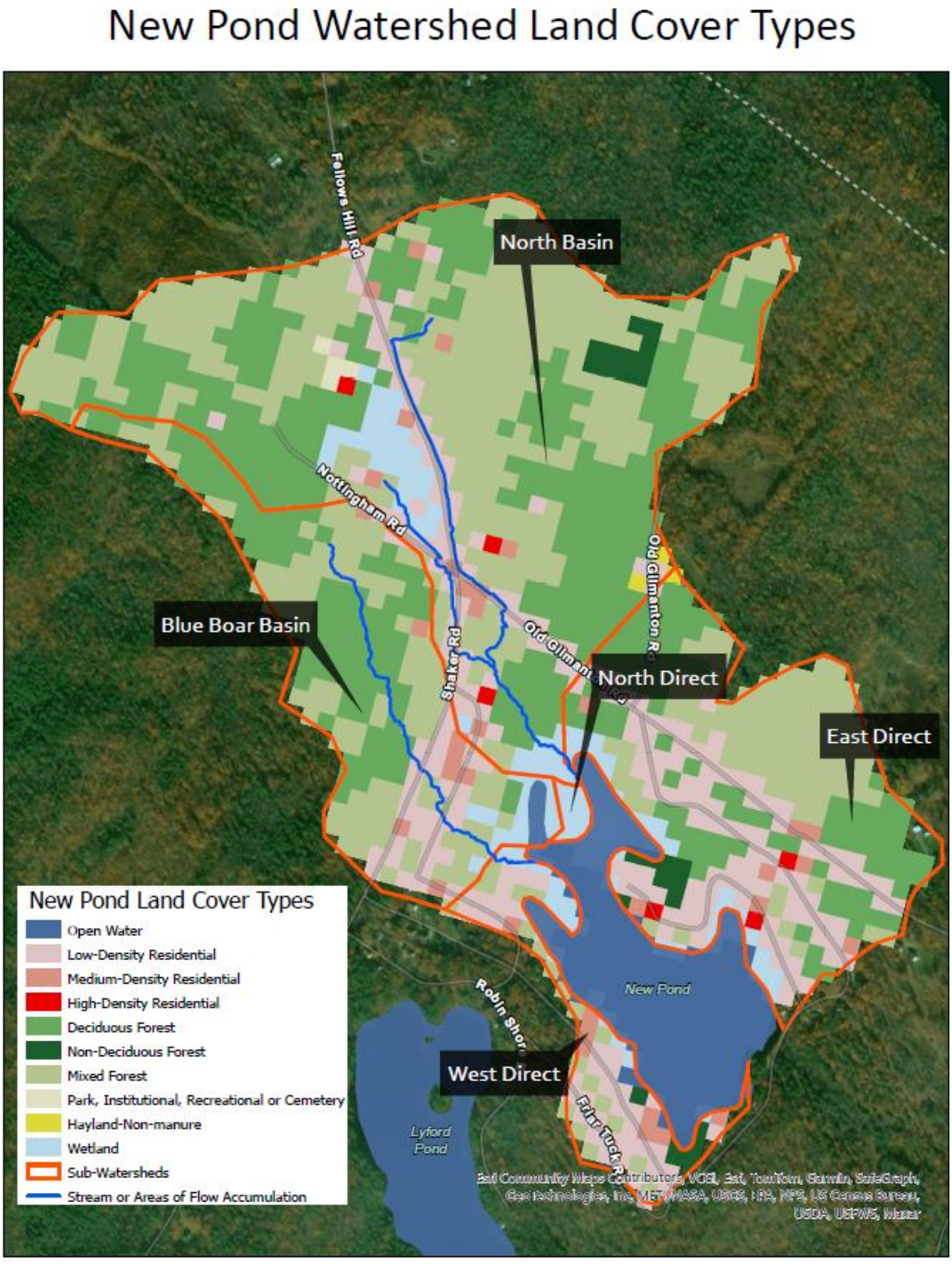
Figure 3-1: New Pond watershed land cover types



The impact of land cover type within a watershed can be illustrated by substituting the low-density residential land cover with deciduous forest land cover in the scenario above. This would reduce the TP export coefficient from 0.34 kg/hectare/year to 0.03 kg/hectare/year and the corresponding total phosphorus load from 2.04 kg to 0.18 kg per year, representing a more than 90% reduction. Recommendations for TP load reductions will be presented in section 7.

The TP load to New Pond combines the watershed load (runoff and baseflow) and direct loads (atmospheric, septic system, and waterfowl). Internal loading for total phosphorus was not included in the model as the pond is not stratified, limiting anoxic (absence of oxygen) conditions and possibilities for internal loading. When dissolved oxygen is present TP solubility is low and remains bound to sediments. All the data and coefficients applied in the LLRM for New Pond are included in Appendix A. Details concerning the source of coefficients are included in the LLRM spreadsheet and are discussed in the Lake Loading Response Model Users Guide and Quality Assurance Project Plan.

Table 3-3: Summary of land cover total phosphorus loading(kg) from sub-watershed RUNOFF with total phosphorus export coefficients used in the Lake Loading Response Model (LLRM) prior to accounting for attenuation.

			Sub-watershed Phosphorus Load (Kilograms)					
Land Cover or Use	**Export Coefficient (kg/ha/yr)**	**Area (Hectares)**	**North Basin**	**Blue Boar Basin**	**North Direct**	**East Direct**	**West Direct**	**Land Cover Totals**
Low-Density Residential	0.34	21.1	2.0	1.0	0.0	2.9	1.3	**7.2**
Medium-Density Residential	0.55	2.5	0.6	0.4	0.0	0.1	0.4	**1.4**
High-Density Residential	0.82	0.6	0.2	0.0	0.0	0.2	0.0	**0.5**
Park, Institutional, Recreational or Cemetery	0.29	0.4	0.1	0.0	0.0	0.0	0.0	**0.1**
Cover Crop	0.8	0.1	0.0	0.0	0.0	0.1	0.0	**0.1**
Hayland - Non-manure	0.37	0.3	0.1	0.0	0.0	0.0	0.0	**0.1**
Deciduous Forest	0.03	50.9	0.8	0.3	0.0	0.4	0.1	**1.5**
Non-Deciduous Forest	0.03	2.6	0.0	0.0	0.0	0.0	0.0	**0.1**
Mixed Forest	0.03	41.3	0.8	0.3	0.0	0.2	0.0	**1.2**
Wetland	0.2	6.4	0.6	0.3	0.1	0.3	0.0	**1.3**
Sub-watershed TOTALS		**126.2**	**5.2**	**2.2**	**0.1**	**4.1**	**1.7**	**13.4**

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Table 3-4: Summary of land cover total phosphorus loading (kg) from sub-watershed BASEFLOW with total phosphorus export coefficients used in the Lake Loading Response Model (LLRM).

		Sub-watershed Phosphorus Load (Kilograms)					
Land Cover or Use	**Total Phosphorus Export Coefficient (kg/ha/yr)**	**North Basin**	**Blue Boar Basin**	**North Direct**	**East Direct**	**West Direct**	**Land Cover Totals**
Low-Density Residential	0.01	0.06	0.03	0.00	0.09	0.04	**0.21**
Medium-Density Residential	0.01	0.01	0.01	0.00	0.00	0.01	**0.03**
High-Density Residential	0.01	0.00	0.00	0.00	0.00	0.00	**0.01**
Park, Institutional, Recreational or Cemetery	0.01	0.00	0.00	0.00	0.00	0.00	**0.00**
Cover Crop	0.01	0.00	0.00	0.00	0.00	0.00	**0.00**
Hayland - Non-manure	0.001	0.00	0.00	0.00	0.00	0.00	**0.00**
Deciduous Forest	0.004	0.11	0.04	0.00	0.05	0.01	**0.20**
Non-Deciduous Forest	0.004	0.00	0.00	0.00	0.00	0.00	**0.01**
Mixed Forest	0.004	0.10	0.04	0.00	0.02	0.00	**0.17**
Wetland	0.004	0.01	0.01	0.00	0.01	0.00	**0.03**
Sub-watershed TOTALS		**0.31**	**0.11**	**0.00**	**0.17**	**0.06**	**0.65**

3.2.2 Atmospheric Deposition

TP contributions to New Pond from atmospheric sources are calculated for the pond surface area (12.48 hectares). Atmospheric sources include TP in rainfall and dryfall (the fall of particles, such as dust, which contain phosphorus). The export coefficient for direct atmospheric deposition is 0.11 kg/hectare/year, results in 1.37 kg TP load to the 12.48-hectare surface area of the pond (Table 3-5) (Schloss, 2013).

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Table 3-5: Total Phosphorus Loading from direct atmospheric deposition to New Pond, Canterbury, NH

	Pond Area (hectare)	Total Phosphorus Export Coefficient (kg/hectare/year)	Total Phosphorus Load (kg)
Direct Atmospheric Deposition	12.48	0.11	1.37

3.2.3 Septic Systems

Direct septic system TP load contributions required an inventory of septic systems around New Pond. Parcels for properties surrounding the lake were identified using the NH Parcel Mosaic – Polygons GIS layer provided by New Hampshire Department of Revenue Administration, and were classified into two groups based on the distance from the shoreline (within less than 100 feet and between 100 – 300 feet). Parcels within these ranges were further classified as year-round (occupied 365 days/year) and seasonal (occupied 90 days/year or less). TP loading was modeled based on assumptions and attenuation factors from Metcalf & Eddy, Inc. (1991). Assumptions included an average household size of 2.5 persons, 0.25 m^3 of water usage per person per day, and an 8.0 mg/L total phosphorus effluent concentration. An attenuation factor of 0.1 was used for properties within 100 feet of the shoreline and an attenuation factor of 0.2 was used for properties between 100 – 300 feet of shoreline.

