Draft Total Maximum Daily Load (TMDL) for Phosphorus in Cayuga Lake

Cayuga, Seneca and Tompkins Counties, New York

April 2021 - Draft

New York State

Department of Environmental Conservation

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SUMMARY

Pursuant to 33 U.S.C. Section 1313(d), Section 303(d) of the Clean Water Act (CWA), states are required to develop a Total Maximum Daily Load (TMDL) for a waterbody/segment that does not meet the water quality standard for a pollutant.

"The TMDL establishes a target for total load of [a] pollutant the water body can assimilate and allocates the load to point sources (called the wasteload allocation [or WLA]) and nonpoint sources (called the load allocation [or LA]). The margin of safety takes into account the uncertainty between the model and the actual environment. Data and information such as land use, water quality monitoring results, modeling techniques, calculation methods and other relevant evidence are included in the TMDL." https://www.epa.gov/tmdl/developing-total-maximum-daily-loads-tmdls.

Informational TMDLs may be developed where water quality standards are being met in the particular waterbody segment(s), but protection of the water quality in the particular segment(s) will assist with achievement of water quality standards in other portions of the waterbody.

In coordination with the United States Environmental Protection Agency (USEPA), the New York State Department of Environmental Conservation (Department or NYSDEC) utilized a whole watershed approach to develop the Cayuga Lake TMDL for total phosphorus (TP) because the water quality of the four segments is influenced by watershed-wide TP inputs, as well as lake circulation and nutrient mixing that influences water quality. Therefore, the Cayuga Lake TMDL is comprised of: (1) a TMDL for the impaired lake segment (Southern End) to restore water quality to meet the water quality standard and (2) TMDLs for the other three lake segments (Main Lake, Mid-South; Main Lake, Mid-North; Northern End) to be protective of the water quality standard. The Cayuga Lake TMDL includes a whole watershed TP loading capacity to meet or protect water quality standards in all four lake segments. The Cayuga Lake TMDL considers regulated and non-regulated sources of TP to the four individual lake segments and assigns TP reductions to those sources. The Cayuga Lake TMDL recommends a thirty percent reduction in TP loading from the whole watershed to meet the water quality standard in Cayuga Lake.

The Cayuga Lake TMDL is organized into seven sections and appendices:

1. **Section 1** presents the problem statement, scope of the lake segments, and introduces the relevant water quality standard for each segment;
2. **Section 2** provides the description of the lake's entire watershed and sub-watersheds by lake segment, the limnology of the lake, and a review of the current and historical water quality used to determine the need for the TMDL, as well as the data used to develop the TMDL;
3. **Section 3** translates the narrative water quality standard for nutrients into the numeric water quality targets for Chlorophyll-a (Chl-a) for each segment in Cayuga Lake. The targets are based on summer average Chl-a concentrations, and on the most conservative best use for each lake segment. Chl-a is an indicator of algal growth within a lake and is, therefore, a measure of ecosystem response to TP loading;
4. **Section 4** is the assessment of TP pollution sources to Cayuga Lake for each of the lake segments as described in Section 2 for: (1) major NYSDEC-regulated point sources, calculated from facility-specific permitted flow and TP information, and (2) from all non-regulated watershed sources, estimated from tributary monitoring data and watershed

modeling analyses. The inputs from the four sub-watersheds to the lake segments combine to create the total TP load to Cayuga Lake;

5. **Section 5** presents Cayuga Lake's loading capacity – the maximum amount of TP loading that the lake can receive and still meet the water quality standard. The loading capacity was determined using an approved lake water quality model and iterative loading reduction scenarios;
6. **Section 6** assigns LAs and WLAs, per source sector, within each of the four lake segments. The LAs and WLAs are necessary to meet the lake's loading capacity (Section 5). This section also explains the considerations in the Cayuga Lake TMDL for a margin of safety, reasonable assurance, and seasonal variation;
7. **Section 7** outlines steps that can be undertaken by various stakeholders, as well as the Department in its regulatory capacity, to achieve the Cayuga Lake TMDL. This section also provides information to assist stakeholders to prioritize implementation actions. This section provides best management practices for watershed loading reductions for both TP and dissolved phosphorous because different forms of phosphorus from the watershed affect lake water quality differently
8. **Appendices** contain additional important information about Cayuga Lake; the modeling used to complete the Cayuga Lake TMDL; detailed water quality results for the lake; and a list of resources for stakeholders to utilize while implementing the TMDL.

1.0 INTRODUCTION

1.1 Background

In April of 1991, USEPA's Office of Water Assessment and Protection Division published "Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process" (USEPA 1991a). In July 1992, USEPA published the final "Water Quality Planning and Management Regulation" (40 C.F.R. Part 130). Together, these documents describe the roles and responsibilities of USEPA and the states in meeting the requirements of Section 303(d) of the CWA, as amended by the Water Quality Act of 1987, Public Law 100-4. Section 303(d) of the CWA requires states, territories, and authorized tribes (collectively "states") to establish a list that identifies waters within their boundaries that are not meeting state water quality standards (303(d) list). Section 303(d) also requires USEPA and states to develop a TMDL for any pollutant violating or causing violation of an applicable water quality standard for each impaired waterbody or other strategy to reduce the input of the specific pollutants restricting waterbody uses.

A TMDL determines the maximum amount of pollutant load that a waterbody/segment can receive while continuing to meet water quality standards and to support its best use. Load allocations are established for the point and nonpoint sources of pollution that contribute to the impairment, at levels necessary to meet the applicable uses as specified by a water's classification. TMDLs provide the framework that allows states to establish and implement pollution control and management plans with the goal indicated in Section 101(a)(2) of the CWA: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable" (USEPA 1991b). In accordance with this provision, NYSDEC has the responsibility to restore impaired waters and to protect potentially threatened uses.

Based on USEPA's long-term vision and goals, NYSDEC developed a strategy to: enhance TMDL program efficiency; determine and set state priorities to address impaired waters; utilize tools beyond TMDLs; and track success. New York State's Section 303(d) List of Impaired/TMDL Waters (NYS Section 303(d) List) identifies those waters that do not support best uses and that may require development of a TMDL. New York's strategy to prioritize waterbodies on the NYS Section 303(d) List for clean water planning:

- is adaptive and systematic;
- builds on and improves the existing 303(d) programs (e.g., TMDLs, watershed plans, permit modifications, long term control plans);
- is based on data collected by NYSDEC or by external sources of documented and acceptable levels of quality assurance;
- integrates information from other NYSDEC Division of Water (DOW) programs,
- incorporates alternative plans and approaches when applicable; and
- fosters new and enhances existing partnerships.

1.2 Problem Statement

Cayuga Lake (https://www.dec.ny.gov/outdoor/36544.html) is located in the Finger Lakes basin in central New York. Over the past several decades, the lake has experienced degraded water quality that threatens source water quality and has reduced the lake's recreational and aesthetic value.

1.2.1 Scope of Waterbody/Segment Impairment

Cayuga Lake is a large (43,000 acre) waterbody located in the Towns of Montezuma, Aurelius, Springport, Ledyard, and Genoa in Cayuga County, the Towns of Lansing, Ithaca, and Ulysses in Tompkins County, and the Towns of Covert, Ovid, Romulus, Varick, Fayette, and Seneca Falls in Seneca County. A small portion of Cayuga Lake's watershed extends into Cortland, Schuyler and Tioga Counties (less than 5% total area). The lake is divided into four segments on the NYSDEC Waterbody Inventory/Priority Waterbodies List (WI/PWL; https://gisservices.dec.ny.gov/gis/dil/). Classifications, associated best uses, and impairment level are provided in Table 1 and Figure 1).

Table 1. NYSDEC 2016 Waterbody Inventory/Priority Waterbodies List (WI/PWL) 303(d) listing information for Cayuga Lake segments.

Water Index Number	Waterbody Segment (WI/PWL ID)	Classification (Best Use)	Best Use[1]	Cause (Pollutant)	Use(s) Impacted	Impairment Level
Ont 66-12-P296 (portion 4)	Southern End (0705-0040)	Class A (Drinking Water Supply)	The best usages of Class A waters are a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish and wildlife propagation and survival. This classification may be given to those waters that, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary, to reduce naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.	Phosphorus	Public Bathing; Recreation	Impaired
Ont 66-12-P296 (portion 3)	Main Lake, Mid-South (0705-0050)	Class AA(T) (Drinking Water Supply with limited treatment)	The best usages of Class AA waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish and wildlife propagation and survival. This classification may be given to those waters that, if subjected to approved disinfection treatment, with additional treatment if necessary, to remove naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.	Other pollutants, AIS, Algal/Plant Growth	Water Supply	Threatened (Known)
Ont 66-12-P296 (portion 2)	Main Lake, Mid-North (0705-0025)	Class A (T) (Drinking Water Supply)	see Class A above	Other pollutants, AIS, Algal/Plant Growth	Water Supply	Threatened (Known)
Ont 66-12-P296 (portion 1)	Northern End (0705-0030)	Class B(T) (Swimming, Boating, Fishing)	The best usages of Class B waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.	AIS[2], Algal/Plant Growth	Public Bathing	Threatened; Stressed (Known)

[1] 6 NYCRR §§ 701.5 and 701.6

[2] AIS=aquatic invasive species

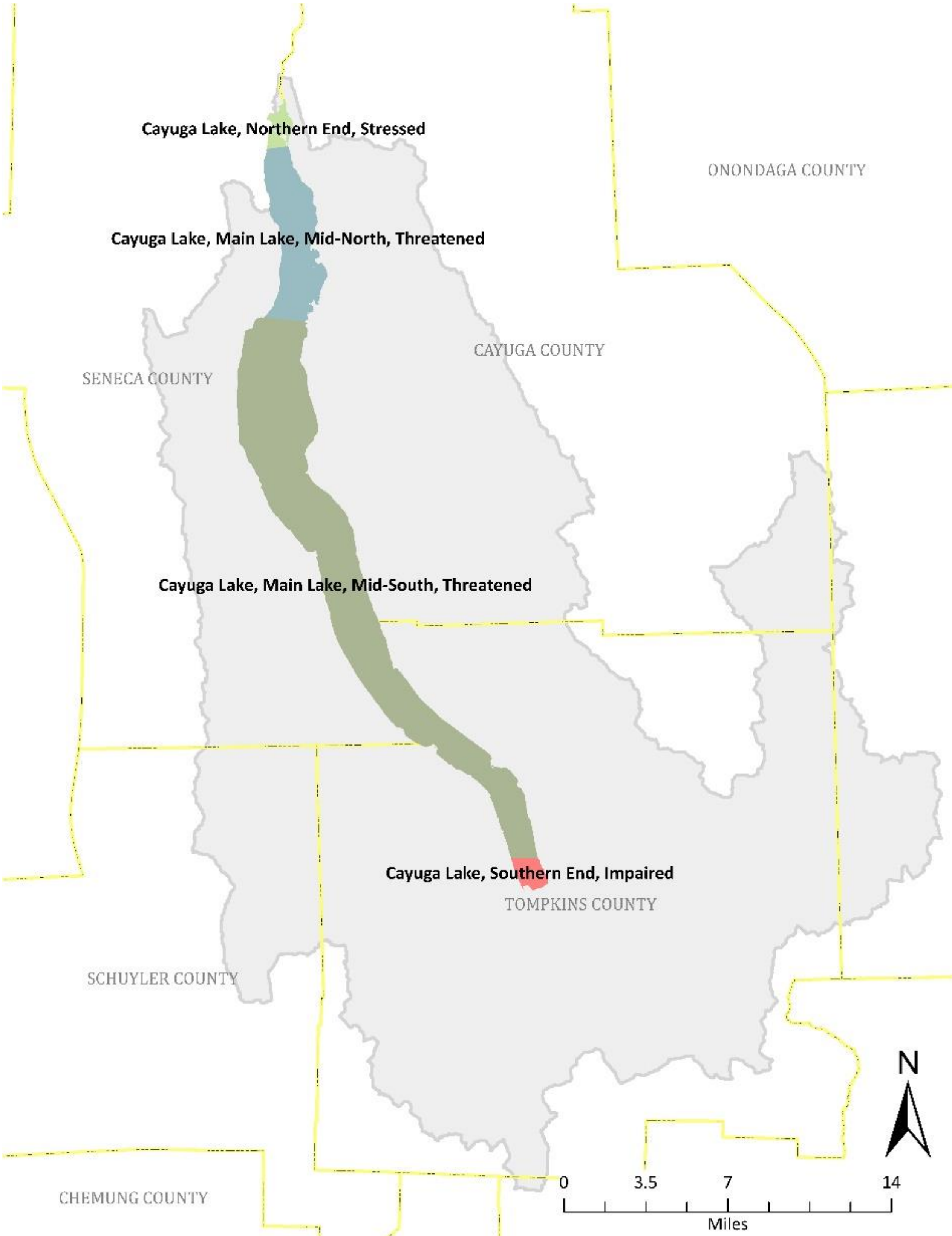


Figure 1. Cayuga Lake WI/PWL Segments and Impairment Level

Of the four segments in Cayuga Lake, only the Southern End segment is impaired. In 2002, the Southern End segment was first listed on the NYS's 2002 303(d) list because it does not support its best uses of primary and secondary contact recreation and is threatened as a public water supply due to a phosphorus impairment. More specifically, NYS's 2016 303(d) list identifies excessive nutrients (phosphorus) and silt/sediment loads from various sources as the causes of non-attainment of the best uses in the Southern End segment.

Phosphorus is often the nutrient limiting primary production (plant growth) in freshwater temperate lakes and ponds and is a primary food for aquatic plants, including algae. High phosphorus levels often contribute to algae blooms and can contribute to the overgrowth of rooted aquatic plants. As these plants are decomposed by microorganisms, dissolved oxygen levels can become depressed, creating conditions that are unsuitable for fish and other wildlife. Excess algae and aquatic plant growth also reduces the recreational and aesthetic value of lake and some forms of harmful algal blooms (cyanobacteria) can produce toxins. Previous empirical investigations have found that phosphorus is most likely the limiting nutrient for freshwater ecosystems with total nitrogen (TN) to TP ratios (TN:TP) greater than 20. In Cayuga Lake, modeling and monitoring data indicate that the limiting nutrient is phosphorus as the TN:TP ratios are often greater than 50.

As more fully described in Section 2, long-term and recent monitoring efforts confirm that the Southern End segment experiences degraded water quality, reducing the recreational and aesthetic value of Cayuga Lake as a whole. Recreational uses are impaired by periodic algal blooms and dense aquatic plant growth along the shoreline (NYSDEC 2018a). In some years, concentrations of TP in the Southern End have exceeded the state guidance value for TP (TOGS 1.3.6), 20 µg/L or 0.020 mg/L, calculated as the mean summer and established for protecting primary and secondary contact recreation uses. [1] For the purposes of the Cayuga Lake TMDL, the Department developed Chl-a water quality targets based on summer average Chl-a concentrations, the narrative water quality standard for nutrients (TP), and on the most conservative best use for each lake segment (see Section 3 and Appendix A for more details). Seasonal variations and a margin of safety were also considered in development of the Cayuga Lake TMDL.

1.2.2 Scope of Unimpaired Segments

The three unimpaired segments and their classifications are provided in Table 1. Portions of Cayuga Lake, including the two largest unimpaired segments, are classified as Class A(T) and Class AA(T) waters because they are a drinking water supply. Currently, there are five active public drinking water supplies that withdraw water from of the lake to serve approximately 40,000 customers (Figure 2 and Table 2).

New York State Department of Health (NYSDOH) and local health departments evaluate the drinking water supply use based on water quality information and monitoring data. NYSDOH's Source Water Assessment Program (SWAP) compiles, organizes, and evaluates information regarding possible and actual threats to the quality of public water supply (PWS). These reports do not address the safety or quality of *treated finished* potable tap water. The information contained within a SWAP assessment report assists in the oversight and protection of public water systems. The most recent SWAP assessment for Cayuga Lake was completed in 2004 and identified a

[1] defined as June 1 through September 30, epilimnetic total phosphorus concentration

moderate susceptibility to contamination for this source of drinking water. Some susceptibility associated with other sources, such as salt mines, was also noted in the assessment (NYSDOH 2004).

The Main Lake, Mid-South and Main Lake, Mid-North segments of Cayuga Lake are currently threatened as a drinking water source due to algal (phytoplankton) biomass concentrations driven primarily by both external phosphorus loading to the lake (NYSDEC 2018) and internal phosphorus circulation. Natural organic matter (NOM) in the form of decaying algae or other vegetation that is present in drinking water sources react with disinfectants used to treat drinking water, such as chlorine, and form disinfection by-products (DBPs). Trihalomethanes (THMs) are a class of organic chemicals and a type of DBP that forms because of the reaction between chlorine and NOM. Sources of NOM include sources from the landscape, such as leaves or other watershed organic material, and in-lake sources, such as phytoplankton (as measured by Chl-a and epiphyton), which is largely controlled by phosphorus in the water column.

The Federal Safe Water Drinking Act (SDWA) sets standards for finished drinking water quality and USEPA has developed rules to limit public exposure to DBPs. Subpart 5-1 of the New York State Sanitary Code sets maximum contaminant levels (MCLs) for DBPs and requires regular testing of finished drinking water for DBPs (10 CRR-NY I 5-1). DBPs can be limited by controlling the sources of NOM into the waterbody and removal or modification of disinfection practices, such as coagulation, granular activated carbon, or membrane filtration (WHO 2008). DBPs are discussed in more detail in Appendix A.

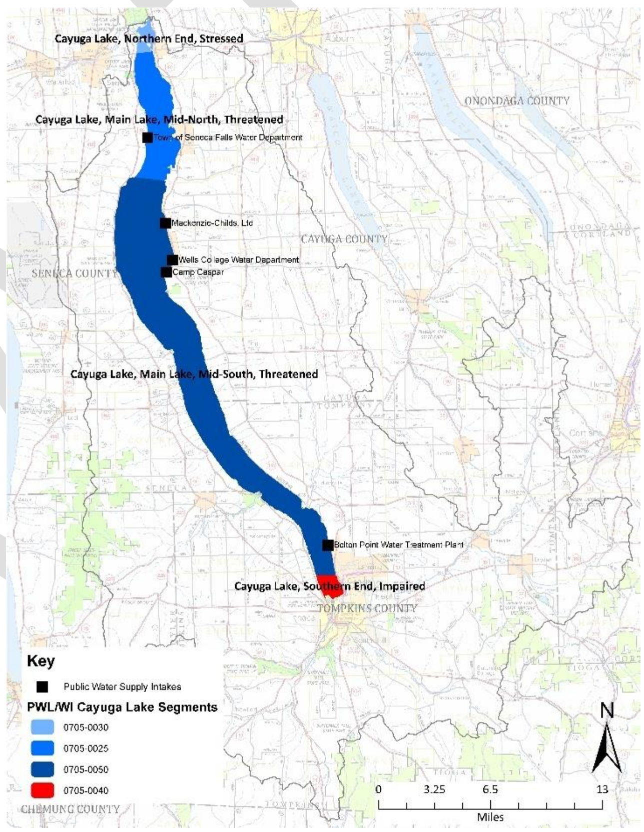


Figure 2. Map of public water supply intakes within Cayuga Lake watershed.

Table 2. Cayuga Lake Drinking Water Supplies

Drinking Water Supply	Drinking Water Intake Location (Lake Segment)	Classification	Service Municipalities	Service Population (approx.)
Bolton Point Water Treatment Facility	Main Lake, Mid-South	Class AA	Town of Dryden; Town of Ithaca; Town of Lansing Village of Cayuga; Heights Village of Lansing; City of Ithaca*	30,000
Wells College Water Department	Main Lake, Mid-South	Class AA	Wells College Village of Aurora	740
Camp Caspar	Main Lake, Mid-South	Class AA	N/A	75
Mackenzie-Childs, LTD	Main Lake, Mid-South	Class AA	N/A	290
Town of Seneca Falls Water Department	Main Lake, Mid-North	Class A	Town of Seneca Falls	9,000

*Bolton Point Water Treatment Facility provides water to some City of Ithaca residents and provides water to other parts of Ithaca and Cornell University during emergencies and planned maintenance periods.

1.3 Applicable Water Quality Standards

New York water quality standards contain criteria for water quality to protect the best uses for a waterbody classification. Water quality standards can be numeric or narrative (6 CRR-NY 703.2). The water quality standard for nutrients is narrative and states that phosphorus and nitrogen shall not be present within the waterbody "in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages."

The Cayuga Lake TMDL was developed based on the most conservative best use for each lake segment. Section 3 presents the numeric water quality targets for Chl-a.

2.0 WATERSHED AND LAKE CHARACTERIZATION

2.1 Watershed Characterization

Cayuga Lake is a multi-use waterbody located in Central New York State within the Seneca-Owsego River Basin. It is the second largest of the eleven Finger Lakes in terms of surface area (43,000 acres) and volume (9,379 million m^3). Cayuga Lake has a drainage basin of approximately 502,000 acres (785 square miles) excluding the surface area of the lake and a small portion of the Seneca River that flows into Cayuga Lake at the north end (Figure 3). The watershed includes 44 municipalities within six counties: Tompkins, Cayuga, Schuyler, Seneca, Cortland and Tioga. Elevations in the lake's basin range from approximately 2,100 feet above mean sea level (AMSL) to as low as 381 feet AMSL at the surface of Cayuga Lake. Over 140 streams flow into the lake along 95 miles of shoreline. The four largest tributaries that flow into the lake ranked by drainage area are: (1) Fall Creek, (2) Cayuga Inlet (which includes drainage from Sixmile and Cascadilla Creeks), (3) Salmon Creek, and (4) Taughannock Creek (Figure 3).

Figure 3. Map Delineating Cayuga Lake Major Tributaries

For the purposes of the Cayuga Lake TMDL, NYSDEC staff determined existing land use and land cover in the Cayuga Lake drainage basin from geographic information system (GIS) datasets in ArcGIS (ESRI). Digital land use/land cover data were obtained from the 2011 National Land Cover Database (NLCD; Jin et al. 2013). The NLCD is a consistent representation of land cover for the conterminous United States generated from classified 30-meter resolution Landsat thematic mapper satellite imagery data. Combined agriculture (pasture/hay and cultivated crops) is the dominant land used in the basin (50%), followed by: combined forest (25%), developed land (6%), shrub and scrub (5%), and wetlands (4%). Agricultural land use is more dominant in the northern portion of the watershed as compared with the southern portion. Land use categories in the watershed are listed in Table 3 and represented graphically in Figure 4.