The classification was informed by residents and members of the Sherwood Forest Shores Association (SFSA). Parcels that were not developed, represented a beach, or did not meet the distance and occupancy criteria, were labeled as “other” and not identified as having a septic system. Figure 3-2 and Table 3-6 provide the results of the inventory, and the resulting total phosphorus loads from septic systems. Further details concerning the calculation of the total phosphorus load from septic systems are available in Appendix A.

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Figure 3-2: Map of tax parcels used to calculate septic system contributions to the total phosphorus load to New Pond, Canterbury, NH.

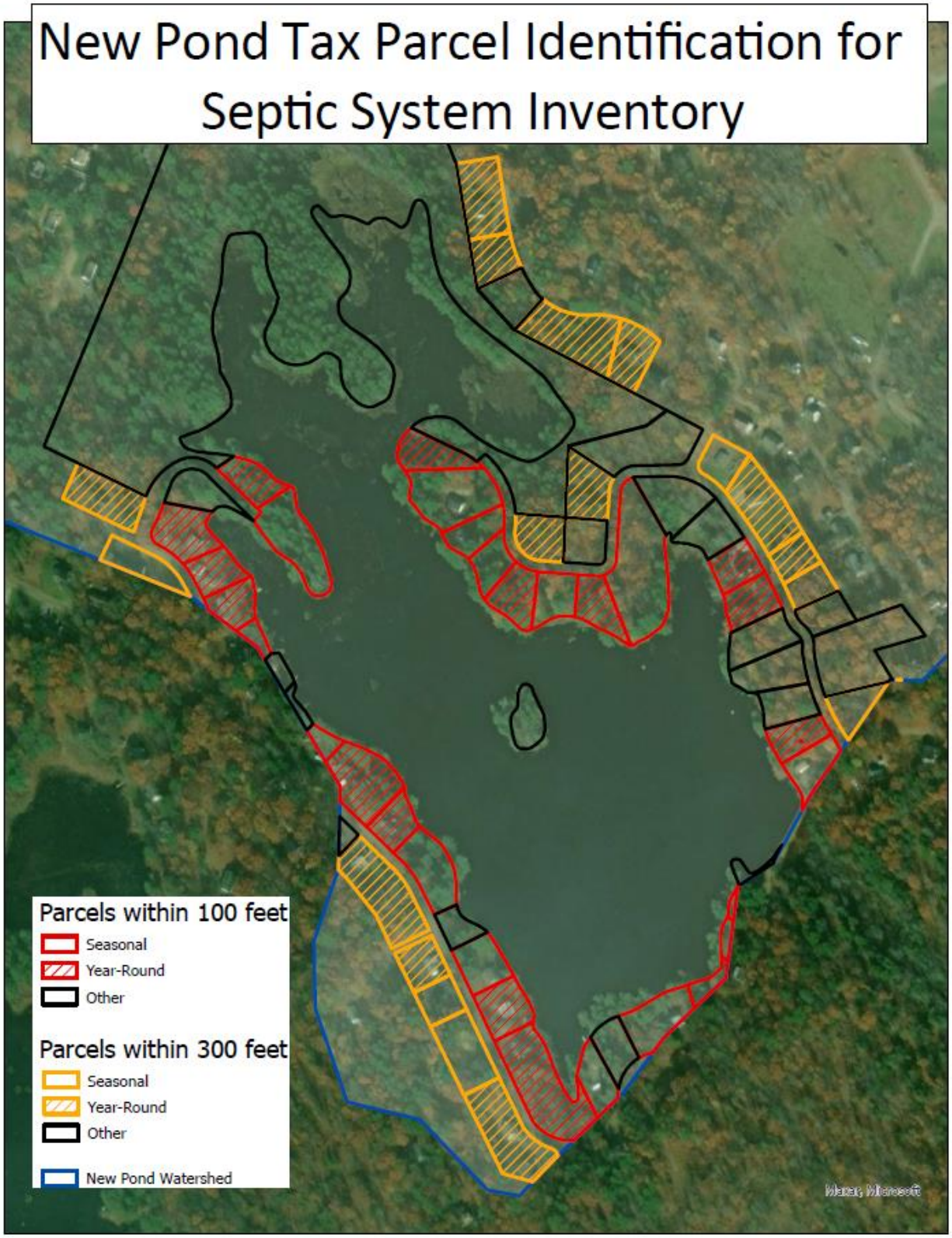

Table 3-6: Septic system inventory and contributions to total phosphorus loading to New Pond Canterbury, NH

Septic System Classification	Distance from Pond (ft)	Days of Occupancy per Year	Number of Septic Systems	Total Phosphorus Load (kg/yr)
Class 1	Within 100	365	14	**5.1**
Class 2	100 - 300	365	12	**2.2**
Class 3	Within 100	90	8	**0.7**
Class 4	100 - 300	90	6	**0.3**
TOTALS				**8.3**

3.3 Current Response to Total Phosphorus Loading

The data summarized in Tables 3-1 through 3-6 were used to model the current response of New Pond to TP loading. Loading values are summarized in Table 3-7 with a TP load of 22.54 kg, which is equal to an input concentration of 33.3 µg/L.

Table 3-7: Summary of water and total phosphorus loading for New Pond, Canterbury, NH.

Yearly Load to Pond	Hydrologic Input (m^3)	Total Phosphorus (kg)	Percent of Total Load
Atmospheric	132,288	1.37	6.1%
Watershed	536,979	10.88	48.3%
Septic Systems	6,719	8.29	36.7%
Waterfowl	n/a	2.00	8.9%
TOTAL	**675,986**	**22.54**	**100%**

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Table 3-8: Lakes Loading Response Model (LLRM) total phosphorus results, mean model values, and observed means (deep spot, n=31) for New Pond, Canterbury, NH.

Model	Predicted Mean Model Total Phosphorus Concentration (µg/L)	Observed Means Total Phosphorus Concentration (µg/L)
Mass Balance (Maximum Concentration)	31.9	
Kirchner and Dillon (1975)	14.3	
Larsen and Mercier (1976)	21.3	
Jones and Bachmann (1976)	23.1	
Reckhow General (1977)	9.8	
Mean (excluding Mass Balance) ± Standard Deviation	**17.1 ± 6.2**	**14.5 ± 3.2**

The predicted mean TP concentration from the LLRM is 17.1 µg/L. This value is within a standard deviation of the mean total phosphorus concentration of 14.5 µg/L for the observed value for the deep spot. The difference between the predicted and observed total phosphorus concentration means may be the result of data only being collected during summer months. The LLRM does not account for seasonal impacts on water quality. During the winter months New Pond is typically ice covered and thermally stratified, which could lead to anoxic conditions on the pond bottom. Anoxic conditions increase the solubility of phosphorus possibly leading to higher concentrations in the water, which would not be observed during summer sampling.

Agreement between models used in the LLRM and observed values for chl-*a* is similar to results for TP. The mean predicted value for chl-*a* is 6.1 µg/L which is 17.3% higher than the 10-year mean for observed values at 5.2 µg/L.

Table 3-9: Lakes Loading Response Model (LLRM) chlorophyll-*a* results, mean model values, and observed means (deep spot, n=28) for New Pond, Canterbury, NH.

Model	Predicted Mean Model Chlorophyll-*a* Concentration (µg/L)	Observed Means Chlorophyll-*a* Concentration (µg/L)
Carlson (1977)	5.3	
Dillon and Rigler (1974)	4.5	
Jones and Bachmann (1976)	5.1	
Oglesby and Schaffner (1978)	6.9	
Modified Vollenweider (1982)	8.6	
Mean ± Standard Deviation	**6.1 ± 1.6**	**5.2 ± 1.5**

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4.0 Total Maximum Daily Load

4.1 Maximum Annual Load

The annual load capacity is defined by the US EPA in 40 C.F.R. § 130.2(f) as, "The greatest amount of loading that a water can receive without violating water quality standards." The loading capacity is to be protective even during critical conditions for TP loading to nutrient enriched lakes, such as during summer when the pond is most biologically active. The LLRM was used to calculate the target annual TP load in (kg TP/yr) from the 12.0 µg/L target in-lake TP concentration discussed in Section 2.4. The TP loads that could practically be reduced were decreased until the target TP in-lake concentration was achieved.

The total maximum annual TP load that is expected to result in an in-lake annual mean TP concentration of 12.0 µg/L was estimated to be 15.9 kg/yr, which represents an approximate 30% reduction from existing conditions Table 4-1.

Table 4-1: Current loading of total phosphorus, target loads, and needed load reductions for New Pond, Canterbury, NH.

Inputs		Current Load (kg/yr)	Target Load (kg/yr)	Load Reductions (kg/yr)	% Reduction
Atmospheric		1.37	1.37	0	0%
Waterfowl		2	1	1	50%
Septic Systems		8.3	8.3	0	0%
Sub-Watersheds	North Basin	3.9	1.9	1.9	50%
	Blue Boar Basin	1.6	0.8	0.8	50%
	North Direct	0.1	0.1	0.1	0%
	East Direct	3.7	1.8	1.8	54%
	West Direct	1.6	0.8	0.8	56%
Annual Load (Modeled)		**22.5**	**15.9**	**6.6**	**29%**

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4.2 Maximum Daily Load

Although a daily loading timescale is not meaningful for ecological prediction or long-term watershed management of lakes and ponds, a daily pollutant load for TP has been calculated to meet the recommendations of the EPA Memorandum, "Establishing TMDL "Daily:" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et. Al., No. 05-5015 (April 25, 2006) and Implications for NPDES permits," which recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment. The lack of long periods of continuous simulation data, flow, and loading data necessitates the application of a statistical estimation of the maximum daily load. Options for expressing daily loads for TMDLs has been published by the EPA and the following expression was used to calculate the maximum daily load (EPA, 2006). The expression assumes that the loading data are log-normal distributed and based on a long-term mean load calculated by the empirical model and an estimation of the variability in loading.

$$MDL = LTA \cdot e^{[z\sigma - 0.5\sigma^2]}$$

Where:

MDL = maximum daily limit
LTA = long-term average (Annual Maximum Load/365 days)
Z = z-statistic of the probability of occurrence
σ = standard deviation
σ^2 = $\ln(CV^2+1)$
CV = coefficient of variation

Previous work performed on 18 watersheds draining to Goose Pond (NHLAK801060103-01) and Bow Lake (NHLAK600030604-01) provided both the standard deviation (1.0) and coefficient of variation (1.1) for total phosphorus loading. The long-term average of 43.56 g/day was calculated by dividing the annual total phosphorus load of 15.9 kg/yr by 365 day and converting the mass to grams. The maximum daily limit (MDL) for total phosphorus for New Pond is 0.14 kg/day or 0.31 lbs/day**.** It should be noted that it is expected that most daily total phosphorus loads will be well below this value, and exceedance of the MDL is more problematic during the more biologically active months. Several days of loads near the MDL would likely lead to algal blooms, including harmful algal blooms. Overall, meeting the annual total phosphorus load is more practical for nutrient management.

4.3 Antidegradation

New Hampshire Administrative Rules Chapter Env-Wq 1708 outlines the antidegradation provisions for surface waters. The purpose of these provisions is to protect and maintain existing designated uses and the associated water quality. Env-Wq 1708.02(a) states that antidegradation shall apply when, "any proposed new or increased activity, including point source and nonpoint source discharge of pollutants, that would lower water quality or adversely affect existing or designated uses". Therefore, this TMDL has been developed assuming no future increase in TP export from the watershed. TP load should be held constant at the 15.9 kg/yr, with any increases in load needing to be offset elsewhere in the watershed.

However, there is no mechanism for regulation or enforcement of TP export from single house lots not requiring a Water Quality Certification or those that fall under the thresholds for alteration of terrain permits (permits are required if there is 100,000 square feet of disturbance proposed or, 50,000 square

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feet proposed disturbance within 250 feet of a lake). Municipalities can regulate development by revising their land use ordinances and regulations to require no additional loading of total phosphorus from new development.

4.4 Critical Conditions and Seasonal Variation

Critical conditions in New Pond typically occur during the summer months when there is more biological activity. During these months excess phosphorus has the potential to stimulate nuisance/harmful algal blooms including cyanobacteria which may have toxic effects. The total phosphorus load was allocated to achieve desired water quality standards during the critical time period that generally spans the summer months. Target TP concentrations were based on summer epilimnetic (surface, or near surface) data applied as a mean annual concentration in the Lakes Loading Response Model (LLRM). The summer epilimnetic concentrations are up to 40% less than mean annual concentrations making them sufficiently low to protect designated uses during critical conditions. Developing the target annual load based on the critical period accounts for seasonal variations as the target load is protective of the most sensitive time of year.

4.5 Reduction Needed

Table 4-1 summarizes the needed TP reductions for in-lake concentration to support designated uses. The Lakes Loading Response Model (LLRM) was used to estimate current and target TP loads. TP load reduction was calculated by subtracting the target TP load (15.9 kg/yr) from the current TP load (22.5 kg/yr). The results indicate a needed reduction target of 6.6 kg TP/yr (29% reduction) to meet the narrative thresholds described in the CALM. Reducing TP loading to achieve the target reduction is predicted to meet the 12.0 µg/L TP threshold for a mesotrophic lake. It is also predicted that the chl-*a* will meet the 5.0 µg/L threshold for a mesotrophic lake with a predicted concentration of 3.8 µg/L.

4.6 TMDL Development Summary

New Hampshire currently has no numerical water quality standard for TP. Assessment for TP relies upon a stressor - response matrix which links responses such as elevated chl-*a* concentrations and low dissolved oxygen to the elevated total phosphorus concentrations stressor. This TMDL is designed to reduce TP and to be protective of New Pond and its designated uses.

Water quality was linked to TP by:

- Choosing a target in-lake TP level, based on historic statewide and in-lake water quality data, best professional judgment, and through consultation with NHDES and EPA, that is sufficient to attain water quality standards and support designated uses. The target in-lake total phosphorus concentration target is 12 ug/L.
- Using the mean of four empirical models that link in-lake TP concentration and load, calibrated to lake-specific conditions, to estimate the load responsible for observed in-lake TP concentrations.
- Determining the overall mean annual in-lake TP concentration from those models, given that the observed in-lake concentrations may represent only a portion of the year or a specific location within the lake.

- Using the predicted mean annual in-lake TP concentration to predict chlorophyll-*a* concentration.
- Using the empirical models to determine the total phosphorus load reduction needed to meet the numeric concentration target.
- Using a geographical information based (GIS) based spreadsheet model to provide a relative estimate of loads from watershed land areas and uses under current and various projected scenarios to assist stakeholders in developing total phosphorus reduction strategies.

A reasonably reliable estimate of TP loading was accomplished using the LLRM with available water quality and watershed data. It offers an estimate of the direction and magnitude of change necessary to support the designated uses protected by NHDES.

5.0 TMDL Allocation

The allocations for the New Pond TMDL are expressed as both annual loads and daily loads. However, annual loads better align with the design and implementation of watershed and lake management strategies. The TMDL requires an allocation of the total load of the resource. The allocation includes a waste load allocation (WLA), load allocation (LA) and margin of safety (MOS). Including the reserve capacity in the calculation is optional, allowing for consideration of future development and changes in pollutant loads. Reserve capacity was not included in the allocation for New Pond because this TMDL has been developed assuming no future increase in total phosphorus export from the watershed (Section 4.3 Antidegradation). The sum of these allocations is equal to the target annual load or TMDL for the resource. Each of these allocations is defined in detail in the following subsections. Seasonal variation is also included in the loading allocations.

The TMDL equation for the New Pond TMDL analysis is as follows:

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

In the case of New Pond, the TMDL is equivalent to the target annual load of 15.9 kg/yr. Allocations of this load are described below.

5.1 Wasteload Allocations (WLAs) and Load Allocations (LAs)

Wasteload allocations (WLAs) are assigned to point source pollution loads. A point source is a discrete conveyance of waste through a pipe, ditch, channel, tunnel or container. Point sources may include stormwater outfalls and runoff when assigned to a National Pollutant Discharge Elimination System (NPDES) permit such as Municipal Separate Storm Sewer System (MS4) permit or through Residual Designation. There are no point source loads in the New Pond watershed, therefore no waste load allocations have been assigned.

Load allocations (LA) are assigned to nonpoint sources of pollution and may include diffuse stormwater runoff, base flow, septic systems, internal recycling, waterfowl and atmospheric deposition. These sources are accounted for in New Pond except for internal recycling. As a shallow non-stratified pond internal recycling is considered insignificant. Table 6-1 details several loading scenarios including the

current load (22.5 kg/yr) and the target load (15.9 kg/yr). The target load of 15.9 kg/yr represents the LA for New Pond, an overall load reduction of 29%.

5.2 Margin of Safety

In TMDLs the margin of safety (MOS) is included in the calculation to account for the uncertainty associated with how well the empirical model represents the actual environment. The MOS can be either implicit or explicit. An explicit MOS sets a value, such as 10%, which is calculated as a portion of the target load for the TMDL. An implicit MOS is not assigned a value and is not directly calculated as a portion of the target load. An implicit MOS is appropriate when the assumptions used to develop the TMDL are conservative enough to sufficiently account for the MOS.

The New Pond TMDL MOS is implicit and based upon the use of data mainly collected in the summer months as well as setting the in-lake target TP concentration to 12 µg/L. Setting the in-lake target based on summertime epilimnetic conditions provides an MOS as the LLRM provides a mean annual concentration. It has been reported that mean annual TP concentrations are often 14% to 40% higher for summer concentrations (Nurnberg, 1996) (Nurnberg, 1998). As a result, absence of fall, winter, and spring data in the model implicitly provides the MOS for the New Pond TMDL.

6.0 Evaluation of Alternative Loading Scenarios

The Lakes Loading Response Model (LLRM) was used to evaluate five alternative loading scenarios to predict TP loads. The scenarios are summarized in Table 6-1.

Table 6-1: Alternative loading scenarios including predicted annual loads, load reductions, and load reductions originating from the watershed.