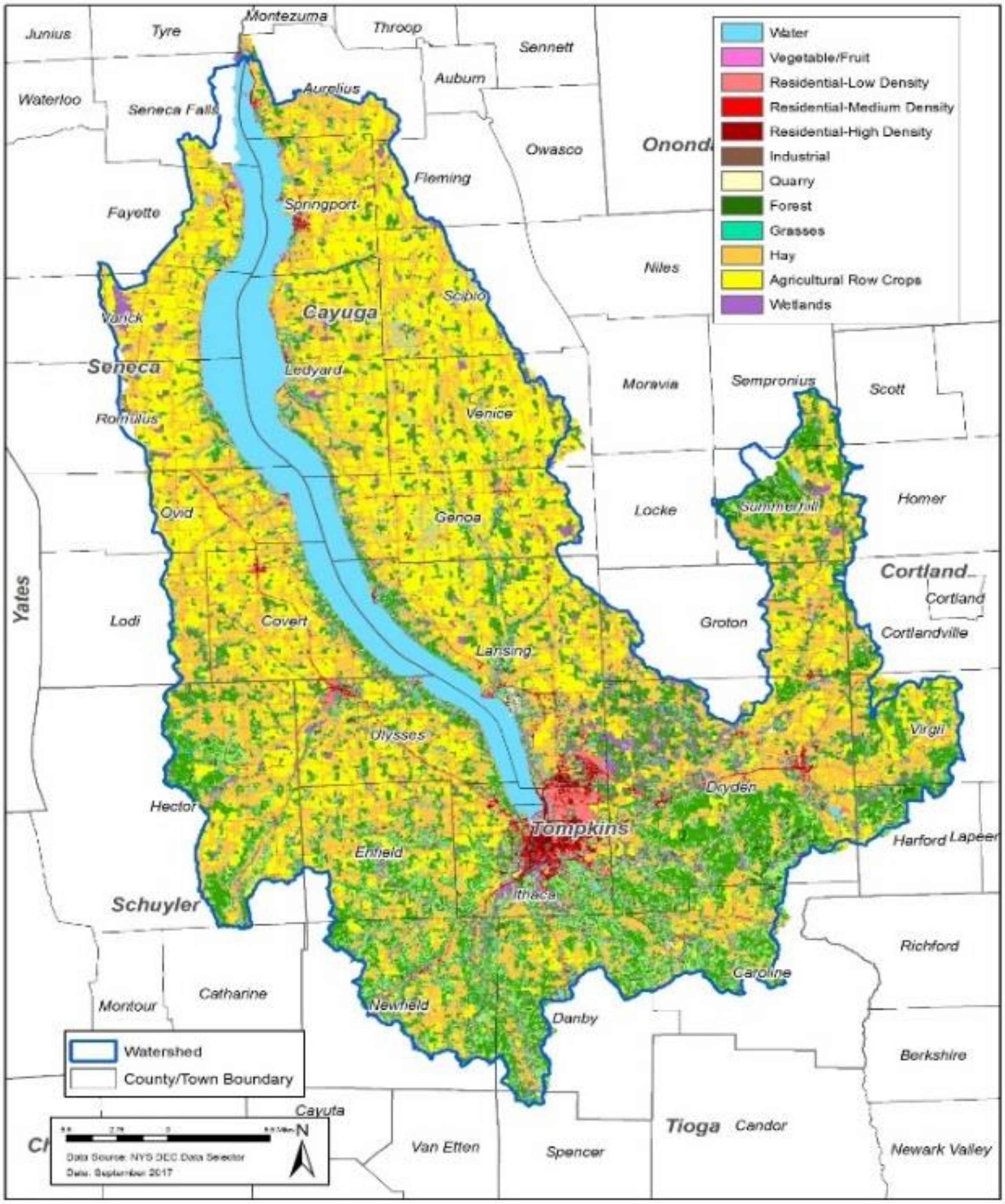


Figure 4. Land Use/Land Cover in the Cayuga Lake Watershed.

Table 3. Land Use (NLCD 2011) Area and Percent Cayuga Lake Watershed

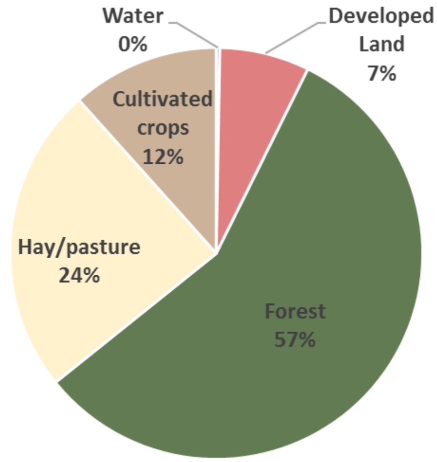
Land Use Category	**NLCD Code**	**Area (acres)**	**Percent of Watershed Area (%)**
Open Water	11	43,000	8.5%
Developed, Open Space	21	21,673	4.2%
Developed, Low Intensity	22	5,748	1.1%
Developed, Medium Intensity	23	2,359	0.5%
Developed High Intensity	24	722	0.1%
Barren Land (Rock/Sand/Clay)	31	659	0.1%
Deciduous Forest	41	81,887	15.9%
Evergreen Forest	42	11,403	2.2%
Mixed Forest	43	33,571	6.5%
Dwarf Scrub	51	--	--
Shrub/Scrub	52	25,097	4.9%
Grassland/Herbaceous	71	2,385	0.5%
Sedge/Herbaceous	72	--	--
Pasture/Hay	81	126,711	24.7%
Cultivated Crops	82	125,228	24.4%
Woody Wetlands	90	18,933	3.7%
Emergent Herbaceous Wetlands	95	2,661	0.5%
Total	**--**	**502,822**	**100%**

2.1.1. Impaired Segment: Southern End (0705-0040) Watershed Land Use

This segment includes the portion of the lake south of an east-west line through McKinneys Point in the Town of McKinneys. The land use is summarized by major land use category in Table 4 and corresponding figure (right).

Table 4. Summary of land use within the Segment (Southern End 0705-0040) watershed area.

Land Use Category	Acres	Percent Land Use
Cultivated crops	21,875	12
Forest	107,257	57
Hay/pasture	45,571	24
Developed Land	13,284	7
Water	532	<1
Total	188,517	100

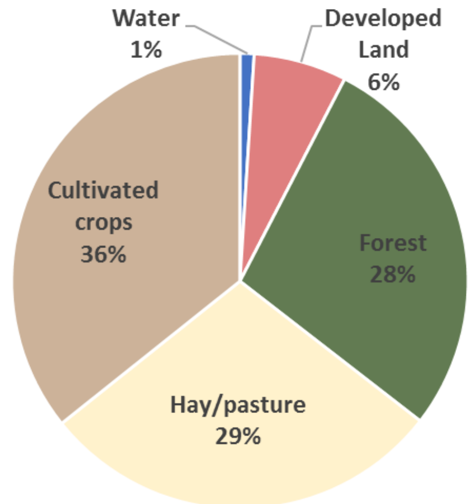


2.1.2. Unimpaired Segment: Main Lake, Mid-South (0705-0050) Watershed Land Use

This segment includes the portion of the lake south of an east–west line extended from Coonley Corners Road in the Town of Coonley Corners and north of an east-west line through McKinneys Point in the Town of McKinneys. The land use is summarized by major land use category in Table 5 and corresponding figure (right).

Table 5. Summary of land use within the Main Lake, Mid-South (0705-0050) watershed area

Land Use Category	Acres	Percent Land Use
Cultivated crops	82,310	36
Forest	64,293	28
Hay/pasture	66,281	29
Developed Land	15,194	6
Water	2,306	1
Total	230,384	100

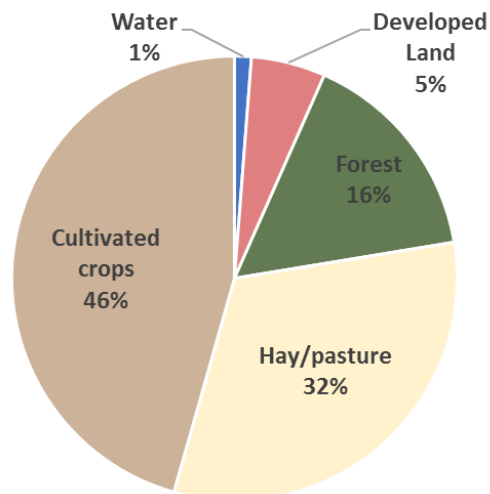


2.1.3. Unimpaired Segment: Main Lake, Mid-North (0705-0025) Watershed Land Use

This segment includes the portion of the lake south of an east-west line extending from Bridgeport–Seneca Falls Road on the west shore to the Village of Cayuga on the east shore and north of an east-west line extended from Coonley Corners Road in the Town of Coonley Corners. The land use is summarized by major land use category in Table 6 and corresponding figure (right).

Table 6. Summary of land use within the Main Lake, Mid-North (0705-0025) watershed area

Land Use Category	Acres	Percent Land Use
Cultivated crops	23,154	46
Forest	8,011	16
Hay/pasture	16,238	32
Developed Land	2,740	5
Water	619	1
Total	50,763	100

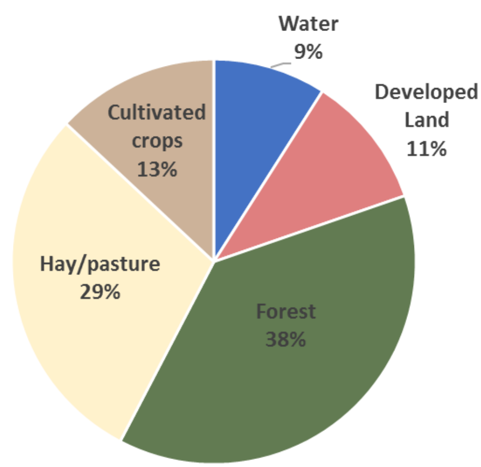


2.1.4. Unimpaired Segment: Northern End (0705-0030) Watershed Land Use

This segment includes the portion of the lake south of Lock 1 in Mud Lock and north of an east–west line extending from Bridgeport-Seneca Falls Road on the west shore to the Village of Cayuga on the east shore. The land use is summarized by major land use category in Table 7 and corresponding figure (right).

Table 7. Summary of land use within the Northern End (0705-0030) watershed area

Land Use Category	Acres	Percent Land Use
Cultivated crops	243	13
Forest	706	38
Hay/pasture	545	29
Developed Land	199	11
Water	168	9
Total	1,862	100



2.2 Lake Morphometry

Figure 5 shows a bathymetric map for Cayuga Lake. Table 8 summarizes key morphometric characteristics for Cayuga Lake. Cayuga Lake is long, extending 38 miles from Ithaca to the Seneca River outlet at Mudlock (G/FLRPC 2000), and narrow (average width of 2.8 miles). Cayuga Lake drains north to the Seneca River which flows to Lake Ontario. The Southern End segment has a shallow shelf - less than 33 feet maximum depth.

There is complex and dynamic circulation between the Southern End and the main lake (Effler et al. 2010; UFI 2017; Gelda et al. 2015). Due to its north-south orientation, winds from the north or south produce considerable wave activity and a lake-long subsurface seiche (Ludlam 1967). The internal seiche and intermittent upwelling complicate circulation patterns and increase flushing rates on the Southern End segment and link the water quality between the Main lake and the Southern End. The lake is monomictic; it strongly stratifies in the summer and has a water residence time of approximately 8-10 years (Mullins 1998, Callinan 2001).

Table 8. Morphometric Characteristics of Cayuga Lake

Surface Area (acres)	43,000
Elevation (ft. AMSL)	381
Maximum Watershed Elevation (ft AMSL)	2,090
Maximum Depth (ft.)	435
Mean Depth (ft.)	179
Length (miles)	38
Width at widest point (miles)	3.5
Mean width (miles)	1.75
Shoreline perimeter (miles)	95.3
Direct Drainage Area (acres)	240,000
Watershed: Surface Area Ratio	12:1
Hydraulic Residence Time (years)	10

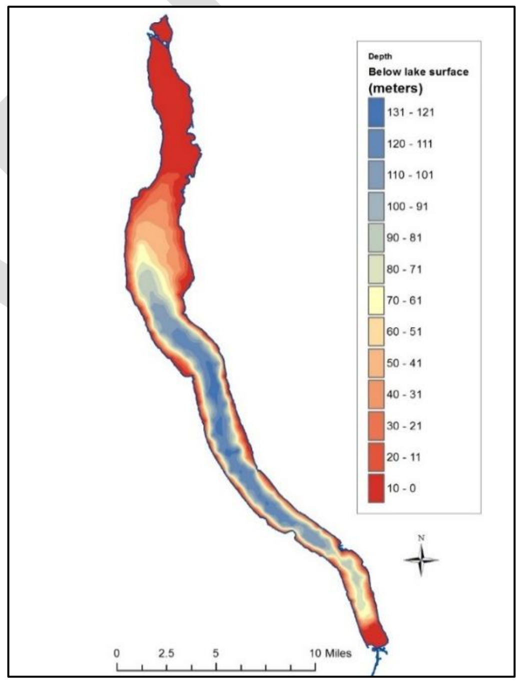


Figure 5. Bathymetric Map of Cayuga Lake

2.3 Water Quality

In the 1970s, numerous researchers documented the water quality of Cayuga Lake (Likens 1974; Schaffner and Oglesby 1978; Oglesby and Schaffner 1978). These and other early studies are summarized in “The Lakes of New York State, Volume 1” (Bloomfield 1978). Since the late 1990’s, Cayuga Lake has been intensively monitored at multiple locations by NYSDEC, the Citizens Statewide Lake Assessment Program (CSLAP), private research, and academic programs (Table 9).

In 2017, two sites on Cayuga Lake were added to CSLAP in the Main Lake, Mid-South (Class AA) and Main Lake, Mid-North (Class A) segments (NYSDEC 2018b). The following year, three additional sites were added to the CSLAP with at least one sampling location in each of the four segments (NYSDEC 2019). Water quality perception, field data such as clarity and temperature, and samples for water chemistry were collected at 1.5m below the surface. In 2018, major water quality indicators showed that Cayuga Lake is mesotrophic or moderately biologically productive, consistent with the conclusions of the other contemporary monitoring programs for the lake (NYSDEC 2018b)

Table 9. Summary of Water Quality Investigations in Cayuga Lake from 1970s-Present

Study	Summary	Years	Segments	Water Quality Summary	Reference
Cayuga Lake Modeling (CLM) Project[1]	Data set used in the development of the Cayuga Lake TMDL Analysis[1]	2013	All 4 segments	mesotrophic	Appendix B and UFI 2014
Cornell University Lake Source Cooling Water Quality Monitoring Program[1]	Data set used in the development of the Cayuga Lake TMDL Analysis	1998-2012	Southern End/Main Lake, Mid-South	mesotrophic	Cornell 2012
Water Quality Study of The Finger Lakes	Historical water quality reference for Cayuga Lake	1996-1999	Southern End/ Main Lake, Mid-South	oligo-mesotrophic	Callinan 2001
Disinfection By-Products study (DBPs)[1]	Special Study development of numeric nutrient criteria	2004-2007	Main Lake, Mid-South	mesotrophic	Callinan et al. 2013
Citizen Statewide Lake Assessment Program (CSLAP)[1]	Routine sampling program that provides key historical and current water quality reference for Cayuga Lake.	2002-2007, 2017	Main Lake, Mid-South	oligo-mesotrophic	NYSDEC
		2018-present	All 4 segments	mesotrophic	NYSDEC
Lakes of New York State, Volume 1	Historic information about Cayuga Lake	1970s	Main Lake, Mid-South	oligo-mesotrophic	Bloomfield 1978
FLI Comparative Limnology and Hydrogeochemistry of the Finger Lakes	Historic and informational water quality of Cayuga Lake	2005-present	Southern End/ Main Lake, Mid-South	mesotrophic	Halfman et al. 2017
Water Quality of the Northern End of Cayuga Lake	Historic and informational water quality of Cayuga Lake	1991 to 2006	Main Lake, Mid-North	oligo-mesotrophic	Makarewicz et al. 2007

[1] Collected under an approved quality assurance project plan for the purposes of Cayuga Lake assessment or TMDL development

2.3.1 2013 Cayuga Lake Modeling (CLM) Project

In 2013, lake-wide sampling and frequent sampling of the Southern End segment were conducted on Cayuga Lake to support the CLM Project (UFI 2014) used in development of the Cayuga Lake TMDL. Lake-wide sampling was conducted twice per month (bi-weekly) April – October at lake sites 1-9 and one site IL located near the mouth of the Cayuga Inlet channel (Figure 6). Frequent sampling of the Southern End segment included sites 1-3 and IL (Figure 6) and was conducted twice per week over the June – September interval. Numerous water quality indicators were monitored to support the development of the CLM Project, including field measurements (temperature, oxygen, specific conductance), biological samples (phytoplankton, zooplankton), and laboratory samples from multiple sites and depths. Laboratory samples included: forms of phosphorus, nitrogen, and carbon, Chl-a, silica, and suspended solids. For a more detailed look at the results of the 2013 sampling program, see Appendix B and UFI 2014.

The CLM Project data indicated that individual TP concentrations were greater than 20 µg/L at the Southern End (Sites 1-2) with summer average values also greater than 20 µg/L. The TP concentrations of both Main Lake segments and the Northern End segment (Sites 3-9) ranged between 12 and 17 µg/L. Summer average Chl-a concentrations ranged between 4-5 µg/L for most of the lake but were less than 4 µg/L at the northern most site (Site 9). Secchi disk clarity was highest in the Main Lake, Mid-South, with summer average values ranged between 4-6 m. The southern and northern sites had slightly lower clarity (less than 4 m). Conditions in 2013 indicated that Cayuga Lake was mesotrophic and were consistent with historical and other contemporary monitoring efforts on the lake.

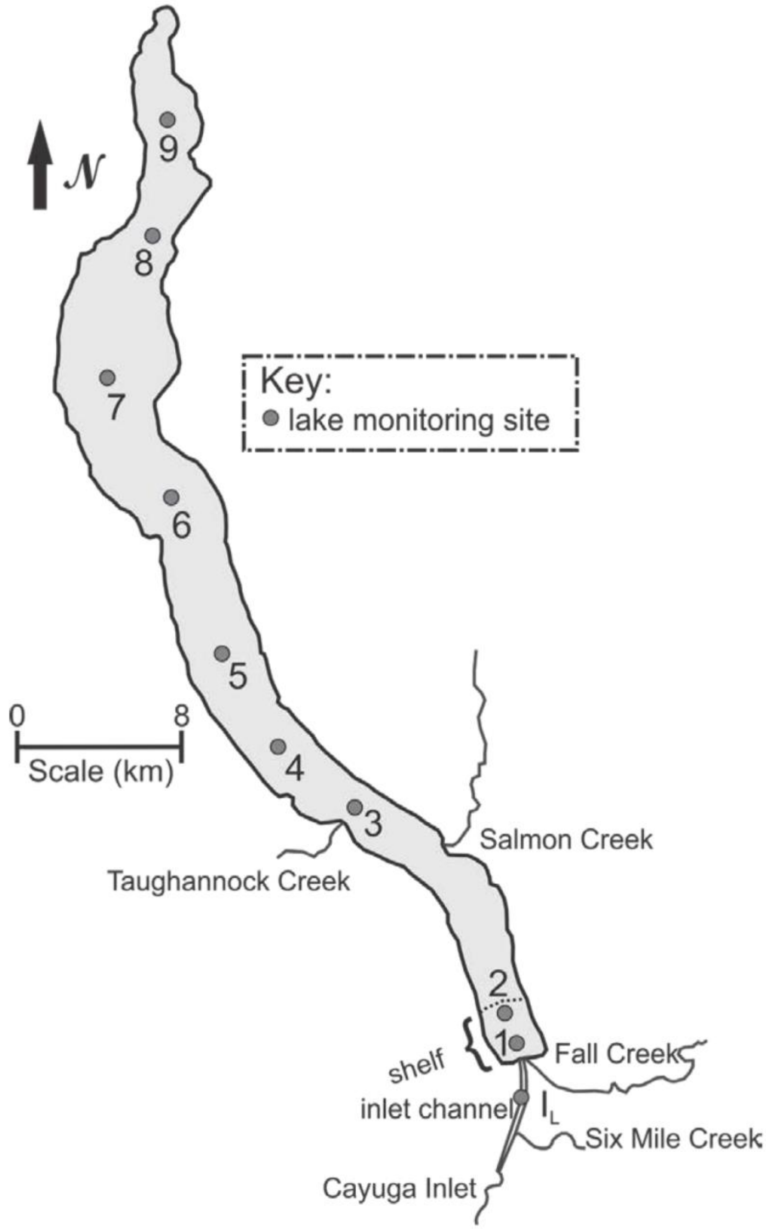


Figure 6. 2013 Cayuga Lake Modeling Project sampling locations

2.3.2 Cornell University Lake Source Cooling and Other Water Quality Monitoring Programs

As a condition of the Cornell University Lake Source Cooling (LSC) State Pollutant Discharge Elimination System (SPDES) permit (issued by NYSDEC for 2013-2018), Cornell University committed to funding a water quality and modeling study to monitor ambient water quality in the Southern End and main Lake Mid-South segments of Cayuga Lake and analyze trends of trophic

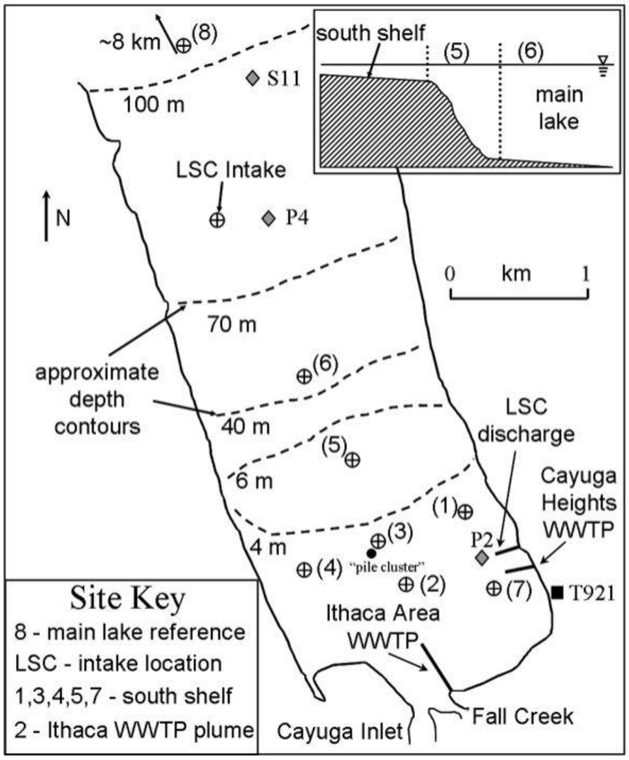


Figure 6. Cornell University LSC Monitoring Sites, 1998-2012 (Cornell 2013)

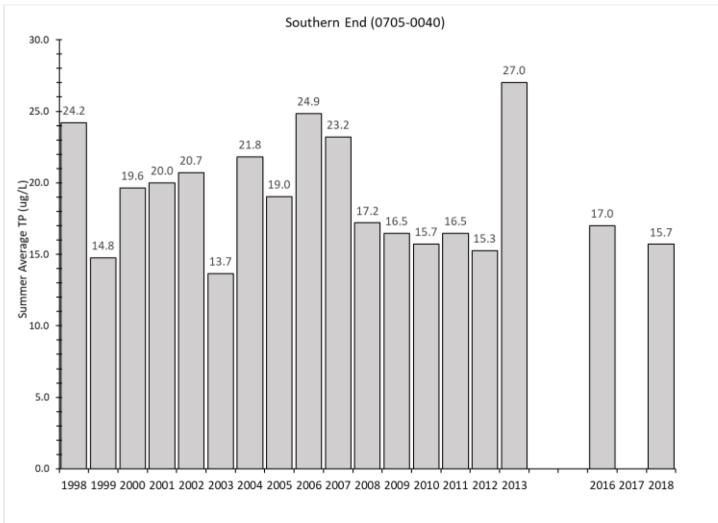
state indicators. Water quality monitoring was conducted by Upstate Freshwater Institute (UFI) from 1998 to 2006 and by Cornell University from 2007 to 2012. Data collected through this program is referred to as the "LSC dataset." This monitoring consisted of biweekly samples collected from surface waters of the lake from mid-April through late October. Water chemistry samples were analyzed by UFI for TP and soluble reactive phosphorus (SRP), Chl-a, turbidity, and Secchi disk transparency. Five sites were located within the Southern End (inset Figure 6); two sites were in the Main Lake; two sites were in the Main Lake, Mid-South segment near the Southern End boundary; one site was located at the LSC intake; and one site was located in the main lake and used as a reference site (Figure 7). Several sites￼).