Inputs		Current Load (kg/yr)	No Septic (kg/yr)	No Waterfowl (kg/yr)	Predevelopment (kg/yr)	Target Load (kg/yr)
Atmospheric		1.37	1.37	1.37	1.37	1.37
Waterfowl		2	2	0	2	1
Septic Systems		8.3	0	8.3	0	8.3
Sub-Watersheds	North Basin	3.9	3.9	3.9	1.9	1.9
	Blue Boar Basin	1.6	1.6	1.6	0.7	0.8
	North Direct	0.1	0.1	0.1	0.1	0.1
	East Direct	3.7	3.7	3.7	1.0	1.7
	West Direct	1.6	1.6	1.6	0.2	0.7
Annual Load		**22.5**	**14.2**	**20.5**	**7.3**	**15.9**
Load Reduction kg/yr (%)		**0 (0%)**	**8.3 (37%)**	**2.0 (8.9%)**	**15.2 (67%)**	**6.6 (29%)**
Load Reduction from Watershed kg/yr (%)		**0 (0%)**	**0 (0%)**	**0 (0%)**	**7.0 (64%)**	**5.7 (52%)**

The current load represents baseline conditions and was calculated using recent data and conditions. The baseline conditions are the conditions that currently exist that are leading to the impairments related to elevated TP concentrations. The remaining scenarios provide insights into how TP concentrations may respond to changes within the watershed (Table 6-2).

Table 6-2: Water quality responses to different loading scenarios using the Lakes Loading Response Model (LLRM). Details on empirical models used to calculate means are available in Appendix A Lakes Loading Response Model Coefficients and Scenarios (Baseline and Target).

Inputs	Current Load	No Septic	No Waterfowl	Pre-development	Target Load
Total Phosphorus Load (kg/yr)	22.5	14.2	20.5	7.3	15.9
Mean Annual Total Phosphorus (µg/L)	17	11	16	6	12
Mean Secchi Disk Transparency (m)	2.6	3.7*	2.8	6.2*	3.4*
Mean Chlorophyll-a (µg/L)	6.1	3.3	5.4	1.2	3.8
Peak Chlorophyll-a (µg/L)	21.3	12.1	19	5.1	13.8
Probability of Summer Bloom (Chlorophyll-a > 15 µg/L)	2%	0.1%	1.1%	0%	0.1%

*Secchi disk depth values exceed maximum depth of 3.0 m for New Pond.

6.1 Septic System Removal (No Septic)

The predicted results for removing the TP load added to New Pond from septic systems, are summarized in Table 6-2. Removing septic loading could occur if existing septage was sewered. Removing the 8.3 kg/yr TP septic system load from the baseline model scenario yields predicted mean annual results for TP (11 µg/L) and chl-*a* (3.3 µg/L) that meet NHSWQS. Summer bloom probability (chl-*a* > 15 µg/L) would reduce from 2% to 0.1%. It is important to note that values used from TP export from septic systems are assuming proper system operation, and do not account for failing or inadequate systems, which should be addressed as they are discovered.

6.2 Waterfowl Load Reduction

This scenario examines the impact of reducing the load from waterfowl to zero. This differs from the baseline by 2.0 kg/yr for TP. The response of the model to this reduction of TP predicted a mean annual TP load of 16 µg/L and 5.4 µg/L for mean chlorophyll-a. Additionally, the probability of summer blooms (chlorophyll-a > 15 µg/L) is reduced from 2% to 1.1%. The modeled reductions do not result in water quality that would meet standards for Primary Contact Recreation and Aquatic Life Integrity designated uses. This scenario provides some insight into the impact waterfowl have on TP inputs, which can have management implications.

6.3 Pre-development

The pre-development scenario is intended to provide model results that would represent natural conditions and highlight the natural background total phosphorus load, with no development within the pond watershed. The natural background accounts for non-anthropogenic sources and simulates the condition and loading expected from the landscape in its natural condition. Setting the LLRM to these conditions provides a lower limit for TP loading, providing valuable insights for management of TP in the New Pond watershed.

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To accomplish this in the model, all developed lands were converted to mixed forest, septic system load was removed, and waterfowl and atmospheric loads remained the same. The model results showed a reduction in annual TP loading by 15.1 kg/yr and predicted mean annual totals of 6 µg/L and 1.2 µg/L for TP and chl-*a*, respectively. Overall, a 64% reduction of the TP load in the watershed. The probability of a summer bloom (chl-*a* > 15 µg/L) reduces to 0%.

6.4 Target

As discussed in previous sections and summarized in Table 6-2, this TMDL is intended to meet the in-lake TP target for mesotrophic lakes set at 12.0 µg/L. To achieve this, an estimated 29% reduction in TP is needed (Table 4-1 and Table 6-2). Executing the model through the different scenarios summarized above, provides insights into possible source load reductions. The target load scenario simulated the need for a 50% reduction in waterfowl population and a 52% reduction in loading from the surrounding watershed to meet the 12.0 µg/L TP threshold for water quality standards. Though these watershed reductions may seem high, they are within the ranges of recommended pollutant removal strategies, which range from 60 to 70% (Winer, 2000). Reductions may be sought from other sources such as septic systems, but the lack of detailed information on septic system construction, operation, performance, and maintenance, makes it difficult to assign specific management strategies that would reduce TP loading. The target load scenario is only one example of a combination that could reduce TP loading to achieve the 12.0 µg/L threshold, other combinations are possible. Though the target load provides a reasonable accounting for TP contributions to New Pond, a combination of reduction measures implementation is typically needed to meet load reduction goals.

7.0 Implementation

This TMDL identifies a TP load reduction of 6.6 kg/yr (29%) (Table 6-1), it is likely that most of this reduction will be realized from watershed reductions. The target load scenario identifies a 5.7 kg/yr reduction from the watershed, accounting nearly 86% of the 6.6 kg/yr total reduction needed (Table 6-2). As this TMDL assumes no future increases in phosphorus loading from the watershed, it is recommended that the Town of Canterbury and the Sherwood Forest Shores Association (SFSA) adopt practices, measures, and, when appropriate, municipal ordinances that protect water quality,.

Many practices that can be adopted are known as stormwater control measures (SCMs) and are largely focused on limiting pollutant loading from storm water runoff. SCMs are classified into three general categories: low-impact development (LID) practices, non-structural SCMs, and structural SCMs. Low impact designs (LIDs) are landscape management approaches and practices intended to reduce runoff and pollutant loading through stormwater runoff management (EPA, 2012). Examples of LID include development of rain gardens, vegetated swales, and green roofs, all designed to limit direct runoff of stormwater to surface waters. Nonstructural SCMs are designed to reduce the contact of stormwater with potential pollutant sources. Leaf litter removal, street sweeping and catch basin cleanout are examples of nonstructural SCMs. Structural SCMs are physical structures that reduce the amount of stormwater runoff and/or reduce stormwater pollutant concentrations. Common structural SCMs are permeable pavements and the installation of rain barrels. The New Hampshire Stormwater Manual provides detailed information for SCM selection, design and planning as well as additional information relevant to watershed protection (UNH Stormwater Center, 2025).

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Reduction of total phosphorus exports from the watershed can be achieved by employing some of the SCMs detailed in the New Hampshire Stormwater Manual and are summarized in Table 7-1. It is important to note that implementing SCMs to reduce total phosphorus often have the added benefit of reducing other pollutants such as total nitrogen, total suspended solids, and bacteria. Appendix A of the manual provides fact sheets to assist with SCM selection and implementation using a tiered approach to help identify the effectiveness of the measures.

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Table 7-1: General Suitability of Stormwater Control Measures (SCMs) to Treat Common Stormwater Pollutants from the New Hampshire Stormwater Manual.*

	Applicable EPA Performance Curve[2]	Pollutant of Concern				
		TN	TP	TSS	Metals[3]	Bacteria[4]
Nonstructural Source Controls[5]						
Catch Basin Cleaning	--	No	No	No	No	No
Leaf Litter Pickup	--	No	No	No	No	No
Snow and Ice Management	--	No	No	No	No	No
Street Sweeping	--	No	No	No	No	No
Structural Treatment						
Bioretention System (Infiltrating)	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
"Hybrid" Bioretention System	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
Infiltration Basin	Infiltration Basin	Yes	Yes	Yes	Yes	Yes
Infiltration Trench	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Permeable Pavement (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Subsurface Infiltration Chamber	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Bioretention System (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Bioretention with ISR (Filtering)	Biofiltration with ISR	Yes	Yes	Yes	Yes	Yes
Permeable Pavement (Filtering)	Porous Pavement	Yes	Yes	Yes	Yes	Yes
Dry Well	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Gravel Wetland	Gravel Wetland	Yes	Yes	Yes	Yes	Yes
Impervious Area Disconnection	IA Disconnection	Yes	Yes	Yes	Yes	Yes
Leaching Catch Basin	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Roof Drip Edge (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Roof Drip Edge (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Stormwater Wetland	Gravel Wetland	Yes	Yes	Yes	Yes	Yes
Tree Box Filter (Infiltrating)	Infiltration Trench	Yes	Yes	Yes	Yes	Yes
Tree Box Filter (Filtering)	Biofiltration	No	Yes	Yes	Yes	Yes
Extended Dry Detention Pond	Dry Pond	No	No	No	Yes	Yes
Flow-Through Treatment Swale	Grass Swale	No	No	Yes	No	No
Green Roof	N/A - reduces EIC	No	No	No	No	No
Rain Barrel/ Cistern (with reuse)	IA Disconnection (Storage)	No	No	No	No	No
Sand Filter	Sand Filter	No	Yes	Yes	Yes	Yes
Wet Pond	Wet Pond	No	Yes	Yes	Yes	No

*Please see the New Hampshire Stormwater Manual for additional information and context including details on footnotes.

In addition to SCMs, erosion and sediment control measures (E&SC) can also be adopted and implemented to reduce TP export from the watershed during proposed construction. Eroded soils and sediments can transport additional TP from the watershed to New Pond. Development of E&SC plans could provide protection against additional TP export related to future development and redevelopment. E&SC measures are designed to reduce soil and sediment transport associated with construction and redevelopment. As with SCMs, the New Hampshire Stormwater Manual is a valuable resource for providing guidance on E&SC measure selection and implementation. Table 7-2 summarizes selection guidance and includes references to New Hampshire's Code of Administrative Rules Chapter Env-Wq 1500 Alteration of Terrain (NHDES, 2024). Appendix B of the New Hampshire Stormwater Manual provides fact sheets for the selection of E&SC measures.

Table 7-2: Selection of Construction Period Erosion and Sediment Control Measures from the New Hampshire Stormwater Manual.*

Stormwater Control Measure	Env-Wq-1500 Reference	Control Objective													
		Cold Weather Stabilization	Prevent natural resource degradation	Prevent soil displacement by raindrop splash	Prevent sheet and rill erosion	Prevent wind erosion	Prevent gully erosion	Convey construction runoff	Intercept sediment, sheet flow, slope length < 100 ft	Intercept sediment, sheet flow, slope length > 100 ft	Intercept sediment, area < 5 acres	Intercept sediment, area > 5 acres	Intercept sediment from construction traffic	Intercept sediment from excavation dewatering	Enhance settling of fine silts and clays
Erosion Control Measures															
Construction Phasing	1505.03-1505.06	●	●	●	●	●	●								
Dust Control	--	○	●			●									
Surface Roughening	--	○	●		●		●			○					
Soil Stockpile Practices	--	●	●	●	●	●									
Temporary and Permanent Mulching	1506.01	●	●	●	●	●									
Temporary and Permanent Vegetation	1506.02		●	●	●	●	●								
Temporary Erosion Control Blanket and Matting	1506.03	●	●	●	●	●	●								
Diversion Ditch/ Berm	1506.12	●	●		●		●	●		○					
Slope Drain	--		●				●	●							
Tree Preservation and Protection	--														
Sediment Control Measures															
Silt Fence	1506.04	●	●						●		○				
Turbidity Curtain	--														
Erosion Control Mix Berm	1506.05	●	●						●		○				
Filter Sock	--														
Straw or Hay Bale Barrier[2]	1506.06	●	●						●		○				
Temporary Check Dam	1506.07	○	●								○				
Temporary Storm Drain Inlet Protection	1506.08	●	●								○				
Temporary Construction Exit	1506.09	●	●										●		
Temporary Sediment Trap	1506.10	○	●								●			●	
Temporary Sediment Basin	1506.12	○	●								●	●		●	
Construction Dewatering	1506.11	○	●					●						●	
Flocculants	1506.13		●												●

*Please see the New Hampshire Stormwater Manual for additional information and context including details on footnotes.

Additional resources exist for homeowners and small businesses to select and implement SCMs. Soak Up the Rain New Hampshire is a volunteer program managed by NHDES providing guidance to help mitigate stormwater impacts. NH Lakes is a nonprofit organization with the mission to restore and preserve the health of New Hampshire's lakes. In addition to informational resources, NH Lakes manages the Lake Smart Program, which encourages community members to adopt practices that help protect water quality. Development of septic rules, such as those adopted by the Town of Sunapee, can also be effective as the rules require private septic systems within 250 feet of lakes and ponds over 10 acres to be pumped once every three years. Additionally, septic system inspections take place upon the sale of these properties, as well as any waterfront property in the state on lakes greater than 10 acres, as a requirement of RSA 485-A:39.

The total phosphorus load from waterfowl is currently estimated at 2.0 kg/yr. The target load allocates 1.0 kg/yr to waterfowl (Table 6-1). It is recognized that loading from waterfowl is an approximation that could be improved with more detailed observations and surveys. Contributions from waterfowl can fluctuate from year to year based on migration, breeding and overwintering patterns. Phosphorus contributions can be reduced through elimination of waterfowl feeding, using visual deterrents (i.e. coyote decoys), and shoreline vegetated buffers.

The TMDL process is intended to give a direction and goal for watershed planning and management. Planning and management require continued water quality monitoring. Planning should be adjusted as necessary as water quality conditions improve, deteriorate, or respond unexpectedly.

7.1 Grants and Loans

7.1.1 Clean Water Act Section 319 Grants

Though limited, a funding opportunity exists through the CWA §319, which was established to assist nonpoint source control efforts. This grant money can be used for technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring aimed at reducing nonpoint source pollutant loading (EPA, 2024). Watershed management plans developed using CWA §319 funds are required to include the following nine elements (also known as elements a.) through i.) identified by the USEPA (EPA, 2024):

- Identification of causes of impairment and pollutant sources.
- An estimate of the load reductions expected from management measures.
- A description of the nonpoint source measures needed to achieve load reductions.
- An estimate of the technical and financial assistance needed and the cost.
- An information and education component.
- A schedule for implementation.
- Description of milestones to determine if goals are being met.
- Criteria to determine progress in reducing loads.
- Monitoring to evaluate effectiveness of implementation efforts over time.

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This TMDL directly addresses the first two elements and indirectly parts of the other elements. Further information concerning CWA §319 in New Hampshire is available at the NHDES Watershed Assistance Grants website.

7.1.2 Clean Water Act Section 604(b) Water Quality Planning Grants

CWA §604(b) Water Quality Planning Grants support local initiatives for water quality management planning. Eligible recipients include, but are not limited to, municipalities, regional planning commissions, watershed associations, and lake, pond, river or estuary associations. Projects eligible for funding include: conducting monitoring to address specific water quality concerns; planning stormwater retrofits to address water quality impairments; green infrastructure to manage wet weather; working with municipalities committed to adopting specific model ordinances to address water quality planning concerns; and developing watershed-based plans that include the 9 required elements (a through i) outlined in section 7.1.1. Preference is given to projects aligning with priorities identified in the New Hampshire Nonpoint Source Pollution Program Plan 2025-2029 (NHDES, 2024). Further information concerning CWA §604(b) in New Hampshire is available at the NHDES Watershed Assistance Grants website.

7.1.3 Clean Water State Revolving Fund

The Clean Water State Revolving Fund (CWSRF) program provides low cost financing for water quality planning infrastructure projects including nonpoint source pollution control, stormwater runoff mitigation, and green infrastructure (EPA, 2025). Funding is also available for water pollution control, watershed protection and watershed restoration projects. Some CWSRF programs initiatives have received 100% principal forgiveness for select stormwater planning evaluations, including the development of watershed-based (a through i) plans (NHDES, 2024). Further information concerning the CWSRF Loan Program in New Hampshire is available at the NHDES Clean Water State Revolving Fund Program website.

7.1.4 Conservation Grant Program

The Conservation Grant Program is managed by the New Hampshire State Conservation Committee. These grants are competitive and are funded through the Conservation & Heritage License Plate Program and are also known as “Moose Plate” grants. Eligible applicants include (NHDAMF, 2025):

- County Conservation Districts.
- County Cooperative Extension Natural Resources.
- Municipalities, including agencies and commissions engaged in conservation programs.
- Qualified nonprofit organizations engaged in conservation programs.
- Public and private schools (kindergarten through Grade 12).
- Scout groups.

Six focus areas identified by the Conservation Grant Program include areas relevant to New Pond and its watershed:

- Water Quality and Quantity: Restore, enhance, maintain or protect.

- Wildlife Habitat: Create, restore, enhance, manage or protect.
- Soil Conservation and Flooding: Reduce or prevent erosion or improve soils.
- Best Management Practices: Plan and implement for agriculture, storm or forestry.
- Conservation Planning: Accomplish a conservation project or outcome that includes a public involvement component.
- Land Conservation: Permanent land protection through conservation easement or fee acquisition and/or associated transaction and stewardship costs.

Moose Plate funding is entirely nonfederal and can be used to match CWA §319 Watershed Assistance Grant funds when project goals meet the criteria for each funding program (NHDES, 2024).

8.0 Monitoring Plan

Water quality monitoring has occurred on New Pond since 1985 but did not become consistent until 2002. The most recent 10 years of data were used for the purposes of developing this TMDL and for water quality modeling. The primary site for water quality modeling was the deep spot (Figure 2-4). Water quality samples collected during the summer are commonly analyzed for epilimnetic total phosphorus, chlorophyll-a, Secchi disk transparency, and dissolved oxygen.

The NHDES Volunteer Lake Assessment Program (VLAP) has been the primary monitoring program active on New Pond. VLAP is a citizen-based lake sampling program aimed at assisting NHDES in evaluating lake quality throughout the state. New Pond has an active VLAP collaboration with members of the SFSA and NHDES. The SFSA is a homeowners' association that manages the Sherwood Forest Shores Subdivision in the Town of Canterbury. Samples collected by volunteers are analyzed for alkalinity, chlorophyll-*a*, chloride, color, pH, Secchi disk transparency, specific conductance, total phosphorus, and turbidity. It is recommended that VLAP sampling continues to allow future assessments and to document water quality responses to changes in the watershed. In addition to the water quality parameters typically analyzed through the VLAP program it is recommended that dissolved oxygen (DO) concentration and saturation be added to assess the response to changes in total phosphorus concentrations. DO should be monitored at multiple depths to develop a vertical profile. If possible, attempts should be made to collect water quality samples during a variety of weather conditions to assist assessment efforts.

Low density development dominates the shoreline and adjacent areas of New Pond (Figure 3-1). As a result, septic systems represent a significant source of total phosphorus loading (37%) to New Pond (Table 6-1). A survey of septic systems would help confirm model input, including the assumption that there are no failed septic systems. Additionally, bird counts should be regularly recorded to better quantify and understand the contribution of waterfowl to total phosphorus loading and the efficacy of mitigation efforts.