Similar to the data collected during the NYSDEC 1996-1999 Finger Lakes study, TP and Chl-a data collected in 1998 and 1999 were typical of oligo-mesotrophic or moderately unproductive lakes within the Main Lake, Mid-South and Southern End segments. In the early 2000s, monitoring data indicated an increase in productivity at the southern pelagic zone sites (i.e., Southern End and Main Lake, Mid-South). Average Chl-a concentrations in Main Lake, Mid-South ranged from 4.5-7.8 µg/L over the course of the study. Summer average Chl-a concentrations were higher in 2006-2011 than in preceding years both on the Southern End and Main Lake, Mid-South, although not as high as some observations made in the 1970s (Cornell 2012). Summer average concentrations of TP and Chl-a at the Main Lake, Mid-South sites were generally consistent with mesotrophic trophic state classification (Cornell 2012).

TP concentrations were higher on the Southern End compared to Main Lake, Mid-South locations each year; although, numerous studies have shown that much of the elevated TP concentrations in the Southern End are due, in part, to phosphorus associated with sediment particles (Effler et al. 2010, Gelda et al. 2016). Declines in phosphorus loading from point sources were observed after 2006 corresponding to the completion of key wastewater treatment plant upgrades. The Ithaca Area Wastewater Treatment Facility (Ithaca Area WWTF; SPDES # NY0026638) started using tertiary treatment in 2006 and its SPDES permit was modified to include a 40 lbs/day mass effluent limitation, which is 0.36 mg/L phosphorous concentration at design flow (13.1 MGD). Cayuga Heights Wastewater Treatment Facility (Cayuga Heights WWTF; SPDES # NY0020958) began using a new phosphorus treatment process in 2009 and its SPDES permit was modified to include a 0.35 mg/L phosphorus concentration effluent limitation. The data collected through sampling programs associated with the wastewater treatment plant upgrades were used in the development of the Cayuga Lake TMDL.

2.3.3 Summary of Historical Water quality for the Southern End and Main Lake, Mid-South segments

The summer average TP and Chl-a concentrations from 1998-2018 (data was not available for 2014 and 2015) for the Southern End and Main Lake, Mid-South segments are shown in Figure 8 and 9, respectively).



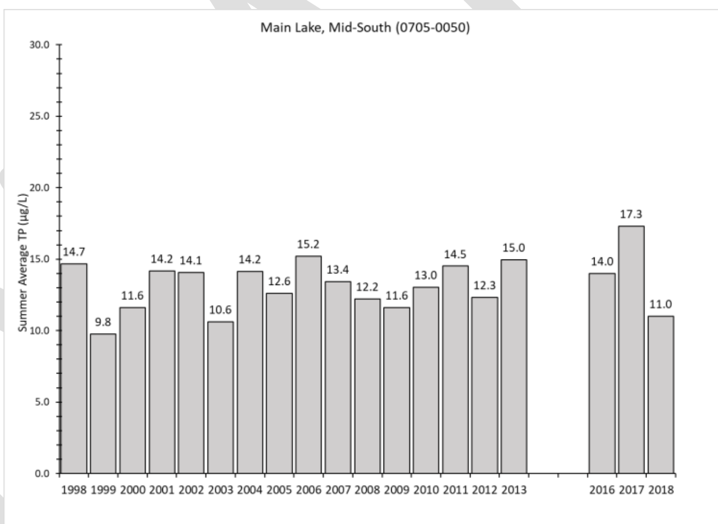


Figure 7~~8~~. Summer (June-September) Average Total Phosphorus Concentrations for Cayuga Lake over the 1998-2018 interval for the: (Top) Southern End segment and (Bottom) the Main Lake, Mid-South segment (Adopted from Cornell 2013).

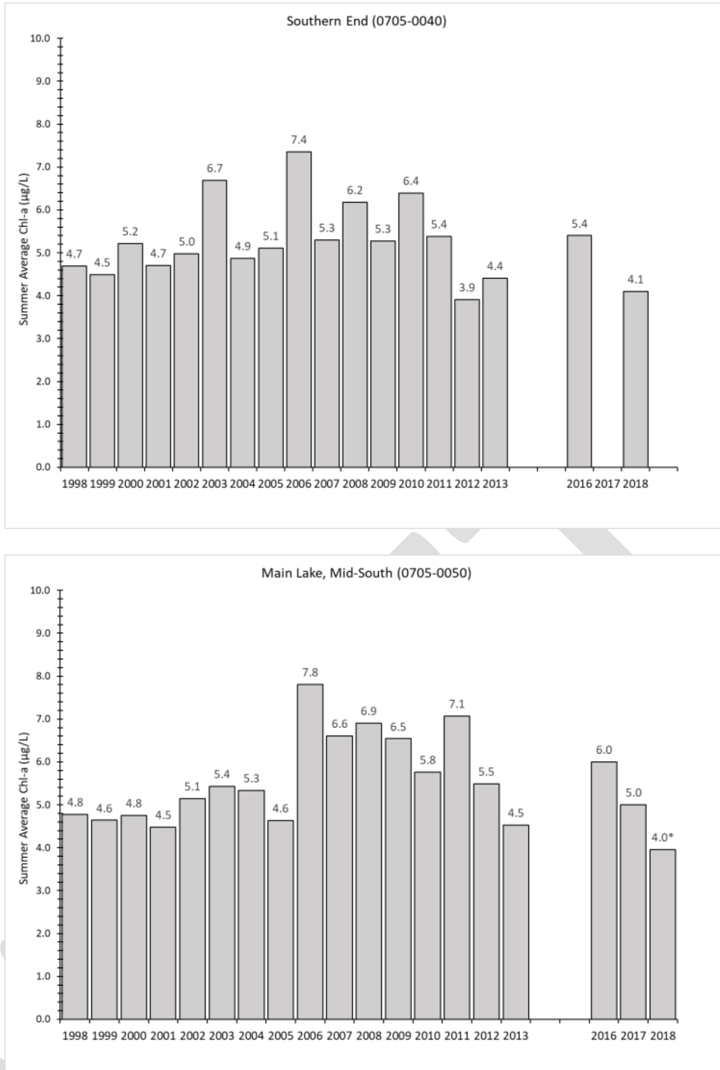


Figure 8~~9~~. Summer (June-September) Average Chlorophyll-a Concentrations for Cayuga Lake over the 1998-2018 interval for the: (Top) Southern End segment and (Bottom) the Southern End segment (Adopted from Cornell 2013).

3.0 NUMERIC WATER QUALITY TARGET

Numeric water quality targets are quantitative values used to measure whether or not the applicable water quality standard is attained.

Cayuga Lake has four segments with independent water classifications. The Southern End; Main Lake, Mid-South; and Main Lake, Mid-North segments are classified as Class A, Class AA, and Class A, respectively, which means that the best uses of these segments of the lake are as a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The Northern End segment is Class B, which means that the best uses are primary and secondary contact recreation and fishing. All segments of the lake must also be suitable for fish, shellfish and wildlife propagation and survival. New York State has a narrative water quality standard for nutrients: “none in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages” that applies to all lake segments. NYSDEC developed a corresponding guidance value for TP to provide a numeric interpretation of that narrative standard.

An exceedance of the TP guidance value alone does not always result in “growths of algae, weeds and slimes that will impair the waters for their best usages” as detailed in the narrative water quality standard. In order to determine the pollutant loading capacity for a waterbody, one or more numeric water quality targets must be developed that describe in-lake conditions and which correspond to attainment of the water quality standard. Chlorophyll-a is an indicator of algal growth within a lake and is, therefore, a measure of ecosystem response to phosphorus loading. Since phosphorus has been identified as the limiting pollutant during the summer season when algal blooms occur, it was necessary to develop a correlation between the TP loading and the Chl-a numeric representation concentrations. In addition, NYSDEC developed the Chl-a water quality targets for the protection of source water use based on the relationship between Chl-a and the potential production of disinfection by-products in finished drinking water (Callinan et al. 2013).

NYSDEC identified Chl-a water quality targets of less than or equal to 4 µg/L, 6 µg/L, and 10 µg/L corresponding to the highest (most conservative) best use for each lake segment to meet the water quality standard for Class AA, Class A, and Class B, respectively (Table 10). The Chl-a water quality targets for Class AA and Class A segments are protective of both the recreational and water supply best uses, whereas the Chl-a water quality target for the Class B segment is protective of its recreational best use (See Appendix A for a discussion of how the Chl-a correlates to a possible range of TP values based on collected TP vs Chl-a data, and why a Chl-a water quality target is selected over a TP concentration target for these segments). Therefore, numeric water quality targets for Chl-a will be used in the Cayuga Lake TMDL.

Table 9~~10~~. Water quality targets by regulatory segment

Waterbody Segment (WI/PWL ID)	**Classification/Highest Best Use**	**Summer Average Total Chlorophyll-a Target (µg/L)**
Northern End (0705-0030)	Class B – Swimming, Boating, Fishing	10 µg/L
Main Lake, Mid-North (0705-0025)	Class A – Drinking Water Supply	6 µg/L
Main Lake, Mid-South (0705-0050)	Class AA – Drinking Water Supply with limited treatment	4 µg/L
Southern End (0705-0040)	Class A – Drinking Water Supply	6 µg/L

4.0 ASSESSMENT OF SOURCES

4.1 Analysis of Total Phosphorus (TP) Contributions

As explained in section 2.3.2, as a condition of the Cornell University Lake Source Cooling SPDES permit (issued by NYSDEC in 2013), Cornell University committed to funding a water quality and modeling study to inform the development of the Cayuga Lake TMDL. Cornell University funded the development of two models: a watershed and a lake model. The watershed model, SWAT (Soil and Water Assessment Tool version SWAT-VSA v2012; Fuka et al. 2016) Model predicts the movement of water, phosphorus, other nutrients, and suspended solids from the watershed to the lake. The lake model, CLM, predicts water motion in the lake and how phosphorus affects water quality conditions, and algae and zooplankton growth (UFI 2014; 2017). Development of both models was overseen by a NYSDEC Cayuga Lake Technical Advisory Committee (CLTAC; https://www.dec.ny.gov/lands/88250.html) and by USEPA's Model Evaluation Group (MEG; https://www.dec.ny.gov/lands/95403.html). A description of the models and performance metrics can be found in Appendices B-C. (A discussion of model calibration and validation can be found in Section 5.1.1).

The SWAT watershed model and independent nutrient loading estimates (FLUX32; USACOE 2013) were used in combination with the CLM to develop the Cayuga Lake TMDL. The loading estimates and assessment of nutrient sources from nonpoint sources to Cayuga Lake were determined by:

1. Estimating nutrient loading to the lake from five streams intensely monitored as part of the 2013 CLM monitoring program using FLUX32 analysis based on observed nutrient and stream flow data to determine phosphorus loading to the lake from measured streams;
2. Extrapolating nutrient loading to unmonitored streams based on land area and land use; and
3. Utilizing SWAT to determine the appropriate loads by land use within each sub basin.

The FLUX32 analysis and results are detailed in the Phase 1: Monitoring and Modeling Support for a Phosphorus/Eutrophication Model for Cayuga Lake Report (https://www.dec.ny.gov/docs/water_pdf/cornelllscclmpphase1.pdf). The SWAT model is described in the Phase 2 Final Report: A Phosphorus/Eutrophication Water Quality Model for Cayuga Lake (pages 8-1 to 8-10 in https://www.dec.ny.gov/docs/water_pdf/cornelllscclmpphase2.pdf).

The point source load estimates included in the CLM are the effluent limitations in SPDES permits, rather than current loading rates for the scenario runs. For facilities without existing discharge or phosphorus effluent limitations, loadings were estimated based on performance of similarly sized facilities with available measurements (Phase 1: Monitoring and Modeling Support for a Phosphorus/Eutrophication Model for Cayuga Lake Report; https://www.dec.ny.gov/docs/water_pdf/cornelllscclmpphase1.pdf).

The watershed TP loads were inputted to the CLM to predict in-lake water quality and Chl-a concentrations. The CLM utilizes the CE-QUAL-W2 hydrothermal transport model framework (Cole and Wells 2015) for physical and thermal processes and incorporates much of CE-QUAL-W2 nutrient and algal dynamics. Detailed discussion of CLM and the CE-QUAL-W2 nutrient and algal growth framework and calibration discussion can be found in the Phase 1: Monitoring and Modeling Support for a Phosphorus/Eutrophication Model for Cayuga Lake Report, Phase 2 Final Report: A Phosphorus/Eutrophication Water Quality Model for Cayuga Lake and the Phase 2 Report.

Average TP loading to Cayuga Lake from all sources over the 1998-2013 interval was estimated to be 1,210 pounds/day (lbs/d) (441,620 pounds/year (lbs/yr)). Approximately 91% of the TP load to Cayuga Lake is from nonpoint sources and 9% from point sources. Tables 11-14 for the Cayuga Lake segments, arranged from South to North, present an assessment of the sources.

Table 10~~11~~. Estimated sources of TP loading to Cayuga Lake (pounds/day) to the Impaired Southern End (0705-0040) segment with annual TP loading rates, parenthetically.

Impaired Segment Sources	**Current TP Loading in Pounds per Day (lbs TP/d) (1998-2013 Annual Average in lbs TP/yr)**	**Percent to Segment**	**Percent to Lake**
	Nonpoint sources		
Cultivated crops [a]	105 lbs TP/d (38,384)	39	8.7
Hay/pasture [a]	62.1 lbs TP/d (22,683)	23	5.1
Forest + Wetlands	26.5 lbs TP/d (9,673)	9.8	2.2
Developed Land	2.30 lbs TP/d (857)	0.9	0.2
Water	-	-	-
Total nonpoint source load	***196 lbs TP/d (71,597)***	***72.7***	***16.2***
	Onsite Septic Systems		
Onsite Septic Systems	***1.00 lbs TP/d (372)***	***0.4***	***0.1***
	Point source [b]		
Cayuga Heights WWTF (NY0020958)	5.80 lbs TP/d (2,130)	2.2	0.5
Dryden WWTF (NY0029190)	3.40 lbs TP/d (1,226)	1.2	0.3
Freeville WWTF (NY0110493)	3.10 lbs TP/d (1,143)	1.2	0.3
Ithaca Area WWTF (NY0026638)	40.0 lbs TP/d (14,600)	14.8	3.3
Lake Source Cooling (LSC) (NY0244741)	6.40 lbs TP/d (2,336)	2.4	0.5
MS4s [c]	13.8 lbs TP/d (5,051)	5.1	1.1
Total point source load	***72.6 lbs TP/d (26,486)***	***26.9***	***6.0***
TOTAL	**270 lbs TP/d (98,455)**	**100**	**22.3**

[a] Farmsteads located in the watershed that are covered under the New York State Environmental Conservation Law Concentrated Animal Feeding Operation (CAFO) SPDES general permit are identified in Appendix F, Table 1. Runoff from farm fields is accounted for in the nonpoint source agricultural load.
[b] TP load at current permit limits.
[c] MS4s are listed in Appendix F, Table 2. MS4 loading is accounted for in the developed land load.

Table 11~~12~~**.** Estimated sources of TP loading to Cayuga Lake (pounds/day) to the Unimpaired Main Lake, Mid-South (0705-0050) segment.

Impaired Segment Sources	Current TP Loading in Pounds per Day (lbs TP/d) (1998-2013 Annual Average in lbs TP/yr)	Percent to Segment	Percent to Lake
	Nonpoint sources		
Cultivated crops [a]	540 lbs TP/d (197,121)	72.9	44.7
Hay/pasture [a]	127 lbs TP/d (46,483)	17.2	10.5
Forest + Wetlands	24.0 lbs TP/d (8,757)	3.2	2.0
Developed Land	13.9 lbs TP/d (5,091)	1.9	1.2
Water	-	-	-
Total nonpoint source load	***705 lbs TP/d (257,452)***	***95.2***	***58.4***
	Onsite Septic Systems		
Onsite Septic Systems	***2.70 lbs TP/d (1,001)***	***0.4***	***0.2***
	Point sources [b]		
Interlaken WWTP	2.50 lbs TP/d (914)	0.3	0.2
Aurora WWTP	2.50 lbs TP/d (913)	0.3	0.2
Trumansburg WWTP	1.04 lbs TP/d (380)	0.1	0.0
Lansing Residential Center WWTP	-	-	-
MS4s [c]	27.1 lbs TP/d (9,883)	3.7	2.2
Total point source load	***33.1 lbs TP/d (12,090)***	***4.4***	***2.7***
TOTAL	**741 lbs TP/d (270,543)**	**100**	**61.3**

[a] Farmsteads located in the watershed that are covered under the New York State Environmental Conservation Law Concentrated Animal Feeding Operation (CAFO) SPDES general permit are identified in Appendix F, Table 1. Runoff from farm fields is accounted for in the nonpoint source agricultural load. [b] TP load at current permit limits.
[c] MS4s are listed in Appendix F, Table 2. MS4 loading is accounted for in the developed land load.

Table ~~13~~12. Estimated sources of TP loading to Cayuga Lake (pounds/day) to the Unimpaired Main Lake, Mid-North (0705-0025) segment.

Impaired Segment Sources	Current TP Loading in Pounds per Day (lbs TP/d) (1998-2013 Annual Average in lbs TP/yr)	Percent to Segment	Percent to Lake
	Nonpoint sources		
Cultivated crops [a]	138 lbs TP/d (50,443)	73.2	11.4
Hay/pasture [a]	32.6 lbs TP/d (11,895)	17.3	2.7
Forest + Wetlands	6.10 lbs TP/d (2,241)	3.3	0.5
Developed Land	10.5 lbs TP/d (3,832)	5.6	0.9
Water	-	-	-
Total nonpoint source load	***187 lbs TP/d (68,411)***	***98.1***	***15.5***
	Onsite Septic Systems		
Onsite Septic Systems	***0.76 lbs TP/d (276)***	*0.4*	*0.1*
	Point sources [b]		
Union Springs WWTP	2.75 TP/d (1,004)	1.44	0.2
MS4s	-	-	-
Total point source load	***2.75 TP/d (1,004)***	***1.44***	***0.2***
TOTAL	**191 lbs TP/d (69,691)**	**100**	**15.8**

[a] Farmsteads located in the watershed that are covered under the New York State Environmental Conservation Law Concentrated Animal Feeding Operation (CAFO) SPDES general permit are identified in Appendix F, Table 1. Runoff from farm fields is accounted for in the nonpoint source agricultural load. [b] TP load at current permit limits.

Table 13~~14~~. Estimated sources of TP loading to Cayuga Lake (pounds/day) to the Unimpaired Northern End (0705-0030) segment.

Impaired Segment Sources	Current TP Loading in Pounds per Day (lbs TP/d) (1998-2013 Annual Average in lbs TP/yr)	Percent to Segment	Percent to Lake
	Nonpoint sources		
Cultivated crops [a]	5.92 lbs TP/d (2,161)	73.7	0.5
Hay/pasture [a]	1.40 lbs TP/d (510)	17.4	0.1
Forest + Wetlands	0.26 lbs TP/d (96)	3.3	0.0
Developed Land	0.45 lbs TP/d (164)	5.6	0.0
Water	-	-	-
Total nonpoint source load	***8.03 lbs TP/d (2,931)***	***100***	***0.7***
	Onsite Septic Systems		
Onsite Septic Systems	-	-	-
	Point sources [b]		
MS4s	-	-	-
Total point source load	-	-	-
TOTAL	**8.03 lbs TP/d (2,931)**	**100**	**0.7**

[a] Farmsteads located in the watershed that are covered under the New York State Environmental Conservation Law Concentrated Animal Feeding Operation (CAFO) SPDES general permit are identified in Appendix F, Table 1. Runoff from farm fields is accounted for in the nonpoint source agricultural load. [b] TP load at current permit limits.

4.1.1 Agricultural Sources

Agricultural land encompasses approximately 50% or 252,000 acres of the Cayuga Lake watershed . Of that agricultural land, 25% is hay and pastureland and 24% is cultivated row crops. Phosphorus loading from agricultural land originates primarily from the application of manure and fertilizers and eroded soil transported off-field during precipitation induced erosion during runoff events. Runoff from farm fields is accounted for in the nonpoint source agricultural load.

Concentrated Animal Feeding Operations (CAFOs), located within the Cayuga Lake Watershed, that are covered under the Environmental Conservation Law (ECL) CAFO SPDES General Permit, are identified in Appendix F (Table 1). There are currently no CAFOs covered under the CWA CAFO SPDES General Permit within the Cayuga Lake watershed. Under the ECL CAFO SPDES General Permit no discharge of process water is permitted, and nutrients applied to the landscape are done so at agronomic rates. Therefore, discharges from CAFOs is assumed to be zero (0).

4.1.2 Developed Land

Developed land comprises 31,000 acres (6%) of the Cayuga Lake watershed. TP loading from this land use contains contributions from overland storm water runoff from fertilized lawns; wash-off from urban and rural roads; leaking or malfunctioning sewer systems; ditch erosion; and soil disturbance. This load does not account for contributions from malfunctioning septic systems. Shoreline development can have a large phosphorus loading impact to nearby waterbodies in comparison to its relatively small percentage of the total land area in the drainage basin.

4.1.3 Forested Lands and Wetlands

Forested lands (including shrub and grassland) comprise 154,000 acres or approximately 30% of the Cayuga Lake drainage basin. Wetlands comprise an additional 23,000 acres or 5%. TP loading from forested lands and wetlands consists primarily of overland runoff.