Prior to implementation of any new monitoring activities associated with this TMDL, it is recommended that NHDES be consulted to help ensure that the monitoring plan will achieve its objectives. Monitoring assistance from NHDES is contingent on the availability of sufficient staff and funding.

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9.0 Reasonable Assurances

The TMDL provides reasonable assurances that nonpoint source reductions will occur by providing information on the cooperative efforts of the NHDES and watershed stakeholders to initiate the process of addressing nonpoint source pollution in the watershed. The successful reduction in nonpoint TP loading, however, depends on the willingness and motivation of stakeholders to get involved and the availability of federal, state and local funds, similar to those introduced in Section 7.1.

Section 5.1 describes how non-regulated load allocations for nonpoint sources were determined. NHDES fully acknowledges that it will take a concerted effort to reduce phosphorus loading to the maximum extent practicable from as many sources as possible to fully support designated uses in this waterbody. In some cases, phosphorus reductions from individual sources can and should be greater than the prescribed reductions in this TMDL, and to compensate for areas of the watershed where greater reductions are not attainable.

10.0Public Participation and Substantive Changes

This section will be completed following the public comment period

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References

Dunn, T., & Leopold, L. B. (1978). *Water in Environmental Planning.* San Francisco, CA: W.H. Freeman and Company.

ENSR. (2007, September). *Determination of Total Maxium Daily Load (TMDL) for 158 Acid Impaired and 21 Aluminum Impaired New Hampshire Ponds*. Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/final-acid-lake-tmdl-report-158-lakes.pdf

EPA. (2006). *Establishing "Daily" Load in Light of the Decision by the U.S. Court of Appeal for the D.C. Circuit in Friends of teh Earth, Inc. v. EPA, No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.*

EPA. (2012). *Terminology of Low Impact Development.* Washington, DC: United States Environmental Protection Agency.

EPA. (2023b, August 11). *Identifying and listing impaired waters under clean water act*. Retrieved from www.epa.gov: https://www.epa.gov/tmdl/identifying-and-listing-impaired-waters-under-clean-water-act

EPA. (2023d, November 14). *Overview of Total Maxium Daily Loads (TMDLs)*. Retrieved from https://www.epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls

EPA. (2024, June 24). *319 Grant Program for States and Territories*. Retrieved from www.epa.gov: https://www.epa.gov/nps/319-grant-program-states-and-territories

EPA. (2024, August 8). *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. Retrieved from www.epa.gov: https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

EPA. (2024, July 25). *United State Environmental Protection Agency*. Retrieved from What are the Effects of HABs: https://www.epa.gov/habs/what-are-effects-habs

Maine DEP. (2025, 01 03). *Maine Stormwater Best Management Practices Manual*. Retrieved from www.maine.gov: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/

NEIWPCC. (2007, October 24). *Northeast Regional Mercury Total Maximum Daily Load*. Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/final-mercury-tmdl-report.pdf

NHDES. (1998). *Lake Trophic Data - New Pond, Canterbury NH.* Concord, NH: NHDES.

NHDES. (2008a). *New Hampshire Stormwater Manual.* Concord, NH: New Hampshire Department of Environmental Services.

NHDES. (2008b). *New Hampshire Stormwater Manual: Volume 2 Post-Construction Best Management Practices Selection & Design.* Concord, nh: New Hampshire Department of Environmental Services.

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NHDES. (2008c). *New Hampshire Stormwater Manual: Volume 3 Erosion and Sediment Controls During Construction.* Concord, NH: New Hampshire Department of Environmental Services.

NHDES. (2016, December 1). *New Hampshire Code of Administrative Rules Chapter: ENV-Wq 1700 Surface Water Quality Standards.* Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/Env-Wq%201700.pdf

NHDES. (2019). *NHDES' Lake Trophic Survey Program.* Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/bb-16.pdf

NHDES. (2020). *New Hampshire Department of Environmental Services.* Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-public-notice-of-tmdl-studies.pdf

NHDES. (2021). *New Hampshire Code of Administrative Rules.* Retrieved from Chapter Env-Wq 1100 Public Bathing Places: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/env-wq-1100.pdf

NHDES. (2024, September 20). *2024 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology*. Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/r-wd-24-06.pdf

NHDES. (2024, 11). *NHDES 2024 Surface Water Quality Assessment Viewer*. Retrieved from https://nhdes-surface-water-quality-assessment-site-nhdes.hub.arcgis.com/apps/23aca0560af74cfa9f0d39f4125ce479/explore

NHDES. (2024, November). *Volunteer Assessment Programs*. Retrieved from https://www.des.nh.gov/water/rivers-and-lakes/volunteer-assessment-programs

Nurnberg, G. (1996). Trophic State of Clear and Colored , Soft and Hardwater lakes with Special Consideration of Nutrients, Anoxia, Phytoplankton and Fish. *Journal of Lake and Reservoir Management*, 432-447.

Nurnberg, G. (1998). Prediction of annual and seasonal phosphorus concentrations in stratified and unstratifies polymictic lakes. *Limnology and Oceanography*, 1544-1552.

R.S.A. (1996, July 1). Retrieved from https://www.gencourt.state.nh.us/rsa/html/L/485-A/485-A-mrg.htm

U.S.C. § 1251-1387. (2002, November 27). Retrieved from https://www.epa.gov/sites/default/files/2017-08/documents/federal-water-pollution-control-act-508full.pdf

UNH. (2007). *Landscaping at the Water's Edge An Ecological Approach: A Manual for New Hampshire Landowners and Landscapers.* Durham, NH: University of New Hampshire Cooperative Extension.

USGS. (2019). *NLCD 2019 Land Cover (CONUS)*. Retrieved from Multi-Resolution Land Characteristecs Consortium (MRLC): https://www.mrlc.gov/data/nlcd-2019-land-cover-conus

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USGS. (2021). *Multi-Resolution Land Characteristics Consortium.* Retrieved from https://www.mrlc.gov/data/references/national-land-cover-database-2021-landcover-imperviousness-nlcd2021

Winer, R. (2000). *National Pollutant Removal Performance Database for Stormwater Treatment Practices.* Ellicot City: Center for Watershed Protection.

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Appendix A Lakes Loading Response Model Coefficients and Scenarios (Baseline and Target)

A.1 Baseline Loading Scenario – Selected tables from the Lakes Loading Response Model.

Table A.1.1: Standard water yield and precipitation values for the baseline model run for New Pond.

MEASURE	VALUE	SOURCE
STANDARD WATER YIELD (CUBIC FEET/SECOND/SQUARE MILE)	1.0	From USGS 01089100 Soucook River at Pembroke, Near Concord, New Hampshire
PRECIPITATION (METERS)	1.06	From Concord Municipal Airport mean from 2010 to 2022

Table A.1.2: Land use precipitation and phosphorus export coefficients for runoff and baseflow for the baseline model run for New Pond.

	RUNOFF EXPORT COEFFICIENTS		BASEFLOW EXPORT COEFFICIENTS	
LAND USE	Precipitation Coefficient (Fraction)	Phosphorus Export Coefficient (kg/ha/yr)	Precipitation Coefficient (Fraction)	Phosphorus Export Coefficient (kg/ha/yr)
Urban 1 (Low Density)	0.30	0.34	0.25	0.010
Urban 2 (Medium Density/Highway)	0.50	0.55	0.15	0.010
Urban 3 (High Density/Commercial)	0.60	0.82	0.05	0.010
Urban 4 (Industrial)	0.50	1.27	0.05	0.010
Urban 5 (Institutional, Recreational or Cemetery)	0.30	0.29	0.30	0.010
Agric 1 (Cover Crop)	0.50	0.80	0.30	0.010
Agric 2 (Row Crop)	0.30	0.37	0.30	0.010
Agric 3 (Grazing)	0.30	1.50	0.30	0.010
Agric 4 (Hayland-Non Manure)	0.30	0.37	0.30	0.010
Forest 1 (Deciduous)	0.20	0.03	0.40	0.004
Forest 2 (Non-Deciduous)	0.20	0.03	0.40	0.004
Forest 3 (Mixed Forest	0.20	0.03	0.40	0.004

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Forest 4 (Wetland)	0.05	0.20	0.40	0.004
Open 1 (Wetland/Pond)	0.05	0.01	0.40	0.004
Open 2 (Meadow)	0.30	0.20	0.30	0.004
Open 3 (Cleared/Disturbed Land)	0.80	0.05	0.05	0.010
Other 3	0.60	2.20	0.05	0.050

Table A.1.3: Areal sources and internal loading sources of total phosphorus for the baseline model run for New Pond. (Internal loading set to zero as the pond does not stratify)

SOURCE	Affected Lake Area (ha)	Phosphorus Export Coefficient (kg/ha/yr)	Phosphorus Load (from coefficient) (kg/yr)	Period of Release (days)	Phosphorus Rate of Release (mg/m2/day)	Phosphorus Load (from rate) (kg/yr)
Direct Atmospheric Deposition	12.48	0.11	1.3728			
Internal Loading	0	40.02	0	300	13.34	0

Table A.1.4: Waterfowl load of total phosphorus for the baseline model run for New Pond assuming 6 months of residence.

SOURCE	Number of Source Units	Volume (cu.m/yr)	Phosphorus Load/Unit (kg/unit/yr)	Phosphorus Concentration (ppm)	Phosphorus Load (kg/yr)
Waterfowl	20		0.10		2

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Table A.1.5: Septic system total phosphorus loads for the baseline model run for New Pond.