4.1.4 Residential On-Site Septic Systems

Estimates of on-site septic system contributions to TP loading are based upon several assumptions, including: (1) population served by on-site septic systems; (2) system failure rates; (3) per capita TP load; and (4) seasonal phosphorus uptake in the drain field.

Septic systems treat human waste using a collection system that discharges liquid waste into the soil through a series of distribution lines that comprise the drain field. In properly functioning on-site septic systems, phosphates are adsorbed and retained by the soil as the effluent percolates through the soil to the shallow saturated zone. Some of the TP in the soil is also taken up by plants. Therefore, contributions from properly functioning on-site septic systems, with sufficient setbacks from waterbodies, contribute very little in terms of TP loading to nearby waterbodies. However, deficient on-site septic systems can contribute dissolved phosphorus to nearby waterbodies. For example, ponding is when the discharge of waste collects on the soil surface (where it is available for runoff) – this indicates an on-site septic system malfunction. Short-circuited on-site septic systems (i.e., those systems near surface waters where there is limited opportunity for phosphorus adsorption to take place) also contribute phosphorus loads. On-site septic systems in close proximity to a waterbody are subject to potential short-circuiting, with those closer to the lake more likely to contribute greater loads. Detecting subsurface failures is extremely difficult and estimates of failure rates vary substantially so it is likely that reported failure rates may represent a low estimate of actual failures. For the purposes of the Cayuga Lake TMDL, conservative estimates were used - 65% of the systems were properly functioning, 25% were short-circuiting, and 10% were ponded (hydraulic failure to the surface; USEPA 2002). For a review of the septic analysis for the Cayuga Lake TMDL see Appendix F.

Other factors that impact on-site septic system function include: (1) soil type and depth to bedrock; (2) depth to water table; (3) system age; and (4) system maintenance schedule. System age and maintenance also contribute to septic performance. Changes in living conditions (e.g., number of residents, duration of occupation, home additions and upgrades) also impact on-site septic system functioning.

4.1.5 Point Sources

4.1.5.1 Wastewater Treatment Facilities

The following SPDES facilities are included in the Cayuga Lake TMDL because they likely have the greatest impact on Cayuga Lake water quality: eight permitted municipal wastewater treatment plants (WWTF) (Class 05 and 07) and one industrial facility (Class 01) that has a phosphorus limit. Five WWTFs and the Cornell Lake Source Cooling facility, identified in Table 11, are located within the Impaired Southern End segment’s watershed.

4.1.5.2 Construction

Construction activities that involve one or more acres of soil disturbance in the watershed are subject to the conditions of the SPDES General Permit for Stormwater Discharges from Construction Activity (current permit information: https://www.dec.ny.gov/chemical/43133.html) and must also comply with the New York State Stormwater Management Design Manual (or its equivalent) to control post-construction stormwater discharges and the Enhanced Phosphorus Removal Standards. There are no sites with individual construction stormwater SPDES permits in the Cayuga Lake watershed.

Implementation of the practices required by the SPDES General Permit for Stormwater Discharges from Construction Activity minimizes loading of sediment and nutrients due to construction activity and would, therefore, preclude it as a significant source of phosphorus to the Lake. For the purposes of the Cayuga Lake TMDL, phosphorus loading as a result of construction activity was not specifically modeled, but was considered in the loading capacity for other sources.

4.1.5.3 Stormwater associated with industrial activities

Stormwater discharges associated with industrial activities within the watershed are covered under individual industrial SPDES permits, the SPDES Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activity (current permit information: https://www.dec.ny.gov/chemical/9009.html), or are not potential pollutant dischargers under the No Exposure Certification. Those facilities with individual industrial SPDES permits are listed in Appendix F. For the purposes of the Cayuga Lake TMDL, phosphorus loading as a result of stormwater associated with industrial activities was not specifically modeled, but was considered in the loading capacity for developed land.

4.1.5.4 Municipal Separate Storm Sewer Systems (MS4s)

There are nine Municipal Separate Storm Sewer Systems (MS4s) in Cayuga Lake watershed, including six in the impaired segment watershed. For the purposes of the Cayuga Lake TMDL, phosphorus loading associated with MS4s was not specifically modeled, but was considered in the loading capacity for developed land.

4.1.6 Other Sources of Phosphorus

4.1.6.1 Internal Loading/Recycling

According to monitoring data and the CLM, Cayuga Lake does not experience internal TP loading; however, Cayuga Lake does experience internal nutrient cycling. Internal loading within some lakes is the phosphorus release from the anoxic sediments into the overlaying waters. This exchange depends on a variety of physical, chemical and biological factors (Wetzel 2001) that do not occur in Cayuga Lake.

Lakes which have been subject to nutrient loading beyond their assimilative capacity for long periods of time may experience internal loading. Lake sediments may have higher concentrations of phosphorus than the water concentrations (Wetzel 2001). This excess phosphorus within the lake sediments may be released back into the lake waters when conditions are favorable. Such conditions can include resuspension of sediments by wind mixing or fish activity (e.g., feeding off bottom of lake), sediment anoxia (i.e., low dissolved oxygen levels near the sediment water interface), high pH levels, die-offs of heavy growths of rooted aquatic plants, and other mechanisms that result in the release of phosphorus (Wetzel 2001).

Although not an internal source of phosphorus, internal nutrient cycling by benthic organisms, like zebra and quagga mussels (collectively referred to as Dreissenid mussels), convert sediment bound phosphorus into dissolved phosphorus (UFI 2014). These organisms filter deposited organic matter and release dissolved phosphorus directly to the upper waters for algal use or into the stratified hypolimnion, which can be mixed throughout the lake by internal waves or during fall turnover.

The presence of Dreissenid mussels may be contributing to an increase in TP cycling in Cayuga Lake (UFI 2014). Dreissenid mussels uptake particulate organic matter and nutrients from the water to support their growth, the remaining nutrients are excreted in feces or pseudofeces (Hecky et al. 2004). This activity may be a significant component of nutrient cycling and cause an increase in TP concentrations in impacted lakes (Hecky et al. 2004). Part of the CLM Project evaluated the potential impact of mussel phosphorus nutrient cycling in Cayuga Lake.

Cornell University conducted a survey of Dreissenid mussel density and biomass at various depths and locations (approximately 100 samples) throughout the lake to estimate mussel filtering rates, respiration process, oxygen consumption, waste excretion, and TP release. This information was used to develop an empirical model that was included in the CLM. The analysis indicated that mussel excretion has increased the amount of dissolved phosphorus in the lake. For detailed discussion of the survey and results see the Phase 1: Monitoring and Modeling Support for a Phosphorus/Eutrophication Model for Cayuga Lake Report, Section 5.4.2 (https://www.dec.ny.gov/docs/water_pdf/cornelllscclmpphase1.pdf).

4.1.6.2 Miscellaneous Sources

Atmospheric deposition, wildlife, waterfowl, and domestic pets are also potential nonpoint sources of phosphorus loading to Cayuga Lake. These small sources of phosphorus are accounted for in the land use loadings.

4.1.6.3 Groundwater

In addition to nonpoint sources delivered to Cayuga Lake by surface runoff, a portion of the TP load from nonpoint sources seeps into the ground and is transported to the lake via groundwater. Groundwater loading is dependent on the overlaying land uses. For the purposes of the Cayuga Lake TMDL, groundwater was not specifically modeled, but are assumed to be captured in the nonpoint source watershed loading estimates.

5.0 PHOSPHORUS LOADING CAPACITY ANALYSIS

The phosphorus loading capacity of Cayuga Lake is the maximum phosphorus load to the lake that results in meeting the water quality standard. The phosphorus loading capacity of Cayuga Lake was analyzed using the CLM described in Appendix B. The CLM simulates in-lake physical, chemical, and biological processes based on user-supplied inputs related to lake bathymetry, tributary inflows, lake outflows, and meteorological conditions. The CLM is a continuous model and can output predictions of lake conditions at hourly or finer time steps.

Analysis of the phosphorus loading capacity of Cayuga Lake was completed by developing “TMDL scenario” model runs from the calibrated CLM to predict the lake response to reduced phosphorus loading from the watershed and points sources. The Department calculated the phosphorus loading capacity for Cayuga Lake based on achievement of the Chl-a water quality target for 15 of the 16 simulated years.

5.1 Lake Modeling Using the Cayuga Lake Model (CLM).

Lakes and reservoirs store phosphorus in the water column and sediment; therefore, water quality responses are generally related to the total nutrient loading occurring over longer time scales (i.e., years). For this reason, phosphorus TMDLs for lakes and reservoirs are generally calculated on an annual basis. USEPA guidance supports the use of annual loads, versus daily loads, as an acceptable method for expressing nutrient loads in lakes and reservoirs (USEPA 1986 and USEPA 1990).). While daily loads have been calculated, the Cayuga Lake TMDL (Section 4, Tables 11-14) includes TP annual loading capacity to guide implementation efforts and because the pollution reduction efficiencies from implementation of the best management practices (BMPs) are expressed on an annual basis. Compliance with the TP loading capacity will result in achievement of the Chlorophyll-a water quality target and, thus, the applicable narrative water quality standard.

5.1.1. Cayuga Lake Model (CLM) Calibration and Validation

A full description of the CLM setup and data used to construct and complete the model can be found in Appendix B. The model was calibrated for 2013 conditions: air and water temperature; meteorology; nutrient loading rates for the watershed and for point sources; and in-lake water quality and biological conditions. The model ran for a 16-year period (1998-2013) and was validated for two years (1999 – a dry year and 2006 – a wet year), which were selected due to their variable hydrological conditions. The CLM performed well in predicting key water quality parameters (e.g., temperature, TP, dissolved P, nitrogen, carbon, and Chl-a) compared to observed concentrations for all sites and depths (Figure 7; Appendix C; UFI 2017). Model performance was deemed acceptable by NYSDEC because its calibration/validation was consistent with the project’s Quality Assurance Project Plan (https://www.dec.ny.gov/docs/water_pdf/clmpqapp20130315.pdf; Table 15) and other models developed for other TMDLs in New York (http://www1.dec.state.ny.us/docs/water_pdf/tmdlconesusaug2019.pdf).

The summer average Chl-a concentrations are the critical conditions for the Cayuga Lake TMDL to ensure that the best uses are restored and protected in Cayuga Lake. The performance of the CLM to predict water quality was evaluated by comparing the observed summer (June-September) average Chl-a and TP water quality data for the unimpaired and impaired segments over the 1998-2013 interval to the model output. The performance results are presented for the Main Lake, Mid-South and Southern End segments in Table 15.

Table 14~~15~~. Observed vs. model predicted summer mean epilimnetic TP and Chl-a concentrations in Cayuga Lake for the Main Lake, Mid-South and Southern End Segments.

Year	Unimpaired Segment (Mid-South, 0705-0050 (Class AA))				Impaired Segment (Southern-End, 0705-0040 (Class A))			
	Observed TP (µg/L)	Modeled TP (µg/L)	Observed Chl-a (µg/L)	Modeled Chl-a (µg/L)	Observed TP (µg/L)	Modeled TP (µg/L)	Observed Chl-a (µg/L)	Modeled Chl-a (µg/L)
1998	14.7	13.5	4.8	4.8	24.2	19.5	4.7	6.2
1999	9.8	8.3	4.6	3.3	14.8	11.7	4.5	4.2
2000	11.6	12.9	4.8	4.4	19.6	19.5	5.2	5.7
2001	14.1	9.5	4.5	3.3	20	15.4	4.7	4.6
2002	14.1	11.7	5.1	3.8	20.7	20.2	5	5.3
2003	10.6	10.9	5.4	4.6	13.7	17.6	6.7	5.7
2004	14.2	13.8	5.3	5.4	21.8	24.2	4.9	7.3
2005	12.6	11.7	4.6	4.9	19	15.4	5.1	5.9
2006	15.2	16.6	7.8	6.1	24.9	28.9	7.4	7.1
2007	13.4	10.8	6.6	4.7	23.2	12.7	5.3	5
2008	12.2	10.9	6.9	4.6	17.2	13.8	6.2	5.1
2009	11.6	10.7	6.5	4.6	16.5	13.8	5.3	5.1
2010	13.0	10	5.8	4.4	15.7	11.5	6.4	4.5
2011	14.5	15	7.1	5.5	16.5	24	5.4	6.4
2012	12.3	10.1	5.5	4.5	15.3	11.4	3.9	4.5
2013	15	12.1	4.5	4.9	27	21.4	4.4	5.8
Average	**13.1**	**11.8**	**5.6**	**4.6**	**19.4**	**17.5**	**5.3**	**5.5**
Average Percent Error		**10%**[1,2]		**18%**		**10%**		**4%**

[1] Error = absolute value of (prediction – observation)/observation ×100. Error is calculated as: absolute value of (prediction – observation)/observation ×100

[2] % Acceptable error thresholds of performance for the CLM based on summer average of the upper waters at 1.5 m depth. TP $\leq$ 25%; Chl-a $\leq$ 50%

5.2 Cayuga Lake Model to Determine Loading Capacity

The Cayuga Lake TMDL scenarios were evaluated using the base loading condition. For the purposes of the Cayuga Lake TMDL, the base loading condition is defined as the aggregate of the measured nonpoint source loading and facility-specific permitted flows and TP concentrations. Permitted flow and TP concentration effluent limitations were used in the development of the Cayuga Lake TMDL because regulated point sources can legally discharge to their permit levels and the TMDL must account for the maximum potential load to the lake.

The CLM was used to define the relationship between phosphorus loading to the lake, the resulting in-lake concentrations of TP, and ultimately, the summer average Chl-a for all lake segments. Analysis of the phosphorus loading capacity of Cayuga Lake was completed by running numerous CLM scenarios of percent reduced phosphorus load from the base condition and finding the reduction needed to meet Chl-a water quality targets. Current average annual base model loading of TP to Cayuga Lake was estimated to be 441,620 lbs TP/y (1,210 lbs TP/d; Section 4). Modeling scenario runs were extensive, extending over 16 years of meteorological, flow, and loading conditions. The categories of scenarios evaluated were: (1) watershed reductions in TP; (2) point source reductions in TP; or (3) combinations of watershed and point source reductions in TP. Appendix D contains the full list of scenarios (approximately 30) evaluated by NYSDEC to determine the TP load capacity. Table 16 contains a list of seven scenarios important for evaluation based on public interest and/or related to the goals of the Cayuga Lake TMDL.

Table 15~~16~~. Description of the CLM phosphorus loading scenarios used in the Cayuga Lake TMDL development. Percentage reductions in the table are from phosphorus base loading.

Scenario	Justification
Total phosphorus load to Cayuga Lake from nonpoint sources reduced by 20 percent. No change in point source loads.	A small reduction in the dominant loading sector to assess lake response.
Total phosphorus load to Cayuga Lake from nonpoint sources reduced by 30 percent. No change in point source loads.	**A practical reduction in the dominant loading sector to assess lake response.**
Total phosphorus load to Cayuga Lake from nonpoint sources reduced by 50 percent. No change in point source loads.	An aggressive reduction in the dominant loading sector to assess lake response.
LSC facility effluent “pipe” moved from the Southern End to a deep-water discharge (depth of 80m) in the Main Lake, Mid-South segment. No other changes.	Assess the lake response with this point source moved from the impaired segment into the Mid-South segment, out of the photic zone.
LSC facility phosphorus limit (currently 6.4 lbs/day) increased to 7.6 lbs/day (LSC effluent “pipe” at current location on the Southern End). No other changes.	Approximate the lake response by increasing this point source by 120%.
LSC facility phosphorus limit decreased to 4.8 lbs/day (LSC effluent “pipe” at current location on the Southern End). No other changes.	Approximate the lake response by reducing this point source by 25%.
Total phosphorus loads to the lake from point sources reduced to 0 lbs/day. No other changes (UFI, 2017)	Approximate the lake response if no point sources were allowed to discharge to the lake. Used to inform SPDES permit change considerations.

5.3 CLM Scenario Results to Achieve Water Quality Targets

Observed summer averaged Chl-a concentrations exceeded the 6 µg/L target in the Southern End segment 4 years out of the 16-year the monitoring period (1998-2013; Figure 9). Figure 10 presents the estimated summer average Chl-a concentrations for the Base model scenario used in the development of the Cayuga Lake TMDL.

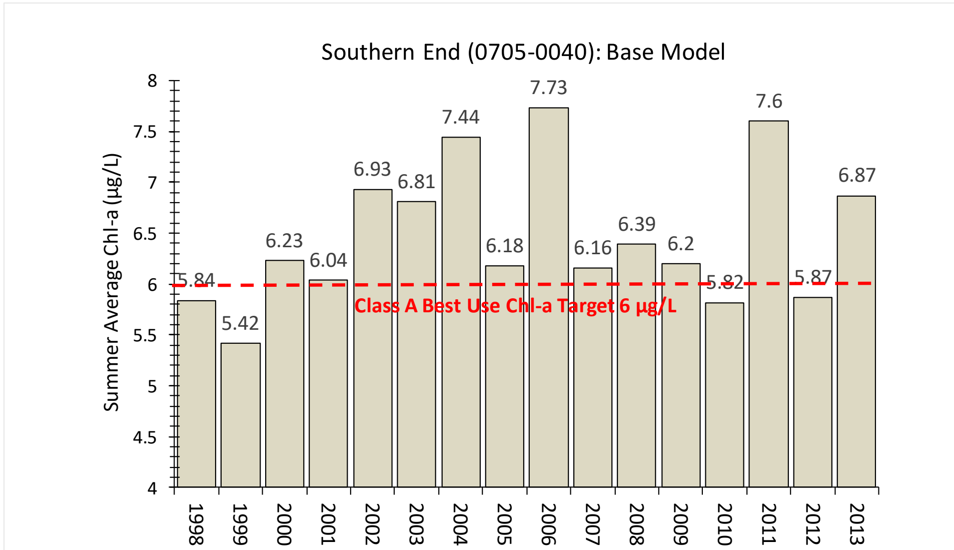


Figure 9~~10~~. Modeled, base scenario summer averaged Chl-a concentrations in the Southern End segment.

The scenario that demonstrated achievement of the Chl-a water quality target for the Southern End segment and provided reasonable protection for the Unimpaired segments for Cayuga Lake, was a watershed-wide **30% reduction in TP loading.** In that scenario, a Chl-a water quality target of 6 µg/L is achieved in the Southern End segment 15 years out of the 16-year period (Figure 11). The Chl-a water quality target was not met in model year 2011 even after a 30% reduction in TP load. 2011 was an abnormal year due to extreme meteorological conditions that resulted in extremely high nutrient loading to the lake. Values in Figure 11 were rounded based on analytical accuracy.

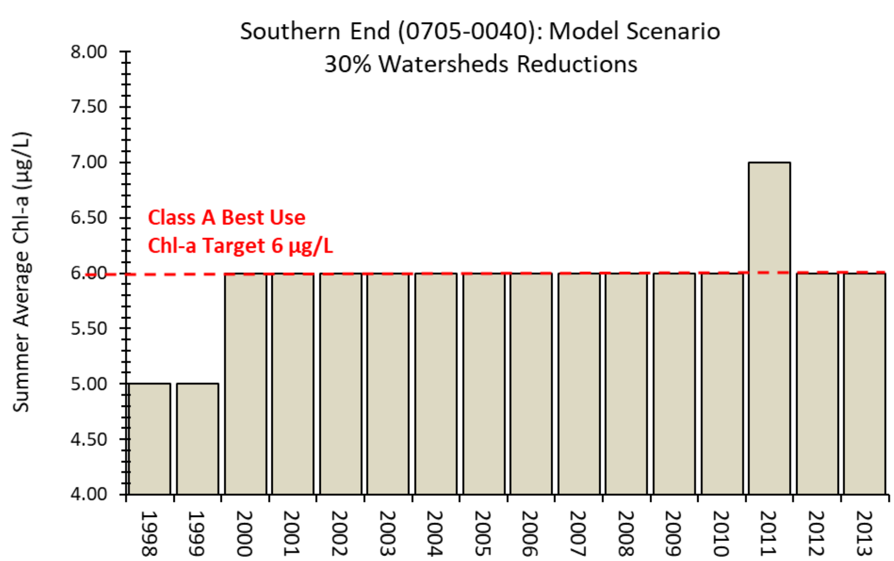


Figure 10~~11~~. Modeled summer averaged chlorophyll-a concentrations in the Southern End segment.

To achieve the in-lake Chl-a water quality targets in all segments, the Cayuga Lake TMDL recommends a 30% reduction in TP loading. Therefore, the phosphorus loading capacity to Cayuga Lake is estimated to be 310,415 lbs TP/yr (or 850 lbs TP/d) for the entire watershed.

- For the Southern End segment watershed, the maximum TP load that will ensure attainment of the Chl-a target is 78,039 lbs TP/yr (214 lbs TP/d); and
- For the Unimpaired segment watersheds (combined), the maximum TP load that will ensure attainment of the Chl-a target is 232,376 lbs TP/yr (636 lbs TP/d).

6.0 TMDL LOAD ALLOCATIONS

The objective of a TMDL is to provide a basis for allocating loads among the known pollutant sources such that, when appropriate control measures are implemented, water quality standards will be achieved. WLAs are assigned to discharges regulated by SPDES permits (i.e., point sources). Unregulated loads (i.e., nonpoint sources) are assigned LAs. A TMDL is expressed as the sum of all individual WLAs, LAs, and an appropriate margin of safety (MOS), which takes into account uncertainty (Equation 1).

Equation 1. Calculation of the TMDL

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

As presented in Section 5, the TP loading capacity for the Southern End segment is 214 lbs TP/d (78,039 lbs TP/yr) and 636 lbs TP/d (232,377 lbs TP/yr) for the Unimpaired segments of the lake. Together, those numbers represent the loading capacity of the Cayuga Lake TMDL in the equation.

To achieve the 30% watershed-wide reduction to meet the Cayuga Lake TMDL loading capacity, LAs were applied consistently to each nonpoint source sector across all of the four waterbody segments . To achieve the loading capacity for each segment and the lake overall, necessary nonpoint source load reductions by land use type are:

- Cultivated crops – 42% reduction
- Hay/pasture – 40% reduction
- Forest – 15% reduction
- Developed use – 10% reduction
- Septic Systems – 5% reduction

Each lake segment's percent reduction varied depending on the TP contributions from nonpoint and point sources within its sub-watershed, the proportion of the segment's TP load to the lake (table below), and reductions that are reasonably achievable. It is important to note, the combined reductions from each lake segment results in a 30% reduction watershed-wide in TP loading required to meet the lake's loading capacity and Cayuga Lake TMDL's water quality targets (Section 3).

Segment	Current TP Load (lbs/d)	Cayuga Lake TMDL Allocation with 10% Margin of Safety (lbs/d)	Percent Reduction (%)
Impaired Southern End segment (0705-0040)	270	214	21
Unimpaired Main Lake, Mid-South segment (0705-0050)	741	502	32
Unimpaired Main Lake, Mid-North segment (0705-0025)	191	130	32
Unimpaired Northern End segment	8.03	5.39	33

6.1 Impaired Segment Overview of Load and Waste Load Allocations and Load Reductions

The LA and WLA for the Southern End segment is presented in Table 17.