Septic System Grouping (by occupancy or location)	Days of Occupancy/Yr	Distance from Lake (ft)	Number of Dwellings	Number of People per Dwelling	Water per Person per Day (cubic meter)	Phosphorus Concentration (ppm)	Phosphorus Attenuation Factor	Water Load (cubic meter/yr)	Phosphorus Load (kg/yr)
Group 1 Septic Systems	365	<100	14	2.5	0.25	8	0.2	3194	5.1
Group 2 Septic Systems	365	100 - 300	12	2.5	0.25	8	0.1	2738	2.2
Group 3 Septic Systems	90	<100	8	2.5	0.25	8	0.2	450	0.7
Group 4 Septic Systems	90	100 - 300	6	2.5	0.25	8	0.1	338	0.3
Total Septic System Loading		n/a	n/	n/	n/a			**6719**	**8.3**

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Table A.1.6: Land use areas (hectares) by watershed basins for the baseline model run for New Pond.

LAND USE	North Basin	Blue Boar Basin	North Direct	East Direct	West Direct	Total Area
Urban 1 (Low Density)	6.0	2.8	0	8.6	3.7	21.1
Urban 2 (Medium Density/Highway)	1.0	0.7	0.0	0.1	0.7	2.5
Urban 3 (High Density/Commercial)	0.3	0.0	0.0	0.3	0.0	0.6
Urban 4 (Industrial)	0.0	0.0	0.0	0.0	0.0	0.0
Urban 5 (Institutional, Recreational or Cemetery)	0.4	0.0	0.0	0.0	0.0	0.4
Agric 1 (Cover Crop)	0.0	0.0	0.0	0.1	0.0	0.1
Agric 2 (Row Crop)	0.0	0.0	0.0	0.0	0.0	0.0
Agric 3 (Grazing)	0.0	0.0	0.0	0.0	0.0	0.0
Agric 4 (Hayland-Non Manure)	0.2	0.0	0.0	0.1	0.0	0.3
Forest 1 (Deciduous)	27.5	8.8	0.0	12.2	2.3	50.9
Forest 2 (Non-Deciduous)	1.0	0.0	0.0	0.7	0.9	2.6
Forest 3 (Mixed Forest	26.0	9.4	0.0	5.7	0.3	41.3
Forest 4 (Wetland)	3.2	1.4	0.5	1.3	0.0	6.4
Open 1 (Wetland/Pond)	0.0	0.0	0.0	0.0	0.0	0.0
Open 2 (Meadow)	0.0	0.0	0.0	0.0	0.0	0.0
Open 3 (Cleared/Disturbed Land)	0.0	0.0	0.0	0.0	0.0	0.0
Other 3	0.0	0.0	0.0	0.0	0.0	0.0
Total	**65.4**	**23.1**	**0.5**	**29.1**	**7.9**	**126.1**

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Table A.1.7: Summary of total phosphorus loads, concentrations and export coefficients for the baseline model run for New Pond.

MEASURE	North Basin	Blue Boar Basin	North Direct	East Direct	West Direct
WATER OUTPUT (CUBIC METERS/YR)	277,775	97,676	2,318	125,109	34,102
TOTAL PHOSPHORUS OUTPUT (KG/YR)	3.9	1.6	0.1	3.7	1.6
TOTAL PHOSPHORUS OUTPUT (MG/L)	0.014	0.016	0.043	0.029	0.048
REALITY CHECK CONC. (FROM DATA)	0.014	0.014	0.044	0.019	0.019
CALCULATED CONCENTRATION/MEASURED CONCENTRATION	1.000	1.169	0.972	1.542	2.509
BASIN EXPORT COEFFICIENT	0.06	0.07	0.18	0.13	0.21
TERMINAL DISCHARGE? (1=YES 2=NO)	1	1	1	1	1

Table A.1.8: Baseline total phosphorus load summary for New Pond. The resulting total phosphorus concentration would be 33.0 ppb.

LOAD SOURCE	TOTAL PHOSPHORUS (KG/YR)
ATMOSPHERIC	1.4
INTERNAL	0.0
WATERFOWL	2.0
SEPTIC SYSTEM	8.3
WATERSHED LOAD	10.9
TOTAL	22.5

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Table A.1.9: Baseline water load summary for New Pond.

LOAD SOURCE	WATER (CUBIC METERS/YR)
ATMOSPHERIC	132,288
SEPTIC SYSTEM	6,719
WATERSHED LOAD	536,979
TOTAL	675,986

Table A.1.10: Terms and values used for the baseline model run for New Pond.

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE
TP	Lake Total Phosphorus Conc.	ppb	From in-lake models	To Be Predicted
KG	Phosphorus Load to Lake	kg/yr	From export model	23
L	Phosphorus Load to Lake	g P/m2/yr	KG*1000/A	0.181
TPin	Influent (Inflow) Total Phosphorus	ppb	From export model	33
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data, if available	18.96
I	Inflow	m3/yr	From export model	675986
A	Lake Area	m2	From data	124800
V	Lake Volume	m3	From data	167000
Z	Mean Depth	m	Volume/area	1.400
F	Flushing Rate	flushings/yr	Inflow/volume	4.048
S	Suspended Fraction	no units	Effluent TP/Influent TP	0.569
Qs	Areal Water Load	m/yr	Z(F)	5.667
Vs	Settling Velocity	m	Z(S)	0.796
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.553
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.332

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Table A.1.11: Model formulas and predicted results for the baseline run for new pond. Mass balance and Vollenweider values are reported for reference but not included in the average of model values. The mean measured values were obtained from 10 years of data stored in NHDES' Environmental Monitoring Database.

NAME	FORMULA	PREDICTED CONCENTRATION (ppb)
Mass Balance	TP=L/(Z(F))*1000	32
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	14
Vollenweider 1975	TP=L/(Z(S+F))*1000	28
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	21
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	23
Reckhow General (1977)	TP=L/(11.6+1.2(Z(F)))*1000	10
Average of Model Values		17.1
Mean Measured Value		14.5

Table A.1.12: Measured chlorophyll-*a* and transparency values for New Pond obtained from the latest 10 years of data in NHDES' Environmental Monitoring Database.

PARAMETER	VALUE
Mean Chlorophyll-*a*	5.2 ppb
Peak Chlorophyll-*a*	8.4 ppb
Mean Secchi Transparency	2.2 m
Maximum Secchi Transparency	3.1 m

Table A.1.13: Model results for predicted mean chlorophyll-*a* values.

Model	Predicted Chlorophyll-*a* (ppb)
Carlson 1977	5.3
Dillon and Rigler 1974	4.5
Jones and Bachmann 1976	5.1
Oglesby and Schaffner 1978	6.9
Modified Vollenweider 1982	8.6
Mean	5.2

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Table A.1.14: Model results for predicted peak chlorophyll-*a* values.

Model	Peak Chlorophyll-*a*(ppb)
Modified Vollenweider (TP) 1982	25.2
Vollenweider (CHL) 1982	17.6
Modified Jones, Rast and Lee 1979	20.9
Mean	21.3

Table A.1.15: Model results for predicted mean and maximum Secchi Transparency.

Model	Secchi Transparency (m)
Oglesby and Schaffner 1978 (Mean)	2.6
Modified Vollenweider 1982 (Maximum)	4.4

Table A.1.16: Model results for predicted bloom probability as percent of time for New Pond.

Concentration	Bloom Probability
Probability of Chlorophyll-*a* >10 ppb	10.7%
Probability of Chlorophyll-*a* >15 ppb	2.0%
Probability of Chlorophyll-*a* >20 ppb	0.4%
Probability of Chlorophyll-*a* >30 ppb	0.0%

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A.2 Target Loading Scenario – Selected tables from the Lakes Loading Response Model.

Table A.2.1: Standard water yield and precipitation values for the target model run for New Pond.

MEASURE	VALUE	SOURCE
STANDARD WATER YIELD (CUBIC FEET/SECOND/SQUARE MILE)	1.0	From USGS 01089100 Soucook River at Pembroke, Near Concord, New Hampshire
PRECIPITATION (METERS)	1.06	From Concord Municipal Airport mean from 2010 to 2022

Table A.2. 2: Land use precipitation and phosphorus export coefficients for runoff and baseflow for the target model run for New Pond.

	RUNOFF EXPORT COEFFICIENTS		BASEFLOW EXPORT COEFFICIENTS	
LAND USE	Precipitation Coefficient (Fraction)	Phosphorus Export Coefficient (kg/ha/yr)	Precipitation Coefficient (Fraction)	Phosphorus Export Coefficient (kg/ha/yr)
Urban 1 (Low Density)	0.30	0.34	0.25	0.010
Urban 2 (Medium Density/Highway)	0.50	0.55	0.15	0.010
Urban 3 (High Density/Commercial)	0.60	0.82	0.05	0.010
Urban 4 (Industrial)	0.50	1.27	0.05	0.010
Urban 5 (Institutional, Recreational or Cemetery)	0.30	0.29	0.30	0.010
Agric 1 (Cover Crop)	0.50	0.80	0.30	0.010
Agric 2 (Row Crop)	0.30	0.37	0.30	0.010
Agric 3 (Grazing)	0.30	1.50	0.30	0.010
Agric 4 (Hayland-Non Manure)	0.30	0.37	0.30	0.010
Forest 1 (Deciduous)	0.20	0.03	0.40	0.004
Forest 2 (Non-Deciduous)	0.20	0.03	0.40	0.004
Forest 3 (Mixed Forest	0.20	0.03	0.40	0.004
Forest 4 (Wetland)	0.05	0.20	0.40	0.004
Open 1 (Wetland/Pond)	0.05	0.01	0.40	0.004
Open 2 (Meadow)	0.30	0.20	0.30	0.004
Open 3 (Cleared/Disturbed Land)	0.80	0.05	0.05	0.010
Other 3	0.60	2.20	0.05	0.050

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Table A.2.3: Areal sources and internal loading sources of total phosphorus for the target model run for New Pond. (Internal loading set to zero as the pond does not stratify)

SOURCE	Affected Lake Area (ha)	Phosphorus Export Coefficient (kg/ha/yr)	Phosphorus Load (from coefficient) (kg/yr)	Period of Release (days)	Phosphorus Rate of Release (mg/m2/day)	Phosphorus Load (from rate) (kg/yr)
Direct Atmospheric Deposition	12.48	0.11	1.3728			
Internal Loading	0	40.02	0	300	13.34	0

Table A.2.4: Waterfowl load of total phosphorus for the target model run for New Pond assuming 6 months of residence.