Table 16~~17~~. TP TMDL for Southern End segment (0705-0040) as daily loads and existing TP loads by source.

Impaired Segment Sources	Existing TP Load (lbs TP/d)	TMDL Allocation (lbs TP/d)	Reduction Percent
Load Allocation (LA)	***197***	***124***	***37***
Cultivated crops*	105.2	61.0	42
Hay/pasture*	62.1	37.3	40
Forest	26.5	22.5	15
Developed Land	2.35	2.11	10
Onsite Septic Systems	1.02	0.97	5
Wasteload Allocation (WLA)	***72.6***	***70.5***	***3***
Ithaca Area WWTP (IAWWTP) (NY0024228)	40.0	40.0	0
Cayuga Heights WWTP (CHWWTP) (NY0020958)	5.84	5.84	0
Dryden WWTP (NY0029190)	3.36	3.36	0
Freeville WWTP (NY0110493)[1]	3.13	1.04	67
Lake Source Cooling (LSC) (NY00244741)	6.40	6.40	0
MS4s	13.8	13.8[+]	0
LA + WLA	***270***	***194***	**28**
Margin of Safety (MOS 10%)	**-**	**19.4**	**-**
Total	***270***	**214**	**21**

*Farmsteads located in the watershed that are covered under a Concentrated Animal Feeding Operation (CAFO) permits are identified in Table 1, Appendix F. CAFO farm fields are accounted for in the nonpoint source agricultural load.
[+] MS4s in the Impaired segment are currently practicing enhanced P removals as per current permit requirements.
[1] WLA based on the TMDL recommendation to modify the permit to include a TP limit of 1 mg/L.

6.2 Load Allocation for Impaired Segment

The LAs were subdivided for the TMDL according to the four dominant land use categories: cultivated crops, hay/pasture, forested and developed. The forest category includes runoff from forests in silvicultural management. Agriculture includes activities involved with cultivated crops and hay/pasture lands. Developed refers to a variety of land uses including homes, lawns, driveways, and back roads found in lightly developed rural areas of the Cayuga Lake watershed, as well as large parking lots, commercial buildings, and streets found in town centers, and other densely developed areas.

6.3 Wasteload Allocation for Impaired Segment

The TMDL considers four permitted WWTFs and Cornell University's LSC facility that discharge into the watershed for the Southern End segment (Table 18). Those WWTFs and LSC comprise 21.8% of the annual TP load to the Southern End segment (Table 11).

In 1995, Ithaca Area WWTF (SPDES NY0026638) in Tompkins County requested a flow increase to 13.1 million gallons per day (MGD), from their previous permitted flow limit of 10 MGD. The phosphorus effluent limitation in the unmodified permit was 1.0 mg/l. NYSDEC approved the flow increase and discontinued the existing limitation for phosphorus of 1.0 mg/l through SPDES permit modification. NYSDEC also established a phosphorus effluent limitation as a no net increase limit to ensure that when Ithaca Area WWTF was discharging at its new flow limit of 13.1 MGD, it would not be discharging more phosphorus than it previously did under the 10 MGD permitted flow. The no net increase formulation used the 95th percentile of the annual average flow and concentration for three years to calculate an average existing phosphorus discharge load to Cayuga Lake. That value, 40 lbs/day, was set as the phosphorus load limit for the WWTF. The TMDL recommends that the Ithaca Area WWTF permit be modified to include a TP concentration effluent limitation of 0.5 mg/L and maintain the 40 lbs/day limit.

The other three WWTFs have SPDES permitted TP effluent limitations and have chemical phosphorus treatment; therefore, the TMDL does not recommend WLA reductions for any of those WWTFs. However, the TMDL recommends a modification to the Freeville WWTF SPDES permit (SPDES NY0110493), to include a TP concentration effluent limitation of 1.0 mg/L (Table 18) to be consistent with current statewide approach for facilities with secondary treatment technology..

In addition, the Cayuga Lake TMDL recommends that weekly soluble reaction phosphorous (SRP) monitoring be added to the SPDES permits for the four wastewater treatment facilities within the Cayuga Lake watershed for the impaired segment for at least two years. This information will be used to evaluate whether it is appropriate to impose SRP limits on WWTFs and, if appropriate, science-based SRP limits may be determined for the SPDES facilities. Because SRP is immediately available for biological growth and has the greatest potential result in algal growth relative to the other forms of phosphorus, it is critical to understand the SRP loads from SPDES permitted facilities to achieve Chl-a water quality targets.

Cornell University's LSC facility (SPDES NY0244741) withdraws water from the hypolimnion at 73 meters to meet summer cooling demands at Cornell University. The spent cooling water is discharged to the Southern End segment. However, these impacts are small and do not appear to influence Chl-a concentrations at monthly/annual time scales according to the CLM results. These findings are consistent with the water quality modeling scenarios, specifically that on annual time scales, changes in point source loading have little impact of lake water quality. Therefore, the TMDL does not recommend a WLA reduction for the Cornell University LSC SPDES permit.

There are six municipalities in the Cayuga Lake watershed that are covered under the MS4 GP-15-003. The municipalities are City of Ithaca, Town of Ithaca, Town of Dryden, Village of Cayuga Heights, Town of Newfield, and Town of Caroline. The TMDL does not recommend a TP reduction assuming compliance by those MS4s with the SPDES MS4 General Permit. Compliance with the SPDES MS4 General Permit is determined by DEC's compliance monitoring program and facility reporting and certification requirements.

Table 17~~18~~. Current (actual) and permitted SPDES phosphorus loads to the Impaired Southern End. C = concentration; Q = flow.

SPDES #	Facility	C (mg/L)	Q (MGD)	Permitted TP load (lb TP/d)	Permitted TP load (lb TP/yr)	Actual current TP load (lb TP/d)	Actual current TP load (lb TP/yr)
NY0026638	Ithaca Area WWTF	0.5**	13.1	40	14,600	18	6,571
NY0020958	Cayuga Heights WWTF	0.35	2	5.84	2,130	7.8	2,840[1]
NY0029190	Dryden WWTF	1	0.4	3.36	1,226	1.9	688
NY0244741	Lake Source Cooling	-	45.6	6.4	2,336	2.2	786
NY0110493	Freeville WWTF	1[+]	0.125	1.04[+]	382	est.[*] 3.13	est. 1,143

[+] The concentration for Freeville WWTF is a recommendation of this TMDL.
[1] Cayuga Heights WWTF experienced several phosphorus limit violations during the monitoring period which caused its average TP load to exceed the permitted limit. Corrective actions have resulted in the facility currently meeting its permit limit.
*est.= estimated based on average DMR phosphorus monitoring data from similar sized facilities.
** The concentration for Ithaca Area WWTF is a recommendation of this TMDL.

6.4 Unimpaired Segments Overview of Load and Waste Load Allocations and Load Reductions

The LAs and WLAs for each of the three unimpaired segments are presented in Tables 19-21.

Table 18~~19~~. TP TMDL for Main Lake, Mid-South segment (0705-0050) as daily loads and existing total phosphorus loads by source.

Unimpaired Main Lake, Mid-South Segment Sources	Existing TP Load (lbs TP/d)	TMDL Allocation (lbs TP/d)	Reduction Percent
Load Allocation (LA)	***708***	***425***	***40***
Cultivated crops*	540.1	313	42
Hay/pasture*	127.3	76.4	40
Forest+	24.0	20.4	15
Developed Land	13.9	12.6	10
Onsite Septic Systems	2.74	2.61	5
Wasteload Allocation (WLA)	**33.1**	**28.1**	**15**
Interlaken WWTF (NY0029289)[1]	2.50	0.84	67
Aurora WWTF (NY0023558)	2.50	2.50	0
Trumansburg WWTF (NY0029190)	1.04	1.04	0
MS4s	27.1	27.1	0
LA + WLA	**741**	**456**	**39**
Margin of Safety (MOS 10%)		**45.6**	
TOTAL	***741***	**502**	**32**

*Farmsteads located in the watershed that are covered under a Concentrated Animal Feeding Operation (CAFO) permits are identified in Table 1, Appendix F. CAFO farm fields are accounted for in the nonpoint source agricultural load.

Table ~~20~~19. TP TMDL for Main Lake, Mid-North segment (0705-0025) as daily loads and existing total phosphorus loads by source.

Unimpaired Main Lake, Mid-North Segment Sources	**Existing TP Load (lbs TP/d)**	**TMDL Allocation (lbs TP/d)**	**Reduction Percent**
Load Allocation (LA)	***188***	***115***	***39***
Cultivated crops*	138	80.2	42
Hay/pasture*	32.6	19.6	40
Forest+	6.14	5.22	15
Developed Land	10.5	9.45	10
Onsite Septic Systems	0.76	0.72	5
Wasteload Allocation (WLA)	***2.75***	***2.75***	***0***
Union Springs WWTF (NY0024228)	2.75	2.75	0
MS4s	-	-	-
LA + WLA	**191**	**118**	**38**
Margin of Safety (MOS 10%)		**11.8**	
TOTAL	**191**	**130**	**32**

*Farmsteads located in the watershed that are covered under a Concentrated Animal Feeding Operation (CAFO) permits are identified in Table 1, Appendix F. CAFO farm fields are accounted for in the nonpoint source agricultural load.

Table 20~~21~~. TP TMDL for Northern End segment (0705-0030) as daily loads and existing total phosphorus loads by source.

Unimpaired Northern End Segment Sources	**Current TP Load (lbs TP/d)**	**TMDL Allocation (lbs TP/d)**	**Reduction Percent**
Load Allocation (LA)	**8.03**	**4.90**	**39**
Cultivated crops*	5.92	3.43	42
Hay/pasture*	1.40	0.84	40
Forest+	0.26	0.22	15
Developed Land	0.45	0.40	10
Onsite Septic Systems	-	-	-
Wasteload Allocation (WLA)	**-**	**-**	**-**
MS4s	-	-	-
LA + WLA	**8.03**	**4.90**	**39**
Margin of Safety (MOS 10%)		**0.49**	**-**
TOTAL	**8.03**	**5.39**	**33**

*Farmsteads located in the watershed that are covered under a Concentrated Animal Feeding Operation (CAFO) permits are identified in Table 1, Appendix F. CAFO farm fields are accounted for in the nonpoint source agricultural load.

6.5 Load Allocation for Unimpaired Segments

The LAs were subdivided for the TMDL according to the four dominant land use categories: cultivated crops, hay/pasture, forested and developed (Tables 19-21). The forest category includes runoff from forests in silvicultural management. Agriculture includes activities involved with cultivated crops and hay/pasture lands. Developed refers to a variety of land uses including homes, lawns, driveways, and back roads found in lightly developed rural areas of the Cayuga Lake watershed, as well as large parking lots, commercial buildings, and streets found in town centers and other densely developed areas.

6.6 Wasteload Allocation for Unimpaired Segments

The TMDL considers four permitted WWTFs that discharge within the Unimpaired segments. Those four permitted WWTF comprise 4.7% of the TP load to those segments. Three of the four WWTFs have SPDES permitted TP effluent limitations and have chemical phosphorus treatment; therefore, the TMDL does not recommend a WLA reduction for any of those WWTFs. . However, the TMDL recommends a modification of the Interlaken WWTF SPDES permit (SPDES NY0029289; Table 22) to include a TP concentration effluent limitation of 1.0 mg/L to be consistent with current statewide approach for facilities with secondary treatment technology.

In addition, the Cayuga Lake TMDL recommends that weekly soluble reaction phosphorous (SRP) monitoring be added to the SPDES permits for the four wastewater treatment facilities within the Cayuga Lake watershed for the unimpaired segment for at least two years. This information will be used to evaluate whether it is appropriate to impose SRP limits on WWTFs and, if appropriate, science-based SRP limits may be determined for the SPDES facilities. Because SRP is immediately available for biological growth and has the greatest potential result in algal growth relative to the other forms of phosphorus, it is critical to understand the SRP loads from SPDES permitted facilities to achieve Chl-a water quality targets.

There are six municipalities in the Cayuga Lake watershed that are covered under the MS4 GP-15-003. The municipalities are City of Ithaca, Town of Ithaca, Town of Dryden, Village of Cayuga Heights, Town of Ulysses, and Town of Lansing. The TMDL does not recommend a TP reduction. assuming compliance by those MS4s with the SPDES MS4 General Permit. Compliance with the SPDES MS4 General Permit is determined by DEC's compliance monitoring program and facility reporting and certification requirements.

Table 21~~22~~. Current (actual) and permitted SPDES phosphorus loads to the unimpaired segments of Cayuga Lake. C= concentration; Q= flow.

SPDES #	Facility	C (mg/L)	Q (MGD)	Permitted TP load (lb TP/d)	Permitted TP load (lb TP/yr)	Actual current TP load (lb TP/d)	Actual current TP load (lb TP/yr)
NY0024228	Union Springs WWTF	1	0.33	2.75	1,004	0.64	233
NY0023558	Aurora WWTF	1	0.3	2.5	913	0.60	219
NY0024902	Trumansburg WWTF	0.5	0.25	1.04	380	0.16	60
NY0029289	Interlaken WWTF	1+	0.1	0.84+	305+	est. 2.5	est. 914

+ The concentration for Interlaken WWTF is a recommendation of this TMDL.
*est.= estimated based on average DMR phosphorus monitoring data from similar sized facilities.

6.7 Margin of Safety

The MOS takes into account the uncertainty between the model and the actual environment. It may be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions in a model), explicit (i.e., expressed in the TMDL as a portion of the loadings), or a combination of both (USEPA 1991b). For the Cayuga Lake TMDL, the MOS is a combination of both; explicitly expressed during the allocation of loadings and implicitly accounted for in model inputs. The Cayuga Lake TMDL contains an explicit MOS corresponding to 10% of the loading capacity and is included in the LAs and WLAs in Tables 17 and 19-21. The MOS is appropriate given the confidence in the CLM determined from the large dataset used to construct and test the CLM's performance (Appendix C). Additionally, an implicit MOS is provided in the CLM where WWTFs were conservatively modeled using design flows (not actual flow) (Tables 18, 22). Implicit MOS also could have been provided by making conservative assumptions at various steps in the TMDL development process (e.g., by selecting conservative model input parameters or a conservative TMDL target). However, making conservative assumptions in the modeling analysis can lead to errors in projecting the benefits of BMPs and in projecting lake responses.

6.8 Critical Conditions

TMDLs must consider critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions are represented by the combination of loading, waterbody conditions, and other environmental conditions that result in impairment and violation of water quality standards. Critical conditions for an individual TMDL typically depend on applicable water quality standards, characteristics of the observed impairments, source type and behavior, pollutant, and waterbody type. Critical conditions considered in the development of the Cayuga Lake TMDL include evaluating conditions for Chl-a concentrations in Cayuga Lake during the growing season months when temperatures are conducive to aquatic plant growth. The CLM performed well at predicting Chl-a in the summer months as compared to observed data for multiple sites over the 16-year modeling period.

In terms of TP loading, accurate representation of spring runoff from the watershed is considered critical because wet weather events transport significant quantities of nonpoint source loads into Cayuga Lake and impact water quality. Water quality ramifications of these nutrient loads are most severe during middle or late summer due to the impact on Chl-a growth. The CLM was an accurate representation of watershed runoff because the year-round loading inputs to the CLM were based on comprehensive monitoring data collected in 2013 with additional datasets available over the 2003-2006 period. The data collected represented a diverse range of meteorological and hydrological conditions and final loading estimates used in the Cayuga Lake TMDL were made for every day over the 1998-2013 period and were verified with historical observations for TP (UFI 2014).

6.9 Seasonal Variations

Seasonal variation in nutrient loading and lake response is captured within the models used for the Cayuga Lake TMDL. The models were developed and tested using a 16-year period (1998-2013) that was representative of meteorological conditions in the Cayuga Lake watershed (UFI 2014, UFI 2017) and included periods (months, years) of varying flow regimes. Chlorophyll-a concentrations in Cayuga Lake vary seasonally, with higher concentrations occurring during growing season months. The Chl-a water quality targets were evaluated during growing season months ensuring seasonal variation was taken into account in the development of the Cayuga Lake TMDL.

6.10 Reasonable Assurance

USEPA guidance states that TMDLs developed for waters impaired by both point and nonpoint sources should provide ‘Reasonable Assurances’ that nonpoint source reduction will be achieved (USEPA 1991b).

The Cayuga Lake TMDL provides ‘Reasonable Assurance’ that phosphorous loadings will be reduced to result in the achievement of Chl-a water quality targets. These targets, and the nutrient loadings modeled necessary to attain them, are designed to ensure the water in Cayuga Lake will meet the best usages of the segments, with a 10% phosphorous loading MOS.

Reasonable assurance of achieving the LAs relies upon a blend of existing programs, which have proven successful in reducing loads from targeted source sectors, and innovative solutions based on proven science to reduce nonpoint source loads.

7.0 IMPLEMENTATION SECTION

7.1 Summary

The Cayuga Lake TMDL was developed to restore the Impaired Southern End segment water quality and to protect the best uses for all segments and classifications in Cayuga Lake.

The objective of the implementation section is to provide stakeholders with resources and recommendations to select appropriate and effective management actions that will achieve the Cayuga Lake TMDL TP reductions that will restore and protect the best uses. However, attainment of the water quality standards will depend on achieving the Chl-a water quality target concentrations for each lake segment. The section provides resources and guidance for the implementation of the Cayuga Lake TMDL, including:

- Identification of active stakeholder groups working within the Cayuga Lake watershed to protect and restore water quality;
- Alignment of the Cayuga Lake TMDL with existing management actions and priority projects identified in other established plans;
- Discussion of the importance of understanding the forms of phosphorus when selecting BMPs;
- Estimation of phosphorus loading by sub-basins within the Cayuga Lake watershed to assist stakeholders to prioritize implementation; and
- Categorization of the cost-benefit of various BMPs and recommendation of specific nonpoint source BMPs

Appendix G: Implementation Resources contains relevant information about funding programs and other resources that may be leveraged for project implementations, as well as BMPs for phosphorus and sediment pollution reduction.

Information contained in this section may be used to assist stakeholders in identifying the most appropriate and effective BMPs within each sub-basin to reduce sources of phosphorus. In addition, the information may help stakeholders to prioritize, by sub-basin, target pollutant source sectors, to identify opportunities to develop Cayuga Lake watershed-wide implementation programs, and to evaluate relative implementation costs and reductions.

This implementation section offers recommendations to achieve water quality targets provided by the detailed and comprehensive analysis of the Cayuga Lake TMDL. The best management activities described here were informed by the recommendations identified in existing Cayuga Lake plans, literature reviews of phosphorus reduction strategies, other TMDLs, Nine Element Watershed plans, and established watershed-based plans, such as the Chesapeake Bay Watershed Implementation Plan.

A critical factor to successfully implement a TMDL is the identification of appropriate pollution reduction strategies available (e.g., BMPs and regulatory tools). Coordination with state agencies, federal agencies, local governments, and stakeholders will ensure that the proposed management alternatives are technically and financially feasible. NYSDEC, in coordination with these local interests, will address the sources of impairment in the Cayuga Lake watershed, match management strategies with those sources, align available resources for implementation, and ultimately improve the water quality of Cayuga Lake.

For Cayuga Lake, seeking appropriate reductions in agricultural loads is key because these loads represent the dominant external loading sector and the greatest proportion of the total controllable load to the lake. In addition, agricultural BMPs are generally more cost-effective compared to reductions in wastewater or urban runoff loads. For the agricultural source sector, implementation relies upon voluntary installation of BMPs by local stakeholders and compliance with the conditions of the CAFO SPDES General Permits. The ambient water quality of Cayuga Lake will indicate water quality improvement achieved due to watershed management actions. Stream monitoring to quantify nutrient and sediment contributions from individual tributaries and subwatersheds would provide useful information to help identify priority areas, direct resources, and understand the effectiveness of implemented BMPs. The implementation of nonpoint source BMPs is expected to primarily be a continuation of the work of various stakeholders throughout the watershed, including, but not limited to:

Cayuga County Health Department	Finger Lakes-Lake Ontario Watershed Protection Alliance
Cayuga County Soil and Water Conservation District (SWCD)	Finger Lakes Regional Watershed Alliance
Cayuga County Water Quality Management Council	Genesee Finger Lakes Regional Planning Council
Cayuga County Water Resources Council	NYS Department of Agriculture and Markets (NYSAGM) / NYS Soil and Water Conservation Committee
Cayuga Lake Monitoring Partnership	Schuyler County SWCD
Cayuga Lake Watershed Intermunicipal Organization	Seneca County Health Department
Cayuga Lake Watershed Network	Seneca County SWCD
Community Science Institute	Tompkins County Health Department
Cornell University	Tompkins County SWCD
Cortland County SWCD	Tompkins County Water Resource Council
Finger Lakes Land Trust	

Existing Watershed and Strategic Plans

There are two existing watershed plans for Cayuga Lake: the Cayuga Lake HABs Action Plan (https://www.dec.ny.gov/docs/water_pdf/cayugahabplan.pdf) and the Cayuga Lake Watershed Restoration and Protection Plan (CLWRPP 2017; https://www.cayugalake.org/wp-content/uploads/clwrpp_2017_final_4_30_17.pdf. The CLWRPP is intended to assist the ongoing annual planning effort, assess progress, and prioritize corrective actions. The CLWRPP is implemented by the Cayuga Lake Watershed Intermunicipal Organization (IO). Both plans describe actions to improve or protect Cayuga Lake water quality and have been used by the above stakeholders to that end over the past several years.

In 2018, as part of Governor Cuomo's Harmful Algal Bloom (HAB) Initiative, the Cayuga Lake HABs Action Plan was developed collaboratively by NYSDEC, NYSDOH, NYSAGM and a diverse group of steering committee members to combat HABs in Cayuga Lake. Numerous watershed protection and nutrient reduction strategies were identified and if implemented will help to achieve the targets of the Cayuga Lake TMDL. These two plans and the recommended implementation actions identified in the Cayuga Lake TMDL will assist stakeholders identify implementation projects.

The Cayuga watershed contains parts or all of six counties (Cayuga, Seneca, Tompkins, Cortland, Schuyler, and Tioga) each with active Soil and Water Conservation Districts. Each district develops Agricultural Environmental Management (AEM) Strategic Plans with measurable actions, every five years with the goal of advancing environmental stewardship and protecting land and water quality. The Districts provide technical assistance to landowners to evaluate practices and implement best management practices.

7.1 Forms of Phosphorus

Understanding the relative contributions of the different forms of phosphorus from different sources within the Cayuga Lake watershed was a critical component in the development of this Implementation Section because the various forms of phosphorus differ in their ability to support algal growth and, therefore, impact the aquatic environment differently. This information should be considered as recommended management actions are considered so that the most appropriate BMPs will be selected.