SOURCE	Number of Source Units	Volume (cu.m/yr)	Phosphorus Load/Unit (kg/unit/yr)	Phosphorus Concentration (ppm)	Phosphorus Load (kg/yr)
Waterfowl	10		0.10		1

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Table A.2.5: Septic system total phosphorus loads for the target model run for New Pond.

Septic System Grouping (by occupancy or location)	Days of Occupancy/Yr	Distance from Lake (ft)	Number of Dwellings	Number of People per Dwelling	Water per Person per Day (cubic meter)	Phosphorus Concentration (ppm)	Phosphorus Attenuation Factor	Water Load (cubic meter/yr)	Phosphorus Load (kg/yr)
Group 1 Septic Systems	365	<100	14	2.5	0.25	8	0.2	3194	5.1
Group 2 Septic Systems	365	100 - 300	12	2.5	0.25	8	0.1	2738	2.2
Group 3 Septic Systems	90	<100	8	2.5	0.25	8	0.2	450	0.7
Group 4 Septic Systems	90	100 - 300	6	2.5	0.25	8	0.1	338	0.3
Total Septic System Loading		n/a	n/	n/	n/a			**6719**	**8.3**

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Table A.2.6: Land use areas (hectares) by watershed basins for the target model run for New Pond.

LAND USE	North Basin	Blue Boar Basin	North Direct	East Direct	West Direct	Total Area
Urban 1 (Low Density)	6.0	2.8	0	8.6	3.7	21.1
Urban 2 (Medium Density/Highway)	1.0	0.7	0.0	0.1	0.7	2.5
Urban 3 (High Density/Commercial)	0.3	0.0	0.0	0.3	0.0	0.6
Urban 4 (Industrial)	0.0	0.0	0.0	0.0	0.0	0.0
Urban 5 (Institutional, Recreational or Cemetery)	0.4	0.0	0.0	0.0	0.0	0.4
Agric 1 (Cover Crop)	0.0	0.0	0.0	0.1	0.0	0.1
Agric 2 (Row Crop)	0.0	0.0	0.0	0.0	0.0	0.0
Agric 3 (Grazing)	0.0	0.0	0.0	0.0	0.0	0.0
Agric 4 (Hayland-Non Manure)	0.2	0.0	0.0	0.1	0.0	0.3
Forest 1 (Deciduous)	27.5	8.8	0.0	12.2	2.3	50.9
Forest 2 (Non-Deciduous)	1.0	0.0	0.0	0.7	0.9	2.6
Forest 3 (Mixed Forest	26.0	9.4	0.0	5.7	0.3	41.3
Forest 4 (Wetland)	3.2	1.4	0.5	1.3	0.0	6.4
Open 1 (Wetland/Pond)	0.0	0.0	0.0	0.0	0.0	0.0
Open 2 (Meadow)	0.0	0.0	0.0	0.0	0.0	0.0
Open 3 (Cleared/Disturbed Land)	0.0	0.0	0.0	0.0	0.0	0.0
Other 3	0.0	0.0	0.0	0.0	0.0	0.0
Total	**65.4**	**23.1**	**0.5**	**29.1**	**7.9**	**126.1**

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Table A.2.7: Summary of total phosphorus loads, concentrations and export coefficients for the target model run for New Pond.

MEASURE	North Basin	Blue Boar Basin	North Direct	East Direct	West Direct
WATER OUTPUT (CUBIC METERS/YR)	269,407	94,760	2,027	119,569	29,310
TOTAL PHOSPHORUS OUTPUT (KG/YR)	1.9	0.8	0	1.7	0.7
TOTAL PHOSPHORUS OUTPUT (MG/L)	0.007	0.008	0.008	0.014	0.024
REALITY CHECK CONC. (FROM DATA)	0.014	0.014	0.044	0.019	0.019
CALCULATED CONCENTRATION/MEASURED CONCENTRATION	0.5	0.60	0.17	0.75	1.26
BASIN EXPORT COEFFICIENT	0.03	0.03	0.03	0.06	0.09
TERMINAL DISCHARGE? (1=YES 2=NO)	1	1	1	1	1

Table A.2.8: Target total phosphorus load summary for New Pond. The resulting total phosphorus concentration would be 33.0 ppb.

LOAD SOURCE	TOTAL PHOSPHORUS (KG/YR)
ATMOSPHERIC	1.4
INTERNAL	0.0
WATERFOWL	1.0
SEPTIC SYSTEM	8.3
WATERSHED LOAD	5.1
TOTAL	15.8

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Table A.2. 9: Target water load summary for New Pond.

LOAD SOURCE	WATER (CUBIC METERS/YR)
ATMOSPHERIC	132,288
SEPTIC SYSTEM	6,719
WATERSHED LOAD	515,073
TOTAL	657,080

Table A.2.10: Terms and values used for the target model run for New Pond.

SYMBOL	PARAMETER	UNITS	DERIVATION	VALUE
TP	Lake Total Phosphorus Conc.	ppb	From in-lake models	To Be Predicted
KG	Phosphorus Load to Lake	kg/yr	From export model	16
L	Phosphorus Load to Lake	g P/m2/yr	KG*1000/A	0.126
TPin	Influent (Inflow) Total Phosphorus	ppb	From export model	24
TPout	Effluent (Outlet) Total Phosphorus	ppb	From data, if available	18.96
I	Inflow	m3/yr	From export model	654080
A	Lake Area	m2	From data	124800
V	Lake Volume	m3	From data	167000
Z	Mean Depth	m	Volume/area	1.338
F	Flushing Rate	flushings/yr	Inflow/volume	3.917
S	Suspended Fraction	no units	Effluent TP/Influent TP	0.786
Qs	Areal Water Load	m/yr	Z(F)	5.241
Vs	Settling Velocity	m	Z(S)	1.502
Rp	Retention Coefficient (settling rate)	no units	((Vs+13.2)/2)/(((Vs+13.2)/2)+Qs)	0.576
Rlm	Retention Coefficient (flushing rate)	no units	1/(1+F^0.5)	0.336

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Table A.2.11: Model formulas and predicted results for the target run for new pond. Mass balance and Vollenweider values are reported for reference but not included in the average of model values. The mean measured values were obtained from 10 years of data stored in NHDES' Environmental Monitoring Database.

NAME	FORMULA	PREDICTED CONCENTRATION (ppb)
Mass Balance	TP=L/(Z(F))*1000	24
Kirchner-Dillon 1975	TP=L(1-Rp)/(Z(F))*1000	10
Vollenweider 1975	TP=L/(Z(S+F))*1000	20
Larsen-Mercier 1976	TP=L(1-Rlm)/(Z(F))*1000	16
Jones-Bachmann 1976	TP=0.84(L)/(Z(0.65+F))*1000	17
Reckhow General (1977)	TP=L/(11.6+1.2(Z(F)))*1000	7
Average of Model Values		11.85
Mean Measured Value		14.5

Table A.2.12: Measured chlorophyll-*a* and transparency values for New Pond obtained from the latest 10 years of data in NHDES' Environmental Monitoring Database.

PARAMETER	VALUE
Mean Chlorophyll-*a*	3.9 ppb
Peak Chlorophyll-*a*	13.9 ppb
Mean Secchi Transparency	3.5 m
Maximum Secchi Transparency	4.9 m

Table A.2.13: Model results for predicted mean chlorophyll-*a* values.

Model	Predicted Chlorophyll-*a* (ppb)
Carlson 1977	3.1
Dillon and Rigler 1974	2.6
Jones and Bachmann 1976	3.0
Oglesby and Schaffner 1978	3.9
Modified Vollenweider 1982	6.0
Mean	3.9

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Table A.2.14: Model results for predicted peak chlorophyll-*a* values.

Model	Peak Chlorophyll-*a*(ppb)
Modified Vollenweider (TP) 1982	17.2
Vollenweider (CHL) 1982	11.1
Modified Jones, Rast and Lee 1979	13.5
Mean	13.9

Table A.2.15: Model results for predicted mean and maximum Secchi Transparency.

Model	Secchi Transparency (m)
Oglesby and Schaffner 1978 (Mean)	3.9
Modified Vollenweider 1982 (Maximum)	4.9

Table A.2.16: Model results for predicted bloom probability as percent of time for New Pond.

Concentration	Bloom Probability
Probability of Chlorophyll-*a* >10 ppb	1.7%
Probability of Chlorophyll-*a* >15 ppb	0.2%
Probability of Chlorophyll-*a* >20 ppb	0.0%
Probability of Chlorophyll-*a* >30 ppb	0.0%

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