The two major categories of phosphorus are particulate and dissolved. Particulate phosphorus includes phosphorus in organisms, minerals from rock and soil, and phosphorus adsorbed (adhesion to solid material, forming a film on the surface) onto dead particulate organic matter (Wetzel 2001). Dissolved phosphorus includes orthophosphate, polyphosphates (found in detergents), phosphorus combined with adsorptive colloids (particles that do not settle and cannot be separated out by ordinary filtering or centrifuging), and low molecular weight phosphate esters (Wetzel 2001).

Phosphorus exists in multiple forms (Dodds 2003) that differ in their ability to support algal growth (DePinto et al. 1981, Young et al. 1985). Three forms of phosphorus are commonly measured: total phosphorus (TP), total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP). Particulate phosphorus (PP) is derived from the difference between TP and TDP. Soluble unreactive phosphorus (SUP) is derived from the difference between TDP and SRP. SUP is often identified as dissolved organic phosphorus. As demonstrated in Figure 12, the dissolved forms of phosphorus are more readily available (or bioavailable) to support algal growth than the particulate forms (Auer et al. 1998, Effler et al. 2012). The bioavailability of particulate phosphorus varies by the source but is generally not highly available (Sharpley and Menzel 1987, Prestigiacomo et al. 2016). It is important to note that even though particulate P is generally less available than dissolved forms, because the PP component dominates TP load (Prestigiacomo et al. 2016), management of PP is critical in waterbody protection and restoration. The bioavailable portion of particulate phosphorus becomes available to algae through desorption and decomposition processes that disassociate the bioavailable portion from the particulates (DePinto et al. 1981). SRP is completely and immediately available for algae and often serves as a surrogate of the total bioavailable phosphorus.

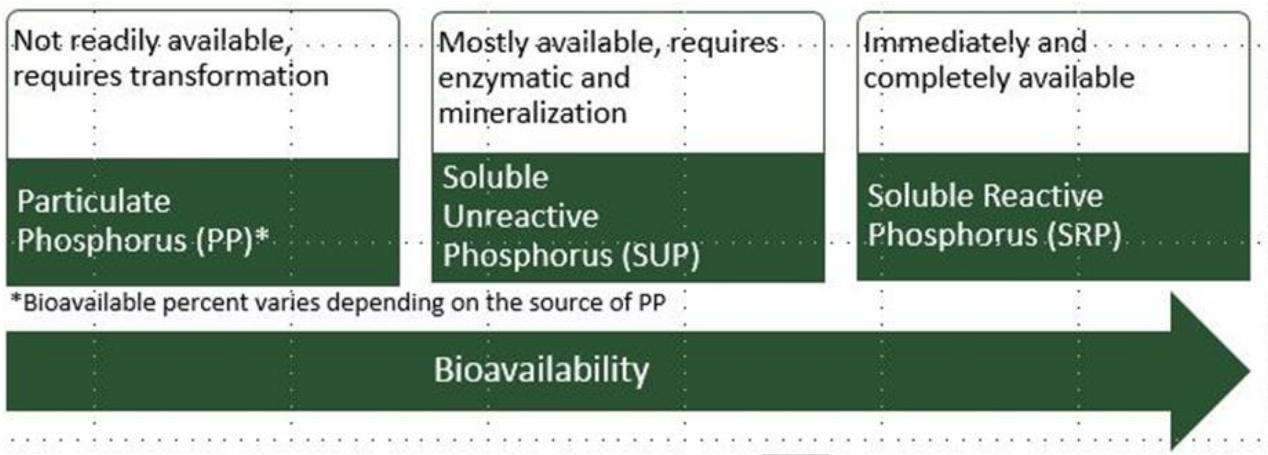


Figure 12. Forms of phosphorus and relative bioavailability.

7.2 Sub-Basin Relative Loading Characteristics

The following figures and tables describe the relative loading and land use characteristics for each of the modeled sub-basins within the Cayuga Lake watershed for the TMDL. Figure 13 show a map of the Cayuga Lake sub-basins and the corresponding modeled sub-basins (map number) used in the CLM; Table 23 cross-walks the Cayuga Lake sub-basin name with the map number (sub-basins used in the CLM).

Figure 13. Map of Cayuga Lake sub-basins. Map numbers may be used to correspond to the modeled sub-basins listed in Table 21.

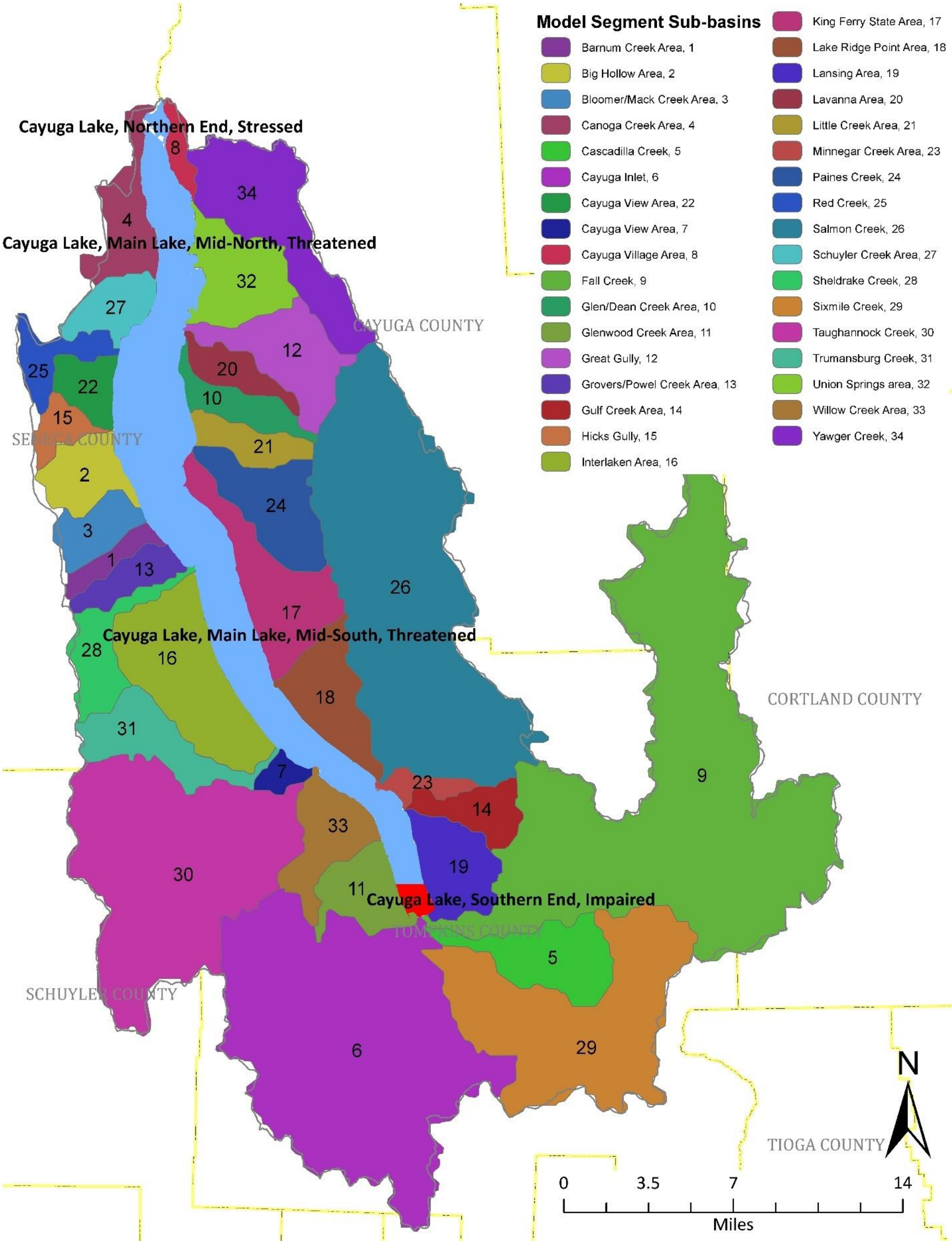


Table 22~~23~~. Map number that corresponds to the sub-basin name and sub-basin name used in the CLM (See Figure 13).

Map #	Sub-basin Name	Model Sub-basin Name	Map #	Sub-basin Name	Model Sub-basin Name
1	Barnum Creek Area	ug9	18	Lake Ridge Point Area	ug5
2	Big Hollow Area	ug11	19	Lansing Area	ug2
3	Bloomer/Mack Creek Area	ug10	20	Lavanna Area	ug13
4	Canoga Creek Area	ug14	21	Little Creek Area	ug11
5	Cascadilla Creek	ug1	22	Cayuga View Area	ug12
6	Cayuga Inlet	Cayuga Inlet	23	Minnegar Creek Area	ug4
7	Cayuga View Area	ug5	24	Paines Creek	ug11
8	Cayuga Village Area	ug15	25	Red Creek	ug12
9	Fall Creek	Fall Creek	26	Salmon Creek	Salmon Creek
10	Glen/Dean Creek Area	ug12	27	Schuyler Creek Area	ug13
11	Glenwood Creek Area	ug2	28	Sheldrake Creek	ug7
12	Great Gully	ug13	29	Sixmile Creek	Six Mile Creek
13	Grovers/Powel Creek Area	ug8	30	Taughannock Creek	Taughannock Creek
14	Gulf Creek Area	ug3	31	Trumansburg Creek	ug5
15	Hicks Gully	ug11	32	Union Springs area	ug13
16	Interlaken Area	ug7	33	Willow Creek Area	ug4
17	King Ferry State Area	ug6	34	Yawger Creek	ug15

ug – ungaged, these areas do not have continuously monitored stream flow

Overview of Potential Sources of Phosphorus

The amount and form (particulate P or dissolved P) of phosphorus reaching waterbodies (overland flow or runoff) depends on the soils, slope, land cover, weather, land use, and other pollution sources). Runoff from land uses with exposed soils (e.g., cultivated land) is generally higher in particulate phosphorus. Runoff from land uses with covered soils (e.g., grassland, forest) carries less sediment, and the dissolved forms of phosphorus can dominate (Sharpley and Menzel 1987).

The bioavailability of particulate P varies depending on the source. Chemical, biological, biochemical, and physical processes influence the interaction between particulate and dissolved phosphorus forms.

The magnitude and relative contribution of external phosphorus loads from various nonpoint sources is fundamental information to support the implementation of the TMDL (USEPA 1991b).

Due to the importance of dissolved P forms affecting receiving waterbody quality, the Cayuga Lake TMDL recognizes that only a portion of the TP loading into the lake is in a form that can immediately support algal growth. Studies of Cayuga Lake suggest that the composition of the TP pool can vary substantially between sources (Effler et al 2010, Gelda et al 2015a and Gelda et al 2015b).

Table 24 summarizes, by sub-basin, the average annual watershed nonpoint source TP loads, the relative of percent of the TP load, sub-basin area, and the average TP lbs/acre. Table 25 summarizes, by sub-basin, the average annual nonpoint source SRP load, the relative percent of the SRP load, percent of average annual TP load and percent of SRP of TP load. The information provided in Tables 24-25 were obtained from the CLM loading inputs and knowledge of each subbasin's defined area.

Table 23~~24~~. Annual average NPS TP loads (1998-2013), sub-basin areas and TP export (lbs/acre/year) from all sources in sub-basins that input into the impaired Southern End Cayuga Lake segment and unimpaired Cayuga Lake segments.

Impaired Southern End Segment Cayuga Lake sub-basins					
Map #	**Sub-basin Name**	**Modeled Source Name**	**Avg TP Annual (1998-2013) lbs/yr**	**Sub-basin Area (acre)**	**TP lbs/yr/acre**
9	Fall Creek	Fall Creek	43,102	84,785	0.51
29	Sixmile Creek	Six Mile Creek	12,550	32,023	0.39
5	Cascadilla Creek	ug1	3,120	9,201	0.34
6	Cayuga Inlet	Cayuga Inlet	18,248	62,507	0.29
Unimpaired Main Lake, Mid-South and Mid-North and Northern End Segments Cayuga Lake Sub-basins					
Map #	**Sub-basin Name**	**Modeled Source Name**	**Avg TP Annual (1998-2013) lbs/yr**	**Sub-basin Area (acre)**	**TP lbs/yr/acre**
26	Salmon Creek	Salmon Creek	79,881	58,954	1.35
7, 22	Cayuga View Area	ug5	24,565	18,510	1.33
16	Interlaken Area	ug7	30,406	22,919	1.33
3	Bloomer/Mack Creek Area	ug10	5,988	4,519	1.32
2	Big Hollow Area	ug11	29,526	22,368	1.32
10	Glen/Dean Creek Area	ug12	16,582	12,602	1.32
23	Minnegar Creek Area	ug4	12,534	9,522	1.32
11	Glenwood Creek Area	ug2	18,292	13,928	1.31
13	Grovers/Powel Creek Area	ug8	5,210	3,978	1.31

12	Great Gully	ug13	35,808	27,342	1.31
14	Gulf Creek Area	ug3	6,050	4,685	1.29
4	Canoga Creek Area	ug14	9,116	7,125	1.28
17	King Ferry State Area	ug6	15,748	12,331	1.28
8	Cayuga Village Area	ug15	23,082	18,157	1.27
1	Barnum Creek Area	ug9	3,046	2,565	1.19
30	Taughannock Creek	Taughannock Creek	21,701	43,504	0.50

Table 24~~25~~. Annual average SRP loads (1998-2013) and percent of SRP of the TP load from all sources in Cayuga Lake watershed by modeled sub-basins.ug = ungauged tributary.

Map #	Sub-basin Name	Modeled Source Name	Avg Annual SRP lbs/yr	% of avg annual SRP load
9	Fall Creek	Fall Creek	4111.8	11.0
6	Cayuga Inlet	Cayuga Inlet	3424	9.1
29	Sixmile Creek	Six Mile Creek	2306	6.2
5	Cascadilla Creek	ug1	567	1.5
Unimpaired Main Lake, Mid-South and Mid-North and Northern End Segments Cayuga Lake Sub-basins				
Map #	**Sub-basin Name**	**Modeled Source Name**	**Avg Annual SRP lbs/yr**	**% of avge annual SRP load**
26	Salmon Creek	Salmon Creek	8523	22.8
30	Taughannock Creek	Taughannock Creek	2556	6.8
12	Great Gully	ug13	1,638	4.4
16	Interlaken Area	ug7	1,545	4.1
2	Big Hollow Area	ug11	1,500	4.0
7,22	Cayuga View Area	ug5	1,248	3.3
8	Cayuga Village Area	ug15	1173	3.1
11	Glenwood Creek Area	ug2	929	2.5
10	Glen/Dean Creek Area	ug12	842	2.2

17	King Ferry State Area	ug6	800	2.1
--	--	Seneca River	763	2.0
23	Minnegar Creek Area	ug4	637	1.7
4	Canoga Creek Area	ug14	463	1.2
14	Gulf Creek Area	ug3	307	0.8
3	Bloomer/Mack Creek Area	ug10	304	0.8
13	Grovers/Powel Creek Area	ug8	265	0.7
1	Barnum Creek Area	ug9	155	0.4

The percent land use, percent TP load, and percent SRP loads for each modeled sub-basin are shown in Tables 26-28. The information is organized by impaired and unimpaired segment and listed in alphabetical order.

Table 25~~26~~. Percent land use by sub-basin for the Cayuga Lake Impaired Southern End segment and unimpaired segments.

Impaired Southern End Segment Cayuga Lake sub-basins							
Map #	**Sub-basin Name**	**Modeled Sub-Basins**	**% Cultivated crops**	**% Forest**	**% Hay/ pasture**	**% Urban and developed land**	**% Water**
5	Cascadilla Creek	ug1	5	67	16	11	0.2
6	Cayuga Inlet	Cayuga Inlet	10	60	23	7	0.2
9	Fall Creek	Fall Creek	16	48	29	7	0.4
29	Sixmile Creek	Six Mile Creek	4	71	18	7	0.3
Unimpaired Main Lake, Mid-South and Mid-North and Northern End Segments Cayuga Lake sub-basins							
Map #	**Sub-basin Name**	**Modeled Sub-Basins**	**% Cultivated crops**	**% Forest**	**% Hay/ pasture**	**% Urban and developed land**	**% Water**
1	Barnum Creek Area	ug9	35	17	42	6	2
2	Big Hollow Area	ug11	52	23	17	6	2

3	Bloomer/Mack Creek Area	ug10	44	20	30	5	1
4	Canoga Creek Area	ug14	34	22	30	10	4
7	Cayuga View Area	ug5	30	42	15	10	3
22	Cayuga View Area	ug12	49	13	31	5	2
8	Cayuga Village Area	ug15	11	31	36	13	10
10	Glen/Dean Creek Area	ug12	36	20	35	4	4
11	Glenwood Creek Area	ug2	15	38	36	10	2
12	Great Gully	ug13	54	15	28	3	0.1
13	Grovers/Powel Creek Area	ug8	47	12	34	6	2
14	Gulf Creek Area	ug3	11	51	30	8	0
15	Hicks Gully	ug11	41	14	39	7	0
16	Interlaken Area	ug7	37	20	35	7	2
17	King Ferry State Area	ug6	40	25	24	6	5
18	Lake Ridge Point Area	ug5	39	32	24	4	2
19	Lansing Area	ug2	6	34	17	43	1
20	Lavanna Area	ug13	43	19	35	3	0.1
21	Little Creek Area	ug11	44	17	30	7	2
23	Minnegar Creek Area	ug4	20	24	25	28	3
24	Paines Creek	ug11	48	21	28	3	0.1
25	Red Creek	ug12	47	23	25	6	0.1
26	Salmon Creek	Salmon Creek	47	25	25	4	0.0
27	Schuyler Creek Area	ug13	48	17	27	7	1.
28	Sheldrake Creek	ug7	39	16	40	5	0.3

30	Taughannock Creek	Taughannock Creek	23	40	32	5	0.1
31	Trumansburg Creek	ug5	29	27	37	7	0.1
32	Union Springs area	ug13	50	14	27	7	3
33	Willow Creek Area	ug4	27	37	29	5	2
34	Yawger Creek	ug15	44	14	38	4	0

Table 26~~27~~. Percent annual TP load based on average annual loads (1998-2013) by source sector within sub-basins for the Cayuga Lake Impaired Southern End segment and unimpaired segments.

Impaired Southern End Segment Cayuga Lake sub-basins						
Map #	**Sub-basin Name**	**Modeled Sub-basins**	**% Load from Cultivated crops**	**% Load from Forest**	**% Load from Hay/ pasture**	**% Load from Urban and developed land**
5	Cascadilla Creek	ug1	28	27	24	22
6	Cayuga Inlet	Cayuga Inlet	43	19	27	11
9	Fall Creek	Fall Creek	54	12	26	8
29	Sixmile Creek	Six Mile Creek	25	31	29	15
Unimpaired Main Lake, Mid-South and Mid-North and Northern End Segments Cayuga Lake sub-basins						
Map #	**Sub-basin Name**	**Modeled Sub-basins**	**% Load Cultivated crops**	**% Load Forest**	**% Load Hay/pasture**	**% Load Urban and developed land**
1	Barnum Creek Area	ug9	70	3	23	4
2	Big Hollow Area	ug11	86	3	8	4
3	Bloomer/Mack Creek Area	ug10	79	3	15	3
4	Canoga Creek Area	ug14	72	3	17	8
7	Cayuga View Area	ug5	74	8	10	9

22	Cayuga View Area	ug12	82	2	14	3
8	Cayuga Village Area	ug15	39	8	35	17
10	Glen/Dean Creek Area	ug12	74	3	20	3
11	Glenwood Creek Area	ug2	49	9	31	12
12	Great Gully	ug13	85	2	12	2
13	Grovers/Powel Creek Area	ug8	79	2	16	4
14	Gulf Creek Area	ug3	42	15	32	11
15	Hicks Gully	ug11	75	2	19	5
16	Interlaken Area	ug7	73	3	19	6
17	King Ferry State Area	ug6	80	4	13	4
18	Lake Ridge Point Area	ug5	79	5	13	3
19	Lansing Area	ug2	19	9	16	56
20	Lavanna Area	ug13	78	3	17	2
21	Little Creek Area	ug11	79	2	14	5
23	Minnegar Creek Area	ug4	52	5	17	27
24	Paines Creek	ug11	82	3	13	2
25	Red Creek	ug12	82	3	12	4
26	Salmon Creek	Salmon Creek	83	3	12	3
27	Schuyler Creek Area	ug13	81	2	12	4
28	Sheldrake Creek	ug7	74	2	20	4
30	Taughannock Creek	Taughannock Creek	64	8	24	5
31	Trumansburg Creek	ug5	66	5	23	6

32	Union Springs area	ug13	82	2	12	4
33	Willow Creek Area	ug4	68	7	20	5
34	Yawger Creek	ug15	78	2	18	2

Table 27~~28~~. Percent annual SRP load based on average annual loads (1998-2013) by source sector within sub-basins for the Cayuga Lake Impaired Southern End segment and unimpaired segments.

Impaired Southern End Segment Cayuga Lake sub-basins						
Map #	**Sub-basin Name**	**Modeled Sub-basins**	**% Load Cultivated crops**	**% Load Forest**	**% Load Hay/ pasture**	**% Load Urban and developed land**
5	Cascadilla Creek	ug1	7	28	40	25
6	Cayuga Inlet	Cayuga Inlet	12	23	51	14
9	Fall Creek	Fall Creek	17	16	55	12
29	Sixmile Creek	Six Mile Creek	6	31	47	16
Unimpaired Main Lake, Mid-South and Mid-North Segments Cayuga Lake sub-basins						
Map #	**Sub-basin Name**	**Modeled Sub-basins**	**% Load Cultivated crops**	**% Load Forest**	**% Load Hay/ pasture**	**% Load Urban and developed land**
1	Barnum Creek Area	ug9	28	4.1	60.9	7.3
2	Big Hollow Area	ug11	52	6.9	31.0	10.2
3	Bloomer/Mack Creek Area	ug10	39	5.4	48.5	7.4
4	Canoga Creek Area	ug14	30	5.9	49.1	14.8
7	Cayuga View Area	ug5	35	15.0	32.2	18.0
22	Cayuga View Area	ug12	42	3.4	47.7	7.1
8	Cayuga Village Area	ug15	10	8.9	61.3	19.8

10	Glen/Dean Creek Area	ug12	32	5.5	57.1	5.6
11	Glenwood Creek Area	ug2	14	10.6	60.4	14.9
12	Great Gully	ug13	47	4.1	44.6	3.9
13	Grovers/Powel Creek Area	ug8	39	2.9	50.7	7.8
14	Gulf Creek Area	ug3	12	16.3	58.6	13.6
15	Hicks Gully	ug11	32	3.4	55.6	8.8
16	Interlaken Area	ug7	31	5.1	53.9	10.2
17	King Ferry State Area	ug6	40	7.5	43.7	8.9
18	Lake Ridge Point Area	ug5	40	9.9	43.8	6.7
19	Lansing Area	ug2	5	8.7	25.9	60.7
Map #	**Sub-basin Name**	**Modeled Sub-basins**	**% Load Cultivated crops**	**% Load Forest**	**% Load Hay/pasture**	**% Load Urban and developed land**
20	Lavanna Area	ug13	36	4.8	54.5	4.6
21	Little Creek Area	ug11	38	4.6	47.1	10.0
23	Minnegar Creek Area	ug4	17	6.1	37.9	38.8
24	Paines Creek	ug11	43	5.8	46.6	4.4
25	Red Creek	ug12	43	6.5	41.5	8.7
26	Salmon Creek	Salmon Creek	44	7.1	42.8	5.9
27	Schuyler Creek Area	ug13	43	4.6	43.4	9.5
28	Sheldrake Creek	ug7	31	3.9	57.9	6.8
30	Taughannock Creek	Taughannock Creek	23	12.1	57.5	7.4
31	Trumansburg Creek	ug5	25	7.1	57.8	10.5
32	Union Springs area	ug13	44	3.7	42.3	10.4

33	Willow Creek Area	ug4	27	11.0	53.4	9.0
34	Yawger Creek	ug15	36	3.4	56.4	4.7

The above tables represent conditions modeled during the development of the TMDL. As newer monitoring data from the watershed becomes available, it should be carefully considered in future implementation efforts.

Recommended BMPs, BMP Efficiency and Cost

Selecting appropriate BMPs depends on numerous factors including: the target pollutant(s), target pollutant form, pollutant reduction goals, resources and economic considerations, and land availability. BMPs can be managerial, involving changes to social practices, while others can be structural by requiring the design and construction of infrastructure. Source BMPs target nutrient reduction strategies such as preventing nutrient run-off from sediment, while transport interrupting BMPs capture sediment and nutrients off-site before entering receiving waters. In addition, BMPs differ in their ability to target specific forms of P. Management of dissolved P is a continuing area of research; practices designed for the conservation of soluble P in addition to TP are recommended in the Cayuga Lake TMDL and supported in the scientific literature (Ritter and Shiromohammadi 2000 and Sharpley et al. 2006). Also, researchers have identified that management of bioavailable P is the most cost-effective strategy in reducing the effects of eutrophication (Sonzogni et al. 1982).

As stakeholders identify and prioritize specific management actions on the ground, the following factors should also be considered: cost-benefit of BMP, local support of project, feasibility and cost to the landowner, landowner agreements, completion of feasibility studies, and eligibility of project under existing funding mechanisms. When applying this approach on farms, the priority BMPs are determined in a site-specific manner by the farmer and the planner through the AEM and NRCS conservation planning process. Based on the Chesapeake Assessment Scenario Tool (CAST v 2019) relevant to NYS, Table 29 has been developed to help farmers and agricultural conservation professionals further gauge the most cost effective BMPs for TP reduction from their specific soils, management, and farm locations in the watershed.. Table 30 has been developed to help communities select the most cost effective BMPs for TP reduction from developed lands. Together with the information presented in Table 24 through 28, stakeholders would be able to focus on the priority sub-watersheds and estimate the relevant BMPs to get the most pollution reduction in the most cost-effective manner. It should be noted, that various BMPs have a range of positive impacts on other resources, such as nitrogen conservation, soil health, carbon sequestration, greenhouse gas mitigation, adaptation to climate change, habitat, etc. that aren't listed in Tables 29 and 30. Priorities and final decisions for BMP implementation for any specific farm or developed land should be based on planning and with these co-benefits in mind. Programs available to support BMP implementation can be found in Appendix G: Implementation Resources.

Table ~~29~~28. Agricultural BMPs and the TP pounds reduced and cost to reduce TP. (X = applicable, Unknown = not enough information to determine applicability)

			Targeted Nutrient Form[1]	
BMP Name	**TP Pounds Reduced**	**Cost to Reduce Pound of TP**	**Sediment bound pollutants (particulate) and nutrients**	**Dissolved pollutants and nutrients**
Riparian Forest Buffer on Pasture with Exclusion Fencing	High	Low	X	X
Riparian Herbaceous Cover on pasture with fencing	High	Low	X	X
Riparian Forest Buffer Narrow with Exclusion Fencing	Medium	Low	X	X
Heavy Use Area Protection	Medium	Low	X	unknown
Riparian Herbaceous Cover-Narrow on pasture with Exclusion Fencing	Medium	Low	X	X
Roof Runoff Structure	Medium	Low	X	unknown
Riparian Herbaceous Cover Narrow on cropland	Low	Low	X	X
Feed Management	Low	Low	X	X
Tree/Shrub Establishment	Low	Low	X	unknown
Riparian Forest Buffer on Cropland	Low	Low	X	X
Constructed Wetland	Low	Low	X	X
Prescribed Grazing	Low	Low	X	unknown
Forage Harvest Management	Low	Low	X	unknown
Conservation Tillage	Low	Low	X	unknown
Nutrient Management Plan	Low	Medium	X	X
Watering Facility	Low	Medium	X	X
Riparian Herbaceous Cover on cropland	Low	Medium	X	X
Riparian Forest Buffer Narrow on Cropland	Low	Medium	X	X
Manure Injection	Low	Medium	X	unknown
Roofs and Covers	Low	High	X	unknown
Waste Management System	Low	High	X	X

			Targeted Nutrient Form[1]	
BMP Name	**TP Pounds Reduced**	**Cost to Reduce Pound of TP**	**Sediment bound pollutants (particulate) and nutrients**	**Dissolved pollutants and nutrients**
Cover Crops	Low	High	X	X

[1] Ritter and Shiromohammadi 2000

Table 29~~30~~. Developed land BMPs and the TP pounds reduced and cost to reduce TP. (X = applicable, Unknown = not enough information to determine applicability)

			Targeted Nutrient Form[1]	
BMP Name	**TP Pounds Reduced**	**Cost to Reduce Pound of TP**	**Sediment bound pollutants (particulate) and nutrients**	**Dissolved pollutants and nutrients**
Tree Planting	High	Low	X	unknown
Riparian Forest Buffer	High	Low	X	X
Infiltration Basin	High	Medium	X	unknown
Vegetated Swale	Medium	Low	X	unknown
Stormwater Pond	Medium	Low	X	unknown
Filter Strip	Medium	Medium	X	X
Bioretention	Medium	Medium	X	unknown
Vegetated Filter Strip	Medium	Medium	X	X
Dry Detention Pond	Low	Medium	X	unknown
Nutrient Management Plan	Low	Medium	X	X
Street Sweeping	Low	Medium	X	unknown
Floating Wetland	Low	High	X	X
Diversion	Low	High	X	X
Porous Pavement	Low	High	X	unknown
Reduction of Impervious Cover	Low	High	X	unknown

[1] Ritter and Shiromohammadi 2000

<u>Priority BMPs</u>

The following Priority 1 BMPs were adapted from the Cayuga Lake Harmful Algal Bloom Action Plan (NYSDEC 2018d) and will support implementation of the Cayuga Lake TMDL. Priority 1 projects are considered necessary to manage water quality and reduce HABs in Cayuga Lake, and when implemented in priority areas (Section 7.1), will reduce phosphorus loading to Cayuga Lake.

Short-term (3 years)

1. Implement runoff reduction BMPs on agricultural and non-agricultural lands to reduce nutrient runoff and soil erosion in the watershed. These BMPs would be implemented by local SWCDs and other partners, and include:
    - Planting cover crops on cropland that is prone to erosion and nutrient runoff when left unprotected. Cover crops are a specific type of vegetative cover that are carefully planted on a field that would otherwise be left bare after a cash crop is harvested. A cover crop diffuses heavy rainfall, protecting the soil surface from erosion. In addition, a cover crop allows for living roots to be present throughout much of the year adding rich organic matter to the soil and trapping nutrients that would otherwise be prone to runoff if the soil is left bare after harvest;
    - Field erosion control systems (grassed waterways, shaping and grading, and water and sediment control basins (WASCoBs) to promote stormwater retention and minimize concentrated runoff (e.g., rills, gullies);
    - Stabilization of drainage swales through establishment of vegetation and/or installation of check dams;
    - Stream bank stabilization using both hard armoring and natural stream design methods to lessen the potential for severe and sudden sedimentation from large and/or re-occurring storm events;
    - Installation of control facilities at the outlets of drainage swales (prior to entering the lake or tributaries) to promote sediment and nutrient capture;
    - Runoff reduction BMPs for farmsteads: roof runoff management, barnyards, laneways/access roads, and bunk silos;
    - Conduct a pilot test on drainage tile BMPs;
    - Establish vegetated riparian buffers to inhibit or reduce nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams; and
    - Rehabilitate degraded vegetated buffers to improve riparian habitat function on tributaries to Cayuga Lake.
2. Implement roadside ditch and culvert improvement projects on currently failing ditch systems to reduce and capture sediment. BMPs could include:
    - Timing of cleanout to minimize soil erosion;
    - Properly sizing culverts and channels to avoid headcuts and other erosion.
    - Use of erosion control practices to assist in ditch stabilization; and
    - Installation of check dams or other facilities to reduce flow velocities, minimize erosion, and promote sedimentation.

Mid-term (3 to 5 years)

1. Increase SWCD staffing through appropriations to focus capacity to plan and implement projects (e.g., planners, engineers, technical staff) to mitigate soil erosion and reduce nutrient pollution in subwatersheds through all counties that drain to Cayuga Lake.
2. Implement Agricultural Environmental Management (AEM) Tier 3A Resource Management Plans to reduce sediment and nutrient runoff on crop farms and AEM Tier 3A Nutrient Management Plans (NMPs) on non-CAFO beef/dairy operations.
3. Establish a program to monitor, inspect, and sample existing septic systems within the Cayuga Lake watershed to maximize the functional capacity of these systems and minimize nutrient contribution.
    - Replace septic systems within the Cayuga Lake watershed, with priority to those systems identified as deficient in the above program and are within 250 ft. of Cayuga Lake or tributaries (NYSDEC 2018d). Cayuga Lake and the Cayuga Lake watershed counties are participating in the statewide septic repair program, with funding provided by the counties, administered through Environmental Facilities Corporation (EFC).
4. Build capacity of SWCDs in the Cayuga Lake watershed to implement erosion and sediment control measures on agricultural and non-agricultural lands through purchase of conservation equipment. Equipment can be owned and operated by one or more SWCDs and shared across SWCD and municipalities. Needed equipment includes:
    - Bark blowers to effectively mulch soils and stabilize large highly erodible critical areas;
    - Wood waste recycling equipment to convert municipal and culvert debris into useful material;
    - Specialized seeders for cover crop applications, including independent Highboy seeders or high horsepower tractors for tow behind models;
    - Straw mulchers;
    - Hydroseeders; and
    - Manure handling equipment (injection, boom spreader, drag line for immediate incorporation of manure to minimize runoff potential).
5. Implement a comprehensive municipal stormwater program, including hydraulic evaluation and mapping of drainage, as well as the replacement and upgrade of subsurface drainage and culverts to provide improved separation of stormwater from freshwater resources. This project is envisioned to be a collaborative effort among SWCDs and municipalities in the Cayuga Lake watershed.
6. Install stream stabilization facilities (e.g., log or stone revetments or vanes, vegetated riparian buffers) on select tributaries, as identified by local SWCDs and municipalities or other relevant stakeholders, where bed and bank erosion is contributing significant sediment nutrient loads.
7. Plant trees and shrubs, on available municipal lands and willing landowner properties, along the lake shoreline and along tributaries (e.g., Trees for Tribs program) to stabilize riparian habitat and to reduce solar heat load.
8. Implement livestock exclusion programs to reduce livestock direct access to waterbodies

9. Implement manure management techniques to be conducted by, but not limited to, local SWCDs including:
   - Manure incorporation and spreading equipment to minimize runoff potential;
   - Manure cover and flare storage systems with solid-liquid separation to expand existing storage capacity and open up extended farmer options for nutrient management;
   - Satellite manure storage systems to be able to efficiently recycle/incorporate manure on fields located off site from farmsteads; and
   - Manure storage and transfer lines to implement AEM Tier 3B Comprehensive Nutrient Management Plans designed to recycle manure and other farm nutrients to maximize soil health and crop uptake while minimizing runoff to Cayuga Lake.
10. Acquire and conserve lands within the watershed to protect and maintain existing buffers before increased subdivision and land conversion impacts these functioning systems.

Long-term (5 to 10 years)

1. Acquire and conserve lands within the watershed to reduce existing or future land use impacts on water quality. Potential parcels may include areas to protect established riparian buffer areas, sensitive riparian settings, increase/expand contiguous buffered areas, and/or that offer protection of extensive natural areas providing water quality benefits. Initial analysis and prioritization of acquisition projects is important for selecting lands best situated to provide lasting conservation and water quality benefits.
2. Construct wetlands or enhance/restore existing wetlands within the watershed to reduce nutrient and sediment loads. In the Cayuga Lake HAB Action Plan, Figure 25 shows the locations within the Cayuga Lake watershed that have either hydric, very poor, or poorly drained soils, but are not currently mapped wetland habitats according to the National Wetland Inventory (NWI) database. These locations should be targeted for proposed new wetlands as they are more likely to support wetland hydrology and vegetation.
3. Investigate the ability to complete a feasibility study to install municipal sanitary sewer infrastructure to service residences in Seneca County to reduce septic system input to Cayuga Lake in that area. A local municipality could pursue funding through EFC's Engineering Planning Grant to complete feasibility study.
4. Investigate and develop a feasibility study to install municipal sanitary sewer infrastructure to address the homes on Honoco and Lake Roads in the Towns of Ledyard and Genoa. A local municipality could pursue funding through EFC's Engineering Planning Grant to complete feasibility study.
5. Map field drainage tile lines (underground pipes that drain and convey excess soil and water for crop cultivation), where practical, used for agricultural purposes to build a database, conduct a pilot program to test for nutrients, and implement BMPs for tile drain water retention and treatment. This project may be led by, but not limited to, local SWCDs.

For additional projects and actions, please see the Cayuga Lake HABs Action Plan.

7.3 Agriculture

Agriculture represents approximately 50% of the Cayuga Lake watershed land use and agriculture lands deliver a majority of the TP load annually to Cayuga Lake. Reductions in this sector are critical for successful implementation of the Cayuga Lake TMDL.

New York State supports environmental and economically sustainable agriculture and recognizes the historic, cultural, environmental, and economic importance of maintaining agricultural viability in the Cayuga Lake watershed. On-going communication is critical to finding ways to reduce the environmental impact of farms while protecting the open space, vistas, rural economic development, food, fiber, and energy that they provide to all of us.

To this end, NYSDEC has been working with both environmental and farming stakeholders in New York State for over a decade to achieve environmental compliance for all New York's agricultural community. A carefully coordinated effort between NYSDEC, NYSAGM, and the NYS Soil and Water Conservation Committee actively supports increased conservation planning and BMP implementation on farms through programs within the Agricultural Environmental Management (AEM) framework: Agricultural Nonpoint Source Abatement and Control Program (AgNPS), the Climate Resilient Farming Program (CRF), the AEM Base Program, and the Source Water Buffer Program..

This coordinated effort works to document farm statistics and best management practices, develop watershed and site-specific agricultural plans, and implement and evaluate those practices. New York farmers are active stewards and statewide, more than 12,000 farms of all types and sizes are involved in AEM, a program that responds to environmental needs with cost effective improvements that benefit farms and communities.

7.3.1 Recommended Phosphorus Management Strategies for Agricultural Runoff

There are two primary and intertwined programs in New York that address agricultural water qulaity: the AEM Program and the CAFO regulatory program. The careful coordination of a strong regulatory program with financial incentives and a strong local implementation team all based on sound science and applied research is the recipe for a successful agricultural water quality program.

It is important to note that under the New York CAFO program, farms that qualify are required to have permit coverage (https://www.dec.ny.gov/permits/6285.html). As of March 2021, 33 ECL CAFOs are permitted in the Cayuga Lake watershed. New York's AEM program is currently working with many additional farms in the watershed. NYS AEM program is described in detail in Appendix G.

Agricultural Best Management Practices

The agricultural BMPs identified in Table 29 are recommended to best address the nutrient sources from agricultural activities. NYSDEC selected these BMPs based on technical guidance and information developed through the Chesapeake Bay Program and recommendations from the NYS Chesapeake Bay Watershed Program's technical meetings with NYS agricultural experts and farmers. These BMPs are practical and reasonable considering available funding, technical staff, time, and farm operator cooperation for implementation.

These BMPs have been shown to be highly cost-effective in reducing nutrient runoff, much like the reductions shown from implementation of comprehensive nutrient management plans. Many of the BMPs also involve source control or stream protection, so they have local benefits and tend to be fiscally sustainable. In addition, many practices reduce the impacts of atmospheric nitrogen deposition by reducing ammonia emissions and/or providing nitrogen retention. Agricultural practices can also be very cost-effective because some involve operational changes without major capital commitments. A description of the recommended agricultural BMPs can be found in Appendix G.

7.3.1 Agricultural BMP Selection

When selecting a BMP, the maps and tables in Section 7.1 have been developed to help communities select cost effective BMPs and target specific forms of P to reduce P from agricultural lands in critical areas of the Cayuga watershed. Programs available to support BMP implementation can be found in Appendix G: Implementation Resources.

7.4 Wastewater Sector

Any new permitted facilities within the Cayuga Lake watershed, in both the Impaired and Unimpaired subwatersheds, should be required to address the existing load allocations and meet strict requirements, either water quality-based effluent limitations (WQBELs) or technology based effluent limitations (TBELs), whichever is more restrictive and protective of water quality. In addition, the SPDES permits for any new and upgraded facilities should include phosphorus removal treatment and other conditions to meet all NYS requirements for either groundwater or surface water discharges. Point source contributions (assuming permit limits) to Cayuga Lake were found to be small relative to nonpoint, but regulation of these sources is an important part of implementing the Cayuga Lake TMDL.

7.4.1 Recommended Phosphorus Management Strategies for Wastewater Dischargers

The Cayuga Lake TMDL recommends that weekly soluble reactive phosphorous (SRP) monitoring be added to the SPDES permits for the eight wastewater treatment facilities within the Cayuga Lake watershed for both the impaired and unimpaired segments for at least two years. This information will be used to evaluate whether it is appropriate to impose SRP limits on WWTFs and, if appropriate, science-based SRP limits may be determined for the SPDES facilities. Because SRP is immediately available for biological growth and has the greatest potential result in algal growth relative to the other forms of phosphorus, it is critical to understand the SRP loads from SPDES permitted facilities to achieve Chl-a water quality targets.

7.4.2 Lake Source Cooling

Based on its permit conditions, Lake Source Cooling contributes 0.5% of the total phosphorus load annually to Cayuga Lake. The WLA for TP for the LSC facility is to maintain the existing limit of 6.4 lbs/day (6/1/2020; https://www.dec.ny.gov/data/IF/SPDES/NY0244741/Permit.IndSPDES.NY0244741.2020-06-01.Modification_x.pdf).

7.4.3 Combined Sewer Overflows

There are no combined sewer overflows (CSOs) in the Cayuga Lake watershed.

7.4.4 Accounting for Growth in the Wastewater Sector

In order to successfully achieve the Cayuga Lake TMDL targets, SPDES permits for new discharges should include enforceable provisions to achieve a 100% offset of the new loadings. Municipal facilities may secure offsets by assimilation of existing onsite systems and other existing wastewater treatment systems for which WLAs have been provided. Expansion of flow capacity can also be accommodated by improved treatment to meet the load limits. New or expanded discharges of any size will require regulation under an individual SPDES permit to implement offset provisions to ensure no increase of the TMDL TP.

7.4.5 NYS Dishwaters Detergent and Nutrient Runoff Law

In 2010, the NYS Dishwasher Detergent and Nutrient Runoff Law (Chapter 205 of the laws of 2010) was signed into law to reduce phosphorus entering the waste stream from dish detergent and fertilizers. The Dishwasher Detergent and Nutrient Runoff Law amended Environmental Conservation Law section 35-0105 and added a new Title 21 to Article 17 to the Environmental Conservation Law, respectively.

By limiting the sale and use of fertilizer, the Dishwasher Detergent and Nutrient Runoff Law helps local governments reduce phosphorus loads and meet water quality standards in areas where there is excessive phosphorus. In turn, this reduces the costs incurred by local governments and private entities to remove excess phosphorus from stormwater and wastewater. Through the implementation of this law, water quality will improve for recreational and other uses of the state's waters, including Cayuga Lake. For more information: https://www.dec.ny.gov/chemical/67239.html.

7.5 Recommended Phosphorus Management Strategies for Developed Land Use

The maps and tables in Section 7.1 have been developed to help stakeholders select cost effective BMPs and to target specific forms of P to reduce P from developed lands in critical areas of the Cayuga watershed. Programs available to support BMP implementation can be found in Appendix G: Implementation Resources.

DEC includes construction and post construction requirements in comprehensive technical standards that are referenced in the SPDES General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (SPDES MS4; GP-0-15-003) and SPDES General Permit for Stormwater Discharges from Construction Activity (GP-0-20-001). .

7.5.1 Municipal Separate Storm Sewer Systems (MS4s)

GP-0-15-003 was issued in April 2015, with a modification which took effect on January 13, 2016. GP-0-15-003 authorizes the discharge of stormwater from small MS4s in automatically or additionally designated areas (regulated area). GP-0-15-003 is available online at http://www.dec.ny.gov/chemical/43150.html. There are six municipalities in the Cayuga Lake watershed that qualify as small MS4sand are covered by GP-0-15-003. These six municipalities are all located in Tompkins County and cover approximately 21,000 acres within the Cayuga Lake watershed. The City of Ithaca dominates the regulated area (approximately 10,700 acres). The other six smaller municipalities are: Village of Lansing, Town of Dryden, Village of Cayuga Heights, Town of Newfield, Town of Ulysses, and Town of Caroline.

The Cayuga Lake TMDL recommends that the following be incorporated into the subsequent SPDES MS4 General Permit as requirements applicable to all small MS4s within TMDL watersheds:

- Develop comprehensive maps of MS4 watershed and outfalls;
- Develop and provide public education and outreach on the sources of phosphorus (e.g., use of phosphorus-free fertilizers, leaf litter collection, proper disposal of wash water);
- Prioritize inspection of illicit discharge, detection and elimination within area of high illicit potential, such as plant nurseries, big box stores, and other commercial businesses that may be a source of phosphorus;
- Prioritize inspection of construction activities;
- Increase good housekeeping/pollution prevention BMPs for municipal operations and facilities, such as more frequent catch basin cleaning, street sweeping, and facility inspections; and
- Incorporate, where feasible[2], cost-effective runoff reduction techniques and green infrastructure during planned municipal upgrades including municipal right of ways (e.g., bioswales, green streets, porous pavement, replacement of closed drainage with grass swales, replacement of the existing islands in the parking lots with bioretention or curb cuts to route the flow through below-grade infiltration areas).

Construction Stormwater

Before commencing a construction activity, the owner or operator of a construction project that will involve soil disturbance of one or more acres must obtain coverage under the SPDES General Permit for Stormwater Discharges from Construction Activity (GP-0-20-001). This permit is available at: http://www.dec.ny.gov/chemical/43133.html. This permit was issued in January 2020 and became effective on January 29, 2020. DEC requirements for construction activities are included in the permit.

Owners or operators with projects covered under GP-0-20-001 are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP) that meets criteria set forth by DEC or their equivalent. All SWPPPs must include an erosion and sediment control plan that addresses the potential for pollutants to be discharged during soil disturbance through implementation of practices consistent with the *New York Standards and Specifications for Erosion and Sediment Control*. Many construction sites must also address the potential for pollutants to be discharged

[2] Consideration of feasibility should include type of land use or municipal operation, suitability of soils, presence of utilities, potential for exacerbating existing contamination problems, safety issues, maintenance requirements, and expected lifespans of available technologies.

during post-construction through implementation of practices (Chapter 10) consistent with the *New York State Stormwater Management Design Manual*.

7.5.2 Outreach, Partnerships and Support through New York's Stormwater Programs

Through funding and shared goals and responsibilities, the architects of New York's Phase II stormwater program also instilled the principal of partnership into program implementation. DEC works closely with regulated MS4s, but has also developed assistance programs with other partners such as Soil and Water Conservation Districts (SWCD) through the State Committee and NYSAGM; Regional Planning Councils through the NYS Association of Regional Councils (NYSARC); and County Water Quality Coordinating Committees, through the Regional Planning Councils. All of these groups are conduits for information and services to the regulated communities (developers, designers, and municipal officials and staff) and interested parties, as well as conduits for feedback from those groups.

Funding to Support New York's Local Stormwater Programs

- **Water Quality Improvement Projects:** http://www.dec.ny.gov/pubs/4774.html
- **Clean Water Act Section 604(b):** The Clean Water Act provides for funding to states for regional water quality management planning projects.[3]

Stormwater Training Programs

Training designers and reviewers is an informal, preventative compliance activity that is very cost effective. Designers generally want to develop designs that comply with all applicable requirements. Training allows designers to better understand the requirements and reviewers to better understand what to accept.

Since the inception of the Phase II stormwater program, New York has invested substantial resources in stormwater training through DEC staff; Syracuse University; The State University of New York, College of Environmental Science and Forestry; Soil and Water Conservation Districts; Regional Councils; Cornell Cooperative Extension; NYS Department of State; NYS Department of Transportation; and other partners. Training focuses on developers, design professionals, municipal officials, and construction inspectors. Design professionals and professionals that review Stormwater Pollution Prevention Plans receive between 500 and 1,000 training hours per typical year.

Under GP-0-20-001, certain contractors (Trained Contractor) and certain Qualified Inspectors are required to complete four hours of DEC-endorsed training in the principles and practices of erosion and sediment control (E&SC) every three years. To satisfy this training requirement, DEC has partnered with County Soil and Water Conservation Districts across New York to deliver a 4-hour E&SC training course.[4]

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[3] Information about the 604(b) funding program is on the DEC website at: http://www.dec.ny.gov/lands/53122.html.
[4] DEC maintains a calendar of stormwater training opportunities online at: http://www.dec.ny.gov/chemical/8699.html.

Outreach on the DEC Website

DEC uses the MakingWaves email listserv[5] and an email list of all MS4 permit holders as outreach tools to announce activities of DEC's Division of Water. Stormwater topics are among the items announced via the MakingWaves listserv and are the focus of the MS4 permit holder email list. In addition, DEC invites public input on draft documents. The Division of Water maintains a "Public Review Documents" webpage[6] where information is posted about documents that are available for public review and comment. Documents posted on this webpage are usually announced through DEC's Environmental Notice Bulletin[7], a weekly publication.

7.7 Compliance and Enforcement

7.7.1 Introduction to the DOW Compliance and Enforcement Program

DEC protects New York's water resources through various regulations, policies, and partnerships. The agency's Division of Water, Bureau of Water Compliance (BWC), with support from the Office of General Council and the Division of Law Enforcement, manages compliance elements of the SPDES Permit Program and enforcement against those discharging to the waters of the state without a permit or beyond the authority of their permit.

7.7.2 Water Quality Management

To address current challenges and ongoing needs, DOW implements its policy and priorities on a continuous basis through the water management cycle (Figure 16). This cycle consists of five basic steps, each interdependent upon the others. These steps are: (1) Monitoring, (2) Assessment, (3) Planning and Management, (4) Implementation and Permitting, and (5) Compliance and Enforcement

[5] The MakingWaves listserv is available at: http://lists.dec.state.ny.us/mailman/listinfo/makingwaves.
[6] The Public Review Documents webpage is available at: http://www.dec.ny.gov/chemical/41392.html.
[7] The Environmental Notice Bulletin is available at: http://www.dec.ny.gov/enb/enb.html.

Figure 11~~14~~. Watershed Management Cycle

Monitoring Plan

DEC gathers information on the health of the state's waters by monitoring important characteristics such as pH, dissolved oxygen, temperature, and numerous chemical and biological components in key locations throughout the state (https://www.dec.ny.gov/chemical/23848.html). This data is supplemented with the results of aquatic organism sampling, as the type and number of these organisms assist in determining the health of a waterbody. Monitoring data become part of DEC's Waterbody Inventory/Priority Waterbody List.

To determine the effectiveness of the implementation actions associated with the Cayuga Lake TMDL, water quality monitoring on Cayuga Lake and in the watershed will be coordinated with the existing NYSDEC programs such as Rotating Integrated Basin Studies (RIBS), Lake Classification and Inventory (LCI), River and Streams Monitoring program, and Citizens Statewide Lake Assessment Program (CSLAP). Additionally, several stakeholders conduct monitoring on Cayuga Lake and its watershed. These combined, contemporary monitoring datasets will be useful to update and guide future implementation actions, as well.

Rotating Integrated Basin Studies (RIBS)

The objectives of NYSDEC's RIBS program are to assess the water quality of all waters of the state, including the documentation of good quality waters and the identification of water quality problems; identify long-term water quality trends; characterize naturally occurring or background conditions; and establish baseline conditions for use in measuring the effectiveness of site-specific restoration and protection activities. RIBS program water quality data and information are used to support assessment and management functions within DOW, including the Waterbody Inventory/Priority Waterbodies List (WI/PWL), New York State's Clean Water Act Section 305(b) Water Quality Report, and Section 303(d) List of Impaired Waters of the state. The program is designed so that all major drainage basins in the state are monitored every five years. Currently, RIBS is in the Finger Lakes basin from 2016-2018 and is scheduled to return in 2021-2023.

Lake Classification and Inventory (LCI)

LCI is DEC's monitoring program which collects data that is used to support water quality assessments and management activities of ponded waters within New York state. LCI samples are analyzed for standard lake water quality indicators, with a focus on evaluating eutrophication status (http://www.dec.ny.gov/chemical/31411.html). In addition, routine field measurements are made including water depth, water temperature, and Secchi disk transparency.

River and Stream Monitoring Programs

Monitoring Cayuga Lake's tributaries is critical to assess water quality improvements from nonpoint source BMPs. Especially important is monitoring at the mouths of important streams and in targeted sub-basins. NYSDEC maintains several stream and flowing waters monitoring programs including: biological monitoring (http://www.dec.ny.gov/chemical/23847.html), water chemistry sampling for common nutrients and pollutants, toxicity assessments, and Water Assessments by Volunteer Evaluators (WAVE; http://www.dec.ny.gov/chemical/92229.html).

Citizens Statewide Lake Assessment Program (CSLAP)

In 2017, two sites were selected for monitoring on Cayuga Lake as part of CSLAP's expansion into the Finger Lakes. One site is in the Main Lake, Mid-North segment (0705-0025-Class A) of Cayuga Lake. The second site is in the Main Lake, Mid-South segment (0705-00500-Class AA) which corresponds to a long-term monitoring location in Cayuga Lake. In 2018, CSLAP was expanded to five sites in Cayuga Lake with one site within each lake segment. Currently, samples are collected eight times per summer (May through September) for trophic state and algal indicators, including water clarity (Secchi depth) and perception assessments. Standard lake water quality indicators, with a focus on evaluating eutrophication status include: total phosphorus, nitrogen (nitrate, ammonia, and total), chlorophyll-a, pH, specific conductivity, color, and calcium.

Coordination of External Monitoring Programs

Several academic, non-profit, and volunteer groups perform routine monitoring on Cayuga Lake and in the watershed. Partners include: Cayuga Lake Watershed Network, Cornell University, the Finger Lakes Institute (FLI) at Hobart and William Smith Colleges, and the Community Science Institute (CSI) in Ithaca. Coordinated monitoring among these groups is recommended and include proper quality assurance/quality control measures to ensure that proper assessments and associated management decisions can be made.

Assessment

Assessment evaluates if a waterbody is supporting its 'best use', such as being a source of drinking water or being used for swimming or fishing, based on water quality standards and water quality data. DEC maintains a Waterbody Inventory/Priority Waterbody List[8] of the waters that do not meet standards or are unable to support their best uses and a CWA Section 303(d) list (https://www.dec.ny.gov/chemical/31290.html) of those impaired waters that may require development of a TMDL.

Planning and Management

Water resources found on the Priority Waterbodies List (PWL) have problems attributable to different sources of pollution such as malfunctioning sewage treatment plants, street runoff during storm events, or contaminated runoff from industrial, farming, or construction activities. DEC uses the PWL to manage water resources and plan staff assignments. Examples of water quality management plans currently underway are upgrades to municipal wastewater systems discharging to Onondaga Lake and the Long Island Sound. Upgrades will enhance the removal of phosphorus and nitrogen. Excessive amounts of these nutrients in wastewater discharge support undesirable plant growth and reduce oxygen available to aquatic life.

Implementation and Permitting

Monitoring, assessment, and management planning all contribute to implementation of the SPDES Permit Program. SPDES permits issued for discharges to waters of the state may contain performance standards that protect water quality. They also may include schedules of compliance that require the permittee to upgrade or install new treatment technology by a specific date. In addition, DEC works cooperatively with local governments and organizations to encourage control of nonpoint sources of pollution, such as polluted runoff from stormwater and agriculture operations.

Compliance and Enforcement

Compliance assurance and enforcement includes the evaluation of discharge monitoring reports that permitees submit as a condition of their SPDES permit. DEC evaluates these reports to determine a facility’s compliance status. DEC also relies on facility inspections and other reports, such as monthly operating reports, to determine compliance status. Upon identifying a minor violation of a SPDES permit, DEC may initiate informal enforcement action by sending a warning letter or a Notice of Violation (NOV) to prompt a voluntary return to compliance. When a voluntary return to compliance does not occur, or as conditions may warrant, formal enforcement action is considered. Formal enforcement actions include an Order on Consent, Notice of Enforcement Hearing and Complaint, Cease and Desist Directive, Commissioner’s Order, or a ticket issued by an environmental conservation officer (ECO). For more information about compliance and enforcement see https://www.dec.ny.gov/docs/water_pdf/togs142.pdf).

7.8 Recommended Phosphorus Management Strategies: Other Source Categories

7.8.1 On-site Septic Systems

The TP loading from on-site septic systems to Cayuga lake is estimated to be a small contributor to Cayuga Lake overall, but local effects of septic inputs remain poorly understood. More than

57,000 people are served by approximately 22,160 on-site septic systems in the Cayuga Lake watershed. Of these systems, there are 5,512 within 250 feet of Cayuga Lake shoreline.

On-site septic systems less than the threshold in ECL section 17-0701(6) are regulated by NYSDOH or are delegated by NYSDOH to county health departments. Additionally, county health departments are responsible for ensuring that new septic systems are installed properly. Malfunctioning systems which discharge to surface waters may also be referred to NYSDEC.

On-site septic systems greater than the threshold in ECL section 17-0701(6), including private, commercial and institutional systems, are regulated by DEC. Construction standards for these systems are found in DEC's Design Standards for Intermediate-Sized Wastewater Treatment Systems (https://www.dec.ny.gov/permits/95768.html).

Cayuga County Health Department's On-site Septic System Inspection Program

The Cayuga County SWCD provides services to county landowners for septic system inspections (dye tests) that are mandated by the Cayuga County Health Department. The District also provides percolation tests, septic system designs, and inspections of newly installed septic systems in compliance with Cayuga County and NYS State Health Codes. A summary of Cayuga County's inspection program is provided below:

Cayuga County's SWCD enforces the Cayuga County Sanitary Code which requires that all septic systems be inspected periodically and at the time of a property transfer (https://www.cayugacounty.us/DocumentCenter/View/2021/Cayuga-County-Sanitary-Code-PDF). Cayuga County SWCD also reviews plans for new and modified/repaired septic systems proposals, investigates complaints related to septic systems, provides technical assistance to septic systems installers and designers, provides a list of registered septic system installers and septic tank pumpers, and answers questions from the public regarding septic system operation and maintenance. For more information, see Cayuga County's website http://www.cayugacounty.us/Community/Health/Environmental-Health/Septic-System-Installation-and-Inspection.

7.8.2 Forestry Conservation Practices

Although forested land is a small contributor to overall TP loading, proper forestry practices are key for minimizing future phosphorus loss from these areas.

The DEC BMP Field Guide, found at https://www.dec.ny.gov/lands/37845.html is a practical tool for loggers, foresters, and landowners. It presents suggestions, guidelines, and technical references on a variety of timber harvesting practices, including skid trails, haul roads, and landings. The guide is to be used as a menu of options to protect soil, water, and timber resources from loss or degradation which reduces phosphorous loading into the watershed.

These BMPs are usually recommended as part of a forest management plan, developed through the DEC Forest Stewardship Program or others, or are required per Section 480a of the Real Property Tax Law on Certified tracts or required in sales agreements for timber harvests on DEC managed Multiple Use, Reforestation and Unique Areas, collectively known as State Forests. The implementation of forestry BMPs reduces the amount of nutrients and sediments that might otherwise be introduced into waters during timber harvesting activities.

Soil and Water Conservation Districts are also able to develop AEM Tier 3A forest conservation plans with farmers to avoid or reduce sediment and nutrient losses from management activities in woodlands on farms. The priority BMPs that stem from the plan are based on NRCS standards and the DEC BMP Field Guide referenced, above.

7.8.3 Land Conservation

New York's Open Space Plan identifies and targets high-priority open space lands, including forests, for acquisition and preservation using State EPF. Conservation easements are held in perpetuity by a public entity, such as the State, or by one of many not-for-profit land trusts (e.g., Finger Lakes Land Trust, Otsego Land Trust, The Nature Conservancy and other regional land conservancies). The NYSAGM Farmland Protection Program offers funding for local planning, direct farmland projection, and land trusts to advance agricultural land conservation goals.

7.9 Other Key Program Areas

Floodplains

Floodplains play an important hydraulic function in river systems. Undisturbed floodplains dissipate flood water energy and allow flood waters to infiltrate native soils. These functions reduce erosion potential and facilitate natural processes to attenuate nutrients. In addition, disturbance of structures and fill materials during a flood lead to deposition of large quantities of sediment and other debris that contribute to violations of the state narrative water quality standard.[9] Further, such sediments carry nutrients and other contaminates that have the reasonable potential to cause or contribute to violations of water quality standards. Improved local government administration of floodplain development regulations will reduce nutrient and sediment transported downstream during flood events. This can be accomplished by enhancing the current FEMA/State program, whereby DEC conducts Community Assessment Visits and Community Technical Assistance Contacts, works with municipalities to take corrective actions, and reports resulting findings to FEMA.

Wetland Restoration and Streambank Rehabilitation

Flooding, streambank erosion, gravel deposition and nutrient loading are common problems in New York. Addressing these issues takes a firm understanding of how the watershed functions in relation to its hydrological characteristics, drainage patterns, topography, land cover, land uses and misuses, precipitation events and other parameters.

Wetland Restoration benefits:

- **Attenuating Floods:** Wetlands, especially in the headwaters of a watershed, through their water holding capabilities and vegetation, can desynchronize rainfall runoff events, thus reducing flood peaks and downstream erosion. Novitzki (1985) found that a watershed with

[9] New York's narrative water quality for deposition is: "None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages." 6 NYCRR § 703.2

about five percent wetlands could have a 50 percent reduction in peak flood flows compared to a watershed that had none.

- **Enhancing Water Quality:** Wetlands retain sediment and nutrients during rainfall events and can be an important nutrient and sediment sink.
- **Increasing Wildlife and Habitat Diversity:** Wetlands provide unique habitats that increase species diversity and habitat connectivity.

Streambank rehabilitation benefits:

- **Reducing excess sediment:** The presence of sediment is a natural and necessary part of a healthy stream. The addition of excess sediment, however, can cause great harm to the aquatic ecosystem, including:
  - Disruption of natural stream order and flow
  - Damage to fish species through direct abrasion to body and gills and loss of fish spawning areas due to the filling in of gaps in streambeds
  - A breakdown in the aquatic food chain as sediment suffocates small organisms living in the streambed
  - Accelerated filling in of dams and reservoirs
  - A change in the water composition
- **Address stream instability and its changes to watershed hydrology:** Poorly understood stream intervention further aggravates stream stability and increases flooding potential, which can impact human health and welfare, including:
  - Severe bank erosion that threatens homes, transportation systems and other structures
  - Increased flooding events
  - Loss of utilities
  - Loss of economic viability of stream corridors

DEC “Trees 4 Tribs” Program

Since 2007, New York State’s Trees for Tribs Program has been working to reforest New York’s tributaries, which flow into and feed larger rivers and lakes. The goal of the program is to plant young trees and shrubs along stream corridors, also known as riparian areas, to prevent erosion, to increase flood water retention, to improve wildlife and stream habitat, and to protect water quality. Trees for Tribs has engaged more than 8,751 volunteers in planting more than 101,416 trees and shrubs at 614 sites across New York State.

Trees for Tribs provides landowners, municipalities, and conservation organizations with low-cost or no-cost native plants and free technical assistance. Native bareroot trees and shrubs are provided by the Saratoga State Tree Nursery, which has specialized in reforesting New York State since 1911. Trees for Tribs focuses on comprehensive watershed restoration designed to protect "green infrastructure," and the tree plantings serve as the first line of defense against storm and flooding events, protecting property, water quality, and fish and wildlife habitat. In addition to planting trees, the program also promotes BMPs for communities and encourages new programs, policies and investments in tributary protection. For information on how to participate: https://www.dec.ny.gov/animals/77710.html.

7.9.1 Ecosystem-Based Management

In an effort to promote a more integrated response to complex ecosystem problems, in 2006, New York enacted the New York Ocean and Great Lakes Ecosystem Conservation Act (L. 2006, c. 432).The law added a new Article 14 to the New York State Environmental Conservation Law and directed state agencies to employ ecosystem-based management (EBM) principles in state agency programs. EBM is an emerging, integrated approach to natural resources management that considers the entire ecosystem, including humans, to achieve improved environmental conditions and sustained ecosystem services that support human needs and social goals. Additionally, the EMB approach is consistent with the priority goals of the Great Lakes Action Agenda (https://www.dec.ny.gov/lands/91881.html). Since Cayuga Lake is located within the Great Lakes watershed, this law provides important considerations for state agencies that ultimately will improve water quality in Cayuga Lake.

7.9.2 Local Roads

Although roadside ditches have long been used to enhance road drainage and safety, traditional management practices have been a significant, but unrecognized contributor to flooding and water pollution, with ditch management practices that often enhance rather than mitigate these problems. Stabilizing road ditches and banks is a local priority, not only to minimize stream pollution, but also to improve highway safety and reduce ditch maintenance. Changes in how water flows along and across roads can reduce erosion and flooding problems. Stream road crossings frequently contribute to stream instability due to channel alterations and floodplain encroachments that may occur. Dredging and other maintenance activities intended to protect this infrastructure may also contribute to stream destabilization.

Several roadway practices are beneficial, including hydro-seeding, grade breaks (check dams), under-drains, French mattresses (allowing water under the road through course stone), crown reshaping, profile and cross slope modification, high-water bypass techniques and the use of different surface aggregates. In-stream design structures, such as cross vanes, also protect bridges and culverts. In addition to TP reduction, wetlands and other buffers also can be specifically designed and constructed or restored to capture road ditch runoff to reduce energy, capture sediments, and provide opportunity to denitrify atmospheric and automobile exhaust sources of nitrogen. Incorporating these concepts into planning, implementation, and training efforts is essential.

The Cornell Local Roads Program Local Technical Assistance Program (LTAP) Center (http://www.clrp.cornell.edu/) provides training, technical assistance, and information to municipal officials and employees responsible for the maintenance, construction, and management of local highways and bridges in New York State. It is one of 58 Centers established under the LTAP of the Federal Highway Administration. Soil and Water Conservation Districts also provide technical assistance with road bank stabilization and erosion prevention associated with road systems.

7.9.6 Green Infrastructure for Wet Weather

What is Green Infrastructure?

The term green infrastructure (GI) describes a variety of site design techniques and structural practices used by communities, businesses, homeowners, and others for managing stormwater. On a larger scale, GI includes preserving and restoring natural landscape features such as forests, floodplains, and wetlands, and reducing the amount of land covered by impervious surfaces. On a smaller scale, GI practices include green roofs, pervious pavement, rain gardens, vegetated swales, planters and stream buffers. For more information, see https://www.dec.ny.gov/public/915.html.

Why is Green Infrastructure Important?

As stormwater (i.e., rain and melting snow) flows over the ground and impervious surfaces, it collects debris, chemicals, sediment, and other pollutants. Those pollutants may end up in nearby lakes, rivers, and streams where people swim, fish, recreate, and draw drinking water, or in local sewer systems.

Benefits of Green Infrastructure

When managing stormwater, green infrastructure practices can be less expensive than expanding or building new sewer and water treatment systems. GI practices also have a number of secondary benefits including: aesthetic improvements; cleaner air; energy savings; urban cooling; climate change mitigation; and improved human health.

8.0 PUBLIC PARTICIPATION

Notice of availability of the Draft Cayuga Lake TMDL was made to local government representatives and interested parties. The Draft Cayuga Lake TMDL was publicly noticed in the Environmental Notice Bulletin on 04/07/2021. A 45-day public comment period was established for soliciting written comments from stakeholders prior to the finalization and submission of the TMDL for USEPA approval. On XX, XX, 2021, DEC hosted an informational meeting to describe the draft TMDL to stakeholders.

8.1. Response to Comments

To be included following the close of the public comment period.

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10.0 Appendices

A – Numeric Nutrient Criteria (NNC) Endpoints

B – Cayuga Lake Model (CLM) description

C – CLM Model performance

D – CLM Modeling scenarios to achieve LA, WLAs

E – Lake Source Cooling (LSC) Facility

F – SPDES Permits in the Cayuga Watershed

G – Implementation Resources